Investigation of the capsize

and sinking of the

fishing vessel

Solway Harvester **BA794**

11 miles east of the Isle of Man

on 11 January 2000

with the loss of 7 lives

Marine Accident Investigation Branch
Carlton House
Carlton Place
Southampton
SO15 2DZ

Report No 1/2006
20 January 2006

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purpose is to attribute or apportion liability or blame.

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GLOSSARY OF ABBREVIATIONS

ALB	All weather lifeboat
BCP	Burness Corlett & Partners
BMT	British Maritime Technology SeaTech Limited
CCTV	Closed circuit television
CSO	Coflexip Stena Offshore
DGPS	Differential Global Positioning System
DSV	Diving Support Vessel
EPIRB	Emergency Positioning Indicating Radio Beacon
FA	Fishermen’s Associations
FIFG	Financial Instrument for Fisheries Guidance
FTAG	Fishing Training Advisory Group
FV	Fishing Vessel
GPS	Global Positioning System
HMS	Her Majesty’s Ship
HRU	Hydrostatic Release Unit
HS	Significant wave height
JONSWAP	Joint North Sea Wave Project
(M+F)	Merchant Ships and Fishing Vessels
MAFF	Ministry of Agriculture Food and Fisheries
MCA	Maritime and Coastguard Agency
MRCC	Maritime Rescue Co-ordination Centre
MRSC	Maritime Rescue Sub-Centre
MSA	Maritime Safety Agency
OPCON	Operational Control
RFA	Royal Fleet Auxiliary
ROV	Remotely Operated Vehicle
RSS	Registry of Ships and Seafarers
SFIA	Sea Fish Industry Authority
SFPA	Scottish Fisheries Protection Agency
SSRC	Ship Stability Research Centre
TP	Modal (or peak) period
UKFVC	United Kingdom Fishing Vessel Certificate
UTC	Universal Co-ordinated Time
VHF	Very High Frequency

GLOSSARY OF TERMS

Angle of vanishing stability	Angle at which the GZ curve crosses the base line stability.
Bellies	The netting on the underside of the scallop dredge.
Detain	MCA will not permit the vessel to proceed to sea until serious deficiencies have been rectified and the vessel re-surveyed for compliance.
Dodging	Hove to. When inclement weather halts the voyage and the ship is manoeuvred so as to ride it out in the most comfortable position.
Dredge	Steel-framed basket which is dragged across the seabed to collect shellfish.
Ejector	A device which uses the Venturi effect to draw water from the bilge.
Fishing Vessel Code	The Code of Safe Working Practice For The Construction And Use of 15 Metre Length Overall to Less Than 24 Metre Registered Length Fishing Vessels.
Gilson	The mast from which the fishing gear is lifted.
GZ Curve	A diagram showing the righting lever at each angle of heel. (A stability curve)
JONSWAP	A representation of the regular wave frequencies present in the spectrum of a random seaway.
Kort nozzle	Duct surrounding the propeller to increase thrust.
Painter	Rope leading from the liferaft inflation trigger.
Risk assessment	A formal technique for assessing safety by identifying hazards, assessing the likelihood of each hazard occurring, and the potential consequences if it does.
Running	Moving in the same direction as the waves.
Shaker	A mechanical device which is shaken by an unbalanced rotor, driven by a hydraulic motor which agitates the catch causing debris to fall into rubbish chutes and the shellfish to move towards the picking trays.
Significant wave height	The mean of the third highest waves.
Sword	The rake-like bar fitted to the leading edge of the scallop dredge.
Transmotor	A well-known make of 24V direct current generator.

FOREWORD

At about 1745 on 11 January 2000, the Scottish Ballantrae registered scallop dredger *Solway Harvester* sank with the loss of her seven-man crew 11 miles south-east, and within the territorial waters, of the Isle of Man. The Marine Accident Investigation Branch started its investigation almost immediately. Its initial enquiries revealed evidence of several safety shortcomings which gave rise to serious concerns about the safety of fishing vessels. A *Safety Bulletin* outlining these concerns and making immediate recommendations was published on 23 February 2000.

The original MAIB report of the investigation of the capsize and sinking of *Solway Harvester* was completed and, after the statutory consultation process, was ready for publication in February 2002. The Isle of Man Attorney General objected to publication on the grounds of possible prejudice to the pending criminal proceedings by the Isle of Man Government against the owner of *Solway Harvester*. Exceptionally, the MAIB decided to delay publication of the report.

On 17 June 2002, the owner was charged with the manslaughter of the seven crew members on *Solway Harvester* when she sank.

When, subsequently, it became apparent that the case would take considerably longer to come to court than had been anticipated, the MAIB became concerned that the lessons to be learned and the safety recommendations arising from its investigation would be seriously delayed in being brought to the public's attention. Therefore, on 13 June 2003, the MAIB published a *Summary Report* of the investigation. This merely outlined a reconstruction of the events leading to the loss of *Solway Harvester*, based on information gleaned during the investigation, and also included additional safety recommendations to those published in the *Safety Bulletin*.

The owner's trial started on 11 April 2005 and ended on 18 May 2005 when Deemster Moran QC decided, as a matter of law, that he had a duty to stop the case from proceeding further, and directed the jury to return verdicts of "not guilty".

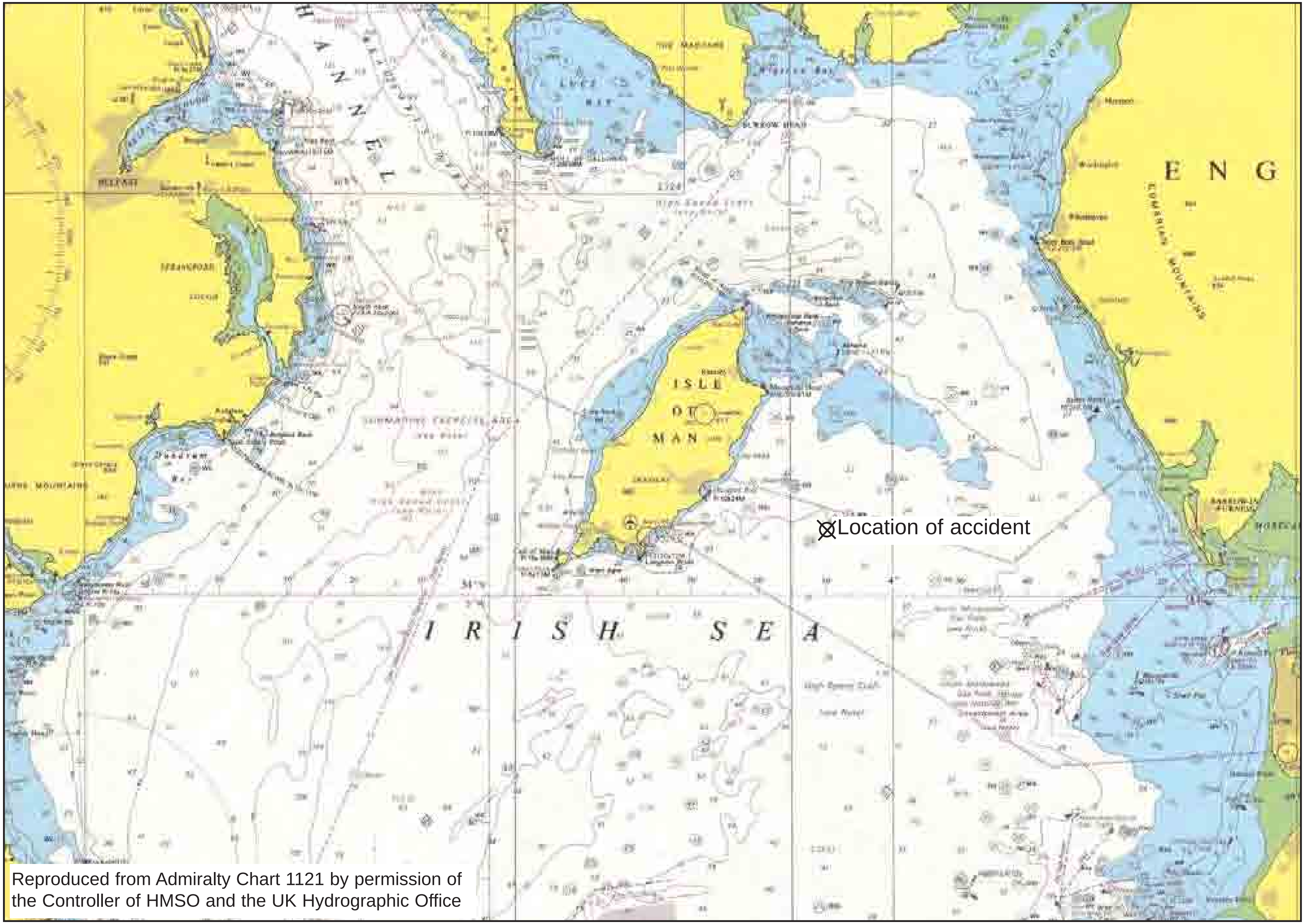
Subsequent to the trial, the MAIB has considered all the evidence presented, as well as a loss scenario developed for the defence. This has resulted in some minor textual amendments, but did not affect the MAIB's conclusions or recommendations.

This means that, some 6 years after the loss of *Solway Harvester*, and nearly 4 years after its original report had been prepared, only now can the MAIB publish its full investigation report.

The report which follows contains virtually everything that was in the original, but with some additional material used during the trial, and a section on reports and related information which has come to the attention of the MAIB since the drafting of the original report. The section "Action Taken" gives information on the status of implementation of the recommendations contained in the MAIB *Summary Report*.

S R MEYER
Chief Inspector of Marine Accidents

January 2006



Location of accident
IRISH SEA
ISLE OF MAN
ENG
HANNEL
LUCE BAY
CUMBRIAN MOUNTAINS
Reproduced from Admiralty Chart 1121 by permission of the Controller of HMSO and the UK Hydrographic Office

SYNOPSIS

On the evening of 11 January 2000, the Marine Accident Investigation Branch (MAIB) was informed that a fishing vessel was missing, feared lost, south-east of the Isle of Man. This was confirmed the following morning, and an investigation began immediately. The missing vessel was the 19.43m Scottish scallop dredger *Solway Harvester.*

Following a short period spent in harbour over the New Year holiday, *Solway Harvester* sailed to resume fishing on 6 January 2000. She returned briefly to the Isle of Whithorn early in the morning of 10 January to land her catch before sailing, once again, for the scallop beds north of Wales. By 1800 the next day, she had sunk in a position south-east of the Isle of Man. The weather was very bad and her crew of seven drowned.

Subsequent events included a search for the wreck, an underwater survey, the recovery of the bodies by the Isle of Man authorities and, eventually, the salvage of the vessel. MAIB inspectors carried out extensive interviews, a very detailed examination of the wreck and a range of model tests.

Although the wreck showed signs of damage, the investigation was able to explain the reason for this from the information gathered during the underwater survey and the forensic examination of the hull. The flattened stem was found to have been caused by the seabed when she hit it bow down and nearly inverted. There was compelling evidence that she had capsized to starboard and had inverted before sinking.

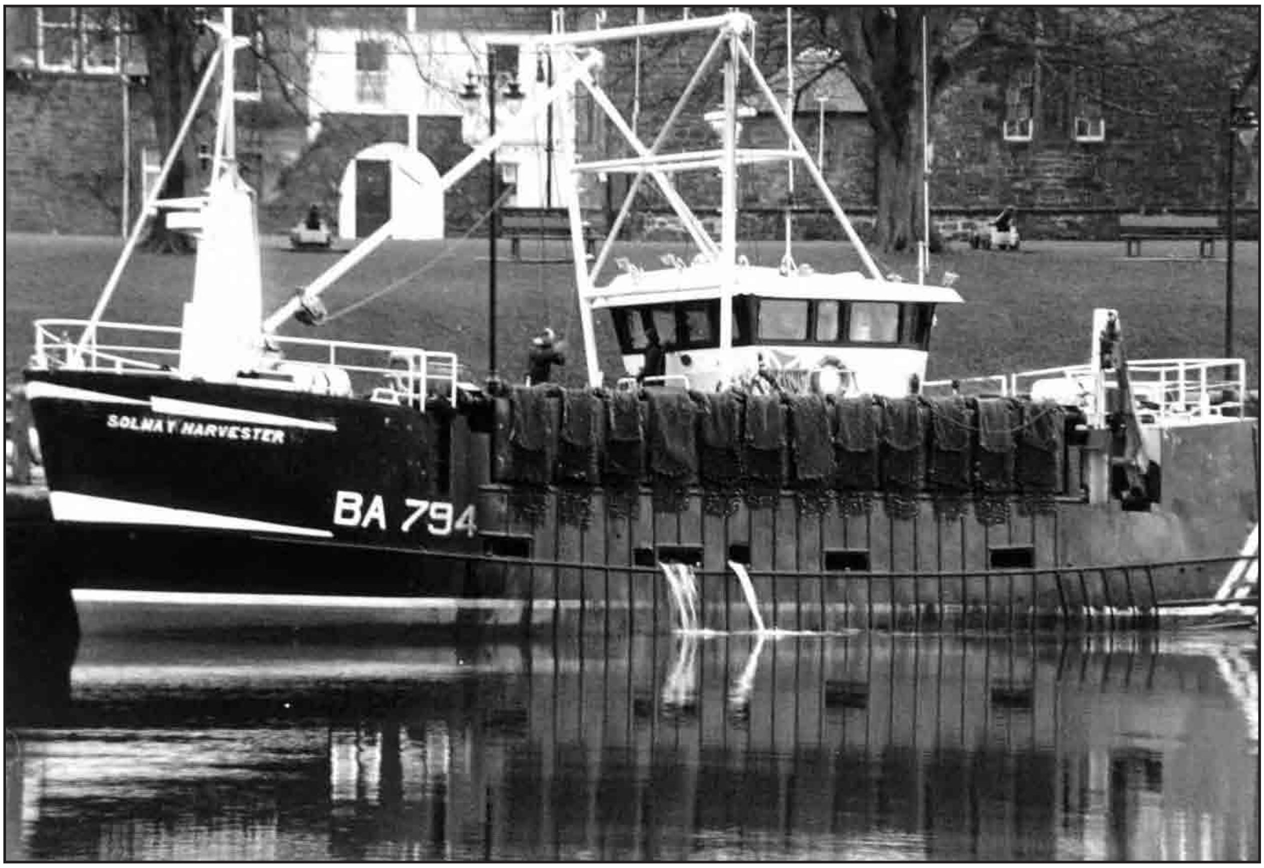
There was no sign whatsoever of a collision.

The evidence gathered during the investigation indicated *Solway Harvester* began to take water into her fish room through open ice scuttles while she was underway during the late afternoon of 11 January 2000. She was, at that time, heading for shelter in the lee of the Isle of Man. It was a foul night, and a strong south-westerly wind was blowing. She stopped and, with the way off her, came beam to sea and started to roll heavily. The floodwater in the fish room reduced her stability to such an extent that she became vulnerable to a capsize. The heavy rolling in large waves caused her cargo of bagged scallops and loose gear to shift and this, together with the reduced stability, caused her to capsize at about 1745.

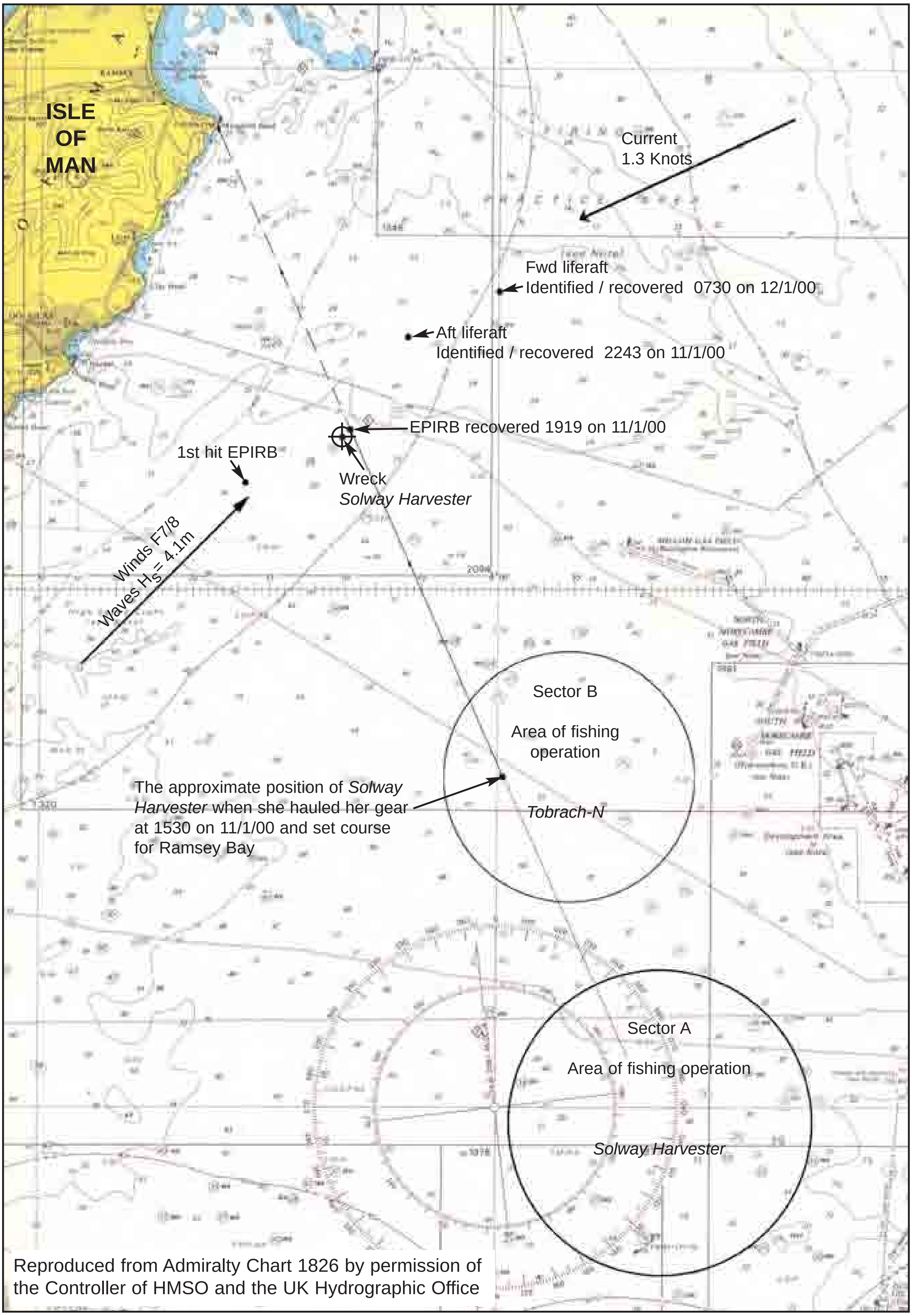
The investigation found that her bilge alarm was not functioning prior to the accident. Without this, it is probable that those on board were unaware she was taking water into the fish room until, probably, a few minutes before the accident. It also found that the bilge pumping arrangements were not working as intended.

With about 6 to 9 tonnes of water in her fish room, evidence of a shift in weight on board, the failure of her watertight integrity and the effects of heavy rolling meant she lost her stability. A capsize was inevitable.

During the trial in the Isle of Man, an alternative theory was put forward by the defence. This suggested that *Solway Harvester* could have capsized because the scallop bags, stowed in her fish room, shifted without the presence of water. This dry capsize scenario has been carefully evaluated, but is not considered sustainable by the MAIB; it would not, in any case, affect the conclusions or recommendations of this investigation.



Solway Harvester (photograph courtesy of Peter Brady)


ISLE OF MAN
Current
1.3 Knots
Fwd liferaft
Identified / recovered 0730 on 12/1/00
Aft liferaft
Identified / recovered 2243 on 11/1/00
EPIRB recovered 1919 on 11/1/00
1st hit EPIRB
Wreck
Solway Harvester
Winds F7/8
Waves H_S = 4.1m
Sector B
Area of fishing operation
Tobrach-N
The approximate position of *Solway Harvester* when she hauled her gear at 1530 on 11/1/00 and set course for Ramsey Bay
Sector A
Area of fishing operation
Solway Harvester

SECTION 1 - FACTUAL INFORMATION

All times are UTC

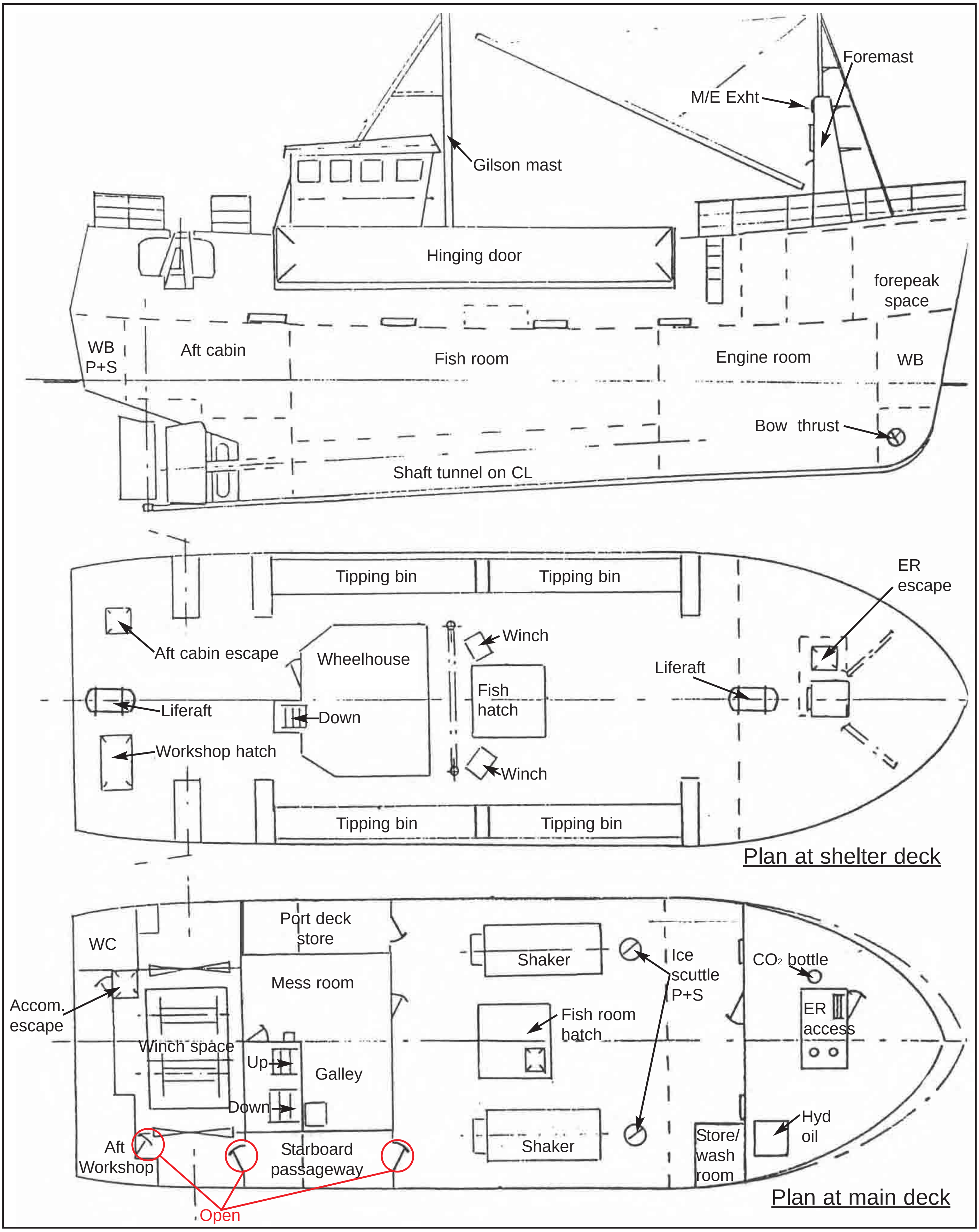
1.1 VESSEL AND ACCIDENT PARTICULARS

Vessel

Name	:	*Solway Harvester*
RSS number	:	B 13361
Port of registry	:	Ballantrae
Type	:	Fishing vessel (scallop dredger)
Crew	:	Seven
Fishing number	:	BA 794
Registered length	:	19.43m
Overall length	:	21.32m
Breadth mld	:	6.93m
Depth amidships mld	:	3.85m
UKFV certificate	:	Issued on 18/09/97, valid to 15/10/2000
Construction	:	Steel with shelter deck
Built	:	1992 at Hepworth Shipyard, Paull, Hull
Registered owners	:	Jack Robinson (Trawlers) Ltd, First Floor, Bargate, Grimsby, DN34 4SS

Accident

Position of accident	:	54° 05.85'N 004° 09.87'W
Time and date	:	Approximately 1745 on 11 January 2000
Casualties	:	All seven crew lost their lives



General Arrangement - *Solway Harvester* BA 794

1.2 VESSEL DESCRIPTION AND LAYOUT

Solway Harvester was built in 1992 at Hepworth Shipyard, Paull, Hull, UK, and surveyed in accordance with the Fishing Vessel (Safety Provisions) Regulations 1975.

A general arrangement of the vessel is at **Figure 2**.

Solway Harvester was arranged with the wheelhouse aft above the accommodation spaces, the fish room amidships below a full length steel shelter deck, and the engine room forward with the engine exhaust gas uptakes forming part of the forward mast structure.

With the engine room positioned forward, the propeller shaft passed through a tunnel under the fish room. Access to the shaft tunnel was through a small weathertight hatch in the aft bulkhead of the engine room. The sides of the shaft tunnel were the inner bulkheads of four diesel oil storage tanks with a total capacity of 20742 litres. These fed the service tank of 906 litres in the port aft corner of the engine room.

The main engine was a Caterpillar 3412 with a maximum power output of 485kW at 1800 rpm. It connected to the propeller shaft through a 6.11:1 ratio reversing gearbox. Morse cables linked the engine throttle and gearbox selector to the controls in the wheelhouse. The throttle was operable from inside the engine room, with the option of by-passing and isolating the controls in the wheelhouse. The main engine, through drive belts off its front end, also powered three direct current 24V generators, two Desmi water pumps and one Jabsco water pump.

The generators were Transmotors type DCG-55 EVR, each capable of supplying 150A at 24V to maintain the charge on the three banks of batteries. The battery banks were in three steel boxes in the engine room, numbers 1 and 2 to port and number 3 to starboard.

The Desmi pumps were S70-50-175 with 50mm diameter outlets. Each drew seawater through a strainer and screw-down valve, providing a constant supply of water to both ends of the tipping bins and the shakers. The strainers and valves were at the forward end of the shaft tunnel. Each side was supplied by its own pump but, by opening a valve in the engine room, one could supply both sides. The lever valves, controlling the supplies to the bins and shakers, were overhead on each side of the main deck. The port pump also supplied the deck wash hose, whose valve was overhead on the port side of the main deck.

The main bilge pump was a Jabsco series 50270 with a 50mm diameter outlet. It drew seawater through a strainer and screw-down valve under the floor plates on the starboard side of the engine room. It discharged either directly through an overboard valve or through the 10 ton Giljector ejector, whose suction connected to a valve manifold on the aft bulkhead of the engine room. The valve manifold was fitted with four screw-down non-return valves, and could draw water from the fish room bilge (slush well), engine room bilge, tunnel bilge or aft ballast tanks.

The auxiliary engine was a Caterpillar 3306B with a maximum power output of 194kW at 1800 rpm. It was positioned on the starboard side of the engine room and it powered the hydraulic systems, the auxiliary bilge pump and a fourth Transmotor DCG-55 EVR direct current 24V generator. The auxiliary bilge pump was also a Jabsco series 50270.

The bilge system was arranged so that either the main bilge pump or the auxiliary could supply the ejector, but not simultaneously. It was also possible to supply the ejector from the Desmi pumps. Alternatively, the Jabsco pumps could discharge bilge water directly overboard.

The engine room was fitted with a float switch to the bilge alarm.

The engine room was also fitted with a CCTV camera with a monitor in the wheelhouse positioned in front of the helmsman's seat.

Access to the engine room was through a weathertight door from the forepeak space. The forepeak space provided storage for spare gear, such as chains, springs, shackles, and drums of hydraulic and lubricating oil. The hydraulic oil tank of 1136 litres capacity was in the starboard aft corner. Under the forepeak space was the forepeak ballast tank with a capacity of 7.5 tonnes. The engine exhaust trunk was in the centre of the space. A vertical ladder led up to the forward hatch on the shelter top where it opened to port of the exhaust trunk in the foremast. A watertight bulkhead sealed the aft end of the forepeak space. A weathertight door led to the main deck through this bulkhead.

The main deck was about 8 metres long by 7 metres wide and was enclosed by a non-watertight deck shelter. To port and starboard was a shaker and picking tray for cleaning and sorting the catch. The catch dropped into the shakers from troughs built into the shelter top on both sides.

The removable picking trays were positioned over the 400mm diameter ice scuttle openings set into the deck, and through which the catch dropped into the fish room for bagging and stowing.

Along each side of the main deck were six openings comprising freeing ports and rubbish chutes from the shakers. In the forward starboard corner a small wash room could be accessed through a portal in its inboard bulkhead. The watertight bulkhead at the aft end had three weathertight doors, one to the starboard passageway, another to the crew's mess and the third to the port deck store. Fitted to this bulkhead was a CCTV camera pointing forward; its monitor was in the wheelhouse.

In the centre of the deck was the large unloading hatch (1530mm x 1530mm) with a coaming height of 465mm. Inset into this was the smaller (600mm x 600mm) fish room access hatch with a steel ladder to the fish room.

The fish room was about 8m long by 6.5m wide. It was lined with Nilflam foam block insulation behind wood panelling. Cooling coils were attached to the deckhead. Two 1100mm high hoppers were positioned at the forward end, each tapering from 1100mm wide by 850mm at their tops, to 210mm by 210mm at their base. The catch was dropped into the hoppers through the ice scuttles overhead. By operating levers on the side of the hoppers, internal flaps released the catch into bags for stowing.

On the centre-line of the fish room, and positioned at the forward bulkhead, was an ice machine capable of making 2 tonnes of ice per day from seawater.

The fish room floor sloped aft to drain into the slush well on the centre-line at the aft bulkhead. The well had a capacity of 1.25 tonnes, and was fitted with a hinged steel cover each side of the centre-line. A float switch to the bilge alarm was positioned under the port cover, and the bilge suction and strainer were to starboard.

The starboard passageway, fitted with weathertight doors at both ends, linked the main deck to the winch space aft of the galley and mess.

Two trawl winches, with their drum axes fore and aft, were arranged each side of the centre-line. The warps from the winches passed outboard over sheaves on the ends of outriggers. The outriggers were short struts from which the fishing gear was towed. They were stowed vertically against the vessel's side when not in use, and were lowered horizontal by a hydraulic ram for fishing.

A workshop lay aft of the winch space and to starboard with access through a weathertight door. It contained a workbench with tool racks above and a 240V generator underneath for welding. Above the generator was a large deck hatch in the shelter top. From the workshop a light wooden door led into a lobby with access to the emergency escape route from the aft cabin, where the crew slept. A shower and toilet space were at the far end of the lobby.

The mess adjoined the galley. It had a forward facing weathertight door opening on to the main deck and a wooden door aft into a lobby. The aft cabin was at the foot of the stairs from the lobby. Another flight of stairs led from the lobby to the wheelhouse.

In the centre of the wheelhouse was the helmsman's seat with engine throttle/gear levers, autopilot and steering joystick adjacent to starboard. A bilge alarm panel with audio and visual warnings was to port. Several items were positioned in front of the helmsman, including the CCTV monitor (which could be switched between the engine room and main deck cameras), a video-plotter and two echo sounders. The throttle lever for the auxiliary engine, the engine ignition switches and instruments were housed in the console above the CCTV monitor.

To port was the main 24V electrical distribution panel with a radar above it. To starboard of the radar was a DGPS navigator and the throttle lever for the auxiliary engine. Further again to starboard was a Furuno GP 50 navigator. On either side of the wheelhouse was a duplicate engine throttle/gear lever and steering joystick. Two VHF handsets were overhead and in easy reach of the helmsman. A radar/plotter was also fixed to the deckhead. Other navigational equipment fitted in the wheelhouse included a Navtex and weatherfax.

Solway Harvester had a small permanent list of about 2° to starboard.

1.3 FISHING GEAR AND OPERATIONS

Solway Harvester's fishing gear comprised two 12m long trawl beams, each with twelve queenie dredges and weighing 5.4 tonnes. A set of scallop dredges and bellies, weighing 2.8 tonnes, was stored in the fish room. Spare bellies and swords were stored in a pound on the main deck and more spare swords in a pound on top of the shelter.

The fishing gear was stowed on top of the shelter, immediately inboard of the bins. The frames of the dredges lay across the tops of the bins so that the bags hung over the side. To shoot the gear it was lifted off the deck on the gilsons, and lowered over the side until the trawl warp leading from the outriggers took the weight. The gilson wires would be disconnected, the outriggers lowered, and the trawl warp paid out to a length appropriate to the depth of water. The vessel then towed at a constant speed over the ground of about 3 to 4 knots, usually the equivalent of about 1400 to 1500 rpm. The engine revolutions could vary, however, between 1100 and 1700 rpm depending on the strength of the current, its direction, and the sea conditions.

After about an hour, the gear was hauled in on the warps, and the outriggers were raised so the gilson wires could be connected. The gear was then hauled towards the deck and hooked to chains at each end, draping the dredges over the hydraulically-operated doors on the vessel's sides. The doors rotated through the horizontal to a position vertically above their hinges, with the dredges hanging off pegs along their free edges. This tipped the contents of the dredges into the tipping bins. The deckhands shook each dredge to get all the shells to drop into the tipping bins. Once empty, the gear was shot away again. If it was a good haul, the gilson wires were then connected to the tipping bins and the two ends of the bins were lifted in turn to tip the catch through the hole in the shelter top on to the shakers beneath. If the haul was small, the catch might be left until the next one was added to it.

The catch was sorted on the shakers so that stones and other debris could be extracted and discarded down chutes into the sea. The selected queenies were dropped through the picking trays into the hoppers in the fish room. When the hoppers were full the catch was released into bags for stowing. A bag held, on average, 50kg of shells. Each was tied off along its top edge and stood about 900mm high with a girth of about 1200mm. They were stowed horizontally fore and aft with ice in between.

The bags were stowed against the aft bulkhead of the fish room to a height of six rows. More bags were stowed to port to remove the vessel's inherent starboard list. The bags stopped at the edges of the slush well. The next tier of bags began immediately forward of the previous one, but those in front of the slush well were usually stowed to a reduced height, typically about three bags high to allow access to the bilge strainer. This was repeated until all the catch was stowed. Any by-catch of fish was gutted and stowed in ice, in boxes down the port side.

On her final trip, *Solway Harvester* had 208 bags (10.4 tonnes) of queenies stowed in her fish room. They probably occupied two full tiers and part of a third extending to about 2.7m forward of the aft bulkhead **(Figure 3)**. She might have had 1 to 2 tonnes from her last hauls in the tipping bins.

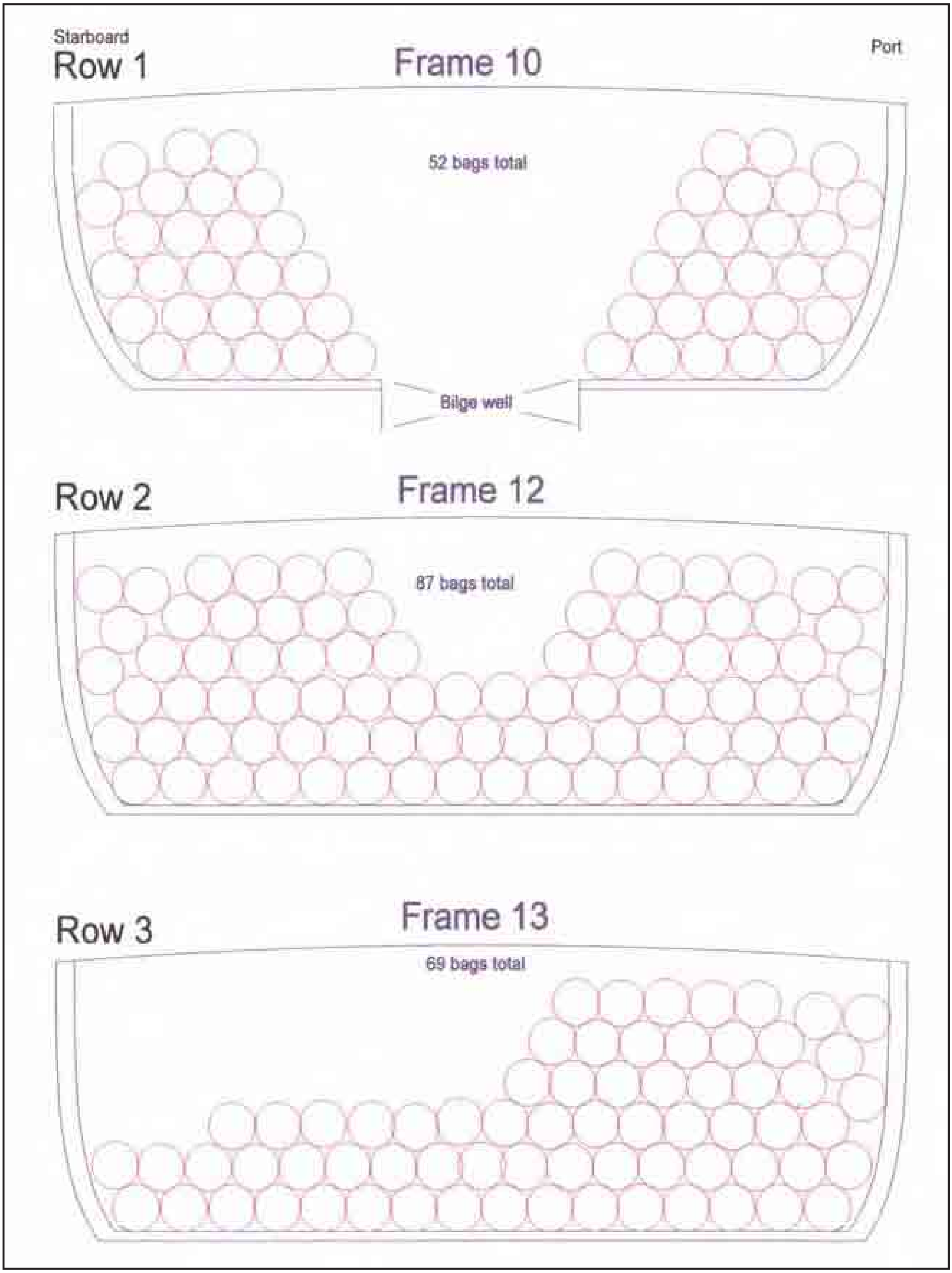
1.4 BACKGROUND TO THE FINAL VOYAGE

The scallop is one of the most commonly available, and highly prized shellfishes in both Great Britain and on the Continent. Its flesh is especially tasty when fresh, and is generally regarded as a delicacy. Scallops are usually found in clean, relatively shallow, water where the ground is soft. There are beds off the south and west coasts of England, much of the Scottish coast, and in the Irish Sea. The beds found off the Isle of Man and to the north of Wales are renowned for producing good quality catches.

The scallop is harvested by fishing vessels known as scallop dredgers or scallopers. Fitted with powerful engines they tow dredges fitted with "toothed swords" over the seabed. The swords' teeth prise up the scallops so that they collect in bags fixed to the dredges which are in turn recovered to the surface at frequent intervals. Depending on the type and size of vessel, the dredges are hoisted on to the vessel's gunwale and emptied on to the deck, into tipping bins or some other suitable receptacle. They are then sorted, placed in bags and stored in the fish room until they are landed.

Scallopers deploy from a number of ports around the British Isles, including the Dumfriesshire port of Kirkcudbright on the north coast of the Solway Firth. One of the vessels operating from Kirkcudbright in early 2000 was the 19.43m long *Solway Harvester*. She had been doing so since 1992 and was regarded as a successful scalloper. During this time she encountered all the normal

Figure 3



Probable stowage of 208 bags of shellfish in the fish room challenges and many of the problems that all fishing vessels face each day. Since entering service *Solway Harvester* had had three regular skippers. The first was Richard Gidney, later to become her owner, while the third, and last, was Craig Mills.

Before her loss, there had been two serious flooding incidents on board *Solway Harvester*. In September 1997, she was heading south in rough weather and the crew were sent to fit the covers to the ice scuttles to prevent seawater entering the fish room. A couple of hours later about 0.3m of water was found in the fish room. It was then realised that one of the scuttle covers was missing. This scuttle cover was never replaced.

The second incident occurred on 21 December 1999, just 3 weeks before she sank, and was very similar to her final accident.

Solway Harvester was dodging at night in bad weather. The mate was on watch; the skipper and the rest of the crew were turned in. The mate routinely inspected the fish room at 0700 and, on this particular morning, found it flooded. The five deckhands were roused and tried to clear the bilge suction strainer in the fish room but, because of the high water level, were unable to do so. The skipper was then called and, having taken a look, told the crew to bale the water out with buckets. He then went up to the wheelhouse, leaving four of the crew passing buckets of water up to two others on the main deck. Shortly afterwards the skipper returned, and said he needed three of the crew to shoot the fishing gear away. This left the mate and two others to deal with the flooding.

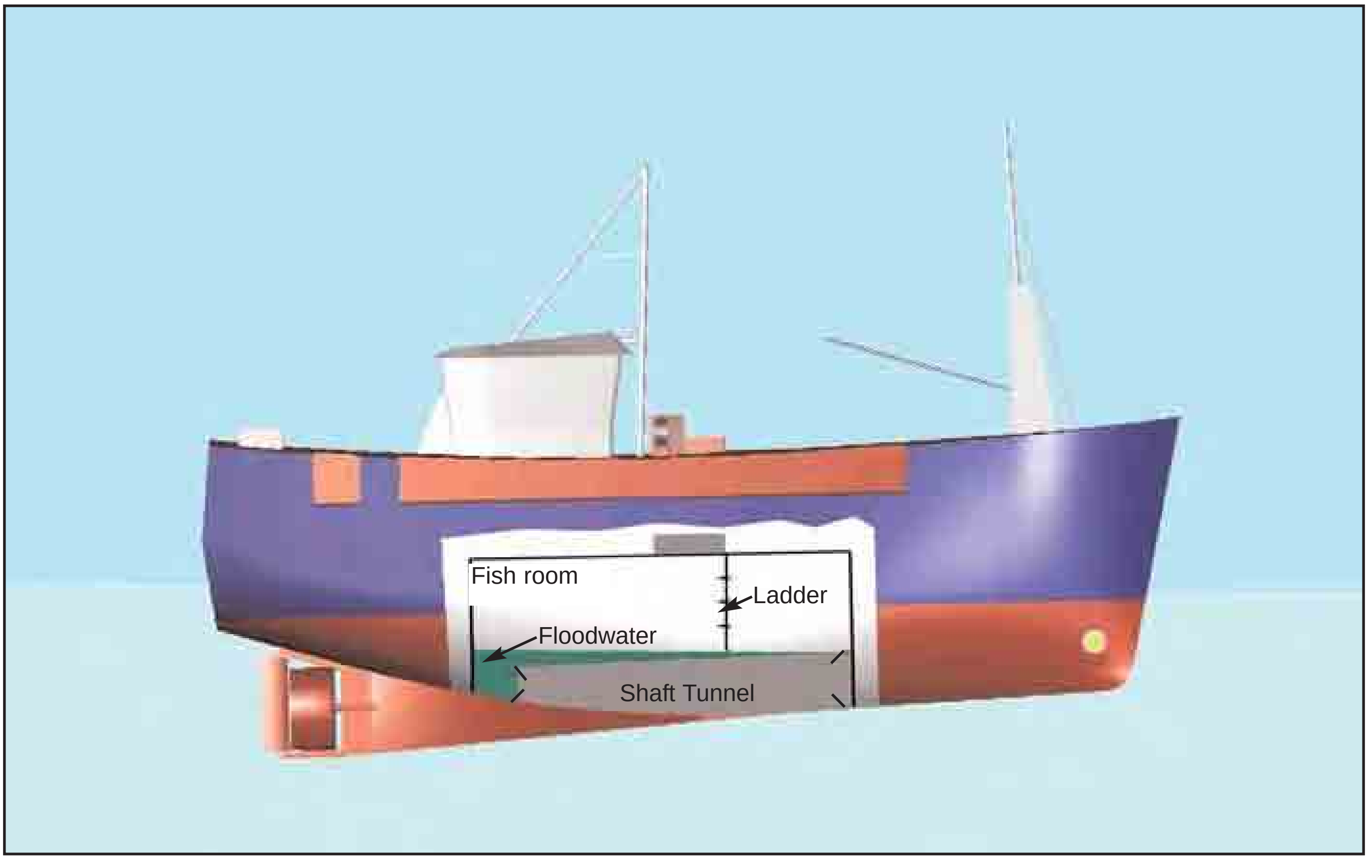
The water level on that occasion varied from about 0.3m deep at the aft end, to almost level with the bottom of the forward bulkhead **(Figure 4)**. As the vessel rolled it surged from side to side, and was splashing up to the deckhead. At one stage a deckhand was swept off his feet and found himself having to swim for a moment or two.

A number of scallop bags slid back and forth across the deck, smashing into the wood panelling at the end of each roll and bursting. The lowest strake of panelling on the starboard side was badly damaged.

It took the crew about 30 to 60 minutes to clear the floodwater, but over 3 hours to clean-up the fish room before they could resume processing and stowing the catch. Once the water level was low enough, the strainer in the slush well was removed and cleared and was found to contain debris from the torn scallop bags. The bilge well was also full of spilled queenies from the burst bags and these, too, had to be removed before the bilge system could be used to pump the fish room dry.

Eyewitnesses attributed the flooding to water draining off the main deck through the ice scuttles via the gaps under the flanges of the picking tray pipes. Melting ice and water seepage from the catch contributed a small amount.

Figure 4



Flooding of the fish room in early December 1999

While the crew cleared the fish room, fishing continued. Three hauls were made, and the contents stowed in the tipping bins, filling them. No further hauls were made until the fish room was ready for processing to be resumed.

The flooding occurred when the vessel was running and dodging. She had her stern to the weather for several hours during the night but, during the hour before the flooding was discovered, she had been dodging back to the fishing grounds.

There is no evidence that the skipper told anybody else about this flooding. The skippers of *Tobrach-N* and *Solway Ranger* were unaware of it.

In a VHF conversation with *Tobrach-N*'s skipper, probably during the last trip before Christmas, the skipper mentioned that he would be taking *Solway Harvester* to Garlieston so he could clear the starboard Desmi pump's blocked sea suction.

On 22 December 1999, *Solway Harvester* was lying alongside in Garlieston harbour. An electrician was on board repairing the radar when the skipper asked him to have a look at the bilge alarm float switch in the fish room because it was not working. The electrician did so and found the cable to the float switch broken in the shaft tunnel, apparently caused by a rope flailing around the propeller shaft. It could not be repaired immediately because the break had occurred inside the watertight bulkhead gland between the slush well and the shaft tunnel. A new float switch, complete with moulded cable, was ordered.

On Boxing Day, with the vessel high and dry in Garlieston, the skipper and his partner tried to examine the sea suction inlet to the starboard Desmi pump, but were unable to do so because it was dark and access was difficult because of the muddy seabed.

On 28 December, *Solway Harvester* left Garlieston to fish off Burrow Head. She returned to Kirkcudbright on 30 December with 260 bags of a small type of scallop known collectively as quins, or queens, but often referred to as queenies. She remained alongside until 6 January.

Solway Harvester left Kirkcudbright again on Thursday 6 January to dredge for queenies in the Irish Sea about 20 miles off the north Wales coast. Her crew comprised the skipper and five others.

She sailed with a fish room bilge alarm known, to the skipper, to be defective.

Because the regular mate was absent, the skipper remained in the wheelhouse throughout the time she was in transit or fishing. He rested when *Solway Harvester* anchored off Anglesey on the Friday and Saturday nights.

The trip was not problem free; the 24V generators' belts broke three or four times. Each time the skipper stopped the main engine and went to the engine room to fit new belts. The regular mate could have done this had he been there but, in his absence, the skipper had no option but to look after the engine room machinery as well. He also visited the fish room every 3 or 4 hours.

At about midnight on Sunday 9 January, she landed 243 bags (227 bags of queenies and 16 bags of scallops) at the Isle of Whithorn, the skipper's home port.

While in harbour some crew changes took place. One of the regular members, Martin Milligan, rejoined, having been ashore for the previous trip because of sickness. Another man left because his baby son was ill.

Two other regular crew members, the mate, and a deckhand who was ill, were not sailing on this trip and were replaced by Robin Mills and David Mills.

Solway Harvester sailed at about 0130 on 10 January and was followed 24 hours later by her sister vessel *Tobrach-N*.

Solway Harvester headed south into the Irish Sea to work sector 'A' **(Figure 1)**. Seven people were on board.

1.5 NARRATIVE

Solway Harvester had a successful start to her fishing trip. When Craig Mills, her skipper, spoke to his opposite number in *Tobrach-N* at about 0930 on Tuesday 11 January 2000, he said he had already filled 150 to 155 bags of scallops and was pleased. The weather was also discussed. The wind at the time was light, force 2, but the forecast was bad.

Using VHF radios, the two skippers chatted on and off throughout the day as they continued to fish and the weather slowly deteriorated.

Solway Harvester was seen hauling her gear at 1530 some 1.5 miles east of *Tobrach-N.* The conditions were deteriorating further, and the two skippers discussed the situation. With the wind now SW force 7 to 8 and the forecast continuing poor, Craig Mills said he planned to head for shelter at Ramsey Bay, about 27 miles to the north-west **(Figure 1)**. He said he would stay there for a few hours to allow the crew to have an evening meal in relative comfort, and then catch the tide for Kirkcudbright.

Tobrach-N, meanwhile, hauled at 1545 and headed towards Douglas, 23 miles away.

During *Solway Harvester*'s passage towards Ramsey Bay, Craig Mills made several telephone calls. He spoke to the transport manager at West Coast Sea Products (the company purchasing the vessel's catch), between 1530 and 1600 to inform him they would have about 200 bags on board.

He rang a sales representative of Wallace Oils at 1557 and ordered a road tanker delivery of 12000 litres of gas oil to meet the vessel in Kirkcudbright on Wednesday morning. He said nothing to indicate there were any problems on board.

At 1559, he rang *Solway Harvester'*s regular mate at home, but only got his answering machine.

A few minutes later, he telephoned the regular crewman, who had missed the trip because he had been ill, to let him know when they were landing. Everything sounded normal. He said they were leaving the fishing grounds and heading for shelter in Ramsey Bay. He was in good humour, saying he and the others were "knackered". They talked about the weather and the skipper said "…I'm telling you it's really wild out here, can ye no hear the waves hitting the side o' the boat?" There was nothing to suggest he was concerned about the weather conditions.

The skipper rang the works manager of Deeside Engineering Ltd at 1616, to ask for a welder at 0800 on Wednesday morning to rebuild the worn drive cogs on the main winch. During the conversation he said he was "battened down" and coming home.

At 1619, there was a very brief call (7 seconds) to the fisheries call centre of the Scottish Fisheries Protection Agency (SFPA). They have no record of this so the line was probably engaged.

At 1638, the skipper rang his partner. He told her he had been trying to contact the mate to find out when he was returning to work, and said he had left a message on his answering machine threatening to dismiss him if he didn't turn up for the next trip. She asked how things were, and he said that the weather was "screaming" and they were heading for Ramsey Bay. As with all the other calls he made that afternoon, he gave no hint of any problem.

Between about 1644 and 1710, the skippers of *Solway Harvester* and *Tobrach-N* chatted to each other on VHF and discussed a number of things including the weather. Craig Mills remarked how comfortable *Solway Harvester* was, considering the poor sea conditions. He said they were doing 8 knots at 1400 rpm, that there were no problems on board, and that he was looking forward to having tea in Ramsey Bay. *Tobrach-N*'s skipper recalls the conversation being interrupted by the sound of Craig Mills's mobile telephone ringing. Before terminating the conversation Craig Mills promised to get back to him in about 10 minutes once he had answered it. He never did.

The call was from *Kingfisher'*s skipper. It was logged at 1710 and lasted 3 minutes, during which time the two skippers talked about a suitable anchorage off the north Wales' coast where *Kingfisher* was going to ride out the night.

Craig Mills then rang the skipper of *Q-Varl,* who was at home because his vessel was in port undergoing repairs, for a chat. He said weather conditions were poor and that Manx radio was forecasting winds up to 50 knots. Once again he did not sound concerned. He said *Solway Harvester* was 15 or 16 miles from Ramsey Bay, and that they would shelter there until the tide was right for Kirkcudbright. They discussed a generator failure on *Q-Varl* and made plans to fish together later in the week. The skipper of *Q-Varl* said their conversation stopped at 1729, when he could hear another telephone ringing on board. It was the last communication with *Solway Harvester*.

Nothing more was heard from her until 1747 when the polar orbiting satellite Sarsat04 detected signals from an emergency position indicating radio beacon (EPIRB) on 406MHz and 121.5MHz. The signals were identified as coming from an EPIRB registered to the fishing vessel *Solway Harvester*. Liverpool Maritime Rescue Sub-Centre (MRSC) received this information and initiated enquiries about her. The owner, Richard Gidney was contacted to ask if she was in the area indicated. He confirmed she was.

The owner tried to contact *Solway Harvester* himself on the mobile telephone, but found it switched off. He then rang *Tobrach-N'*s skipper to tell him that *Solway Harvester'*s EPIRB had activated, and asked if he had spoken to Craig Mills recently. *Tobrach-N*'s skipper then tried to raise *Solway Harvester* himself on VHF and by telephone, but without success. The owner then asked him to head for Ramsey Bay to search for *Solway Harvester*. *Tobrach-N* altered course to match the route taken by her sister vessel, and everyone on board came into the wheelhouse to help look for her.

Once the owner had confirmed the vessel could not be contacted, the MRSC alerted the all weather lifeboat (ALB) at Ramsey, Isle of Man, for immediate launch, and put a rescue helicopter on immediate readiness. At 1840, rescue helicopter R122 scrambled and the ALBs at Ramsey, Douglas and Port St Mary were launched. The Workington ALB, already afloat on exercise, was diverted to the search.

A “Mayday” relay was broadcast. Many vessels responded, including the Royal Fleet Auxiliary oil-tanker *Bayleaf*, which was to the west of the Isle of Man.

R122 was on scene at 1920 and “homed” on the EPIRB’s 121.5MHz signal. About 11 miles south-east of Ramsey, and near *Solway Harvester’*s last estimated position, its crew found the EPIRB and hoisted it aboard the helicopter **(Figure 1)**. It was positively identified as *Solway Harvester’*s, and a check revealed it had been activated automatically.

By 2000, the winds had freshened to south-west severe gale force 9, gusting storm force 10. The very rough seas made conditions difficult for the ALB searches, and heavy rain reduced visibility further. More aircraft joined the search.

Sometime between 2100 and 2200, *Tobrach-N* reached Maughold Head at the southern extremity of Ramsey Bay, but found no sign of *Solway Harvester*. Sea conditions were severe, and because *Tobrach-N’*s 24V generators were still giving problems, she anchored for the night just inside the bay.

At 2243, *Bayleaf* saw an unopened liferaft canister. This was recovered about midnight by Douglas’ ALB and identified as *Solway Harvester*’s aft liferaft **(Figure 1)**.

The search continued throughout the night.

At 0630 the next morning, *Tobrach-N* rejoined the search. By that time the weather had moderated, and an hour later the Workington ALB recovered a second unopened liferaft **(Figure 1)**. It was identified as *Solway Harvester’*s forward liferaft.

About midday, the survey vessel *Humber Surveyor*, working on a pipeline project in the Morecambe Bay gasfield, arrived on scene to carry out a sonar search of the seabed. At about 1400, a target in the vicinity of the last estimated position of *Solway Harvester* and matching her characteristics, was found in position 54° 05.85’N 004° 09.87’W some 11 miles east-south-east of Douglas, and inside

Manx territorial waters **(Figure 1)**. This position was incorrectly transcribed in communications, resulting in the wreck marker buoy dropped by RFA *Bayleaf* being placed in position 54° 05.97’N 004° 09.77’W, some 500m from the wreck.

With no hope remaining of finding survivors, the search terminated at dusk on 12 January 2000.

1.6 POST-LOSS ACTIVITY

With the loss confirmed, the MAIB started an investigation. Two inspectors travelled to Kirkcudbright to make preliminary enquiries and brief the families of their intentions.

On 12 January 2000, the skipper of another scalloper, *Solway Ranger*, searched the seabed under the wreck marker buoy using a fish finder sonar, but found nothing there. He then extended the search and located the wreck of *Solway Harvester* on the seabed about 500m away. He passed this information to the MCA to correct the wreck’s position.

As with many other fishing vessel tragedies, operational staff from the Royal Navy contacted the MAIB to ask if naval vessels could help in any way. Although the newly identified seabed contact located by *Humber Surveyor* was, in the MAIB’s opinion, almost certainly *Solway Harvester*, it was important to identify it positively before any underwater survey could be contemplated. The MAIB gratefully accepted the Navy’s offer and asked for assistance in positively identifying the wreck.

On 15 January, the minehunter *HMS Sandown* broke off from routine operations and proceeded to the position reported by the survey vessel. Once in position she quickly located the new target, and sent down a remotely operated vehicle (ROV) to identify it. It was *Solway Harvester.* She was found to be lying on her starboard side in 35m of water.

Coincident with this initial activity, and in the days immediately following her loss, speculation about the cause of her sudden disappearance began. Foremost among these was that she had been involved in some form of collision. Three possibilities featured:

- She had been sunk by a submarine,
- She had been in collision with another vessel, or
- She had been holed after hitting a part submerged container lost overboard from a cargo ship.

The part-submerged container theory grew because a number of empty mayonnaise tubs were found floating in the vicinity of the wreck during the search operation. For weeks afterwards these were being washed ashore along the north-west coast of England. Subsequently, they were traced to a consignment of plastic buckets and lids from a blue forty-foot container, gross weight 5071kg; one of four lost off mv *Coastal Bay* on 31 October 1999. One container came ashore at Port Erin, Isle of Man, on 2 November 1999. *Coastal Bay* had been on passage from Liverpool to Dublin when the containers were lost 45 miles south-west of the Isle of Man.

The MAIB noted the various theories about the causes of *Solway Harvester'*s loss as its inspectors set about collecting evidence to explain what had happened to her.

1.7 VESSEL HISTORY

Solway Harvester was built at Hepworth Shipyard in Hull in 1992. Jack Robinson (Trawlers) Limited had placed the order on 28 February 1991. The building was financed by the company, and with a grant from the Seafish Industry Authority. Grant assistance was given on the basis that SFIA marine surveyors inspected the vessel at various stages of construction to ensure that the hull and machinery were constructed and installed to the requirements of the SFIA *Rules for the Construction of Steel Vessels below 24.4m registered length* and to good marine practice, and also in accordance with MCA requirements where applicable.

She was the second of a new generation of scallop dredgers operating from Kirkcudbright and was equipped to process scallops and recover the meat. The first was her sister vessel *Tobrach-N*.

The new designs reduced the crews' workload by having an arrangement which emptied the scallop dredges mechanically, instead of manually. This involved the use of horizontally hinged doors built into the vessels' sides. A full length non-watertight, steel shelter further improved the crews' working conditions. Both vessels were successful and two similar ones followed: *Kingfisher* in 1998 and *Solway Ranger* in 1999.

On 1 October 1992, when the SFIA surveyed the vessel, its construction met fully with the MCA requirements, and the relevant paperwork was forwarded to the MCA, which issued a UKFVC shortly afterwards.

Thereafter, under the aforementioned grants scheme there were general conditions imposed on the owner of the vessel to keep it seaworthy, properly insured etc. The SFIA had no remit to inspect or otherwise attend the vessel, even during the "control period" of the grants scheme which ran from 16 October 1992 (the date of registration as a fishing vessel) to 15 October 1997.

In her early years of service, *Solway Harvester*'s equipment and fittings were changed substantially. Her initial fit included a riddle and shaker on each side of the main deck with conveyors to a central scalding tank, and a shell remover offset to port. When she first entered service the shellfish meat passed from the shell remover to the brine tank in the fish room through the port ice scuttle. If there were problems with the processing plant, the catch could be stowed whole. On these occasions, picking trays were placed over both ice scuttles, from which the catch was dropped into hoppers in the fish room. The watertight scuttle covers were attached to the deck adjacent to the ice scuttle openings by a chain.

About six months after the vessel entered service, one of the ice scuttle covers was lost overboard. It was replaced, but *Solway Harvester*'s skipper at the time, Mr Richard Gidney, decided that from then on the covers would no longer be chained to the deck, but would be stowed in the wash room at the starboard forward corner of the main deck when not in use.

For commercial reasons, the riddle and shaker arrangement was removed in 1994. It was replaced by heavy shakers with picking trays attached on each side of the main deck. The catch was dropped down a large diameter pipe welded to the base of each picking tray into the fish room through the ice scuttle. The catch fell into a large hopper suspended from the underside of the deck on each side. The scallops accumulated in the hoppers until they were full. The crew then bagged the scallops for stowing. In January 1996, the last of the redundant processing equipment was removed.

In July 1995, Richard Gidney left *Solway Harvester* to take up a management position in the company ashore. The new skipper's practice was to fit the watertight ice scuttle covers, once fishing was finished, for the passage home. They would not be removed until fishing resumed.

In October 1995, surveyors from the Maritime Safety Agency (MSA), the forerunner of today's Maritime and Coastguard Agency (MCA), carried out a random inspection of *Solway Harvester* in Kirkcudbright. They found a number of deficiencies, including seven relating to basic safety equipment. The list read as follows:

- Two fire extinguishers to provide;
- Four line throwers to provide;
- Twelve parachute flares to provide;
- EPIRB HRU to renew;
- EPIRBs for survival craft to provide;
- Two smoke/light markers to provide;
- Medical chest to provide;
- The forward engine room door seal to repair.

On 26 June 1996, she was slipped at MacDuff shipyard, where she was surveyed by the MSA for the renewal of her UKFVC. During the survey, the changes to the processing equipment were discussed, and the surveyor asked for the vessel's stability to be re-examined. A stability test was carried out in early September, which revealed she no longer met the stability regulations.

To correct the deficiency, watertight bulkheads were constructed at either end of the passageways to port and starboard of the galley/mess. The work was undertaken in March 1997. The owner informed the MCA by letter that the new bulkheads had been fitted, and the MCA approved the revised stability book. A full UKFVC was issued on 18 September 1997, which was valid until 15 October 2000. The new stability book recorded *Solway Harvester*'s lightship weight as 166.519 tonnes.

The second skipper fitted a hanging rubber mat over the outside of the forward starboard freeing port. This reduced the quantity of water shipped on to the main deck and saved the crew at the starboard picking tray from a drenching in poor weather. In 1998, this was either removed, or it fell off.

The port picking tray was renewed in January 1997. It was removable and hooked on to the end of the shaker. The large circular flange at the base of its down pipe rested unsecured and unsealed on the main deck over the port ice scuttle opening.

In February 1997, Craig Mills took over as skipper.

In September 1997, one of the watertight ice scuttle covers was washed overboard in bad weather. With the cover gone, loose water on the main deck poured into the fish room. By the time the flooding was discovered, the water was about 0.3 metres deep. The water was baled by hand, but the cover was not replaced.

After this, when on passage to or from the fishing grounds in bad weather, the picking tray on the weather side was usually removed to fit the remaining watertight ice scuttle cover. This was to prevent substantial quantities of water getting into the fish room through the flush opening.

In 1998, tipping bins were fitted in the troughs on each side of the deck shelter, and, in January 1999, the starboard picking tray was renewed to the same design as the port one. In April that year a new main engine was fitted.

Sometime, probably in mid-1999, the impeller on the main Jabsco bilge pump failed. The drive belts to the pump were removed and it was never used again. After this the starboard Desmi pump supplied the bilge eductor, in addition to its normal load.

On 9 July 1999, a float switch to the bilge alarm was fitted to the port side of the fish room slush well. Deeside Marine Ltd fitted the bulkhead gland, taking the cable into the shaft tunnel space through the forward boundary of the well. The cable led to the engine room, where it joined the original circuit linking the engine room float switch, to the wheelhouse bilge alarm panel.

In the autumn of 1999, the hinges failed on the steel cover over the bilge suction in the fish room slush well. The cover was discarded, and the vessel operated with this section of the slush well open.

On 3 December 1999, Deeside Marine Ltd replaced the studs to the rudder gland because the threads had stripped as they had been over-tightened.

1.8 OWNERSHIP AND OPERATIONAL MANAGEMENT

Jack Robinson (Trawlers) Ltd owned *Solway Harvester*. The company was a wholly owned subsidiary of RG Holdings Ltd. Richard Gidney owned all shares in RG Holdings Ltd. When the previous owner of Jack Robinson (Trawlers) Ltd retired in July 1997, Mr Gidney bought him out. Mr Gidney was a fisherman and had been one since 1988. He held a Class 2 (Fishing) Certificate of Competency.

Another subsidiary of Jack Robinson (Trawlers) Ltd is Deeside Marine Ltd, an engineering company in Kirkcudbright. It provides general support to the company's fishing fleet.

Solway Harvester's skipper was responsible to Mr Gidney for her satisfactory operation. His responsibilities covered recruiting crews and assigning their duties, arranging provisions and bunkers, organising repairs to the vessel and fishing gear, and overall maintenance. He was also responsible for the safety of the vessel and her crew, the navigation, profitability and reporting to the then Ministry of Agriculture Food and Fisheries (MAFF). It was usual for the skipper and owner to have an informal chat about the fishing and any problems requiring attention when the vessel landed its catch in Kirkcudbright. This normally occurred on Fridays.

Solway Harvester was a profitable vessel. If problems occurred and repairs had to be carried out, the skipper would telephone the works manager of Deeside Marine Ltd before he returned to harbour. The necessary arrangements would then be made to ensure the required parts and labour were ready when the vessel arrived alongside.

The earnings of *Solway Harvester's* skipper and crew were based on a share of the value of the catch. In addition, the skipper could earn an annual bonus based on the profit from the vessel for that year. This was settled at a year-ending meeting between the owner and the skipper, usually around Christmas. Profit was defined as the vessel's earnings for the year, less any expenditure incurred. Expenditure included money spent on safety equipment. The skipper's bonus was 1.75% of the profit and was about £5000 in 1999.

The meeting also provided an opportunity for the owner to discuss the skipper's overall performance and how it could be improved. The year ending 1999 was the skipper's best performance so far and, on this occasion, the owner could not see how it could be improved. The meeting was brief.

1.9 HEALTH AND SAFETY MANAGEMENT

The *Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997* required all employers to appoint a competent person to be reponsible for health and safety on board their vessels. The owner of Jack Robinson (Trawlers) Ltd intended to make himself the competent person once the company had completed its risk assessments.

The 1997 Regulations, which came into force on 31 March 1998, also required that a risk assessment was drawn up for each vessel. A risk assessment for *Solway Harvester* had not been made before the accident.

1.10 THE CREW

Seven people were on board *Solway Harvester* for her last voyage. They were Craig Mills, Robin Mills, David Mills, David Lyons, Wesley Jolly, John Murphy and Martin Milligan. They all died.

Craig Mills was the skipper. He was 29 and had been a fisherman since leaving school. He obtained a Class 2 (Fishing) Certificate of Competency in July 1994 which allowed him to skipper fishing vessels up to 24m registered length within a predefined area. Previously he had skippered another Jack Robinson fishing vessel, *Karianda*, for about 18 months and had become *Solway Harvester's* skipper in February 1997.

Robin Mills was the skipper's brother. He was 33. A self-employed painter and decorator by profession, very occasionally he sailed if the vessel was short-handed. In the preceding two years he had sailed on three occasions, the last in January 1999. (When Craig was skipper of *Karianda*, Robin accompanied him on ten trips over the 18 months from July 1995.) From January 1989 to August 1992 he was an auxiliary coastguard.

David Mills was the skipper's cousin and also an auxiliary coastguard. He was 18 and had worked on and off as a fisherman since leaving school in May 1998, but had been looking for a different career. He joined *Solway Harvester* and was, like Robin Mills, on board at the skipper's request to help because he was short-handed.

David Lyons was 17. He had been a deckhand on *Solway Harvester* since September 1998.

Wesley Jolly had been a deckhand on *Solway Harvester* for about 5 months. He was 17.

John Murphy had been a fisherman for about 2½ years, all on *Solway Harvester*. He was 22.

Martin Milligan was 26 and had worked as a fisherman for about 18 months, all spent on board *Solway Harvester*. For the previous eight years he had worked in a sawmill.

John Murphy, David Lyons and Craig Mills had attended the mandatory fishermen's basic safety training courses. The others had not.

1.11 WEATHER AND SEA CONDITIONS

The weather conditions were deteriorating rapidly when *Solway Harvester* sank on 11 January 2000. At 1700, and again at 1800, the meteorological station at Ronaldsway, Isle of Man, measured wind speeds of 29 knots with maximum gusts of 40 knots from 210° (force 7 to 8 from south-west by south).

The deck log of the Isle of Man Steam Packet Company's ferry, *Ben-my-chree*, which was on passage from Heysham to Douglas at the time, recorded "winds SW8, sea very rough, swell moderate" at 1700. At that time she was a mile north of the spot where *Solway Harvester* sank.

The tidal stream was setting about 1.3 knots in a west-south-westerly direction and almost directly into the wind and sea when *Solway Harvester* disappeared. The effect of wind against tide creates short steep seas and, very often, breaking waves. All the evidence indicates that such conditions prevailed that evening.

The MAIB and Isle of Man Constabulary obtained an independent assessment of the sea conditions at around the time of *Solway Harvester*'s loss. The Meteorological Office Marine Consultancy, and WNI/Oceanroutes, assessed that, ignoring the effects of the tide, the significant wave height was between 3.5 and 4.0 metres. With the wind against tide effects included, there would have been steep breaking waves of, probably, between 4.0 and 4.75 metres high. The largest waves could have been about 80% higher, at between 7.2 metres and 8.55 metres.

1.12 UNDERWATER SURVEY

Once the wreck of *Solway Harvester* had been positively identified, the MAIB sought the earliest possible opportunity to conduct an underwater survey. The Branch was fortunate on two counts. It was able to secure the services of *Mansal 18*, a dedicated survey vessel with which it had worked before. Not only was she available at short notice, but there was also every prospect of a fair weather window opening up. The contract was let, and, on 15 January 2000, *Mansal 18* sailed from Aberdeen for the Irish Sea.

The ship, and the remotely operated vehicle (ROV) team on board her, were allocated the task of carrying out a detailed underwater survey of the sunken wreck and the surrounding seabed. They also had the task of photographing everything which was accessible. A secondary aim, but of great importance to the families, was an undertaking to see if any bodies were visible.

The camera-fitted ROV was deployed from *Mansal 18* on Tuesday 18 January 2000. Racal Survey Limited was the main contractor, which in turn sub-contracted Rovtech Limited for part of the survey. Two inspectors from the MAIB directed operations.

The wreck was located at 1330 that day. She was lying on her starboard side, aligned south-westerly/north-easterly, on a compact sandy bottom and at a depth of 35m.

The initial survey was carried out using a Tiger, non-work class, ROV. A work class Sealion ROV was used to open the landing hatch to gain access under the shelter. The same vehicle was used to open the wheelhouse door. Both openings were closed on completion to ensure that nothing inside, which might have been relevant to the investigation, floated out. However, the landing hatch could not be secured closed, and when the *CSO Wellservicer* inspected the wreck, later in January, the hatch was found open and swaying in the current.

A full inspection of the port side showed no hull damage above or below the waterline. The guardrails near the bow were standing, but were buckled.

The freeing ports were unobstructed. One body was seen through the fourth freeing port from forward and on the port side of the working deck.

The port fishing gear lay against the side of the wheelhouse. Its dredges were draped over the wheelhouse top despite being attached to the underside of the trawl beam. Near amidships, one of the dredges on the trawl beam was still hooked over its peg on the underside of the hydraulically-operated doors. The forward end of the trawl beam lay against the forward guardrails.

The aft port tipping bin was in its fully extended position, which would have been vertical had the vessel been afloat and upright but, lying on her starboard side, it was horizontal. It was not connected to the gilson wire. The forward port tipping bin was angled slightly out of its trough.

The vessel's stern was undamaged. The rudder was hard over to starboard. Neither the Kort nozzle, nor the propeller, was damaged **(Figure 5)**.

The visible part of the starboard side was inspected. The foremost 2 metres, extending aft from the bow along the top edge of the shelter, was substantially damaged **(Figure 6)**. The stemhead was set back, causing buckling of the shelter top. Guardrails in this area were buckled and torn away.

The head of the starboard arm of the gilson frame was bent under.

No other damage was seen on the hull's starboard side. Both sections of the tipping bins were angled out of their troughs, the aft section more prominently. The starboard fishing gear lay on the seabed close to the wreck, and was seen to pass underneath the aft tipping bin.

The starboard side of the wheelhouse exterior was inaccessible and not viewed. The wheelhouse door was closed, with paper protruding between the door and the frame on both sides. The wheelhouse windows were unbroken. Queenie

Photographs showing undamaged kort nozzle and rudder

Figure 5a

Upper half of rudder stock

Figure 5b

Lower half of rudder stock

Figure 5c

Port side of kort nozzle

shells covered the port windows. A limited view of the interior of the wheelhouse was possible through the forward windows. The auxiliary engine control lever was in the low idle position.

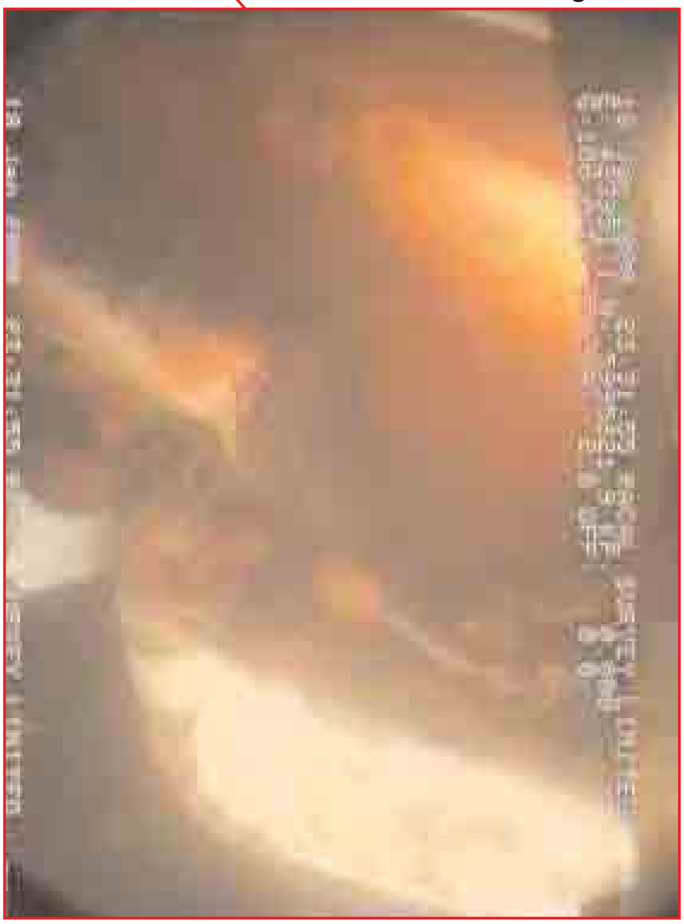
The work class ROV opened the wheelhouse door and attempted, unsuccessfully, to drive inside. Although the view through the wheelhouse door was limited it was possible to make out the central, main engine control lever in the vertical or neutral position.

The radar antenna on the forward face of the foremast was damaged, and the rigging above it was destroyed.

The access hatch from the shelter top to the forepeak space was open, with its free end resting on the deck. The main landing hatch amidships was closed, and secured by one of its four clips; its small access hatch was open. The emergency escape hatch, port side aft, was shut and secured. The large hatch to starboard over the workshop was fully open with the free edge resting against the guardrails across the transom; it hinged aft. The weathertight door leading into the workshop was open.

Figure 6a

Figure 6b



Bow damage

The work class ROV opened the main landing hatch, and the smaller ROV dropped through the opening. Visibility was very poor and access was restricted to the area inboard of the shakers. The weathertight door into the galley/mess was secured in the open position. The small weathertight access door to the port deck store looked ajar, but this could not be verified. A large red gas cylinder attached to a burning torch prevented access to the starboard passageway door.

The weathertight access door to the forepeak space was secured in the open position. The fish room hatch was securely closed, but the small access hatch through it was open. The restricted view into the fish room meant that only the access ladder could be seen.

The forward liferaft was missing from its cradle. Its straps had released and the hydrostatic release unit (HRU) was not there. The aft liferaft was also missing, but its securing straps were in place, and the HRU appeared not to have operated.

The hydraulically-operated outriggers were stowed.

1.13 RECOVERY OF THE CREW'S BODIES

In late January 2000, the Isle of Man Administration engaged the diving support vessel *CSO Well Servicer* to raise the wreck of *Solway Harvester*, and recover the bodies found on board.

On 27 January, *CSO Well Servicer* arrived in Ramsden Dock, Barrow-in-Furness, to embark key personnel from the Isle of Man Constabulary, the MAIB and the coroner's consultants, Poseidon Maritime Ltd (PML). Representatives of *Solway Harvester'*s owner and insurers also joined the vessel. She sailed at 1630 on 29 January, and arrived at the wreck site 5 hours later.

CSO Well Servicer carried an ROV and a team of saturation divers. At 2350, a diving bell with three divers inside was lowered to the seabed. Their first task was to survey the wreck for damage and to investigate the status of the deck hatches. If they found any open, they were to close them to prevent anything escaping. The preliminary survey showed the shelter top was rippled and split at the base of the foremast. It also revealed the presence of two bodies on the main deck; subsequently identified as Craig Mills and Martin Milligan.

The divers then attached air bags to the wreck in preparation for bringing it upright. By 1730 on Sunday 30 January, the wreck was upright on the seabed. Loose gear was secured and the fishing gear was cut away and lifted on board *CSO Well Servicer*. The starboard side of the wreck was fully revealed for the first time. A diver's survey showed no damage apart from that already seen at the bow.

At 0920 on 31 January, divers entered the fish room to begin removing the bagged queenies and scallops. At 1708, another body was discovered in the fish room and was later identified as John Murphy. The bags of shellfish were removed from the hold and their contents emptied over the starboard side. A tally was kept, and by 0730 on 1 February, 176 bags had been removed.

The divers also found 18 scallop dredges on the starboard side of the fish room. Their total weight was 2.16 tonnes. Eight fish boxes were also removed.

The salvage operation continued, with the divers placing air bags inside the fish room to provide buoyancy. Adverse weather conditions delayed the lift until 1500 on 2 February when the salvors tested the system by lifting the wreck 7 metres above the seabed.

The forward lifting sling slipped 50 minutes later, and the wreck fell to the seabed, damaging the rudder and Kort nozzle, and ending up on her starboard side.

By 1800 on 3 February, the salvors had recovered the situation, and the wreck was raised to a position 5 metres above the seabed. It was decided to carry the wreck, suspended just above the seabed, into the shelter of Laxey Bay. The transit was necessarily slow while the weather window closed. The operation was halted at 2200 because of the worsening sea conditions and, at 0600 the next morning, the decision was taken to suspend everything. The wreck was lowered to the seabed while it was still possible to do so in a controlled manner, and the main lifting gear removed.

A decision was taken at 1000 to postpone any further attempts until the onset of more settled weather. Since the crew's bodies would not be recovered until the wreck was raised, it was decided to use divers to recover the bodies. Three volunteered to perform this task.

The dive was made. The location of three bodies had already been established, but it was still not known where the others were. One diver searched the aft cabin and found the four missing bodies.

The bodies of all seven crew were recovered to *CSO Well Servicer* and transferred to the supply vessel *Scotian Shore* in the shelter of Laxey Bay. They were landed at Douglas at 0100 on 5 February. A postmortem examination showed they had all drowned.

During the course of the operation the divers reported the "as found" status of all weathertight doors and hatches.

The ice scuttles on the main deck were found open with no covers in place. The door to the engine room from the forepeak space was also open, and the door from the main deck to the forepeak space had been tied open. Both the doors to the port deck store and the starboard passageway were open and the door to the galley/mess had been secured open. The aft door of the starboard passageway was open, leading to the secured open workshop door.

1.14 *SAFETY BULLETIN*

With the bodies recovered, and the ROV and divers' surveys complete, the MAIB was able to make a preliminary assessment about what had been found. It concluded that there were shortfalls in *Solway Harvester*'s watertight integrity.

There was already intense and growing speculation about the cause of her loss. It was, therefore, felt essential that an interim statement should be released to reflect the view of the MAIB's inspectors: that the damage seen on the wreck was compatible with it impacting the seabed, and not that she had been involved in a collision.

Of even greater significance, however, was the need to draw attention to some fundamental safety shortcomings which had been discovered.

The mechanism for achieving this was for the MAIB to publish a *Safety Bulletin* in which immediate safety recommendations were made and, on 23 February, No. 1/2000 was issued **(reproduced in Annex 1)**.

The safety shortcomings discovered were serious. In addition to the initial concerns about watertight integrity of the main deck, the liferafts were found to be out of date for servicing, had not been secured correctly and would not have been available to the crew had they escaped from the sinking wreck.

It was also found that several members of the crew had not undertaken any safety training. It was felt that if these findings reflected standards in other fishing vessels, it was essential the industry was alerted to them without delay. If similar deficiencies existed elsewhere, they could be corrected before there was another accident. The bulletin contained three recommendations: two to the fishing industry and one to the MCA.

The MCA accepted the recommendation, and carried out spot checks on a number of similar vessels. Several were detained until safety equipment was restored to the required standard.

1.15 THE CASUALTIES

A coroner's inquest was opened and adjourned in Douglas on 5 February 2000. Details of the casualties were released, together with where they had been found and what they were wearing at the time of the accident.

Martin Milligan was found on the main deck. He was wearing a fleece top and orange oilskins. His feet were bare, but a pair of wellington boots was found nearby.

Craig Mills was also found on the main deck. He was wearing green trousers, a T-shirt and rigger boots.

John Murphy was found in the fish room. He was wearing a bomber jacket over a T-shirt, tracksuit bottoms, wellington boots and rubber gloves.

David Lyons and David Mills were in their bunks in the aft cabin, wearing sports shirts, tracksuit bottoms and socks.

Robin Mills was on the floor of the aft cabin in a T-shirt and shorts.

Wesley Jolly was behind the ladder to the lobby adjoining the galley/mess. He wore a white fleece top over two T-shirts with two pairs of tracksuit bottoms and socks.

1.16 RECOVERY OF THE WRECK

On 20 June 2000, the heavy lift vessel *Norma,* owned and operated by Scaldis-Salvage and Marine Contractors, under contract to the Isle of Man Department of Home Affairs but funded jointly with MAIB, left Douglas for the wreck site. Later that evening the wreck of *Solway Harvester* was located where *CSO Well Servicer* had left it some 5 months earlier. *Norma* was positioned over the wreck using four anchors attached to wire hawsers and load meter winches.

Divers, working throughout the following day, connected two large hooks, suspended from *Norma's* lifting frame, to the wreck. It was hoped to lift it that evening, but the weather deteriorated and the operation had to be postponed.

Early the following morning, one of *Norma's* anchor hawsers parted in the worsening sea conditions, and it became increasingly difficult to hold her in position. The two large lifting hooks attached to the wreck damaged the wheelhouse and the gilson frame. The decision was taken to recover the remaining anchors, extract the lifting hooks from the wreck, and return to Douglas until the weather improved. This also allowed a replacement anchor to be rigged.

Three days later, the conditions had improved sufficiently to enable the lifting operation to continue, and *Norma* returned to the wreck. Divers worked the slack tidal periods during the following day to re-attach the lifting hooks to the wreck. The lift resumed at 2030 on 26 June, and, 40 minutes later, *Solway Harvester* was brought to the surface. She had a pronounced list to starboard, so the salvors drained the tanks on the starboard side.

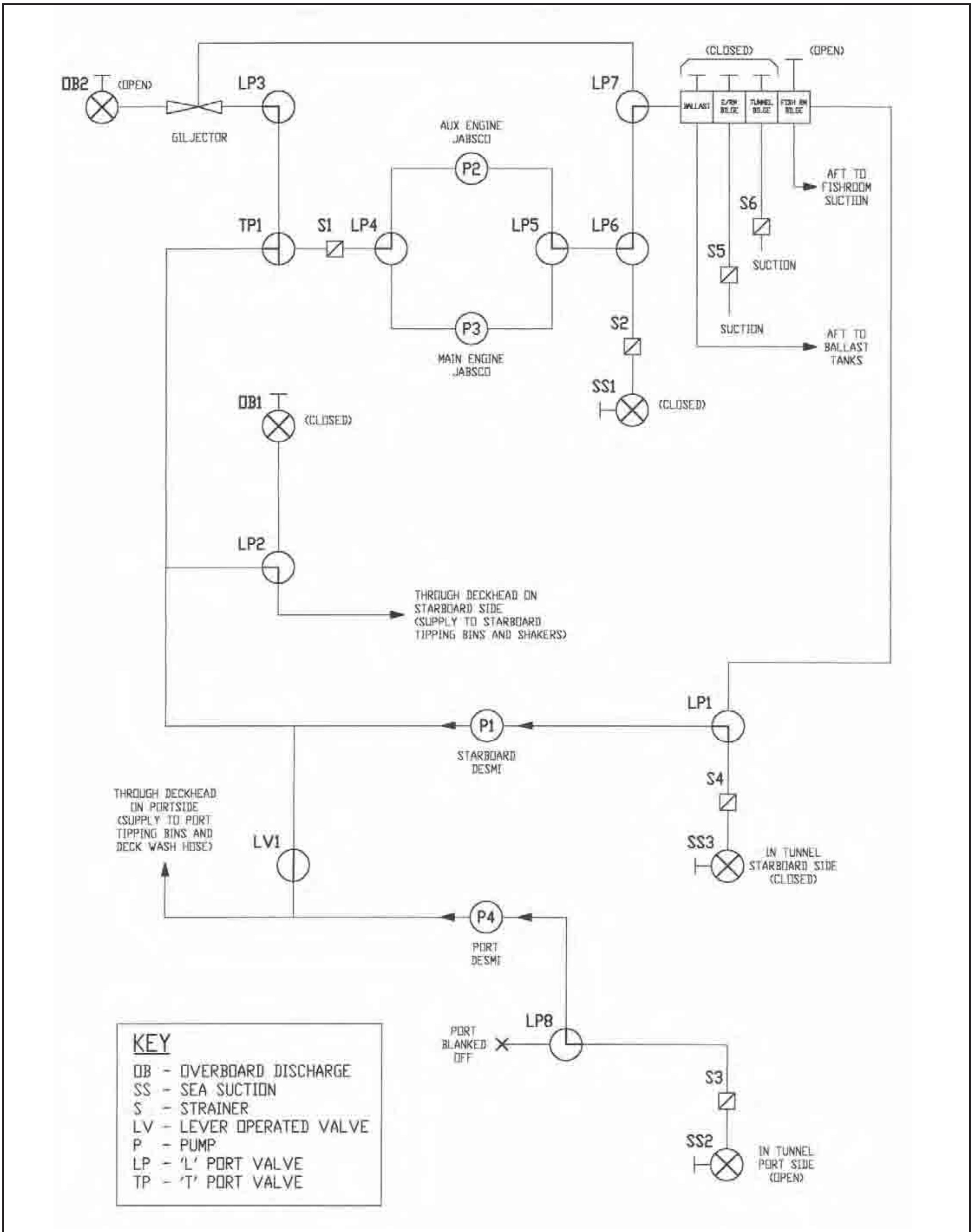
The following evening, the salvaged *Solway Harvester* was towed, afloat, into Ramsey, Isle of Man. She was moored alongside so that she could be pumped dry, and the salvage equipment removed. Apart from a minor leak near the rudder tube, caused by damage incurred during the previous salvage attempt, her hull was totally watertight.

In mid-July, the salvor's chief engineer briefed the Isle of Man Constabulary about the work undertaken on board the wreck. It was essential to know what had been moved or changed by the salvors during the wreck's recovery.

The briefing was from memory, not contemporary notes. Consequently, the state of the valves at the time of the loss cannot be known with certainty. However, only one valve's setting appeared at odds with the rest, and that was LP7's, which, during interviews, the chief engineer said he had definitely moved. During the trial he said that he had put the valve back in the same place and in the same position. Normally its spindle would have been turned to "three o'clock". The position of this valve does not impact on the analysis of the cause of the accident, but it makes it difficult to understand the skipper's last actions in the engine room. The MAIB has nevertheless taken the evidence given during interviews at face value for its analysis. The chief engineer's evidence follows:

- In the aft cabin the valve to the aft starboard ballast tank, which had been found closed, was opened.
- In the engine room, the ballast tank valve on the bilge valve manifold had been opened and the open fish room valve closed (**Figure 7** is a schematic of bilge system "as found" by the salvors).
- The plug of the 'L' port valve, LP7, had been removed to allow the contents of the aft starboard ballast tank to drain into the engine room bilge. It had been replaced, but turned, so that the 'L' icon on the valve stem was apex down - it had been found in the half past three position **(Figure 7)**.
- The fuel valve manifold's end cover, and the forward and aft starboard fuel tanks' valves, were opened to drain the contents of the starboard fuel tanks into the engine room bilge. There had been no diesel.
- The salvors closed the sea suction on the port side, to the fish room cooling plant and ice machine. The hatch leading to the shaft tunnel, which had been secured closed, was opened - the tunnel was full of water and was pumped out.
- In the forepeak space the hydraulic oil tank was drained. It contained no hydraulic oil.

Figure 7



Bilge schematic “as found”

1.17 WRECK EXAMINATION

On 28 June 2000, and once it had been made safe, a detailed examination of the wreck began. Several organisations were involved, including a team acting on behalf of the Isle of Man Coroner, MAIB inspectors, and representatives of the vessel's insurers and owner. *Solway Harvester's* regular mate assisted throughout. The scene on board was one of complete devastation.

During the survey, the wreck was slipped at the Booth W Kelly's shipyard in Ramsey for a thorough examination of its hull and through-hull fittings.

The detailed findings of the survey are reported in **Annex 3 (see also Figure 8)**, but crucial findings are covered here.

1.17.1 The wheelhouse interior

The main engine control lever was upright in the neutral position, indicating that the propeller shaft was de-clutched. The mate estimated that the adjacent independent engine speed controller was set for approximately 1400/1500 rpm. On the control panel the main engine ignition was 'on'.

Figure 8

Left hand panel

Circuit	Status
Wheelhouse	On
Electronics	On
Navigation	On
Wheelhouse	On
Engine room	On
Ice plant	Off
Wheelhouse	On
Electronics	On

Changeover switches

Switch	Setting
Auxiliary	3
No1 alternator	1
No2 alternator	1
No3 alternator	1

Main breakers

No 1 battery	On
No 1 generator	On
Aux generator	Off
No 2 generator	On

Right hand panel on-line

Battery	Circuit	Status
no.2	Process plant	Off
no.2	FW pump	On
no.2	Aux circ pump	Off
no.2	Heating pump	On
no.2	Aux clutch	Off
no.2	CO2 alarm	On
no.2	Tunnel lights	On
no.2	Process plant	Off

Battery meters

	Volts	Amps
No 1	0	-150
No 2	15	10
No 3	15	80

Main breakers

No 1 battery	On
No 3 generator	On
No 3 battery	On

Position of circuit breakers/switches/gauges on electrical panels in engine room

The auxiliary engine ignition was 'off'. Its control lever was set for minimum engine revolutions.

The battery-operated wheelhouse clock had stopped at 1742.

The middle window on the starboard side was open.

A key for the ice scuttles' covers was found in the wheelhouse.

1.17.2 The main deck

Loose gear and fittings, including the picking trays, were heaped to starboard between the shaker and the wash room. Both shakers had moved to starboard, and were lying against deck pillars or other structures. Most of the short posts, on which the hollow legs of the shakers fitted, were in place.

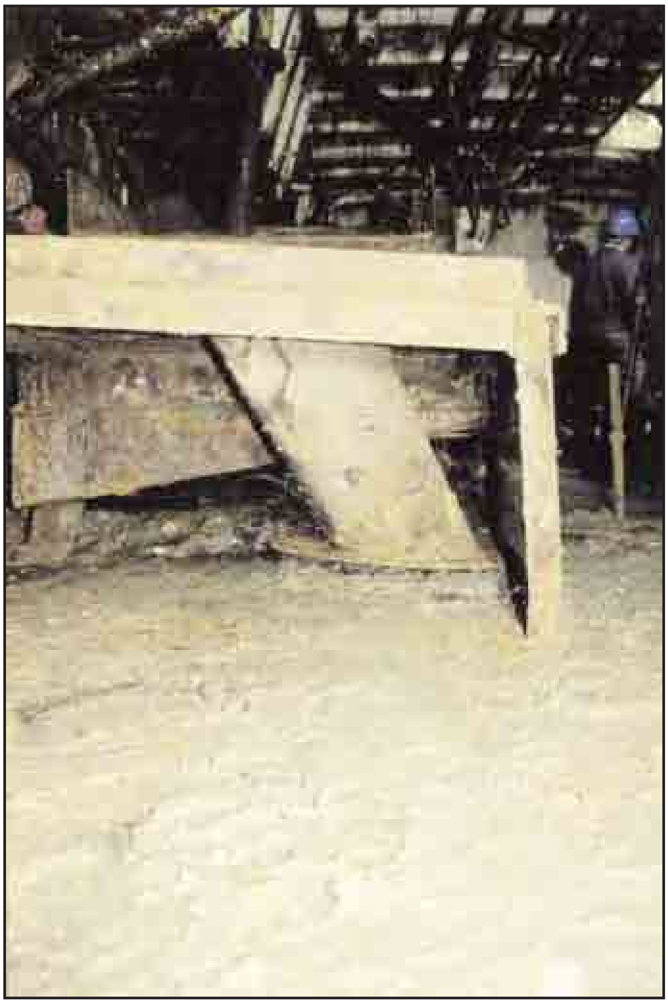
The starboard shaker and picking tray were moved back into position. The fit between the picking tray's pipe and the ice scuttle showed a 30mm gap between the pipe's flange and the deck at its outboard edge. At the inboard edge it rested on the deck **(Figure 9)**. This could not be done for the port side.

Looking to port

Figure 9a

Looking aft

Figure 9b



Photographs showing the gap between the deck and the flange on the starboard picking tray

Looking to starboard

Figure 9c

Port ice scuttle opening Figure 10

The port and starboard ice scuttles were open **(Figure 10 - port scuttle shown)**. One of the watertight covers was found among the pile of loose gear on the starboard side, between the shaker and the wash room. The other was not found. Another securing key for the ice scuttles' covers was in the small wash room.

A dredge sword was jammed between the pipes running along the deckhead.

The three valves controlling the water supplies to the starboard tipping bins and shaker were closed. On the port side, the aft tipping bin's valve was open, but the other two were closed. The valve to the deck wash hose on the port side was closed.

The door to the forepeak space was tied open with cord.

The door to the galley/mess was secured open by one of its clips, while that to the port deck store was ajar.

The doors to the starboard passageway were open but unsecured.

The watertight bulkheads, installed in 1997 by Deeside Marine Ltd, were examined and revealed that the pipe runs through them were not fitted with watertight glands. The bulkheads had been cut around the pipes, leaving gaps large enough, in many places, to insert the fingers of one hand **(Figure 11)**. The bulkheads were not watertight.

1.17.3 The forepeak space

The deck was set down about 150mm on the centre-line above the forepeak tank.

The hull and deckhead plating was buckled on the starboard side of the stem. Shackles, nuts, bolts and springs were found compressed into the folded steel of the damaged deckhead and shell plating **(Figure 12)**.

The door into the trunk below the foremast, leading to the engine room and foredeck hatch, had been tied open.

Figure 11

The “watertight” bulkheads showing gaps around pipe penetrations

Figure 12a

Figure 12b

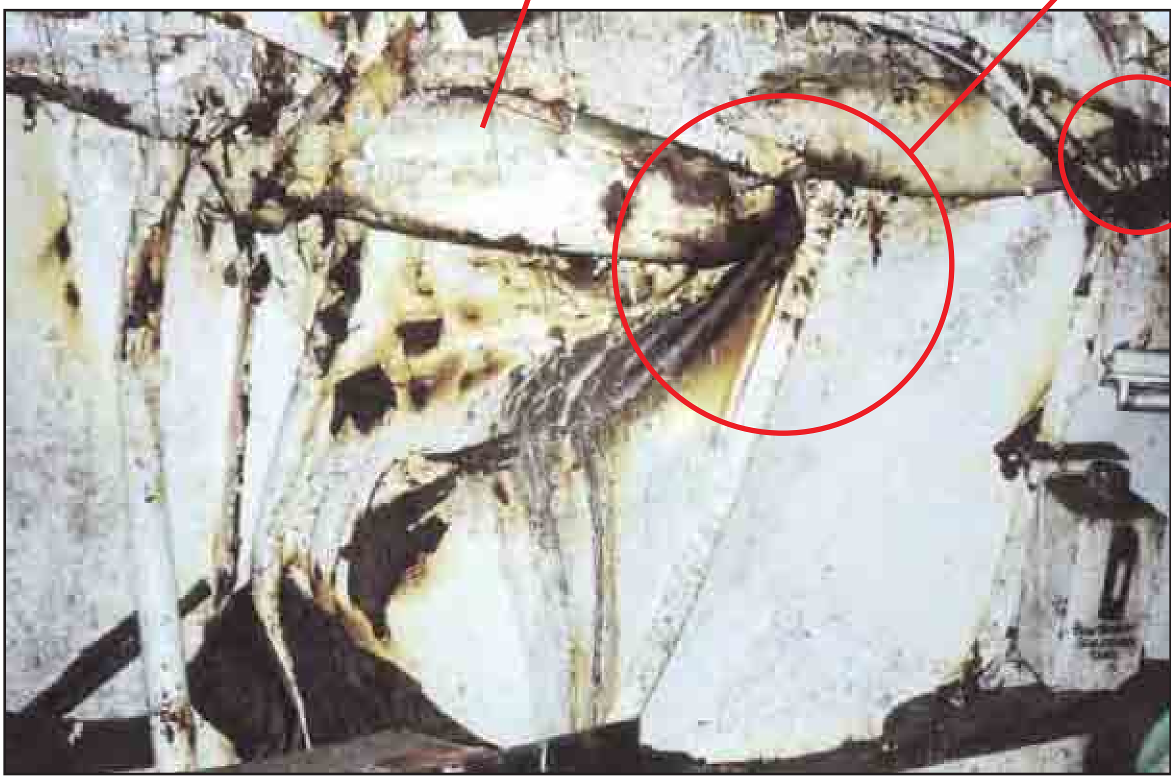


Figure 12c

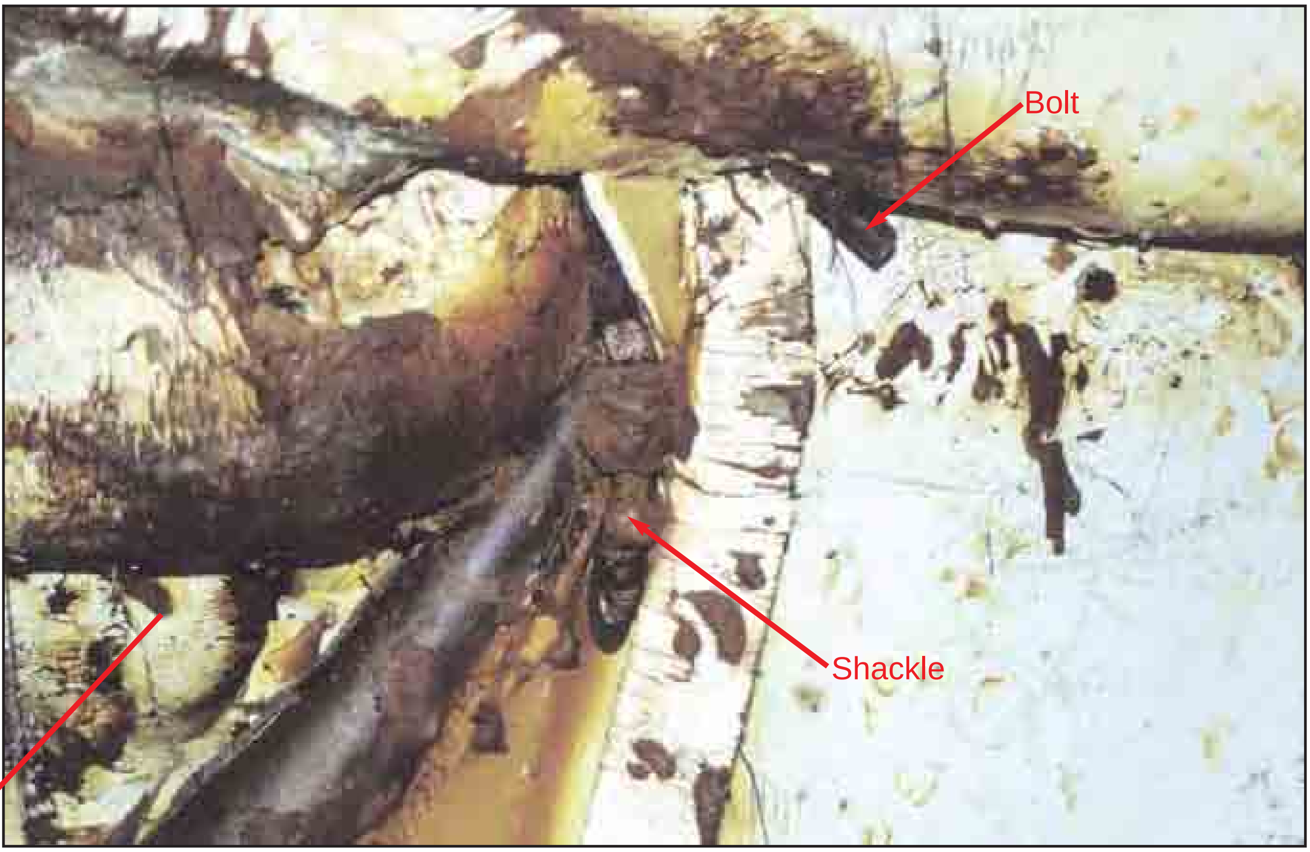
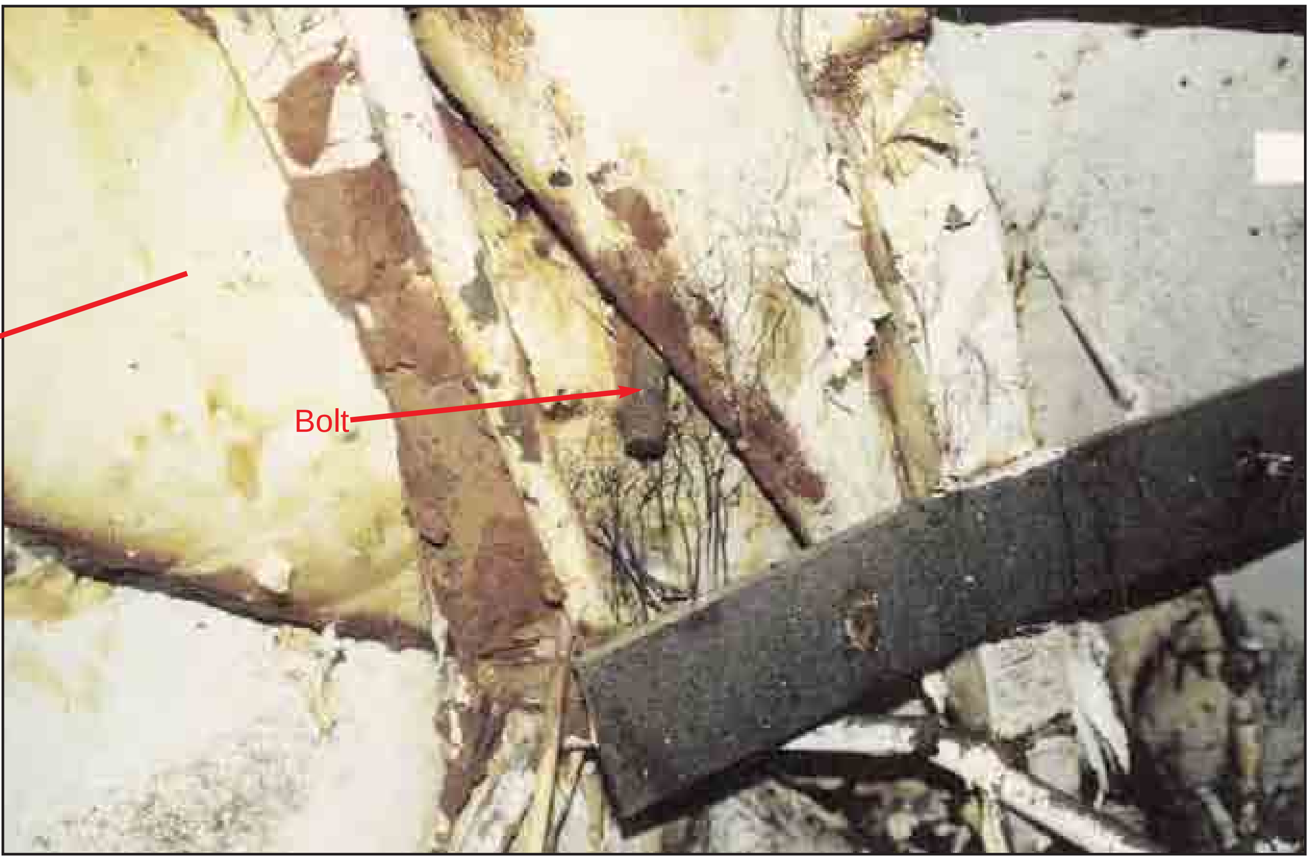


Figure 12d



Photographs showing the bow damage from inside the forepeak space showing debris trapped in the buckled steel

1.17.4 The engine room

The engine room floor plates had been strewn around the compartment. One was stuck between the main engine exhaust pipe and the deckhead with its free end pointing down and to port **(Figure 13)**. The batteries had been scattered; two were outboard of the auxiliary engine.

The cross-connecting valve, LV1, between the port and starboard Desmi pumps, was open **(see Figure 7)**. The overboard discharge valve from the ejector, OB2, was open and clear. The ejector was removed for examination (see Section 1.20).

The four screw-down non-return valves in the bilge chest were removed. Each was found in working order with nothing in the valve chest to interfere with their correct operation.

The main engine-driven Jabsco pump had no drive belts. The auxiliary engine Jabsco had drive belts, but the switch for the electric clutch was off. Both the port and starboard Desmi pumps had belts. All four pumps were removed for examination (see Section 1.20).

Moving the main engine throttle/gear lever in the wheelhouse had no effect on the governor control lever on the engine, so the only means of adjusting engine speed was <u>from inside</u> the engine room. It was found in this mode with the governor control lever 60% of the way between idle and maximum **(Figure 14)**. Wheelhouse control was regained by lifting the governor control lever, and rotating it about its own axis through 180°. Once this adjustment had been made the throttle and gearbox control cables, and their links, were fully operational from the wheelhouse.

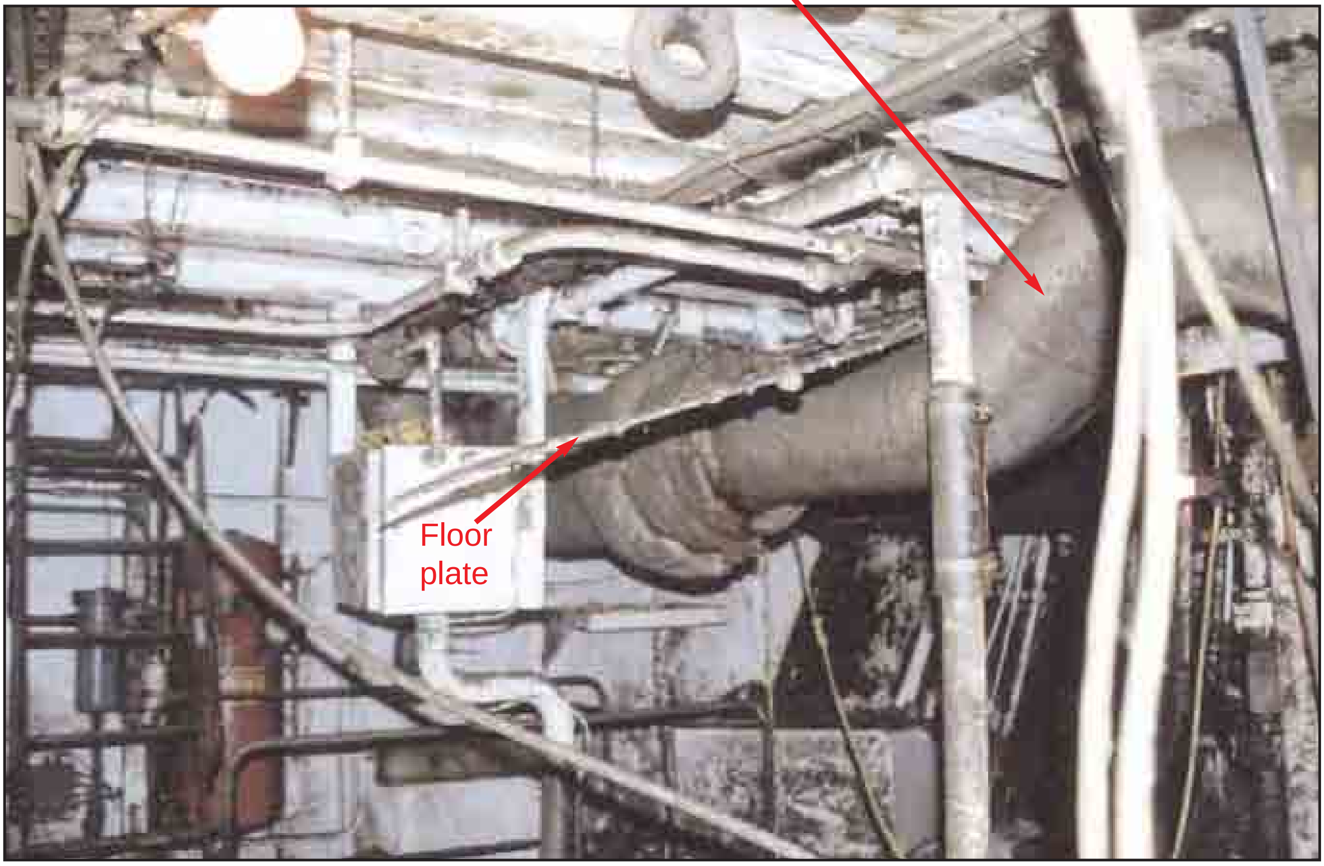
A Caterpillar-accredited mechanic from the shipyard assisted with the examination of the main and auxiliary engine. The investigation concluded that both engines were operable at the time *Solway Harvester* capsized.

1.17.5 The shaft tunnel

The sea suction to the starboard Desmi pump, SS3, was closed; its strainer choked with mud. The sea suction to the port Desmi, SS2, was open with its strainer partially choked. The tunnel's bilge suction was about 60% obstructed by a rag.

The cable to the fish room bilge alarm float switch had been cut and the ends of the wire neatly bared. It was tied in a coil on the port side of the tunnel about 2 metres forward of the aft bulkhead **(Figure 15)**. The bulkhead gland to the float switch showed no cable on the tunnel side.

Figure 13

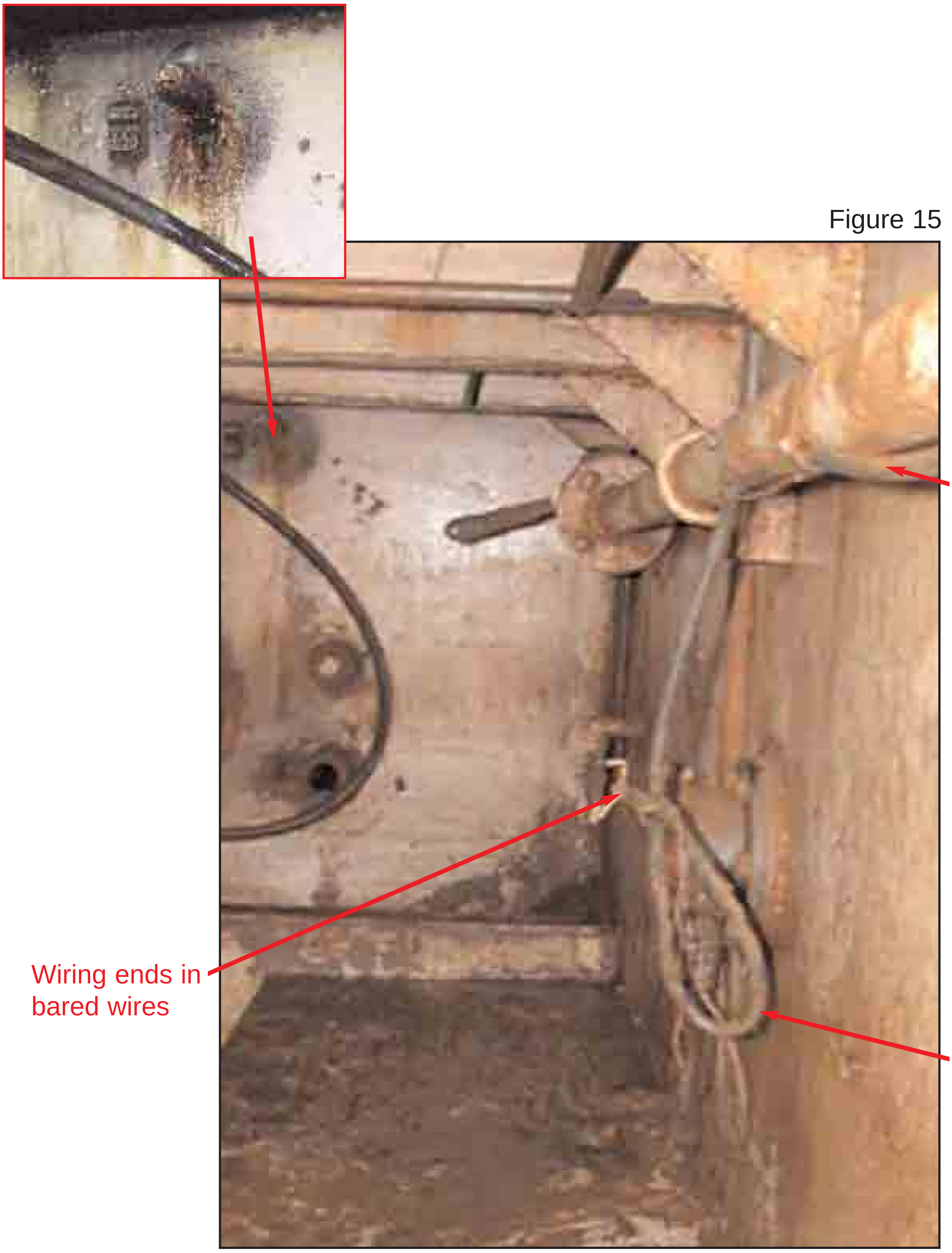


Floor plate found above exhaust pipe

Figure 14

The governor control lever on the main engine

Figure 15



Bilge alarm wiring (disconnected) in the shaft tunnel

1.17.6 The fish room

The space contained a quantity of loose shells which filled 32 scallop bags. A red handled screwdriver was wedged in the deckhead just inboard of the starboard hopper. Seven spare bellies, weighing 616kg, were removed.

The starboard cover to the slush well was found among the debris along the starboard side with its hinges broken. The port cover was in place. The bilge alarm float switch was fitted in the port side of the well, and moved freely. The bulkhead gland had been welded around the upper half of its circumference; its lower periphery was not watertight. A test showed that water drained through this slight gap at a rate of about 5 litres per minute from the full fish room slush well on the other side of the bulkhead. The centre of the bulkhead gland was 120mm below the top of the slush well.

Two bolts, threads upwards, secured the starboard strainer's lid. Four bolts were missing. The bilge suction was clear. The mesh inside the strainer was about 50% blocked with bag fibres.

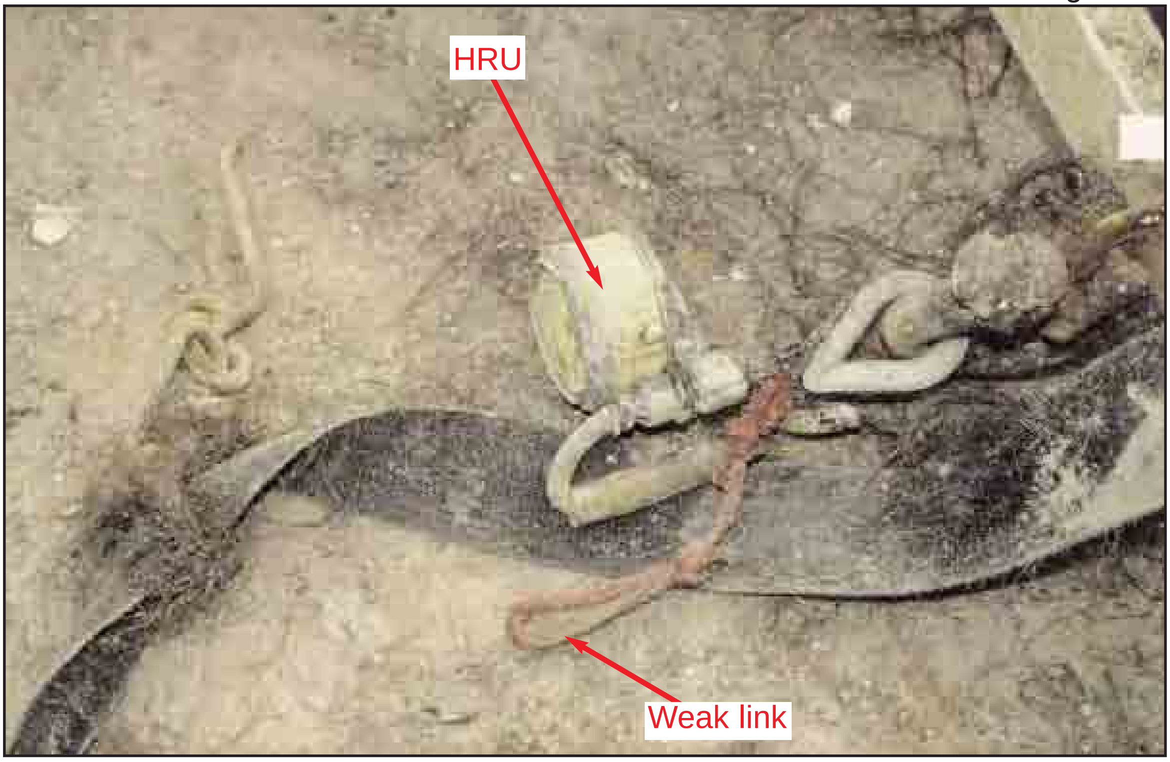
1.17.7 The workshop

The workshop's weathertight door was secured open by one of its clips. The 240V generator was switched off.

1.17.8 The shelter top

The lashings on the aft liferaft cradle were still fast and the HRU had not operated. The weak link was unbroken and its free eye empty **(Figure 16)**. The expiry date on the unit was 9/98. The HRU on the forward liferaft cradle had operated and cut the lashings.

Figure 16



The aft liferaft securing straps and HRU

1.17.9 The hull

The hull was substantially damaged in three areas: the bow at the level of the shelter top, over the boundary of the forepeak ballast tank and the Kort nozzle. The nozzle, together with the rudder **(Figure 17)**, had been damaged during the first salvage attempt. The resulting leak near the rudder stock was repaired on the slipway and the rudder removed. Other than this, the hull was watertight.

The bow damage was localised, and although the hull plating was folded, there was no hole **(Figure 18)**. At the level of the shelter top, the damage began 300mm to port of the centre-line and extended 2900mm in a straight line across to the starboard side **(Figure 18 and 19)**. The stemhead was set back 400mm folding the deck plating behind it.

Figure 17

Salvage damage to kort nozzle and rudder

Figure 18

Bow damage

Figure 19

Bow damage viewed from the shelter top

The total damaged area was small. Examination of the hull in the immediate vicinity of the damage showed no "foreign" paint deposits.

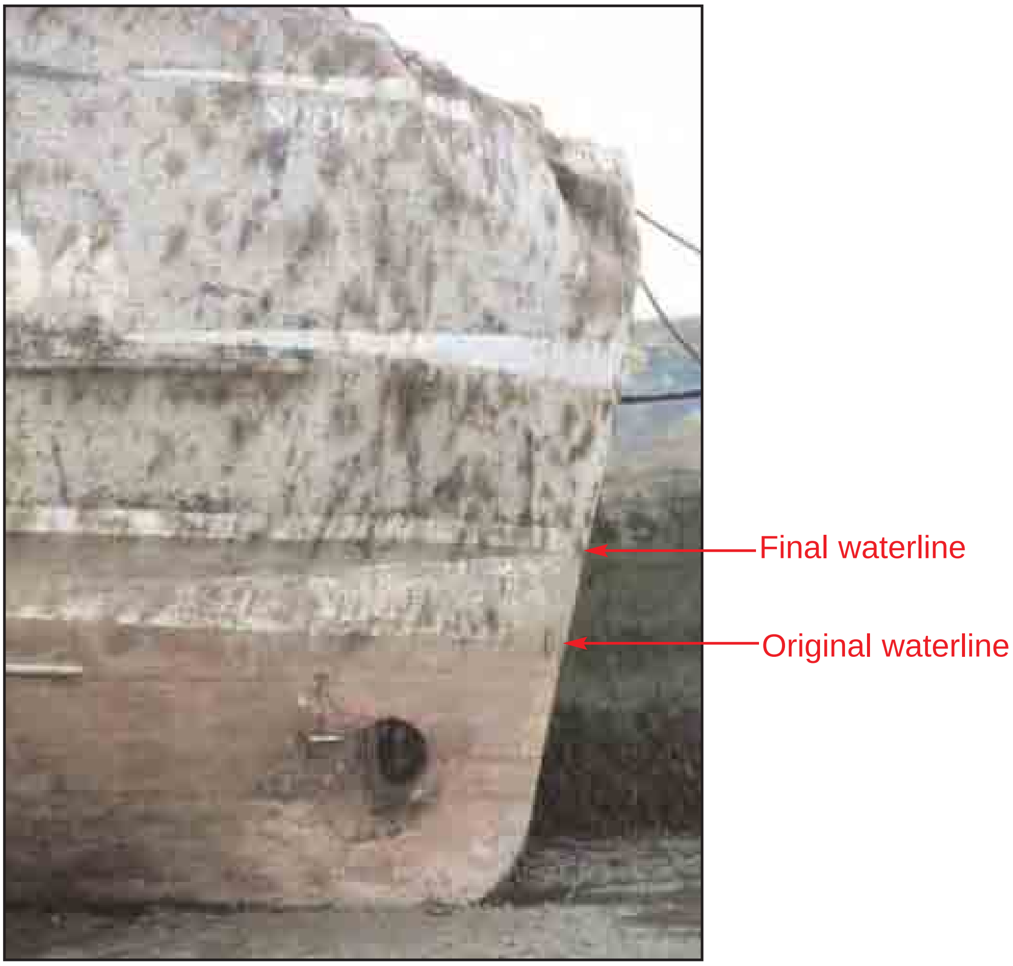
The hull shell over the length and depth of the forepeak ballast tank was noticeably set in on both sides of the vessel, showing dishing between adjacent frames.

The original waterline had, at some time, been painted over to raise it by about 0.6m **(Figure 20)**.

1.17.10 The steering gear

The steering gear appeared to have been operable.

Figure 20



Overpainting of the vessel's original waterline

1.18 STABILITY TEST

On 2 August 2000, the MAIB carried out an inclining test on the wreck in Ramsey harbour. The aim was to establish the centre of gravity in a known condition of loading, so that her stability on 11 January could be estimated.

In preparation for the test, all fuel tanks were opened and pumped dry, and all water tanks were filled to overflowing. The spare gear in the fish room and mattresses, and cushions from the accommodation, were removed. Spare gear scattered around the main deck was replaced in the central pound. The shakers and picking trays were in their original positions. Both sets of fishing gear were removed. The spare gear in the forepeak space was left in situ, and the engines and exhaust trunks were drained of water. All gear removed was weighed.

The test took place in light winds and calm water. Consistent results were obtained.

The fish room insulation was sodden with water. Experience from other investigations showed this could take years to dry out, so samples were taken to determine their water content. Using these data, an allowance of 3 tonnes was made for the water contained in the insulation.

The lightship weight was estimated to be about 3.5 tonnes (about 2%) heavier than that determined from the inclining test in 1996.

The test provided the data for estimating the vessel's condition on 11 January 2000 **(Figure 21)**. Calculations showed that *Solway Harvester* would have met the stability standard in the *Fishing Vessel (Safety Provisions) Regulations 1975,* providing all weathertight doors, scuttles and hatches were closed **(Figure 22)**.

1.19 LIFERAFTS

The two liferafts recovered from the sea were sent to the manufacturer's factory in Birkenhead. MAIB inspectors, the Manx Police and experts from RFD, the manufacturer, examined them both on 28 January 2000.

They were type Surviva 8 models, serial numbers 19027 and 18928, and contained full emergency rations. Their service record cards showed that they were last serviced at Cosalt in Aberdeen on 3 September 1996. They had previously been serviced in September 1995 and July 1994, and were due for their next in September 1997. There was no record that this had been done.

Both canisters showed minor impact damage. On No. 19027 all four bursting bands were in place, but only two remained on No. 18928. The canister of No. 19027 was covered in grease residue indicating it had been the liferaft stowed near the foremast and under the well greased landing winch.

The ends of the painters on both rafts protruded about 2 metres from the canisters. They were undamaged and displayed the original heat-sealed ends. Both liferafts inflated satisfactorily when their painters were pulled.

Both rafts contained their full safety equipment inventory, but all the emergency rations were out of date. The distress flares expired in August 1998.

Figure 21

Compliance: Vessel passes requirements in this condition

Longitudinal dimensions about AFT PERP (STN 0) (-ve aft, +ve forward)
Vertical dimensions about MLD SHELL AMIDSHIPS (+ve above, -ve below)

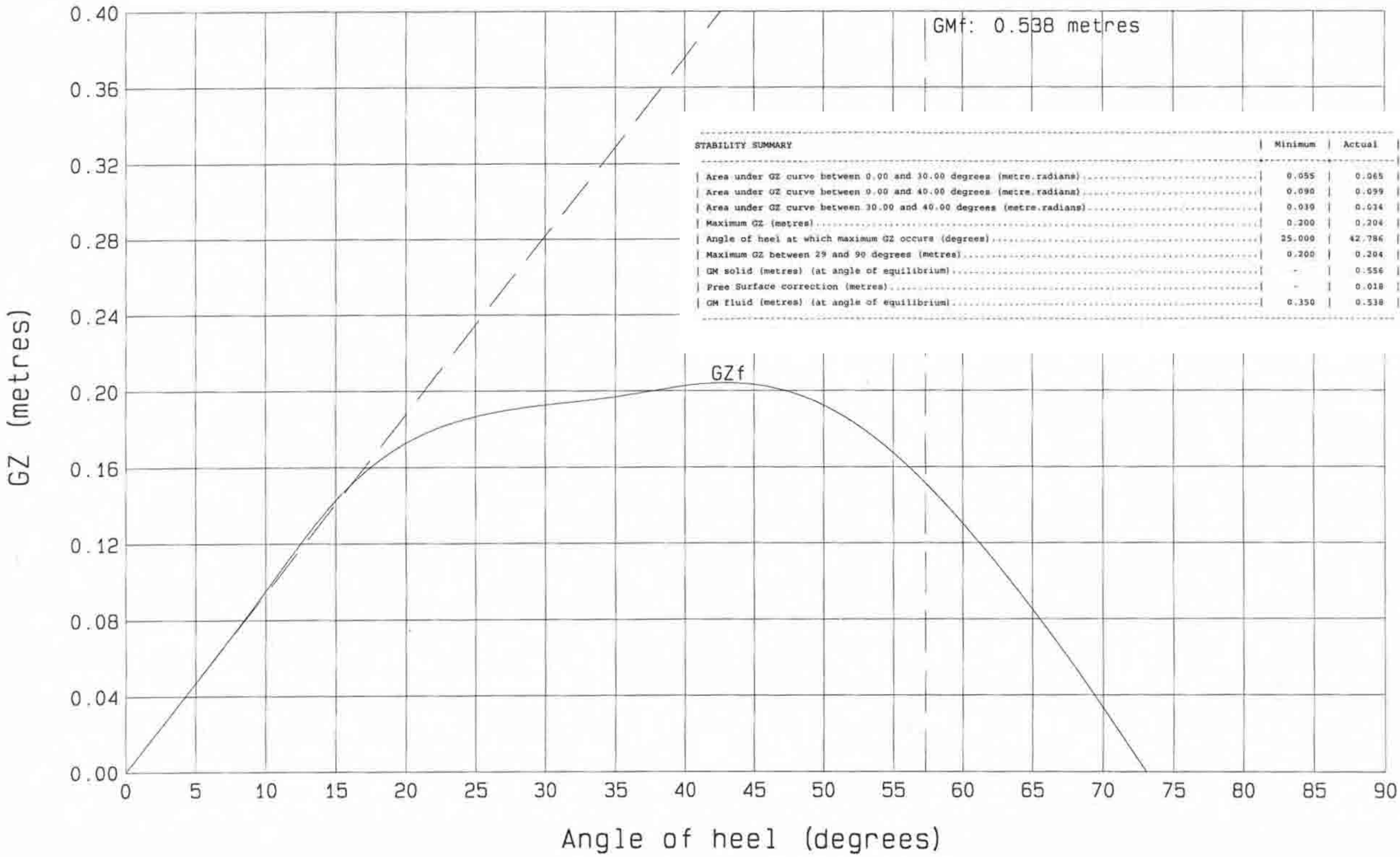
	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	OIL FUEL FWD PORT	0.872	9.936	8.664	0.451	0.393	0.796
2	OIL FUEL FWD STBD	0.872	9.936	8.664	0.451	0.393	0.793
3	OIL FUEL AFT PORT	3.163	6.962	22.021	0.824	2.606	0.868
4	OIL FUEL AFT STBD	3.163	6.962	22.021	0.824	2.606	0.889
5	OIL FUEL DAILY SERVICE	0.770	12.920	9.948	3.040	2.341	0.175
	TOTAL OIL FUEL	8.840	8.068	71.318	0.943	8.340	3.521
6	WATER BALLAST AFT STBD	4.250	-1.041	-4.424	3.142	13.353	0.000
7	WATER BALLAST AFT PORT	4.250	-1.041	-4.424	3.142	13.353	0.000
8	WATER BALLAST FORWARD	7.706	17.641	135.942	2.917	22.478	0.000
	TOTAL WATER BALLAST	16.206	7.842	127.093	3.035	49.185	0.000
9	FRESHWATER AFT CENTRE	1.175	-1.009	-1.186	2.311	2.715	0.491
10	CREW AND EFFECTS	0.800	9.500	7.600	4.800	3.840	-
11	STORES AND PROVISIONS	0.075	4.500	0.338	4.300	0.323	-
12	ENGINE SPARES	0.150	0.100	0.015	2.200	0.330	-
	FISHING GEAR PORT	2.582	8.100	20.914	5.500	14.201	-
14	FISHING GEAR STARBOARD	2.794	8.100	22.631	5.500	15.367	-
15	FISHING GEAR SPARE DREDGES	2.160	10.600	22.896	1.600	3.456	-
16	FISHING GEAR SPARE BLLS A	0.616	10.600	6.530	1.600	0.986	-
17	FISHING GEAR SPARE BLLS B	0.352	13.500	4.752	6.000	2.112	-
	TOTAL FISHING GEAR	8.504	9.140	77.723	4.248	36.122	0.000
18	SCALLOPS IN BAGS IN HOLD	10.400	5.500	57.200	1.800	18.720	
19	SCALLOPS + DEBRIS IN BINS	0.000	0.000	0.000	0.000	0.000	0.000
20	SCALLOPS IN SHAKERS	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL SCALLOPS	10.400	5.500	57.200	1.800	18.720	0.000
	DEADWEIGHT TOTAL	46.150	7.369	340.102	2.591	119.575	4.012
	LIGHTSHIP	174.705	8.015	1400.261	3.355	586.135	-
	DISPLACEMENT	220.855	7.880	1740.363	3.195	705.710	4.012

Free Surface Correction (Total Free Surface Moment/Displacement)	0.018
VCG fluid	3.214

Estimated loading condition for 11 January 2000

Condition: ESTIMATED LOADING CONDITION ON 11 JANUARY 2000

Compliance: Vessel passes requirement in this condition



STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.065
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.099
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.034
Maximum GZ (metres)	0.200	0.204
Angle of heel at which maximum GZ occurs (degrees)	25.000	42.786
Maximum GZ between 29 and 90 degrees (metres)	0.200	0.204
GM solid (metres) (at angle of equilibrium)	-	0.556
Free Surface correction (metres)	-	0.018
GM fluid (metres) (at angle of equilibrium)	0.350	0.538

Figure 22

Stability curve for 11 January 2000 showing compliance with regulations when the ice scuttles and doors are closed watertight

1.20 PUMP EXAMINATION AND TESTS

The two Desmi pumps and the ejector were opened up for examination in the shipyard workshop. A splinter of timber, about 75mm x 20mm x 10mm, was found lodged in the suction side of the ejector.

The port Desmi pump had been supplied to Deeside Services in November 1997. Its interior face was severely eroded so that three-quarters of its circumference was perforated. The clutch had been removed from the pump at some time and had been replaced with a standard pulley which meant that the pump was permantly driven; there was no means of disengaging it from the engine.

The starboard Desmi was in a poor condition. The bearing housing and the impeller appeared to be from the original 1991 model. The pump shaft was not the correct type for the clutch that was fitted. The clutch itself was inoperable, the electric circuits were burnt out and it had been welded up at three points,so that the clutch could never be disengaged.

The main Jabsco pump, the original bilge pump, was inoperable because the impeller vanes had been destroyed, but the auxiliary bilge pump was found to be in full working order.

The Desmi pumps were sent to their manufacturer for inspection. Following this, the port Desmi pump, the main and auxiliary Jabsco pumps, the ejector and the fish room bilge suction strainer were sent to Gilkes in Kendal, Cumbria, for testing. Representatives of the coroner’s consultants (PML) and the MAIB attended the tests.

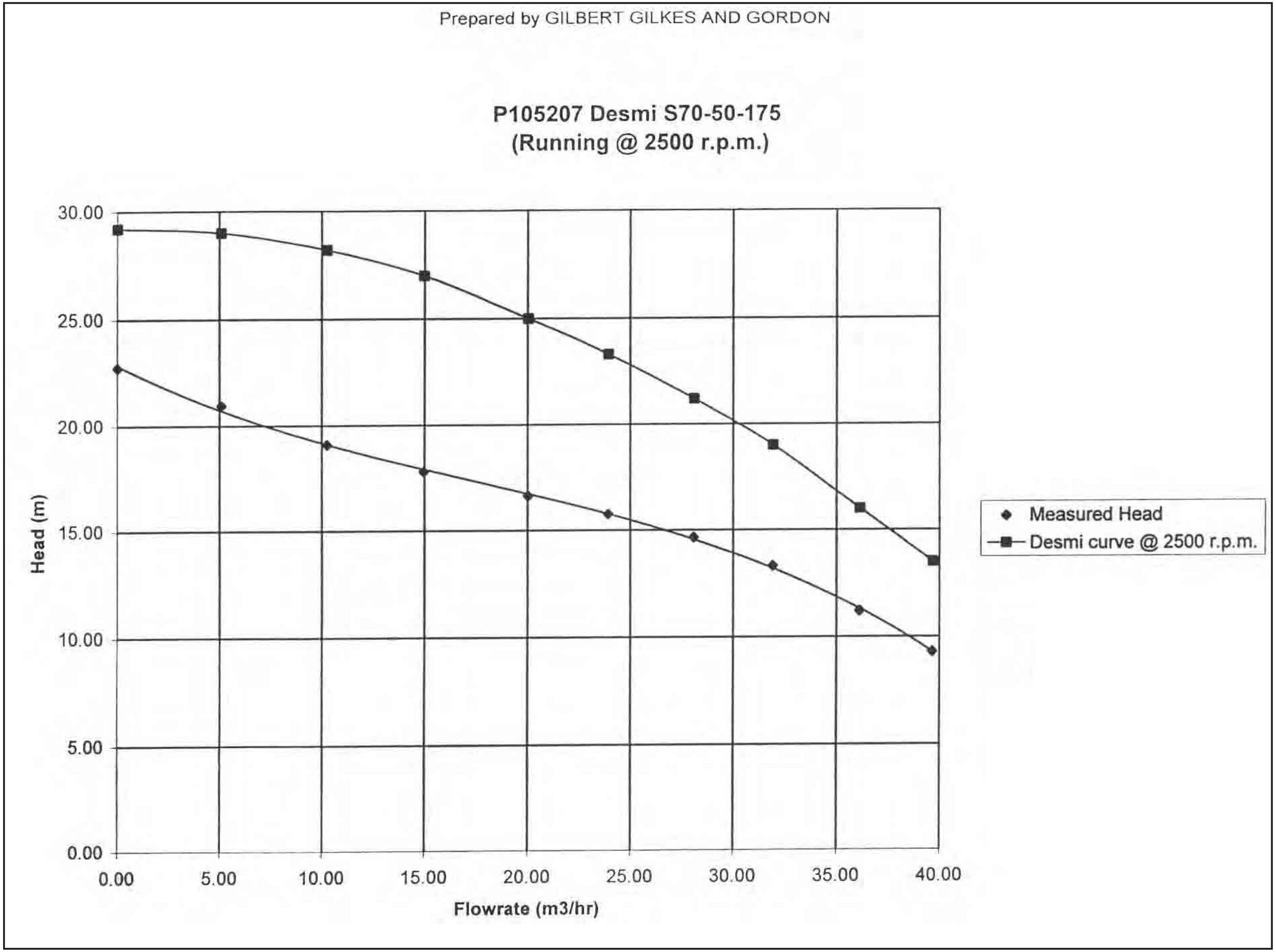
The port Desmi pump worked but, because of the internal damage, the pressure head from the pump was a third below the manufacturer’s specification over much of its operating range **(Figure 23)**. Despite this, the pump’s output was still adequate to “power” the ejector.

The splinter of wood found inside the ejector did not noticeably impair its performance.

Blocking 75% of the area of the bilge suction strainer gauze did not noticeably reduce the rate of discharge of bilge water.

The tests also investigated how the open pipe branch to the aft port tipping bin might have affected the bilge system’s output. Inserting a short open branch into the test rig reduced the rate of bilge water discharge. This was investigated further by calculations taking account of the actual pipe lengths and bends measured on the wreck. It was found with the supply to the port tipping bin open, the bilge discharge reduced from about 10.7 tonnes/hr to about 8.2 tonnes/hr. Subsequent tests in April on the wreck, with the pump operating through the vessel’s piping system, obtained substantially lower values (see Section 1.22).

Figure 23



Test bed results for port Desmi pump

1.21 SCALE MODEL TESTS AND NUMERICAL SIMULATIONS

To gather further information, and to test some possible theories, the two organisations involved in separate investigations of the same accident, the MAIB and the Isle of Man Police, decided to commission model tests and computer numerical simulations.

BMT SeaTech Limited (BMT) and the Ship Stability Research Centre (SSRC) at the University of Strathclyde were contracted to investigate the possibility that flooding of *Solway Harvester's* fish room was a factor in the accident. These two organisations were tasked to investigate:

a) the weight of water in the fish room necessary for the drifting vessel to be capsized;

b) the average depth of water which would be found on the main deck near the ice scuttles when the vessel was in transit at 8 knots, and the corresponding rate water would flood through the open ice scuttles into the fish room;

c) the sinking attitude of the vessel.

BMT investigated (a) and (b) using a physical model, and SSRC investigated (a) and (c) using computer numerical simulations.

1.21.1 Model Tests

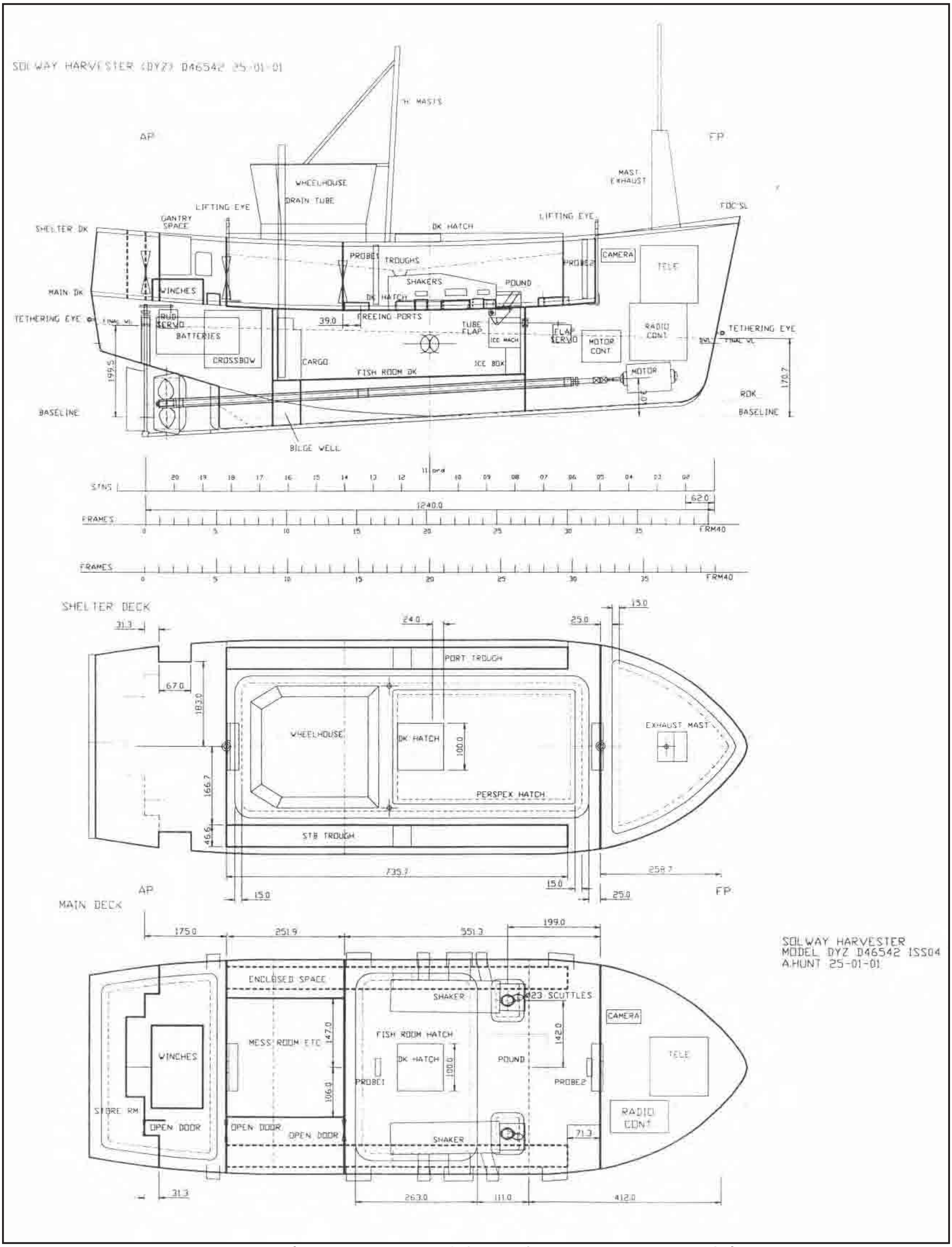
Physical model tests were carried out using a 1/15th scale model of *Solway Harvester* **(Figure 24)** at the DERA Hydrodynamic Test Centre at Haslar in Hampshire.

Annex 4 is a summary of the tests carried out in breaking waves of 4.1m and 6.4m significant wave height. The lower wave height represented the 'typical' wave conditions prevailing when *Solway Harvester* sank, and the other the worst wave groups that could have been encountered in the prevailing conditions.

Testing took place on 4, 5, 17 and 18 January 2001 in the ship tank and on 22 January, 30 April and 11 June 2001 in the manoeuvring basin. The ship tank tests investigated what weight of flooding in the fish room could have led to the vessel capsizing when drifting with waves on her port beam. In these tests the fish room was sealed and could not flood beyond its initial level. The starboard passageway doors were open.

The model did not capsize in the 4.1 metres high waves in any of the conditions tested. Because the spectra represented 'typical' sea conditions the model did not encounter the larger breaking waves which could have occurred at sea during the relatively short duration of each test run, about 10 minutes model scale. At full scale this would have equated to about 39 minutes.

Figure 24



General Arrangement of the *Solway Harvester* model

The model capsized in the 6.4 metres high breaking waves, but only if flooding of the fish room reduced its stability. Capsizing was always initiated by a group of large breaking waves rolling the vessel 30° to 40°. Since the investigation was interested in the circumstances leading to capsizing, most tests were carried out in the ‘worst’ wave conditions.

It capsized if the fish room was flooded with 18 tonnes of water.

If a 0.5 tonne weight was added to each tipping bin, representing the catch that might have been left in the bins, capsizing occurred with 15 tonnes flooding.

It capsized with 9 tonnes of water in the fish room if a 3.7 tonnes weight was also shifted 2 metres to starboard in the fish room; representing the possible movement of spare gear and 10% of the cargo in the flooded fish room.

Capsizing invariably followed the same pattern. After surviving the initial violent roll of between 30° to 40° the model appeared to recover, but listed heavily to starboard (typically about 20°) because of flooding to the starboard passageway, and the retained water on the main deck. If the water on the main deck was able to drain away through the freeing ports, the model’s list slowly reduced and it did not capsize. But, if, instead of draining away, the amount of water actually increased, the list increased slowly until, finally, the model lay on its side and then capsized.

The outcome was dependent upon the initial stability of the model and, most importantly, the angle of vanishing stability. If this exceeded about 25°, the model survived the prevailing wave conditions. If less, it capsized. Flooding the fish room reduced the stability of the model and the angle of vanishing stability. Adding weights at the tipping bins, or adding weights to represent a movement of cargo and spare gear, reduced it further.

The purpose of the manoeuvring tank tests was to investigate the depth of water on the main deck near the ice scuttles when the vessel was in transit; and to measure the corresponding rate at which water accumulated in the fish room from flooding through the open scuttles. This data was necessary for estimating how quickly water might have accumulated in the fish room when *Solway Harvester* made for Ramsey Bay.

The results showed that, when the model started with a dry fish room, water accumulated at a mean rate of about 4 tonnes/hr, but ranging from 2.3 tonnes/hr to 7.5 tonnes/hr, with the waves 30° abaft the beam. In beam seas this increased to a mean of about 5 tonnes/hr, ranging from 3.2 tonnes/hr to 7.4 tonnes/hr. When the model started with 9 tonnes of water in the fish room, the mean rates dropped to about 1.5 tonnes/hr and 2 tonnes/hr respectively, with corresponding ranges of 1.0 to 2.2 tonnes/hr and 1.4 to 2.5 tonnes/hr. This was a consequence of the marked effect the fish room flooding had in reducing the motion of the model. Measurements on the drifting model indicated reductions in maximum and significant roll angles of about 25%.

For the condition where the fish room was dry initially, and waves were 30° abaft the beam, water drained off the main deck through the leeward scuttle for about 3% of the total time and through the windward scuttle for about 6%. In the first case the maximum water depth at the scuttle was 38mm and in the latter 210mm. In both cases the average duration of the outward flow was about 2 seconds.

For the condition where the fish room was dry initially and waves were on the beam, water drained off the main deck through the leeward scuttle for about 6% of the total time.

When the tests were repeated with the fish room flooded by 9 tonnes of water, drainage through the open scuttles occurred for less than 1% of the total time.

It was not possible to model all aspects of the environment *Solway Harvester* encountered during her last hours, such as the spread of the waves about their mean direction, or the wind and its interaction with the waves. Also, because of scaling effects, the thin film of water, which might continuously cover the deck of the full size vessel, could not exist on the model. As a result the model tests probably under-predicted the rate of ingress of water into the fish room off the main deck, but this cannot be quantified.

1.21.2 Computer numerical simulations

The Ship Stability Research Centre (SSRC), of the University of Strathclyde, carried out computer numerical simulations between March and August 2001. These allowed the investigation team to expand on the results of the model tests by examining other combinations of factors that might have had a bearing on the accident.

The simulations involved the vessel drifting beam on to the waves and an examination of the effects of a number of parameters such as flooding of the fish room, the movement of cargo and spare gear in the fish room, and closing the doors to the starboard passageway. The simulations covered no more than 20 minutes of the vessel's drifting. The interval would be less when the vessel capsized. Each run began with a specific weight of water in the fish room, but included the effect of water spilling periodically on to the main deck and draining into the fish room to increase the weight of water there. In many cases, therefore, the weight of water in the fish room at capsize was more than had been there initially. A summary of this work is contained in **Annex 5**.

The results of the simulations confirmed what had been found in the model tests; the vessel could have capsized in the prevailing conditions only if the fish room was flooded, substantially reducing her stability. Capsize was always initiated by a group of large waves.

When the starboard passageway doors were open, the weight of water in the fish room at capsizing was between 6 and 9 tonnes depending upon what other factors were involved; but with the doors closed this increased to about 10 to 12 tonnes.

Capsizing also followed the same pattern seen in the model tests. The initial large roll in a group of high steep waves resulted in a permanent list; and the accumulation of water on the main deck finally caused the vessel to heel beyond the point of vanishing stability and capsize.

The simulations modelled the effect of additional water draining through the ice scuttles into the fish room. This was important, showing that the vessel capsized readily once a permanent list to starboard of about 20° had developed and the ice scuttles were immersed almost continuously. The list emanated from the combined effects of flooding to the starboard passageway, a movement of cargo and spare gear in the fish room, and retained water on the main deck.

The simulations also allowed the opportunity to study the effect of applying the movement of cargo and spare gear "dynamically" when the vessel first rolled past 25°. This was shown to be important with the impetus of the weight movement exacerbating the roll to starboard and leading to immediate flooding of the starboard passageway.

Once *Solway Harvester* was listing about 20° to starboard, the simulation showed that she would capsize within 5 minutes if the starboard picking tray remained in place, but in less than 1 minute if the picking tray had been displaced.

Both the simulations and the physical model tests were carried out for the prevailing sea conditions of 4.1 metres significant wave height and 8.6 seconds peak period, but the two teams of researchers selected different wave spectra to model this basic sea condition. The consistency in the results showed that the choice of wave spectrum was not critical, providing the spectrum produced realistic groups of steep large waves.

1.22 FULL-SCALE TESTS

1.22.1 **Downflooding tests** were carried out on the wreck in Douglas on 14 February 2001. These were conducted to determine how quickly water could drain into the fish room off the main deck through the gap between the starboard picking tray pipe and the ice scuttle. The test was very simple. Water was held around the base of the picking tray pipe by a low watertight enclosure and drained into the fish room where it was collected in a 0.22 m^3 barrel. The time taken to fill the barrel was recorded, and the downflooding rate calculated.

It took 56 seconds for the barrel to fill when the water level in the enclosure was just at the flange, and the pumps were delivering at their maximum capability. This equates to a flooding rate of 14.14 tonnes/hr through one scuttle.

A more extensive series of tests along similar lines was carried out on 25 April 2001. Before they were started, care was taken to position the picking tray so that the smallest gap was left between the pipe flange and the ice scuttle ring. This gap measured 30mm on one side, and nothing at the other where the flange rested on the ring.

The starboard picking tray and shaker were examined to check that the observed gap was not caused by any damage, distortion and misalignment sustained in the sinking. The top plate of the picking tray was not found to be flat, and it undulated by up to 15mm in places. This, it was thought, had always been present and was probably introduced during fabrication. The hollow legs on the shaker's frame fitted over the locating posts on the deck resulting in no obvious distortion of the frame. So while the investigation could not rule out the possibility that distortion of the deck equipment had affected the sizes of the gaps between the picking trays and the deck, its effect was probably small.

This conclusion was supported by the evidence of former members of the crew, who, when shown the arrangement, confirmed that there had been gaps between both picking trays' pipes and the deck. Their recollections of the sizes of the gaps varied between about 15mm and 30mm, and that movement of the picking trays as the vessel rolled caused the gaps to widen.

The MAIB was satisfied that the arrangement tested was very close to that present on the vessel when she was lost, and that a more accurate representation could not be achieved.

An initial series of tests was carried out to estimate the maximum rate at which water could drain through the gap under the starboard picking tray flange. A rate of about 55 tonnes/hr was achieved, but higher rates would have been possible had the water been supplied at a greater rate. The test was repeated with the picking tray removed, and the rate increased to about 91 tonnes/hr. These tests gave an indication of what was possible, without constraining the depth of the water in the enclosure.

The next series of tests looked at the rates occurring if the water was no deeper than the gap under the picking tray flange.

They showed that water drained through the gap under the picking tray flange at such a high rate that the water level in the enclosure did not rise above the top of the gap until the inflow to the enclosure exceeded a rate of about 36 tonnes/hr. It was concluded that the picking tray did not noticeably reduce the rate at which water drained off the deck into the fish room when the depth of water above the ice scuttle ring was less than the height of the gap between the ring and the flange. For the remainder of the tests, therefore, the picking tray was removed.

Two tests examined the relationship between the depth of water above the ice scuttle ring, and the rate at which water cascaded over the edge of the scuttle opening. Because the ice scuttle ring is set to the deck's camber, the depth of water over the ring reduces from outboard to inboard. So at some depths only the outboard part of the ring is submerged. When the depth was 23mm at the outer extremity of the ring, approximately 50-60% of the ring's circumference was submerged and the rate of downflooding was 19.1 tonnes/hr. This reduced to 1.7 tonnes/hr when the maximum depth was 10mm and about 40% of the circumference was submerged; but in this case the flow was intermittent and sometimes stopped altogether when the wreck rolled slightly in the harbour swell.

In other tests, a 12mm thick flat square steel plate was placed over the ice scuttle to mimic the best possible fit between a picking tray flange and the scuttle. Corrosion of the surface of the ice scuttle ring produced small gaps at the interface. Downflooding rates of between 6.9 and 12.6 tonnes/hr resulted when the water level inside the enclosure was maintained, in turn, flush with the tops of three corners of the plate.

1.22.2 **Bilge pumping tests** were carried out on the wreck in Douglas on 14 February to check the effectiveness of the vessel's bilge system by connecting it to a portable pump with a capacity similar to that of the port Desmi. The tests showed how the performance of the ejector was affected when the pump was also supplying the shakers and tipping bins. The ejector's performance was determined by measuring the time it took to empty the fish room slush well.

When the pump was supplying the ejector only, the slush well emptied in 12 minutes (4.9 tonnes/hr). With one branch open, the time increased to 16 minutes (3.7 tonnes/hr). It took 20 minutes (3.0 tonnes/hr) when the pump supplied both the ejector and the port side shaker and tipping bins. When the starboard side shaker and tipping bins were also added, the water level in the well did not drop. The ejector no longer created sufficient suction to draw the bilge water from the slush well.

The tests also showed there was sufficient suction to hold a scallop shell, or empty scallop bag, across the open end of the bilge suction pipe when the pump was supplying the ejector and the port shaker and tipping bins. It was also found that there was insufficient suction to draw the bag into the pipe.

These tests clearly showed that the discharge from the bilge ejector was probably wholly dependent upon the total number of outlets drawing from the port Desmi pump at the same time. This was indicative of the likely performance of *Solway Harvester*'s bilge pumping system on 11 January 2000. The results were not conclusive, however, because the pump tested was not the vessel's, nor was it using the original sea suction piping.

1.22.3 Bilge pumping tests on 24 & 25 April 2001. It was decided to repeat the tests with the vessel's port Desmi pump reassembled and installed on the wreck. This was done on 24 & 25 April in Douglas.

Following the salvage, the sea inlet valve to the port Desmi, the port and starboard Desmi pumps, the two Jabsco pumps and the ejector had been dismantled for examination. For the test, the starboard Desmi pump and the two Jabsco pumps were not re-installed; the pipe flanges to the starboard Desmi pump were blanked off and the circuit to the two Jabsco pumps isolated by valves "TP1" and "LP7".

The system in the engine room was leak free when under test. Some leaks were noted in the system on the working deck, but these were from flanged joints and not as a result of pipe failure or fracture. As there was no reason to believe that the leaks, which were minor, had not been present before the vessel sank, no attempt was made to rectify them.

The system was not subjected to a hydrostatic test. The MAIB tested the system in its "as found" condition, believing that a more accurate model for the system's performance at the time of the vessel's loss could not be achieved.

Any degradation of the piping system since the vessel sank, because of changes in surface roughness inside pipes from corrosion or marine growth, cannot be quantified, but the MAIB estimates the effect to be minor. When the ejector was removed from the wreck it showed no significant marine growth and, when tested, performed slightly above the manufacturer's specification. But, as a precaution, the system was given a good flushing before measurements started. A further indication of the absence of any significant restriction to flow through the system was shown by the output from the deckwash hose supplied by the port Desmi pump. The hose was used during the downflooding trials, and had a measured output of 17.4m^3/hr.

Throughout the tests, the rotational speed of the port Desmi pump was maintained at a constant 2500 rpm.

The results of this second series of tests confirmed the results of those conducted earlier.

With all other outlets from the port Desmi pump discharge line closed, the slush well was emptied in an average time of 12mins 0secs (4.9 tonnes/hr).

When the outlet to the aft starboard tipping bin was opened, the time increased to 14mins 15secs (4.1 tonnes/hr).

When the outlets to the aft starboard tipping bin, the port shaker and the starboard shaker were opened, there was no discernible drop in the level of water in the slush well after 7 minutes. The test was then stopped. It had been carried out with the outlets to the forward starboard tipping bin and the forward and aft port tipping bins open. No water emerged from these three outlets. It was thought that this was probably caused by compression and kinking of the rubber hoses at the outlets hidden under the bins themselves.

When only the outlets to the aft starboard bin and starboard shaker were open, the slush well emptied in 37mins 30secs (1.6 tonnes/hr).

When only the outlet to the port shaker was open, the slush well emptied in 22mins 30secs (2.6 tonnes/hr).

With only the deck wash hose outlet open, the time to drain the well was 19 mins 40secs (3.0 tonnes/hr). The output from the deck wash hose in this condition was 15.8 tonnes/hr.

Inspection of the valves after the last test showed that the valve to the starboard aft tipping bin remained open when the operating lever was moved to the closed position. The locking screw on the valve disc had stripped, disconnecting the disc from the movement of the lever. It is not known when it became defective but the surface appearance of the valve's internals suggested that the valve disc had been in the open position when *Solway Harvester* sank.

1.22.4 **Cargo movement tests** were done in Kirkcudbright on 20 April 2001, with the invaluable help of West Coast Sea Products Ltd. Full bags of scallops were stacked inside a tipping road trailer. The trailer was tilted until the stack of bags started to collapse, at which point the inclination was noted. The steel floor of the trailer was lined with wooden pallets to provide a degree of friction similar to the concrete deck in the fish room.

Three different stacking arrangements were tested. The inclination at which collapse began varied from 18° to 25°. In each case one side of the stack was against the trailer's steel side. The stacks collapsed because the upper bags rolled, and slid over those beneath. Not once did the lowest row of bags on the trailer's floor slide from under those above.

1.22.5 **Spare gear movement tests** were carried out on board the wreck in Douglas on 24 April. The objective of the tests was to determine the approximate roll angle at which the spare dredges in the fish room could have begun to slide across the deck. A complete dredge, weighing 120kg including the belly and the frame, was dragged across the deck of the fish room, and the horizontal pull was measured on a spring balance. The pull was 50kg, indicating that it would begin to slide if the vessel rolled to about 25°. Evidence from former crew members (during the court case in May 2005) made clear, however, that the spare gear was normally stowed between pillars in the fish room in such a way that no shift was possible even in very severe rolling.

1.22.6 Video recordings on board *Tobrach-N* at sea

In January and February 2001, BMT SeaTech, under contract to the Isle of Man police and the MAIB, and with the full co-operation of the vessel's owner, fitted three video cameras to *Solway Harvester*'s sister vessel *Tobrach-N*.

One camera was fitted in the wheelhouse looking forward, to record the extent of rolling and the prevailing weather conditions. The others were fitted at the forward end of the main deck, one looking down the length of the deck towards the fish room hatch and the other, most importantly, looking towards the forward freeing port on the port side. These cameras were located to provide an overall impression of how much water entered through the freeing ports on to the main deck.

All three cameras, fitted with long-life batteries, were activated by the skipper pressing a single switch in the wheelhouse. Once switched on they ran for 15 minutes and then stopped automatically. The skipper was asked to switch on when the vessel was on passage in rough weather, especially if the waves were on the beam or just aft of the beam. It was hoped that this would build up a picture of the likely quantities of water shipped on the main deck of *Solway Harvester* during her last voyage. When the vessel returned to Kirkcudbright on Fridays the harbourmaster replaced the tapes and batteries with new ones.

After delays, caused by several technical problems, the system finally produced a 45 minute video recording on a trip in late March 2001 with the vessel on passage in force 5 to 6 conditions, including a period where the waves were on her starboard beam. Unfortunately, and unknown to the skipper, the crew had blanked off the forward freeing port on the port side to prevent water coming through it and wetting them as they worked at the port picking tray. The corresponding freeing port on the starboard side had been blanked off previously. Therefore, the feature of most interest and importance to the investigation, the quantity of water shipped through the forward freeing ports, could not be recorded.

The camera fitted at the forward end of the main deck, looking down the length of the deck towards the fish room hatch, showed that in the prevailing conditions the deck was continuously awash under a covering of about 12mm of moving water, with periodic surges to much greater depths.

SECTION 2 - ANALYSIS

2.1 GENERAL

During the months following the loss of *Solway Harvester*, the MAIB analysed the mass of evidence collected during the investigation to determine why she sank so quickly, and why none of those on board survived.

This process used evidence obtained from interviewing many people associated with *Solway Harvester,* photographs from the underwater survey, the findings of divers and the very detailed inspection of the wreck and its equipment once it had been recovered. The analysis also made use of information gathered from the wide range of tests and calculations conducted.

The key objective of the investigation was to establish not only <u>what</u> happened, but of greater importance, <u>why</u> it happened. Unless the reasons why certain things happened are understood, it is unlikely the correct lessons will ever be learned.

The sole aim of the investigation was to prevent something similar happening again.

2.2 THE COLLISION THEORY

Following the accident, there was widespread conjecture that *Solway Harvester* might have sunk following a collision with another vessel, a submarine or a submerged container.

When the wreck was raised, the watertight integrity of the hull was found to be intact and *Solway Harvester* floated without assistance once it was salvaged. No hole, or other damage was found which might have indicated the vessel had been in a collision.

Examination of the damage to the bow from inside the wreck revealed loose items, such as shackles, nuts, bolts and springs trapped in the distorted steel of the forepeak deckhead and shell plating. These items were found almost directly above the storage shelves from which they fell, but disposed to the starboard side. From the foregoing, it is clear that *Solway Harvester* was inverted when the damage to the bow occurred and accordingly, the damage must have taken place <u>after</u> the vessel had capsized.

The MAIB is satisfied that the sinking of *Solway Harvester* was not the result of a collision with another vessel, a submarine or a submerged container. The discovery of margarine containers in the search area immediately after her loss was pure coincidence, and had no connection with the accident.

2.3 FURTHER EVIDENCE FOR A CAPSIZE

With collision ruled out, the inspectors turned their attention to the detailed examination of the hull and its equipment to determine the cause of the sinking.

Evidence of a capsize was seen throughout the wreck.

The engine room floor plate, jammed between the main engine exhaust piping and the deckhead **(Figure 13)**, confirmed that *Solway Harvester* had capsized, probably to starboard. The locations of some of the batteries out of Nos 1 and 2 battery boxes on the port side provided similar confirmation. They were found to starboard and, in getting there, had not only crossed the full width of the engine room, but had also passed over the tops of the main and auxiliary engines.

There was further compelling evidence on the main deck to show that at some stage *Solway Harvester* had completely inverted. The hollow legs of the heavy shakers were not over the locating posts on the deck. This could only have occurred, without damaging all the posts, if the shakers had "fallen" off them.

Everywhere numerous heavy items of equipment, including a sword, spanners, nuts, bolts, springs and shackles and a screwdriver, were all found lodged between pipes and cables in the deckhead; again confirming the vessel had turned almost completely upside down.

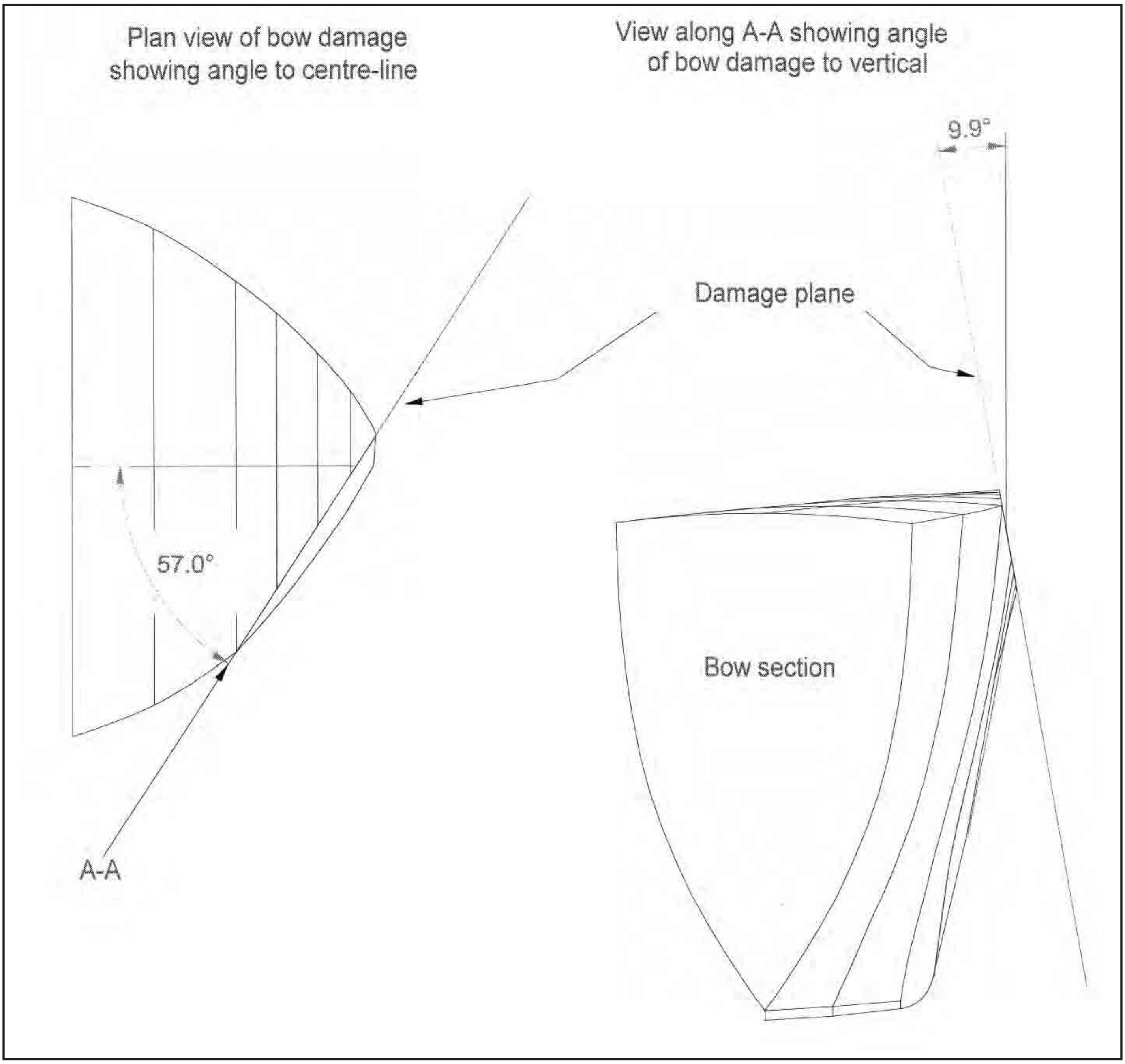
Finding the wreck lying fully on its starboard side, indicated the centre of gravity of the sinking vessel was substantially to starboard. This would have occurred only if the vessel had capsized to starboard causing all loose gear to shift to that side.

The MAIB concluded that there was abundant and compelling evidence to show that *Solway Harvester* capsized to starboard and had inverted before descending to the seabed.

Solway Harvester capsizing would also explain why the bodies of all the crew were found inside the wreck and why no distress message was sent. Capsizing is sudden, and once begun, rapid and unstoppable, giving anyone inside little chance of escape.

2.4 HULL AND MAST DAMAGE

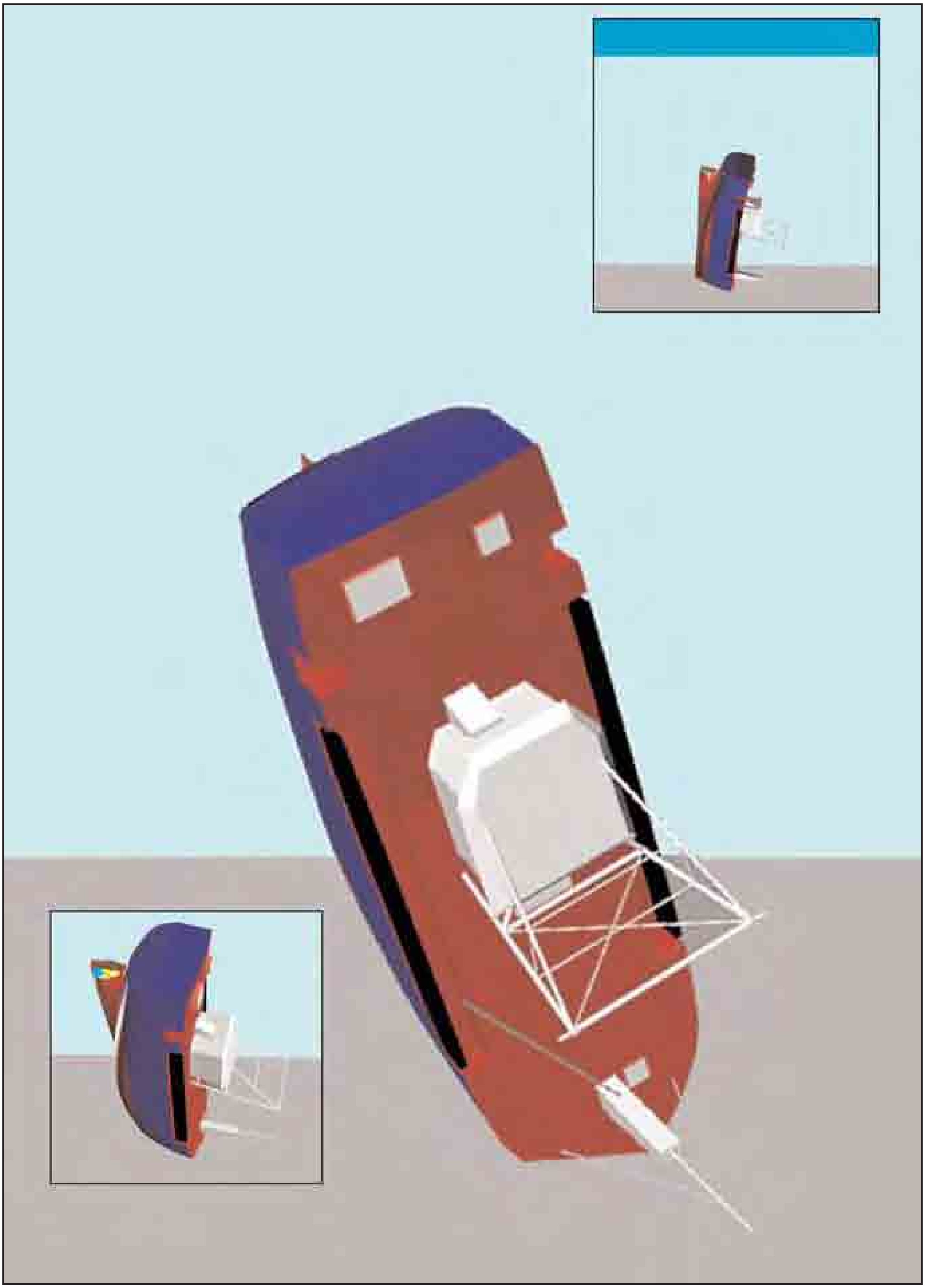
It was still necessary to determine what had caused the bow damage. Examination showed it was roughly a flat surface. Its orientation was about 57° to the wreck's centre-line in plan and sloping about 10° past the vertical **(Figure 25)**. Because the shaped steel of the bow had been flattened so conspicuously, the only viable explanation was that it had been caused by an impact with a flat surface. This, and knowing the damage had occurred after the vessel had



Orientation of the 'flat' bow damage

capsized, led the investigation to conclude that the only feature which could have caused it was the seabed, and that the damage occurred on impact, when *Solway Harvester* was in a near bow down attitude **(Figure 26)**. Supporting this conclusion was the total lack of evidence of a contact with any other steel vessel or object.

The positions of the four tipping bins indicated that she had sunk bow-first. All had hinges near the mid-length of the vessel. The aft bins, hinging forward, were completely extended but the forward bins, hinging aft, were only slightly so. This conclusion was supported by the discovery that the loose gear in the port deck store was pressed against the forward bulkhead, and that the aft liferaft had slipped from its lashings. This could only occur if the vessel had been nearly vertical.



The orientation of *Solway Harvester* as she hit the seabed

Also, in marked contrast to the obvious bow damage, there was a complete lack of any sinking damage to the transom, rudder or Kort nozzle.

There were two main reasons why the vessel sank by the bow:

- The first was that after the vessel capsized, the stow of bagged queenies in the fish room completely collapsed. The bags could only fall forward along the length of the starboard side of the fish room, which is where divers found them during the preparations for the recovery of the wreck. This substantial forward movement of weight would tend to lower the bow.

- Secondly, as the vessel floated on her starboard side with the bow slightly down because of the shift of cargo, the sea would have flooded into the forepeak space through the two 140mm diameter pipes attached to the starboard side of the foremast. As the bow sank further, other flooding routes into the engine room would have been immersed; such as the ventilation duct on the starboard side of the main deck, and the ventilation grille in the foremast.

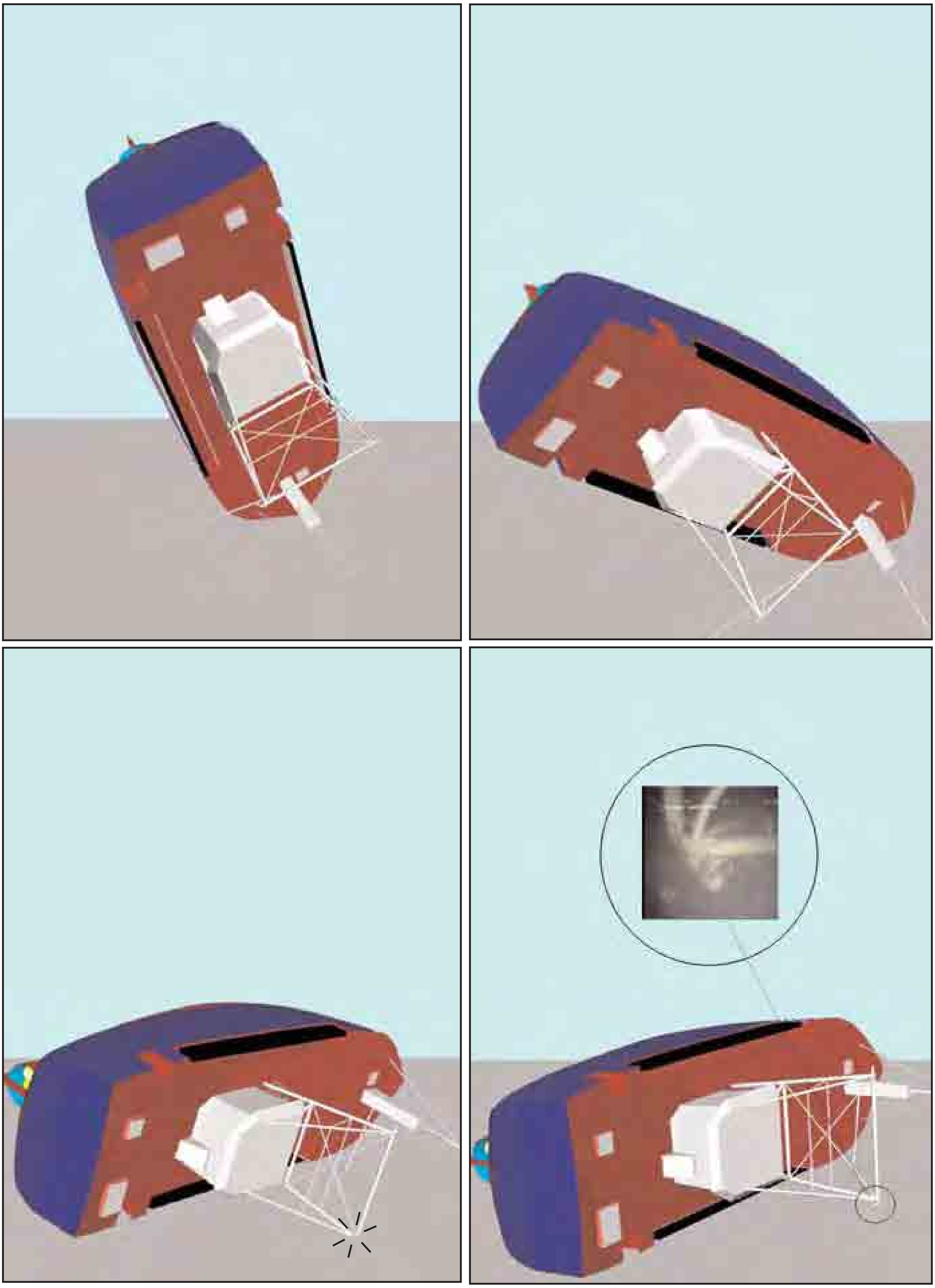
The only other part of the hull's structure to have been substantially damaged was the boundary of the forepeak ballast tank, which was set in all round. This crushing was caused by water pressure as the vessel sank. Very similar discoveries have been found by MAIB on other small fishing vessels which have sunk in water much the same depth.

Analysis of the damage, and its implications, showed the forepeak tank was not pressed full when subjected to high external water pressure. Since the tank was invariably kept full, some water probably drained out through the tank's air pipe before *Solway Harvester* sank, indicating that she floated for some minutes after capsizing. If the vessel then sank rapidly, allowing insufficient time for the tank to refill before the bow reached its crushing depth, the resultant damage would match that seen.

The aft ballast and fresh water tanks were not crushed. This was probably because of two factors: they were higher in the vessel and could not drain to the same extent as the forward tank. They were also smaller and relatively stronger.

It is concluded that *Solway Harvester* hit the seabed bow-first, just to starboard of her centre-line, inclined about 10° off the vertical with her deck facing the seabed **(Figure 25, 26, 27 and 28)**. As a result, the forward part of the shelter deck was buckled, canting the foremast aft. Following the initial impact, she fell on to her starboard side, buckling part of the gilson frame in the process **(Figure 27)**.

Figure 27



Solway Harvester coming to rest on the seabed

Figure 28

Comparison between the photographed bow damage and 3D model

2.5 CAPSIZING

From the last telephone calls Craig Mills made, it is known that *Solway Harvester* was making for shelter and was not fishing. All the evidence supports this assessment.

At the time of her loss, the position of the engine/gearbox control was upright, with the engine running, showing that the gearbox was in the neutral position, so the propeller shaft was de-clutched. *Solway Harvester*, therefore, was stopped and was drifting. Vessels of this design drift beam to sea when stopped in windy conditions, and this would have meant she was fully exposed to the wind and waves. In such a situation she would have been rolling heavily. The wind would have posed no danger, even with gusts of up to 40 knots, but steep seas, and most especially breaking waves, would have presented her with a potential problem.

Skippers of similar vessels, and former crew members, were interviewed to understand how *Solway Harvester* would have coped when drifting beam on to such seas. Without exception they expressed the opinion that she would have ridden the waves effortlessly and safely. The model tests and computer simulations confirmed this. *Solway Harvester* was shown to be a very good sea vessel, possessing a reserve of stability quite adequate to survive the conditions prevailing on 11 January 2000.

But the sea is unpredictable. Every now and then a group of breaking waves will appear substantially higher than the norm; very occasionally approaching twice the observed wave height. Nevertheless, the model tests and simulations showed that *Solway Harvester* should have survived such an encounter, although she could have rolled beyond 30° with the initial impact.

Considering a roll of this degree, prompted the investigation to look at its effect on the stow of bagged scallops in the fish room. Discussions with former crew members revealed that the stow did not run continuously from one side of the fish room to the other, but stopped either side of the bilge slush well. In other rows there was a dip in the centre to allow access to the slush well, and a preponderance of bags to port to counteract the vessel's in-built permanent list to starboard. A plan was drawn of the likely stow for the 208 bags of scallops on board *Solway Harvester* when she capsized **(Figure 3)**. This showed three unsupported areas, potential sites for bag movement if the roll exceeded 25° (see 1.22.4 Cargo movement tests).

Assuming that *Solway Harvester* was rolled 35° to starboard by a large wave on her port side, then the worst foreseeable movement of the cargo was levelling off involving about 50 bags in the stow **(Figure 29)**. This would have shifted the centre of gravity of the whole stow about 0.5m to starboard, causing the vessel to list 3°. On its own, this is insignificant. This analysis is supported by the experiences of the scallop fishermen interviewed during the investigation who collectively had over 100 man-years in the industry. Several recalled occasions when bags fell from the stack after a large roll, but this had never placed their vessels in any danger.

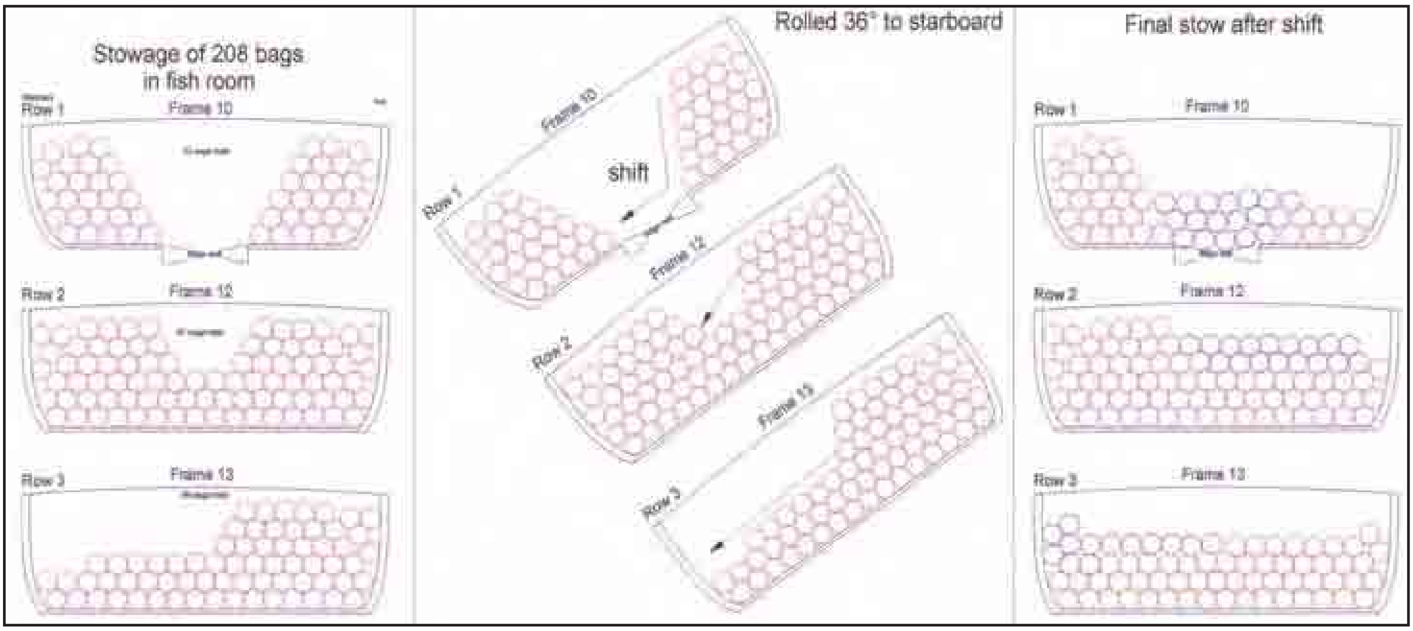
The investigation looked at the possibility that the 2.8 tonnes of unsecured spare dredges in the centre of the fish room could have moved and, if so, by how far. Again full-scale tests were carried out, showing that the gear could move if the roll exceeded 25° (see 1.22 Cargo movement tests). In a 35° roll the gear could move up to about 2m. Adding this to the effect of the cargo movement could give the vessel a steady list of about 6°, which, again, would not have caused the loss of the vessel.

The final possibility is that the last haul, or hauls, were not processed, but had been left in the tipping bins. The weight of the last haul(s), shellfish and debris is unknown; but it was probably between 1 and 2 tonnes in total. This would have further reduced the vessel's stability, but very slightly, and not enough to prevent her survival.

The failure to explain the capsizing led to the unavoidable conclusion that the actual stability of the vessel, when she capsized on 11 January 2000, was substantially less than that determined by the stability test on 2 August 2000 (see 1.18 Stability test); this test had been the basis for the calculations thus far.

The investigation looked for evidence that *Solway Harvester*'s stability had been impaired.

Figure 29



The worst foreseeable movement of scallop bags in the fish room

2.6 STABILITY

Two factors could have substantially reduced *Solway Harvester's* stability: a failure of watertight integrity, or loose water (free surface effect).

- **A failure of watertight integrity**

  The MCA assessed and approved *Solway Harvester*'s stability on the basis that, in the event of her heeling to 40°, no water could enter any space on board which contributed to her buoyancy and stability. These watertight spaces were well defined. They were the hull below the main deck, the forepeak space, the starboard passageway, the galley/mess area, the port deck store, and the poop containing the workshop and the shower/toilet spaces **(Figure 30A)**. The remainder of the volume enclosed within the shelter was non-watertight because of the freeing ports.

If water did manage to penetrate these watertight spaces then her stability would be degraded, or even destroyed.

Therefore, an examination was made to assess *Solway Harvester's* watertight integrity at the time of her loss.

The inspection of the wreck revealed that the crew had secured open the weathertight door to the aft workshop. The doors to the starboard passageway were open, but were unsecured. Unlike the passageway doors, which had to be tied back to keep them open, the workshop door's mid-height handle simply fitted over a retaining spigot. These doors should have been securely shut when the vessel was at sea, and usually were.

Anyone who has experienced the lively motions of a vessel at sea will appreciate that doors are not left free to swing; they are always secured in either the open or closed position. It is thought unlikely that once secured closed, even if only by the top clip, as was the usual practice on board, the starboard passageway doors would have opened during the sinking.

The conclusion reached was that someone had probably opened the doors, but had insufficient time to tie them back, or close them, after passing through at, or about, the time of the loss.

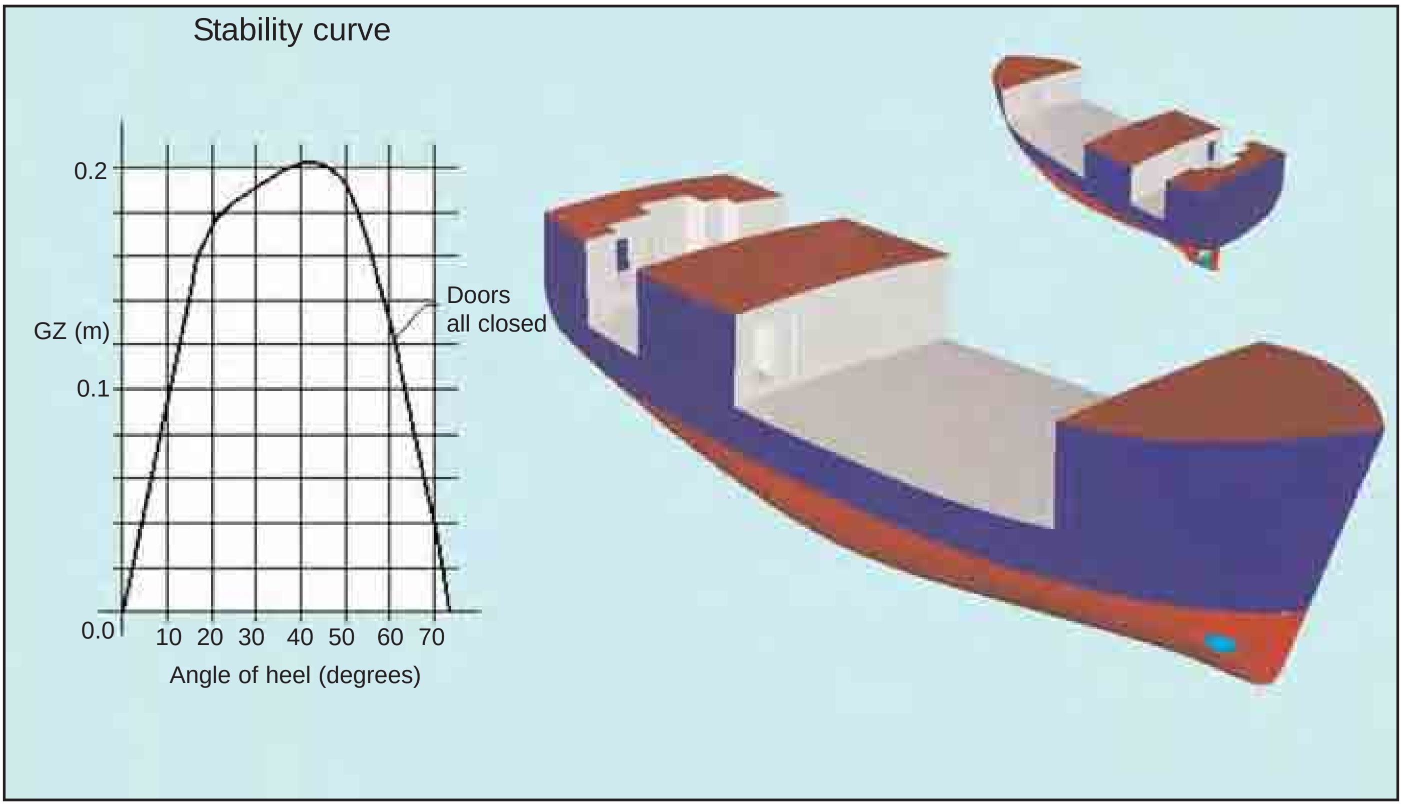
Each of these weathertight doors, if open, led to a loss of reserve buoyancy, and substantially reduced her resistance to capsizing **(Figure 30B)**. However, the results of the model tests and computer simulations with all three doors open, convinced the MAIB that the vessel would not have capsized unless some other factor was involved.

The investigation found two open ice scuttles on the main deck, which was a serious breach in *Solway Harvester*'s watertight integrity. These immersed if the vessel heeled beyond about 20°. The sea would then have had direct access to the fish room. Since there was no readily available means for closing them to make them watertight, the vessel no longer met the stability regulations.

However, although this defect was extremely serious the model tests showed that, even with the ice scuttles fully open, less than 1 tonne of seawater flooded into the fish room when the vessel was rolled by a group of large breaking waves. This extent of flooding to the fish room, even when combined with the earlier factors, was insufficient to cause capsizing in the prevailing conditions.

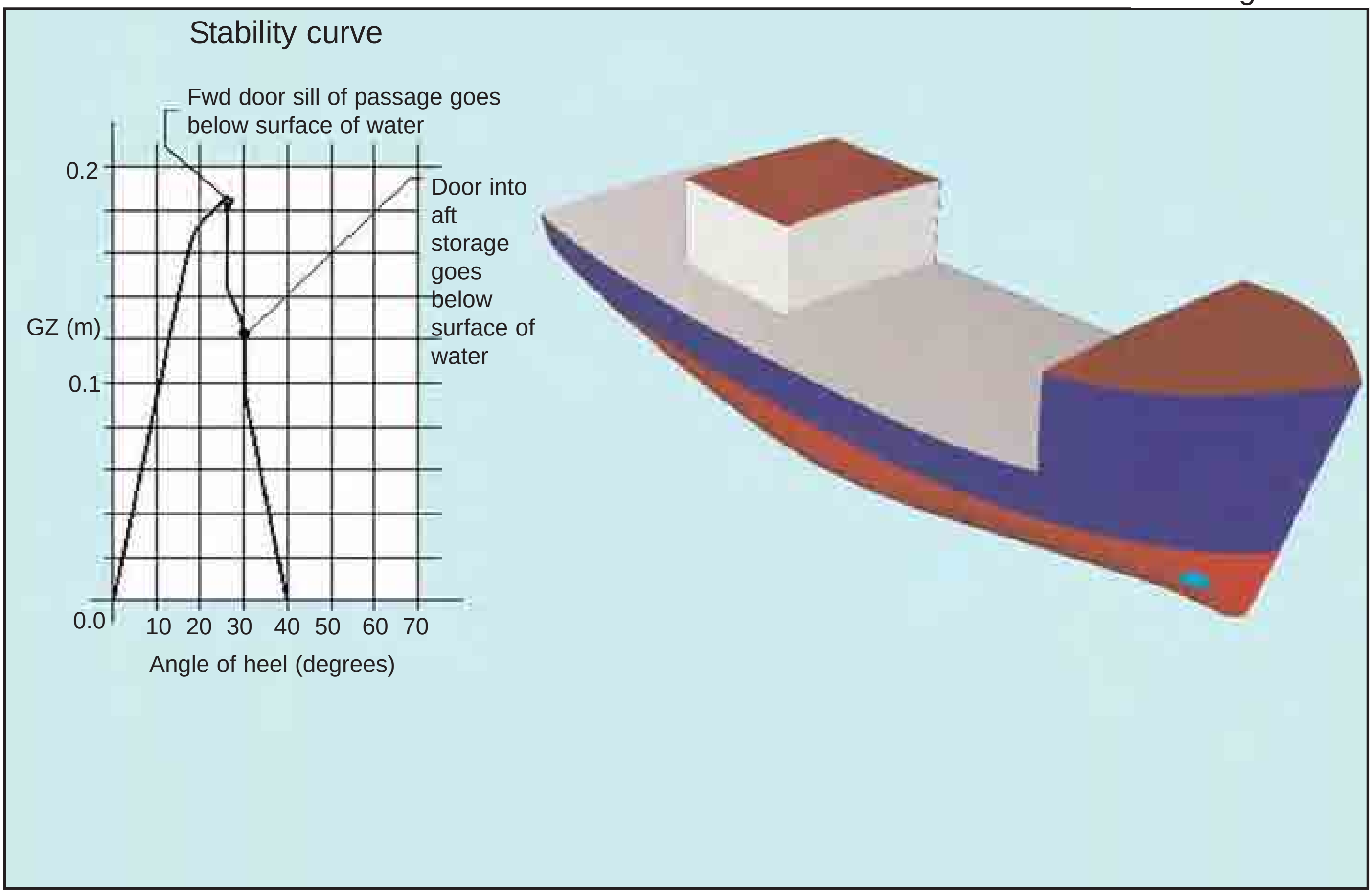
To generate the circumstances which led to *Solway Harvester* capsizing on 11 January, some other factor must have been present to reduce her stability to such an extent that she turned over.

Figure 30A



Buoyant spaces assumed in trim and stability book

Figure 30B



Effective buoyant spaces when heeling to starboard up to 40°

- **Loose water (free surface effect)**

  If there was a quantity of water somewhere on board with a large free surface, this could have been the fundamental cause of the capsize and the hidden factor which critically reduced her stability. The only two areas where a large free surface could conceivably develop were the main deck and the fish room.

  The simulation and model tests showed that the generously sized freeing ports on the main deck prevented a dangerous build up of water on the main deck in the prevailing sea conditions. Attention turned, therefore, to the fish room.

  Solway Harvester's fish room extended, unobstructed, across her full breadth and 40% of her length. The presence of even a relatively small depth of water in such a large space would have the ability to substantially reduce, or even destroy, the vessel's stability **(Figure 31)**.

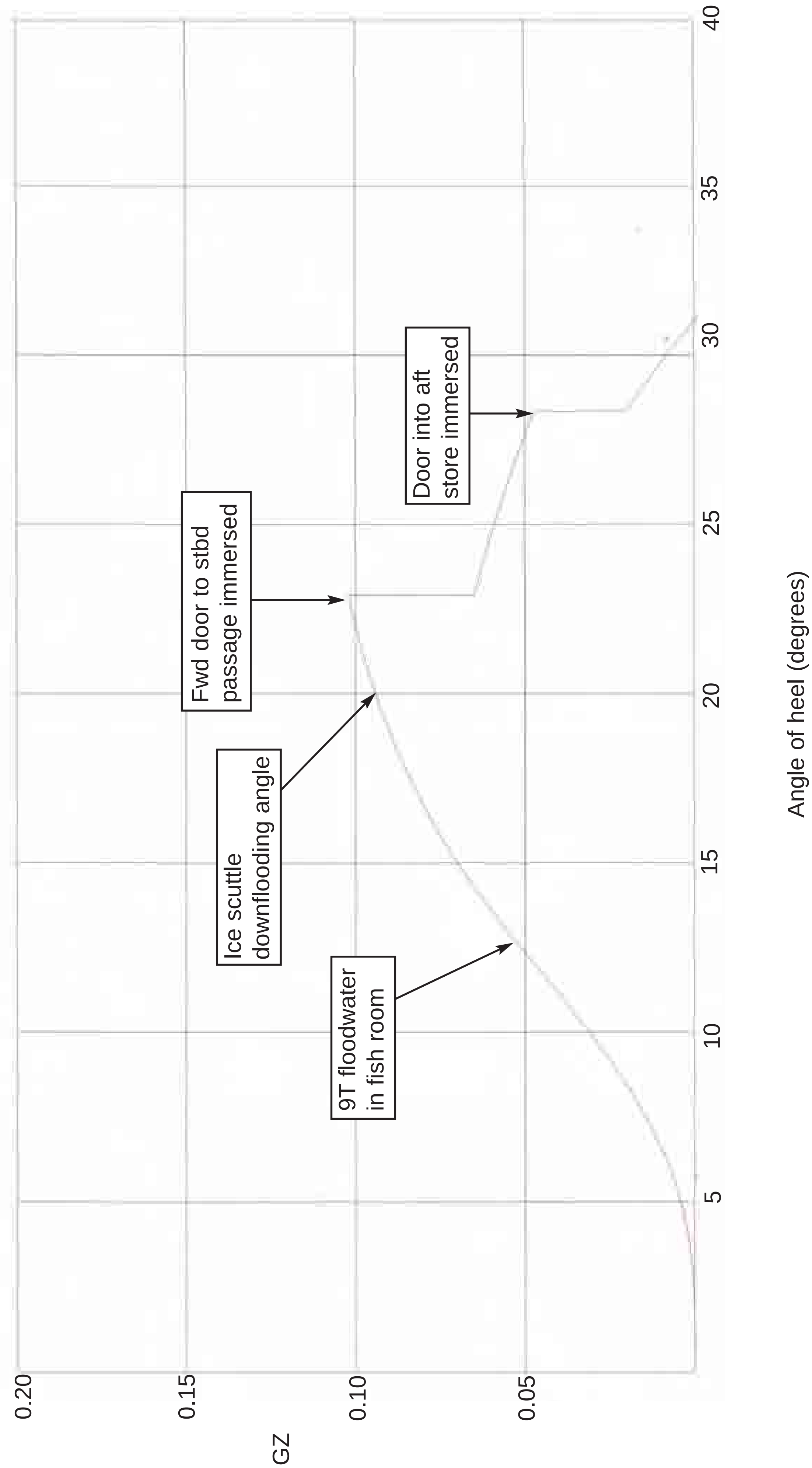
Investigations showed that about 230mm to 300mm of water at the aft end of the fish room (equivalent to between 6 and 9 tonnes) could have initiated the chain of events which led to the capsizing. Of all the configurations which the physical and computer models were subjected to, the only time they capsized was when the fish room was flooded. It became evident that, if such a quantity of water had somehow managed to penetrate the fish room, it could have led to the capsizing.

The MAIB had looked at all possible factors and had found that only if flooding of the fish room was involved did *Solway Harvester* lose sufficient stability to capsize. This, then, was believed to be the key to the vessel's loss. Other evidence also suggested that the fish room had flooded.

The model tests and simulations, consistently showed that as more water flooded the fish room, the less *Solway Harvester* would have rolled and the more comfortable she would have seemed.

During the last telephone conversation between *Solway Harvester's* skipper and his colleague on board *Tobrach-N* which ended at 1710, the former had commented that he was surprised how comfortable *Solway Harvester* was, considering the poor sea conditions. This is the only hint from the numerous telephone and radio calls made during the hour before *Solway Harvester* capsized, that something unusual might have been happening. What the skipper had described, very accurately reflected how his vessel would ride if its roll motion had been reduced in some way. The most plausible explanation for such a possibility was that the fish room was steadily flooding and acting as a roll-damping tank.

Figure 31



The effect of fish room flooding on stability

The skipper would have needed a very pressing reason to stop his vessel and allow her to drift beam on to the prevailing very rough sea conditions. Serious flooding to the fish room could have been this reason. Although there are other possible explanations for his action, there is no better evidence for any, and none fits all the known facts as well as this.

John Murphy's body was found in the fish room. As the acting cook on this trip he might have gone into the fish room to collect food for the evening meal. But if so, it doesn't explain satisfactorily why a red handled screwdriver, which was normally kept in the wheelhouse, was also found there. That screwdriver, with an adjustable spanner (which was not found), was normally used to unbolt the top of the bilge suction strainer when it required cleaning. It is possible that he went to the fish room to collect food and discovered the flooding and, after warning the skipper, returned with the screwdriver to see if he could clear the bilge strainer. Only two of the usual six bolts were in place, the others were not found.

If he had climbed down into a flooded fish room, the water could not have been deep near the base of the ladder. It would have only been about 100mm deep, barely covering the toes of his boots, if 9 tonnes of water had been present **(Figure 4)**. But 9 tonnes of water in the fish room was enough to lead to the vessel capsizing in those sea conditions.

2.7 FLOODING OF THE FISH ROOM

The investigation turned its attention to how the fish room might have flooded. The first question asked was whether there was any history of previous flooding. There was, twice. The first occasion had been in September 1997, the second occasion was just 3 weeks previous to the loss of the vessel.

There were other occasions when flooding of the fish room would have occurred but for the vigilance and prompt action of the crew. Often, at least once a month, the crew found the water level rising in the fish room slush well despite the continuous application of the bilge ejector. This was usually discovered sufficiently early, and before the bilge water spilled out of the well into the fish room. Occasionally, it spread slightly beyond the well, and buckets were used to remove the water to gain access to the bilge suction strainer. In December 1999, the rising bilge water was not discovered in time, and resulted in serious flooding of the fish room.

Eye witnesses to the fish room flooding, in December 1999, said it had been caused by water draining off the main deck through the gaps under the flanges of the picking tray pipes, with melting ice and water seepage from the catch contributing a small amount.

The examination of the hull around the fish room, and attached piping systems, showed they were watertight and leak free. There was no possibility of floodwater entering the fish room, other than through the known openings: the main hatch, its recessed access hatch and the ice scuttles. The main unloading hatch with its substantial coaming had been shut throughout, and the access hatch was sufficiently far off the deck not to be the first place where water might enter. This left the ice scuttles.

When the wreck was examined, both ice scuttles were open, and there was no evidence to either show, or suggest, they had been covered at any time. Only one cover was actually found on board and that was among the confusion of swords piled between the wash room and the starboard shaker. It had probably been stowed with the swords in the nearby pound. The other cover was never found and it was reported as having been lost overboard over two years before the accident. It had never been replaced.

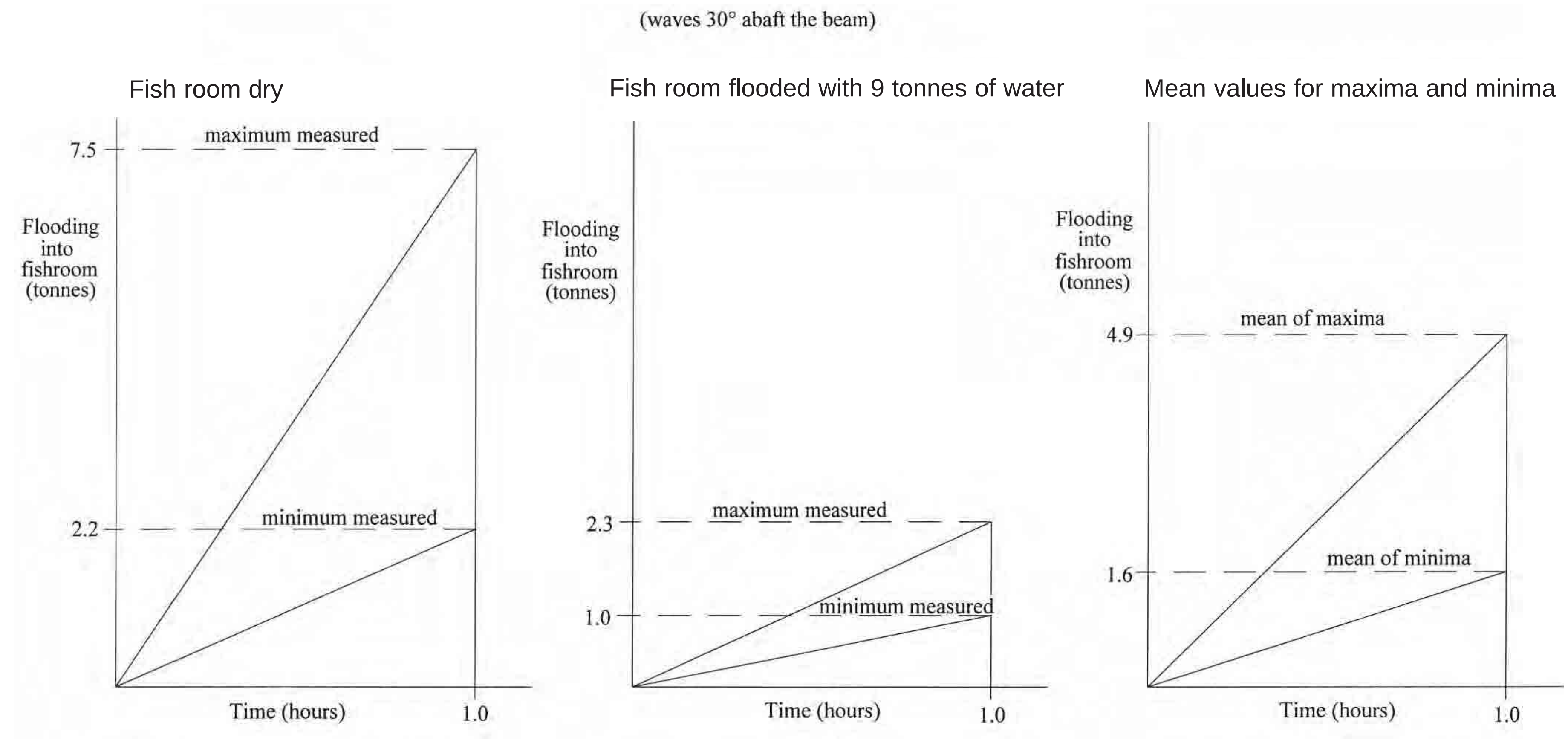
A detailed examination of the ice scuttles showed nothing to prevent water flooding into the fish room from the main deck, apart from the picking tray pipe flanges. These were not sealed to the deck, and the starboard one did not fit tightly.

Re-assembling the starboard shaker and picking tray showed a mean gap of about 15mm around the circumference of the flange **(Figure 9)**, which the MAIB believes was very close to that present on the vessel when she was lost (see Section 1.22.1). Legs on the port shaker had broken off, preventing it from being returned to its original position, so the gap under the port picking tray could not be reconstructed. However, former members of the vessel's crew confirmed that the gaps under both picking trays were similar when the vessel was in service.

Full-size downflooding tests on the wreck showed that water could drain off the deck into the fish room, through the gap under the starboard picking tray flange, at rates of up to 36 tonnes/hr (72 tonnes/hr for both scuttles), before the picking tray flange was immersed impeding the flow. Rates of over 55 tonnes/hr (110 tonnes/hr for both scuttles) were possible with the picking tray in place. But while these tests gave an indication of the ease with which water could drain off the deck into the fish room, they could not replicate the intermittent flow of water surging through the forward freeing ports on to the deck near the ice scuttles. This was investigated at model scale, and by video recordings taken on board the sister vessel *Tobrach-N*.

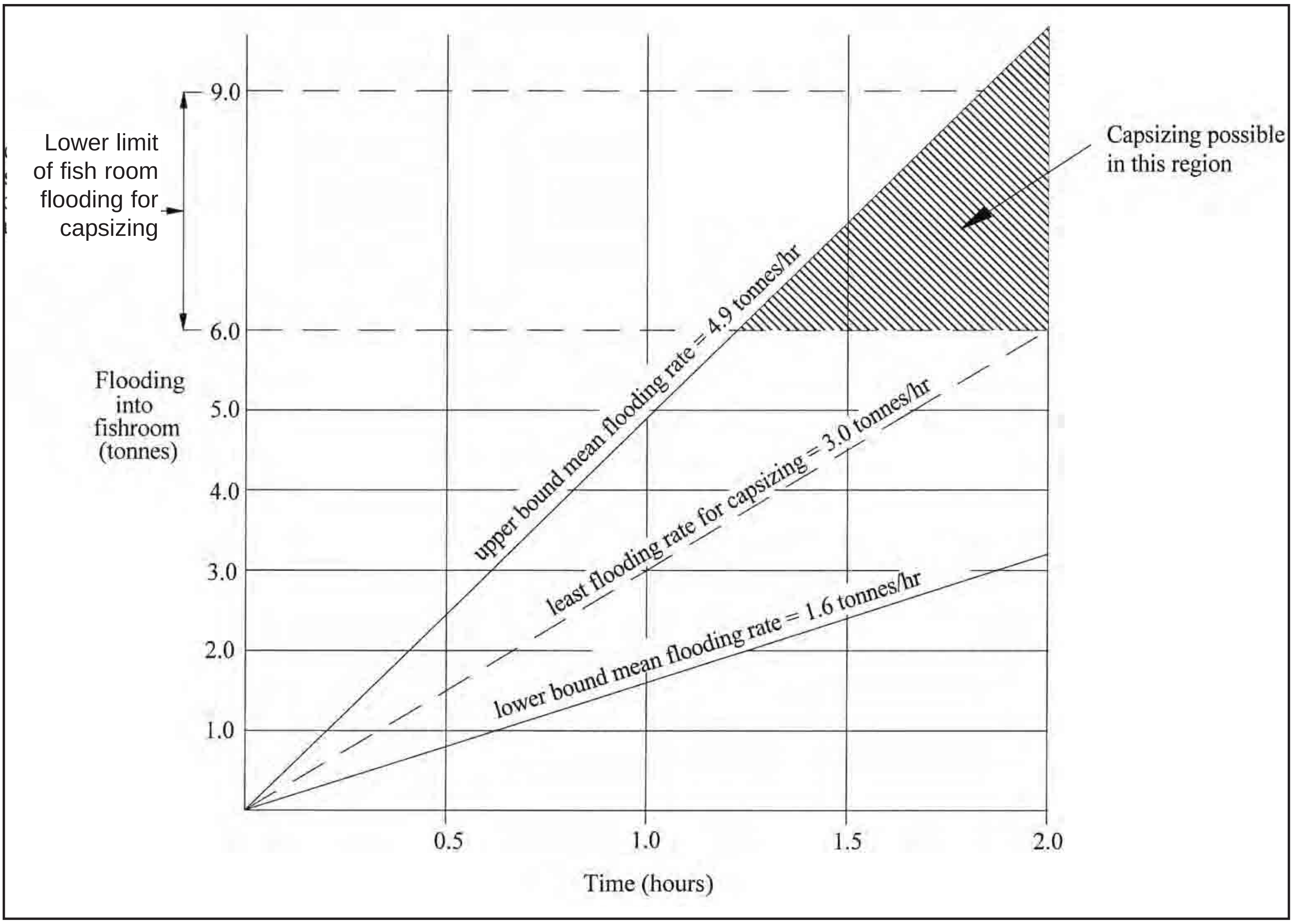
The model tests showed that water spilled infrequently and randomly on to the main deck near the ice scuttles, and could not be predicted. It was further complicated because the rate of water spilled on to the deck reduced as the flooding of the fish room increased, and caused the vessel's rolling to decrease. By repeating the tests a number of times, mean values and the likely range of values were derived **(see Figures 32 and 33)**. This data indicated that flooding of the fish room by water spilling on to the main deck from the sea, and draining through the ice scuttles, could possibly have led to the capsizing, if it had continued undetected for at least 1¼ hours. However, the model tests were carried out with the ice scuttles fully open and the picking trays removed; the likely effect of the picking trays on these results was then assessed.

Figure 32



Flooding rates through ice scuttle openings measured in model tests

Figure 33



Flooding of the fish room - equating possible flooding rates and time frames

This assessment required an estimate of the likely maximum flow rates through the ice scuttles. Since the windward and leeward ice scuttles were seen to be immersed only 6% and 3% of the time, the water actually flowed into the fish room over a total time of only 3.6 and 1.8 minutes per hour for the windward and leeward ice scuttles respectively. Thus, the maximum flow rate was substantially greater than the calculated hourly average flow rates. Using these figures, it was estimated that the likely maximum flow rates at one ice scuttle were approximately 33 tonnes/hr if the mean flooding rate to the fish room was 3 tonnes/hr, and 54 tonnes/hr if the mean was 4.9 tonnes/hr. The full-size downflooding tests showed that these rates were within the discharge capacity of the gap between the starboard picking tray flange and the ice scuttle ring. It was concluded that the presence of the picking trays would not have made a substantial difference to the rate of flooding of the fish room from water spilling on to the main deck from the sea.

The analysis of the model and full-size test results indicated that up to about 4.9 tonnes of water per hour (equivalent to a bucketful of water every 16 seconds down both ice scuttles) could have drained off the main deck into the fish room in the prevailing sea conditions. So for the critical 6 to 9 tonnes of water to accumulate in the fish room, the flooding would have to pass unnoticed for at least 1¼ hours. The investigation had to consider whether this was possible.

Without witnesses to provide an answer, it became necessary to establish the most likely time when somebody last inspected the fish room.

Solway Harvester hauled her last catch at 1530 and the crew might have processed it immediately. If so, the fish room would have been unoccupied from about 1615, approximately 1½ hours before she capsized.

If the catch was not processed, but had been stored in the tipping bins with the intention of leaving it there until the vessel reached the shelter of Ramsey Bay, the last time anyone would have visited the fish room was when they were bagging the previous haul. In this case, the fish room would have been unoccupied from about 1515, or about 2½ hours before she capsized.

It is difficult to know which procedure was followed. When the vessel inverted, anything in the tipping bins was scattered over the seabed, which explains why the tipping bins were found empty. The scallop shell debris found lying on the port wheelhouse windows could have come from the dredges draped over the wheelhouse top.

The starboard shaker was found containing queenie shells weighing about 640kg, or the equivalent of about 19 bags of full shells. It is impossible to say whether this was part of an unprocessed catch, or the debris left by the salvage divers when they cleared the fish room. The MAIB believes it was probably the latter. Nineteen bags of queenies, from part of one haul on one side, was far more than the average 3 bags per haul per side the vessel had been catching in her first 24 hours.

One of *Solway Harvester*'s former crew interpreted the expression "battened down", used by the skipper in his telephone conversation with Deeside Marine's works manager, to indicate that the last catch had been processed, and that all the work was finished. Perhaps Martin Milligan, whose body was found wearing waterproof trousers and bib, had been tidying up the main deck after the last catch had been processed and bagged.

Others thought the skipper would have waited until he reached sheltered water before processing the catch. The mate felt that, because the sliding blocks on the outriggers were not tied back to prevent them from banging, it was probable the catch had not been processed and was left in the tipping bins. Once fishing operations stopped, it was the usual practice, in bad weather, to fit the remaining cover over the windward (most exposed) scuttle. On this occasion it was not. It will never be known why, but it might indicate that fishing operations were not quite over, or that the shellfish in the tipping bins were to be put through later. The job would be completed once the vessel reached the shelter of Ramsey Bay and the scuttle cover replaced.

Although it is impossible to say what happened on 11 January, regarding processing or not processing the catch, it had little bearing on the final outcome. No matter which of the two actually happened, there was sufficient time for at least 6 to 9 tonnes of water to flood into the fish room, and remain there if there was no means of pumping it out.

The MAIB also considered the possibility that *Solway Harvester*'s fish room flooded in the same way as a previous incident reported by *Tobrach-N* when the deck wash hose had been left discharging into one of the loading hatches. On *Solway Harvester*, because of the gaps between the picking trays and the deck, the hose would not necessarily have had to discharge directly down the picking trays. It could have had a similarly dangerous effect if left discharging across the deck towards one of the open ice scuttles. The output from the deck wash hose was measured at 15.8 tonnes/hr on the wreck, so it needed only a small proportion of this flow to have caused a substantial quantity of water to accumulate in the fish room in 1½ to 2 hours.

The deck wash hose was used at the end of a trip for flushing debris from the shakers and picking trays. It could, therefore, have been in use immediately before the crew turned in. Martin Milligan might have been using it later, if he had stayed on deck tidying up after the other five turned in. It is not known.

Although the valve to the deck wash hose was found shut off when the wreck was inspected, it would be most unlikely to have been found open. Had anyone discovered this to be the source of the flooding in the minutes before the accident, it must be assumed they would have done something about it and turned it off immediately.

Although it is possible that the deck wash hose could have contributed to the flooding, this is considered unlikely because the usual practice was to turn the deck wash valve off after use. If Martin Milligan, described as an intelligent and conscientious young man, was about on the main deck, the possibility of the deck wash hose contributing to the flooding was even more remote.

The model and full size tests demonstrated that the fish room could have flooded in the prevailing conditions simply from water draining off the main deck through gaps between the picking tray flanges and the ice scuttles. It had done so on an earlier occasion. If, in addition to this source of flooding, there was also water coming from the deck wash hose, the MAIB believes that *Solway Harvester* would have got into difficulties earlier.

From all the evidence examined, the investigation concluded that the fish room flooded from water draining off the main deck and through the ice scuttles. The time taken is uncertain, but was probably between about 1½ and 2 hours. This matches the time she was on passage heading towards shelter.

2.8 BILGE ALARMS

Whatever means would have been available to detect flooding, the one system that was specifically designed, and installed, to detect it, was the fish room bilge alarm. But it was not available. The cable to the fish room bilge alarm float switch had been severed. *Solway Harvester* sailed on her last voyage without a functioning fish room bilge alarm, relying upon the bilge ejector, drawing water continuously from the fish room slush well, to keep the fish room dry.

Bilge alarms provide early warning of rising bilge water. The warning should allow people sufficient time to tackle any flooding before it gets out of hand or, if it becomes impossible to contain, to abandon ship. Bilge alarm sensors should be fitted to any space frequently unoccupied, where undetected flooding could threaten the safety of the vessel.

Even though it was not a statutory requirement, after *Tobrach-N*'s fish room flooded on 23 April 1998, the owner fitted bilge alarms on her. He also fitted one in the fish room of *Solway Harvester*. The flooding on *Tobrach-N* had been discovered when the vessel heeled heavily as the scallop gear was hauled on board at the end of a tow. At the time, it was estimated that floodwater reached a depth of 450mm at the aft bulkhead of the fish room, but reduced to nothing at the forward end.

The coastguard was alerted, a rescue helicopter flew out a salvage pump and an RNLI lifeboat stood by her. *Tobrach-N*'s crew assembled on the open deck in their lifejackets and one of her liferafts was launched and inflated. She was pumped dry and *Solway Harvester* escorted her back to Kirkcudbright. Weather conditions were good with winds easterly force 4 and sea state 2 (waves 0.3 - 0.6 metres high).

The source of the flooding was thought to be the deck wash hose which had been left running inside one of the hatches above the hoppers in the fish room. No leaks or other explanation were found.

The accident was reported to the MAIB. The MAIB was satisfied that the actions taken by the owner and skipper of *Tobrach-N*, that is to fit a bilge alarm in the fish room and to carry a portable emergency salvage pump, would help to prevent a recurrence.

Had *Solway Harvester*'s fish room bilge alarm sensor been working, her skipper would have been alerted to the rising bilge water before it overflowed from the slush well. Given this timely warning, it is highly likely the accident would have been averted. There would have been ample time to empty the bilge well and ensure her stability remained safe. Even if the bilge pumping/ejector system had been ineffective, there would have been time to radio for help or, at worst, prepare the crew to abandon ship.

The bilge alarm sensor in the fish room was inoperable when *Solway Harvester* began her final trip, and her skipper knew it. But he might also have known that the *Fishing Vessels (Safety Provisions) Regulations 1975* only required a working bilge alarm sensor to be fitted in the engine room. *Solway Harvester* complied with the regulations so, in terms of the prescriptive regulations, there was no legal impediment to his taking his vessel to sea with the bilge alarm sensor in the fish room not functioning.

Flooding of the fish room was a known hazard in *Solway Harvester*, and the skipper relied on the continuous operation of the bilge pump to maintain a dry fish room. Frequently on the previous trip he visited the fish room with a torch, and there is every reason to believe he was checking the level of bilge water in the slush well. Clearly, the level of bilge water in the fish room needed constant monitoring.

On 22 December 1999, the skipper asked an electrician to inspect the bilge alarm. He did so, and said a new sensor with its moulded cable was required. It can be assumed that had a new sensor been readily available, it would have been fitted. They cost less than £50 but tend to be vulnerable to damage, and often require replacement. The argument for holding a spare is compelling. As a result of this investigation, the MAIB has made a safety recommendation to the owners of fishing vessels on revising their stores policy (see Section 5.3).

2.9 BILGE PUMPING SYSTEM

Solway Harvester's bilge pumping system was based on a main engine-driven Jabsco pump, and an auxiliary engine-driven Jabsco pump. Although the pumps could run simultaneously, shared pipelines meant that only one could supply the ejector. Either of these pumps could also be used without the ejector, as independent bilge pumps, but not at the same time. If both bilge pumps were out of action then one of the two Desmi pumps, used only in conjunction with the ejector, could act as the bilge pump. It was also possible to supply the ejector simultaneously from both Desmi pumps and one of the Jabsco pumps. However, at the time of the accident, the number of operable pumps had been reduced to two: the port Desmi and the auxiliary engine Jabsco pump.

Tests showed that the damage to the port Desmi reduced its performance by about 30%. The loss in performance of this pump would have occurred gradually and been difficult to detect as long as it could still “power” the ejector. Because of this, it probably passed unnoticed by the skipper and, unless it was drawn to his attention, the owner would have been unaware of it.

Such an arrangement still met the safety regulation calling for two pumps with independent power sources. However, tests on the bilge ejector, when powered by the port Desmi pump, showed that the maximum output attainable was 80 litres/min (4.9 tonnes/hr) (see Section 1.22.3). This was substantially below the 150 litres/min (9.2 tonnes/hr) attributed to the pump/ejector combination in MCA records (Form FV 2). But together with the auxiliary Jabsco (rated at 280 litres/min for direct bilge pumping) the available bilge pumping capacity during the vessel's final trip still complied with the requirements of the *Fishing Vessels (Safety Provisions) Rules 1975*.   These rules state that a vessel of *Solway Harvester*'s size must have "not less than two bilge pumps … having a total capacity of not less than 275 litres per minute. At least one such pump shall be a power pump having a capacity of not less than 140 litres per minute … where two power pumps are provided, each pump shall be independently driven".

During the trial, Deemster Moran QC said, *As a matter of law, it would appear that the regulations do not specify the capacity of both pumps, but only one of them as a minimum. Therefore, if that one pump exceeds the minimum by a margin which brings it close to the required combined capacity, it may be the case that the regulations are fulfilled with a second pump that is next to useless, in terms of emptying a bilge. … It [is a] rather startling realisation that the regulation, if it is intended to build in a spare pump of useful capacity, completely fails to do so*."

At the time of the accident, the port Desmi was believed to have been acting as the bilge pump. However, the "as found" setting of the bilge system valve LP7 (see Section 1.16) meant that the ejector was not discharging any bilge water. The setting of valve TP1 showed that the auxiliary Jabsco was not pumping the fish room bilge directly; also it could not because the electric clutch to the pump was switched off.

However, it is reasonable to assume that until *Solway Harvester* was stopped, the port Desmi was being used with the ejector to pump the fish room bilge. Since it ran continuously while the main engine was running, the bilge water in the slush well should have been drained constantly.

The survey of the wreck found no blockage in the bilge system capable of reducing the suction from the fish room slush well. Although the bilge suction strainer in the fish room was 50% blocked, the strainer's generous size still allowed the ejector to draw bilge water from the slush well at an undiminished rate.

Usually, during fish room flooding incidents, loose debris is caught up in the swirling water and drawn into the open end of the bilge suction pipe to block it. But this had not happened on *Solway Harvester*, indicating that the bilge ejector suction from the slush well was probably either very weak, or completely absent when the fish room was flooding.

It is possible a scallop shell was drawn against the bilge suction, cutting-off the flow of water completely. Had this happened, it would have dropped off as soon as the pump stopped, and would have left no evidence for those investigating the cause of the accident. Although such an event was technically possible, the investigation looked for a more tangible explanation for the bilge system's apparent ineffectiveness.

The effectiveness of the bilge pumping system depended upon the suction from the ejector, which in turn depended on the rate at which the port Desmi pumped water directly through the jet of the ejector. This rate depended on the number of outlets in use on the discharge side of the pump. On *Solway Harvester's* last trip, the port Desmi pump not only supplied the ejector for bilge pumping, but also outlets to each tipping bin and one outlet to each shaker. It also supplied the deck wash hose when required.

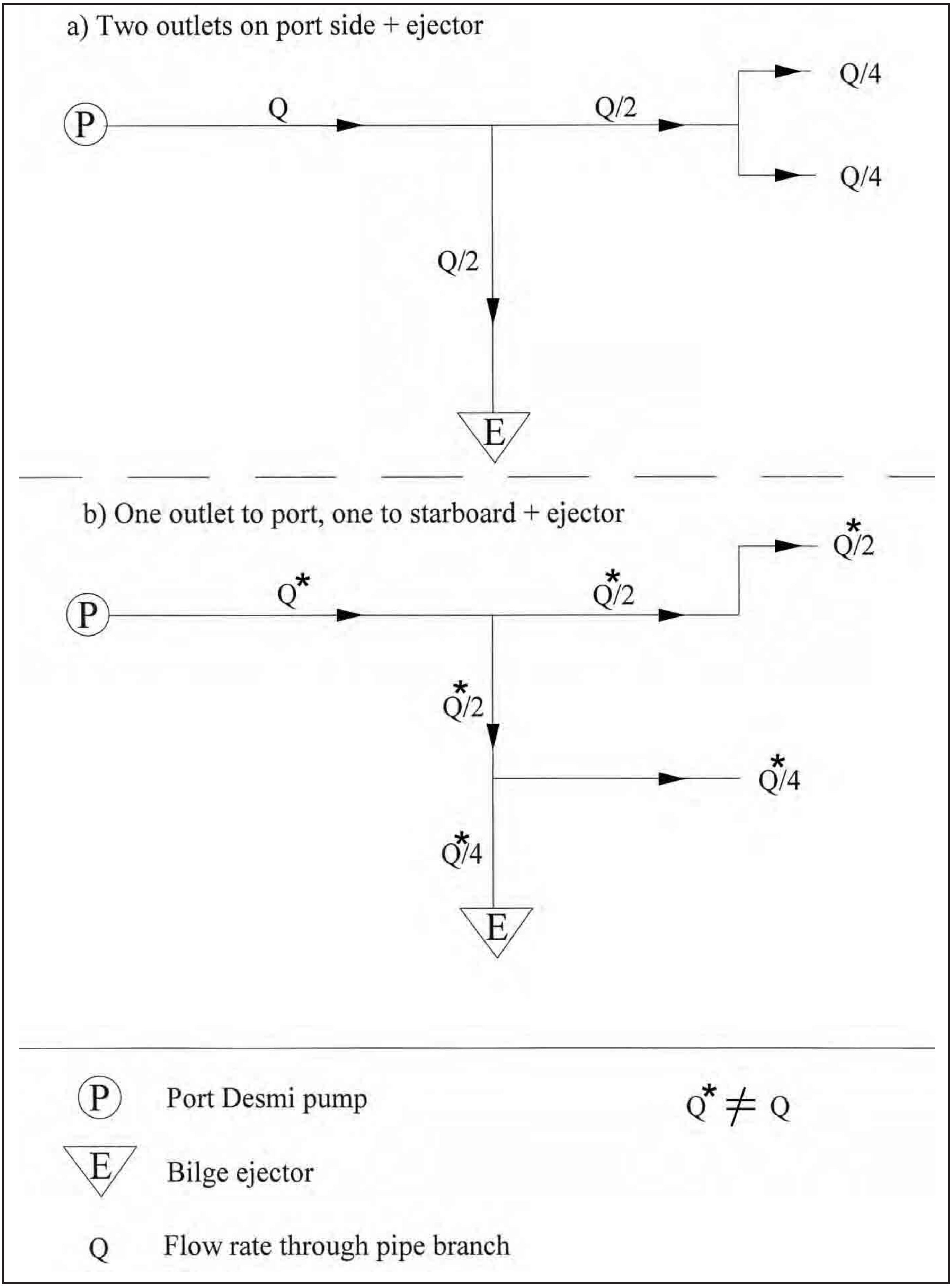
Tests showed that when the port Desmi pump was supplying one, or more, tipping bins and both shakers, the discharge from the slush well in the fish room reduced to nothing.

It was common practice on *Solway Harvester* for the water supplies to the tipping bins and shakers to be left on when fishing stopped. So, when the main engine was running, water was supplying the tipping bins and shakers from where it drained overboard. However, because of the demand on the pump, the discharge from the slush well in the fish room would have ceased. This was probably the situation on 11 January as *Solway Harvester* made her way to Ramsey Bay, and would explain why the continuously running bilge pumping system did not stop the fish room flooding.

However, when the wreck was surveyed, all but one of the shaker and tipping bin supply valves were found closed. This seemed unusual. It was expected that all would be open or all shut. There was no operational need to keep one open. It was unlikely to have been overlooked as it was close to others which were shut. There are two possible hypotheses: Firstly, the valves had been closed in a hurry to increase the rate of discharge from the ejector, but the person trying to shut them was interrupted.

Secondly, both after valves had deliberately been left open (the starboard valve was found by MAIB to have been defective and open (1.22.3). Regardless of the reasons, the port Desmi pump would have been supplying two outlets, one on each side. This was likely to have been more demanding on the pump than supplying two outlets on the same side **(Figure 34)** which, tests showed, reduced the discharge from the bilge well to 1.6 tonnes/hr. In this circumstance, the discharge from the bilge well would probably have been negligible.

It is concluded that, because the port Desmi pump was supplying other outlets, in addition to the bilge ejector, the discharge rate from the slush well was negligible. This meant that instead of the water being pumped out as it should, had the full suction been available, nothing was happening and the fish room was steadily filling.



Comparison of flow into ejector’s jet

2.10 PREVIOUS FLOODING INCIDENTS

Before final conclusions could be drawn about what probably happened, the previous incidents of flooding on board *Solway Harvester* were reviewed, to find out why she capsized on this occasion, but had remained upright previously.

On at least two previous occasions, *Solway Harvester*'s fish room had flooded because water had drained off the main deck through the open ice scuttles. On neither occasion had she capsized. It is possible there was less water present. It would have been very difficult to estimate the quantities involved with the water surging back and forth and from side to side. Although witnesses described the level at the aft end as 0.3 metres, the estimate should be used with caution. Nonetheless, taken at face value, it indicates that 9 tonnes of water was present.

Evidence shows that on the two previous occasions *Solway Harvester* kept making way, and the skipper remained in the wheelhouse in control of the vessel while the mate sorted out the flooding. At least once she had been heading into the waves. Although she would have been both pitching and rolling, she would not have been rolling as heavily as when lying stopped on 11 January.

Once the way has come off, a vessel will lie beam to sea. *Solway Harvester* would have done likewise, and given the conditions prevailing on the evening of 11 January 2000, with a gale blowing and the wind against tide effects, the seas were steep and breaking. Since she had been heading in a northerly direction, it is almost certain the weather would have been on her port side. Thus when she was lost, *Solway Harvester* was lying stopped, port beam to the weather, in short steep breaking seas.

2.11 EFFECTS OF WEATHER

As the way came off, *Solway Harvester* would have turned slightly to put the weather on her beam, and there can be no doubt she would have started to roll very heavily. The model tests and computer simulations have shown that in such a condition, an encounter with a group of large breaking waves could have rolled her beyond 30° to starboard. The MAIB believes this was sufficient, with the vessel's stability reduced by flooding of the fish room, to initiate the chain of events leading to her capsize and sinking.

It is concluded that flooding of the fish room critically reduced *Solway Harvester*'s stability so that she capsized in the prevailing conditions.

2.12 A RECONSTRUCTION OF THE LIKELY EVENTS LEADING UP TO THE ACCIDENT

It is possible to produce a reconstruction of the likely events immediately preceding the loss of the vessel, although some of the detail is necessarily speculative.

Solway Harvester's skipper finished the last of a series of calls on the vessel's mobile telephone and VHF radio at 1729. He was in the wheelhouse chair monitoring the vessel's passage to Ramsey Bay some 12 miles away. At least four of the crew were in their bunks in the aft cabin, and possibly one or both of the others were up and about elsewhere.

A few minutes later the skipper became aware that something was not right. Perhaps it was the vessel's subdued motion, or he noticed a list had developed, or he had been alerted to a problem by one of the crew. There is no means of telling precisely what induced the skipper to leave the wheelhouse, but there is no disputing that he did. He probably left because something, or someone, alerted him to flooding in the fish room.

Before leaving the wheelhouse he pulled the throttle/gear lever back to the neutral position, and moved the throttle lever to maintain the engine speed at about 1400 rpm. This should have ensured the bilge pump and generators continued to run to capacity. He also turned on the exterior floodlights to illuminate the vessel to warn other shipping; they would normally have been switched off while underway. He turned off the autopilot to stop unnecessary rudder movement.

As the way came off, *Solway Harvester* came beam on to the sea with the wind and waves on her port beam. She started to roll more heavily. The skipper was no doubt uneasy at leaving the vessel in this vulnerable position in the prevailing weather, but he had nobody else on board with sufficient experience either to sort out the flooding, or to handle the vessel in the very rough conditions.

Making his way forward he would have seen a substantial quantity of water surging from side to side in the fish room.

It is likely he would have wondered why the bilge pump, set to continuously pump the fish room slush well, wasn't working as it should. He would have set about checking the system. The easiest way to check if the ejector was clear would have been to see that there was water flowing through it. He probably went back into the wheelhouse to pick up a torch, and then walked across the top of the shelter to look over the starboard side by the foremast at the discharge.

He might have suspected that the bilge suction was blocked in the fish room, but since the strainer was underwater he could not verify this. John Murphy was found inside the fish room. The red handled screwdriver normally kept in the wheelhouse was found in the fish room. As the screwdriver was normally used to remove the strainer cover, he might have been in the fish room trying to clear the submerged bilge suction strainer.

At some point the skipper was in the engine room. Possibly he used the fore-deck hatch to get there; it was later found open. It is not known what he was trying to do in the engine room, but it is known that it involved taking local control of the engine speed by lifting the governor control lever on the main engine, and rotating it through 180°. This was the position in which it was found, and it was unlikely that anyone else on board would have known how to do it.

The orientation of valves LP7, LP6, LP5 and LP4 **(Figure 7)** might indicate that he had begun to align the auxiliary bilge pump with the fish room suction. He did not finish the task as valves TP1, LP2, LV1 and OB1 still had to be set **(Figure 7)**, and the clutch to the auxiliary pump was disengaged. He had returned to the main deck before *Solway Harvester* capsized.

The doors to the starboard passageway and the workshop had been opened, possibly to get something from the workshop.

Probably in an attempt to increase the ejector's suction capacity further, someone appears to have closed the valves supplying water to the starboard shaker, starboard tipping bins, the port shaker and port forward tipping bin. These valves were normally open at sea. The valve to the aft port tipping bin was found open when inspected after the accident, suggesting that there had not been enough time to complete the process.

It is likely that the beam seas rolled *Solway Harvester* to a very large angle, probably 30° to 40°. This caused some cargo, and the spare gear in the fish room, to slide to starboard. *Solway Harvester* would have recovered to a list of about 20° to 25°, but was prevented from coming further upright by the movement of cargo and spare gear to starboard, the water trapped in the starboard passageway, and water retained on the main deck.

Water would have continued to flood into the starboard passageway and the aft workshop through the open weathertight doors.

The starboard ice scuttle was submerged, causing massive additional flooding to the fish room and eroding the vessel's stability still further.

The flooding would have continued until all positive buoyancy had been destroyed, and she sank.

2.13 SAFETY ISSUES - GENERAL

No accident is the result of a single event. It is caused by several things coming together to create the circumstances that lead to it happening. Most problems can be predicted and, to prevent anything going wrong, a number of measures can be taken. In this case, these include the integrity of the design and construction, the regulatory framework, surveys and inspections, safety management, the training and competence of everyone on board and the general operating standards. Each issue makes a contribution to safety and acts as a defence, but, if they all fail, the accident occurs.

It is the MAIB's task to identify these defences and, so far as it is possible, to explain why they failed. If it identifies something that is missing and needs to be introduced to prevent something similar happening again, it will make a suitable recommendation.

Many of the causal factors in an accident, such as seen with the loss of *Solway Harvester*, might have been in place for some time and either nobody had noticed, or they had, but failed to realise the significance and had done nothing about it. Once again, the reasons for any such failure must be explained. Unless the reasons for a failure are understood, it is very likely the same thing will happen again.

The MAIB started this process by examining the design of *Solway Harvester*.

2.14 DESIGN ISSUES

The MAIB investigation showed that *Solway Harvester*, and similarly designed vessels built for the south-west Scotland scallop fishery, were potentially safe and seaworthy vessels. It found, however, that critical aspects of *Solway Harvester*'s design, and later modifications, were questionable. These included the ice scuttles, the accessibility of the fish room bilge strainer, and the addition of watertight bulkheads to improve stability. There was also concern about the size of the fish room, and the consequence on stability of flooding.

2.14.1 The ice scuttles

One critical design decision was to install ice scuttles for passing the shellfish meat from the shell remover on the main deck into the fish room. When she was first built the meat passed through the port ice scuttle; the starboard one remained closed.

The sister vessel, *Tobrach-N*, did not have processing equipment and the shellfish were bagged whole. In place of flush ice scuttles she had two conventional weathertight hatches with 460mm coamings. (When MAIB inspectors viewed *Tobrach-N* on 13 January 2000 the hatch covers were not there, but suitable closing devices have since been fitted.) The MAIB was informed that *Solway Harvester* was fitted with ice scuttles rather than conventional hatches because they were required to provide sufficient 'drop' between the riddles and the shell remover. The normal two-stage process involved the scallops passing from the shaker to the picking tray (as fitted to *Tobrach-N*). It required less 'drop' than the longer process adopted in *Solway Harvester*, where the catch passed from the riddle to the picking tray, and thence to the shell remover via the scalding tank.

However, the processing equipment on *Solway Harvester* soon became redundant. The basic practice of dropping the catch through the ice scuttles into the fish room was retained, but was achieved via picking trays positioned over both ice scuttles. Until then, the picking trays had been used only if the processing plant failed, now they were in use continuously during fishing operations.

The ice scuttles still served as the opening through which the catch passed but, since the processing plant was no longer in use, there was no need for the increased 'drop' they provided. There was no reason to retain them other than to make use of an existing facility. Conventional hatches with coamings and weathertight covers (such as those fitted in *Tobrach-N)*, would have worked just as well. They would also have been safer and prevented the accident to *Solway Harvester*.

As part of the investigation, MAIB inspectors sought the views of fishing vessel designers and surveyors on the merits of ice scuttles. They cited two practices to illustrate that flush deck hatches were an established, and acceptable, means of passing the catch from the working deck to the fish room. The first was the flush deck scuttles used on the traditional Scottish herring boats, while the second was the hydraulically-operated loading hatch on large stern trawlers.

Both situations were carefully considered, but the MAIB believes there are fundamental differences between these hatches and those in *Solway Harvester,* and that any comparison was misleading. On board *Solway Harvester*, the ice scuttles had to be open all the time the vessel was fishing; while on the other vessels they are only opened for short periods when the catch is being loaded into the fish room, and would have been clearly visible. On *Solway Harvester*, the picking tray pipes obscured the ice scuttles and, as such, hid any water ingress.

Had the ice scuttles been removed once they were no longer required, and been replaced by conventional hatches, the flooding on 11 January could not have occurred. Nobody recognised the potential dangers of retaining the ice scuttles.

The MAIB had no information about how widespread the use of ice scuttles was on United Kingdom-registered fishing vessels. The MCA has accepted and implemented a recommendation from the MAIB on the use of ice scuttles (see 5.2.9).

2.14.2 Accessibility of the fish room bilge strainer

The two previous flooding incidents showed up another design problem; the difficulties in gaining access to the fish room bilge suction if it blocked. On both occasions the crew had to bale out with buckets until the water level was low enough for the strainer to be reached and cleared.

The strainer to the fish room slush well was fitted at the top of the bilge suction pipe in the well, which was situated at the lowest point in the fish room, the aft end. When the level of bilge water was high and the strainer became blocked, it was submerged. Access was further aggravated by the bags of shellfish stowed against the aft bulkhead.

Regulation 37 of the *Fishing Vessels (Safety Provisions) Rules 1975* says, "….bilge suctions shall be fitted with readily accessible strainers……..". Those on *Solway Harvester* were readily accessible when the fish room was empty and dry, but extremely difficult to reach if flooding in excess of 0.2m occurred and when the fish room was loaded with shellfish. MCA and SFIA surveyors had accepted the arrangement.

Conventionally arranged fishing vessels, with the fish room forward and the engine room aft, often have the fish room strainer and an isolating valve inside the engine room. If the fish room then floods, and the strainer becomes blocked, it can be isolated then opened up and cleared from inside the engine room. But prevention is better, and attention to the cleanliness of the bilge well, and precautions against debris falling into it, should have minimised the likelihood of a complete blockage of the suction (see Section 2.16).

Since her flooding, *Tobrach-N* has always carried a portable petrol-driven salvage pump which is stored in the forepeak. *Solway Harvester* did not. MGN 49(F) *Losses of fishing vessels through flooding* observes: "the carriage of a portable diesel-driven salvage pump ………could have saved many vessels" **(Annex 6)**. A salvage pump is essential if the fish room slush well strainer is inaccessible, to provide an alternative means of pumping the fish room should the strainer become blocked.

It has been shown that a very important factor in this accident was the movement of bagged queenies in the fish room. This occurred because the continuity of the rows of bags was broken to allow access to the bilge strainer. Had this access not been required, the rows could have run from one side of the fish room to the other without a break; movement of the bags would have been virtually impossible, probably delaying, or possibly even preventing, *Solway Harvester* from capsizing.

The MCA has accepted and implemented a recommendation from the MAIB on accessibility of bilge suction strainers (see 5.2.2), and a recommendation on the stowage of catches (see 5.2.1).

2.14.3 The addition of watertight bulkheads to improve stability

In 1996, it was found that *Solway Harvester* did not meet the regulations on stability. The problem was "solved" by adding watertight bulkheads to port and starboard of the galley/mess deckhouse. The MCA approved the arrangement.

The addition of the watertight bulkheads, and the weathertight doors in them, were crucial to ensuring the vessel's stability. This importance was stressed in *Solway Harvester'*s stability book. It contained two warnings about the necessity to keep weathertight doors to buoyant spaces closed at sea. On page 7, "I<u>n severe weather sufficient stability can only be maintained if the hull, deckhouses and focsle are kept weathertight</u>", and on page 18, "All openings into weathertight spaces to be kept securely fastened at sea when not in use".

On the starboard side, the new watertight bulkheads enclosed the passageway between the main deck and the winches. There is no indication that the doors at either end of the passageway had been secured open when the vessel capsized; and the evidence of former crew indicates both doors were normally secured closed, using the top centre clip on each, when on passage.

However, the passageway was the direct route from the main deck to the aft workshop and toilet. It was the indirect route to the aft cabin without having to pass through the mess room. It was in frequent use. This meant that the doors in the watertight bulkheads were opened and closed continually. Shortly before *Solway Harvester* capsized, someone might have followed this route in a hurry because he was aware of the emergency, and did not, understandably, close the doors behind him.

If, as the MAIB believes, the vessel rolled 30° to 40° to starboard, water would have poured into the passageway through the open doors. The substantial loss of buoyancy, causing a large reduction in the vessel's range of stability, would have been a major factor in the capsizing (see Section 2.6).

This is not the first time the MAIB has made such a discovery.

- When *Margaretha Maria* sank in 1997 with the loss of four lives, the weathertight doors to the poop were found to have been secured open and as such, would have contributed to her rapid sinking.
- *Pescalanza* was lost in heavy seas in 1998 because weathertight doors, which were left open, permitted downflooding to the accommodation and engine room.
- On *Audacious II*, lost in 1998, an open weathertight door allowed her engine room to flood. This was responsible for disabling the vessel.
- When *Silvery Sea* sank in the immediate aftermath of a collision in 1998 and all five crew were lost, open weathertight doors inside the shelter had allowed the rapid and unrestricted flooding.

- In 1997, *Sapphire* sank while on passage in rough weather, with the loss of four fishermen. A weathertight door on the starboard side was found open, allowing the flooding of the engine room.

Utilising the buoyancy of the starboard passageway was a low cost solution to the stability problem on *Solway Harvester*. It was not, however, the most satisfactory because there could be no guarantee that the doors would be closed to provide the necessary buoyancy when it was most needed. The practical ergonomics of the layout were overlooked to achieve, on paper, compliance with the regulations.

Unfortunately, to utilise the starboard passageway for additional buoyancy, a freeing port in that area had to be sealed. Water could only drain away over the doors' sills at either end, and the passageway would retain about 1.3 tonnes of water if flooded to the depths of the doors' sills. So, not only was there a loss of buoyancy but the problem was compounded by a residual heeling moment from the trapped water. Computer simulations showed this to be one of the critical factors preceding every capsize.

The MCA has accepted and implemented a recommendation from the MAIB on the criteria for accepting "new" buoyancy (see 5.2.11).

2.14.4 The relatively large fish room

The large fish room meant that very low levels of flooding could lead to the vessel capsizing. The *Fishing Vessel (Safety Provisions) Regulations 1975*, require the stability of fishing vessels to be examined with all spaces, except dedicated tanks, dry. The regulations do not, therefore, require the consequences of flooding to internal spaces to be examined, and few designers would look into this aspect of their design.

However, the design of small fishing vessels has changed markedly over the last 25 years. The MAIB's experience of many accidents involving fish room flooding is that a similar sized traditional Scottish fishing vessel would not have capsized with a comparable low level of flooding in the fish room.

The MCA has accepted and implemented a recommendation from the MAIB on fishing vessel design (see 5.2.13).

2.15 THE MISSING ICE SCUTTLE

This report has already discussed the design aspects of the flush deck ice scuttles. The investigation also probed the relevance of the missing ice scuttle cover. It had been missing for some time.

Solway Harvester was operating with one watertight ice scuttle cover missing. The *Fishing Vessel (Safety Provisions) Regulations 1975* were uncompromising. They state "……flush deck scuttles of the screw, bayonet or equivalent type and manholes may be fitted where these are essential for fishing operations and shall be capable of being closed watertight and shall be permanently attached to the structure, provided that such scuttles and manholes may be effectively weathertight only when closed if their design, size and disposition is such that no danger is likely to result from the absence of complete watertightness.”

The MAIB attempted, therefore, to establish why such an obvious hazard was not recognised, corrected or even reported.

The owner’s experience was that the forward part of the deck near the ice scuttles was generally dry, and not much water ever got down into the fish room.

The skipper thought the previous two flooding incidents had occurred because his crew had not been careful enough. In the first instance the watertight cover had not been fitted correctly and in the second, he attributed the flooding to the mate not checking the fish room as frequently as instructed.

There is nothing to suggest the skipper saw the flooding as a fundamental watertight integrity problem. If flooding occurred he could adequately manage the risk by continuously pumping the fish room slush well and making frequent inspections. Had he realised the full implications of what was happening, it must be hoped that he would have done something that would have guaranteed it could not happen again. In the event he did not, and the established practice of relying on frequent inspections and constant pumping continued.

There is no evidence from anything revealed to MAIB inspectors that either the owner or the skipper realised that even a modest depth of floodwater in the fish room could have been the catalyst for a disaster.

MAIB inspectors formed the view, during discussions with the owner, that he believed that because the vessel was sub-divided by watertight bulkheads throughout her length, the flooding of any one compartment could not cause her loss. The skipper’s actions showed that he probably shared the same erroneous view. In fact, the only bulkheads in fishing vessels which are required to be watertight, are the collision bulkhead and the bulkheads each end of the main machinery. Unlike passenger ships, for example, there is no requirement for fishing vessels to be able to survive the flooding of any one watertight compartment.

In a perverse way, the previous flooding accidents probably reinforced this view, and increased their confidence in *Solway Harvester* and her ability to survive in any condition. Flooding of the fish room was, to them, an inconvenience and an obstacle to landing good quality catches. Flooding increased the workload on board, and the processing factory would reject any of the catch contaminated with bilge water.

The MCA has accepted and implemented a recommendation from the MAIB on watertight integrity (see 5.2.3).

2.16 MAINTENANCE OF THE FISH ROOM SLUSH WELL

Another factor considered by the MAIB was the broken cover to the fish room slush well. Without the protection provided by the grid, there was nothing to prevent any large item dropping into the well near the open end of the bilge suction pipe. It could then be drawn to the pipe to block it completely. MGN 49(F) *Losses of fishing vessels through flooding* (current at the time of the loss) advises "DO fit grids over the fish hold slush well ……".

With the grid in place, any debris would have to be less than about 10mm in section to pass through the drainage holes into the well. Items of this size could pass through the pipe and into the strainer. Regular cleaning should have ensured that the bilge system remained operational at all times. It was the practice in *Solway Harvester* to clean the bilge suction strainer and the slush well at the end of every trip. How well this was done is unknown, but because of the missing protective grid, it would not have been a straightforward task and could well have led to some debris being overlooked. The owner was unaware of the missing grid.

The MAIB has issued a recommendation to the owners of fishing vessels to inspect the vessels in their fleets to ensure the protective covers over the fish room slush wells are in working order. The companies should also ensure that its skippers and mates fully understand the importance and function of these items (see Section 5.3).

2.17 QUALIFICATIONS AND COMPETENCY

Both the skipper and owner held Class 2 (Fishing) certificates of competency.

The syllabus for the certificate is laid down in the MCA booklet *Deck Officer (Fishing) Requirements and Syllabuses* **(Annex 7)**. It requires those sitting the examination to have knowledge of basic stability. The word 'competency' is not defined, but the MAIB believes it should be a statement of practical skills, experience, knowledge and a willingness to follow the range of regulations and rules.

The skipper's competency or knowledge of stability cannot be measured or assessed. Findings from other investigations, however, indicate that other skippers are not as well acquainted with the principles of stability as their profession can justifiably expect. In short, the MAIB has evidence to show that knowledge of stability is, at least among some skippers, inadequate.

There is no means of knowing whether the skipper had any idea of the risks he was running by not properly addressing the causes of the previous flooding incidents. It will never be known if he fully appreciated the danger posed by a relatively small depth of loose water in the fish room; his actions strongly suggest he did not.

The stability component, in the syllabus for the Class 2 (Fishing) certificate, lacks one important feature relevant to the safety of a fishing vessel such as *Solway Harvester;* it does not cover the regulation, function or limitations of watertight bulkheads in fishing vessels.

There have been many accidents investigated by the MAIB that highlight the capsizing danger from downflooding through open weathertight doors and hatches.

The MCA has accepted and implemented a recommendation from the MAIB on watertight integrity, capsize avoidance and the role of watertight bulkheads (see 5.2.3).

2.18 LIFERAFTS

During the search for *Solway Harvester* on the evening of 11 January 2000, two liferaft canisters were found floating with the undamaged tails of the painters protruding from them. The canisters were identified as belonging to *Solway Harvester.* The inflation mechanisms for the liferafts had not been activated.

A liferaft inflates when its 20 metres-long painter has been completely pulled out of the canister and given a final sharp tug to release compressed CO_2 into it. If the liferafts are launched manually this is done by hand but, when a vessel sinks, they are designed to float free with the painter trailing behind. The liferaft painter should be attached to the hydrostatic release unit (HRU) which in turn is attached to the vessel. As the vessel sinks the HRU will release the liferaft, leaving the painter still attached to the vessel through the weak link. When the painter has been fully pulled out the tension will release the compressed CO_2 inflating the liferaft. The resulting buoyancy will break the weak link, allowing the liferaft to float free, inflated and ready for boarding. This is fully described in MGN 104(M+F) *Stowage and Float Free Arrangements for Inflatable Liferafts* which is reproduced in **Annex 9** of this report.

Only part of this process happened in *Solway Harvester*. When she sank, both liferafts floated free, although only one was released through the operation of its HRU. Their painters should have been attached to the HRUs. They were not.

It is not known why, or for how long, the painters had not been attached. Additionally, the liferafts had not been serviced since September 1996, and the HRUs were also time expired.

The *Fishing Vessels (Life Saving Appliances) Regulations 1988* required liferafts to be serviced annually. They should, therefore, have been serviced in September 1997, and annually thereafter.

The MAIB considers that the shortcomings with the liferafts and HRUs had no bearing on the final outcome, but the implications of the discoveries were serious, and needed to be addressed. Consequently the MAIB *Safety Bulletin* 1/2000, which was published in February 2000, reminded all concerned of the need for the checking of liferafts and HRUs (see **Annex 1**).

2.19 BASIC SAFETY TRAINING

The *Fishing Vessels (Safety Training) Regulations* 1989 (current at the time of the loss), required that all serving fishermen born after 1 March 1954 undertake safety training, and that all new entrants to the fishing industry undertake safety training before going to sea for the first time. Persons born before 1 March 1954 were exempt. The safety training consisted of instruction in sea survival, fire-fighting and first-aid.

Although four of *Solway Harvester'*s crew had not undertaken this training, there is no evidence to show this was a factor in this accident. The requirement for every member of the crew to have a basic understanding of safety features can mean the difference between life and death. The risk of an accident will be greatly reduced if everyone on board has received basic training in safety matters. There is already ample evidence elsewhere to show that some of those who have received basic survival training have owed their lives to knowing what to do in an emergency.

In 1997, the MAIB investigated the death of the skipper of fv *Flamborough Light,* another fishing vessel owned by Jack Robinson (Trawlers) Ltd. The investigation found that two of the vessel's crew had not, as in *Solway Harvester*, completed their basic safety training. As with this investigation, inspectors concluded it was not a factor. The MAIB's report contained, nonetheless, recommendations to owners of fishing vessels, one of which addressed basic safety training.

After the accident involving *Flamborough Light*, Jack Robinson (Trawlers) Ltd, with the SFIA, tried to arrange training locally for young men going to sea in their fishing vessels. The initiative was, however, unsuccessful.

The MAIB recommended in its *Summary Report* that the SFIA should combine forces with the Fishermen's Federations and Associations to examine ways of ensuring such training can be made available (see 5.2.15).

2.20 HEALTH AND SAFETY ON BOARD *SOLWAY HARVESTER*

2.20.1 Safety Management

Solway Harvester's skipper was a senior member of Jack Robinsons (Trawlers) Ltd management team. He was responsible for the operation of a vessel worth over £0.5 million which grossed over £0.5 million in 1999.

The *Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997* states "…it is the duty of employers to protect the health and safety of workers …… so far as is reasonably practicable. The principles for ensuring health and safety are: ……….e) adoption of a coherent approach to management of the vessel or undertaking, taking account of health and safety at every level of the organisation……".

In essence, this means that the company was responsible for implementing an effective safety management system to ensure its skippers carried out the company's statutory duties on health and safety, including the safety of the vessel as a workplace.

However, at the time of *Solway Harvester's* loss, it was normal practice for owners of fishing vessels engaged in share fishing to rely on competent skippers to take such steps as were necessary to ensure that their vessels were safely operated and maintained in a safe state.

The skipper of *Solway Harvester* was given a free hand to run the vessel, to organise repairs and to order essential equipment. Craig Mills had his own *Solway Harvester* cheque book which he used to pay for equipment and to pay the crew.

Review meetings between the skipper and owner took place every week or ten days and focussed mainly on the profitability of the vessel; the owner would generally ask if the skipper had any problems. It does not appear that safety was covered at any other time. The defects to liferafts and other LSA showed, for instance, that neither the skipper nor the owner had checked the safety equipment on board *Solway Harvester* for at least 27 months. Nor had they done anything to ensure a system existed to prevent such an oversight. The MAIB concluded there was no effective control on the skipper's actions with regard to health and safety matters.

Notwithstanding the competence and experience of encumbent skippers, it is important that the owners of fishing vessels do establish effective procedures to provide guidance and standards of safety for fishermen working on their vessels. Fishing vessel owners should therefore engage a suitably qualified marine safety expert to undertake a comprehensive review of safety management throughout the company, and to produce an effective safety management system for its vessels and crews.

2.20.2 Risk assessment

The requirement to undertake risk assessments was publicised in both a Marine Guidance Note issued in early 1998 and in *Fishing News*. MGN 20 (M+F) introduced the legislation, and covered the implications for employers and employees. It contained an annex giving guidance on risk assessment **(Annex 8)**.

However, MGN 20 (M+F) states: "The requirement to assess risk relates only to risks which arise directly from the work activity ..…. which have the potential to harm the person(s) actually undertaking that work, or who may be affected by that work. The requirement to assess risk does not extend to any ……… external hazards which may imperil the ship…… which may cause harm to those on board or to others."

Therefore, risks to the safety of the vessel do not have to be formally assessed. However, the MCA recognised the potential value of extending the principle of risk assessment to identify and control hazards affecting the safety of the fishing vessel itself. The MCA asked the SFIA to produce a risk assessment template for these hazards in a format similar to the Safety Folder which had already been produced to facilitate workplace risk assessments on fishing vessels. This was done, and the results were presented to the Fishing Industry Safety Grop in November 1999, but, unfortunately, no agreement could be reached and the initiative failed.

The MAIB is confident that extending the application of risk assessment methodology to identify and control hazards that might impinge on the structural or watertight safety of the fishing vessel would provide the industry with an important tool for improving the safety of the fishing fleet. If a risk assessment had been applied in this way to *Solway Harvester,* it should have identified that the vessel was being operated unsafely, and that critical safety equipment was missing, inoperable, or out of date. Flooding of the fish room should have emerged as a likely hazard, and measures could have been introduced to rectify the situation.

The ice scuttles could have been replaced by conventional hatch coamings with weathertight covers. The company could have instructed the skipper to ensure all bilge alarms were working before the vessel proceeded to sea. A third measure could have been to instruct the skipper to ensure the main and auxiliary bilge pumps were both fully operational before taking the vessel to sea. It might also have been decided that the vessel should carry a portable diesel-driven salvage pump because of the difficulty of access to the strainer in the fish room slush well. A blocked strainer would have rendered both dedicated bilge pumps ineffective.

The advantages of the technique are clear.

A safety recommendation was made to MCA, who have taken action (see Section 5.2.10).

2.21 SURVEY ISSUES

2.21.1 General overview

Safety regulations exist to prevent accidents. Although in place in January 2000, they failed, for a number of reasons, to prevent the loss of *Solway Harvester*. It is important that those reasons are understood so that safety within the fishing industry is improved.

When the wreck was inspected after the accident, a number of deficiencies, many of them serious, were discovered: they included the following major deficiencies:

1. A missing watertight ice scuttle cover.
2. An unsecured watertight ice scuttle cover.
3. Liferaft HRUs out of date.

4. Liferafts incorrectly installed.
5. Liferafts' servicing overdue by 2 years.
6. Main engine-driven, Jabsco bilge pump inoperable.
7. Watertight bulkheads poorly fitted and non-watertight.
8. Cover missing from fish room slush well.
9. Distress flares missing.
10. Four crew without basic safety training.
11. No risk assessment.

Had *Solway Harvester* been inspected by MCA surveyors on the day she sank, there were enough shortcomings for her to be detained.

Nothing had been done to maintain the vessel's lifesaving appliances (LSA) since the MCA survey in 1996. The survey for the renewal of *Solway Harvester's* UKFVC was due in October 2000. It would appear that the skipper of *Solway Harvester* had left the maintenance of his vessel's safety equipment until an MCA survey required it.

The MCA was surveying each UK fishing vessel at least once every four years for the renewal of its United Kingdom Fishing Vessel Certificate, without which the vessel cannot operate. If resources permit, the MCA also carries out inspections; random checks on fishing vessels in a particular port. In the five years from January 1995 to December 1999 the MCA carried out inspections in the port of Kirkcudbright on five occasions:

October 1995	2 vessels inspected
September 1996	7 vessels inspected
December 1996	2 vessels inspected
1997	none
1998	none
March 1999	1 vessel inspected
September 1999	2 vessels inspected

Solway Harvester was one of the vessels inspected in October 1995. General inspections are intended to deter fishing vessel operators from allowing safety standards to fall during the four years between the mandatory UKFVC renewal surveys. It is a key part of the overall safety management system for the fishing industry.

Such a policy failed to deter *Solway Harvester*'s skipper from allowing safety standards to fall to an unacceptably low level, probably because the likelihood of inspection was low - *Solway Harvester* had not been inspected in the 3 years since Craig Mills became skipper.

A safety recommendation was made to MCA to review its policy on fishing vessels inspections; this has been accepted and implemented (see Section 5.2.5).

2.21.2 Safety Management

Current safety management thinking is moving away from the prescriptive lists of safety equipment, which for many years has been the core of most fishing vessel safety legislation. The move nowadays is towards safety management systems based on risk assessment. It recognises that the people best placed to achieve a safe working environment are the operators, employers and employees. The traditional requirement for a vessel to carry specific safety equipment, although still an essential safety component, is recognised as no longer being the sole guarantor of safety.

The legislation initiating this fundamental change in the fishing industry's safety culture, is the *Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997*, which came into force on 31 March 1998.

The MCA's role in the new system is to ensure compliance with the legislation, and that new management methods are introduced throughout the fishing industry. This process is ongoing.

The investigation sought to establish the MCA's record in auditing compliance with the Health and Safety at Work regulations. During the 31 months between the legislation coming into force, and the end of October 2000, there is no record of any fishing vessel having been detained for non-compliance. Furthermore, there is no record of any fishing vessel operator having been issued with improvement or prohibition notices for the same reason. It is concluded that compliance with the legislation was not, in the months before January 2000, being audited by the MCA.

A safety recommendation was made to MCA to enhance safety audits on fishing vessels; this was accepted and implemented (see Section 5.2.6).

2.21.3 Inspection of watertight bulkheads

The non-watertight aspect of the bulkheads' installation was not a factor in the accident. It does, however, focus attention on the inherent risks associated with the MCA accepting work on the basis of a letter from an owner saying work had been done. The practice depends on trust but, as this accident has demonstrated, it is not without risk.

The MCA fishing vessel surveyors regularly issue approvals on the basis of a letter. It is an accepted practice and avoids the necessity of the vessel's operator having to pay a fee to cover a specific visit. The intention is that vessels affected are visited when a surveyor is next in her home port on other business. The MAIB accepts that such an approach is reasonable where the item is neither critical to the safety of the vessel, nor expensive to install properly. It believes, however, that when watertight bulkheads have been constructed to bring a vessel's stability up to the standards required, an on-site inspection is essential. Such an inspection would also provide an opportunity for a surveyor to brief the skipper and crew on the importance of keeping the doors closed when not required.

A safety recommendation was made to MCA to review its policy on the survey of remedial work; this was accepted (see Section 5.2.12).

2.21.4 Modifications to fishing vessels

When the MCA issued a UKFVC it was accompanied by a standard letter, which stated "…. Should any changes be made to the craft (i.e. new name, engine, winch, mast, power block, etc) the Maritime and Coastguard Agency of the Department for Transport must be informed. Such changes could invalidate the Certificate…….". *Solway Harvester*'s stability book contained the following warning on page 18: "It is extremely important that no alterations to the vessel or additions are carried out to the vessel or fishing gear until the effects on stability have been calculated".

Solway Harvester was substantially modified in 1994 when shakers and picking trays were fitted on the main deck. In 1996, in preparation for the vessel's first UKFVC renewal survey, the redundant processing equipment was removed. At the survey, the changes were discussed with the MCA surveyor. This was the first indication the MCA knew about them, and the surveyor gave instructions for her stability to be checked by inclining test. The results showed her stability was below the standard required in the regulations. Fitting watertight bulkheads outboard of the deckhouse structure was intended to rectify the defect.

In 1998, *Solway Harvester* was equipped with four tipping bins each weighing 0.5 tonne when empty and located at the top of the shelter. After a heavy haul the bins could hold as much as 1 to 2 tonnes of shellfish and stones. With the bins rotated upwards their centres of gravity could rise a further 1.5 to 2 metres. The impact on *Solway Harvester'*s stability could have been substantial, but the MAIB's inclining test showed that her stability still met the required standard if her watertight integrity was maintained. In 1999, the main engine was replaced with one of the same type.

The MCA was not consulted when any of these changes were carried out. The MAIB has established that the MCA's policy in such situations is to check that the changes are acceptable and, if not, to have them rectified.

In the MAIB's experience, this is not an isolated case. It is essential that fishermen are informed about the dangers of not reporting changes made to their vessels to the MCA.

A safety recommendation was made to MCA to review its policy for dealing with cases when substancial changes have been made to fishing vessels, this has been accepted and implemented (see Section 5.2.8).

2.21.5 Accessibility of sea suctions in the shaft tunnel

The sea suctions and strainers to the port and starboard Desmi pumps were located at the forward end of the shaft tunnel. To close the sea suction valves or to clear the strainers, someone had to enter the shaft tunnel through the small hatch in the aft bulkhead of the engine room. Under normal circumstances this was awkward, but no real problem for most able-bodied persons; but if the tunnel was flooding, the valves could be rendered inaccessible very quickly.

On *Tobrach-N* the valves were fitted with linkages to allow their closure at the entrance to the hatch without the need to enter the tunnel. *Solway Harvester* did not have this arrangement.

A recommendation was made to MCA to issue guidance on the remote access to seawater inlet valves in shaft tunnels, this has been accepted and action is to be taken (see Section 5.2.14).

2.21.6 Capacity of bilge ejectors

Tests on the port Desmi pump, in combination with the bilge ejector, showed that the maximum output attainable was 80 litres/min (4.9 tonnes/hr). This was substantially below the 150 litres/min (9.2 tonnes/hr) attributed to the pump/ejector combination in MCA records (Form FV 2). Part of this shortfall in performance was because of the poor condition of the pump. Tests also showed that the effectiveness of the ejector reduced as the total number of outlets being supplied simultaneously by the pump increased, and in some circumstances the ejector stopped drawing bilge water altogether.

The *Instructions for the Guidance of Surveyors* states: "Where a bilge ejector is fitted, the surveyor should be satisfied that the seawater pump fitted in combination with the ejector has sufficient capacity to ensure that the ejector will discharge bilge water at the rate required by the Rules". This indicates a test is required.

What *Solway Harvester's* skipper believed about the capabilities of the port Desmi pump is unknown. However, his willingness to rely upon it to keep the fish room dry, as well as to supply the water for cleaning the catch, indicates that he possibly overestimated its capabilities.

A safety recommendation was made to MCA to issue guidance regarding acceptance of seawater pumps in combination with bilge ejectors; this has been accepted and implemented (see Section 5.2.4).

SECTION 3 - ADDITIONAL REPORTS, WORK AND INFORMATION

3.1 REPORTS

Poseidon Maritime Limited (PML) produced a report for the Isle of Man Government titled *An Investigation into the Loss of Fishing Vessel Solway Harvester* on 11 January 2000. This five-volume document formed a basis for the prosecution of the owner of *Solway Harvester*. Most of the material included in the PML reports was available to the MAIB and was considered in this analysis.

The PML reports did not, however, include the results of a further study by the Ship Stability Research Centre (SSRC) which considered the motions, flooding and behaviour of *Solway Harvester* when underway at a range of speeds and on various courses.

Burness, Corlett and Partners (BCP), acting for the owner, produced a report, with appendices, which commented on the PML and SSRC work, and also reported on a new series of model tests which were commissioned from BMT SeaTech Limited using the original scale model of *Solway Harvester*. The BCP report discussed, extensively, a 'dry capsize' scenario, whereby *Solway Harvester* capsized without significant flooding of the fish room, but because of a major cargo shift.

ENI/Oceanroutes produced, for the court, a further report on the weather, before and at the time of the loss. This amplified the information available about the conditions in the hours before *Solway Harvester* sank.

3.2 OTHER SOURCES

Evidence presented in court, before the trial was halted, added some information about procedures on board and other matters; many of these have been included in this MAIB investigation report. The trial also allowed some of the technical witnesses to give their evidence, but only in support of the prosecution case. The technical experts instructed by the defence did not have the opportunity to present the results of their investigation, before the trial was halted.

3.3 DISCUSSION OF NEW MATERIAL

3.3.1 Weather Conditions

The new ENI/Oceanroutes report added more detail of the sea and wind conditions in the hours before the sinking. From the time *Solway Harvester* left the fishing grounds to seek shelter, the wind was steadily increasing the sea conditions so that, certainly in the last hour before she sank, the seas were similar to those that existed at the time of sinking.

MAIB Comment:
This supports the MAIB's consideration on the amount of water that might have entered her fish room while on passage.

3.3.2 SSRC Additional Simulations

These simulations were performed for seas 45°, 35° and 25° abaft the beam and at engine settings equivalent to 8, 8.5 and 9 knots speed in calm seas. The simulations were performed with the vessel on a fixed course and this was achieved by removing any yaw forces and hence motions. The results showed a strong relationship between fish room flooding (water on deck) and both heading and speed. The further the seas were off the beam, the less water came on deck; and higher speed also reduced deck wetness.

Solway Harvester steamed a course to shelter that put the wind and sea nearly 25° abaft her starboard beam. These simulations showed that the flood rate into the fish room on this heading, and at the most likely speed, was not very much different from that when stopped and lying naturally to the seas.

The simulations also investigated the effect of the yaw restriction and indicated that a vessel free to yaw would probably take about 60% more water into the hold than a vessel where the yaw motions were removed. This inflow rate was around 6 tonnes per hour.

3.3.3 BCP Report and 'Dry Capsize' Scenario

Dry Capsize
Although the BCP Report accepts significant flooding into the fish room as a possibility, it states that a 'dry capsize' following serious cargo shift was more likely – that is, water in the fish room had no causal effect.

The scenario suggests that

a) *Solway Harvester* came beam on to the seas for some reason other than the discovery of flooding in the fish room;

b) she then lay close to beam on to the seas rolling very heavily, being held beam on by the wind, and the roll motions being increased by a close coupling of the seas with the boat's natural roll period;

c) the excessive motions caused her cargo and spare gear stowed in the hold to move resulting in a capsize.

d) additionally there was a suggestion that a dredge beam might have been displaced at some stage and, hanging over the side, would have contributed to the capsize.

MAIB Comment:
This was supported by calculations of heeling moments for the cargo and spare gear which were greatly in excess of the moments estimated by either PML or the MAIB, and by further model tests, both of which are discussed below.

Heeling moments
The heeling moment suggested by BCP were 13 tonne-metres for the cargo and 7 tonne-metres for the spare gear giving a total heeling moment of 20 tonne-metres compared to a value of about 5 tonne-metres for the cargo and 5.6 tonne-metres for spare gear from MAIB's estimates.

Evidence in court from crew members made clear, however, that the spare gear was stowed between pillars in the fish room in such a way that no shift was possible even in very severe rolling.

Professor MacFarlane of Strathclyde University also gave an opinion in court that the large cargo heeling moment opined by BCP was wrong. He suggested a most likely maximum shift of cargo resulting in a heeling moment of about 5 tonne-metres for a good cargo stow in the rolling experienced by *Solway Harvester*, just over 6 tonne-metres if the aftermost row of bags had been stowed without support and never more than 9 tonne-metres even if the stow had been very poor.

SRRC had performed simulations with cargo shifts of 7 and 7.5 tonne-metres. The vessel only capsized in these situations if either there was around 6 tonnes of water in the fish room with the picking trays in place, or if the fish room was dry but the picking trays were completely removed. That is, *Solway Harvester* would not have capsized if the ice scuttles had been closed.

MAIB Comment:
It is considered that BCP have over-estimated the maximum heeling moment very considerably – using a heeling moment of 20 tonne-metres when a more likely value would appear to be 6 tonne-metres.

Further scale model tests
To investigate the 'dry capsize' scenario, a series of further scale model tests were commissioned by BCP on behalf of the owner, using the same scale model and contractor, BMT, as used during the MAIB sponsored tests. These tests differed in a number of ways from the earlier tests.

The first difference was that the model was adjusted to lay across the beam seas more frequently than in the early MAIB tests – based on the idea that the wind would hold her head further off the seas. This was achieved by actively holding the model in a given position with lines controlled from the side of the tank. The effect was to produce substantially larger roll motions in these tests than in the previous tests and in the SSRC simulations.

It should be noted that this was a different form of yaw restraint from that used by SSRC in their simulations discussed above. SSRC removed energy and so reduced overall motions (and deck wetness). The BCP model tests took energy from yaw and forced it into roll to increase that motion.

The second difference was that the model was tested with substantial amounts of off-centre weight on board – with heeling moments of 20, 30 and 40 tonne-metres, and also with a dredge beam suspended over the side of the vessel. The heeling moments were made up as follows:

- 4 tonne-metres for wind heel on the assumption the wind was constant and on the beam;
- 4 tonne-metres for a known weight imbalance on the vessel on the assumption it had not been corrected by cargo stow;
- 13 tonne-metres for a maximum cargo shift;
- 7 tonne-metres for the maximum shift of spare gear.

This total of 28 tonne-metres was rounded to 30 tonne-metres for some tests.

BCP then discovered that the model had been constructed in such a way that the righting moment at angles greater than 31º was excessive. This was to avoid complete capsize of the model which would have damaged the instrumentation. The wheelhouse was made over buoyant which came into effect at large angles of heel. To compensate for this, BCP added a further 10 tonne-metres of heeling about 5º that applied in all conditions – that is the boat in its initial condition was pre-heeled by an offset weight. The pre-heel was almost 20° in this condition.

MAIB Comment:
The introduction of an artificial heel would appear to bring into question the authenticity of the test results.

The outcomes were interesting, however, in that they confirmed that *Solway Harvester* would not capsize when beam on to very extreme wave groups with the fish room empty, even with a heeling moment of 30 tonne-metres applied and with one dredge beam suspended off the side of the vessel unless the workshop area was open to the sea.

Reasons for stopping *Solway Harvester*

The 'dry capsize' scenario also required a reason for stopping *Solway Harvester* other than the discovery of fish room flooding.

It was suggested at the owner's trial that the skipper's normal practice was for the fish room to be checked on an hourly basis. Knowing that his bilge alarm was not functioning, it is likely that he would have continued this practice on *Solway Harvester*'s last trip.

MAIB Comment:
Why would he leave the engine out of gear to go to the fish room? He knew the vessel would come beam on to the sea and roll more heavily. If he was going to inspect the fish room then it would have been logical to have kept the vessel moving and in autopilot.

Perhaps there had been a problem in the engine room that needed the skipper's attention. During the evidence given in court it was noticed that a drive belt to No. 2 Transmotor was in place, but twisted. Emphasis was also placed on the soot or carbon material found on the hands of one of the crew and in the lungs of another, both of whom were found outside the accommodation, and could have been working in the engine room at some stage. It seemed, however, to suggest a failure of one Transmotor, which required the main engine to be stopped for repairs. *Solway Harvester* then capsized because of a shift in cargo.

MAIB Comment:
If this had happened, the capsize must have occurred after the repairs had been completed because there was no evidence of any deficiencies in the vessel's electrical supply and her main engine was running when she sank. Additionally, evidence was given in court by the former mate of *Solway Harvester* that a failure of a Transmotor for one battery bank would be compensated at sea by using jump leads to take current from another charged (and charging) set of batteries. No repair to a Transmotor would be required, or even attempted in very rough weather.

3.4 OVERVIEW OF NEW INFORMATION

The MAIB has reconsidered its findings in the light of the reports and work detailed in this section, the evidence given in court in the 2005 trial, and BCP's findings as presented in December 2005.

The only work that substantially challenges the findings of the MAIB investigation is the "Dry Cargo" scenario developed by BCP for the defence. This scenario has been carefully considered by MAIB, and for the reasons briefly summarised in section 3.3.3 above, the MAIB does not consider this scenario to be sustainable. However, even if the scenario was accepted as a theoretical possibility, it would not alter the conclusions of this report (section 4) or the recommendations issued as a result of the MAIB's investigation **(Annexes 1 and 2)**.

SECTION 4 - CONCLUSIONS

4.1 LIKELY LOSS SCENARIO

With the vessel drifting and the fish room partially flooded, *Solway Harvester* would have rolled heavily; this motion caused some cargo and spare gear to shift. Once at an angle of heel of 20º - 25º massive downflooding into the fish room through the starboard ice scuttle would occur. This, in addition to flooding into the starboard passageway, would have resulted in the loss of stability and then capsize. [2.12]

4.2 SAFETY ISSUES

The following safety issues were identified in the foregoing analysis. They are not listed in order of priority.

1. One ice scuttle cover was missing from the vessel, and had been for some time. The other ice scuttle cover was not in place. [2.7, 2.15]
2. The picking tray pipe flanges were not sealed to the deck and the starboard one did not fit tightly. [2.7]
3. The bilge alarm in the fish room was not functioning. [2.8]
4. No bilge alarm spares were carried on board. [2.8]
5. The fish room bilge suction was not easily attainable for cleaning and clearing. [2.14.2]
6. The fish room bilge (slush well) grid was broken and allowed large items of debris to clog the suction. [2.16]
7. The dedicated bilge pumps (Jabsco) were not properly maintained. [2.9]
8. Bilge pumping rates using a Desmi pump and Giljector were very much reduced when the pump was simultaneously supplying other outlets. [2.9]
9. The accessibility of sea suctions and strainers in the shaft tunnel was poor. [2.21.5]
10. The large size of the fish room meant that relatively low levels of flooding could lead to the vessel capsizing. [2.6, 2.14.4]
11. The bags stowed in the fish room were unsupported. [2.5]
12. The spare gear in the fish room was not secured. [2.5]

13. The “watertight” bulkheads fitted in 1996 were not watertight. This change was not surveyed by MCA. [2.21.4]

14. A freeing port had to be sealed when the starboard alleyway was used to enhance buoyancy. [2.14.3]

15. Weathertight doors on board had been left open and, therefore, compromised the watertight integrity of the vessel. [2.6]

16. Knowledge of stability is, at least among some skippers, inadequate. [2.17]

17. The vessel’s liferafts were installed incorrectly, and their servicing was overdue. [2.18]

18. Not all the crew on board had undertaken the mandatory safety training. [2.19]

19. There was no effective safety management system in place either ashore or on board. [2.20.1]

20. The mandatory risk assessment had not been carried out. [2.20.2]

21. Modifications to the vessel were carried out without notifying the MCA. [2.21.4]

22. MCA surveyed fishing vessels every four years for the renewal of its UK Fishing Vessel Certificate. [2.21.1]

SECTION 5 - ACTION TAKEN

5.1 *SAFETY BULLETIN*

During, and arising from, the *Solway Harvester* investigation the MAIB issued *Safety Bulletin* 1/2000 on 23 February 2000 (see **Annex 1**). A number of recommendations were addressed to owners and skippers of UK fishing vessels and to the Maritime and Coastguard Agency.

5.1.1 Safe Practice

The MCA was recommended to take immediate action in its promotion of safe practice and its enforcement of safety requirements on the four areas of concern raised by the loss of Solway Harvester:

- *the watertight integrity of main decks*
- *the service history of liferafts*
- *the correct installation of liferafts*
- *crew's completion of the mandatory basic safety training courses.*

Immediately, the MCA accepted the two-part recommendation. Shortly afterwards, two fishing vessels were detained after significant safety flaws were found. The Agency's normal survey and inspection procedures include the areas of concern identified by the MAIB.

The recommendation was implemented, as follows:

The 15-24m Code requires that freeboard decks are of watertight construction and extend from stem to stern with positive freeboard throughout in any condition of loading of the vessel. Any openings in the deck are required to be fitted with weathertight or watertight closing appliances.

The Code also requires that liferafts and serviceable hydrostatic release units are serviced annually by an authorised agency and non-serviceable hydrostatic release units are replaced by their expiry date.

The Code requires that liferafts are:

- readily available for safe and rapid use in an emergency;
- capable of being launched in unfavourable conditions of trim and with the vessel heeled 15° either way;
- stowed in such a way to permit them to float free, inflate and break free if a vessel should sink;
- stowed clear of any overhanging projections, gear or rigging.

The Code also refers to MGN 104 (M&F) – Stowage and Float Free Arrangements for Inflatable Liferafts and MGN 130 (F) The Stowage of Liferafts and EPIRBS on UK Registered Fishing Vessels. The latter of these has now been superceded by MGN 267(F) and is to be read in conjunction with MGN 104(M&F).

Funding was in place, from Financial Instrument for Fisheries Guidance (FIFG) and allocated from DEFRA and the devolved administrations of Scotland, Wales and Northern Ireland, until 31 March 2005 (having been extended for a year) for fishermen to receive the basic safety training courses free of charge. Vessels with crew who have not received the basic training after this date are liable to detention.

Oral examiners have required fishing vessel candidates to demonstrate an understanding of how to fit Hydrostatic Release Units (HRUs) correctly. The manufacturer of the most common type used on UK fishing vessels has modified the design to ensure that it is more difficult to fit incorrectly.

MCA surveyors and sector managers have targeted fishing vessels and are taking corrective action when liferaft and other deficiencies have been noted. During the year ending 31 March 2003, an MCA Preventative Project was carried out in Scotland and Northern Ireland which focused on the attitudes and behaviour with relation to Health and Safety among fishermen on boats of over 24m in length. Liferaft, HRU and risk assessment issues were covered during these inspections.

5.1.2 Watertight Integrity

The MCA was also recommended to examine all vessels of similar design to Solway Harvester to ensure the watertight integrity of the main deck.

MCA accepted this action and has provided the following comment:

MCA carried out targeted inspections of vessels of similar design to the *Solway Harvester*. These inspections resulted in the detention of *Karianda BA356* and *St Keverne H340*, in February 2000, for safety related deficiencies. During the financial year 2003-2004, the MCA planned to target inspections on 1395 fishing vessels and conduct mandatory inspections of fishing vessels in the 15 to 24 metre length range in addition to their statutory renewal surveys.

5.2 SUMMARY REPORT

On 13 June 2003, the MAIB published its *Summary Report* of the investigation which also included a number of recommendations addressed to fishing vessel owners, to the Sea Fish Industry's Authority and the Fishermen's Federations/ Associations, and to the Maritime and Coastguard Agency (see **Annex 2**).

The current status and, where appropriate, feedback and action taken by the addressees between the publication of the *Summary Report* and publication of this report has been added.

5.2.1 Safe stowages of catches

The Maritime and Coastguard Agency is recommended to issue guidance to industry emphasising the need to stow catches in the fish hold securely to prevent them shifting at sea. [4.2.11]

MCA accepted this recommendation and has implemented it. Comments received from the MCA are as follows:

Phase 1: In January 2005, MGN 281(F) and the recommended format for freeboard and stability information were issued; the MGN and book had been developed and approved by FISG Stability sub-group. The new format provides guidance and Instructions to the skipper on the need for catches to be securely stowed.

Phase 2: MCA is to issue guidance to industry on stowage of catches in the fish hold. The Fishing Vessels Stability Working Group of FISG is addressing simplified guidance on stability and stowage of catches will feature in this.

5.2.2 Bilge suction strainers

The Maritime and Coastguard Agency is recommended to review, and revise as necessary, the guidance to industry and surveyors regarding the accessibility of bilge suction strainers in fish rooms. [4.2.5]

MCA accepted this recommendation and has implemented it. Comments received from the MCA are as follows:

Bilge pumping systems have already been considered in detail, by MCA and the fishing industry, during the development of new requirements for fishing vessels (in the form of a Fishing Vessel Code). This Code requires that:-

1. All bilge suctions should be fitted with readily accessible strainers;
2. New vessels should be fitted with duplicate bilge systems;
3. Bilge pump (main and reserve) facilities should be increased.

Additionally, Guidance for Survey and Inspections of Fishing Vessels is currently being developed and this includes guidance and clarification on bilge pumping system requirements for both new and existing vessels.

5.2.3 Guidance on watertight integrity

The Maritime and Coastguard Agency is recommended to issue guidance to industry and fishermen's training colleges about watertight integrity, capsize avoidance and the role of watertight bulkheads on fishing vessels. [4.2.10]

MCA accepted this recommendation and has implemented it. Comments received from the MCA are as follows:

The first element was achieved and completed in November 2001 in the form of the "Beam Trawler" video. As regards the second element, it is considered that this can be closed as this course is advanced in its development and control was passed to SEAFISH and the FISG Training Group to deliver the course to Industry.

5.2.4 Seawater pumps and ejectors

The Maritime and Coastguard Agency is recommended to issue guidance to the industry and surveyors regarding acceptance of seawater pumps in combination with bilge ejectors. [4.2.7 / 4.2.8]

MCA accepted this recommendation and has implemented it. The following comment was received:

The new Code requires that bilge ejector pumps, on new and existing vessels, are not accepted as 'power driven pumps'. They will only be accepted when fitted in addition to the minimum requirements stipulated in the Code.

5.2.5 MCA inspections of fishing vessels

The Maritime and Coastguard Agency is recommended to review its policy for the inspection of fishing vessels over 15 metres length overall, to assess their effectiveness in maintaining safety standards between the full surveys for the renewal of UKFVCs; intermediate survey requirements should be implemented. [4.2.22]

MCA accepted this recommendation and has implemented it. The following comments were received:

For the fishing vessels of length between 15 and 24 metres, MCA reviewed its policy of fishing vessel inspections and established a programme of stand-alone intermediate inspections on these vessels. These are carried out separately from surveys.

The Code also requires:

- a certificate renewal survey every 5 years;
- surveys during major repairs or modifications;
- an inspection not less than 24 months and not more than 36 months from the recorded date of the vessel's initial or previous renewal survey;
- annual self certification to ensure that:
  - all fire-fighting appliances, life saving appliances and safety equipment carried on board the vessel have been suitably maintained and are within date;
  - the radio equipment is functioning correctly;
  - the shipborne navigational equipment, nautical publications and lights, shapes and sound signal appliances, required to comply with the Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996, SI No. 75, are carried on board and are functioning correctly;
  - the risk assessment (section 6.1.2 of the Code) remains appropriate to the vessel's fishing method and mode of operation;
  - no known alteration, damage or deterioration to the vessel or her equipment has occurred in service which would affect the vessel's compliance with the requirements of the Code or the vessel's stability;
  - weathertight doors and hatches are functioning correctly; and
  - crew training and certification are valid.

For fishing vessels of 24 metres and over there is a similar regular survey regime introduced by the *Fishing Vessels (EC Directive on Harmonised Safety Regime) Regulations 1999*, which implemented the Torremolinos Convention requirements. This requires:

- a certificate renewal every 4 years;
- annual surveys of radio equipment;
- a survey every 2 years;
- a survey following major repairs and no alterations may be made without the sanction of the MCA.

5.2.6 Safety audits

The Maritime and Coastguard Agency is recommended to enhance safety audits on fishing vessel employers to ensure that compliance with the Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 is achieved throughout the industry. [4.2.19]

MCA accepted this recommendation and has implemented it. The following comment was received:

> It is the employer's responsibility to ensure that a risk assessment, in accordance with the *Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997*, is carried out. The MCA will, during survey and inspections, confirm that the employer has implemented this requirement. This is not just a paper exercise and MCA surveyors are given advice about digging deeper to verify that owners understand the risks and the need to take appropriate measures to prevent or reduce them to acceptable levels. This can include surveyors asking the crew questions, giving safety briefings and highlighting current issues such as those learned from the *Solway Harvester* investigation.

5.2.7 Standard letter accompanying approved UKFVCs

The Maritime and Coastguard Agency is recommended to revise the standard letter accompanying approved UKFVCs to show that changes could not only invalidate the certificate but also seriously endanger the safety of the vessel and her crew. [4.2.21]

MCA accepted this recommendation and has implemented it and provided the following comment:

> The new Code introduces annual self-certification by the owner of the vessel, this process requires the owner to make a declaration confirming that no alteration, damage or deterioration to the vessel has occurred in service.
>
> The standard letter that accompanies a UKFVC has been modified in line with the above recommendation.

5.2.8 Unnotified changes to fishing vessels

The Maritime and Coastguard Agency is recommended to review its policy for dealing with cases where surveyors discover that substantial changes have been made to a fishing vessel, which could endanger the vessel, and which have not been notified to MCA. [4.2.21]

MCA accepted this recommendation and has implemented it. The following comment was provided:

The Code allows the MCA to cancel a vessel's certificate (UKFVC) if the vessel has been significantly modified or changed her mode of fishing without due authorisation.

This is in addition to existing powers available to surveyors, such as detention and the issue of Prohibition and Improvement Notices.

5.2.9 Flush deck scuttles

The Maritime and Coastguard Agency is recommended to issue guidance to industry and surveyors regarding the restrictions in the approved use of flush deck scuttles on fishing vessels.

The Maritime and Coastguard Agency is recommended to amend the Fishing Vessel Safety Regulations to ensure that the use of flush deck scuttles is more tightly controlled, and to phase out their use at sea as quickly as possible. [4.2.1 / 4.2.2]

MCA accepted both these recommendations and has implemented them.

MCA comment:

The fitting and retention of flush deck scuttles was discussed at a recent Fishing Vessel Seminar. An inspection campaign was undertaken on vessels similar to *Solway Harvester*. This resulted in the detention of two vessels in February 2000 for safety related deficiencies. During the financial year 2003/04, the MCA undertook 128 targeted inspections on vessels between 15 and 24m in length. This was out of a total of 362 inspections conducted on vessels of this size. Surveyors are continuing to check these items and ensure owners fit coamings where possible, or remove scuttles if no longer required.

5.2.10 Risk assessment

The Maritime and Coastguard Agency is recommended to review and clarify the guidance on the application of the Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 in respect to risk assessment on the safety of the vessel. [4.2.20]

MCA accepted this recommendation and has implemented it.

MCA comment:

A Risk Assessment Working Group was established under the chairmanship of Seafish to review the contents of the risk assessment folder. This resulted in the issue of a revised colour-coded *Fishing Vessel Safety Folder* in April 2004.

The MCA took into account the recommendations of this group when reviewing and clarifying the guidance provided in *Marine Guidance Note (MGN) 20(M+F)*, and the implementation of *EC Directive 89/391 - Merchant Shipping*, especially in relation to risk assessment on the stability of the vessel.

5.2.11 "New" buoyancy

The Maritime and Coastguard Agency is recommended to review, and revise as necessary, the guidance on the criteria for assessing the acceptability of 'new' buoyancy before approving revised stability books. [4.2.13]

MCA accepted this action. The recommendation is still to be progressed for the following reasons:

During the revision of *Guidance for Survey and Inspections*, which is programmed to be completed at the end of October 2006, MCA will review and revise the guidance on the criteria for assessing the acceptability of "new" buoyancy before approving revised stability books.

5.2.12 Survey of remedial work

The Maritime and Coastguard Agency is recommended to review its policy on the survey of remedial work and, if necessary, revise its guidance to surveyors to ensure that critical items are resurveyed. [4.2.13]

MCA accepted action. The recommendation is still to be progressed for the following reasons:

During the revision of *Guidance for Survey and Inspections*, which is programmed to be completed at the end of October 2006, the MCA will review its policy on the survey of remedial work and issue appropriate guidance.

5.2.13 Fishing vessel design

The Maritime and Coastguard Agency is recommended to consider a research project to investigate whether the trend in modern fishing vessel design towards lower length to breadth ratios is exposing them to an increased risk of capsize in the event of fish room flooding. [4.2.10]

MCA accepted this action. The recommendation is still to be progressed as follows:

A project (RP557) *Suitability of stability criteria applied to small fishing vessels and associated survivability* on this has just started (October 2005). It is programmed to last no longer than 3 months.

5.2.14 Access to seawater inlet valves

The Maritime and Coastguard Agency is recommended to issue guidance to the industry and surveyors on remote access to seawater inlet valves in shaft tunnels. [4.2.9]

MCA accepted action. It is still to be progressed for the following reasons:

The Code specifies that all seawater inlets, scuppers or discharges should have positive means of closure from an accessible position.

The Code additionally requires that in machinery spaces, provision should be made for closing seawater inlets and discharges from above floor plate level.

The MCA will reflect above, with specific reference to shaft tunnels included, during the revision of *Guidance for Survey and Inspections*, which is programmed to be completed at the end of October 2006.

5.2.15 Sea Fish Industry's Authority and Fishermen's Federations and Associations

The following recommendation was addressed jointly to the Sea Fish Industry's Authority and Fishermen's Federations/Associations:

Make it easier for fishing vessel owners to meet their obligations on safety training by examining ways of ensuring it is made readily available to all fishing communities throughout the UK.

Seafish comment:

Seafish secured a £3.5m FIFG and Departmental funding package to deliver a three-year programme of free safety training to fishermen throughout the UK. This programme was extended to a fourth year and came to a conclusion on 31 March 2005. During this time, Seafish has delivered training in safety awareness and accident prevention to over 10,500 fishermen. In addition, free basic safety training has been provided to over 3,500 new entrants who joined the fishing industry during this period and over 2,250 older fishermen who were exempt from the requirement to undertake basic safety training. On 01 January 2005, the Maritime & Coastguard Agency introduced an amendment to the Fishing Vessels (Safety Training) Regulations 1989, requiring all fishermen to attend safety awareness training, all new entrants to attend basic health & safety training and removing the exemption from basic safety training for fishermen born before 01 March 1954. Seafish has secured additional FIFG and Departmental funding to continue the provision of free basic safety training to new entrants and has developed a new course on stability awareness, which it intends to start delivering UK-wide in October 2005.

5.3 GENERAL RECOMMENDATION TO INDUSTRY

General safety recommendations were issued in June 2003 to every owner of a fishing vessel. At the time these were issued, there was not a formal requirement for recipients of MAIB recommendations to provide feedback on how/if these were to be implemented[1]. Accordingly, the status of these recommendations is not known. The recommendations were addressed to fishing vessel owners and skippers and to fishermen's federations / associations in the *Summary Report* published in June 2003 (see **Annex 2**).

- Engage a suitably qualified marine safety expert to undertake a comprehensive review of safety management throughout the company. The aim should be to produce an effective safety management system for its vessels and crews.
- Ensure that any crew member employed on any of its vessels has attended the three mandatory short safety courses in first-aid, survival and fire-fighting.
- Inspect vessels in its fleet to ensure the protective grid over the fish room slush wells are in working order. The company should also ensure that its skippers and mates fully understand the importance and function of these items.
- Revise the arrangement on any vessel in its fleet, so that either the bilge suction strainers in the fish room are easily accessible or vessels are equipped with portable diesel-driven salvage pumps.
- Review the operations of its vessels with regard to the stowage of spare gear and fishing gear to ensure that these items can be properly secured against movement, and issue the appropriate instructions to its skippers in this regard.
- Review its stores policy, in the light of its risk assessments, to ensure spares for critical safety equipment such as bilge alarm sensors, are readily available.
- Equip the fish rooms of their vessels with bilge alarms and large volume shaft tunnels.

[1]The Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 came into force in April 2005. Regulation 15(4) requires any person to whom a recommendation is addressed, to provide feedback within 28 days

5.5 STABILITY AWARENESS TRAINING

A common theme to the loss of *Solway Harvester* and many other fishing vessels which have been the subject of MAIB investigations, is the perception that fishermen have an insufficient knowledge of stability and the factors that can lead to the capsize of fishing vessels. While this issue continues to give cause for concern, corrective action is in place, or is due to be implemented which should help to improve the training and awareness of fishermen in this area. Measures that have been taken since the loss of *Solway Harvester* are as follows:

- The publication by the MCA of the video 'Level Headed' aimed primarily at beam trawlers, this video raises awareness of stability issues and what can be done to avoid accidents.

- The MCA issued MGN 281, which included details of a revised stability book format, and included updated and expanded working instructions for skippers.

- The MCA commissioned a pilot project on stability awareness training, which uses a model fishing boat to demonstrate the effects of flooding and top weight on stability.

- The MCA has issued 'Safety Check Before You Sail' cards to all fishing vessels over 15m LOA. The card includes checks on items that can affect vessel stability.

Measures currently being developed are as follows:

- The FTAG/FISG stability groups are working on the creation and delivery of a stability awareness course aimed at all fishermen.

- The MCA has embarked on a research project (Project 560) to produce simple wheelhouse guides to stability.

As a consequence of the foregoing, no specific recommendation on the provision of stability awareness and/or training has been made in this report.

SECTION 6 - RECOMMENDATIONS

In the light of the recommendations already made in the MAIB Safety Bulletin 1/2000 and the MAIB Summary Report, no further recommendations are considered necessary.

Marine Accident Investigation Branch
January 2006

Safety recommendations shall in no case create a presumption of blame or liability