Report on the Investigation of

the Foundering of

mfv *AMBER ROSE* (B417)

off the Isle of Man

with the Loss of One Life

on 15 October 1998

Marine Accident Investigation Branch
First Floor, Carlton House
Carlton Place
Southampton
SO15 2DZ

Report No 24/2000

Extract from
The Merchant Shipping
(Accident Reporting and Investigation)
Regulations 1999

The fundamental purpose of investigating an accident under these regulations is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as it is necessary to achieve the fundamental purpose, to apportion blame.

CONTENTS

GLOSSARY OF ABBREVIATIONS AND TERM

GM	Metacentric Height
GZ	Righting lever measured between centre of gravity and the line of action of buoyancy force on hull
kg	kilogram
kW	kilowatt
l	litre(s)
m	metres
m^3	cubic metres
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MFV	Motor fishing vessel
MRSC	Maritime Rescue Sub-Centre
ROV	Remotely operated vehicle
rpm	revolutions per minute
RSW	Refrigerated seawater
RUC	Royal Ulster Constabulary
UK	United Kingdom
Ullage	The distance from the top of a tank to the surface of the liquid in the tank
UTC	Universal co-ordinated time

SYNOPSIS

On 15 October 1998 the Marine Accident Investigation Branch (MAIB) was notified that the fishing vessel *Amber Rose* had foundered off the Isle of Man that day and one man had not survived.

The investigation started straight away but had to be suspended on several occasions while waiting the results of an underwater survey carried out by the vessel's insurers. This was hampered by adverse weather and tidal conditions. Further delays to progressing the investigation were due to the conflicting demands on MAIB inspectors who were conducting several investigations at once.

Amber Rose and *Quiet Waters III*, two Northern Irish fishing vessels, were operating as partner vessels in pair pelagic trawling. Both had been fishing for herring on 15 October 1998 on the grounds to the east of the Isle of Man. After catching a large haul, it was decided to load it aboard *Amber Rose*. She would then head for Ardglass to land.

While *Quiet Waters III* headed for Portavogie, *Amber Rose* remained on the fishing grounds to load the catch. Having filled her three refrigerated seawater (RSW) tanks to capacity she left the remaining herring outboard in the trawl. This was eventually dumped prior to her getting underway. With loading complete, *Amber Rose* headed for Ardglass and set course to pass to the south of the Isle of Man.

During the passage *Amber Rose* capsized and sank in a position 1½ miles south of the Calf of Man. Weather conditions at the time were moderate with a force 5 to 6 south-westerly wind and swell.

The capsize was seen by an eyewitness ashore who raised the alarm.

Liverpool Maritime Rescue Sub-Centre (MRSC) conducted a search and rescue operation during which five members of the crew who had escaped from the sinking vessel, were recovered. They were able to board an inflatable liferaft which had been automatically released when *Amber Rose* sank.

The skipper failed to survive the capsize and was trapped in the accommodation as the vessel sank. His body was recovered from the wreck four months later.

The most probable cause of the capsize and sinking of *Amber Rose* was undetected flooding of the forward spaces.

Contributory causes were: the failure of the bilge alarm in the RSW tank space, overloading of the vessel, the failure to have the vessel's stability re-calculated after substantial modifications and not having the vessel re-inclined after a refit in Buckie.

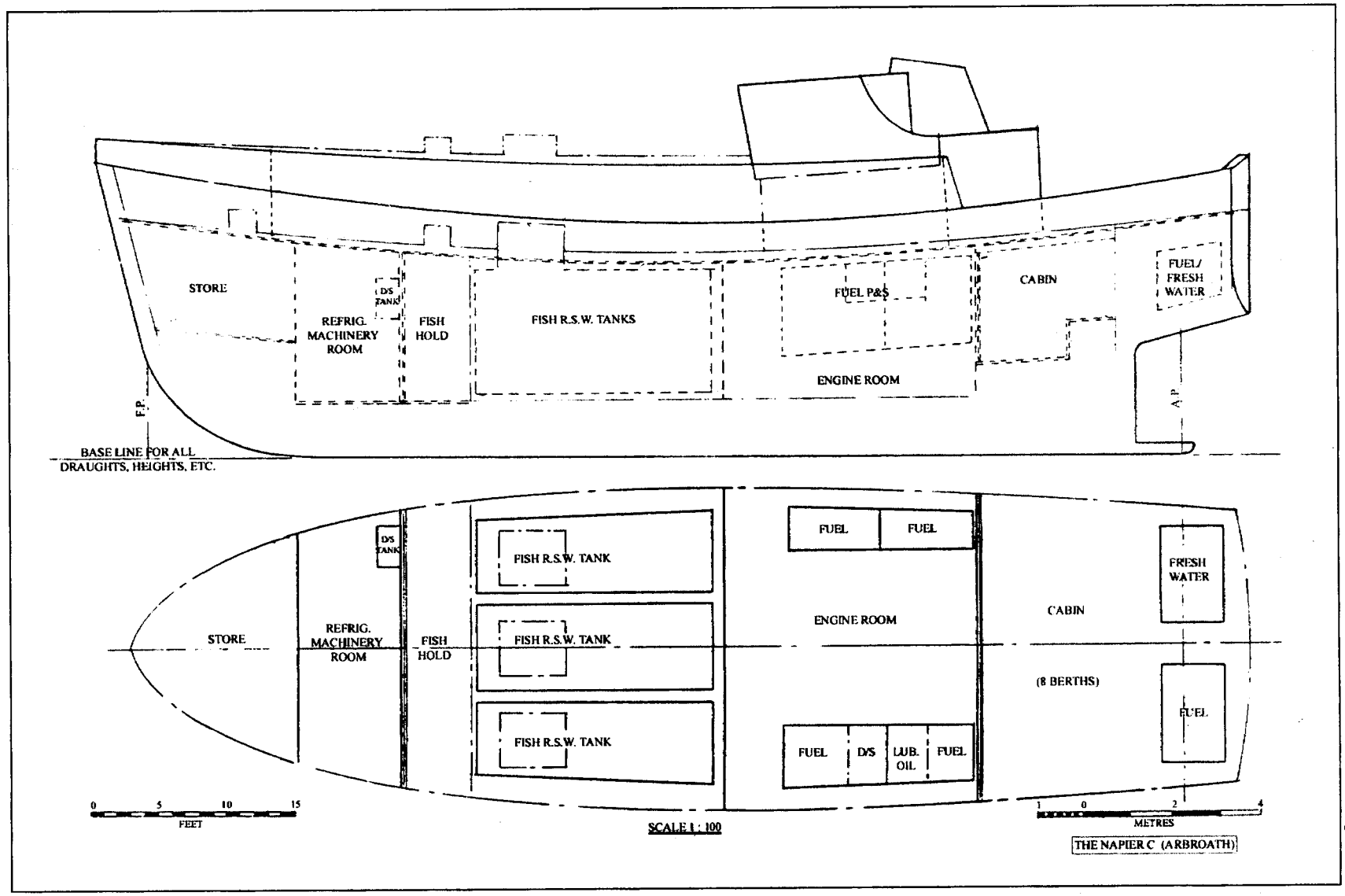
The investigation has resulted in three recommendations to the Maritime and Coastguard Agency (MCA) covering: detention procedures, improving fishermen's awareness and understanding of stability, and the reliability and maintainability of bilge alarms.

VESSEL AND ACCIDENT PARTICULARS

Name	:	*Amber Rose* **(Figure 1)**
Type	:	Fishing Vessel (Pelagic Trawler)
Port of Registry	:	Belfast
Fishing Number	:	B 417
Built	:	1979 J&G Forbes Boatbuilders, Sandhaven, Fraserburgh, Aberdeenshire
Construction	:	Wood
Owner	:	Mr T T Hughes 3 Newtownards Road, Donaghdee, Co Down, N Ireland
Gross Tonnage	:	90.44
Length Overall	:	26.33m
Length Registered	:	23.88m (measured to ITC69)
Breadth	:	7.46m
Depth	:	3.32m
Propulsion	:	Caterpillar 3508 (634kW) Single Screw Shaft
Crew	:	Six
UK Fishing Vessel Certificate	: :	Issued November 1996 Expiry November 1999
Position of Accident	:	54° 02'N, 004° 47'W
Date and Time	:	15 October 1998, 1000 (UTC)
Injuries	:	1 Fatality
Damage	:	Total loss

Amber Rose after refit
(photograph courtesy of Buckie Shipyard)

Figure 1



Amber Rose - General arrangement

Figure 2

SECTION 1 - FACTUAL INFORMATION

1.1 Description of Vessel (Figure 2)

Amber Rose was built at the boatyard of Messrs J and G Forbes, Sandhaven, Fraserburgh, in 1979. Built of wood, the vessel incorporated one deck above the water line. The wheelhouse was situated aft of amidships, and the main deck was enclosed under a non-watertight three-quarter length shelterdeck.

The crew accommodation was situated below the main deck and aft. The engine room was forward of the accommodation space. Forward of this were the fishroom, refrigeration machinery space, and forepeak spaces. Permanent concrete ballast was installed between frame spaces beneath the main engine.

Incorporated into the main fishroom space were three steel RSW tanks with a total capacity of 80.4m^3. In June 1996, the port and starboard tanks were extended, increasing the total capacity to 87.3m^3.

The RSW tanks were fitted with independent hatch coamings and covers opening through on to the main deck. Each cover was fitted with air vents. Forward of the RSW tanks was the remainder of the fishroom space. This area was used as a conventional fishroom. The machinery for chilling the RSW tanks was housed in the refrigeration machinery space.

Amber Rose was equipped for demersal and pelagic trawling. The main trawl winch was situated forward on the main deck beneath the shelterdeck. A net drum was situated aft of the wheelhouse outside of the shelterdeck, and was fixed in a position 1.8m above the main deck aft.

Amber Rose held a valid UK fishing vessel certificate.

1.2 Bilge Pumping Arrangements

Amber Rose was fitted with the following bilge pumping arrangements:

1.	Fore-peak	Manual whale pump
2.	Refrigeration m/cy space	Manual whale pump
3.	Fishroom	Manual whale pump/main engine driven pump/auxiliary engine driven pump/submersible electrical bilge pump
4.	Engine room	Manual whale pump/main engine-driven pump auxiliary driven pump/submersible electrical bilge pump with bilge alarm system

Refrigeration machinery space, fishroom and engine room bilges were common to each other. Drainage holes had been drilled in both bulkheads approximately 0.6m above the bottom of the bilge to allow water to drain aft.

A submersible electrical bilge pump was fixed to the refrigeration machinery space/fish room bulkhead at a height roughly halfway between the bilge bottom and fish room flooring. A further submersible electrical bilge pump was fitted in the engine room. Both incorporated float switches and monitors connected to the pump, with a visual and audible alarm indicator fitted in the wheelhouse.

1.3 Background to the Voyage

Amber Rose was purchased by her skipper/owner in 1995. Previously named *Scottish Maid* (BF317), she replaced his previous vessel, also named *Amber Rose*.

The skipper/owner of *Amber Rose* had several years' experience in the fishing industry and was a well-known and respected figure in the fishing community of Northern Ireland.

Amber Rose normally operated with the same 6-man crew. The length of time spent at sea depended on the type of fishing she was engaged in. This was usually anywhere between 2-5 days, followed by a period in harbour.

The vessel had recently undergone a refit at Buckie Shipyard before returning to her home port of Portavogie on 25 September 1998.

Since her return she had spent two weeks semi-pelagic trawling for white fish before engaging in pair pelagic trawling for herring on the grounds off the Isle of Man with *Quiet Waters III*, another Portavogie fishing vessel.

Two days before the accident *Amber Rose* landed a small catch of approximately 12 tonnes of herring from the same fishing grounds. On this occasion only the port and starboard RSW tanks were used to store the catch, and it had not been necessary to use the centre tank.

1.4 The Crew

Amber Rose carried a crew of six. The *Fishing Vessels (Certification of Deck Officers and Engineer Officers) Regulations 1984*, required the vessel to carry at least one holder of a Class 2 (Fishing Vessel) Certificate of Competency.

The skipper, who had commanded the vessel since its purchase from her previous owners, was the holder of a (Second Hand Special) No 33218, issued June 1978. This is equivalent to a Class 2 (Limited) Fishing Vessel Certificate of Competency. The acting mate of the vessel was uncertificated, but was an experienced fisherman having been employed on the vessel since the skipper bought her. He had also worked with the skipper on his previous vessels.

Of the four remaining crew members, three had only recently joined the vessel and were young inexperienced fishermen. None had undergone any mandatory basic safety training.

1.5 Environmental Conditions

The weather reported at the time of the incident was a south-westerly wind of force 5 to 6 with a moderate south-westerly swell of 2 to 3m. The visibility was good.

1.6 Narrative of Events (all times are UTC)

With her partner vessel *Quiet Waters III, Amber Rose* sailed from Portavogie at 1800 on Wednesday 14 October 1998, bound for the herring grounds to the east of the Isle of Man.

Both vessels started fishing that evening and made the first haul at approximately 2300. *Quiet Waters III* took the pair trawl, but the catch was lost due to a burst net. At 0300 on Thursday 15 October, after the vessels detected further shoals of herring, the pair trawl was shot away again and both vessels began towing.

At approximately 0500 another haul was made, and it was decided that *Amber Rose* would take the pair trawl and catch on board. The catch was good. *Amber Rose*'s crew estimated it to be more than 90 tonnes of herring.

It was pumped aboard into the three RSW tanks using the vessel's water/fish separator pump. All three tanks were filled to the hatch coamings on the main deck level with additional herring still remaining outboard in the trawl.

The remainder of the catch was dumped back into the sea as *Amber Rose* was unable to transfer the remainder of the herring left in the trawl to her partner vessel. *Quiet Waters III* had already left the grounds to head back to Portavogie. The trawl was heaved aboard and loose herring on the main deck was collected into baskets and tipped into the RSW tanks. All three tanks were secured closed.

One crew member was instructed to start the seawater chilling machinery located forward in the refrigeration machinery space. The rest of the crew squared up on deck for the passage to Ardglass, where the catch would be landed.

The man operating the chilling machinery noticed that the refrigeration machinery space was dry. He had no cause to be concerned. Once the required temperature of the seawater in the RSW tanks had been reached, he made his way aft and turned in. With the exception of the designated watchkeeper, the rest of the crew were already in their bunks.

The skipper had told the watchkeeper, the mate, to proceed on a south-westerly course to pass south of the Chicken Rocks. He was then to alter course to the north-west towards Ardglass. The mate was also told to call one of the crew at 1000 to check the temperature of the seawater in the RSW tanks.

Steaming into the south-westerly wind and sea *Amber Rose* made good approximately 6 knots. She was not rolling unduly and there was nothing to give rise to any concerns about her safety. Everything appeared normal.

At 0955 the mate decided he would not call the crewmember until he had rounded the Chicken Rocks.

Shortly afterwards, course was altered from south-west to north-west. No sooner had he done so when *Amber Rose* took on a heavy list to starboard. He immediately eased back on the main engine and reduced from 1100 to 900 rpm and called the skipper on the talk-back system between the wheelhouse and the cabin.

The skipper was roused almost immediately, and on being informed of the problem instructed the mate to take the main engine out of gear. The mate did so, but the vessel continued to heel over. She capsized and became fully inverted. Her position at the time was 54° 02'N, 004° 47'W and the time very shortly after 1000.

The capsize was rapid. The mate only had time to tell the remainder of the crew via the talk-back system that the vessel was sinking before the wheelhouse was flooded. He just managed to escape through one of the port side windows.

The remaining crew, who had been asleep, were first awoken when the vessel took a heavy list to starboard. The next thing they remember was the skipper shouting for everybody to get up because the vessel was sinking. They began scrambling up the cabin ladder to the galley/messing area. As the seawater flooded in, one managed to open the aft accommodation door. With the exception of the skipper, they all managed to escape.

Once on the sea surface the survivors could see the up-turned hull of *Amber Rose* and shortly afterwards, saw her begin to sink by the head. They estimated the time from when they began abandoning ship until she sank, as approximately 2 to 3 minutes.

At 1003 a member of the public who witnessed *Amber Rose* in difficulties from the shore, raised the alarm by calling the emergency services.

The survivors eventually managed to climb aboard one of the liferafts that had been released and had inflated close by. Once in it they were able to set off some of the emergency flares and activate the onboard emergency position indicating radio beacon (EPIRB). This triggered an alert, which was received by MRSC Liverpool at 1004. A "Mayday" Relay was transmitted to vessels in the vicinity.

No transmissions were received from *Amber Rose*'s EPIRB when she sank.

At 1008 Port Erin lifeboat was launched and tasked to the scene while rescue helicopter R122 was tasked at 1018.

Port Erin lifeboat arrived in the vicinity of the accident at 1033 and recovered the survivors. Shortly afterwards they were transferred from the lifeboat to rescue helicopter R122 and taken to Nobles Hospital on the Isle of Man.

One crewman remained in hospital suffering from ingestion of fuel oil, but the others were discharged the same day and returned to their home port of Portavogie.

1.7 Eyewitness to the Accident

A member of the public driving from Castletown to Port Erin on the Isle of Man, saw *Amber Rose* at 0948. The vessel was east of the Calf of Man on a westerly heading.

He was a keen photographer and often photographed and recorded fishing vessels. On this occasion he was carrying a pair of binoculars with a magnification of 16 x 50.

A couple of minutes later he parked in a nearby lay-by to try to identify the vessel using his binoculars, but was unable to do so. He then decided to drive to the boating lake car park at Port St Mary, 2.5 miles away, to get a better view. There were no other vessels in the vicinity of the fishing vessel.

At 0955 he parked his car. Again, using his binoculars, he identified the vessel as having a "Scottish layout" with a white shelterdeck, aft wheelhouse, and a red transom stern. The vessel was still on a westerly course, and appeared to be heeled over to starboard with her starboard bow low in the water. He saw waves and spray being shipped over the shelterdeck.

On the starboard side of the vessel and aft of the foremast, he could distinguish a dark area and presumed she must have had a net outboard, as this was where this type of vessel normally had a cod-end hatch fitted. He also presumed this was why she was heeling over to starboard.

Shortly afterwards, the vessel appeared to come beam on to sea heeling heavily over on her starboard side, before eventually pivoting back to her original heading. At this point he became concerned for her safety, and decided to get a second opinion from the mechanic at the lifeboat station in Port St Mary.

It took him a couple of minutes to drive to the lifeboat station but on arrival found the mechanic was not there. He then decided to return to the car park to have another look at the vessel. As he entered the car park at 1001, he could just make out the shape of what later transpired to be *Amber Rose*, on the horizon. After parking the car, he used the binoculars to get a better view but, by now, the vessel had disappeared.

At 1003 he telephoned the coastguard, gave his position and reported what he had seen.

1.8 RSW Tanks (Extensions)

When the vessel was built, the three RSW tanks (one centre and two wing tanks, port and starboard) had a total capacity of 80.4m^3 including the hatch coamings. The centre tank had a capacity of 30.4 m^3 and each wing tank had a capacity of 25m^3.

In June 1996, the skipper/owner of *Amber Rose* commissioned John Kearney Ltd, boatbuilders of Annalong, Northern Ireland, to carry out work which was part of a major refurbishment which included re-engining the vessel. It involved extending the port and starboard wing tanks by 1.14m, thereby increasing the capacity of each tank to 28.4m^3. This increased the overall capacity of all three tanks to 87.3m^3, including the hatch coamings.

Form FV10 (A Statement by the Owner of a Fishing Vessel), which is in the vessel's stability data booklet, has the following footnote: "Should any alterations be made in the vessel's permanent structure or equipment so as to affect its watertight or weathertight integrity, or in the amount or disposition of the vessel's weight, the Department of Trade (now MCA) should be notified, and the alteration recorded in the book".

Amber Rose's skipper/owner did not inform the MCA of the alterations to the RSW tanks. The stability data for the vessel was not, therefore, modified.

1.9 Vessel's Stability

Amber Rose had had full stability data prepared in accordance with *The Fishing Vessels (Safety Provisions) Rules 1975*, **(Annex 1)** which had been approved by the MCA.

She underwent a full inclining test on 30 April 1983 at Fraserburgh. The results of this test were used to compile a stability booklet which the MCA (then Surveyor General's Organisation) approved on 20 July 1983.

To meet the minimum stability criteria under *The Fishing Vessels (Safety Provisions) Rules 1975*, it was a requirement that when all three RSW tanks were in use, the space in the hatch coamings would be left empty, and the centre tank would have a minimum ullage of 500mm. This gave a maximum useable tank volume of 69.9m^3.

A roll period test was performed on 19 March 1992 at Fraserburgh as part of the vessel's survey for renewal of her United Kingdom Fishing Vessel (UKFV) Certificate. The GM calculated from this test was 0.59m.

A further roll period test in the same loaded condition was performed at Portavogie on 9 August 1996, again as part of the vessel's survey for renewal of her UKFV Certificate. The GM calculated was 0.59m. However, the surveyor conducting the test was unaware that the port and starboard RSW tanks had been extended. No freeboard measurements were taken, so the additional weight due to the construction of the tank extensions was unlikely to have been detected.

1.10 RSW Tanks (Condition)

During the construction of the port and starboard wing tank extensions carried out by John Kearney Ltd in June 1996, all three RSW tanks were found to be in a very good condition.

Constructed of 7mm steel throughout, there appeared to be no signs of deterioration or weakness in the plating or welding.

The tank extensions were also constructed from 7mm steel, and the work was undertaken by coded welders with no financial constraint from the skipper/owner of the vessel. It is estimated that the tank extensions weighed about 2.3 tonnes.

1.11 Vessel's Refit (Buckie Shipyard)

On 17 September 1998, *Amber Rose* underwent an extensive refit at Buckie Shipyard Limited.

The following work was included during the refit:

1. A double-barrel trawl winch (weight 4250kg), positioned forward on the port side of the main deck, was replaced with a triple-barrel trawl winch (weight 5400kg), positioned forward, athwartships on the centre line of the main deck.

2. A split net drum (weight 3000kg), positioned aft on the starboard side at a height of 0.8m above the main deck, was replaced with a new split net drum (weight 3300kg), positioned aft athwartships on the centre line at a height of 1.8m above the main deck.

3. A hydraulic oil tank (capacity 1000 l), which was amidships on the starboard side of the main deck and 4m above the keel, was replaced with one of 1600 l capacity in the engine room and 2.3m above the keel.

4. Replacement auxiliary engines of the same weight as the original ones, were fitted on the original engine beds.

5. The refrigeration compressor was replaced by one of the same weight and fitted in the same place.

Extra ballast was installed after a meeting between the shipyard and the skipper concerning the starboard list the vessel had before she arrived at Buckie.

Ballast of 3.080 tonnes was installed in the unused fuel tank, positioned aft above the steering flat. Additional ballast of 2.480 tonnes was installed in the engine room.

The work was completed on 23 September 1998, and the skipper/owner of *Amber Rose* was advised by Buckie Shipyard Limited to have the vessel re-inclined so that new stability data could be produced.

Buckie Shipyard's advice to the skipper was declined on the grounds that the new equipment fitted to the vessel was replacing the old equipment taken off. In the skipper's opinion it was "like for like", and on this basis he felt it unnecessary to have her re-inclined.

1.12 Maritime and Coastguard Agency

On 23 September 1998, an MCA surveyor making a routine visit to the port of Buckie, saw *Amber Rose* lying alongside in the harbour. Noticing that extensive alterations had been made, he decided to carry out a routine inspection.

A report of the inspection, which listed six defects and noted the possibility that she would need to be re-inclined, was issued to the skipper.

The matter was further discussed with the MCA principal fishing vessel surveyor when the surveyor returned to Aberdeen. It was then felt that due to the extensive modifications carried out to the vessel, it would be necessary to carry out an inclining experiment to ensure she still met the stability requirements of *The Fishing Vessels (Safety Provisions) Rules 1975* **(Annex 1)**.

On 24 September, a letter was sent to the skipper of *Amber Rose* instructing him to have the vessel re-inclined. He was instructed to make arrangements with a competent naval architect to have the work done, and to inform the MCA of the arrangements so that a surveyor could attend the experiment.

On the vessel's arrival at Portavogie, a visiting MCA surveyor from Belfast stressed the importance to the skipper of having her re-inclined.

During the intervening three weeks the MCA received no reply to the letter, and *Amber Rose*'s skipper made no arrangements to have the vessel re-inclined.

1.13 Repairs to RSW Pipework

On 12 October 1998, 2 days before *Amber Rose*'s final voyage, a local contractor in Portavogie repaired some of the RSW pipework situated in the refrigeration machinery space.

The pipework in question was located in the valve chest area and was holed to a diameter of approximately 10mm.

The skipper was advised by the contractor to have the damaged section of pipe removed and replaced. However, when the skipper learned that the work could not be completed before the following day, he insisted on a temporary repair being made by welding a patch over the damaged area.

The contractor tried to weld a patch in place, but discovered the surrounding area was too thin to weld. This was reported to the skipper. Because the time needed to replace the damaged pipe was too long, the skipper instructed the contractor to apply a chemical metal solution which he had to hand on board.

The contractor reluctantly applied the solution to the damaged pipework and then advised the skipper to keep a regular check on the repair.

1.14 Underwater Survey of the Wreck (1)

On 31 October, just over two weeks after the accident, employees from the Industrial Research and Technology Unit of Lisburn made a voluntary underwater survey of the wreck on behalf of the skipper's family. The skipper and crew of the fishery protection vessel, *Ken Vickers* helped. Also in attendance were volunteer divers from the Royal Ulster Constabulary (RUC).

The purpose of the survey was to establish the orientation and accessibility of the wreck so the skipper's body could be retrieved at a later date.

Due to the difficulties *Ken Vickers* had in remaining stationary above the wreck, and the strength of the tide in the area, only a limited amount of video footage was obtainable.

Although the video footage was of limited value in establishing the cause of the accident, it did show that the entrance to the galley/accommodation area was clear of debris, and that it would be possible for divers to retrieve the body of the skipper.

Four months later, volunteer divers retrieved the body of the skipper from the wreck.

1.15 Underwater Survey of the Wreck (2)

On 3 and 4 September 1999, nearly a year later, the insurers of the vessel commissioned a remotely operated vehicle (ROV) underwater survey to try and establish the cause of her loss.

The survey was carried out by DSND Subsea Ltd, under contract to Hulltech. They had been instructed by the vessel's insurers. J H Macilwaine and Son, marine surveyors, supervised the operation on behalf of the insurers. The survey was conducted onboard the fishing vessel *Heather Maid* CT81.

Three dives were carried out during the slack water periods, to minimise the effect of tidal current. Each dive lasted for approximately 45 minutes. A survey of the outside of *Amber Rose* 's hull and the surrounding seabed was undertaken. Access to the deck area under the shelterdeck of the vessel was restricted.

The wreck was confirmed to be lying in position 54° 00.85'N 004° 50.09'W. It was heeled 25° to starboard, lying NE/SW.

The angle of heel gave easy access to the port side of the undamaged hull. The seabed obscured a proportion of the starboard side of the hull, but the part that was visible on the starboard side was also undamaged.

Not all the scupper openings (freeing ports) were seen; those that were appeared to be unobstructed on both the port and starboard sides.

The propeller and rudder were undamaged. The rudder was turned to starboard.

The large landing hatch, which ran transversely across the top of the shelterdeck, was missing.

The access hatch to the shelterdeck was open.

One of the wheelhouse windows on the port side was half-open. It was not possible to carry out a visual inspection of the interior of the wheelhouse, or of the vessel's controls.

The water/fish separator was sitting half over the aft coaming of the landing hatch opening, skewed to a point slightly to starboard of the centre line.

The fish pump was displaced on top of the shelterdeck in way of the landing hatch opening. The rubber piping from the pump led over the starboard side in a loop. It then ran back on top of the shelter where it hung down through the landing hatch opening into the space beneath. The hydraulic extension hose, which ran to the suction end of the pump, was lying on the seabed close to the starboard side of the hull.

The centre and port trawl wire spurling pipes on top of the shelterdeck were empty. The starboard one contained the trawl warp which led over the top of the starboard guardrails and disappeared into the seabed. The trawl wire was traced along the seabed to the spliced eye on the end of the wire. There was nothing attached.

The starboard net drum contained a pelagic pair trawl. The port net drum was empty, apart from the nylon dog rope used in hauling the trawl on to the starboard drum.

The loading hatches on the starboard and centre RSW tanks were open. The one on the port tank was closed. The hatch cover on the starboard RSW tank was displaced slightly to starboard. There was no sign of their contents.

1.16 Model Tests

The consultation on the draft MAIB report highlighted a lack of knowledge on how low *Amber Rose*'s stability had fallen before she capsized in the sea conditions prevailing on 15 October 1998. In response to this, model tests were commissioned with the Wolfson Unit of the University of Southampton to investigate a number of factors commonly associated with capsize to determine which was the most likely. The following factors were examined: overloading, a high centre of gravity, entrapped water on the main deck, and flooding.

In all cases the model was stationary and beam on to waves which were representative of the prevailing sea conditions on the day of the accident. The model was 1/17 scale. To save time and cost an existing fishing vessel model was modified to the dimensions and upper deck layout of *Amber Rose*. So while the model's hull form was slightly different to that of *Amber Rose*, and had less displacement for a given draught, it was close enough to produce valid results. The tests were carried out for one basic condition of loading, condition D of the draft MAIB report.

The report on the model tests is at **Annex 7** with condition D shown in **Appendix 1** to **Annex 7** (the MAIB added the appendices to **Annex 7**).

SECTION 2 - ANALYSIS

2.1 General

There has been much speculation as to why *Amber Rose* capsized and foundered. Nearly a year elapsed before the insurers were able to conduct a satisfactory underwater ROV survey after several previous attempts were aborted due to bad weather, strong tides and the depth of water for diving operations. The delays have only added to the speculation.

MAIB inspectors have gathered evidence from all those connected with the vessel and have examined the results of the underwater survey. This has enabled them to identify the likely cause of the loss.

At the time of capsize the entire crew were asleep apart from the watchkeeper in the wheelhouse. By all accounts the passage from the fishing ground was, until the moment *Amber Rose* began to heel, entirely normal. The mate who was on watch heard no alarms, and had no indication of any flooding.

The only independent eyewitness to the accident was on land, some 2.5 miles away. He viewed the vessel through powerful binoculars for some minutes and observed, crucially, that she was down by the head.

MAIB inspectors considered a number of possible causes for *Amber Rose*'s loss and these have been looked at during the investigation. Conclusions drawn, and the reasons for discounting those considered most unlikely, are presented in this analysis.

2.2 Maritime and Coastguard Agency

After *Amber Rose* was inspected in Buckie on 23 September 1998, and extensive alterations were found to have been made, the MCA surveyor involved decided on return to his Aberdeen office, to request the skipper to incline the vessel. A letter was sent to the owner requesting him to do so. The surveyor could have decided, or been instructed, to return to Buckie and detain the vessel as an alternative course of action

MCA fishing vessel surveyors try to work with vessel operators on the basis of mutual respect and co-operation. In the majority of cases such an arrangement produces satisfactory results. Sometimes, as in this case, co-operation by the operator is not forthcoming. The request to comply with a written request was ineffective. It was made in the full expectation that the owner, a qualified and experienced skipper, would have acted upon it immediately - given the potential consequences of sailing with inadequate stability.

MCA's actions were entirely reasonable in the circumstances, but it would be appropriate for it to review its criteria for the detention of fishing vessels if doubt exists about their stability.

Without the co-operation of fishing vessel owners and skippers, the MCA cannot effectively discharge its duty to ensure that registered fishing vessels comply with the safety regulations. For the crew's own safety, MCA should be notified of modifications to vessels. It is MCA's

surveyors, not fishing vessel skippers and owners, who have the expertise to gauge the impact modifications will have on stability.

2.3 Underwater Survey (Findings)

The large landing hatch that ran transversely across the top of the shelterdeck and was found to be missing in the underwater survey, was probably displaced when the vessel capsized.

This hatch would have been in use every time *Amber Rose* landed her catch. The deck area under the shelter was non-watertight. It is therefore probable that the hatch was not fully secured once the last catch had been loaded. It was not secured sufficiently to remain in place when she capsized.

The open access hatch to the shelterdeck indicates that the hatch had probably been left down but unsecured. When she capsized the unsecured hatch fell open. It is known that because this hatch was used continually for access to the shelter deck both at sea and in port, it was rarely properly secured. The evidence suggests that this state prevailed at the time she capsized.

The hatch cover on the starboard RSW tank was displaced, and the loading hatches on both the centre and starboard tanks were open. It is unknown whether these hatches were fully secured down. If they had not been secured, the weight of the tank contents falling against the hatches when the vessel capsized, may have been a contributory factor to their having been found open.

Anchors dragged over the wreck by the survey vessels could have disturbed items on the top of the shelterdeck. This would account for the trawl warp leading over the starboard guardrail, the piping and the hydraulic hose from the fish pump on the seabed, and the displacement of the fish pump and water/fish separator on the shelterdeck.

The port side of the hull and the visible part of the starboard side were undamaged. This confirms, along with the evidence from the surviving crew members, that *Amber Rose* had not been involved in a collision.

2.4 Stability

Amber Rose's stability data booklet, approved by the Marine Safety Agency (MSA), was issued in 1983. It showed compliance with the minimum stability criteria in accordance with *The Fishing Vessels (Safety Provisions) Rules 1975* in all loaded conditions, which included departure from the fishing grounds with a full catch onboard **(Figure 3, curve A)**. However, there was a provision that when all three RSW tanks were in use, the volume contained within the hatch coamings was to be left empty and the ullage in the centre tank was not to be less than 500mm.

Amber Rose had undergone several changes which affected her stability. None of these changes had been notified to the MCA by the skipper/owner. Had this been done, new stability data would have been required by the MCA.

In 1996, both the port and starboard RSW tanks were extended, which increased the capacity of each tank to 28.4m^3. Although no significant change to the vessel's stability was detectable when the tanks were empty, a significant change would have been apparent when the tanks were loaded. In addition to this, during September 1998, the vessel underwent a major refit which involved several items on and below deck being replaced or repositioned. Extra permanent ballast was also installed. An estimate of the vessel's lightship weight following these modifications is in **Annex 2**.

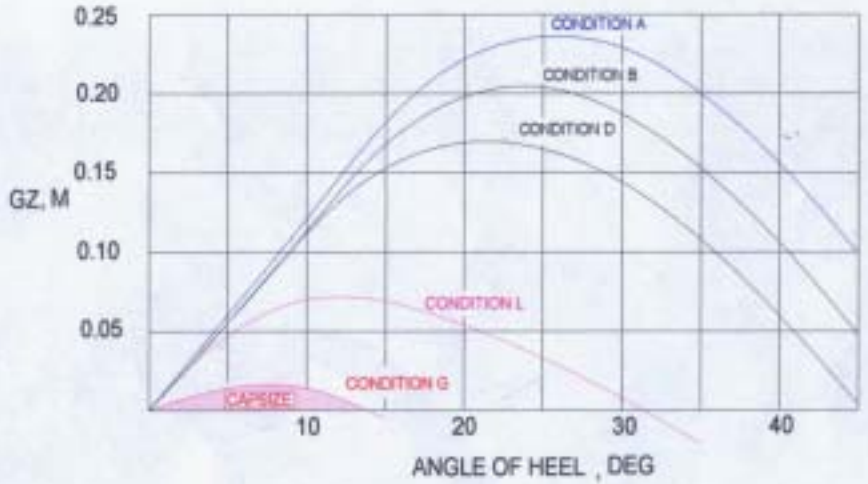
The net result was that when *Amber Rose* left Buckie shipyard she did not comply with the minimum stability criteria set out in her trim and stability booklet for the loading condition with a full catch **(Figure 3, curve B)**. With all three extended RSW tanks filled to the tops of their hatch coamings, *Amber Rose*'s stability was substantially below the requirements **(Figure 3, curve D and Annex 3)** - this is the vessel's estimated stability after stowing her catch on 15 October 1998.

The vessel's trim and stability booklet, approved by the Surveyor General's Organisation in July 1983, restricted the total weight of fish and water in the RSW tanks to 71.6 tonnes. It is estimated that when she capsized, *Amber Rose* was loaded with about 89 tonnes of fish and water, some 17 tonnes over the MCA approved safe carrying capacity. This would have substantially reduced her stability and freeboard.

The model tests showed that this reduction in the vessel's stability, in itself, would not have caused the vessel to capsize in the prevailing sea conditions.

Other possible causes for the capsize of the vessel were examined: rupturing an RSW tank, failure of RSW pipework, the bulk stowage of fish on deck, reduced initial stability due to a very high centre of gravity, entrapped water on the maindeck and undetected flooding.

STABILITY CURVES FOR VARIOUS CONDITIONS OF LOADING



CONDITION A - DEPART GROUNDS CONDITION IN APPROVED TRIM AND STABILITY BOOKLET

CONDITION B - DEPART GROUNDS CONDITION FOLLOWING THE RE-FIT IN BUCKIE

CONDITION D - AS CONDITION B WITH ALL 3 RSW TANKS COMPLETELY FULL

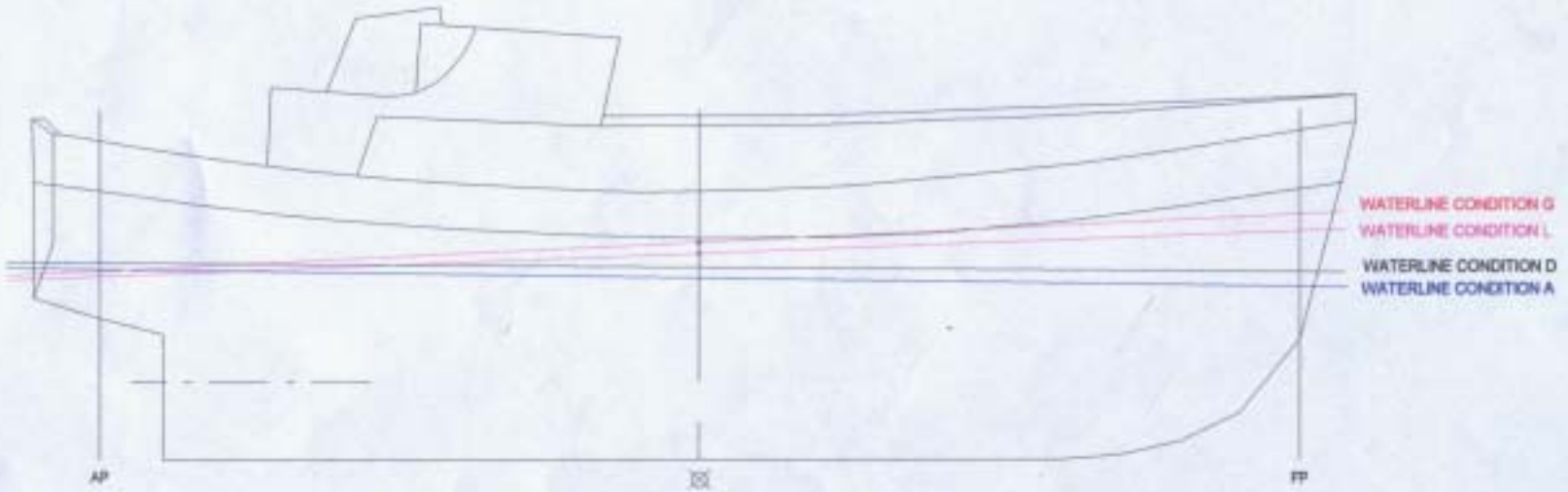
CONDITION G - AS CONDITION D WITH 69 TONNES OF FLOODING IN FWD SPACES

CONDITION L - AS CONDITION A WITH 69 TONNES OF FLOODING IN FWD SPACES

NOTE: FOR CONDITIONS B, D AND G THE LIGHTSHIP WEIGHT HAS BEEN REVISED TO REFLECT CHANGES MADE TO VESSEL

NOTE: CONSIDERATION OF CAPSIZE IS WHEN BEAM-ON TO WAVES IN THE CONDITIONS PREVAILING ON 15 OCTOBER 1998

WATERLINES IN VARIOUS LOADING CONDITIONS



2.5 Flooding (Rupturing of an RSW Tank)

The rupturing of the port RSW tank, and the release of its contents into the bilges, would have been enough to capsize *Amber Rose* to starboard.

It has been assessed that, initially, the RSW tanks were full to the top of the hatch coamings, and that 15% of their contents was seawater. The remainder would have been fish. The specific gravity of the tank contents has been taken as 1.025, the same as seawater.

The critical quantity to be lost from one of the RSW tanks is about 60% of its overall contents. After this point the developing list would become an uncontrollable capsize. The possibility of the port RSW tank rupturing to the extent of depositing its fish content was considered to be most unlikely given the good condition of the tanks when the extensions were added.

The investigation concludes that the cause of capsize was unlikely to be because the port RSW tank ruptured.

2.6 Flooding (Failure of RSW pipework)

Following the repairs carried out to the RSW pipework two days before *Amber Rose*'s final voyage, the possibility of internal flooding due to the failure of this pipework has been considered.

The RSW tanks would have contained a maximum of 15% water content (13.4 tonnes) when the tanks were full. It is likely that a failure in the pipework would have allowed only the water content to escape from the RSW tanks. This would have caused a marginal reduction in stability, but would not have caused the loss of the vessel in the prevailing conditions. *Amber Rose* would still have maintained sufficient stability to prevent her from capsizing.

It is concluded that the cause of capsize was unlikely to have been a result of RSW pipework failure.

2.7 Bulk Stowage of Fish on Deck

Because many fishermen are reluctant to discard any part of their catch, consideration has been given to whether there was any bulk stowage of fish on deck.

Amber Rose would have been vulnerable to capsize in beam seas if, in addition to the three full RSW tanks, about 14 tonnes of loose fish was stowed on deck. The crew's estimate that there were more than 90 tonnes of herring in the trawl, could have left a surplus of approximately 14 tonnes once the RSW tanks had been filled. Had the crew decided to load this surplus, it could only have been stowed loose on deck.

However, there is no evidence that the fish, remaining in the trawl after all three RSW tanks were filled, was bulk stowed on deck.

There would have been no advantage to bulk stowing fish on deck. The price of herring is fully dependent on the quality of the fish on arrival at market. This quality is maintained by the use of RSW tanks. Any herring stowed on deck would have had little or no market value.

It is concluded that the bulk stowage of fish on deck did not occur and was not therefore a factor in the capsize.

2.8 A High Centre of Gravity

Could the extensive refit carried out to the vessel in Buckie, for which no stability assessment was made, have raised the vessel's centre of gravity causing her to capsize when fully laden and rolling in beam seas? Model tests showed that this was not the case.

The model's centre of gravity was raised in three stages, reducing GM from 0.63m to 0.14m (full size). The shift in the vertical centre of gravity was achieved by moving weights on the model without adding additional weights, so the freeboard remained unchanged. At no time was the model near to capsize. The reduction in GM increased the roll period of the model (the two parameters are inextricably linked) so that the short period waves typical of the Irish Sea had less effect and could not excite dangerous rolling.

The reduction in GM achieved on the model was the equivalent on the full size vessel of moving about 45 tonnes (slightly less than one fifth of the vessel's lightship weight) from the bilges onto the main deck. This wholly unrealistic weight shift showed that the cause of the capsize was not due to this mechanism. The stability data for the final condition is shown in **Appendix 2** to **Annex 7**.

2.9 Entrapped Water on the Main Deck

Sealing the freeing ports on the model and pouring first 10 tonnes, then 20 tonnes into the shelter tested the effect of entrapped water on the main deck. Although the model took up a slight angle of loll, a capsize could not occur in the prevailing sea conditions. The stability data for the final condition is shown in **Appendix 3** to **Annex 7**.

2.10 Undetected Bilge Flooding

Flooding in one compartment could have spread throughout the length of the vessel once the height of floodwater exceeded 0.6m because of drainage penetrations in the main bulkheads. However, it was not unknown for the drain holes to choke and for the water to accumulate in the forward spaces.

The model tests showed that when extensive flooding had lowered the amidships freeboard of the vessel to about 0.1m, with the consequent reduction in the maximum righting lever to less than 0.02m and the range of positive stability to about 11° of heel, the vessel capsized. The capsize was very much as the survivors described it - an initial list which gradually worsened to the point when the model rolled over completely with her keel uppermost.

On the basis of the model test results, and the consideration of other possible causes, it is concluded that the most likely cause of the loss of *Amber Rose* was substantial, undetected flooding.

The quantity of floodwater which caused this effect in the model tests was calculated to be about 59 tonnes (full size) **(Appendix 4 to Annex 7)**. Because of the slight difference in hull form between the actual vessel, and the vessel used as the basis for the model, the equivalent weight of floodwater for *Amber Rose* would have been about 69 tonnes (assuming the flooding was restricted to the forward spaces).

The precise location and cause of the flooding is unknown, but some possibilities can be eliminated. A leak from the main engine seawater cooling system can be discounted because not only did the main engine keep running, but no warning lights on the engine control panel illuminated. It is most unlikely that the flooding originated in the engine room for the same reasons.

The port side of the hull was examined closely during the underwater surveys and with no evidence of damage or source of a leak, can be discounted as the source of a major leak.

This suggests that the flooding began in one of the forward spaces, either in the refrigeration machinery space or the RSW tank space. From there flooding may have spread aft into the engine room. Because it could only spread aft through drain holes in the bulkheads, it is likely that the floodwater forward would have been deeper than in the engine room, but this cannot be quantified. The one eyewitness to the accident, observed from the shore, saw that *Amber Rose* was down by the bow. This supports the theory that the flooding was concentrated in the forward spaces.

Had the flooding spread freely aft to the engine room, about 88 tonnes of floodwater would have been required to reduce the stability curve to the point where a capsize would have occurred in the conditions prevailing on 11 October 1998 **(Annex 4)**. This flooding would have been about to a height of 2.0m deep spread equally through all three spaces. Not only would this have been above the bilge alarms in the engine and the RSW tank space, but would also have been nearing the top of the main engine. Flooding to this extent could not have gone unnoticed even in the remote event that the engine kept running. It is therefore concluded that the flooding was concentrated in the forward spaces; and that flooding of the engine room, if it did occur, was minimal and did not reach the level of the bilge alarm in that space.

Confining the flooding to the refrigeration machinery space and the RSW tank space, about 69 tonnes of water would have been needed to cause capsize **(Annex 5)**. This water would have been about 2.7m deep, certainly above the bilge alarm in the RSW tank space. From this it is concluded that this bilge alarm did not work for reasons unknown.

Although 2.7m of water forward would certainly have stopped the refrigeration machinery, there were no audible or visual alarms in the wheelhouse to alert the helmsman. The instrumentation for the refrigeration plant machinery was located inside a cupboard in the wheelhouse, and required someone to open it and inspect the instrument gauges. The normal practice on board was for someone to inspect the refrigeration machinery space periodically. The next inspection was due within minutes of the time at which the vessel capsized.

Whether the source of the flooding was a pipe failure, or a failure of the hull planking on the starboard side (which could not be fully examined), is unknown. It has not therefore been possible to identify the source of flooding or quantify the likely rate at which it occurred.

2.11 The Effects of Overloading

After she had hauled and stowed her last catch on 11 October 1998 *Amber Rose*'s displacement was about 355 tonnes, about 31 tonnes more than the heaviest loading condition for which approval had been given by the MCA. This reduced her minimum freeboard from 0.78m to 0.57m. This would have reduced her stability to below the required standard, and also have reduced the time it would take her to flood to the point of capsize.

It is believed *Amber Rose* capsized when the refrigeration machinery space and the RSW tank space became flooded with 69 tonnes of water. Had she not been overloaded and at her approved maximum displacement of 324 tonnes, 69 tonnes of floodwater would not have capsized her **(Annex 6 - condition L)** in the prevailing conditions. It would have taken about 91 tonnes to capsize her **(Annex 6 - condition M)** - about 30% more. So however long she took to flood with 69 tonnes of water she would probably have taken at least 30% longer to flood with 91 tonnes.

The mate had decided to call the crewman to check the temperature of the RSW tanks as soon as they had rounded the Chicken Rocks. As course had just been altered it is probable that had the vessel not been overloaded, the flooding would have been discovered before capsize occurred. It is impossible to say whether *Amber Rose* would have been saved had the flooding been discovered earlier, but it is highly probable the crew would have had longer to carry out a controlled evacuation, and the skipper might have survived.

2.12 Bilge Alarms

It is concluded the bilge alarm in the RSW tank space did not work. Had it done so, it is possible *Amber Rose* might have been saved, and probable that all the crew would have survived.

The Fishing Vessel (Safety Provisions) Regulations 1975 only require a bilge alarm to be fitted in the engine room. It is however good practice to fit them in other high risk areas such as RSW tank spaces and fish holds. Bilge alarms are relatively cheap to fit, but require frequent testing and careful maintenance to ensure they work properly.

Significant numbers of fishing vessels have been involved in flooding incidents. In some cases this has led to foundering, and sometimes loss of life. Bilge alarm failure is often a contributory factor in these incidents. The loss of *Amber Rose* has reinforced the need to address the reliability and ease of maintenance of bilge alarms.

Banff and Buchan College, Fraserburgh has undertaken valuable research on bilge water detection. The MCA may wish to make use of this work.

2.13 Human Factors

The skipper's reticence in disclosing the modifications made to the vessel to the MCA, and his disregard for the restrictions on the vessel's loading which were contained in her trim and stability booklet, suggests that he had a poor understanding of stability. This raises a concern about the level of knowledge of stability required for the Second Hand Special Certificate, which is equivalent to a Class 2 (Limited) Deck Officer (Fishing Vessel) Certificate of Competency. Such concerns have been raised in several other investigations of fishing vessel founderings.

There is no obvious explanation as to why the mate on watch didn't notice anything untoward with *Amber Rose*'s handling characteristics in the moments before the vessel began to heel to starboard. The observer from the shore noticed she was down by the head at least a minute or two before she finally capsized.

2.14 Lifesaving Appliances

After the survivors escaped from the capsizing vessel, they made their way towards one of the liferafts that had automatically inflated when *Amber Rose* sank. The automatic release of the liferafts confirms that they had been fitted correctly, and this was crucial to the survival of 5 crew members.

Three weeks previously, an MCA survey of the vessel identified deficiencies with the liferaft hydrostatic release units (HRU's). These were consequently replaced.

There were no transmissions from *Amber Rose*'s EPIRB. The reason for this is unknown.

SECTION 3 - CONCLUSIONS

3.1 Findings

The capsize and crew

1. The fv *Amber Rose* B417 capsized and sank in 40m of water, in position 54° 02' N 004° 47' W, shortly after 1000 on 15 October 1998. [1.6]

2. The vessel fully inverted during the capsize. [1.6]

3. The capsize of the vessel occurred when *Amber Rose* changed course putting the prevailing weather conditions on her port beam. [1.6]

4. None of the crew members, apart from the skipper, had undergone any form of basic safety training. [1.4]

5. The vessel was manned in accordance with the *Fishing Vessels (Certification of Deck Officers and Engineer Officers) Regulations 1984*. [1.4]

Flooding and stability

6. *Amber Rose* had undergone several changes which affected her stability. [1.11, 2.4]

7. The Maritime and Coastguard Agency was unaware that the RSW tanks had been extended, which meant that the stability data was not modified. [1.8, 2.4]

8. The vessel was overloaded by 31 tonnes above the MCA approved maximum displacement of 323.7 tonnes. [2.11]

9. When overloaded by 31 tonnes *Amber Rose* did not meet the minimum stability criteria in accordance with *The Fishing Vessels (Safety Provisions) Rules 1975*. [2.4]

10. MCA's action after inspection of *Amber Rose* is considered to be reasonable. [2.2]

11. MCA did not detain *Amber Rose* when it was known that alterations had been made which affected the vessel's stability. [2.2]

12. The capsize was unlikely to have resulted from the port RSW tank rupturing. [2.5]

13. The capsize was unlikely to have been a result of RSW pipework failure. [2.6]

14. The capsize was not the result of bulk stowage of fish on deck. [2.7]

15. The capsize was not due to a high centre of gravity resulting from the extensive refit. [2.8]

16. The capsize was not due to entrapped water on the main deck. [2.9]

17. The most likely cause of the loss of *Amber Rose* was substantial, undetected flooding. The flooding, estimated at 69 tonnes of water when she capsized, was concentrated in the forward spaces. [2.10]

18. The bilge alarm in the RSW tank space failed to work. [2.10]

19. Had the bilge alarm worked, the consequences of the accident could have been much less serious. [2.12]

20. *Amber Rose* was not involved in a collision. [2.3]

21. The skipper's disregard for the restrictions on vessel loading suggests he had a poor understanding of stability. [2.13]

22. The correct deployment of the liferaft was crucial to the survival of 5 crew members. [2.14]

23. The reason for the vessel's EPIRB not transmitting is unknown. [2.14]

3.2 Causes

The balance of probability is that the cause of the capsize and sinking of *Amber Rose* was undetected flooding of the forward spaces.

3.3 Contributory Causes

1. The failure of the bilge alarm in the RSW tank space allowing the flooding to go undetected.

2. Overloading of the vessel reduced her freeboard and stability.

3. The failure to have the vessel's stability re-calculated after increasing the capacity of the RSW tanks and the refit.

4. Not having the vessel re-inclined.

SECTION 4 - RECOMMENDATIONS

The Maritime and Coastguard Agency is recommended to:

1. Consider reviewing its procedures for the detention of fishing vessels in light of this accident.

2. Consider introducing options for improving fishermen's awareness and understanding of stability, including the introduction of mandatory training in stability for holders of Deck Officer Certificate of Competency (Fishing Vessel) Second Hand Special, equivalent to Class 2 Limited.

3. Review the reliability and maintainability of bilge alarms, and investigate alternative means of providing early warning of flooding.

Marine Accident Investigation Branch
July 2000

ANNEX 1

Stability Requirements

Rule 16 of *The Fishing Vessels (Safety Provisions) Rules 1975*, requires that all vessels over 12m in length shall satisfy the following stability criteria after due correction for the free surface effects of liquids in tanks:

a) The area under the curve of righting lever (GZ curve) shall not be less than:

   i) 0.055 metre-radians up to angle of 30 degrees;

   ii) 0.090 metre-radians up to an angle of 40 degrees or such lesser angle of heel at which the lower edges of any openings in the hull, superstructures, deckhouses or companionways, being openings which cannot e closed weathertight, are immersed;

   iii) 0.030 metre-radians between the angles of heel of 30 degrees and 40 degrees or such lesser angle as defined in (ii) above;

(b) The righting lever (GZ) shall be at least 0.20m at an angle of heel equal to or greater than 30 degrees;

(c) The maximum righting lever (GZ) shall occur at an angle of heel not less than 25 degrees;

(d) In the upright position the transverse metacentric height (GM) shall not be less than 0.35m;

Provided that for vessels engaged on single or twin boom fishing, the values of dynamic stability, righting lever and metacentric height given in sub-paragraphs (a), (b) and (c) respectively of this Rule shall be increased by 20%.

ANNEX 2

***Amber Rose* - Estimation of lightship weight after refits**

DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: ESTIMATION OF LIGHTSHIP WEIGHT AFTER REFITS
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel passes requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK AMIDSHIPS (+ve above, -ve below)

	Lightship Item	Weight tonnes	LCG metres	Longitudinal moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	LESS WINCH	-4.250	18.400	-78.200	6.200	-26.350	0.000
2	LESS NET DRUM	-3.000	-0.200	0.600	6.100	-18.300	0.000
3	LESS HYD TANK	-1.000	6.300	-6.300	5.200	-5.200	0.000
4	ADD WINCH	5.400	18.400	99.360	6.200	33.480	0.000
5	ADD NET DRUM	3.300	-0.200	-0.660	7.000	23.100	0.000
6	ADD HYD TANK	1.600	8.900	14.240	2.500	4.000	0.000
7	ADD BALLAST 1	3.080	-0.200	-0.616	3.700	11.396	0.000
8	ADD BALLAST 2	2.480	9.250	22.940	1.600	3.968	0.000
9	TRAWL	2.000	-0.200	-0.400	7.000	14.000	
10	FISH PUMP GANTRY SPLITTER	1.500	0.000	0.000	7.000	10.500	-
11	EXTENSION TO RSW TANKS	2.300	17.029	39.167	3.074	7.070	-
	ADDITIONS TOTAL	13.410	6.721	90.131	4.300	57.664	0.000
	LIGHTSHIP (ORIGINAL)	240.500	10.500	2525.250	3.700	889.850	-
	LIGHTSHIP (REVISED)	253.910	10.300	2615.381	3.732	947.514	0.000
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.000		
				VCG fluid	3.732		

ANNEX 3

Amber Rose - **Deadweight tables, departure fishing grounds:**

a) **approved condition, Trim & Stability book - Condition A**
b) **estimated condition on 15 October 1998 - Condition D.**

DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: CONDITION A - DEPART GROUNDS CONDITION IN APPROVED T+S BOOK
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel passes requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK 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	CREW STORES, ETC	1.200	5.800	6.960	3.960	4.752	0.000
2	FRESH WATER	2.000	-0.200	-0.400	3.560	7.120	1.200
3	FUEL PORT FORWARD	4.500	8.100	36.450	3.140	14.130	0.400
4	FUEL STARBOARD FORWARD	3.000	8.000	24.000	3.300	9.900	0.100
5	FUEL D.S. PORT	0.900	7.200	6.480	3.880	3.492	0.100
	TOTAL FUEL	8.400	7.968	66.930	3.276	27.522	0.600
6	RSW TANK CENTRE	24.100	13.722	330.700	2.501	60.274	9.127
7	PORT RSW	23.750	13.731	326.111	2.880	68.400	1.551
8	STARBOARD RSW	23.750	13.731	326.111	2.880	68.400	1.204
	TOTAL RSW	71.600	13.728	982.923	2.752	197.074	11.882
9	FLOODING FWD M/CY SPACE	0.000	0.000	0.000	0.000	0.000	0.000
10	FLOODING TANK SPACE	0.000	0.000	0.000	0.000	0.000	0.000
11	FLOODING ENGINE ROOM	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL FLOODING	0.000	0.000	0.000	0.000	0.000	0.000
	DEADWEIGHT TOTAL	83.200	12.697	1056.413	2.842	236.468	13.682
	LIGHTSHIP	240.500	10.500	2525.250	3.700	889.850	-
	DISPLACEMENT	323.700	11.065	3581.663	3.480	1126.318	13.682
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.042		
					VCG fluid	3.522	

DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: CONDITION D
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK 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	CREW STORES, ETC	1.200	5.800	6.960	3.960	4.752	0.000
2	FRESH WATER	2.000	-0.200	-0.400	3.560	7.120	1.200
3	FUEL PORT FORWARD	4.500	8.100	36.450	3.140	14.130	0.400
4	FUEL STARBOARD FORWARD	3.000	8.000	24.000	3.300	9.900	0.100
5	FUEL D.S. PORT	0.900	7.200	6.480	3.880	3.492	0.100
	TOTAL FUEL	8.400	7.968	66.930	3.276	27.522	0.600
6	RSW TANK CENTRE	31.235	13.820	431.668	2.860	89.332	0.000
7	RSW TANK PORT	29.109	14.287	415.880	2.974	86.570	0.000
8	RSW TANK STARBOARD	29.109	14.287	415.880	2.974	86.570	0.000
	TOTAL RSW	89.453	14.124	1263.428	2.934	262.472	0.000
	DEADWEIGHT TOTAL	101.053	13.230	1336.918	2.987	301.866	1.800
	LIGHTSHIP	253.910	10.300	2615.273	3.732	947.592	-
	DISPLACEMENT	354.963	11.134	3952.191	3.520	1249.459	1.800
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.005		
					VCG fluid	3.525	

ANNEX 4

Amber Rose - **Flooding of the refrigeration machinery space, the RSW tank space and the engine room - Condition H.**

DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: CONDITION H - CAPSIZE CONDITION - 88T FLOODING TO THREE SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK 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	CREW STORES, ETC	1.200	5.800	6.960	3.960	4.752	0.000
2	FRESH WATER	2.000	-0.200	-0.400	3.560	7.120	1.200
3	FUEL PORT FORWARD	4.500	8.100	36.450	3.140	14.130	0.400
4	FUEL STARBOARD FORWARD	3.000	8.000	24.000	3.300	9.900	0.100
5	FUEL D.S. PORT	0.900	7.200	6.480	3.880	3.492	0.100
	TOTAL FUEL	8.400	7.968	66.930	3.276	27.522	0.600
6	RSW TANK CENTRE	31.235	13.820	431.668	2.860	89.332	0.000
7	RSW TANK PORT	29.109	14.287	415.880	2.974	86.570	0.000
8	RSW TANK STARBOARD	29.109	14.287	415.880	2.974	86.570	0.000
	TOTAL RSW	89.453	14.124	1263.428	2.934	262.472	0.000
9	FLOODING FWD M/CY SPACE	14.214	19.191	272.781	1.812	25.756	26.565
10	FLOODING TANK SPACE	33.553	14.613	490.310	1.595	53.517	86.123
11	FLOODING ENGINE ROOM	40.690	7.949	323.445	1.843	74.992	90.264
	TOTAL FLOODING	88.457	12.283	1086.536	1.744	154.264	202.952
	DEADWEIGHT TOTAL	189.510	12.788	2423.454	2.407	456.131	204.752
	LIGHTSHIP	253.910	10.300	2615.273	3.732	947.592	-
	DISPLACEMENT	443.420	11.363	5038.727	3.166	1403.723	204.752
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.462		
					VCG fluid	3.627	

SAILING STATE

Vessel....: AMBER ROSE
Condition.: CONDITION H - CAPSIZE CONDITION - 88T FLOODING TO THREE SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about USK AMIDSHIPS at FP)	-	4.591
Draft midships (about USK AMIDSHIPS)	-	4.367
Draft aft (about USK AMIDSHIPS at AP)	-	4.143

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard foward (about USK AMIDSHIPS at FP)	-	0.700
Freeboard midships (about USK AMIDSHIPS)	-	-0.036
Freeboard aft (about USK AMIDSHIPS at AP)	-	1.114

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.448 by bow	4.367	0.000	0.000	0.000	0.000
5	0.477 ''	4.381	0.332	0.316	7.229	0.016
10	0.559 ''	4.402	0.638	0.630	3.803	0.009
15	0.669 ''	4.419	0.924	0.939	-6.761	-0.015
20	0.689 ''	4.411	1.185	1.241	-24.532	-0.055
25	0.810 ''	4.413	1.437	1.533	-42.426	-0.096
30	0.925 ''	4.400	1.672	1.814	-62.675	-0.141
35	1.033 ''	4.369	1.893	2.081	-83.025	-0.187
40	1.138 ''	4.317	2.104	2.332	-101.110	-0.228
45	1.242 ''	4.245	2.301	2.565	-116.863	-0.264
50	1.346 ''	4.151	2.484	2.779	-130.538	-0.294
55	1.448 ''	4.035	2.650	2.971	-142.497	-0.321
60	1.547 ''	3.895	2.796	3.141	-153.014	-0.345
65	1.645 ''	3.733	2.922	3.288	-161.981	-0.365
70	1.742 ''	3.550	3.027	3.409	-169.412	-0.382
75	1.837 ''	3.346	3.109	3.504	-174.879	-0.394
80	1.928 ''	3.120	3.170	3.572	-178.558	-0.403
85	2.015 ''	2.876	3.207	3.614	-180.495	-0.407
90	2.101 ''	2.616	3.219	3.627	-180.894	-0.408

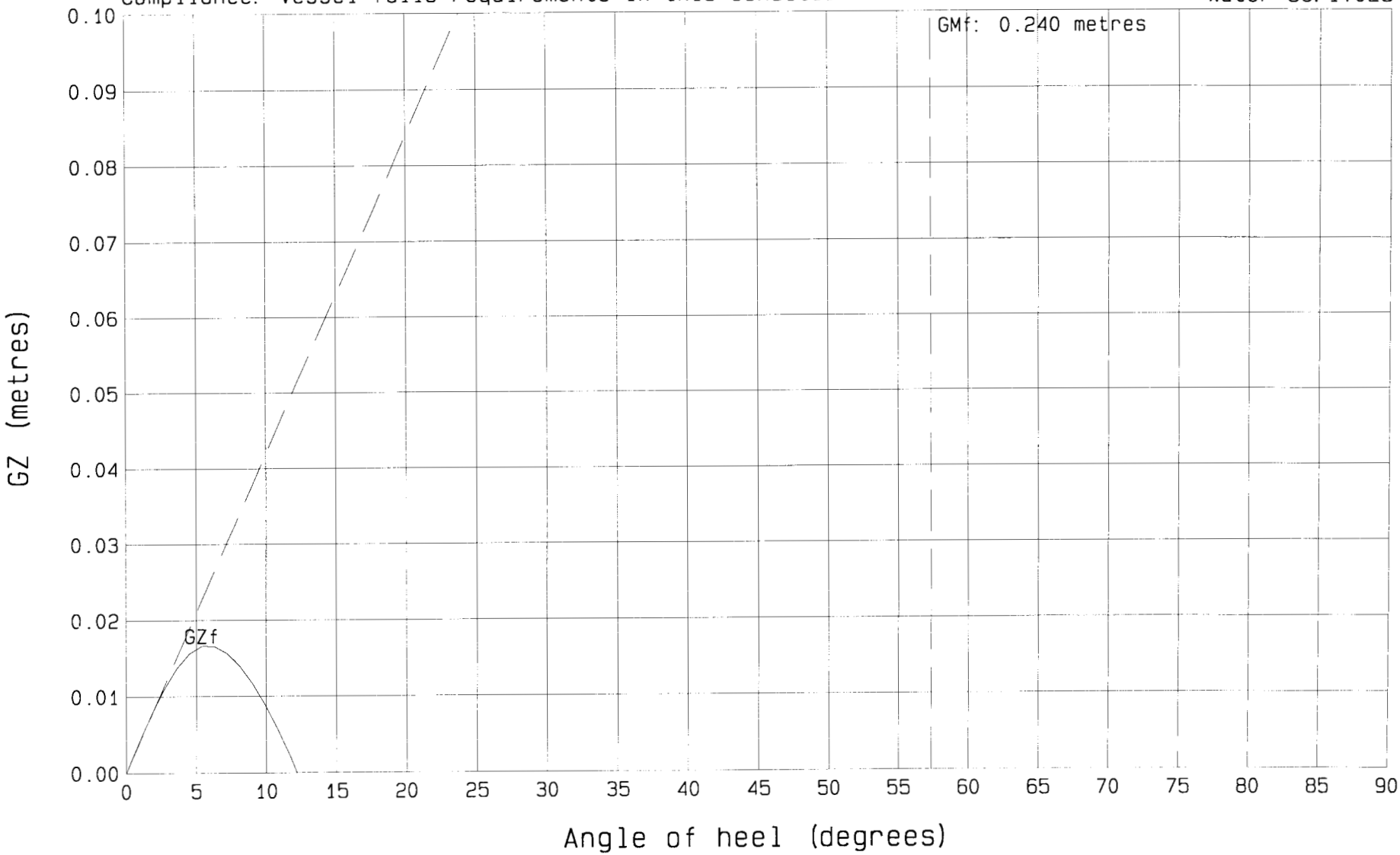
STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.002
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.002
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	0.200	0.017
Angle of heel at which maximum GZ occurs (degrees)	25.000	5.892
Positive GZ heel range (degrees)	-	12.216
GM solid (metres) (upright)	-	0.702
Free Surface correction (metres)	-	0.462
GM fluid (metres) (upright)	0.350	0.240

GZ PLOT

AMBER ROSE

Condition.: CONDITION H - CAPSIZE CONDITION - 88T FLOODING TO THREE SPACES
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025



ANNEX 5

Amber Rose - **Flooding of the refrigeration machinery space and the RSW tank space - Condition G.**

DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: CONDITION G - CAPSIZE CONDITION, 69T OF WATER IN FWD SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK 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	CREW STORES, ETC	1.200	5.800	6.960	3.960	4.752	0.000
2	FRESH WATER	2.000	-0.200	-0.400	3.560	7.120	1.200
3	FUEL PORT FORWARD	4.500	8.100	36.450	3.140	14.130	0.400
4	FUEL STARBOARD FORWARD	3.000	8.000	24.000	3.300	9.900	0.100
5	FUEL D.S. PORT	0.900	7.200	6.480	3.880	3.492	0.100
	TOTAL FUEL	8.400	7.968	66.930	3.276	27.522	0.600
6	RSW TANK CENTRE	31.235	13.820	431.668	2.860	89.332	0.000
7	RSW TANK PORT	29.109	14.287	415.880	2.974	86.570	0.000
8	RSW TANK STARBOARD	29.109	14.287	415.880	2.974	86.570	0.000
	TOTAL RSW	89.453	14.124	1263.428	2.934	262.472	0.000
9	FLOODING FWD M/CY SPACE	22.676	19.198	435.334	2.215	50.227	35.038
10	FLOODING TANK SPACE	46.207	14.670	677.857	1.939	89.595	97.453
	TOTAL FLOODING	68.883	16.161	1113.191	2.030	139.823	132.491
	DEADWEIGHT TOTAL	169.936	14.418	2450.109	2.599	441.689	134.291
	LIGHTSHIP	253.910	10.300	2615.273	3.732	947.592	-
	DISPLACEMENT	423.846	11.951	5065.382	3.278	1389.281	134.291
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.317		
				VCG fluid	3.595		

SAILING STATE

Vessel....: AMBER ROSE
Condition.: CONDITION G - CAPSIZE CONDITION, 69T OF WATER IN FWD SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about USK AMIDSHIPS at FP)	-	4.800
Draft midships (about USK AMIDSHIPS)	-	4.249
Draft aft (about USK AMIDSHIPS at AP)	-	3.699

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard foward (about USK AMIDSHIPS at FP)	-	0.486
Freeboard midships (about USK AMIDSHIPS)	-	0.078
Freeboard aft (about USK AMIDSHIPS at AP)	-	1.554

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	1.103 by bow	4.249	0.000	0.000	0.000	0.000
5	1.148 ''	4.264	0.327	0.313	5.914	0.014
10	1.335 ''	4.301	0.638	0.624	5.900	0.014
15	1.571 ''	4.334	0.925	0.930	-2.085	-0.005
20	1.845 ''	4.360	1.194	1.229	-14.872	-0.035
25	2.152 ''	4.374	1.450	1.519	-29.369	-0.069
30	2.467 ''	4.373	1.692	1.797	-44.673	-0.105
35	2.787 ''	4.355	1.920	2.062	-59.938	-0.141

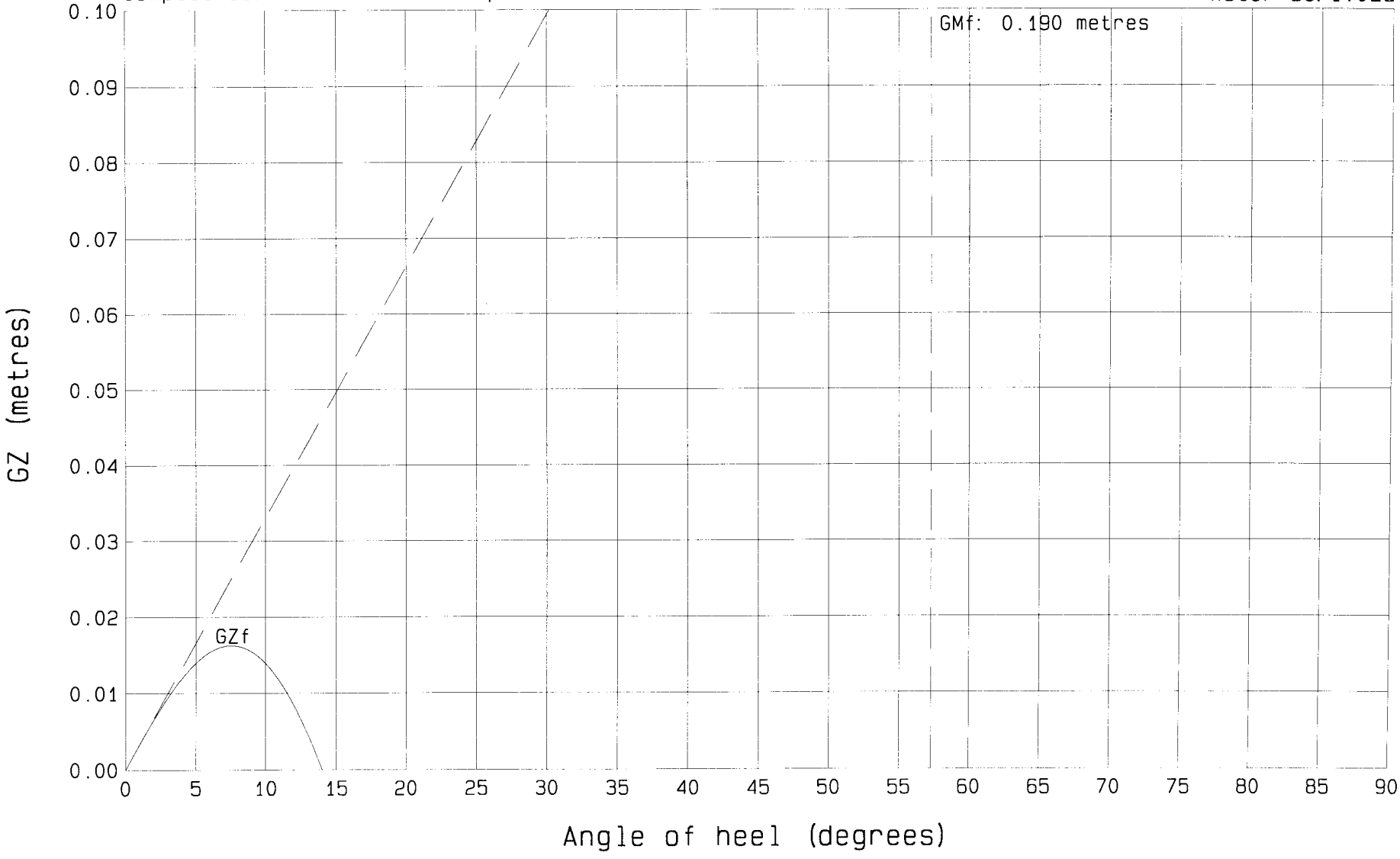
STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.003
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.003
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	0.200	0.016
Angle of heel at which maximum GZ occurs (degrees)	25.000	7.488
Positive GZ heel range (degrees)	-	14.013
GM solid (metres) (upright)	-	0.507
Free Surface correction (metres)	-	0.317
GM fluid (metres) (upright)	0.350	0.190

GZ PLOT

AMBER ROSE

Condition.: CONDITION G - CAPSIZE CONDITION, 69T OF WATER IN FWD SPACES
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025



***Amber Rose* - Flooding of the refrigeration machinery space and the RSW tank space with the vessel at her approved maximum displacement:**

a) **with 69 tonnes of floodwater - Condition L.**
b) **with 91 tonnes of floodwater - Condition M.**

DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: CONDITION L - AS T+S BOOK - 69T FLOODWATER IN FORWARD SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK 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	CREW STORES, ETC	1.200	5.800	6.960	3.960	4.752	0.000
2	FRESH WATER	2.000	-0.200	-0.400	3.560	7.120	1.200
3	FUEL PORT FORWARD	4.500	8.100	36.450	3.140	14.130	0.400
4	FUEL STARBOARD FORWARD	3.000	8.000	24.000	3.300	9.900	0.100
5	FUEL D.S. PORT	0.900	7.200	6.480	3.880	3.492	0.100
	TOTAL FUEL	8.400	7.968	66.930	3.276	27.522	0.600
6	RSW TANK CENTRE	24.100	13.722	330.700	2.501	60.274	9.127
7	PORT RSW	23.750	13.731	326.111	2.880	68.400	1.551
8	STARBOARD RSW	23.750	13.731	326.111	2.880	68.400	1.204
	TOTAL RSW	71.600	13.728	982.923	2.752	197.074	11.882
9	FLOODING FWD M/CY SPACE	22.676	19.198	435.334	2.239	50.772	34.573
10	FLOODING TANK SPACE	46.207	14.674	678.042	1.969	90.982	96.103
11	FLOODING ENGINE ROOM	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL FLOODING	68.883	16.163	1113.375	2.058	141.753	130.676
	DEADWEIGHT TOTAL	152.083	14.267	2169.788	2.487	378.221	144.358
	LIGHTSHIP	240.500	10.500	2525.250	3.700	889.850	-
	DISPLACEMENT	392.583	11.959	4695.038	3.230	1268.071	144.358
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.368		
				VCG fluid	3.598		

SAILING STATE

Vessel....: AMBER ROSE
Condition.: CONDITION L - AS T+S BOOK - 69T FLOODWATER IN FORWARD SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about USK AMIDSHIPS at FP)	-	4.471
Draft midships (about USK AMIDSHIPS)	-	4.030
Draft aft (about USK AMIDSHIPS at AP)	-	3.588

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard foward (about USK AMIDSHIPS at FP)	-	0.817
Freeboard midships (about USK AMIDSHIPS)	-	0.299
Freeboard aft (about USK AMIDSHIPS at AP)	-	1.666

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.883 by bow	4.030	-0.000	0.000	-0.000	-0.000
5	0.898 ''	4.020	0.361	0.314	18.605	0.047
10	0.984 ''	4.009	0.695	0.625	27.521	0.070
15	1.105 ''	3.992	1.000	0.931	27.168	0.069
20	1.253 ''	3.965	1.284	1.231	21.102	0.054
25	1.420 ''	3.927	1.553	1.520	12.823	0.033
30	1.604 ''	3.875	1.807	1.799	3.233	0.008
35	1.791 ''	3.810	2.043	2.064	-8.082	-0.021
40	1.975 ''	3.729	2.259	2.313	-20.895	-0.053
45	2.156 ''	3.630	2.455	2.544	-35.017	-0.089
50	2.332 ''	3.512	2.629	2.756	-50.077	-0.128
55	2.501 ''	3.374	2.780	2.947	-65.611	-0.167
60	2.661 ''	3.216	2.909	3.116	-81.158	-0.207
65	2.811 ''	3.039	3.015	3.261	-96.564	-0.246
70	2.949 ''	2.843	3.096	3.381	-111.950	-0.285

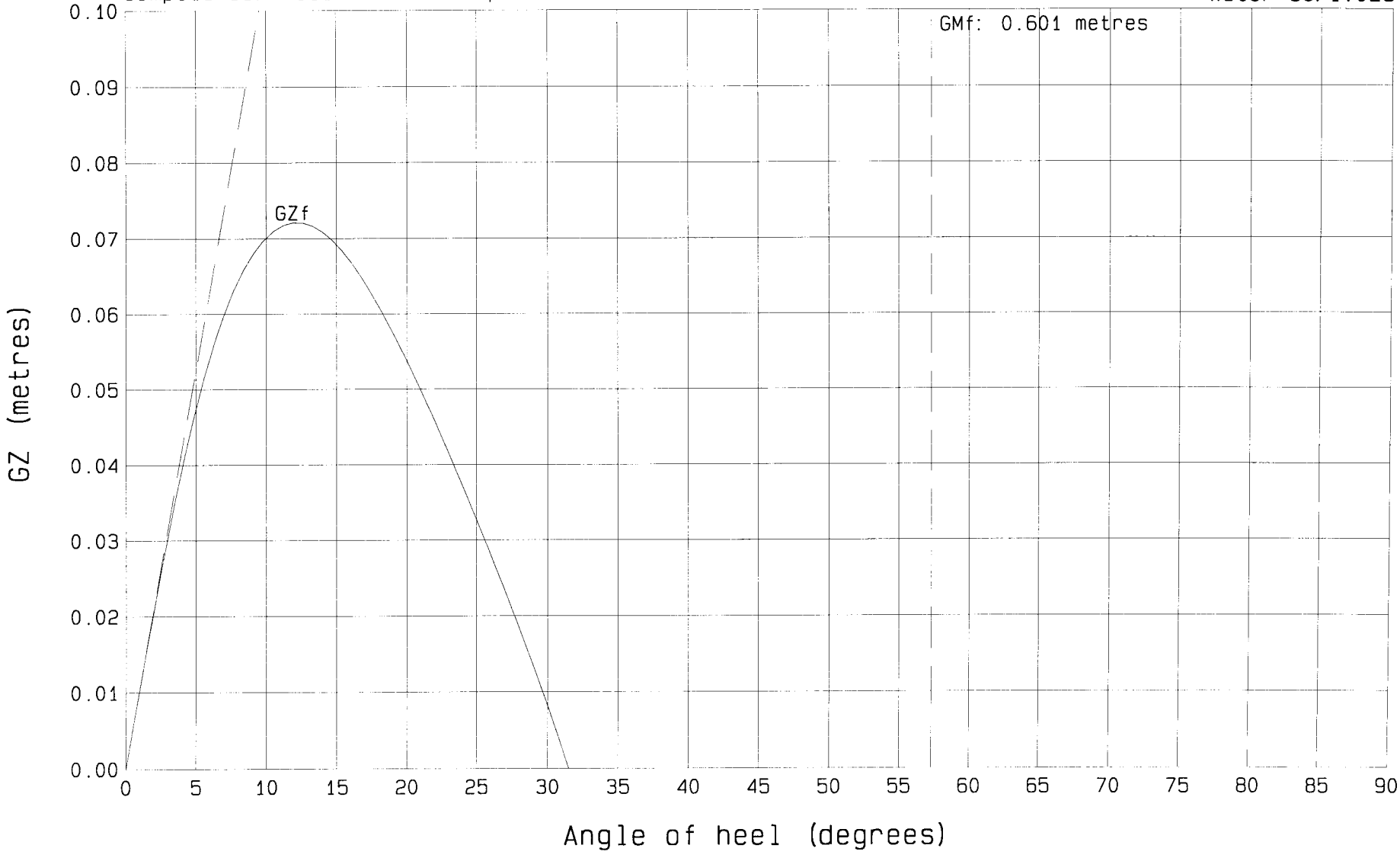
STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.025
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.025
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	0.200	0.073
Angle of heel at which maximum GZ occurs (degrees)	25.000	12.310
Positive GZ heel range (degrees)	-	31.509
GM solid (metres) (at angle of equilibrium)	-	0.969
Free Surface correction (metres)	-	0.368
GM fluid (metres) (at angle of equilibrium)	0.350	0.601

GZ PLOT

AMBER ROSE

Condition.: CONDITION L - AS T+S BOOK - 69T FLOODWATER IN FORWARD SPACES
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025



DEADWEIGHT TABLE

Vessel....: AMBER ROSE
Condition.: CONDITION M - AS T+S BOOK - 91T FLOODWATER IN FORWARD SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about AFT PERPENDICULAR (-ve aft, +ve forward)
Vertical dimensions about USK 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	CREW STORES, ETC	1.200	5.800	6.960	3.960	4.752	0.000
2	FRESH WATER	2.000	-0.200	-0.400	3.560	7.120	1.200
3	FUEL PORT FORWARD	4.500	8.100	36.450	3.140	14.130	0.400
4	FUEL STARBOARD FORWARD	3.000	8.000	24.000	3.300	9.900	0.100
5	FUEL D.S. PORT	0.900	7.200	6.480	3.880	3.492	0.100
	TOTAL FUEL	8.400	7.968	66.930	3.276	27.522	0.600
6	RSW TANK CENTRE	24.100	13.722	330.700	2.501	60.274	9.127
7	PORT RSW	23.750	13.731	326.111	2.880	68.400	1.551
8	STARBOARD RSW	23.750	13.731	326.111	2.880	68.400	1.204
	TOTAL RSW	71.600	13.728	982.923	2.752	197.074	11.882
9	FLOODING FWD M/CY SPACE	31.650	19.204	607.807	2.652	83.936	37.895
10	FLOODING TANK SPACE	59.579	14.664	873.666	2.366	140.964	116.854
11	FLOODING ENGINE ROOM	0.000	0.000	0.000	0.000	0.000	0.000
	TOTAL FLOODING	91.229	16.239	1481.473	2.465	224.900	154.749
	DEADWEIGHT TOTAL	174.429	14.550	2537.886	2.645	461.368	168.431
	LIGHTSHIP	240.510	10.500	2525.355	3.700	889.887	-
	DISPLACEMENT	414.939	12.202	5063.241	3.257	1351.255	168.431
	Free Surface Correction (Total Free Surface Moment/Displacement)				0.406		
				VCG fluid	3.662		

SAILING STATE

Vessel....: AMBER ROSE
Condition.: CONDITION M - AS T+S BOOK - 91T FLOODWATER IN FORWARD SPACES
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about USK AMIDSHIPS at FP)	-	4.952
Draft midships (about USK AMIDSHIPS)	-	4.224
Draft aft (about USK AMIDSHIPS at AP)	-	3.496

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard foward (about USK AMIDSHIPS at FP)	-	0.329
Freeboard midships (about USK AMIDSHIPS)	-	0.100
Freeboard aft (about USK AMIDSHIPS at AP)	-	1.752

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	1.459 by bow	4.224	-0.000	0.000	-0.000	-0.000
5	1.525 ''	4.244	0.329	0.319	4.229	0.010
10	1.755 ''	4.285	0.651	0.636	6.279	0.015
15	2.038 ''	4.322	0.958	0.948	4.248	0.010
20	2.363 ''	4.348	1.250	1.253	-1.089	-0.003
25	2.731 ''	4.366	1.527	1.548	-8.757	-0.021

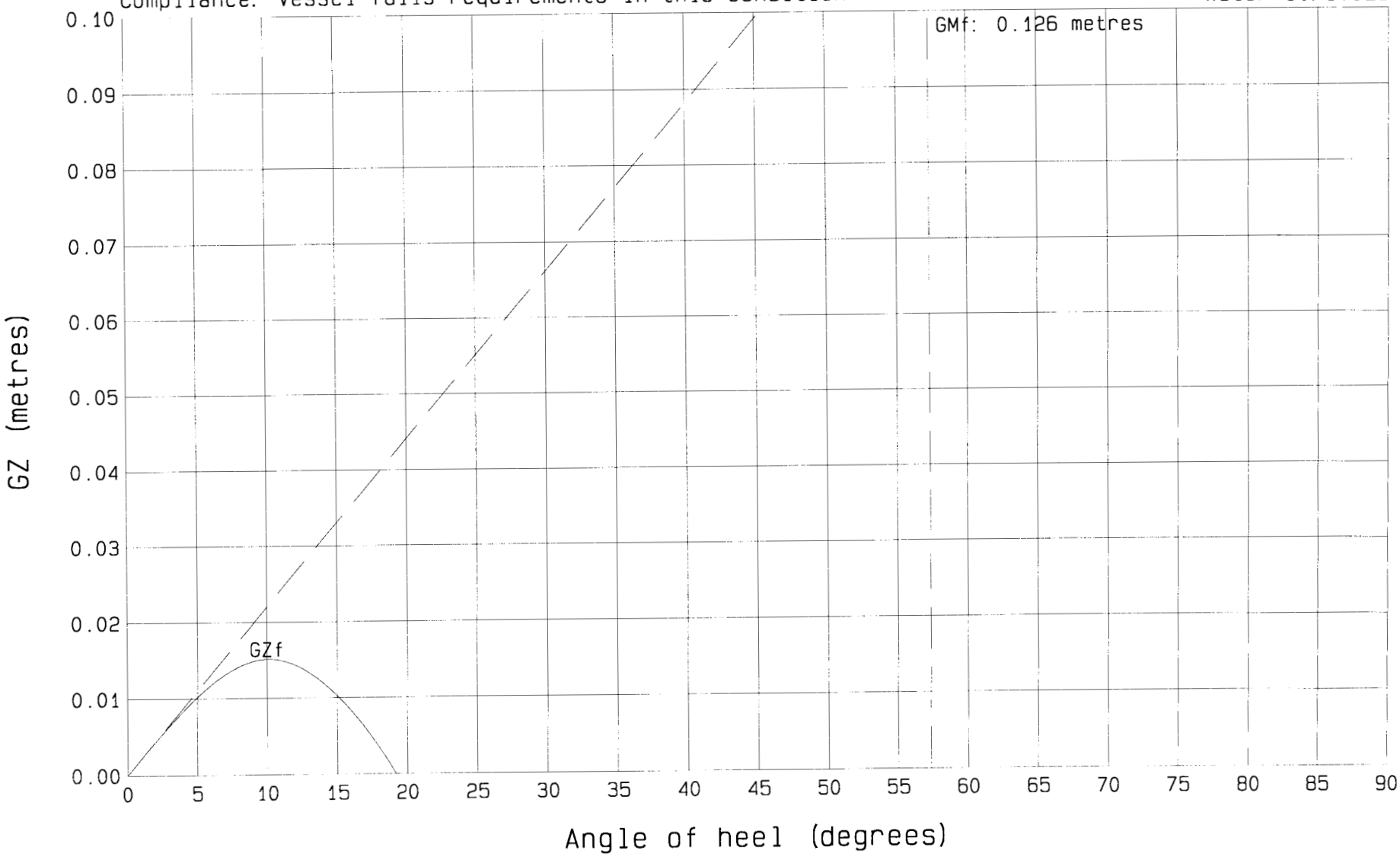
STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.003
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.003
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	0.200	0.015
Angle of heel at which maximum GZ occurs (degrees)	25.000	10.012
Positive GZ heel range (degrees)	-	19.165
GM solid (metres) (at angle of equilibrium)	-	0.532
Free Surface correction (metres)	-	0.406
GM fluid (metres) (at angle of equilibrium)	0.350	0.126

GZ PLOT

AMBER ROSE

Condition.: CONDITION M - AS T+S BOOK - 91T FLOODWATER IN FORWARD SPACES
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025



ANNEX 7

Wolfson Unit report on the model capsizing tests on *Amber Rose*

WOLFSON UNIT
FOR MARINE TECHNOLOGY &
INDUSTRIAL AERODYNAMICS

Marine Accident Investigation Branch

MFV Amber Rose - Model Capsizing Tests

Report No. 1523 **May, 2000**

UNIVERSITY OF SOUTHAMPTON
HIGHFIELD SOUTHAMPTON SO17 1BJ

WOLFSON UNIT

Report No. 1523 **May, 2000**

MARINE ACCIDENT INVESTIGATION BRANCH

MFV Amber Rose – Model Capsizing Tests

INTRODUCTION

The fishing vessel 'Amber Rose' capsized and sank on 15th October 1998, having stopped while returning to port with a full catch, in force 5 – 6 conditions in the Irish Sea. This report describes a modest programme of model tests conducted to assist the accident investigation by simulating possible capsize scenarios.

The tests were witnessed by Mr. Owen Brown of the MAIB, and some tests were also witnessed by Mr. Maurice Napier from the Napier Co. (Arbroath) Ltd., who designed the lines and did stability work.

TEST REQUIREMENTS

The objective of the tests was to determine whether the vessel, in her estimated loading condition, would have been likely to capsize when stationary in beam seas representative of the conditions at the time of her loss. Because of uncertainty in the estimated loading condition and stability, it was required to investigate a range of stability and flooding configurations.

Published wave data for the area in which the accident occurred suggest that the seas in force 5 – 6 conditions would be of 2 – 3 metres significant height, with a modal period of around 10 seconds. At the time of the accident the wind strength had increased from relatively calm over a period of 2 – 3 hours, and so the seastate may have differed from the prediction, which is for a fully developed seastate. The waves

might be smaller than those predicted and, in particular, the wave period may have been significantly less than 10 seconds.

MODEL

A 1:15 scale model of the fishing vessel 'Westhaven' was modified for use in this work. The model had been used for capsizing and sinking tests and comprised the hull, deck, superstructures, masts and principal items of deck equipment and rigging. The modifications included the addition of a mid body section to increase the length, and rebuilding the shelter with appropriate freeing ports. Photographs of the model are presented in Figure 1.

The vessel's principal dimensions are presented in Table 1, together with the dimensions represented by the modified model at a scale of 1:17. The modified model matched the principal dimensions of Amber Rose well, but with a more slender hull form. The displacement therefore could not be matched.

The vessel had undergone an inclining experiment and a roll test, and the model was ballasted to the roll test condition to enable modelling of the roll test and hence match the roll period. The model was ballasted to the required freeboard and GM by conducting an inclining experiment. The ballast weights were then redistributed athwartships to achieve the required roll period. Further ballast was then added to obtain the required test condition, which represented RSW tanks at full capacity. Another inclining experiment was conducted to check that the final GM was correct.

After final ballasting the deck, and the deck to hull joint, were made watertight as far as was practicable with all doors and hatches closed, although some minor ingress was possible though fastenings and other small penetrations.

TEST FACILITY

The tests were conducted in No 3 towing tank at GKN Westland, Isle of Wight. The tank is 200m long, by 4.6m wide, by 1.7m deep, and is fitted with a flap type computer controlled wavemaker.

TEST TECHNIQUE

The model was positioned beam on to the waves, and this heading was maintained by occasional realignment using light lines attached at the stem and stern. The lines were left slack whenever possible.

Regular or irregular waves were generated as required, and the model response was observed. In irregular waves the test durations were in excess of 2 minutes, representing about 10 minutes at full scale.

A video record of the tests was made and is supplied to accompany this report. The recording should be viewed with reference to Table 2 in order to identify the test conditions. A supplementary video recording, from a different location and thus providing a different viewing angle, was made by Mr. Brown.

TEST CONDITIONS AND OBSERVATIONS

All data herein refer to full scale.

Runs 17-20.

Initial tests were conducted in the base condition representing Condition D as presented in the MAIB draught report dated 8th March 2000. Tests were conducted in regular waves over a range of frequencies to determine qualitatively the dependence of response on wave frequency. Whilst it is well documented that the roll response is highly dependent on the frequency of excitation, and the relationship can be measured with accuracy using an instrumented model, without such instrumentation it is difficult to quantify the responses and identify the resonant frequency. It was perceived by the observers that the peak response was at a wave frequency of about 6.6 seconds, whilst the model's natural roll period was 7.4 seconds. It was agreed that tests should be conducted in seastates with modal periods of around 7 seconds. This was significantly less than the predicted period for a fully developed seastate, but could have been representative of the conditions prevailing at the time of the accident. A nominal 3 metres, 7 seconds, seastate was used as a standard for the majority of subsequent runs.

Runs 21-23.

Tests were then conducted in JONSWAP seastates with modal periods of 6.9 – 7.6 seconds, and with significant wave heights of 2.76 – 3.07 metres. Occasional breaking crests impacted on, or washed over the shelter, but there appeared to be no threat of capsize. The freeing ports appeared to effective in clearing water from the deck, both from within the shelter and from the aft deck.

Runs 24-27.

To study the effects of water on deck, the freeing ports in the shelter were closed and a known quantity of water was added to the shelter. First 10 tonnes, and subsequently 20 tonnes of water was added, and tests were conducted in seastates of up to 3.1 metres. Because the shelter contained a ballast weight positioned to port, the centre of gravity of the added water was a little to starboard and a slight list resulted. Tests were conducted with seas approaching from port and starboard to determine whether this list was significant.

The roll motion appeared to be slightly reduced by the presence of the water, which may have acted in a similar way to a roll stabilising flume tank. There appeared to be no threat of capsize.

Runs 28-36.

With the freeing ports reopened, the stability was reduced in three increments by raising ballast, and tests conducted in representative seastates and, in one case, in regular waves of different frequencies.

In the first configuration the GM was reduced from 0.63 to 0.52 metre. This appeared to have little affect on the behaviour so the GM was reduced to 0.28 metre, giving a natural roll period of about 10 seconds. The roll amplitude was notably reduced in the standard seastate of 7 seconds period, and two further seastates with longer periods were also used, in which the roll amplitude increased with the period. The amplitudes remained relatively small however, and there appeared to be no threat of capsize.

Three tests were conducted in regular waves with periods ranging from 8.5 – 10.7 seconds, and the roll amplitude appeared to be greatest in the longest waves.

The GM was then reduced to 0.14 metre, resulting in a natural roll period of 13.4 seconds. This period is significantly greater than the range of possible modal periods of the prevailing seastate. Tests were conducted in seastates with periods of 7.17 and 8.58 seconds, and the observed roll amplitudes were very small.

Runs 37-39.

To investigate the effects of flooding within the hull, the model was returned to the base condition and a measured quantity of water was added in the main compartment. The quantity represented 40 tonnes at full scale but, because of the differing hull forms, a greater quantity would be required to produce the same freeboard reduction on Amber Rose[1]. This resulted in a reduction in freeboard to about 0.17 metre, which was found to have reduced further, to about 0.15 metre at the end of run 37. The increased flooding was left for run 38, and a further ingress during this test, reducing freeboard to about 0.11 metre, was left in for run 39. These three tests therefore represented a total period of about 30 minutes at full scale, although the rate of water ingress to the hull was not correctly modelled.

The model was presented with its starboard side to the oncoming waves, and in each test the model rapidly developed a list to starboard and rolled about that angle. It rolled predominantly to starboard therefore, with virtually no roll to port. The starboard deck edge and freeing ports were under water for much of the time, so that there was a substantial amount of water retained on deck.

In the third test, run 39, the list to starboard progressively increased with each successive wave, until the model capsized slowly and became inverted.

DISCUSSION

The roll behaviour of the model in the estimated condition at the time of loss did not suggest any lack of seaworthiness or possibility of capsize in the assumed seastate, despite the natural roll period being close to that of the seastate modal period. The freeing ports worked adequately, and impacts from significant

[1] Calculations by MAIB indicated that 43.5 tonnes would be required to give the equivalent freeboard reduction on Amber Rose.

breaking crests did not appear to pose any threat. These observations suggest that some other factor was involved in the casualty.

With the initial level of freeboard, the presence of a large quantity of water on deck with freeing ports closed did not cause the vessel any problems, and this does not appear to be the cause of the casualty.

The reduction in roll amplitude associated with reduced GM is the result of the combination of two factors. The wave induced roll moment is proportional to the GM, and the natural roll period increases with reducing GM. With the low GM conditions therefore, the roll forcing was reduced, and the natural roll period increased to a value greater than that of the seastate modal period. With the lowest GM condition, the range of stability is very low, perhaps less than 20 degrees, but the model showed no tendency to roll to such angles. To achieve such a low GM would require very large shifts of weight on board, or the addition of large weights very high on the structure, and such a low GM is not considered a practical possibility for this vessel. Lower GM conditions were not modelled therefore.

When tested with the reduced freeboard, with water in the hull, the model rolled into the waves and took up a permanent list in that direction. This scenario appears to be a very plausible explanation for the casualty, which may have suffered some undetected ingress of water to the hull while on passage. In most respects it appears to model the course of events and behaviour. Accounts of the casualty indicate that it took on a heavy list to starboard immediately after turning beam on to the waves, which were approaching from the port side. The vessel capsized to starboard after the engines were taken out of gear, with the heading unchanged. The difference between the model and full scale events is that the list occurred away from the waves at full scale, but towards them at model scale. At no time did the model show any tendency to list, or roll significantly, away from the approaching waves when in this flooded condition. The different behaviour may be due to differences in the internal arrangements of the vessel and model, which would give rise to different dynamic movements of the floodwater, or to some other factor not modelled or tested. It is possible, for example, that some asymmetry or weight shift caused Amber Rose to list to starboard, which list was subsequently increased by wave action or flooding.

The lowest photograph in Figure 1, of the model internal arrangement, illustrates that one of the red ballast weights in the main compartment was offset to starboard. A foam block was positioned beneath it, and a round ballast weight above it, to port. The floodwater introduced to this compartment therefore was not centred symmetrically. At the start of runs 37 – 39 it was noted that the model had a slight list to starboard, less than 1 degree, but giving a measurable difference in freeboard between the port and starboard sides. This was not considered significant and probably was due to the asymmetric flooding. Water flooded onto the deck within the shelter during these tests and, as noted above, a ballast weight offset to port resulted in the water on deck being centred to starboard when the model was static and upright. The behaviour of the

model showed a very consistent tendency to roll to starboard during runs 37 – 39, but it is possible that these asymmetries were contributory factors.

Table 1. Principal Dimensions

Parameter	Units	Amber Rose	As Represented by the Model
Length Overall	metres	26.2	24.3
Length BP	metres	23.6	23.6
Beam	metres	7.1	7.1
Depth	metres	4.33	4.33
Draught amidships	metres	3.81	3.81
Freeboard amidships	metres	0.52	0.52
Displacement	tonnes	363	307
GM (solid)	metres	0.63	0.63
Roll Period	seconds	7.43	7.43

Table 2. Summary of Tests.

Run No.	Model Configuration	GM (before flooding) metres	Natural Roll Period seconds	Wave Spectrum	Sig. Wave Height metres	Modal Wave Period seconds	Comments
17	Base Condition.	0.63	7.4	Regular	2.40	6.6	
18					2.41	6.8	
19					2.52	6.4	
20					2.93	6.5	
21				JONSWAP	2.76	7.55	
22					2.64	6.97	
23					3.07	6.9	
24	Freeing ports in shelter closed, 10 tonnes water in shelter.		Not Measured		2.80	7.02	Tank beaches left in waves asymmetric.
25	20 tonnes water in shelter, list to starboard.				2.93	7.23	
26					2.83	7.37	Stbd side to waves.
27					3.10	7.07	Port side to waves.
28	Freeing ports reopened.	0.52	Not measured		2.89	7.04	
29	Reduced stability conditions.	0.28	10.0		3.00	6.86	Notably reduced roll amplitude.
30					3.3	8.07	
31					3.37	9.24	
32				Regular	2.93	9.52	
33					2.94	10.72	
34					2.86	8.49	
35		0.14	13.4	JONSWAP	2.92	8.58	
36					3.07	7.17	
37	Base Condition, with 40 tonnes water in bilge, freeboard 0.17 m.	0.63	Not measured		2.95	7.23	Some additional flooding. Freeboard after test 0.15 metre.
38	Continued test, freeboard 0.15 m.				3.03	6.97	Slight additional flooding.
39	Continued test, freeboard 0.11 m.				2.79	7.02	Slow list to stbd then capsize.

Figure 1. Photographs of the model and internal ballast arrangement.

Appendix 1

Model stability in basic condition of loading - Condition D.

DEADWEIGHT TABLE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about STATION 0, AP (-ve aft, +ve forward)
Vertical dimensions about UNDERSIDE OF KEEL (+ve above, -ve below)
Transverse dimensions about centreline (+ve Port, -ve Stbd)

	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	TCG metres	Transverse moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	INTERIOR OF HULL FLOODED	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	DEADWEIGHT TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LIGHTSHIP	310.800	11.712	3640.089	0.000	0.000	3.577	1111.731	-
	DISPLACEMENT	310.800	11.712	3640.089	0.000	0.000	3.577	1111.731	0.000
	Free Surface Correction (Total Free Surface Moment/Displacement)								0.000
							VCG fluid		3.577

SAILING STATE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about Base Line at FP)	-	3.757
Draft midships LBP (about Base Line)	-	3.813
Draft aft (about Base Line at AP)	-	3.868

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP	1.340	1.933
Freeboard at midships LBP	-	0.517
Freeboard at AP	0.915	0.992

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.111 by stern	3.813	-0.000	0.000	-0.000	-0.000
5	0.106 ''	3.797	0.368	0.312	17.391	0.056
10	0.104 ''	3.750	0.733	0.621	34.715	0.112
15	0.106 ''	3.686	1.075	0.926	46.367	0.149
20	0.114 ''	3.614	1.383	1.223	49.676	0.160
25	0.134 ''	3.532	1.661	1.512	46.310	0.149
30	0.165 ''	3.438	1.910	1.788	37.624	0.121
35	0.202 ''	3.330	2.132	2.052	25.076	0.081
40	0.247 ''	3.204	2.331	2.299	9.775	0.031
45	0.292 ''	3.059	2.505	2.529	-7.679	-0.025
50	0.336 ''	2.896	2.654	2.740	-26.662	-0.086
55	0.376 ''	2.716	2.780	2.930	-46.668	-0.150
60	0.414 ''	2.517	2.882	3.098	-67.171	-0.216
65	0.452 ''	2.303	2.960	3.242	-87.741	-0.282
70	0.486 ''	2.073	3.014	3.361	-107.982	-0.347
75	0.511 ''	1.832	3.044	3.455	-127.677	-0.411
80	0.527 ''	1.580	3.051	3.523	-146.527	-0.471
85	0.532 ''	1.319	3.035	3.563	-164.257	-0.528
90	0.526 ''	1.053	2.996	3.577	-180.566	-0.581

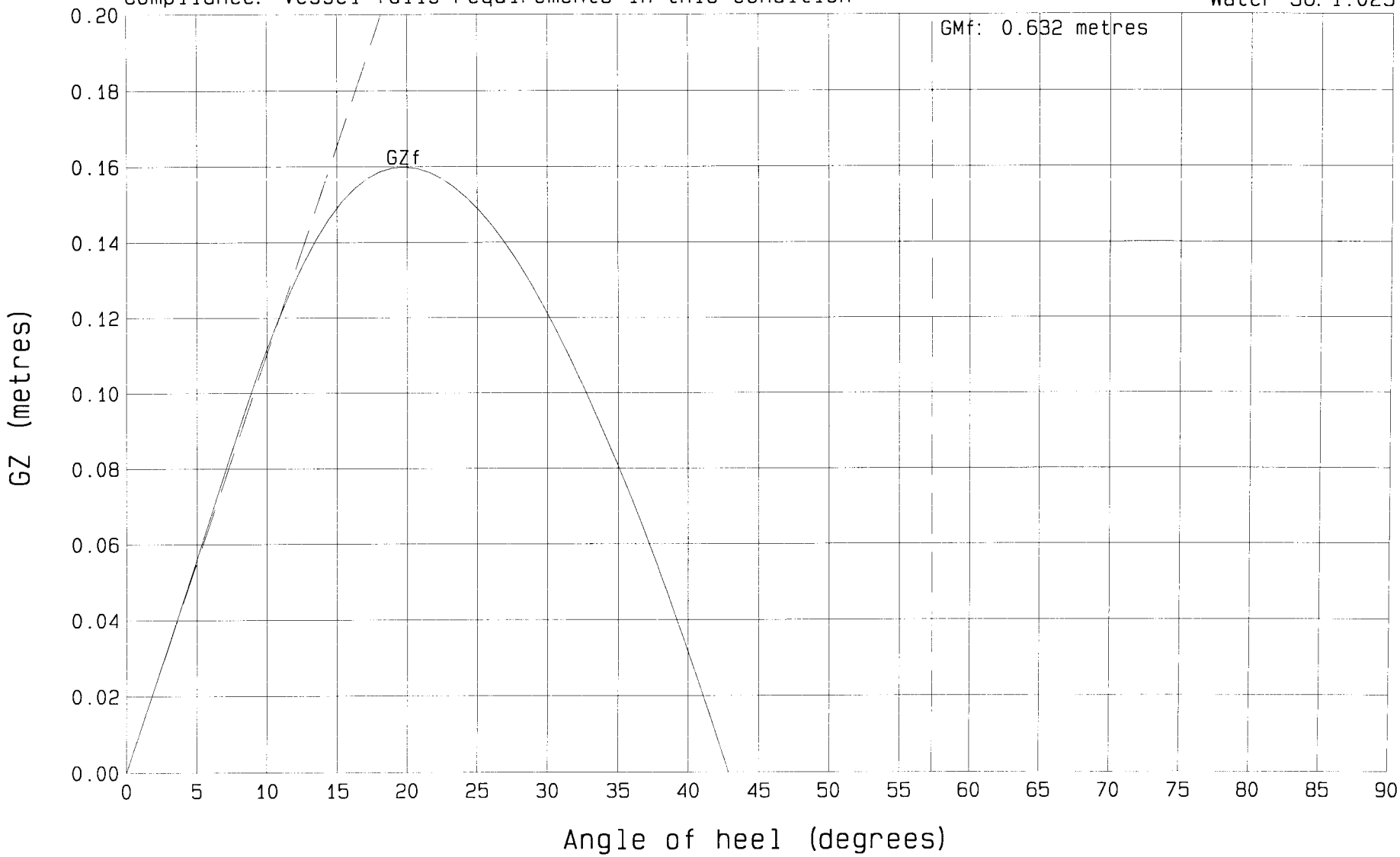
STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.061
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.074
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.014
Maximum GZ (metres)	0.200	0.160
Angle of heel at which maximum GZ occurs (degrees)	25.000	19.979
Positive GZ heel range (degrees)	-	42.862
GM solid (metres) (at angle of equilibrium)	-	0.632
Free Surface correction (metres)	-	0.000
GM fluid (metres) (at angle of equilibrium)	0.350	0.632

GZ PLOT

AMBER ROSE - MODEL TESTS

Condition.: CONDITION D
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025



Appendix 2

Model stability with GM reduced to 0.14m (VCG raised to 4.067m).

DEADWEIGHT TABLE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D - VCG RAISED TO 4.067M
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about STATION 0, AP (-ve aft, +ve forward)
Vertical dimensions about UNDERSIDE OF KEEL (+ve above, -ve below)
Transverse dimensions about centreline (+ve Port, -ve Stbd)

	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	TCG metres	Transverse moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	INTERIOR OF HULL FLOODED	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	DEADWEIGHT TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LIGHTSHIP	310.800	11.712	3640.089	0.000	0.000	4.067	1264.024	-
	DISPLACEMENT	310.800	11.712	3640.089	0.000	0.000	4.067	1264.024	0.000
	Free Surface Correction (Total Free Surface Moment/Displacement)							0.000	
							VCG fluid	4.067	

SAILING STATE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D - VCG RAISED TO 4.067M
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about Base Line at FP)	-	3.757
Draft midships LBP (about Base Line)	-	3.813
Draft aft (about Base Line at AP)	-	3.868

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP	1.340	1.933
Freeboard at midships LBP	-	0.517
Freeboard at AP	0.915	0.992

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.111 by stern	3.813	-0.000	0.000	-0.000	-0.000
5	0.106 ''	3.797	0.368	0.354	4.117	0.013
10	0.104 ''	3.750	0.733	0.706	8.270	0.027
15	0.106 ''	3.686	1.075	1.053	6.951	0.022
20	0.114 ''	3.614	1.383	1.391	-2.411	-0.008
25	0.134 ''	3.532	1.661	1.719	-18.051	-0.058
30	0.165 ''	3.438	1.910	2.034	-38.522	-0.124
35	0.202 ''	3.330	2.132	2.333	-62.275	-0.200
40	0.247 ''	3.204	2.331	2.614	-88.117	-0.284
45	0.292 ''	3.059	2.505	2.876	-115.366	-0.371
50	0.336 ''	2.896	2.654	3.116	-143.325	-0.461
55	0.376 ''	2.716	2.780	3.331	-171.418	-0.552
60	0.414 ''	2.517	2.882	3.522	-199.061	-0.640
65	0.452 ''	2.303	2.960	3.686	-225.765	-0.726
70	0.486 ''	2.073	3.014	3.822	-251.090	-0.808
75	0.511 ''	1.832	3.044	3.928	-274.780	-0.884
80	0.527 ''	1.580	3.051	4.005	-296.506	-0.954
85	0.532 ''	1.319	3.035	4.052	-315.970	-1.017
90	0.526 ''	1.053	2.996	4.067	-332.859	-1.071

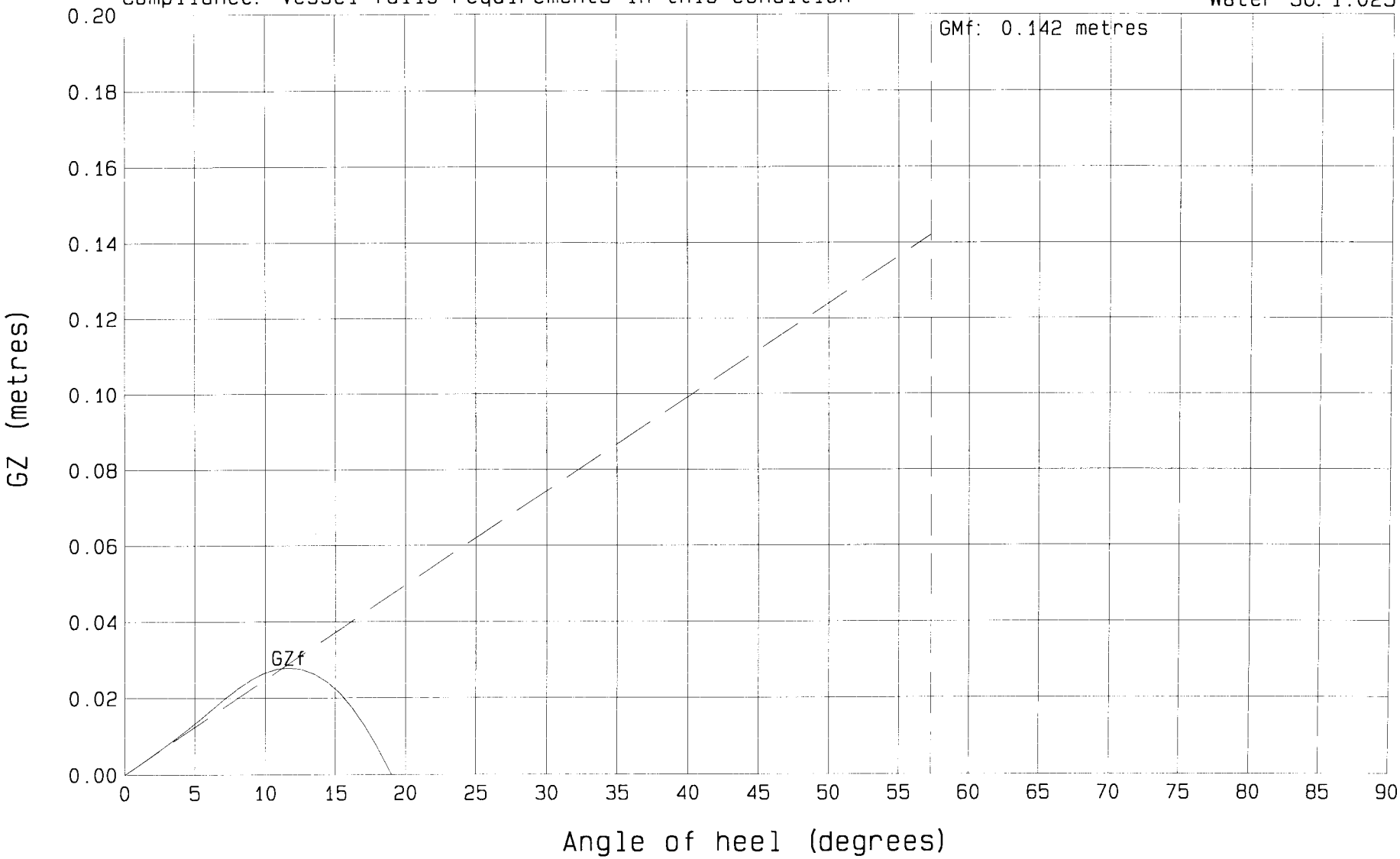
STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.006
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.006
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	0.200	0.027
Angle of heel at which maximum GZ occurs (degrees)	25.000	11.295
Positive GZ heel range (degrees)	-	19.010
GM solid (metres) (at angle of equilibrium)	-	0.142
Free Surface correction (metres)	-	0.000
GM fluid (metres) (at angle of equilibrium)	0.350	0.142

GZ PLOT

AMBER ROSE - MODEL TESTS

Condition.: CONDITION D - VCG RAISED TO 4.067M
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025



Appendix 3

Model stability with 20 tonnes of water trapped inside shelter.

DEADWEIGHT TABLE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D - 20T WATER IN SHELTER
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about STATION 0, AP (-ve aft, +ve forward)
Vertical dimensions about UNDERSIDE OF KEEL (+ve above, -ve below)
Transverse dimensions about centreline (+ve Port, -ve Stbd)

	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	TCG metres	Transverse moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	SHELTER INTERIOR	20.000	12.203	244.060	0.000	0.000	4.530	90.600	327.075
	DEADWEIGHT TOTAL	20.000	12.203	244.060	0.000	0.000	4.530	90.600	327.075
	LIGHTSHIP	310.800	11.712	3640.089	0.000	0.000	3.577	1111.731	-
	DISPLACEMENT	330.800	11.742	3884.149	0.000	0.000	3.635	1202.331	327.075
	Free Surface Correction (Total Free Surface Moment/Displacement)						0.989		
							VCG fluid	4.623	

SAILING STATE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D - 20T WATER IN SHELTER
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about Base Line at FP)	-	3.832
Draft midships LBP (about Base Line)	-	3.837
Draft aft (about Base Line at AP)	-	3.842

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP	1.340	1.705
Freeboard at midships LBP	-	0.376
Freeboard at AP	0.915	0.888

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.017 by stern	3.951	0.000	0.000	0.000	0.000
5	0.011 ''	3.935	0.368	0.403	-11.672	-0.035
10	0.011 ''	3.886	0.780	0.803	-7.538	-0.023
15	0.021 ''	3.808	1.210	1.197	4.399	0.013
20	0.053 ''	3.701	1.638	1.581	18.648	0.056
25	0.113 ''	3.568	2.056	1.954	33.839	0.102
30	0.192 ''	3.408	2.459	2.312	48.772	0.147
35	0.283 ''	3.220	2.843	2.652	63.128	0.191
40	0.377 ''	3.003	3.203	2.972	76.616	0.232
45	0.475 ''	2.761	3.532	3.269	86.919	0.263
50	0.573 ''	2.504	3.816	3.542	90.900	0.275
55	0.669 ''	2.232	4.059	3.787	89.940	0.272
60	0.760 ''	1.949	4.262	4.004	85.376	0.258
65	0.843 ''	1.655	4.427	4.190	78.233	0.236
70	0.913 ''	1.354	4.555	4.345	69.492	0.210
75	0.969 ''	1.049	4.648	4.466	60.175	0.182
80	1.003 ''	0.744	4.708	4.553	51.111	0.155
85	1.010 ''	0.441	4.739	4.606	44.162	0.133
90	1.011 ''	0.144	4.745	4.623	40.105	0.121

STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 13.32 and 30.00 degrees (metre.radians)	0.055	0.021
Area under GZ curve between 13.32 and 40.00 degrees (metre.radians)	0.090	0.054
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.033
Maximum GZ (metres)	0.200	0.275
Angle of heel at which maximum GZ occurs (degrees)	25.000	51.529
Positive GZ heel range (degrees)	-	63.363
GM solid (metres) (at angle of equilibrium)	-	1.421
Free Surface correction (metres)	-	0.989
GM fluid (metres) (at angle of equilibrium)	0.350	0.432

STABILITY SUMMARY (CONTINUED)	Maximum	Actual
Angle of equilibrium (degrees)	-	13.318

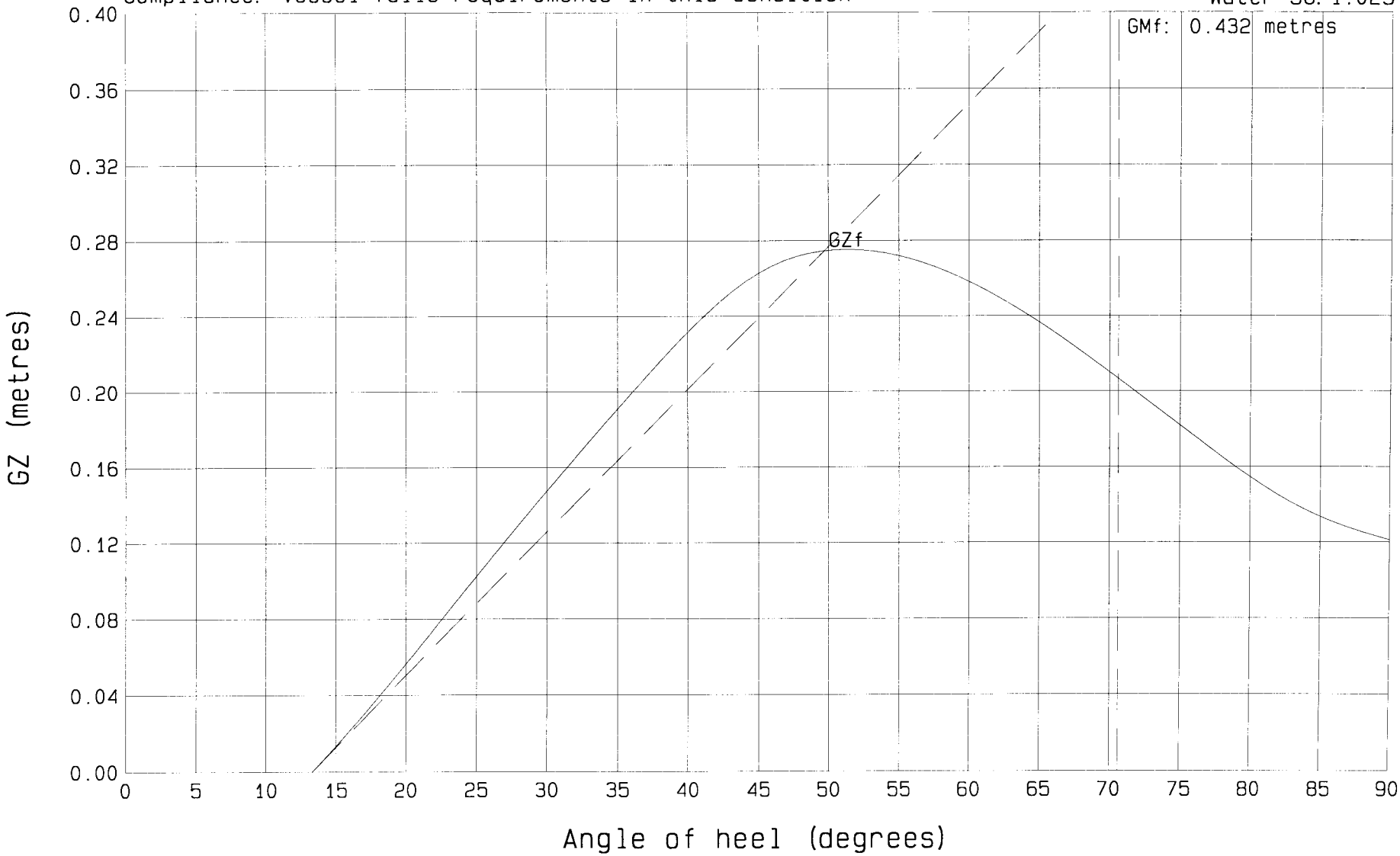
GZ PLOT

AMBER ROSE - MODEL TESTS

Condition.: CONDITION D - 20T WATER IN SHELTER
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025

GMf: 0.432 metres



Appendix 4

Model stability with 58.5 tonnes of floodwater in hull.

DEADWEIGHT TABLE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D PLUS 58.5T OF FLOODING
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about STATION 0, AP (-ve aft, +ve forward)
Vertical dimensions about UNDERSIDE OF KEEL (+ve above, -ve below)
Transverse dimensions about centreline (+ve Port, -ve Stbd)

	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	TCG metres	Transverse moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	INTERIOR OF HULL FLOODED	58.500	12.573	735.521	0.000	0.000	1.549	90.617	265.855
	DEADWEIGHT TOTAL	58.500	12.573	735.521	0.000	0.000	1.549	90.617	265.855
	LIGHTSHIP	310.800	11.712	3640.089	0.000	0.000	3.577	1111.731	-
	DISPLACEMENT	369.300	11.848	4375.609	0.000	0.000	3.256	1202.347	265.855
	Free Surface Correction (Total Free Surface Moment/Displacement)						0.720		
							VCG fluid	3.976	

SAILING STATE

Vessel....: AMBER ROSE - MODEL TESTS
Condition.: CONDITION D PLUS 58.5T OF FLOODING
State.....: Hull without added appendages
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draft forward (about Base Line at FP)	-	4.335
Draft midships LBP (about Base Line)	-	4.219
Draft aft (about Base Line at AP)	-	4.103

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP	1.340	1.355
Freeboard at midships LBP	-	0.111
Freeboard at AP	0.915	0.757

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.232 by bow	4.219	0.000	0.000	0.000	0.000
5	0.237 ''	4.207	0.362	0.346	5.900	0.016
10	0.244 ''	4.191	0.697	0.690	2.339	0.006
15	0.246 ''	4.171	1.005	1.029	-8.823	-0.024
20	0.231 ''	4.145	1.295	1.360	-24.083	-0.065
25	0.201 ''	4.107	1.566	1.680	-42.008	-0.114
30	0.156 ''	4.054	1.821	1.988	-61.555	-0.167
35	0.109 ''	3.984	2.057	2.280	-82.579	-0.224
40	0.060 ''	3.895	2.273	2.555	-104.487	-0.283
45	0.009 ''	3.786	2.470	2.811	-126.045	-0.341
50	0.038 by stern	3.656	2.648	3.046	-146.984	-0.398
55	0.078 ''	3.505	2.805	3.257	-166.852	-0.452
60	0.110 ''	3.334	2.946	3.443	-183.642	-0.497
65	0.134 ''	3.141	3.059	3.603	-200.954	-0.544
70	0.151 ''	2.930	3.162	3.736	-211.750	-0.573
75	0.159 ''	2.700	3.249	3.840	-218.253	-0.591
80	0.155 ''	2.453	3.314	3.915	-222.049	-0.601
85	0.143 ''	2.191	3.356	3.961	-223.263	-0.605
90	0.126 ''	1.916	3.373	3.976	-222.375	-0.602

STABILITY SUMMARY	Minimum	Actual
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.002
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.002
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	0.200	0.016
Angle of heel at which maximum GZ occurs (degrees)	25.000	5.618
Positive GZ heel range (degrees)	-	11.285
GM solid (metres) (upright)	-	0.956
Free Surface correction (metres)	-	0.720
GM fluid (metres) (upright)	0.350	0.236

GZ PLOT

AMBER ROSE - MODEL TESTS

Condition.: CONDITION D PLUS 58.5T OF FLOODING
State.....: Hull without added appendages
Compliance: Vessel fails requirements in this condition

Water SG: 1.025