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MARINE ACCIDENT INVESTIGATION BRANCH

Marine Accident Report 3/99

Report of the Inspector's Inquiry into the Sinking of the Fishing Vessel

Margaretha Maria BM148

with the loss of four crew
between 11 and 17 November 1997

MAIB
is an
INVESTOR IN PEOPLE

July 1999

Marine Accident Investigation Branch
of the Department of the Environment
Transport and the Regions: London

Marine Accident Investigation Branch
Department of the Environment, Transport and the Regions
Carlton House
Carlton Place
Southampton SO15 2DZ

17 June, 1999

The Right Honourable John Prescott MP
Deputy Prime Minister and Secretary of State
for the Environment, Transport and the Regions

Sir

I have the honour to submit the MAIB report into the circumstances which led to the loss of four lives and the sinking of the fishing vessel *Margaretha Maria* between 11 and 17 November 1997.

I have the honour to be
Sir
Your obedient servant

J S Lang
Rear Admiral
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CONTENTS

Glossary of Abbreviations and Acronyms

COSPAS	SAR satellite system (Russian Federation)
CO_2	Carbon Dioxide
EPIRB	Emergency Position Indicating Radio Beacon
GM	Metacentric height
GZ	Righting lever
HMS	Her Majesty's Ship
HRU	Hydrostatic Release Unit
IMO	International Maritime Organization
KG	Distance between keel and centre of gravity
kW	kilowatt
m	metre
m^2	square metre
MAFF	Ministry of Agriculture Fisheries and Food
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MF	Medium frequency (radio)
MHz	Megahertz
mm	millimetre
MoD	Ministry of Defence
MRCC	Maritime Rescue Co-ordination Centre
MSA	Marine Safety Agency (Maritime and Coastguard Agency [MCA] from April 1998)
RAF	Royal Air Force
RCCP	Rescue Co-ordination Centre Plymouth
RN	Royal Navy
RNMDSF	Royal National Mission to Deep Sea Fishermen
ROV	Remotely Operated Vehicle
SAR	Search and Rescue
SARSAT	SAR satellite system (France/USA/Canada)
SOC	Southampton Oceanography Centre
UK	United Kingdom
UKFV	United Kingdom Fishing Vessel
UTC	Universal co-ordinated time
VHF	Very high frequency (radio)

Reproduced from Admiralty Chart 4014 by permission of the Controller of HMSO and the UK Hydrographic Office

Synopsis

In a telex to the Marine Accident Investigation Branch (MAIB), at 0130, 18 November 1997, Falmouth Maritime Rescue Co-ordination Centre (MRCC) reported they had broadcast requests for information on the fishing vessel *Margaretha Maria*. The incident was re-classified as a "Mayday" and, following an unsuccessful search for the vessel, MAIB opened an inquiry late on 18 November.

Margaretha Maria was a 21.54 metre twin beam trawler, operated out of Newlyn, Cornwall, by a properly certificated and experienced crew of four. The vessel carried all mandatory safety equipment and had a valid United Kingdom Fishing Vessel (UKFV) Certificate. The vessel left Newlyn at 1630 on 11 November 1997. Apart from telephone calls made by the crew that evening, there was no further contact with the vessel. A Search and Rescue (SAR) operation began on 18 November, and covered a large area of the western approaches to the English Channel. No sign of the vessel, associated debris, or her crew was found. SAR operations were terminated on 20 November.

A body was recovered in fishing grounds about 50 miles south-west-by-south of Lizard Point on 11 February 1998. It was later identified as that of Robert Holmes, skipper of *Margaretha Maria*. Following a request to the Ministry of Defence (MoD) for assistance in locating the vessel, *HMS Cromer* located the wreck of *Margaretha Maria* on 17 March, about five miles from the position where the skipper's body was recovered.

The wreck was surveyed twice during 1998. Once in April, by a team commissioned by families of the crew, and once by the MAIB in June. Analysis of the surveys' results, stability assessments and consideration of other material formed the basis of the inquiry.

The inquiry concludes that the vessel capsized, flooded aft and sank by the stern. Capsize was most probably due to the derricks being topped while large weights of shells and sand were in the nets. This reduced the vessel's stability sufficiently to induce the capsize. The accident occurred at a time unknown between 11 and 17 November 1997. None of the crew survived. Liferafts and the Emergency Position Indicating Radio Beacon (EPIRB) failed to surface and function as intended.

In particular, this inquiry has revealed that the stability of beam trawlers may be substantially reduced by normal operational movements of derricks and fishing gear. Assessment of this effect is not required by the Maritime and Coastguard Agency (MCA) before a UKFV Certificate is issued.

Recommendations have been made on vessel reporting systems, stability standards of beam trawlers, positioning of EPIRBs and publicising the potential dangers of using high capacity winches on beam trawlers.

Margaretha Maria

Vessel and Incident Particulars

Name	:	*Margaretha Maria*
Port of registry	:	Brixham
Type	:	Fishing vessel (twin beam trawler)
Fishing number	:	BM148
Official number	:	A14854
Registered length	:	21.54m
Overall length	:	22.8m
Beam	:	5.82m
Gross tonnage	:	68.78
Builder	:	N.V.Holland Launch Zaandam Holland
Date built	:	1958
Construction	:	Steel
Main engine, power	:	Caterpillar, 221 kW
Crew	:	Four
United Kingdom Fishing Vessel Certificate	:	Issued at Plymouth on 26 November 1996. Valid to 28 November 1998
Registered owners	:	Messrs Adams & Chope 78 The Strand Newlyn Cornwall
Position of accident	:	49° 00' 41.126"N 005° 59' 21.914"W
Date and time	:	At a time unknown between 11 and 17 November 1997
Damage	:	Total loss
Casualties	:	Four crew lost

SECTION 1
Factual information

(All times quoted are UTC)

1.1 BACKGROUND

Margaretha Maria commenced a seven week period of maintenance and repair on 28 August 1997 and then completed three fishing trips before starting her final voyage. The corresponding landings were on 21, 28 October and 4 November 1997.

The area fished during these three trips was about 60 miles south-south-west of Lizard Point at the western end of the English Channel. Each of the catches was considered good. The sea bed in the area was generally soft, sandy and was crossed by several submarine cables.

1.2 FINAL VOYAGE, SEARCH AND RESCUE

11 November 1997

After taking on board three tonne of ice, *Margaretha Maria* sailed from Newlyn, Cornwall, at 1630 on Tuesday, 11 November 1997 with a crew of four. There were 13,000 litres of diesel fuel on board and fresh water tanks were full. As part of the vessel's pre-sailing checks, VHF, MF radios and portable telephone were confirmed as operational.

The owners expected the vessel to fish the grounds used during the three preceding trips but no definite plan was agreed. She was expected to return to Newlyn on the evening of Monday, 17 November, or early the following morning, but her crew had indicated they would return on Friday 14 November.

On clearing the harbour, the vessel was observed heading south or south-south west.

That evening, the skipper and a crewman of *Margaretha Maria* made contact with family members ashore using the portable telephone. The last call was made at 1915. An attempt to make a return call to the vessel at 2200 the same evening was unsuccessful.

No further radio or telephone traffic from the vessel was heard, and no further sightings of the vessel were reported.

17 November 1997

At 1124, MRCC Falmouth received a telephone call from the Newlyn Fisheries Officer reporting the owner's lack of contact with *Margaretha Maria* since the vessel's departure on 11 November. The vessel's likely fishing area was stated to be in the vicinity of 49° 20'N 005° 30'W.

MRCC Falmouth attempted to contact *Margaretha Maria* using VHF and MF radio and mobile telephone. There was no response.

Having failed to contact *Margaretha Maria* by 1224, MRCC Falmouth raised the status of the incident to "Pan Pan" and began making "Pan Pan" broadcasts on VHF and MF radio. These continued on a regular basis.

Details were also passed to MRCC Corsen, France, and similar broadcast action was commenced by the French authorities.

18 November 1997

By early morning, the vessel was overdue and MRCC Falmouth re-categorised the incident as "Mayday" at 0903.

"Mayday" broadcast action commenced and a request was made to Rescue Co-ordination Centre Plymouth (RCCP) for a Nimrod aircraft to search an area of approximately 2500 square nautical miles, based on the vessel's expected area of operation (**Figure 1**). Availability of military and civilian surface and air units was established.

Checks began of harbours in the south-west of England, southern Ireland and north-west France.

The RAF Nimrod, R51, reported on scene at 1159 and started a radar search. All radar contacts in the area had been identified by 1305. A visual search by R51 then commenced using a track spacing of 1.5 miles.

Following arrangements made with the Spanish authorities, a "Mayday Relay" was broadcast in Spanish.

Two Ministry of Agriculture Fisheries and Food (MAFF) fixed wing aircraft became involved in the search during the afternoon. One searched the area between the basic search area and the UK coast, the second covered an area to the west.

Several objects were sighted in the water. Rescue helicopter, R193, and the tug *Far Minerva* were requested to proceed and investigate. Nothing was found which could be linked to *Margaretha Maria*.

With the onset of darkness, SAR units were released, but broadcast action continued on a two hourly basis. Reports on harbour checks continued to be received.

19 November 1997

During daylight hours, military aircraft on routine training flights were asked to report if they saw anything untoward. Broadcast action continued. Coastguard teams searched the coastline between Gwennap Head and Lizard Point where poor weather was driving large quantities of debris ashore. Owing to the lack of reliable positional information, no dedicated sea or air SAR units were tasked.

20 November 1997

Shoreline searches and broadcast action continued. An RAF Nimrod and a Ministry of Agriculture and Fisheries (MAFF) aircraft were asked to search designated areas and report

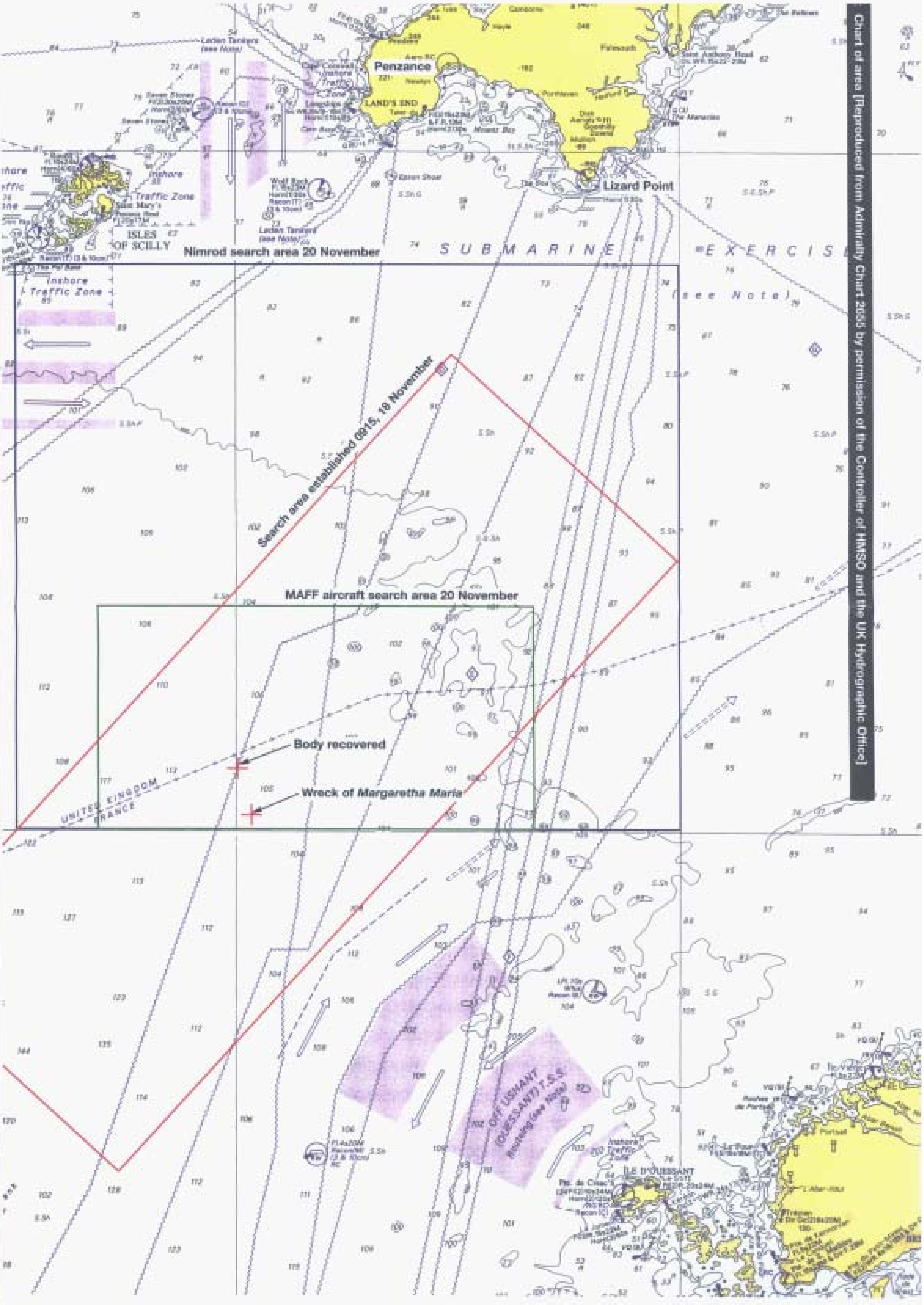


Chart of area [Reproduced from Admiralty Chart 2655 by permission of the Controller of HMSO and the UK Hydrographic Office] anything unusual. An aircraft on charter to the owners of *Margaretha Maria* also searched an area to the owners' instructions. Reported sightings were investigated but none were related to the *Margaretha Maria.*

21 November 1997

MAFF aircraft were again advised to be vigilant. Broadcast action continued until 2357. SAR operations were terminated at 0518 on 22 November.

All further reports of debris coming ashore were investigated by Coastguard teams. None were related to *Margaretha Maria.*

1.3 SEARCH FOR THE WRECK

On completion of SAR operations no search was made for the wreck of *Margaretha Maria.* The decision not to do so was based on the level of uncertainty of her likely fishing area.

On 11 February 1998 a body was recovered in the nets of the fishing vessel *Silver Harvester*, in position 49° 05'.12N 05° 59'.93W, about 50 miles south-west-by-south of Lizard Point (**Figure 1**). The body was passed to the French authorities.

The recovered body was later identified as that of Robert Holmes, skipper of *Margaretha Maria*.

On 19 February, the MAIB sought the help of the Royal Navy to assist in locating *Margaretha Maria* using the position from where the skipper's body was recovered as the search datum. At 0800 on 27 February, *HMS Atherstone* began a sea bed sonar search based on this datum and found several bottom contacts. One was considered significant but worsening weather conditions prevented further investigation and operations were aborted.

Service commitments and poor weather conditions prevented further search activity by RN vessels until 17 March. At 0903 on 17 March, an underwater camera from *HMS Cromer* identified the contact previously reported by *HMS Atherstone*, as the wreck of *Margaretha Maria, BM148*. Its position was given as 49° 00'.592N 005° 59'.478W, about 55 miles south-west-by-south of Lizard Point, in approximately 120 metres of water (**Figure 1**).

1.4 WEATHER

Fishermen operating in the western approaches reported good weather conditions from 11 November. Wind was force 2 to 3 giving slight seas. Conditions remained good until 15/16 November but were poor during the subsequent SAR operations.

1.5 CREW

Following her purchase in the autumn of 1994, *Margaretha Maria* first started fishing with the part owner Mr Malcolm Chope as skipper. Mr Robert Peachy Holmes joined *Margaretha Maria* as mate in February 1995 and became the vessel's skipper in October 1995 when Malcolm Chope took on the responsibility of shore manager of the vessel. Robert Holmes remained skipper of *Margaretha Maria* until her loss.

Robert Holmes was 43 years of age, had a Skipper's Certificate of Service, No 170, dated 11 May 1995 and had experience of other fishing vessels operating from Newlyn.

Mr Peter John Todd joined *Margaretha* Maria in January 1996 as mate. He was 45 years of age and had a Second Hand Certificate of Service, No 140, dated 8 February 1994.

The vessel's two deckhands were Mr Vincent John Marshall and Mr Kerry Todd, son of John Todd the vessel's mate.

Vincent Marshall was 33 years of age and joined the vessel in June 1997. Kerry Todd was 24 years of age and joined the vessel in October 1997, three trips before her loss.

1.6 HISTORY OF VESSEL

Margaretha Maria was purchased in 1976 by UK owners, and transferred to UK registration from the Netherland's flag where it had operated as a beam trawler. The vessel remained with these UK owners until the autumn of 1994 when it was purchased by Messrs Adams and Chope, her ultimate owners.

An inspection of *Margaretha Maria* was performed by a surveyor of the MSA on 28 January 1994 for the renewal of her UKFV Certificate. The previous certificate expiry date was 30 April 1994. This survey identified work which needed to be undertaken before the vessel would be allowed to sail.

Significant work was undertaken following the survey in January. This involved ultrasonic thickness measurements of the hull plating, insulation tests on wiring, an overhaul of the main engine, main gearbox, engine driven pumps and top overhaul of the auxiliary engine.

Before entering service with her new owners, a goalpost gantry was fitted aft of the whaleback and the original gull wing derricks, abeam of the wheelhouse, were removed.

4m long fishing beams were initially used with the new gantry arrangement but the owners replaced them with longer fishing beams measuring 7m. Their greater weight required the vessel's stability to be modified with the addition of 1½ tonne of ballast in the fish hold. The vessel's stability was calculated and operational restrictions were found to be necessary to satisfy statutory requirements. These restrictions limited the fuel capacity and range of the vessel.

The vessel was issued with short term UKFV Certificates pending modifications for stability improvements. These covered the periods 23 February 1995 to 23 August 1995, and 13 November 1995 to 13 April 1996.

To improve stability a weathertight aft shelter was constructed during April/May 1996, after which an inclining test was performed in June. Following this test 1 tonne of ballast was added beneath the cabin floor and was included in the vessel's stability assessment. The stability information subsequently submitted allowed a further short term UKFV Certificate to be issued for the period 2 July 1996 to 17 December 1996.

The Marine Safety Agency's (MSA's) approval of the stability information allowed a full term UKFV Certificate to be issued on 26 November 1996. This was valid to 28 November 1998. The operational restrictions that had previously limited the vessel's fuel capacity were removed.

Figure 2A: **General arrangement (elevation)**

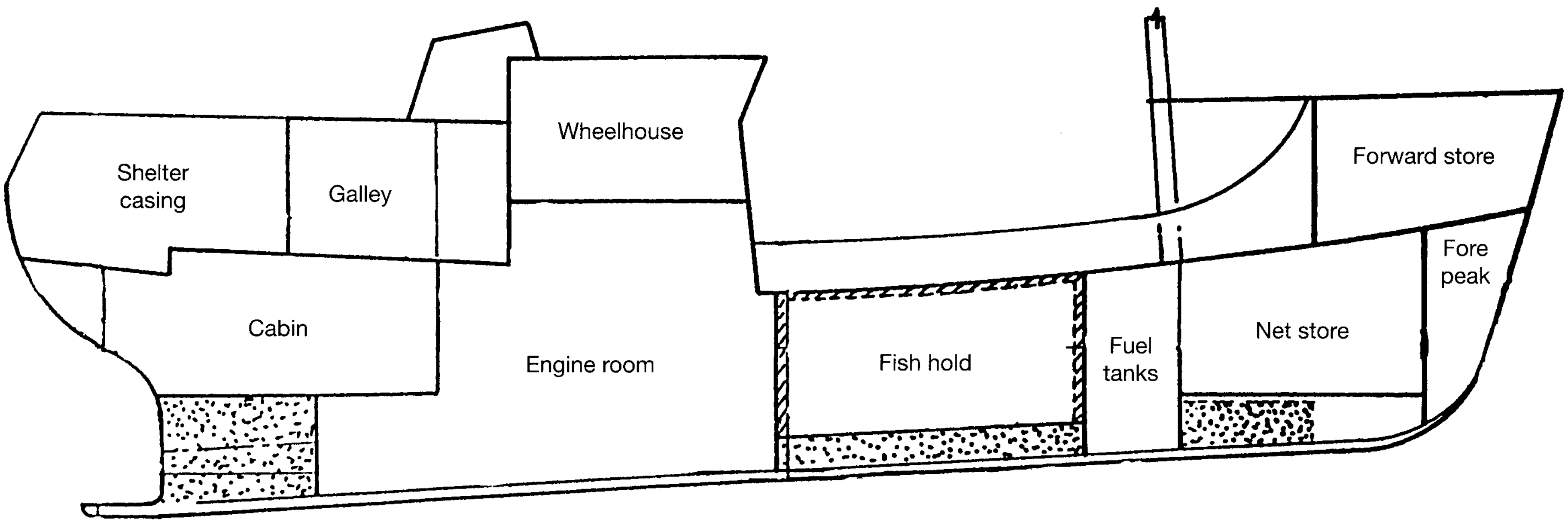
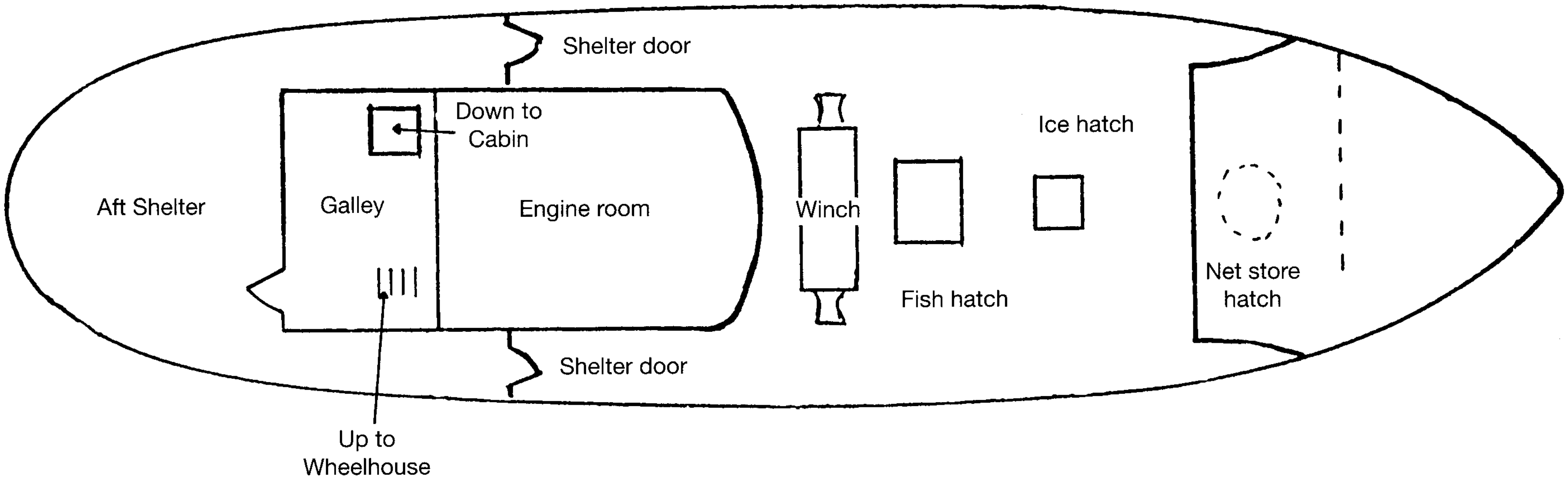


Figure 2B: **General arrangement (plan at main deck level)**



Other work performed shortly before the vessel's loss, and not covered in later sections of this report, included re-balancing and pitching the propeller, re-lining winch brake bands, and a weld repair to the deck adjacent to the fuel tanks and forward bulkhead of the fish hold.

1.7 GENERAL ARRANGEMENT OF *MARGARETHA MARIA*, BM148 (Figures 2A & 2B)

The hull below main deck level was divided into four main compartments. From aft these were; cabin, engine room, fish hold and net store. A small forepeak space was forward of the net store. Between the fish hold and the net store were three fuel tanks arranged transversely across the hull. Straddling the engine room and cabin was a galley/deckhouse structure with the wheelhouse above. Aft and abeam of the galley deckhouse was a steel weathertight shelter.

Access to the shelter from the deck areas abeam of the bridge structure was by two forward facing weathertight doors, one on each side. Each door was hinged on its outboard edge and could be secured open against a bulwark bracket. Access to the galley from beneath the shelter was by a single, weathertight, aft facing door at the aft end of the galley. This door was hinged along its port edge.

Internal access between cabin and galley was by a hatch in the deck of the galley just to port of centre. This hatch cover was hinged along its port edge and could be secured open against the port side of the galley structure. Access to the wheelhouse from the galley was by a short stairway slightly to starboard of centre leading up to it with a door at its top.

A circular hatch in the working deck, just forward of the gantry, provided access to the net store. Forward of the gantry beneath the whaleback, was a store entered by a weathertight door to starboard. Two gas bottles were secured adjacent to this door. One contained oxygen and the other propane. They were fitted with a pair of hoses and a torch. Aft of the gantry two hatches gave access to the fish hold. The forward served the ice lockers, the aft was the main loading and unloading fish hatch.

1.8 STRUCTURAL MODIFICATIONS

To overcome earlier problems caused by marginal stability properties, the weathertight shelter was fitted during April/May of 1996. This enclosed the galley, the structure of which was retained, and provided an internal passage either side and aft of the galley.

A fuel tank inspection hatch just forward of the fish hold was blanked off and its coaming removed. As a replacement, an inspection opening was cut in the forward bulkhead of the tank with access from the net store.

Apart from fitting a different gantry no other major structural alterations were made.

1.9 GANTRY AND DERRICKS (Figure 3)

At the time of her purchase in 1994, the vessel was equipped with a pair of gull wing derricks on the bulwarks either side of the deckhouse. The accompanying beams were 8m long.

Before the vessel entered service with her new owners, the gull wings were removed and a goalpost gantry fitted over the aft bulkhead of the net store. The height of the gantry was 6.5m above the working deck. On the cross bar a lightweight mast was fitted to accommodate navigation lights and the whaleback top was extended to suit the new gantry.

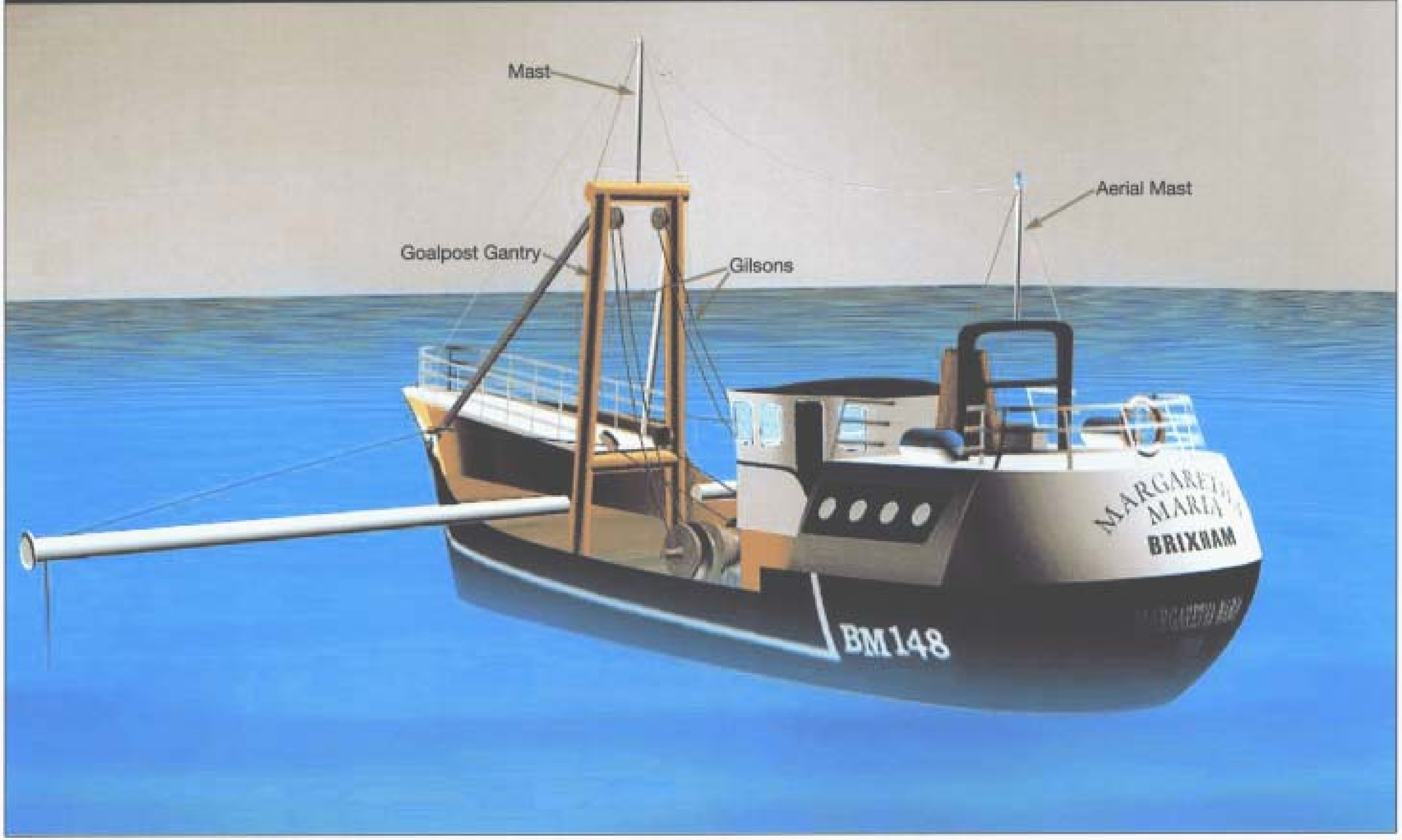
Derricks of 8.5m length were fitted at the lower end of each gantry upright. A gooseneck between each derrick and gantry upright allowed the derricks to swivel about the vertical and horizontal.

Concurrent with this work a frame was constructed immediately forward of the winch. Two sliding sheaves were fitted to the top of the frame so that the towing wires could be kept clear of the deck before leading forward to the whaleback and derricks.

On the forward side of the frame, port and starboard, was a cleat to which both ends of each gilson line were lashed or clipped when not in use.

A lightweight aluminium goalpost gantry or aerial mast was positioned at the forward end of the shelter top, just aft of the wheelhouse. Aerial and span wires ran between this and the mast on the forward gantry.

Figure 3



1.10 WINCH AND CONTROLS

General arrangement

The fishing winch on *Margaretha Maria* was a four drum hydraulically powered unit, manufactured in 1982 and situated on the main deck just forward of the deckhouse. The winch manufacturer quotes its nominal capacity as 18 to 20 tonne. These performance figures were quoted at the stall and dynamic conditions respectively. They also assumed only one layer of wire on the drums and a maximum pressure in the hydraulic power supply system of 200bar.

The drums were split into pairs, each pair serving the towing and topping wires for one side of the vessel. Each wire drum could be power driven when clutched onto its respective drive shaft, or held stationary using a band type friction brake. When manufactured, actuation of the clutches and brakes was by levers and handwheels mounted on the winch's frame. As a retrospective modification, remote operation of clutches and brakes was introduced by the winch's supplying agents.

Drums' selection and drive

When in the power drive mode, each clutch could be engaged with only one wire drum at any time. Only the towing drum or the topping drum of each pair could therefore be driven at any time. The clutches could also be placed in a neutral position, allowing the drive shafts of the winch to turn independently of the wire drums. Extending from each side of the winch was a whipping drum which turned whenever the drive shafts rotated.

Brakes

Winch brakes could be operated locally, by handwheel, or remotely from within the wheelhouse. Remote brake control employed a hydraulic motor on each threaded brake shaft. Rotation of each shaft applied, or released, a brake band as did each handwheel. Hydraulic power supply for the brake motors, which was independent of the system serving the main winch motor, was provided by a hydraulic pump driven by an electric motor in the engine room. This motor could be operated from the wheelhouse, by a switch on the console, or in the engine room. Four self centring brake control levers, situated centrally on the wheelhouse console, served the hydraulic motors on the four brake shafts.

Speed control

Winch speed and direction were controlled only from the wheelhouse; there was no local control facility. The control lever was positioned on the starboard side of the wheelhouse console. This lever, which controlled the swash plate angle of the hydraulic pump and so the rate and direction of output, was self centring to the neutral or zero output position.

Clutches

Clutch operation could be performed locally at the winch or from the wheelhouse using remote controls linked to the clutch levers by cables. The two clutch control levers on the console moved from side to side. Each lever served one clutch. When moved towards the direction of the clutch which a lever served, the respective towing drum was engaged. Moved to point towards the other side engaged the respective topping drum. Thus, when the lever serving the starboard clutch pointed to starboard, drive to the starboard towing drum was engaged. When pointing to port, drive to the starboard topping drum was engaged. The action of the port lever, serving the port clutch, was a mirror image of this. With levers vertical, clutches were in neutral.

Although these levers remained connected to the winch by cables, it was usual practice on *Margaretha Maria* to operate the clutches locally on deck. As the cable connections between winch and wheelhouse were retained, any movement of the winch mounted clutch levers meant the wheelhouse levers acted in sympathy.

The clutches were of the dog type and required the winch drive shafts to be stopped, and possibly turned slightly, to align the dogs before engagement was possible. Similarly, when attempting to disengage a clutch it was necessary to apply the respective brake first, back off the drive motor and then move the clutch lever. Disengaging clutches when under load was not easy due to the effects of friction, a characteristic of dog clutches.

Power supply

At the time the vessel was purchased in 1994, the main hydraulic power supply pump was driven from the main engine by a belt and pneumatic clutch. By mid 1997, wear had developed in parts of this system and it was becoming unreliable.

During the summer of 1997 this system was replaced by a swash plate hydraulic pump and boost pump directly coupled to the main engine. There was no intervening clutch.

A system of winch emergency stop buttons was also installed in 1997: one in the wheelhouse on the console adjacent to the brake levers, and one on each outer forward corner of the deckhouse and accessible from the deck. Each of these buttons would, when operated, open a solenoid controlled diverter valve on the discharge side of the boost pump, and interrupt the power supply to the winch.

Other modifications and repairs

Shortly after installation of the swash plate pump, the winch tended to creep when the control lever was in the neutral or stop position.

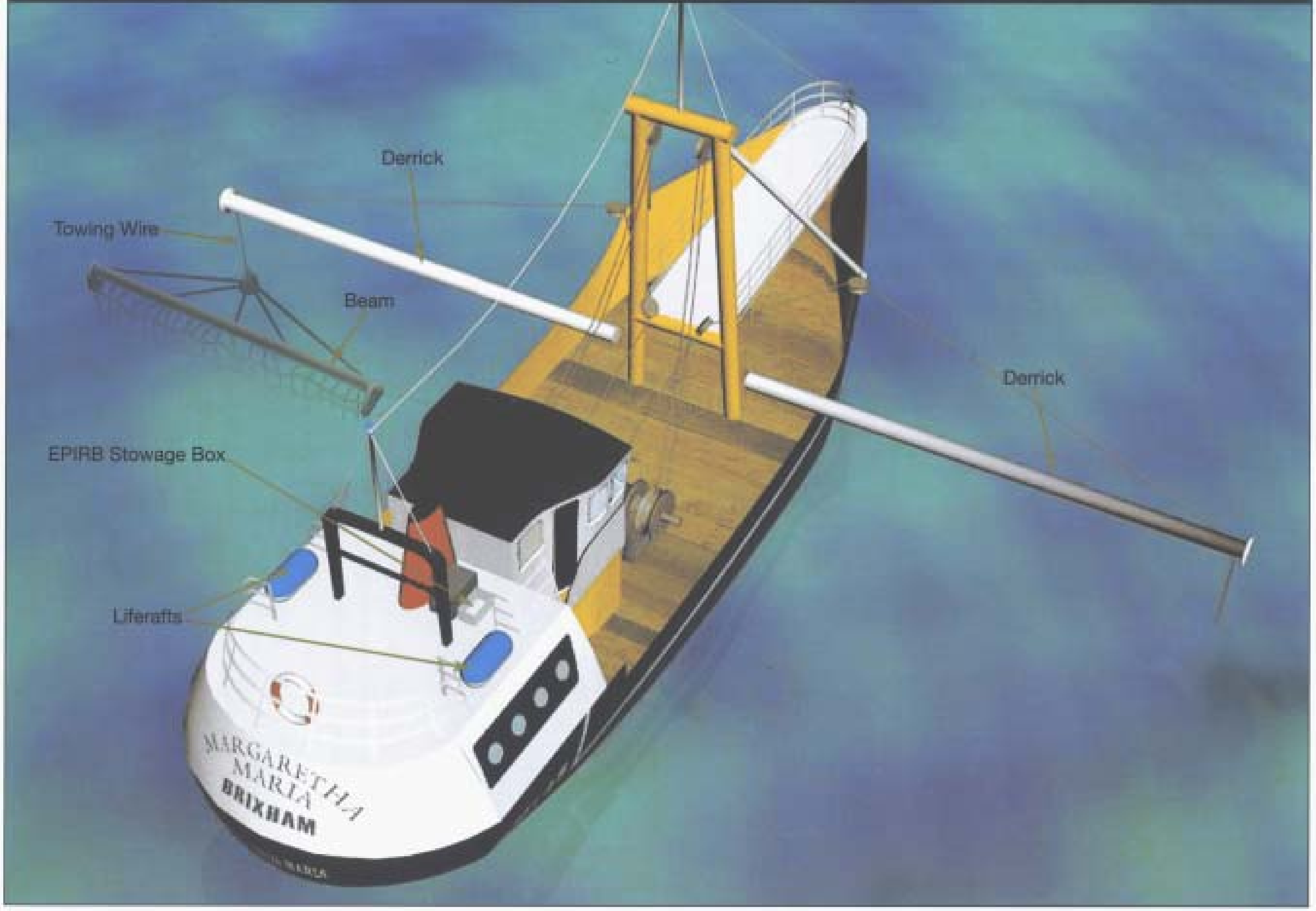
On advice from a hydraulics specialist, the vessel's owner removed the swash plate pump for inspection. It was dismantled and examined at the workshops of a specialist hydraulics company and several internal components were replaced. It was then refitted in *Margaretha Maria*.

The opportunity was also taken to fit a lower capacity boost pump to overcome a noise problem. In addition, a spring loaded indent and plate arrangement was fitted to the swash plate pump's control lever to aid location of neutral. A load test was then performed by engaging clutches, applying brakes fully and placing the control lever to full speed. The system's relief valve was set to open at 275 to 280bar. All three emergency stop buttons were also tested at this stage. This work was completed at 1500 on 11 November 1997. All tests were considered satisfactory. Neutral could be located easily and the modification to reduce system noise was declared successful.

1.11 FISHING GEAR (Figure 4)

Margaretha Maria employed a method of fishing known as twin beam trawling, whereby a derrick extending over either side of the vessel tows a net attached to a heavy beam. The derricks can be lowered and raised with a multi-purchase block arrangement leading to the gantry head and winch. In the towing condition, each derrick is horizontal and is located fore and aft by two stays attached to its head. On *Margaretha Maria* one stay ran forward to

Figure 4


Derrick
Towing Wire
Beam
Derrick
EPIRB Stowage Box
Liferafts
MARGARETHA
MARIA
BRIXHAM

the whaleback, the other aft to the shelter top. These are termed forward and back stays respectively, and are located so they do not restrict the lowering and topping of the derricks.

While towing, the nets remain in contact with the sea bed, with their mouths kept open by a heavy beam and floats. Between each beam and its net is a chain mat which is intended to disturb fish and encourage them to rise and swim into the mouth of the net as it slides over the sea bed. The underside of the net is protected by matting to prevent sea bed damage.

Once within the net's mouth, fish migrate through a converging section of the net, known as the belly, towards the net's closed end known as the cod end. The cod end is that part of the net which is hauled on board by a simple lifting arrangement known as the gilson. Once on deck it is opened to release the fish.

Each set of gear comprising a beam, chain mat and net, is towed by a wire passing from a towing drum on the winch, out to a block on the derrick head via blocks on the whaleback and then to a towing or chain plate. To each chain plate is attached five short chains that form a bridle. The other ends are attached to the beam and its shoes.

To permit the beams to slide easily over the sea bed, each is fitted with shoes, one at either end. Each is free to swivel on the end of its beam and is normally kept in place by a chain on the bridle leading to the chain plate. Each shoe is also attached to its beam by a short length of chain acting as a retainer or preventer.

To each inboard shoe is clipped one end of a line known as a 'lazy decky'. The other end leads to the cod end's entrance and to a line which encircles its throat. When the gear arrives at the surface, weight is taken on the lazy decky using the gilson. The corresponding cod end is then 'choked off', to trap fish in the cod end and provide a means of lifting it inboard.

The total weight of both sets of fishing gear on *Margaretha Maria* comprising two beams, nets and mats, was four tonne. Each beam was 7m long.

The mesh size of the net used for the cod ends was 80mm, and 120mm for the net belly. Each 24mm towing wire was 210 fathoms long.

1.12 HAULING OPERATIONS

On completing a tow, usually of predetermined length, the gear is hauled to the surface and on board to recover any catch. It is then reshot to start another tow.

The likely hauling procedure employed on *Margaretha Maria* involved three of the crew. One would be in the wheelhouse and the other two on deck with one working on the port side and the other to starboard. The fourth member of the crew would be off duty.

Hauling the gear to the surface is under the control of the person in the wheelhouse. Once the gear reaches the surface, the beams cannot be lifted clear of the sea with the derricks horizontal. To provide clearance for lifting the cod ends over the bulwarks, and to give access to the lazy deckies on the inboard shoes of the beam, the two derricks are topped to about 45°. This requires the winch's clutches to be changed from engaging with the towing drums, to engagement with the topping drums. Once the derricks are topped, both clutches of the winch are placed in neutral.

The two gilson lines are then released from the frame just forward of the winch. Leaning over the bulwark rail, each crewman unclips the lazy decky from the inner shoe of his beam and clips it to the respective gilson line. Each man then moves to the whipping drum on his side of the deck and puts turns of his gilson line around the drum. With the winch speed under the control of the man in the wheelhouse, each man on deck controls the lifting of the cod end on his side of the vessel. He has control over this operation by the careful application of weight to the free end of the gilson line coming from the whipping drum.

Once inboard, the cod ends are untied allowing any catch to fall onto the deck ready for gutting and stowing. Each cod end is then retied to close it off and, unless net or other repairs are necessary, the gear is reshot to start another tow. Once the gear is back in the water, the fish are gutted on deck before being iced and stowed in the fish hold.

Margaretha Maria normally carried 100 fish boxes. While empty, half of these were stowed beneath the aft shelter, starboard side, and lashed to a handrail. The remainder were stowed in the fish hold. Filled boxes were stowed at the aft end of the fish hold.

1.13 SAFETY EQUIPMENT

The following items of life saving equipment are recorded in the vessel's Record of Particulars:

2 x six person liferafts
12 parachute flares
2 man overboard units with lights & smoke
4 x line throwing apparatus
1 EPIRB (Emergency Position Indicating Radio Beacon)
4 x lifebuoys
6 x lifejackets
1 x portable VHF radio.

Each liferaft was mounted in a cradle on the upper part of the aft shelter with one to port and the other to starboard **(Figure 4).** Installation incorporated a hydrostatic release unit (HRU) to satisfy the requirement that liferafts should be able to float free. One six person liferaft, serial No 19737, was serviced on 7 March 1997, the second, No 12660, was serviced on 26 March 1997. Liferafts require servicing every twelve months.

The 12 parachute flares were supplied new in November 1994 and have a recommended service life of three years.

New rocket and igniter units were supplied for the four line throwing apparatus in November 1994. These units have a recommended service life of three years.

The man overboard units, with lights and smoke, were supplied new in November 1994. The unit on the port side of the deckhouse was replaced during November 1996 after accidental activation. These units have a recommended service life of three years.

The EPIRB was supplied as an exchange overhauled unit in November 1994 and replaced an identical unit. It was capable of transmitting on 406MHz to COSPAS/SARSAT satellites and 121.5MHz for homing purposes.

The EPIRB was mounted in a stowage box on the shelter top, just aft of the wheelhouse and to the starboard side of the funnel.(**Figure 4**) The stowage box had an integral bellows type HRU which allowed the box's cover to open when immersed to a depth of 4m. The EPIRB was then required to float free at all angles of list and trim up to 45°.

When in its stowage box, the EPIRB's manual switch was intended to be in the 'on' position. A second internal switch was kept open by a magnet built into the stowage box preventing activation of the EPIRB until it had floated free or was removed from the box and the influence of the magnet. This magnetically operated switch therefore served the purpose of automatically activating the EPIRB when released from its stowage box.

The EPIRB's recommended battery service life was four years. The EPIRB was registered on the Coastguard's database in January 1995. This registration was voluntary.

The four lifebuoys were mounted externally on the forecastle and around the aft shelter.

The portable VHF radio and its battery charger was stowed in the aft starboard corner of the wheelhouse.

1.14 STABILITY

Margaretha Maria transferred from Netherlands to UK registration in 1976. Although the Netherlands authorities reported that the vessel had operated safely, the UK administration expressed concern over its standard of stability following a simple roll test. As a result of this concern full stability information was prepared. To ensure the stability requirements of a beam trawler could be met, the centre fuel tank and aft fresh water tank were required to remain empty.

A further set of stability information was approved by the UK administration in 1985. The centre fuel tank and aft fresh water tank were again required to remain empty.

On 6 January 1995, an inclining test was performed following completion of the post purchase refit work. The test results again indicated that the vessel failed to meet the minimum statutory stability requirements unless the aft fresh water tank and the centre fuel tank were maintained empty. A short term UKFV Certificate was issued.

The limited fuel and fresh water capacity placed a restraint on the vessel by limiting its area of operations. Improving her stability by making freeboard modifications and removing top weight were considered impractical. The owners decided to construct a full breadth weathertight aft shelter to improve the vessel's stability, satisfy statutory requirements and allow her area of operation to be expanded.

Following construction of the aft weathertight shelter, the vessel was subjected to an inclining test on 12 June 1996 to establish her KG. This test was performed in Newlyn Harbour.

The results of the inclining test were used to compile stability data which was submitted to MSA for approval. The vessel's stability information was approved by MSA on 10 October 1996. The constraints on fuel and fresh water capacities were lifted.

1.15 FREEBOARD

Values of freeboard were assessed against statutory requirements on each occasion that stability information was submitted for approval. Freeboard was considered satisfactory and was last approved as part of MSA's approval of the vessel's stability information in October 1996.

1.16 SURVEYS OF WRECK

Following the successful search for the wreck of *Margaretha Maria* by HMS *Cromer* in March 1998, two underwater surveys of the wreck were undertaken.

The first was commissioned by families of the lost crewmen and was completed in April 1998. The video material collected during this survey was generously made available to the MAIB to assist its investigation.

Following its analysis, the MAIB concluded that further details of the wreck were necessary before the most likely cause of the vessel's loss could be established.

A second underwater survey was commissioned by the MAIB and was undertaken between 9 and 16 June 1998. Sidescan imagery of the wreck and surrounding sea bed was obtained under the supervision of staff from the Southampton Oceanography Centre (SOC). Data were processed to produce images of the wreck and surrounding sea bed features (**Figure 5**).

On completion of the sonar scan, a remotely operated vehicle (ROV) with on-board lighting, cameras and manipulator was used to collect video images of the wreck. Control of the ROV was from a surface support vessel on which all power supplies, control and image recording systems were housed.

While carrying out this survey, the ROV twice became entangled with nets in the vicinity of the starboard derrick. On the second occasion efforts to free the ROV resulted in failure of the umbilical carrying all power and control systems from the surface. Operations were aborted at 2000 on 15 June. As it was judged that sufficient material had, by then, already been collected to establish the likely cause of the vessel's loss, no further survey work was attempted.

The contractors returned to the wreck and recovered their ROV several weeks later.

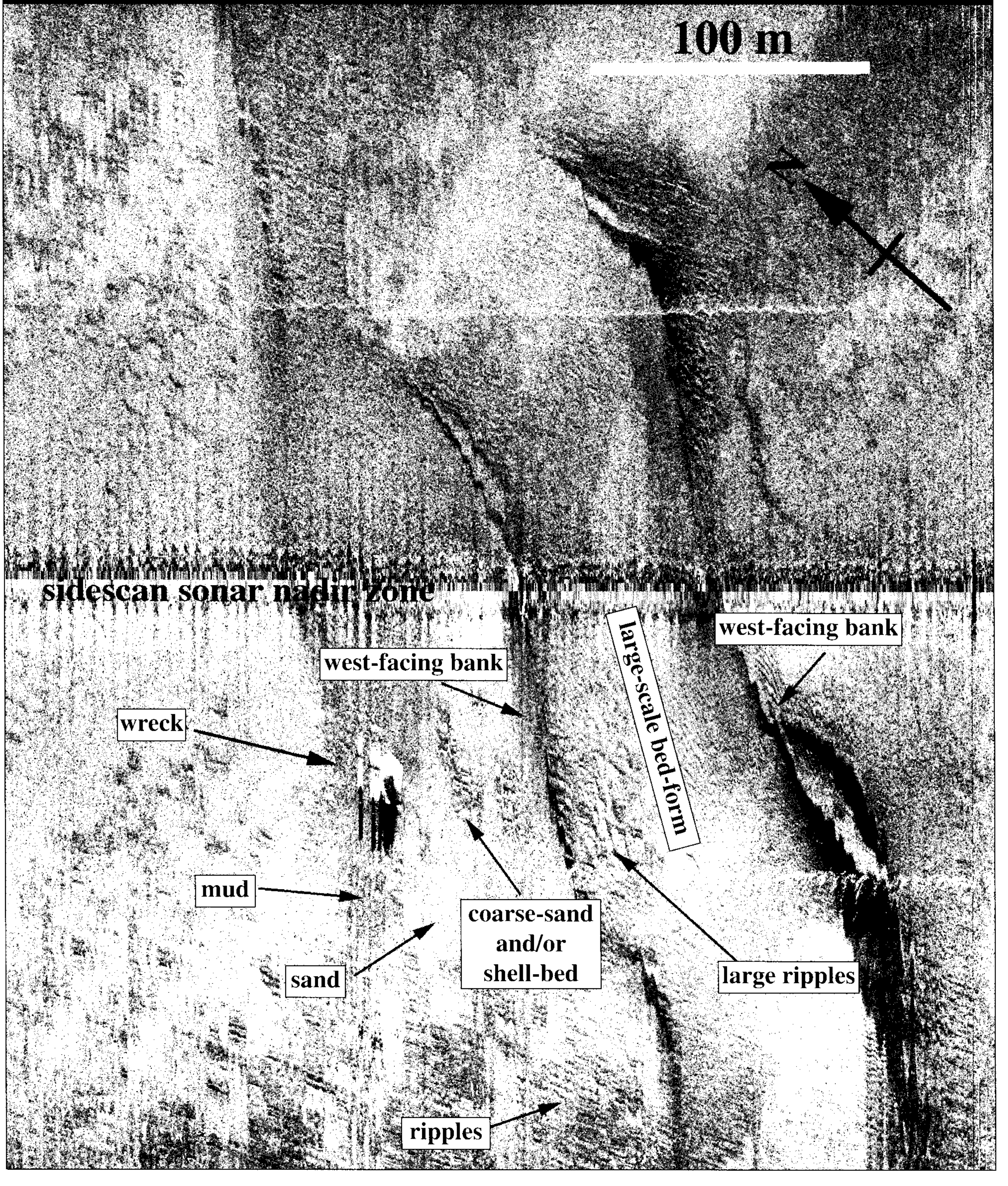
Selected video images were later enhanced, clarified and assembled into mosaics showing important areas of the wreck.

Analysis of video and sonar material allowed the status of many parts of the vessel's structure and equipment to be established as follows:

General

The hull of the wreck was inclined 5° to 10° to starboard in about 120m of water. Some items, particularly wires and ropes, had acquired a significant covering of marine growth. Most other surfaces were generally covered in a light film of growth and silt.

Figure 5: **Sonar scan of wreck and surrounding sea bed**



Port fishing gear (Figure 6)

The port derrick was about 30° to 45° above the horizontal with the topping wire supporting its weight. The forward and back stays were in place and intact. The towing wire was taut and followed its normal route from the winch drum to the chain plate via blocks on the whaleback and the derrick head. The beam, suspended from the chain plate by five chains, was approximately on a level with the bulwark rail. The beam's shoes were in place at each end of the beam.

Hanging from the beam were the chain mat and net, with the net sloping down, outwards and forwards onto the sea bed. The net showed some signs of damage in the belly area, but the cod end was intact and contained a large quantity of shells and other debris.

The weight of the shells in sea water, as seen in June 1998, is calculated to be 1.4 tonne. The earlier video, recorded in April 1998, showed a far greater quantity of sand and shells in this net (**Figure 7**). The quantity seen in April is calculated as having a weight in water of 3.75 tonne.

From the choke line around the cod end, the lazy decky led to a shoe of the beam.

At the inboard end of the derrick, the slip for the quick release gear was in place and had not been operated.

Starboard fishing gear (Figure 8)

The derrick was slightly above the horizontal with its topping wire taut. The forward and back stays were in place and intact. The towing wire was taut and followed its normal route from the winch drum to the whaleback, out to the derrick head block and down to the chain plate.

One beam shoe was in contact with the derrick head. The second shoe was on the sea bed beneath the derrick with the beam leading up. The net was concentrated in the region beneath the derrick and partly wrapped around the beam. It was empty and showed signs of serious damage.

Various items of debris had accumulated on, and around, the derrick and its stays to create an area of confusion. Identified items were the oxygen/propane hoses and torch, a portion of mast from the cross bar of the main gantry and a lifebuoy.

At the inboard end of the derrick, the slip for the quick release gear was in place and had not been operated.

Sitting on the sea bed beneath the derrick was the intact liferaft canister from the starboard stowage cradle.

Port net and beam

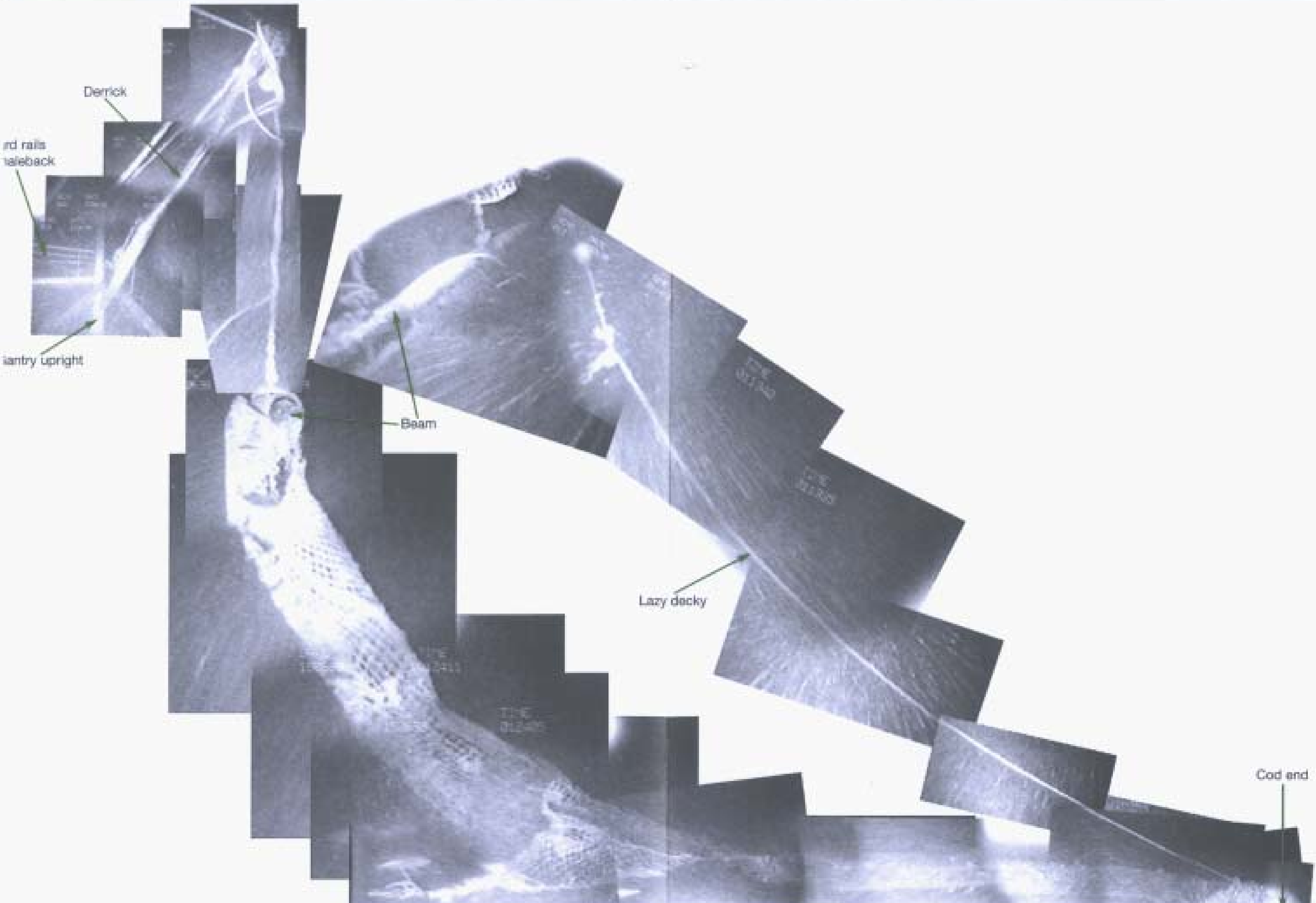
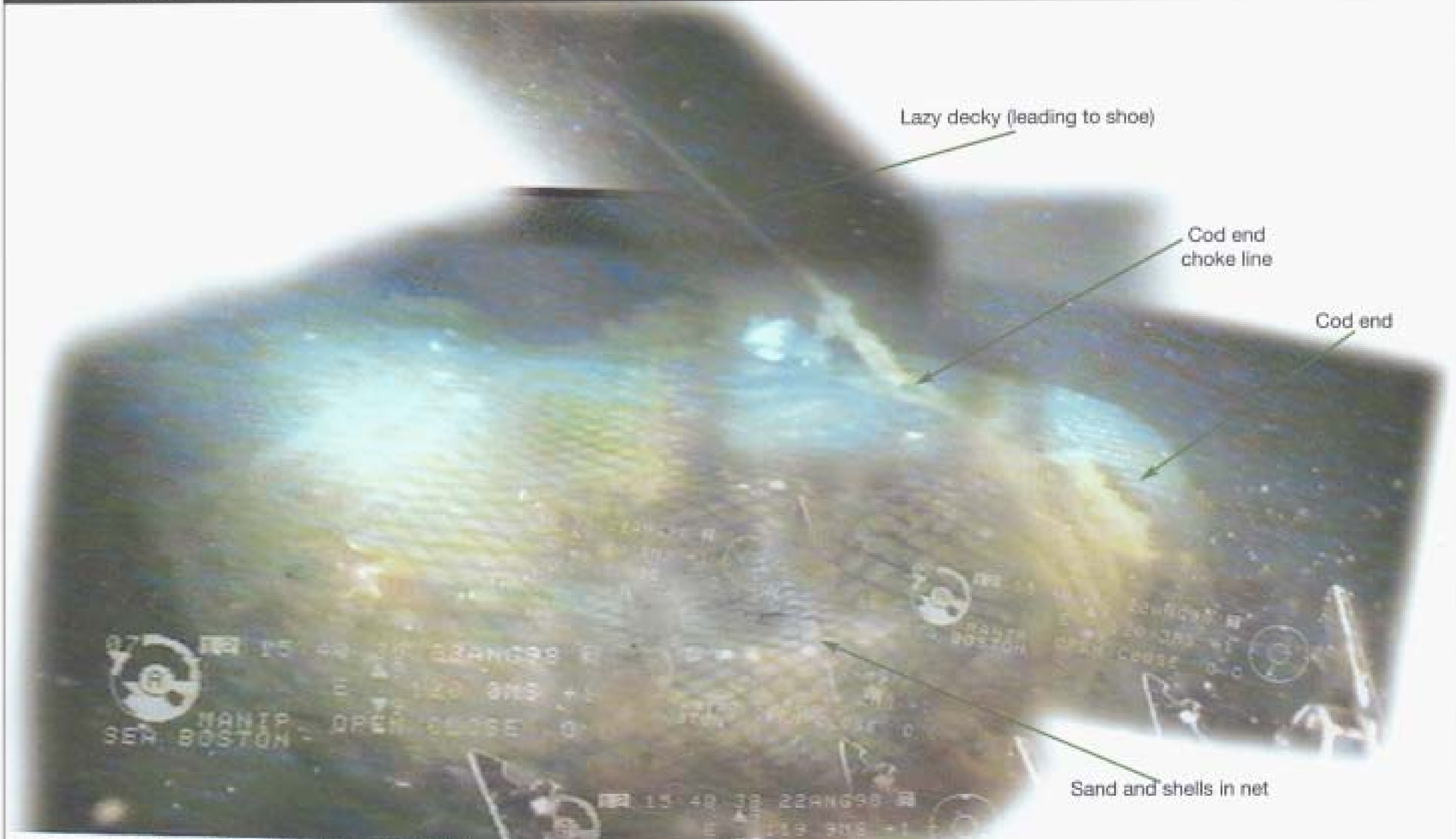


Figure 7: **Port cod end debris**



Cod end mesh size = 80mm (40mm length of side)

Towing and topping wires (Figure 9)

The port and starboard topping and towing wires were in place and followed their normal runs between winch drums to derrick and chain plate on each set of gear.

Each of these four wires was taut.

Gilsons

Port and starboard gilson blocks situated on the gantry were empty. Similarly the gilsons' cleats on the frame just forward of the winch were empty.

Forward gantry

The short mast on the cross bar of the gantry carrying navigation lights was no longer in place. A short stub of this mast remained which displayed a rough fractured surface.

Working deck

Much of the deck area, particularly over the fish hold, was set down and its wooden cladding displaced and fractured.

The hatch cover to the net store was closed, but securing toggles were not in place. The main and inner fish hatch covers were closed. The main fish hatch cover was secured closed with two toggles and the inner secured by one toggle. The forward hatch cover to the fish hold, used for loading ice, was closed and secured by a toggle.

The engine room emergency escape hatch onto the starboard side of the working deck was closed.

Outer hull

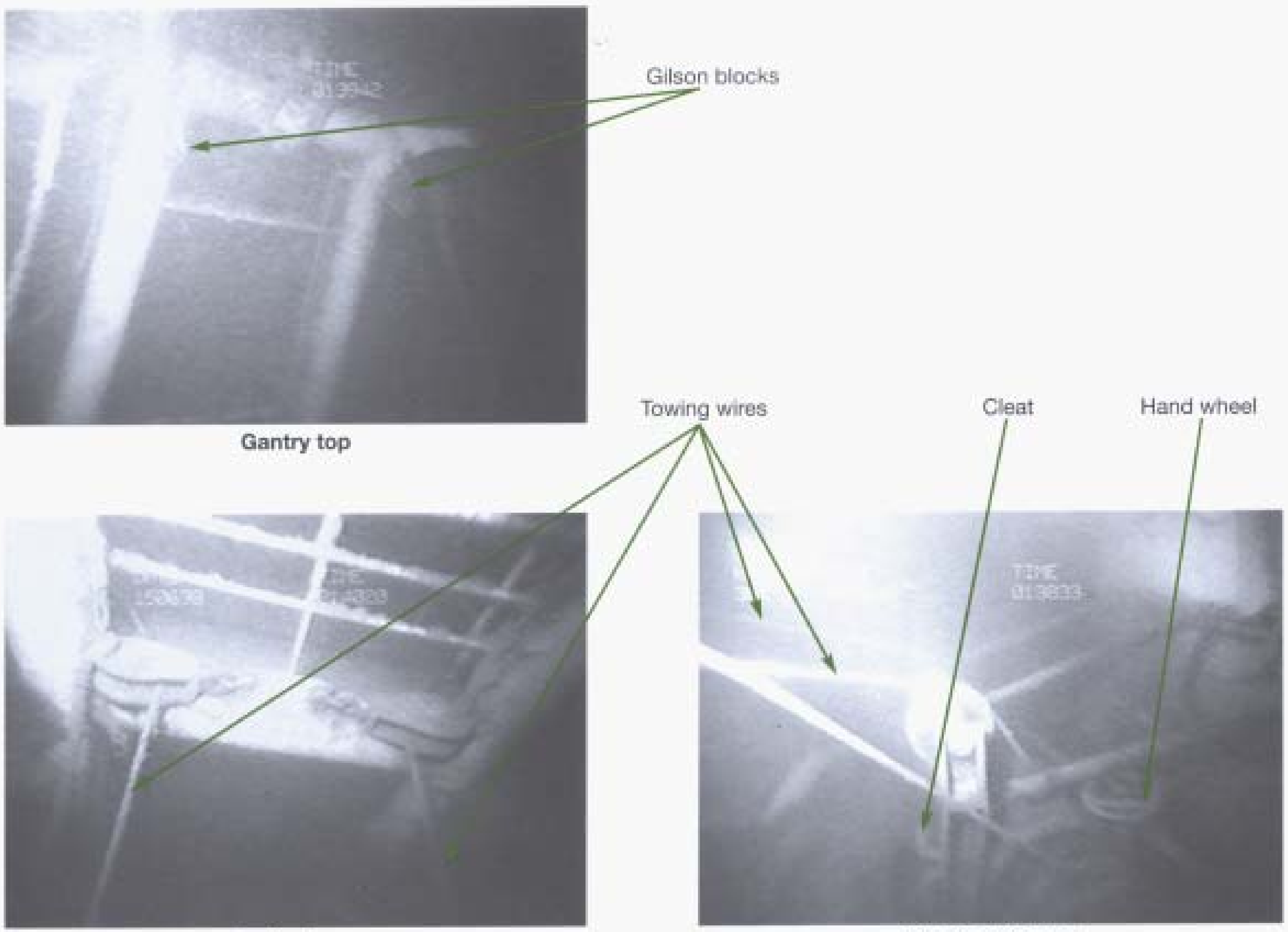
Shell plating of the forepeak was set in. Plating between frames of the fish hold and the net store was also set in. In these areas of damage some paint and anti-fouling coating had flaked off. There were no signs of damage elsewhere on the outer hull.

Winch and frame

Stays between the frame and deckhouse front were fractured. The winch was slightly and unevenly displaced, forward and down.

Both wires from the towing drums were in place over the sliding sheaves on the horse, and were under load. The topping wires ran directly from each topping drum to the gantry top and were under load.

Figure 9



Gantry top

Gantry base

Winch and frame

Aft shelter

The two weathertight doors, one at each side of the shelter, were both open. Each was secured in the open position. The port door was secured open with its normal clip arrangement on the bulwark. Debris prevented inspection of the starboard door's securing arrangements (**Figures 10 and 11**).

The aerial gantry aft of the wheelhouse had fractured at its lower ends and lay across the wheelhouse towards the starboard side.

Whaleback

The weathertight door to the whaleback, starboard side, was open.

Oxygen and propane gas bottles were at the starboard side of the whaleback, adjacent to the door. Hoses from these bottles extended along the starboard derrick to the gas torch below the derrick's head.

Life saving apparatus

The starboard liferaft had been released from its cradle. The intact liferaft canister was on the sea bed beneath the starboard derrick. The liferaft's painter remained attached to the weak link at the securing eye adjacent to the cradle. From there it led forward into the netting beneath the starboard derrick and then into the canister on the sea bed (**Figure 12**).

The port liferaft had been released from its cradle and canister and was spread over the upper part of the wheelhouse front. The liferaft's painter remained attached to the weak link at the securing eye adjacent to the cradle from where it led forward (**Figure 13**).

The cover of the EPIRB stowage box, on the shelter top, was missing and the box itself was empty. Neither the EPIRB nor the cover of its stowage box was seen in any part of the wreck or its equipment (**Figure 14**).

One lifebuoy was entangled with the forward stay of the starboard derrick. Another was in the region of the starboard wheelhouse door with a line running towards a man overboard float on the shelter guard rails.

A man overboard float was in place adjacent to the port shelter door.

Stern gear

Rudder, Kort nozzle and propeller were all in place and showed no signs of damage.

Figure 10: **Port shelter door**

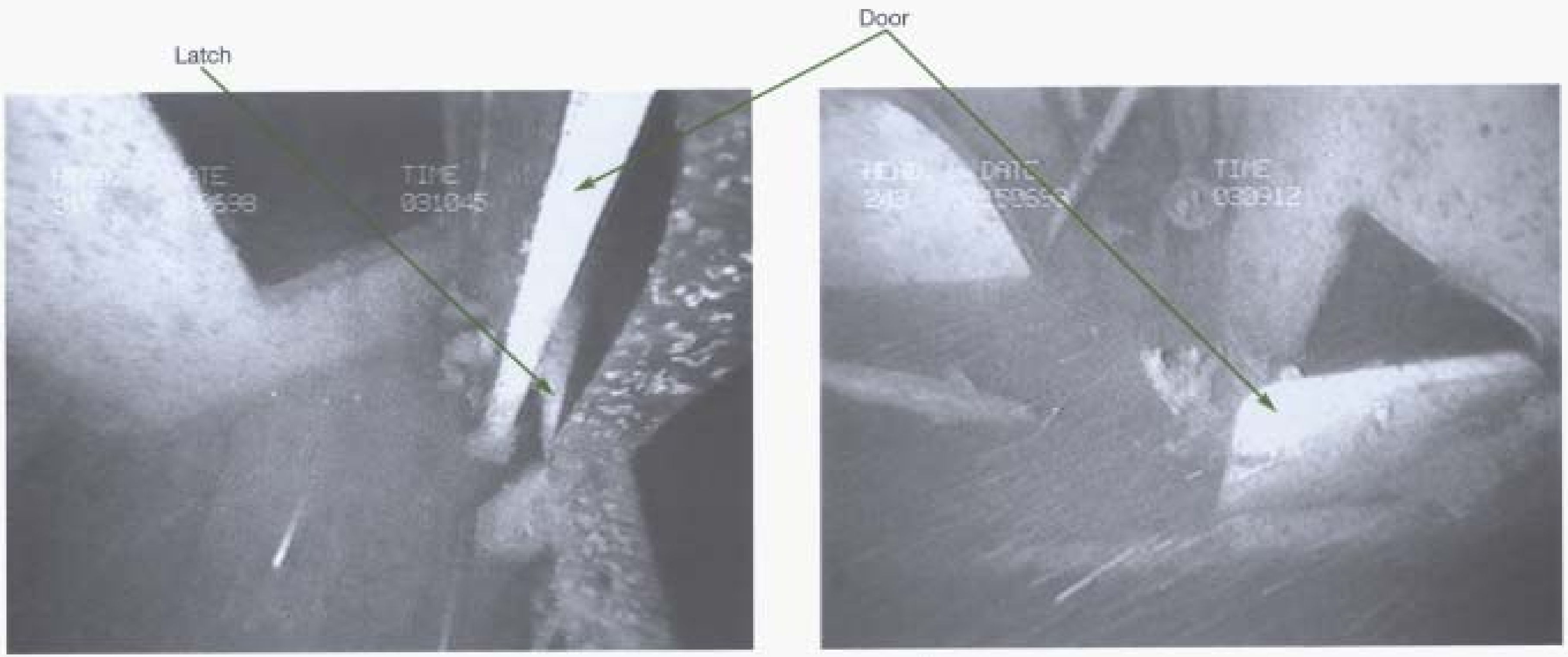


Figure 11: **Starboard shelter door**

Figure 12: **Starboard liferaft cradle**

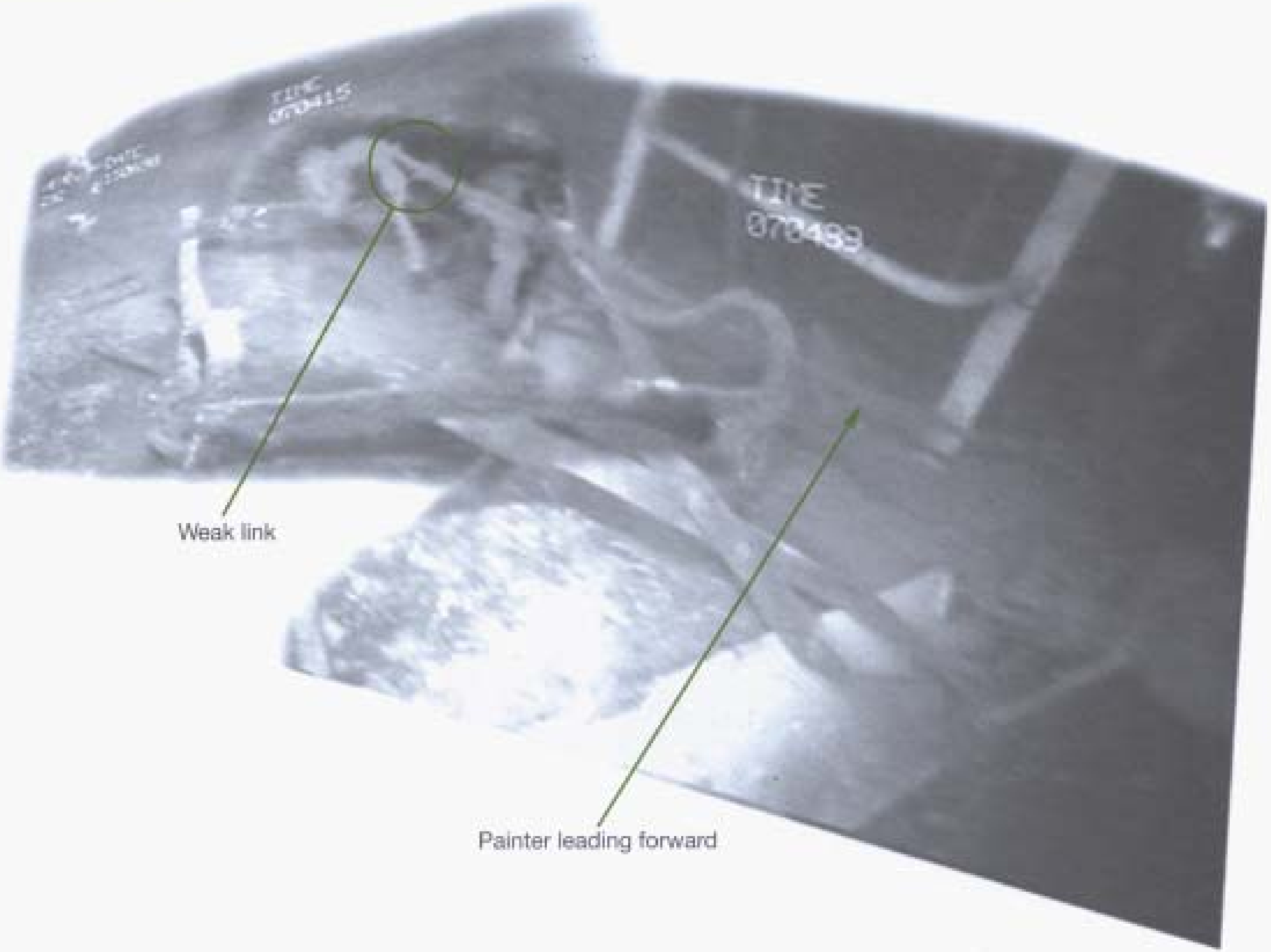


Figure 13: **Port liferaft cradle**

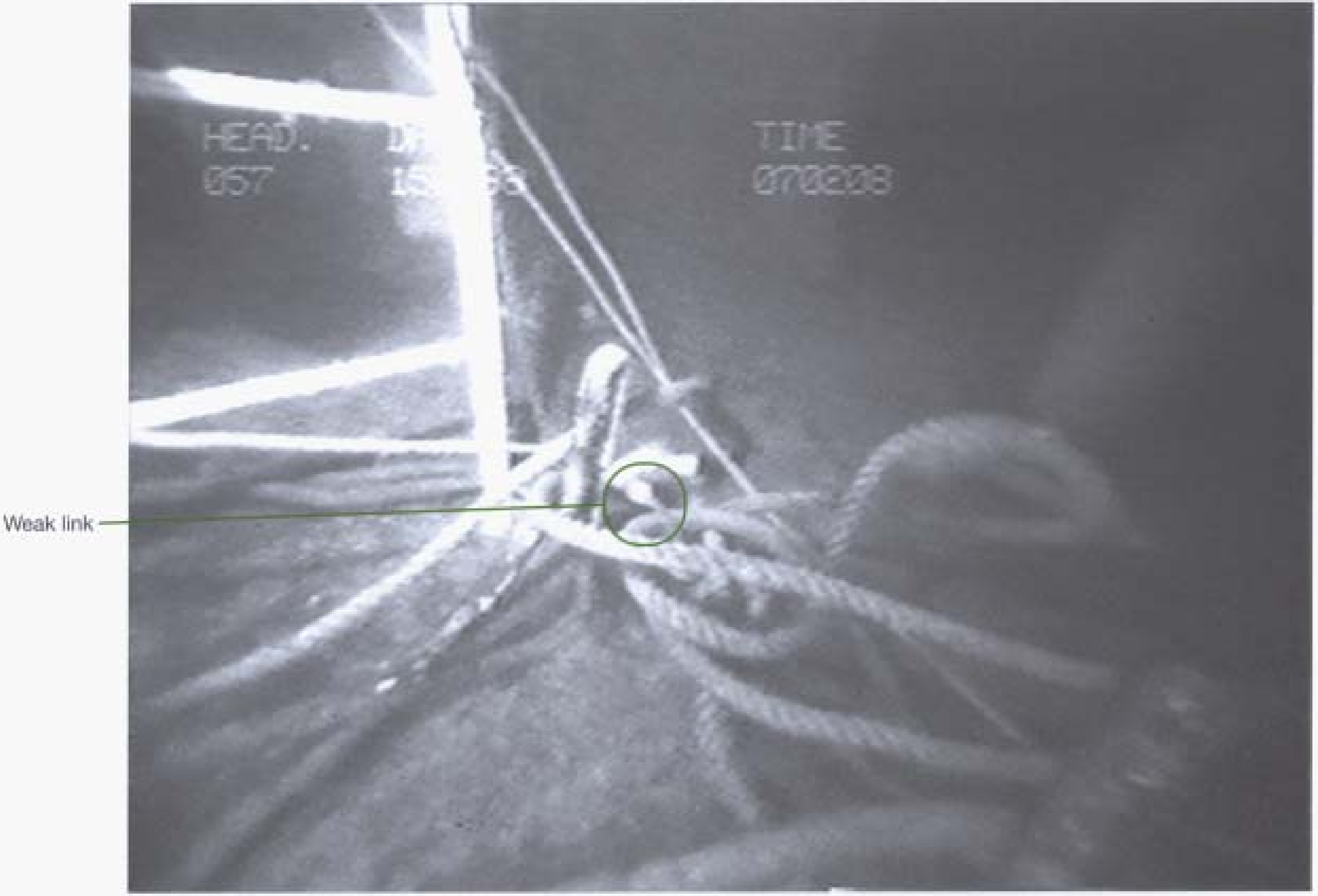
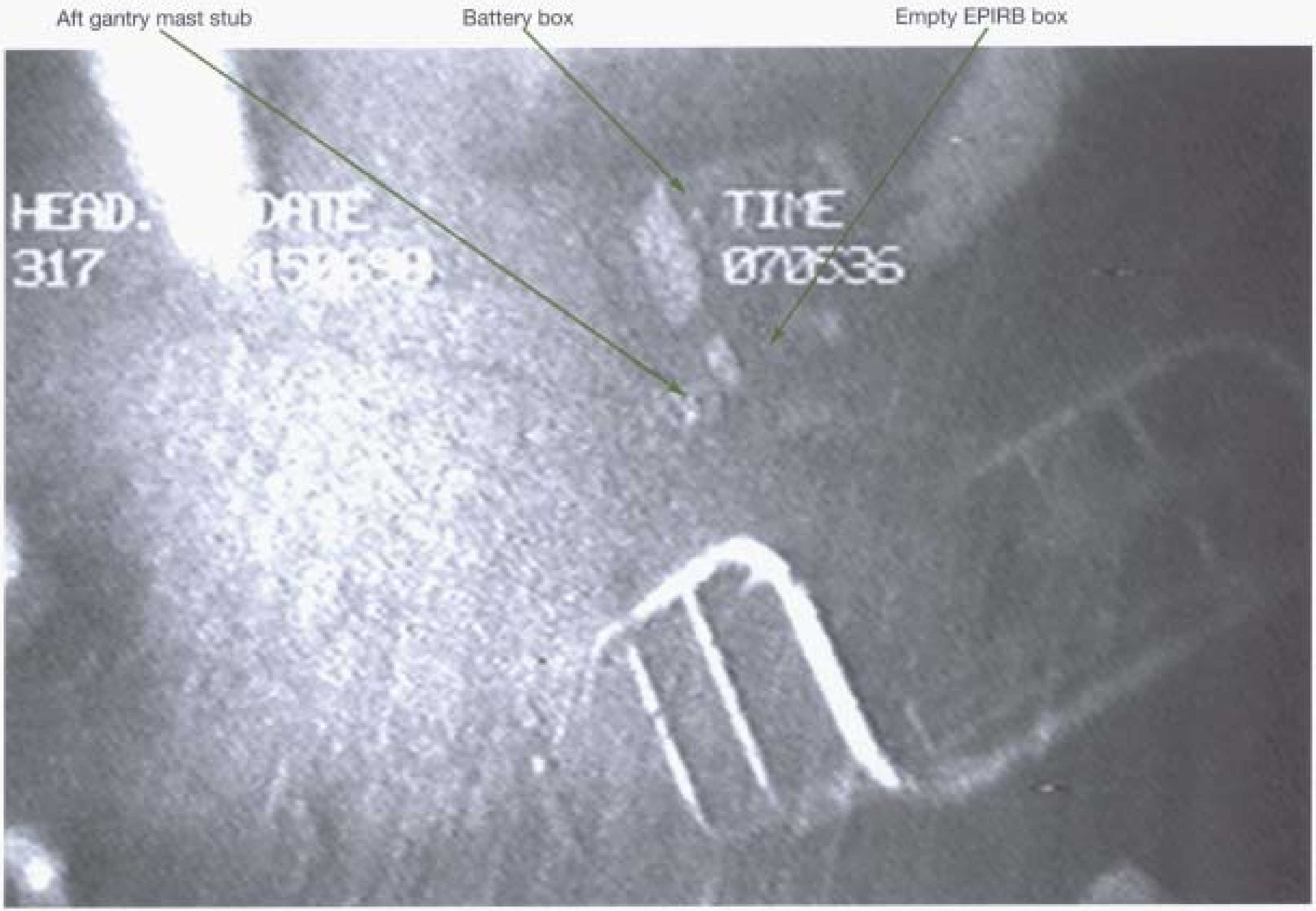


Figure 14: **Shelter top (starboard)**



Wheelhouse

Both port and starboard doors were open. The port door was secured open but access to the starboard door was prevented by the fallen aft aerial mast and could not be checked.

Clutch operating levers for the winch were in the vertical position. Detailed images from this part of the video did not reproduce as a photograph. The face of the wheelhouse clock could not be seen clearly.

Sea bed (Figure 5)

The sea bed in the vicinity of the wreck was sand with widely scattered boulders of moderate size and clumps of shells. Below and immediately adjacent to the wreck a significant quantity of shells was found. These were similar in size and appearance to those found in the port net's cod end.

Lying on the sea bed within ten metres of the port quarter of the wreck, was a CO_2 fire extinguisher of the type carried by the vessel in the starboard side of the wheelhouse.

SECTION 2
Analysis

2.1 POSITION AND TIME OF SINKING

The wreck of *Margaretha Maria* was found in position 49° 00'. 41N 05° 59'.4W, 55 miles south-west-by-south of Lizard Point. The investigation considered whether this was the position where she capsized or whether she had drifted before sinking.

During the underwater surveys of the wreck, a CO_2 fire extinguisher was found on the sea bed within ten metres of the port quarter. It was of a type fitted in the wheelhouse of *Margaretha Maria* where it had been stowed in clips just forward of the starboard door. Only one CO_2 fire extinguisher was carried on board and although the one seen on the sea bed was not recovered and positively identified, it is considered to have been the one fitted in the wheelhouse.

Later sections of this report will conclude that *Margaretha Maria* capsized to port before sinking. With a large angle of heel to port, the starboard wheelhouse door and the fire extinguisher would have been vertically above the open door on the port side. As it was secured by clips and not strapped in position, it would have fallen out with relative ease when the vessel heeled heavily to port and dropped through the open port door. Once clear it would have sunk rapidly and with little deviation from the vertical. The extinguisher's resting place on the sea bed effectively marked the position of the capsize.

It is concluded that the position where the capsize occurred is virtually coincident with the wreck's position on the sea bed.

As far as can be determined nobody saw *Margaretha Maria* after she had cleared the approaches to Newlyn on 11 November 1997. The last known contact with her was at 1915 that same evening.

About five days elapsed before any concern was voiced. Without any reports of the vessel during this period it has been impossible to establish the time of her capsize.

The skipper of *Margaretha Maria* was, however, known to make regular contact with other fishing vessels whenever he was at sea. He did not do so during his last voyage. Although not a reliable indicator, it suggests the capsize may have occurred sooner in the voyage rather than later. As this is, at best, an uncertain indicator, the time of the accident cannot be determined with any greater certainty other than it happened between 11 and 17 November 1997.

Determining the time of sinking is not critical to establishing why *Margaretha Maria* sank. The uncertainty over the time of the vessel's loss did, however, influence the conduct of the SAR operations.

2.2 SAR OPERATIONS

The fundamental objective of search and rescue activity at sea is to locate and recover survivors. It therefore follows that units involved will be looking for signs of life from, or anything associated with, the missing vessel. Floating objects such as liferafts are naturally affected by wind, sea, current and tide, and any interval between a vessel's sinking and the start of SAR operations will result in them drifting substantial distances from the position of sinking.

Six days may have elapsed between the time *Margaretha Maria* sank and the start of the search and rescue operations. Predicting drift over such a long period is not only difficult but becomes increasingly unreliable with the passage of time.

SAR operations began on the morning of 18 November as soon as it was clear that *Margaretha Maria* was overdue. During this first day of the SAR operation, RAF Nimrod and MAFF aircraft searched over 2500 square miles of an area centred on the vessel's presumed fishing grounds.

Their task was complicated by the lack of knowledge as to where *Margaretha Maria* could have been fishing and the time when she might have been lost. The lack of identifiable debris added to the difficulties. It was decided to postpone further air searches until some idea of where to look was identified. It was hoped that this would be achieved by attracting some response to the continuing efforts to raise her by radio, for some report of a sighting, or a transmission from her EPIRB. Military aircraft were requested to remain vigilant during their normal operations. The coastal checks and broadcast action continued but aircraft did not carry out a search on 19 November.

The lack of a reliable recent position presented a major difficulty. Just searching the most likely fishing grounds involved flying over a vast area and, with so little to go on, there was little to justify searching other sea areas. No further information became available to warrant the resumption of an air search on 20 November. However, an RAF Nimrod and MAFF aircraft were asked to return to the area already covered on 18 November and extend it to the north. Other than to satisfy public opinion, the objectives of the searches by these aircraft on 20 November are not clear. The chances of anything useful being found in this extended search were not good.

2.3 VESSEL REPORTING

Many vessels, including *Margaretha Maria*, are equipped with a device known as an Electronic Position Indicating Radio Beacon (EPIRB). Its function is to provide an indicator of a ship loss and a reliable search datum. In this accident no indication was provided by the EPIRB system; the reasons will be considered later.

For personal and commercial reasons, many fishermen are reluctant to broadcast their intended movements or position except in an emergency. This reticence is understandable given their practice of protecting commercially sensitive and hard won information.

Arrangements for routine communications between a skipper and the owners or agents are commonly irregular and often casual. Essential messages concerning landing times, fuel requirements etc. are usually sent when a skipper finds it convenient rather than at set times. Apart from making telephone calls to families when in range of the coast, other communications, particularly to owners and agents, tend to be infrequent and irregular.

Communications between *Margaretha Maria's* skipper at sea and the owners followed this irregular pattern, which meant there was no apparent reason to be concerned about her safety until shortly before she was due to return to port. The anticipated call making arrangements for landing fish and ordering fuel failed to materialise.

Such communication irregularity might have its commercial merits but does nothing to help a search and rescue operation should the need arise. A vessel without a functioning EPIRB can sink and lie on the sea bed for several days without anyone being aware of her loss. Recent accident investigations have revealed that EPIRBs can fail to function when a vessel sinks. There is therefore scope for establishing some alternative means of identifying the approximate position of fishing vessels on a regular basis.

Following the loss of *Margaretha Maria*, a voluntary fishing vessel reporting scheme has been introduced in Newlyn with the assistance of the Royal National Missions to Deep Sea Fishermen (RNMDSF). It is intended to provide vessels with a means of reporting their positions and intended movements on a daily basis. The provision of such information ensures that in the event of an emergency a vessel's approximate position is available and also a time when she was last known to be safe. Such information can greatly help the mounting of an effective search and rescue operation. Using a totally independent organisation to run this scheme, such as the RNMDSF, ensures it is free of a statutory connection and is therefore more likely to be used by fishermen.

As no local fishing vessels have been lost since the scheme was introduced its effectiveness has not been tested. Nevertheless the difficulties experienced during *Margaretha Maria* SAR operations demonstrated the need for reliable and recent positional information. Reporting systems have the potential to provide a valuable back up to EPIRBs, and may save many hours of SAR activity when a vessel is overdue or lost.

The initiative to set up a voluntary reporting system is commendable and is likely to demonstrate its effectiveness in future SAR operations. In view of its potential the MCA is recommended to study the Newlyn scheme. Should it conclude that the system can improve safety it should liaise with and assist the RNMDSF, or other relevant voluntary bodies, to introduce it to other fishing ports.

2.4 SEARCH FOR THE WRECK

During the search operations, a single aircraft was able to scan over 2500 square miles in a few hours. Searching the same area for a wreck on the sea bed requires entirely different techniques and takes very much longer.

Commercial methods for searching the sea bed usually involves a ship towing an active sonar 'body' which transmits a high frequency sound over a short distance on either side of it. Any object located reflects that sound which is then picked up as an echo by the 'body' and passed to the control unit where it is normally displayed to an operator as a shadow on some form of display unit. It is also recorded.

To ensure 'body' stability, towing speed is critical and is limited to between four and five knots. The width of the sea bed lane covered by each tow is typically 300m with an overlap of 50m to ensure proper coverage. Careful control of the surface vessel's course is required to achieve this. A large area of sea surface searched effectively by an aircraft in a few hours, can very easily take two months of 24 hour sonar operations to search for a wreck. Without having an approximate position on which to base a sonar search, even to a few tens of square miles, it can develop into a protracted operation with a very limited chance of success.

On 11 February 1998, a human body was recovered by a fishing vessel in position 49° 05'.12N 05° 59'.93W, and later identified as that of the skipper of *Margaretha Maria*, Robert Holmes. This was the first occasion on which anything identifiable with the missing vessel had been recovered and it also gave the first indication as to where she had been fishing; the western approaches to the English Channel. However, owing to the effects of tidal streams during the three months since the vessel's loss, this position gave little more than a general area within which the wreck might be lying.

Although confirming the general area where the wreck might be it did not provide a sufficiently accurate position to justify mounting a commercial search and the Royal Navy was approached for assistance.

The Navy was in a position to respond without undue delay and tasked the minehunters HMS *Atherstone* and HMS *Cromer* to carry out a search based on the datum provided by the recovered body. It is to the credit of the officers and crews of both ships that they were able to use this limited data to locate the wreck. Without their assistance it is almost certain that no worthwhile investigation into the loss of *Margaretha Maria* would, or could, have been undertaken.

The MAIB acknowledges with gratitude the role played by the Royal Navy in finding the wreck.

2.5 SNAGGING

The snagging of gear on an obstruction is a common problem associated with dragging any type of fishing gear over the sea bed. Typical hazards include cables, pipelines, wrecks and natural features such as rocks.

Any attempt to clear snagged gear may generate large heeling moments and a number of fishing vessels have capsized and sunk in their efforts to do so.

Margaretha Maria towed two sets of nets and beams over the sea bed while fishing. She was also fishing in an area where submarine cables lie. The inquiry considered whether snagging was responsible for the capsize but, very early in the underwater survey, it became apparent that both sets of the vessel's fishing gear were at the surface at the time she was lost. Snagging was not, therefore, the cause.

2.6 HULL DAMAGE

Damage was seen to the working deck and hull forward of the wheelhouse and engine room. None was found aft of the engine room to fish hold bulkhead.

All visible hull damage was distributed over the surfaces of the outer plating and consisted of inward deflection of the plates between frames and stiffeners. In particular, the damage to the plating of the forward peak store was seen to be similar port and starboard, both in nature and extent. No fractures or tears were seen in any part of the hull.

Damage to the working deck consisted of setting down of the decking between areas of greatest support, such as bulkheads and fuel tanks. No tears or fractures were seen in the deck but the presence of timber deck cladding prevented the plating of the deck from being inspected.

The vessel sank in 121m of water giving a corresponding hydrostatic pressure equivalent to a load of 124 tonne/m^2. The hatches to the fish hold and the net store were found in place during the survey and would have prevented water from rapidly entering these spaces as she sank. Large hydrostatic crushing forces would have been generated as a result.

The distributed inward deflection damage found to the hull plating of the fore peak, net store and fish hold, is consistent with the application of hydrostatic pressure. The lack of similar damage to the hull plating of the cabin and engine room indicates that these spaces were able to flood comparatively rapidly, so preventing a large pressure difference between these spaces and the surroundings. This pattern of damage indicates that the aft spaces flooded first to cause the vessel to sink by the stern.

No damage to *Margaretha Maria* was found to suggest she had been in any form of contact or collision with another vessel or large floating object, either before or after she capsized.

2.7 STARBOARD DERRICK AND FISHING GEAR

An explanation is sought to account for the damaged masts and the material entangled around the head of the starboard derrick. Examination of the portion of the forward light mast remaining on the forward gantry shows it had fractured.

Unless the starboard derrick swung up to snag the mast or attached wire before falling back, there is no explanation for the damage. In turn, such a movement of the derrick cannot be explained by any mechanism other than one where the vessel takes on a very large angle of heel to port, followed by her returning to the near upright position. A capsize to port is therefore indicated.

Interference between the starboard derrick and the forward mast is also consistent with the damage to the aft aerial mast, or gantry, which was found collapsed on the starboard side of the wheelhouse. Strung between the two masts were aerial and span wires. The derrick contacting these would have affected both masts, inducing a tendency to bend. Being least stiff in the fore and aft plane, the failure of the aft gantry mast is likely to have been influenced by this bending effect.

This hypothesis is consistent with the attitude of the beam which was found supported on the starboard derrick and sea bed. Unless the derrick had experienced a dramatic movement, such as swinging up and falling back, no explanation can be offered for the final position of the beam.

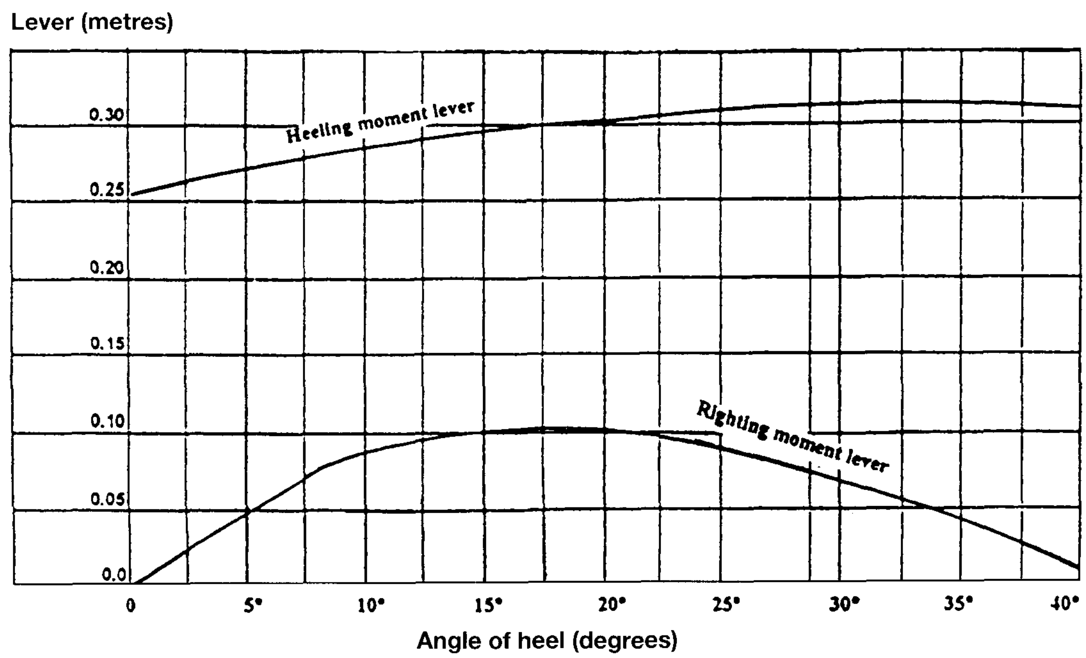
The shock loading applied to the topping wire as the derrick dropped back was also applied to the winch's topping drum and brake. With only the brake resisting motion, the shock is likely to have overcome the brake and induced a brief rotation of the drum. The final position of the starboard derrick was consequently lower than the port derrick.

Swinging of the starboard derrick and beam upwards would also have caused the starboard net to move in an unpredictable fashion. The likely chaotic nature of these movements is shown by the tangle of netting and beam around, and under, the starboard derrick. This is in sharp contrast to the orderly arrangement of the port beam and netting found on the other side of the wreck. More significantly, any swinging of the starboard beam over the adjacent bulwark would have dragged the net over it and, possibly, other parts of the outer hull such as the bilge keel. The likely result of such activity is a damaged net and release of its contents.

The starboard net was found empty.

It may have been damaged earlier in the incident. With both sets of gear at the surface containing substantial weights, the starboard net damage may have been caused by it being overloaded. Release of its contents would have generated a large heeling moment and equivalent heeling lever, significantly larger than the vessel's righting lever as shown in **Figure A**. Capsize to port would have been certain.

Figure A: Comparison of heeling and righting levers, 3.75 tonne in one net with derrick horizontal and shelter doors open (see Condition 1 in Annex 1)



2.8 PORT DERRICK AND FISHING GEAR

The port beam and attached gear were hanging from the derrick's head in their usual relative positions. The derrick was also topped sufficiently to bring the beam level with the bulwark rail and close to where it would be when bringing the cod end on board.

The chain mat and net were also in a normal position relative to the beam. The net stretched down from the beam, outwards and forwards onto the sea bed. Although the net was slightly damaged, there is no indication that the port side gear had experienced the same treatment as on the starboard side.

The most significant feature of the port net was the quantity of material found in the cod end. During the wreck survey in June, the cod end was seen to be full of shells as far as, and slightly beyond, the choke line. During the earlier April survey, both the cod end and the net beyond the choke line were seen to be full of shells and sand (**Figure 7**).

To consider the likely effects of this debris on the stability of the vessel, the in-water weight of the material was calculated. It was assumed that the quantity of shells within the net remained largely unchanged between April and June. In June the cod end was seen to be full of shells as far as the choke line, with a smaller quantity inboard of the choke line. This volume of shells was assumed to have been within the net in April with the matrix between the shells filled with sand. The remaining volume of the net beyond, for a distance of 2m to the left of the choke line as seen in **Figure 7**, was assumed to be filled with sand alone. Dimensions from which these volumes and weights were calculated were taken from the net's mesh size and the size of the cod end. The total weight calculated was 3.75 tonne.

Comparing the two sightings, the virtual absence of sand in the net in June is presumed to be the result of sea water action. How similar action affected the net's contents in the period between the vessel's loss in November and the survey in April is not known. A reasonable assumption can be made that the quantity of material seen in the net in April was no greater than was present at the time of sinking. An extrapolation from April back to the time of sinking would suggest that a much larger amount of material was originally present in the port net. The quantity seen in April has, however, been used to estimate the likely effects on the vessel's stability. The resultant computed weight of 3.75 tonne of material in the port net is probably, therefore, conservative.

Using this figure, a capsize to port due to the resulting heeling moment is clearly possible. With no similar load in the starboard net, stability calculations show that capsize would have been certain(**Figure A**).

2.9 GILSONS AND LAZY DECKIES

Neither port nor starboard gilson was in place in its block on the forward gantry or on the frame forward of the winch (**Figure 9**). During normal steaming or towing, both ends of each gilson were secured to the frame. Both lines may have been swept away by the starboard derrick and gear swinging across in a similar fashion to the mast on the gantry. It is considered most unlikely that both gilsons would have broken away from the frame and run clear of their gantry blocks without leaving some traces of clips or lines on the frame, unless they had been intentionally untied and unclipped previously.

The net and other debris in the region of the wreck's starboard derrick makes identification of the starboard lazy decky uncertain. On the port gear however, the lazy decky is clearly arranged between the cod end's choke line and what would normally be the inboard shoe of the beam (**Figure 6**). During routine hauling operations, this would be the expected state of the lazy decky until unclipped from the shoe and connected to the corresponding gilson line.

The state of the gilsons, lazy deckies and derricks corresponds to a stage in hauling operations where the cod ends were about to be brought inboard, but where the gilsons had yet to be clipped to the lazy deckies.

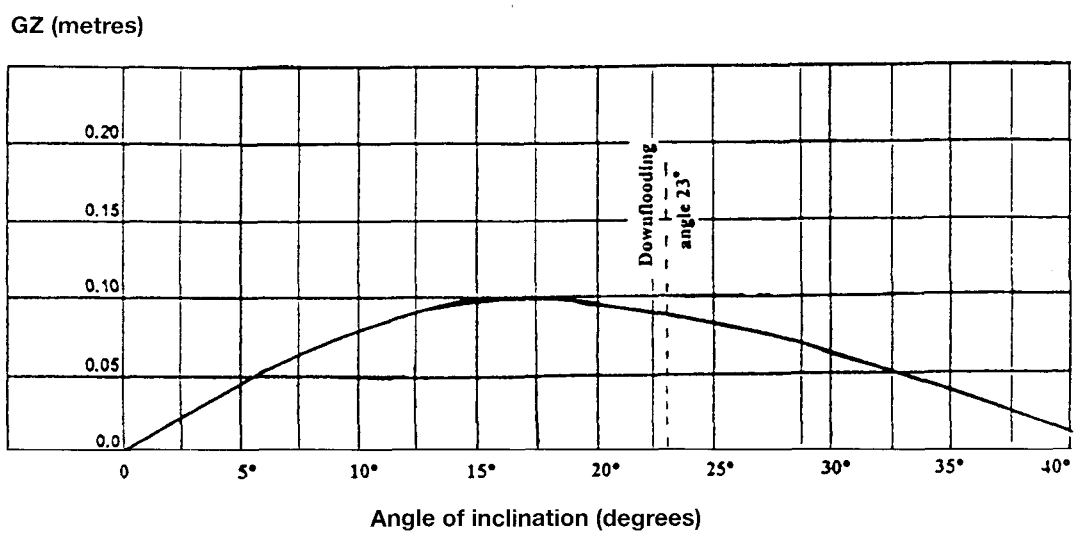
2.10 DEBRIS IN COD ENDS

Various features of the vessel's gear suggests that the crew were preparing to bring the cod ends on board at the end of a tow. However, the crew would almost certainly have recognised they had substantial and exceptional weights in their nets, and that this was caused by something other than fish. This was most probably the reason why they hauled the gear to the surface. They would not have wanted to bring this additional weight on board and, logically, would have wished to clear debris from the nets.

The two sets of gear would have been brought to the surface with the derricks horizontal. Although the effects of the additional weight would have reduced the vessel's stability, it was insufficient to cause a capsize unless the weather was particularly poor **(Figure B and Condition 6, Annex 1)**. The weather over the few days following the vessel's departure from Newlyn was reported to be good.

Having lifted the two sets of gear to the surface, the crew topped the derricks to allow access to the lazy deckies on the beams' inboard shoes. The lazy deckie' could then have been connected to the gilsons to bring the cod ends into the side of the vessel. As the port lazy decky was found still attached to the shoe of its beam it is apparent that the crew had not reached this stage.

Figure B: **GZ curve with derricks horizontal, 3.75 tonne in each net and aft shelter doors open (see Condition 2 Annex 1)**



Clearing debris from nets is not uncommon and, in *Margaretha Maria*, one of two disposal methods was possible. The first required the cod ends to be lifted until the eyes of the selvedge edges could be hooked over the rail pins on the bulwarks. These would support the cod ends while the beams were lowered. The mouths of the nets would follow the beams down to generate a tipping action on the contents which would discharge to the sea by gravity. As the weights would be close to the vessel's centre line to provide only a small heeling lever, simultaneous discharge was not particularly critical.

If the nature and quantity of the net contents made this method unsuitable, a second was available. With the vessel stopped in the water, both sets of gear would be allowed to drop to the sea bed. Unlike normal shooting, when the vessel will be moving through the water, dropping the gear with the vessel stopped is likely to result in the nets landing on the sea bed inverted. They are then towed over the sea bed exposing the unprotected tops of the nets to rocks and other rough material. The net is torn by this action, opens out and allows the debris to be released.

As all weight from the net contents is on the sea bed, and not on the vessel, unsynchronised release of debris is unimportant. The method therefore lends itself to the dumping of heavy weights and could be used if the gear was too heavily loaded to ensure a safe haul to the surface. Nets are, however, damaged by this method and the resumption of fishing will be delayed until repairs are completed. It may also involve having to steam some considerable distance to reach an area where the sea bed is sufficiently rough to cause the required net damage.

These were the options most likely to have been considered by the crew of *Margaretha Maria* once they had brought the cod ends to the surface.

2.11 CAUSE OF THE CAPSIZE

After considering all the available evidence, two possible explanations for the capsize emerge.

Once the cod ends had been hauled to the surface, the crew would have known that they had to safely remove the debris from both nets. Whatever their plans, they were faced with two sets of gear filled with similar quantities of debris. Had they been loaded unevenly the imbalance would have been obvious and a different procedure adopted.

The first explanation for the capsize explores the possibility that the contents of the starboard net were released at some stage after it had been lifted clear of the sea bed. Had this happened the imbalance would have been serious. Stability calculations show that capsize would have been certain, immediate and rapid (**Figure A**). The only likely cause of this would have been a sudden failure of the starboard net, possibly aggravated by damage sustained during the tow. As it is known the starboard gear reached the surface there is no obvious reason why it should have occurred then rather than during the lift.

The alternative explanation focuses on the reduction in stability caused by topping the derricks with the weight of the fishing gear and debris at their ends.

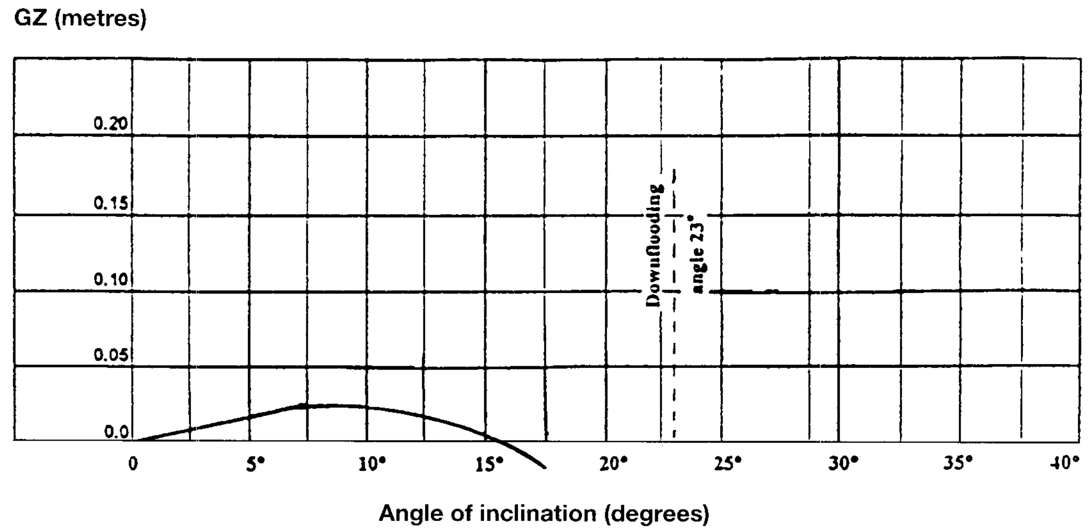
With the two sets of gear at the surface, and the derricks horizontal, *Margaretha Maria* would have retained a measurable level of stability (**Figure B**).

Crew access to the lazy deckies on the inboard shoes of the beams would, however, have been impossible without topping the derricks slightly. To achieve this, steps would have been taken to top both derricks by 30°, or more; sufficient to bring the beams level with the bulwark rails. With the derricks topped by this amount the vessel would have had negligible stability and virtually no resistance to capsize (**Figure C**). It would have required only a small disturbance from the wind or sea, or a combination of the two, to initiate a heel to port. Once a roll had started she would not have been able to recover.

Of the two possible explanations for the cause of capsize, neither is better supported by the evidence than the other but topping the derricks would have had a certain and detrimental effect on the vessel's stability. No other unproved coincidental event, such as net failure, would have been necessary to cause the capsize.

It is therefore assessed that the most probable initiating cause was the topping of the derricks, which reduced stability to such an extent that even the slightest disturbance was sufficient to turn the vessel over.

Figure C: GZ curve with derricks 30° to horizontal 3.75 tonne in each net and aft shelter doors open (see Condition 3 Annex 1)



2.12 QUICK RELEASE GEAR

The vessel was equipped with two sets of quick release gear of a standard type common to beam trawlers and operated by a slip at the inboard end of each derrick. The underwater survey showed that neither had been operated.

Operation of a slip releases the towing block at the derrick head, bringing the towing wire to the vessel's side. The heeling moments generated by the load on the towing wires are correspondingly reduced. Each slip can be operated independently.

Activation of the quick release slips requires a crewman to be on deck and at the base of the gantry. He then needs to operate the respective slip, positioned at about head height. During normal hauling operations, the two crewmen on deck would be in the area of the bulwarks or whipping drums of the winch. Neither man would be within easy reach of the quick release slips. In the event of the vessel heeling suddenly, possibly due to problems with her gear, it would be very difficult to activate the quick release gear in time to prevent a capsize. Where a rapid reduction in heeling moments is essential to a vessel's survival the system has little value.

If quick releases are activated when fishing gear is clear of the sea bed, and successfully limit heeling, difficulties may be experienced in restoring the fishing gear to its operational state. By bringing the towing wire(s) into the side of the vessel, the heeling lever is reduced but the beam and net will also move inwards and possibly to lie beneath her. Access to the beam and net is then impossible, complicating further corrective action and delaying the resumption of fishing. Any reluctance by skippers and crews to activate the quick releases in such circumstances is understandable.

Quick release gear of the type fitted to the derricks of *Margaretha Maria*, may have some value in certain conditions, such as when attempting to free snagged gear. However, in a situation where loads are to be rapidly and simultaneously removed from derrick heads it has little value, largely because of problems of access and the independent operation of the two slips. In this situation, rapid release of the loading may be essential to prevent a vessel capsizing.

It has been calculated that *Margaretha Maria* had very limited stability when both nets containing 3.75 tonne of material were at the surface with the derricks slightly topped. Access and operational problems make prompt operation of quick release gear difficult in a vessel of *Margaretha Maria's* configuration and reduce its value as a means of preventing a capsize.

Installation of this type of quick release gear in fishing vessels may induce a sense of security among crews which, in the event, may prove to be unfounded. Other methods of rapidly removing the adverse effects of large weights in fishing gear should be considered. The importance of being able to release loads on warps of trawlers was a topic covered during the inquiry into the loss of *FV Westhaven*. As a result MAIB made a recommendation to MCA that consideration should be given to requiring all trawlers to be equipped with a method of relaxing or severing trawl warps. As this recommendation was accepted by MCA, no further recommendation on this subject is considered necessary.

There are two basic methods of reducing the size of a heeling moment; reduce the lever or reduce the load. The intended action of quick release gear is to reduce the lever. The alternative is now considered.

2.13 WINCH OPERATIONS

Ingenious devices have been developed and marketed which allow a crew to remotely sever towing warps when a dangerous condition of heeling occurs. Although the heeling loads are rapidly removed the fishing gear is jettisoned and may be costly to recover, repair or replace.

An emergency shut off system had been fitted to the hydraulic power system of *Margaretha Maria's* winch. Stop buttons were arranged in the wheelhouse and on the outer part of the deckhouse which were accessible to crew working by the winch. The primary function of this system was to interrupt power supply to the winch's motor in the event of a person becoming fouled in a wire or drum. Their activation would not result in any powered wire drums running free.

The load on a towing wire may be removed by allowing the wire's winch drum to run free. The drum's brake needs to be released but, of equal importance, the drum needs to be free of its hydraulic motor. The clutch, therefore, also needs to be disengaged.

Margaretha Maria's winch was fitted with dog clutches between the drums and the drive shafts. Although actuation from the wheelhouse was possible, the clutches were normally operated by one of the crew standing on deck just aft of the winch.

Because of the effects of friction, dog clutches resist disengagement when under load and cannot normally be released by hand effort alone. When wishing to do so it is necessary to first stop the winch, engage the brake of the corresponding wire drum and ease the load off the clutch which is then free to be released. This is a time consuming operation, particularly if the objective of declutching is to allow the wire drum to run free. This in itself requires further action to release the drum's brake.

Although some winch control functions were performed from inside *Margaretha Maria's* wheelhouse, the clutch control levers were locally actuated. In particular the clutches needed to be unloaded before they could be released, which is time consuming and is a feature which may cause difficulties and affect safety. Owing to the possible need to allow wires to run free, these characteristics suggest that winches fitted with dog clutches may cause difficulties on vessels operating as twin beam trawlers. The ability to immediately release all brakes and clutches of a winch, to preserve the safety of a vessel, may be vital.

Margaretha Maria was at a stage where both clutches of the winch had been placed in neutral. Any potential difficulties of disengagement did not, therefore, apply. With both clutches in neutral, however, it follows that all four brakes of the winch were on. Had they not been, weight could not have remained on the wires. The weight could have been removed by releasing the brakes, so restoring stability. Although the brakes could have been operated from the wheelhouse, the hydraulic motors would have rotated the spindles in exactly the same way as had they been operated manually. Remote operation was not significantly faster and several seconds might have been required to release the brakes.

Whatever the precise sequence of events leading to the capsize, its prevention might have been possible had the crew been able to remove the loading on the vessel by allowing the towing wires to run free. The brake operating system, although not the most sophisticated or rapid in operation, was probably capable of releasing the brakes with sufficient speed to prevent the capsize. Both sets of gear would then have fallen harmlessly to the sea bed leaving the crew time to assess their problem.

Attempting to prevent the capsize by releasing the winch brakes needs the man in the wheelhouse to react promptly, properly and be in a position to take appropriate action. The reasons why this wasn't done in *Margaretha Maria* cannot be established. An alternative or additional method of rapidly removing warp loads from a vessel may be of value and increase the chances of crew being able to activate a system in an emergency. Again, the recommendations made following the loss of *FV Westhaven* cover this aspect of the *Margaretha Maria* capsize. As a result no further recommendation is seen as necessary.

2.14 WINCH CAPACITY

While hauling the gear to the surface, the crew would have had no accurate indication of the weight of material in their nets. They were probably aware that it was substantial from the feel of the vessel, and by the sounds coming from the winch and wires.

Shortly before *Margaretha Maria* sailed from Newlyn, a new hydraulic booster pump had been fitted to the winch and its hydraulic system to reduce the noise generated. The crew would have had little, if any, opportunity to gain experience of hauling large loads with it and become accustomed to the new noise level.

Margaretha Maria's winch had a nominal hauling capacity of 18 to 20 tonne. The actual hauling capacity was dependent on several factors; hydraulic system pressure; amount of wire on the drums; how neatly the wire is spooled onto the drums and whether the winch is running or is starting from rest. The effect of 200 fathoms of wire on the drums reduced these nominal capacities to between 6.25 and 7 tonne. These figures are based on a hydraulic system pressure of 200bar. However, the pressure relief valve was set to 275 to 280 bar shortly before the vessel left Newlyn. This effectively increased the minimum capacity figures proportionally to 8.75 tonne, starting from rest, and 9.8 tonne when running.

The winch would have had relatively little difficulty lifting the additional weight contained in the nets. However, once the two sets of gear had cleared the sea bed by about 10m, it may have been necessary for just one set of gear to be hauled at a time. Once the laden nets were at the surface the crew were faced with a potentially dangerous situation. Had the winch not been capable of bringing this load to the surface, this situation would not have arisen.

In hauling the two sets of gear to the surface, with the additional weight of between 7.5 to 8 tonne, the winch demonstrated its hauling capability. The winch's capacity to haul such a heavy load led to a dangerous situation developing.

There may be situations where a large winch capacity is of value and can be used without risking a vessel's safety. Freeing snagged gear after operating quick release gear may be one example. There are dangers, however, in using such a large capacity when the weights involved are supported from derricks, especially when topped up.

Designers, builders, owners and others involved in the specification and selection of winches, should be aware of the potential dangers of high capacity winches on beam trawlers. Without a system that gives the fisherman an indication of the winch's load, or limits it, owners should give careful thought to fitting only winches which are capable of hauling loads to the surface which do not adversely affect stability.

MCA should highlight the potential dangers of large capacity winches on twin beam trawlers to owners, skippers, vessel designers, builders, repairers, fitting out yards and those carrying out risk assessments on fishing vessels.

2.15 STABILITY (Figures D, E, F & Annex 1)

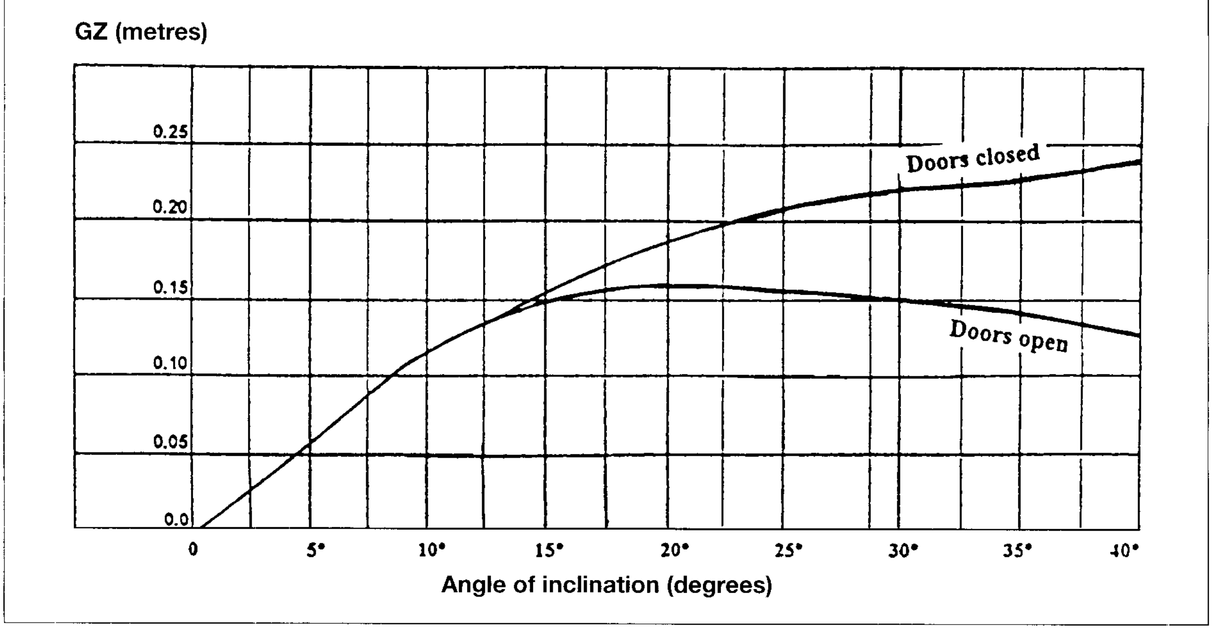
Until *Margaretha Maria* was fitted with the aft shelter, she was required to operate with a fuel tank and a fresh water tank empty to comply with stability requirements. The reason she was fitted with the aft shelter was to enhance her stability characteristics. This aim was achieved.

Owing to the buoyancy offered by the aft shelter, the stability characteristics were only improved in the heeled condition if the shelter was intact. If, for any reason, the shelter's doors were left open, the structure's contribution to buoyancy and stability would disappear. With both doors open, as at the time of sinking, the vessel had little more stability than if no shelter had been fitted.

The inquiry has found that apart from initial GM, *Margaretha Maria* failed to meet minimum requirements for a beam trawler with both beams stowed on deck, the derricks topped to 45° and both shelter doors open (**Figure D**).

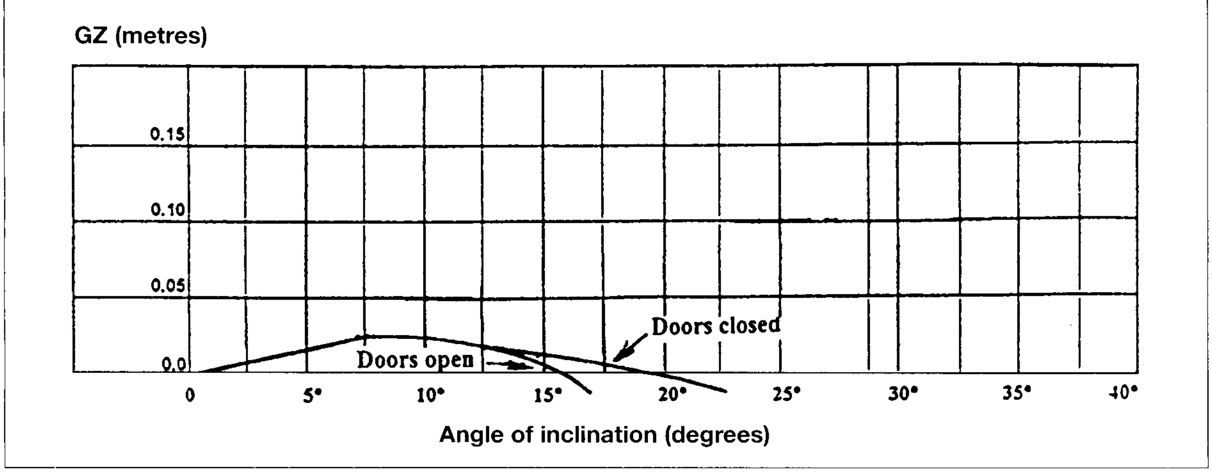
With the shelter doors shut and secured however, *Margaretha Maria* satisfied all statutory stability requirements with all her gear in a similar condition (**Figure D**).

Figure D: GZ curve with beams on deck, derricks topped to 45°, aft shelter doors open and closed (see Conditions 4 and 5 Annex 1)



When the stability of the vessel is considered at the time of capsize, the influence of the shelter becomes less significant. With both derricks topped, and cod ends containing the same estimated 3.75 tonne of debris, the difference in stability between the shelter being intact or not, is negligible (**Figure E**). This should not be seen as an indicator that shelters have no value in providing buoyancy and stability, but it emphasises the strong influence of topping derricks when large weights are taken at the heads of derricks.

Figure E: GZ curve with derricks 30° to horizontal, 3.75 tonne in each net, shelter doors open and closed (see Conditions 3 and 7 Annex 1)



The influence of weights on topped derricks is not a requirement for obtaining MCA approval of the vessel's stability booklet. Twin beam trawlers require a 20% uplift on all stability criteria above the requirements for other types of fishing vessels. To a degree this margin makes allowances for the extra loads which twin beam fishing, and the movement of gear, might generate.

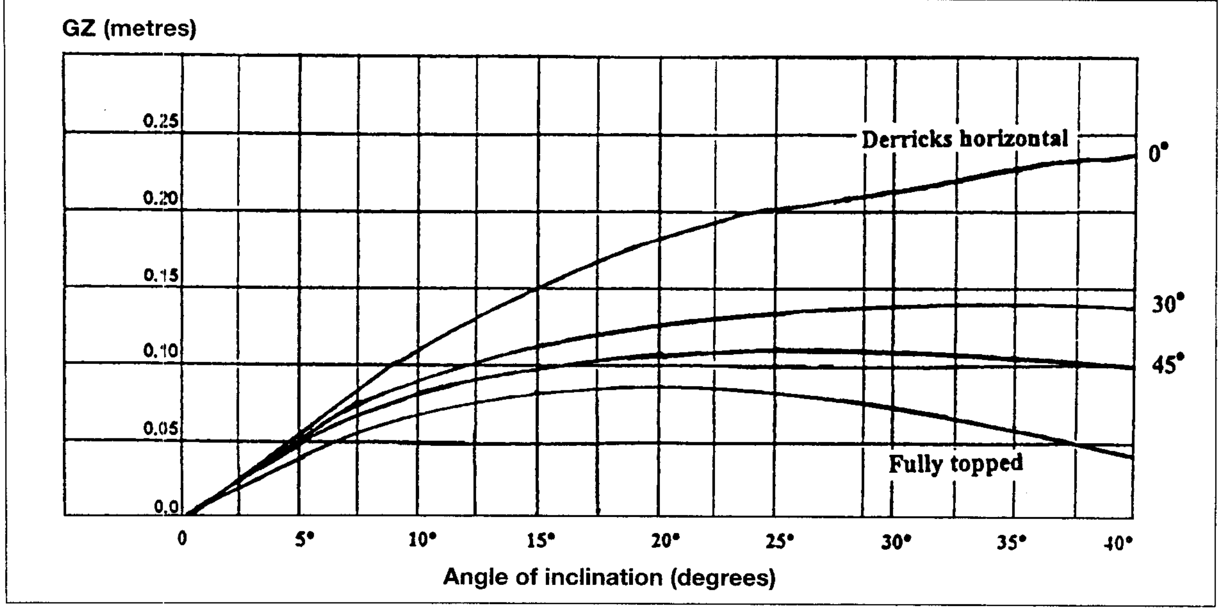
With both derricks horizontal, and the weight of the beams at their ends, the stability of *Margaretha Maria* exceeds all statutory requirements for a beam trawler (**Figure F**).

When both derricks of *Margaretha Maria* are topped to just 30°, each having only the fishing gear's weight at its end, most stability criteria fall to less than the standard required of a non-beam trawler (**Figure F**, 30° curve).

When derricks are topped further to 45°, again with the weight of the beams at their ends, an additional reduction in stability levels occurs (**Figure F**, 45° curve). As these are normal seagoing conditions, albeit for limited periods, a potentially unsafe condition could arise, particularly when the nets contain an unknown weight of fish or debris. The ease with which the 20% stability uplift can be eroded is clear.

Although not a normal seagoing condition, fully topped derricks reduce stability even further (**Figure F**, fully topped curve).

Figure F: **GZ curve showing influence of topping derricks. Shelter doors closed (see Conditions 8, 9, 10 and 11 Annex 1)**



The number of combinations of beam weights, derrick lengths and gooseneck heights may make the application of a blanket set of stability criteria for twin beam trawlers unreliable. The prediction of forces caused by snagging is, likewise, impracticable. Once a vessel's gear has been selected however, its weight and dimensions will be known and it is possible to calculate the effects on stability during normal planned seagoing operations. It will also be possible to assess the effects of any subsequent changes in gear weight or derrick sizes. Being easily quantified, the direct effects of derrick and beam sizes on stability are known and should not be allowed to totally consume the 20% uplift in stability requirements.

As already stated, when both her derricks supporting fishing gear at their ends were topped significantly above the horizontal, *Margaretha Maria's* stability was less than that required of a non-beam trawler. This configuration was, however, a quite normal seagoing condition which meant there were many occasions when she would have failed to meet minimum stability standards required of any type of fishing vessel over 12m long. This inquiry has failed to identify any reason why beam trawlers should not be required to posses the same minimum standard of stability as in other vessels. With lower stability standards, safety would have been compromised. To achieve this minimum standard on *Margaretha Maria* it might have been necessary to limit the angle to which the derricks were topped, which might have been impractical, or limit the weight of fishing gear carried.

Margaretha Maria satisfied statutory stability requirements. However, there is no existing requirement for the effects of fishing gear's weight to be considered when it is suspended from the topped derricks where it has the maximum effect on stability. In this accident this effect depleted the vessel's stability by more than the 20% uplift required of twin beam trawlers, so that she frequently, and quite legitimately, operated with a standard of seagoing stability substantially less than required of other types of fishing vessels.

It is possible that other beam trawlers which presently satisfy the statutory 120% stability requirements may be unable to meet the 100% standard if the weight of their fishing gear is concentrated at the derrick heads, particularly in the topped condition. The amount by which their stability could be less than that of other types of fishing vessels is not known. However, the reduction in *Margaretha Maria's* stability due to this effect was large and suggests that other vessels may be affected by a similar amount.

A study of the relationship between the present 20% additional stability requirement and the actual stability levels of beam trawlers, with beams hanging from derricks topped to normal operational angles, is recommended. The results should be used to review the adequacy of the existing stability requirements of beam trawlers. Whatever the conclusions of the review, the results of the study must, as a matter of urgency, be drawn to the attention of the fishing industry.

2.16 FREEBOARD

Although approaching minimum recommended values amidships, *Margaretha Maria* satisfied all statutory freeboard requirements in the conditions considered during the investigation. Freeboard has an influence on a vessel's stability and is particularly likely to affect the angle at which GZ is a maximum.

Because of this relationship, the previously recommended study into stability requirements for beam trawlers must include an examination of the adequacy of present freeboard requirements.

2.17 WEATHERTIGHT INTEGRITY

The vessel's stability booklet contained a clear set of working instructions and warnings. One of these sets out the importance of keeping all doors and hatches closed when not in use.

Some major watertight compartments, such as the fish hold and store, were closed at the time of sinking and were seen to be so during the underwater survey. An inspection was also made of the hydrostatic damage to the hull which confirmed this assessment. The practice of shutting hatchcovers to these spaces is good seamanship. The status of the hatch cover to the cabin is not known as it was not seen during the surveys. Unless it had been secured in the closed position, with its hinge on the port edge it would have been able to swing open during a large angle heel or capsize to port. A similar mechanism is possible with the door at the aft end of the galley.

The two most significant doors in *Margaretha Maria* were those providing access to the aft shelter. These weathertight doors served to protect the galley and cabin. When closed they prevented water reaching either the galley door or the cabin hatch. When left open this protection vanished. The underwater survey of the wreck found both doors secured in the open position.

Whether the shelter doors were open or closed at the time of capsize, it had negligible effect on the stability of the vessel which remained poor (**Figure E**). Had the shelter's doors been closed, the rate of flooding into the aft spaces might have been reduced, at least until flooding via the wheelhouse began. The vessel might have lingered at the surface as a result, but for what period has not been assessed.

2.18 LIFE SAVING APPLIANCES

2.18.1 Liferafts

Neither liferaft was recovered during the underwater survey of the wreck. There is no doubt they had failed to float to the surface as intended. Both had been serviced by an approved service station in March 1997 and were not required to be serviced again until March 1998. There is no evidence to suggest that either liferaft had failed due to incorrect servicing or that they had not been serviced as required by the regulations.

The liferafts' cradles were situated on top of the shelter aft of the wheelhouse. Both liferaft canisters had been released from their cradles. Each painter remained attached to its respective weak link adjacent to the cradles. This indicates that the liferafts' HRUs, which are required to release at a depth up to 4m, had functioned as intended and that they had been installed correctly.

The underwater survey revealed the weak link on each assembly was still attached to a deck eye and that each painter ran forward towards its respective derrick. The starboard painter followed a path to the intact liferaft canister sitting on the sea bed beneath the starboard derrick. The port painter was not traced beyond the region of the port derrick.

The run of the two painters from the cradles forward indicates the direction of their relative motion once the HRUs had operated. As the predominant force on each canister is likely to have been provided by buoyancy, and would therefore have been directly upwards, only one explanation exists to account for them moving, apparently, forward. *Margaretha Maria* must have sunk rapidly by the stern and would have been nearly vertical by the time the HRUs activated.

As the port liferaft envelope was found on the wheelhouse front and free of its canister, it had obviously broken free from its canister and had inflated when tension was applied to the painter. The painter was found, however, still attached to the weak link of the securing arrangements.

Buoyancy forces on an inflating liferaft are normally expected to break the weak link. With *Margaretha Maria* sinking rapidly stern first, the port liferaft did not have a clear ascent to the surface and her painter became entangled in the port derrick or its gear. This meant that the buoyancy force was most likely absorbed by the derrick and not transmitted to break the weak link.

The reason why the port liferaft failed to function as designed is that its painter fouled the port derrick and gear and failed to exert sufficient force on the weak link to break it.

The intact canister of the starboard liferaft was found on the sea bed beneath the starboard derrick, net and its attachments. The liferaft's painter ran from the weak link, forward along the derrick's backstay to an area of entangled netting at the derrick, and then down into the canister via the normal opening. As this liferaft had not been released from its canister it is assumed that, unlike the port liferaft, insufficient force had been applied to the painter to initiate inflation. As this canister was discovered beneath the starboard derrick and netting it is probable that, during the vessel's sinking, the starboard liferaft canister became trapped beneath or within the netting, so preventing it from floating free and therefore not tensioning the painter to initiate inflation.

The fouling of the starboard liferaft's canister with the starboard derrick is assessed to be the fundamental reason for its failure to function as intended.

The liferafts floated clear of their stowage cradles, but both became entangled with other parts of the vessel preventing proper deployment. During 1998 the MCA commissioned a study into the positioning of liferafts on fishing vessels. The study started during the inquiry into the loss of *Margaretha Maria,* and was in response to a recommendation made in the MAIB report into the loss of another fishing vessel, the *Westhaven*. Information on the performance of *Margaretha Maria*'s liferafts has already been supplied to the study by MAIB. No additional recommendation is judged necessary.

2.18.2 The EPIRB

The EPIRB supplied to *Margaretha Maria* satisfied national and international requirements and was approved by the MSA.

During underwater surveys of the wreck, the cover of the EPIRB's stowage box was seen to be missing. This indicates it had been released as intended and indicates proper functioning of the HRU.

No reports were received from any SAR organisation that transmissions or 'hits' from this EPIRB had been received by a COSPAS/SARSAT satellite.

Details of *Margaretha Maria* and her EPIRB had been voluntarily supplied to the MSA and entered in its database. At the time of the accident these details were correct, apart from a minor misspelling of the vessel's name. As her unique fishing letters and number were also supplied and recorded, this error was not significant. The EPIRB had been checked about four or five months before the vessel's loss and within the manufacturer's recommended six months inspection window.

Failure of the total EPIRB system to operate may have been due to its transmitter being defective. Although fishing vessel inspections have revealed many defects with installation, the probability of an EPIRB failing to transmit when in otherwise good condition, has been found to be very small. The failure rate has been assessed at about 1.5% and although statistically possible, the chances of the EPIRB's transmitter being defective is not considered further.

Several other possible explanations exist for the lack of satellite 'hits' and these are now considered:

Battery output

The manufacturer of the EPIRB, Kannad, recommended battery replacement after four years in service. The EPIRB was supplied to the vessel, as a replacement unit, in November 1994. Its battery was not due for replacement until November 1998 and was thus well within its recommended working life.

Having a battery with an unexpired period of working life does not guarantee correct functioning of an EPIRB. However, manufacturer's data and survey statistics indicate that the unit could be expected to function reliably with a battery of this age. The probability that insufficient battery output caused the EPIRB to malfunction is therefore small.

Incorrect setting

The EPIRB was equipped with a single user controlled switch of the simple 'on' – 'off' type. The 'on' position was the setting to be used at all times when the EPIRB was in service, with the 'off' position being intended for use during transportation or storage.

While in its stowage box, the EPIRB was not required to transmit until released by the activation of the HRU. To prevent transmission prior to release, a second internal switch was fitted which is only activated when the unit is removed from the influence of a permanent magnet situated in the stowage box. This switch was not accessible to the user.

Standard testing procedures require the EPIRB be briefly removed from its stowage box. Provided the user switch is in the 'on' position the EPIRB's strobe light flashes giving an indication of correct functioning. While performing this test, the EPIRB needs to be returned to its stowage box within one minute otherwise it begins to transmit and initiates a false alarm.

Although serving a very simple function, the purpose of the on-off switch could, in the absence of proper operating instructions or care, be misunderstood. An obvious result of leaving the switch in the off position would be the EPIRB failing to transmit, even if properly released and allowed to float to the surface. This possibility has been recognised following a number of incidents world-wide involving units from various EPIRB manufacturers. Instructions for the correct setting and installation of *Margaretha Maria's* EPIRB were attached to the stowage box, both inside and outside, as well as to the EPIRB's casing. The vessel's owners were aware of the correct EPIRB switch settings and had performed routine checks. For any person taking the time and trouble to read and understand these instructions, their clarity and simplicity make incorrect setting of the EPIRB almost inconceivable.

In addition, numerous inspections of EPIRB installations on fishing vessels show that the probability of a unit being switched off is very small; in the order of 2%. Therefore, on balance, it is considered unlikely that *Margaretha Maria's* EPIRB was switched off.

Entrapment

The failure of a satellite hit to be received by any SAR organisation need not indicate EPIRB failure. The beacon may have released correctly but could have become trapped within, or by, the sinking vessel. Had this occurred it would have been unable to reach the surface and transmit as designed.

The final resting places of the vessel's two liferafts gives an indication that the direction of movement of any buoyant object coming from the top of the shelter was forward. The EPIRB's stowage box was situated slightly to starboard of the funnel casing and not far from the starboard liferaft's stowage cradle. It is therefore reasonable to assume that following its release, the EPIRB followed a similar path to that of the starboard liferaft.

On release, the EPIRB would have had to avoid two potential obstacles before floating clear. The first was the starboard net, the second the whaleback. There was no sign of the EPIRB during the underwater survey and it is possible it became trapped in the net adjacent to the starboard derrick and was hidden from view. Alternatively it could have floated through the open door to the whaleback store. Neither of these possibilities can be dismissed and, in view of the manner in which the two liferafts were swept forward on release, either explanation for the EPIRB's disappearance is feasible.

Water ingress

Minimum EPIRB performance requirements specify that the casing remains watertight at a depth of 10m, for at least 5 minutes. *Margaretha Maria* sank in 121m of water. Had the EPIRB failed to clear the sinking vessel promptly once released, it could have experienced a hydrostatic pressure substantially in excess of performance requirements.

Although required to remain watertight to a depth of 10m, the EPIRB fitted to *Margaretha Maria* was capable of remaining watertight, for a limited period, to a depth several times greater than this.This could not, however, be guaranteed.

Experiments, and observations from many wrecks, show that sinking vessels, if not seriously damaged, normally become upright soon after leaving the surface and arrive on the sea bed in that condition. *Margaretha Maria* capsized and sank by the stern but was found upright on the sea bed. It is therefore assumed that while sinking, she too became upright soon after leaving the surface. This clearly did not occur quickly enough to prevent the liferafts from becoming fouled. A similar sequence of events may be applicable to the EPIRB but, as it was not tethered by a painter, it is much more likely to have broken free as the vessel righted during sinking.

However, if the EPIRB was forced to a depth greatly in excess of performance requirements, water ingress may have been sufficient for the unit to lose buoyancy. Damage to electronic components would also be likely.

Increasing EPIRB immersion specifications may, in some accidents result in units floating clear from a substantial depth and transmitting. However, a far more effective solution is seen to be improvement in the positioning of EPIRBs in order to ensure they promptly float clear of a vessel and its equipment.

International agreement, contained in IMO Resolution A.810(19), requires that EPIRBs installed on or after 23 November 1996 should be capable of floating free at a list or trim of any angle. *Margaretha Maria*'s EPIRB, required to float free at a list or trim up to 45°, was installed before this requirement came into force.

Float free capability, whatever the standard employed, may be worthless if the positioning of an EPIRB offers no clear escape path at all specified angles of list and trim. Greater consideration needs to be given to the positioning of EPIRBs on fishing vessels if full advantage is be taken of EPIRBs' designed performance. The results of MCA's study into the float free performance of liferafts are likely to be applicable to the stowage arrangements of EPIRBs. It is recommended that where reasonable parallels exist, MCA apply the results of this study to EPIRBs and make their conclusions known to the industry.

2.18.3 Lifebuoys

Of the four lifebuoys carried by the vessel, only two were sighted during the underwater surveys. One was tangled with the fore stay of the starboard derrick, the other was above the starboard door of the shelter.

Although the remaining two lifebuoys have not been sighted, it is possible than one, or both, remain on the wreck and have been swept into an inaccessible position.

Whatever the fate of the lifebuoys, they are only of use to survivors for a limited period after a sinking. Although it will never be known whether any of *Margaretha Maria's* crew survived the actual capsize and found themselves swimming, their chances of survival were dependent on being rescued promptly or gaining access to a liferaft. The lifebuoys would not have assisted them for more than two or three hours before hypothermia set in. The actual interval between the vessel sinking and the first SAR operation was far too great to have recovered anybody alive.

2.18.4 Lifejackets and flares

The value of lifejackets to any survivors is similar to that offered by lifebuoys. They offer short term assistance until a survivor can reach a liferaft or is rescued.

Lifejackets were stowed within the accommodation spaces and needed to be collected before donning. It is most unlikely there was sufficient time to do this during the capsize. This would not have been necessary had any of the crew been wearing working lifejackets. Had any of the victims been wearing lifejackets at the time of the capsize the prospects of finding and recovering bodies would have increased.

As well as being part of each liferaft's standard equipment, 12 flares were also carried in the wheelhouse. Without time to collect the flares, also very unlikely during a capsize, they would have been of no value to survivors.

2.18.5 Radios

No "Mayday" transmission was apparently made. Given the speed with which the capsize and sinking occurred, the investigation concludes that whoever was in the wheelhouse at the time would have had insufficient time to make the broadcast and, given the circumstances, would have had other things on his mind.

2.19 CREW

For the vessel's area of operation, one person qualified to the minimum level of Deck Officer Certificate of Competency (Fishing Vessel) Class 2 was required to be on board by The Fishing Vessels (Certification of Deck Officers and Engineer Officers) Regulations 1984.

The person nominated as Skipper of the vessel, Robert Holmes, made an application for a certificate of service in April 1995. As a result a Skipper's Certificate of Service was granted. This certificate satisfied the minimum statutory requirements for the vessel's size and area of operation. John Todd held a Second Hand Certificate of Service, limited to use as a Deck Officer Class 3 in the Limited Area. This qualification was in excess of minimum requirements.

Therefore, the vessel complied with the requirements of The Fishing Vessels (Certification of Deck Officers and Engineer Officers) Regulations 1984.

The total crew experience was substantial. Each member was considered by the owners to be capable of performing all tasks necessary in the operation of the vessel. This level of experience suggests that the lessons learned from this accident should be noted by all fishermen including the most experienced.

2.20 RECONSTRUCTION (Figure 15, {1 to 9})

In common with the majority of marine accidents where there are no survivors, nobody saw what happened. Any reconstruction is therefore based on careful analysis of each component part of the entire chain of events.

In order to set out clearly the Inspector's view as to the most likely cause and sequence of the vessel's loss, the conclusions of earlier sections are now collated in the form of a reconstruction of the likely events leading to the sinking. Significant stages of the capsize and sinking are set out in the images of **Figure 15**. Reference is made to the relevant image of **Figure 15** by a number in brackets, thus { }.

After leaving Newlyn on 11 November 1997, *Margaretha Maria* headed for fishing grounds about 60 miles south of Lizard Point. She arrived later that evening, shot her gear and commenced towing. An unknown number of tows were completed before she towed her gear through clumps of shells and sand to fill both nets. The increased drag reduced the vessel's speed. *Margaretha Maria's* watchkeeper became aware of the problem, alerted other crew and began to haul in the gear.

Although the winch made sounds corresponding to the load on it, the sound may have been less than usual following the fitting of the new hydraulic booster pump. Both sets of gear were hauled to the surface successfully. The derricks were still horizontal and the two beams were just below the surface {1}. The crew realised they needed to gain some idea of the quantity of material in the nets before deciding on the best method to clear them. To do this they needed to bring the cod ends to the surface and alongside.

Normal hauling practice suggests that two of the crew were on deck and a third was in the wheelhouse. The brakes on the winch's towing drums were then applied from the wheelhouse. The winch motor was backed off from the wheelhouse, while the clutches were disengaged from the towing drums by the crew on deck. The clutches were then lined up with the topping drums by inching the winch control in the wheelhouse, and the men on deck engaged the clutches. With the topping load taken on the hydraulic system, the brakes on the topping drums were released from the wheelhouse.

The derricks needed to be topped to 30° to 45° above the horizontal to allow the deck crew to reach over the bulwark rail to unfasten the lazy deckies from the inboard shoes {2}. The derricks were topped from the wheelhouse, while the crew on deck waited by the winch. Once the derricks were topped, the brakes of the topping drums were applied from the wheelhouse and the drive motor backed off. The crew on deck placed the winch's clutches into neutral so that the whipping drums of the winch could be used.

In this state, the vessel's stability had almost disappeared due, primarily, to the weights of the fishing gear and debris in the cod ends acting at the outboard ends of the topped derricks.

The two crew on deck released the ends of the gilson lines from the frame and moved to their respective bulwark rail. Before they had the opportunity to release the lazy deckies and clip them to the gilsons, the vessel began to list to port {3}. To the crew, this list probably felt like the continuation of a roll and they are unlikely to have been unduly concerned. They would, however, have been aware that their vessel was rather tender.

Once the vessel had started to heel, her much depleted stability would have meant that she was no longer able to right herself. At this stage, the only step which could have been taken to restore the vessel's stability was the immediate and rapid release of the loads on the derrick ends. This could have been achieved by promptly releasing the brakes on the winch's towing drums and allowing the gear to run free. This was not, or could not be, done in time.

The vessel continued her movement to port, with the port shelter door taking water at 23° of heel, until about 60° when the starboard derrick would have swung to port to make contact with the gantry {4}. The starboard beam followed the derrick, probably swinging further than the derrick, to drag the net over the starboard outer hull and bilge keel. Severe damage to the starboard net probably occurred at about this stage, allowing the contents to discharge into the sea.

The vessel then rapidly heeled beyond 90°, with the heavily laden port net and beam hanging down {5}. The CO_2 fire extinguisher became detached from its clips and fell through the port wheelhouse door into the sea. Downflooding through the wheelhouse and, possibly, galley door extended into the cabin through the hatch which had swung open. The engine room flooded through ventilation openings.

As the cabin and engine room flooded, the stern sank first to the extent that she was nearly vertical before finally sinking {6}. At about this stage the liferafts were released from their cradles and the EPIRB floated free. All three floated upwards. The two liferafts became entangled with the derricks and nets as did, probably, the EPIRB.

The starboard liferaft remained in its container, trapped by the starboard net. The port container floated clear and the liferaft inflated, but its painter was entangled with the port beam, preventing it floating to the surface.

Flooding of the aft end continued and the vessel gradually left the surface stern first. Hydrostatic pressure gradually increased, causing structural failure of the deck over the fish hold and net store. These two spaces then flooded, allowing the vessel to move towards the upright condition while sinking {7}.

When near the upright the starboard derrick fell pulling the beam behind {8}. Its weight was again taken on the topping wire. The forward mast was torn from the gantry by the falling derrick, pulling forward and fracturing the aft mast.

The vessel continued towards the sea bed, finally making contact and coming to rest almost upright {9}.

Figure 15 (1–4)

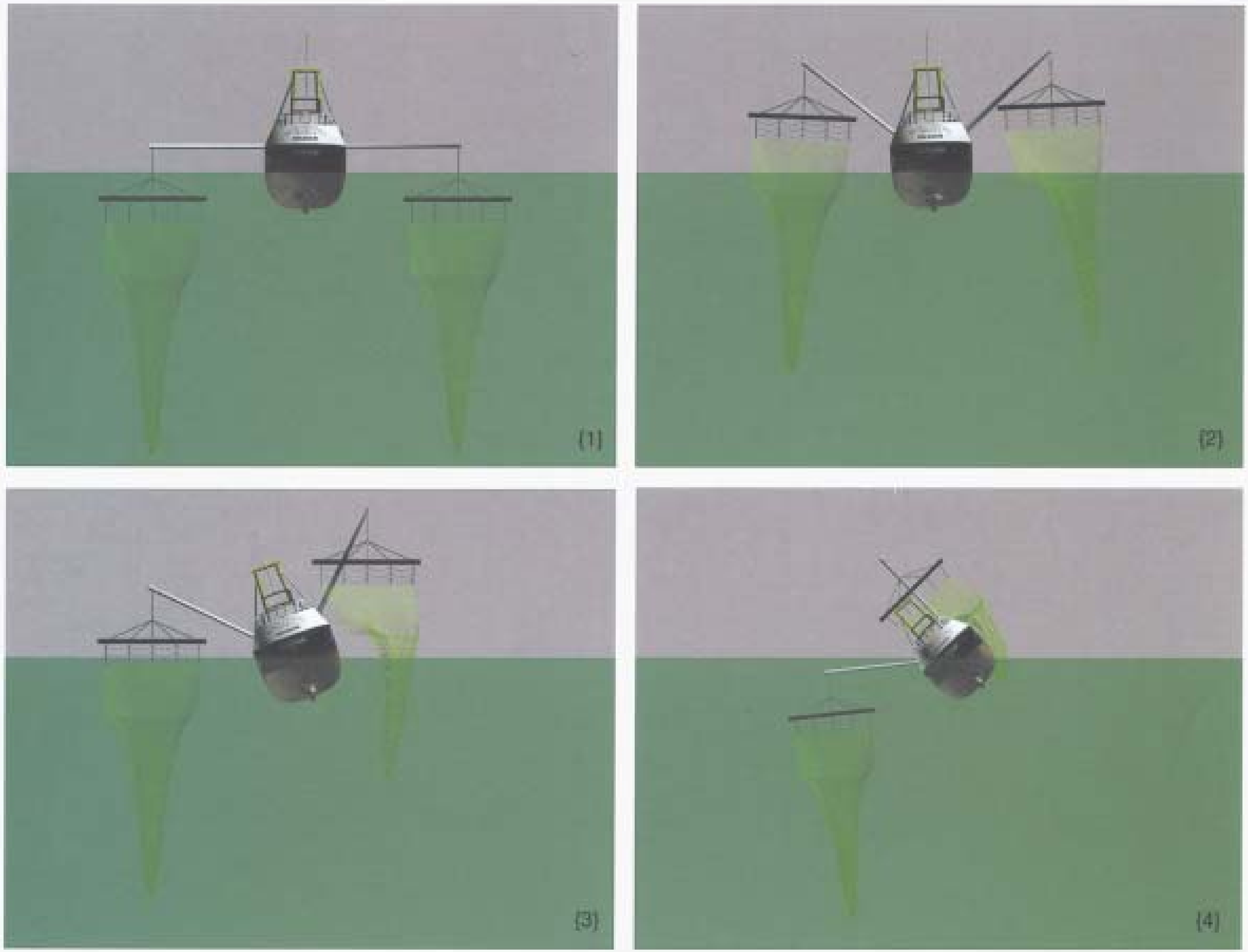


Figure 15 {5-8}

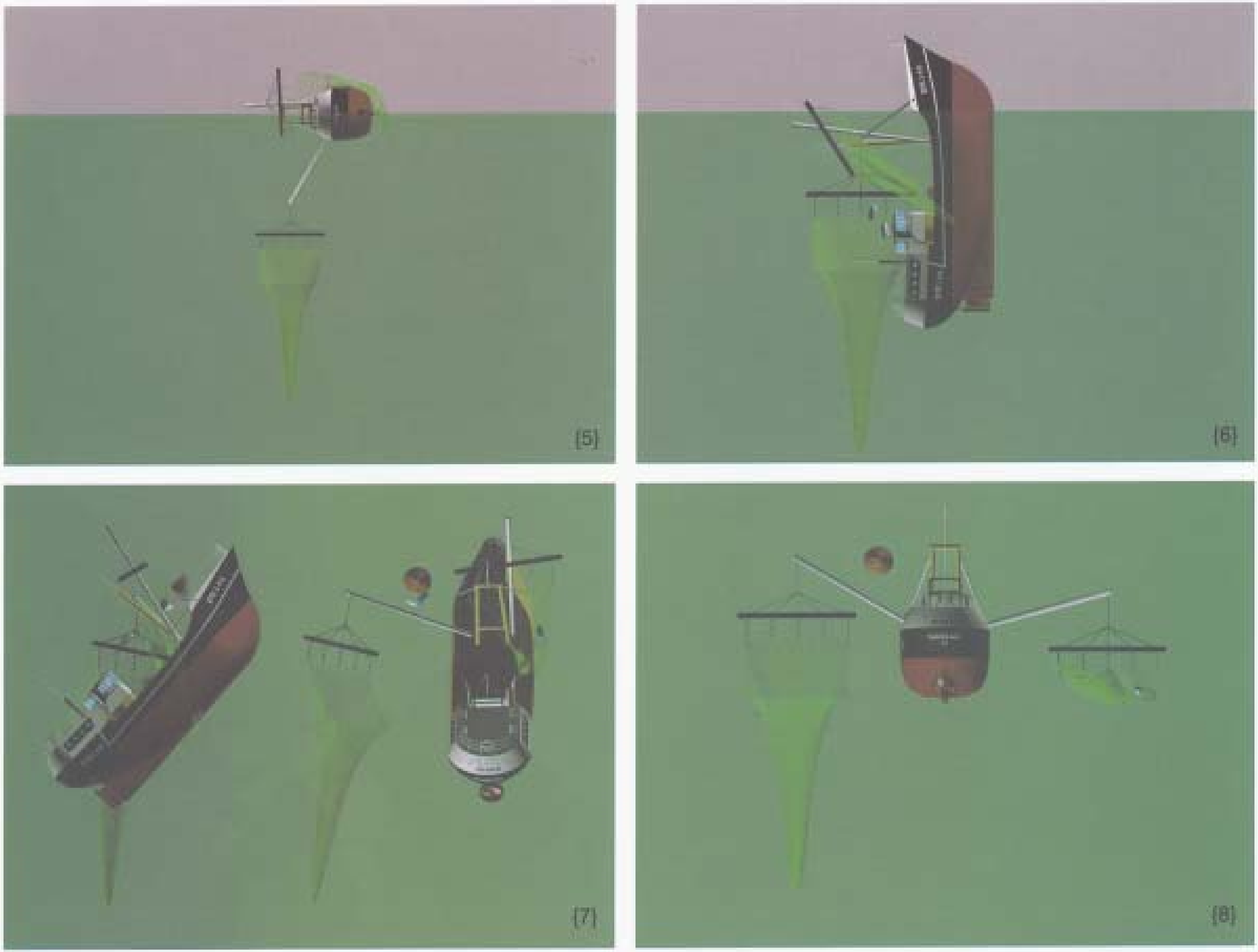


Figure 15 (9)

SECTION 3
Conclusions

3.1 FINDINGS

The sinking

1. Both sets of the vessel's fishing gear were at the surface. [2.5]

2. Snagging did not contribute to the vessel's loss. [2.5]

3. The vessel capsized to port in position 49° 00'.41N 05° 59'.4W. [2.1, 2.7]

4. The capsize was most probably caused by loss of stability resulting from derricks being topped with 3.5 to 4 tonne of debris in each net. [2.11]

5. The standard type quick release gear was unsuitable for rapid and simultaneous operation to reduce heeling moments. [2.12]

6. The accident occurred at a time unknown between 11 and 17 November 1997. [2.1]

7. The vessel did not drift after she capsized. [2.1]

8. The aft spaces flooded first, causing the vessel to sink by the stern. [2.6]

9. Hull damage in way of fish hold, net store and forepeak were caused by hydrostatic pressure. [2.6]

10. No damage was found to suggest any form of contact with another vessel or large floating object. [2.6]

Weathertight integrity and stability

11. The vessel satisfied all statutory stability requirements provided the shelter remained intact. [2.15]

12. Both weathertight doors on the aft shelter were secured open at the time of sinking. [2.17]

13. With the shelter's weathertight doors open, the vessel had no significantly higher level of stability than if no shelter had been fitted. [2.15]

14. With the shelter's weathertight doors open, the vessel failed to satisfy statutory stability requirements. [2.15]

15. Capsize would not have been prevented by having the shelter's weathertight doors closed. [2.17]

16. Open weathertight doors on the shelter may have increased the rate of flooding of the aft spaces. [2.17]

17. With derricks topped to 30° or more, and only the fishing gear's weight at their ends, stability was significantly less than the standard required of any type of fishing vessel in the seagoing condition. [2.15]

18. With derricks topped to 30°, and significant weight in each net, the vessel's stability was reduced to a dangerous level. [2.11]

19. With derricks topped to 30°, and significant weight in each net, there was little difference in the vessel's stability whether shelter doors were open or closed. [2.15]

20. With derricks topped to 30°, and significant weight in each net, leaving the shelter doors open did not significantly contribute to the vessel's capsize. [2.17]

21. The control systems for the winch's brakes and clutches did not contribute to the capsize. [2.13]

22. The vessel's winch was capable of hauling weights to the surface which could seriously affect the vessel's stability. [2.14]

Search and rescue

23. SAR operations began on the morning of 18 November, as soon as it was clear *Margaretha Maria* was overdue. [2.2]

24. During the first day of SAR operations, RAF Nimrod and MAFF aircraft searched over 2500 square miles of sea. [2.2]

25. Uncertainty over vessel's likely fishing area, and the lack of identifiable wreckage, meant no aircraft were committed to the search during 19 November. [2.2]

26. Termination of SAR operations by air, after the first day, was justified. [2.2]

27. Other than to satisfy public opinion, the objectives of the searches by aircraft on 20 November were unclear. [2.2]

Life saving appliances

28. The HRU on each liferaft functioned as intended. [2.18]

29. Both liferafts failed to float to the surface as intended. [2.18]

30. There is no evidence to suggest that either liferaft failed due to being incorrectly serviced, or not serviced as required by regulation. [2.18]

31. The fundamental reason for the failure of the port liferaft to function as intended, was the fouling of the painter with the port derrick and stays. [2.18]

32. The fundamental reason for the failure of the starboard liferaft to function as intended, was the fouling of its canister with the starboard derrick and net. [2.18]

33. The EPIRB supplied to *Margaretha Maria* was of a type which satisfied national and international performance requirements. [2.18]

34. The EPIRB's HRU functioned as intended and released the cover of the unit's stowage box. [2.18]

35. No SAR organisation, UK or foreign, reported that any transmissions or 'hits' from the EPIRB had been received by COSPAS/SARSAT satellites. [2.18]

36. The EPIRB probably became fouled in the vessel's nets or under the whaleback. [2.18]

37. The lifebuoys, lifejackets and flares were of little value to survivors of the vessel's capsize and sinking. [2.18]

The vessel and crew

38. *Margaretha Maria* had a UKFV Certificate, issued on 26 November 1996 and valid until 28 November 1998. [1.6]

39. The vessel's manning exceeded the minimum requirements of The Fishing Vessels (Certification of Deck Officers and Engineer Officers) Regulations 1984. [2.19]

40. The combined fishing experience of the skipper and crew was substantial. [2.19]

3.2 CAUSAL FACTORS

Margaretha Maria capsized and sank due to a large weight of debris in her nets adversely affecting stability when derricks were topped.

Factors which contributed to the capsize were:

- the ability of the vessel's winch to haul large weights of unknown size to the surface,

- the lack of a practical facility to rapidly remove or reduce heeling forces from the vessel.

A factor which contributed to the speed of flooding was:

- open weathertight doors on the shelter.

SECTION 4
Recommendations

The Maritime and Coastguard Agency is recommended to:

4.1 Study the vessel reporting system presently in place and operated in Newlyn. If the MCA concludes that the system contributes to safety, it should liaise with the RNMDSF or other relevant voluntary bodies, with a view to assisting them to introduce the system to other fishing ports.

4.2 Highlight the potential dangers of large capacity winches on twin beam trawlers. In particular, owners, skippers, vessel designers, builders, repairers, fitting out yards and those persons who may undertake risk assessments on fishing vessels should be targeted in order that they can judge the safety implications of a proposed winch installation.

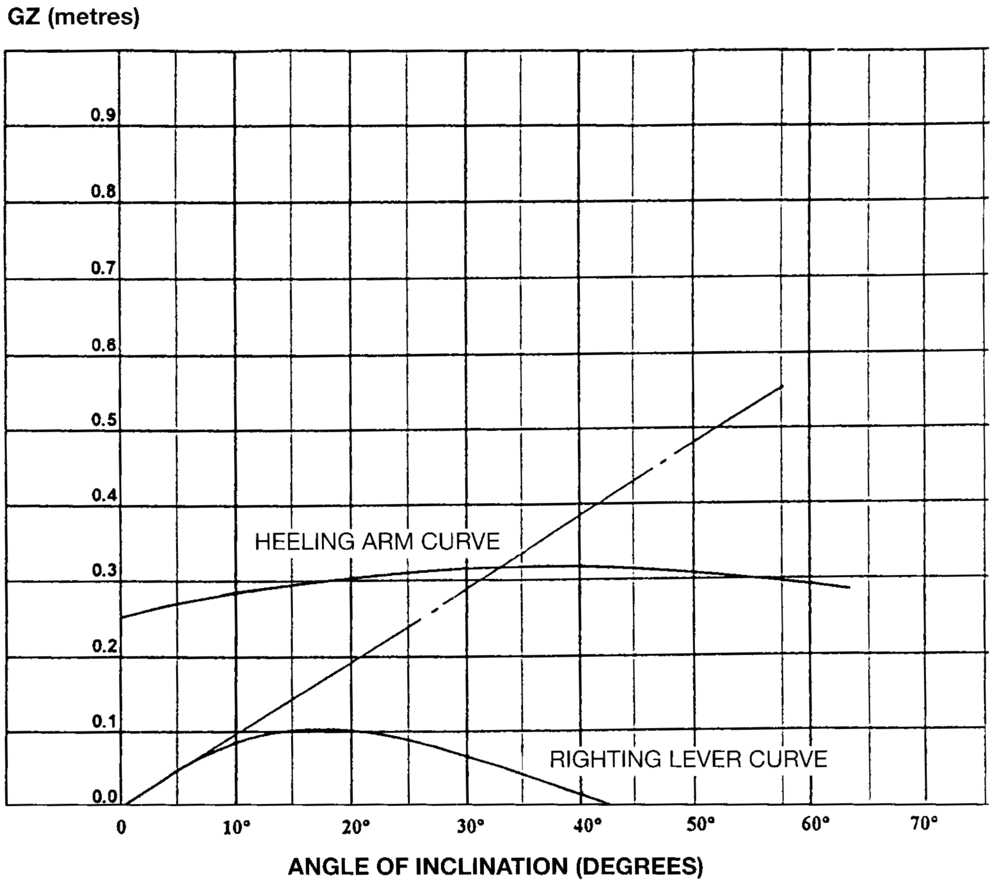
4.3 Make a study of the actual seagoing stability levels of a sample of operational beam trawlers. The study should be made in the condition where the beams are freely suspended from their derricks topped to normal maximum operational angles and the results compared to the present stability requirements. They should also be used to review the adequacy of the existing stability and freeboard requirements. The findings must be made known to the industry as a matter of urgency.

4.4 Use the results of their existing study into the float free performance of liferafts to identify any common factors in the stowage and performance of EPIRBs. Should they exist, MCA should apply the results to EPIRBs and make their conclusions known to the industry.

ANNEX 1

Stability Assessments

Condition 1: Beams at derrick ends, additional 3.75 tonne in one net and with derrick horizontal (access doors to shelter open)



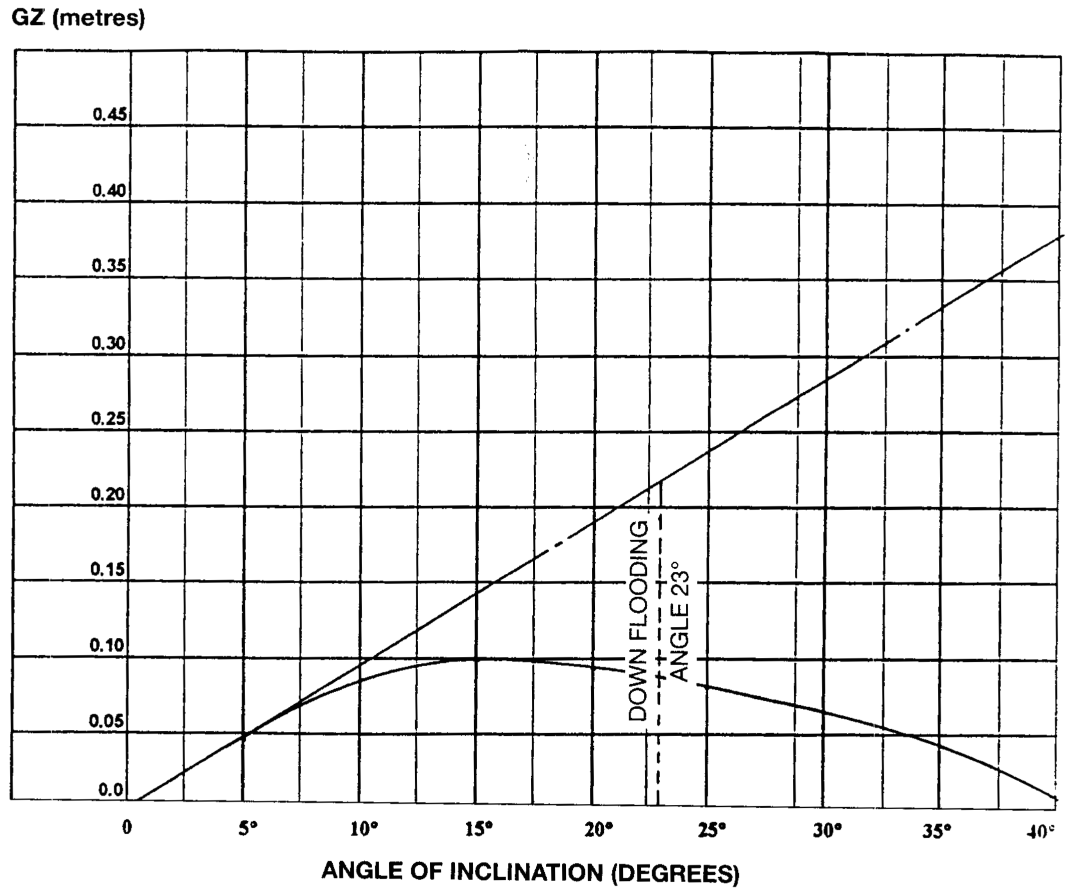
	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.041*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.048*	0.108 M.Rads
Area Difference from 30° to 40°	0.007*	0.036 M.Rads
Angle at which Maximum GZ Occurs	17°*	25 Degrees
GZ at 30°	0.067*	0.240 Metres
Initial GM (Fluid)	0.533	0.420 Metres

*Failure to satisfy minimum criteria

AS THE DERRICK HEELING ARM IS GREATER THAN THE RIGHTING LEVER (GZ) THE VESSEL WILL CAPSIZE WHEN LOADED IN THIS MANNER

FREEBOARDS **In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel**	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	2.989	2.170
2. To Main Deck at Side at A.T. (HDA)	0.834	0.788
3. To Poop Deck at Side at A.T.	N/A	—
4. To Top of Main Deck Sheathing at Midships	0.356	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.366	—

Condition 2: Both derricks horizontal, beams at derrick heads with additional 3.75 tonne in each net. Shelter doors open.

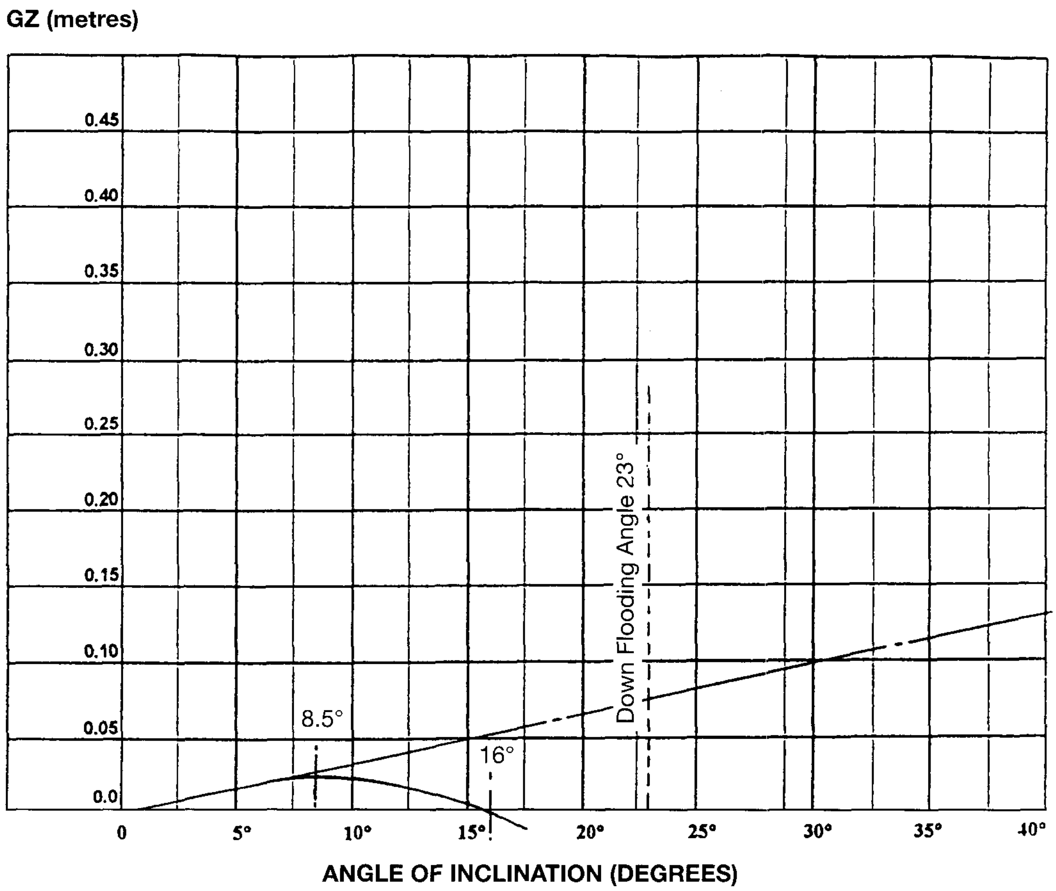


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.039*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.046*	0.108 M.Rads
Area Difference from 30° to 40°	0.007*	0.036 M.Rads
Angle at which Maximum GZ Occurs	15°	25 Degrees
GZ at 30°	0.065*	0.240 Metres
Initial GM (Fluid)	0.541	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS **In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel**	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	2.904	2.170
2. To Main Deck at Side at A.T. (HDA)	0.834	0.493
3. To Poop Deck at Side at A.T.	3.204	—
4. To Top of Main Deck Sheathing at Midships	0.314	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.343	—

Condition 3: Both derricks 30° above horizontal, beams at derrick heads with additional 3.75 tonne in each net. Shelter doors open.

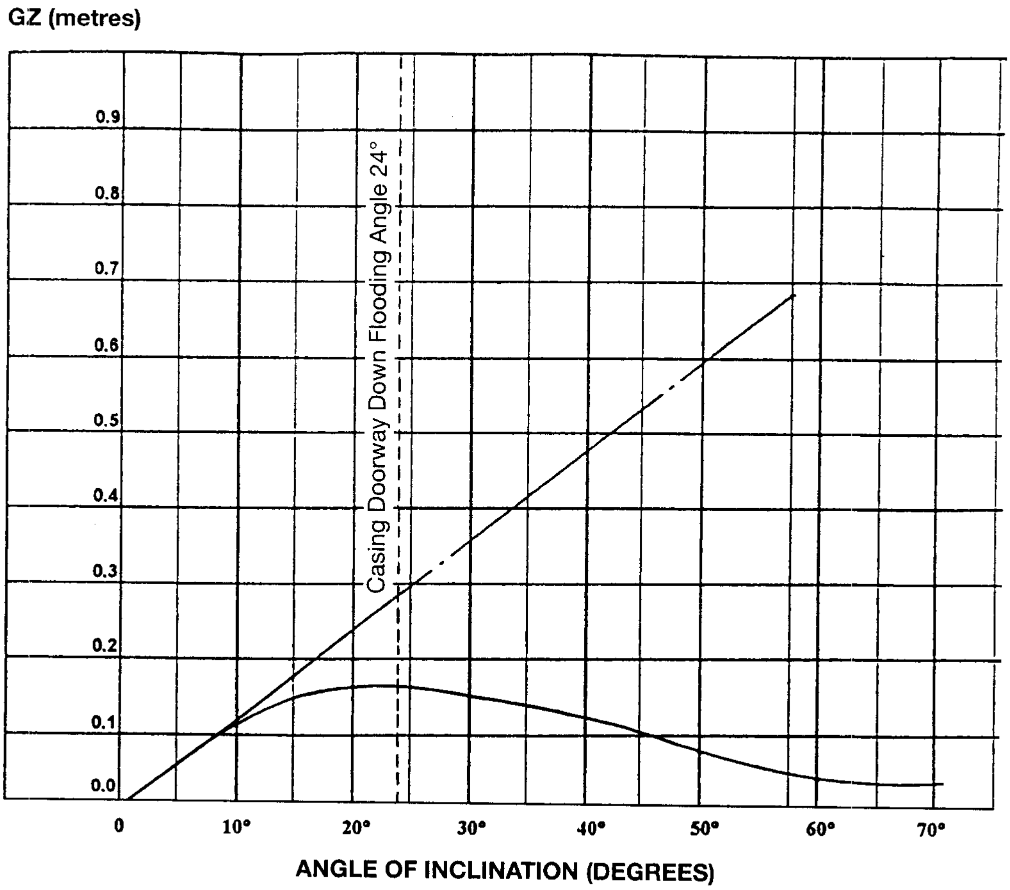


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0233 x (1))	0.004*	0.066 M.Rads
Area Under Curve up to 40°	0.000*	0.108 M.Rads
Area Difference from 30° to 40°	0.000*	0.036 M.Rads
Angle at which Maximum GZ Occurs	8.5°*	25 Degrees
GZ at 30°	– 0.112*	0.240 Metres
Initial GM (Fluid)	0.187*	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	2.904	2.170
2. To Main Deck at Side at A.T. (HDA)	0.834	0.493
3. To Poop Deck at Side at A.T.	3.204	—
4. To Top of Main Deck Sheathing at Midships	0.314	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.343	—

Condition 4: Both beams on deck, derricks topped to 45° above horizontal. Shelter doors open.

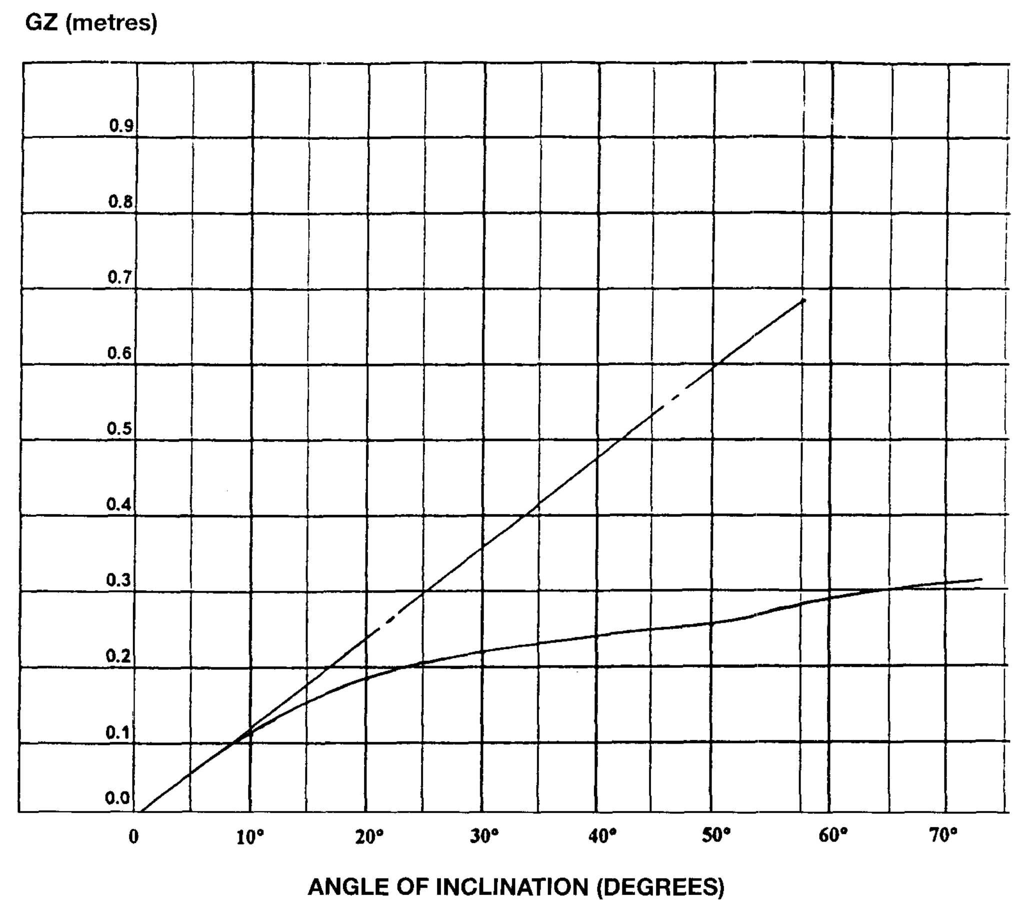


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.064*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.088*	0.108 M.Rads
Area Difference from 30° to 40°	0.022*	0.036 M.Rads
Angle at which Maximum GZ Occurs	22°*	25 Degrees
GZ at 30°	0.151*	0.240 Metres
Initial GM (Fluid)	0.684	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel	Actual Value (Metres)	Required Minimum (Metres)
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	3.077	2.170
2. To Main Deck at Side at A.T. (HDA)	0.830	0.788
3. To Poop Deck at Side at A.T.	N/A	—
4. To Top of Main Deck Sheathing at Midships	0.398	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.387	—

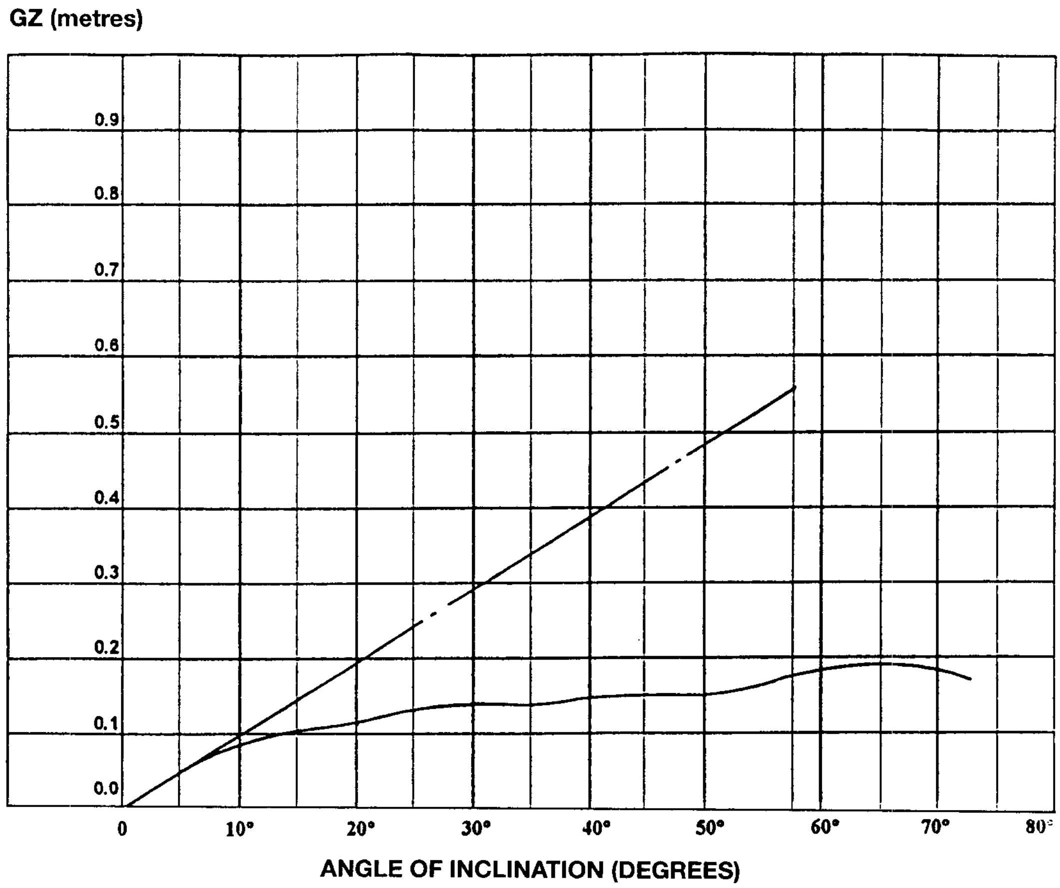
Condition 5: **Both beams on deck, derricks topped to 45° above horizontal. Shelter doors closed.**



	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.073	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.113	0.108 M.Rads
Area Difference from 30° to 40°	0.040	0.036 M.Rads
Angle at which Maximum GZ Occurs	over 70°	25 Degrees
GZ at 70°	0.309	0.240 Metres
Initial GM (Fluid)	0.684	0.420 Metres

FREEBOARDS **In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel**	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	3.077	2.170
2. To Main Deck at Side at A.T. (HDA)	0.830	0.493
3. To Poop Deck at Side at A.T.	3.200	—
4. To Top of Main Deck Sheathing at Midships	0.398	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.387	—

Condition 6: Both derricks horizontal, beams at derrick heads with additional 3.75 tonne in each net. Shelter doors closed.

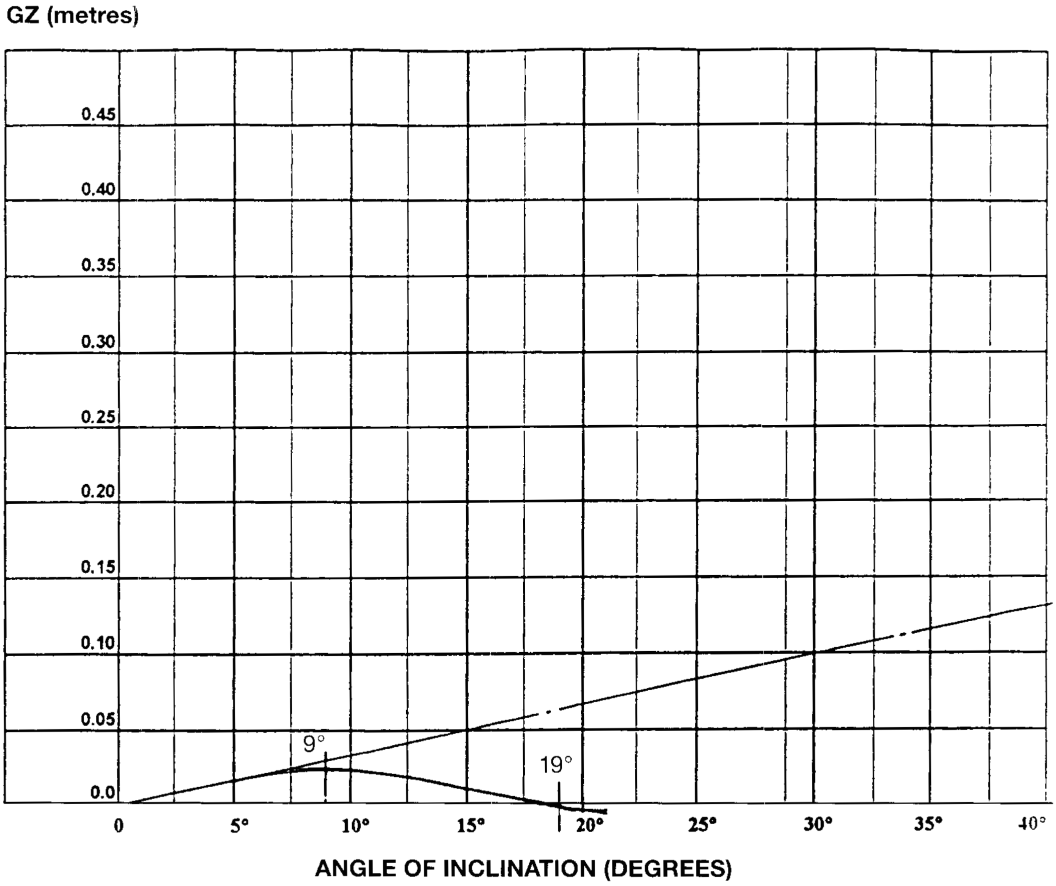


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.049*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.075*	0.108 M.Rads
Area Difference from 30° to 40°	0.026*	0.036 M.Rads
Angle at which Maximum GZ Occurs	65°	25 Degrees
GZ at 65°	0.190*	0.240 Metres
Initial GM (Fluid)	0.541	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	2.904	2.170
2. To Main Deck at Side at A.T. (HDA)	0.834	0.493
3. To Poop Deck at Side at A.T.	3.204	—
4. To Top of Main Deck Sheathing at Midships	0.314	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.343	—

Condition 7: Both derricks 30° above horizontal, beams at derrick heads with additional 3.75 tonne in each net. Shelter doors closed.

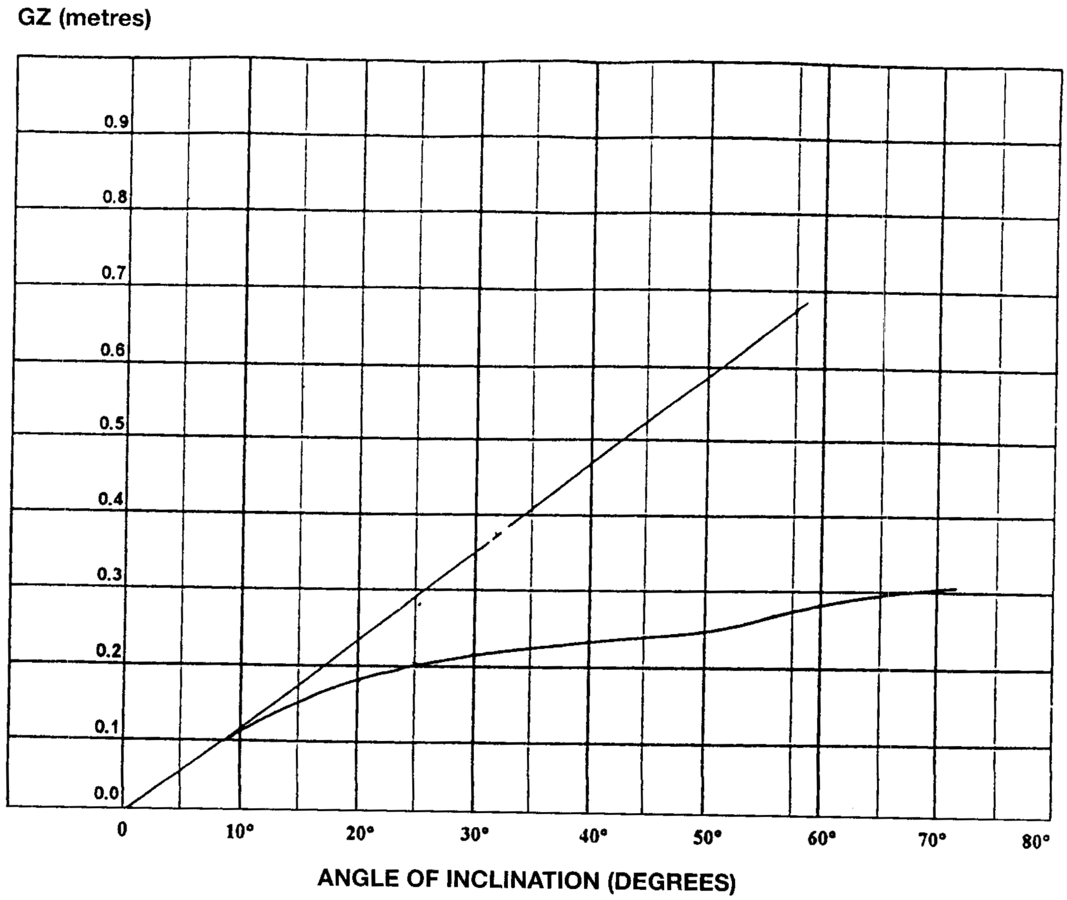


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0276 × (1))	0.005*	0.066 M.Rads
Area Under Curve up to 40°	0.000*	0.108 M.Rads
Area Difference from 30° to 40°	0.000*	0.036 M.Rads
Angle at which Maximum GZ Occurs	9°*	25 Degrees
GZ at 30°	-0.035*	0.240 Metres
Initial GM (Fluid)	0.187*	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	2.904	2.170
2. To Main Deck at Side at A.T. (HDA)	0.834	0.493
3. To Poop Deck at Side at A.T.	3.204	—
4. To Top of Main Deck Sheathing at Midships	0.314	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.343	—

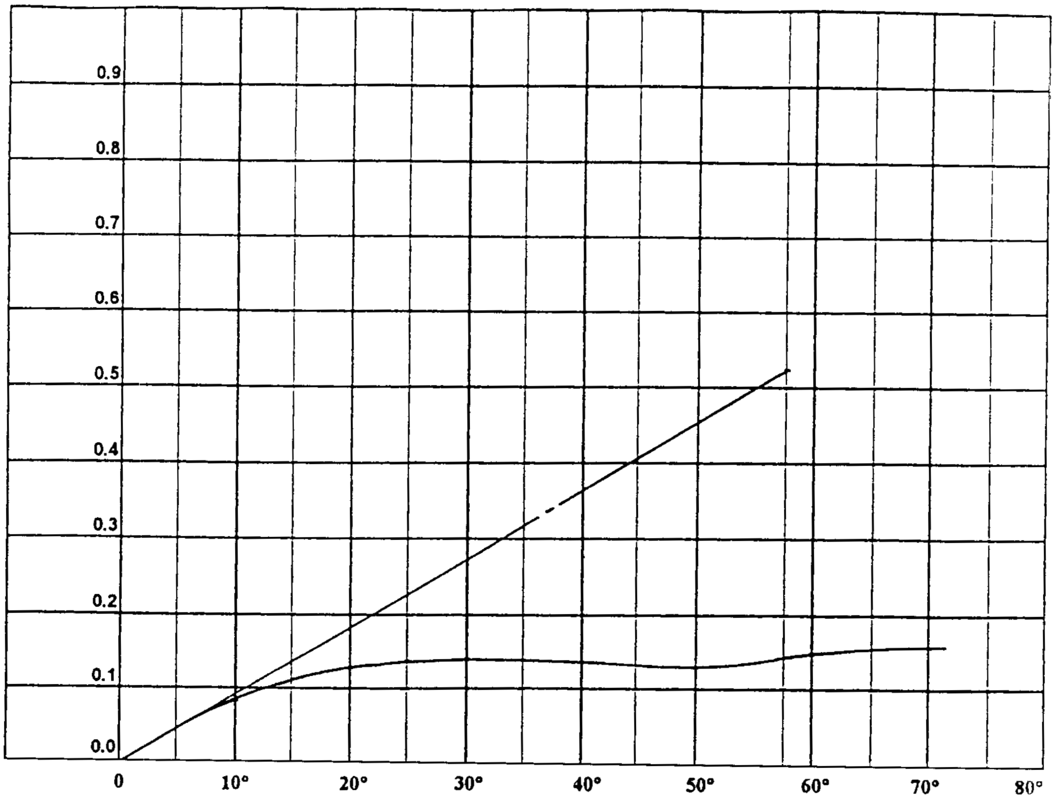
Condition 8: **Both derricks horizontal, beams at derrick ends, nets empty. Shelter doors closed.**



	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.072	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.111	0.108 M.Rads
Area Difference from 30° to 40°	0.039	0.036 M.Rads
Angle at which Maximum GZ Occurs	OVER 70°	25 Degrees
GZ at 70°	0.302	0.240 Metres
Initial GM (Fluid)	0.676	0.420 Metres

FREEBOARDS **In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel**	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	3.077	2.170
2. To Main Deck at Side at A.T. (HDA)	0.830	0.493
3. To Poop Deck at Side at A.T.	3.200	—
4. To Top of Main Deck Sheathing at Midships	0.398	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.387	—

Condition 9: Both derricks topped 30° above horizontal, beams at derrick ends, nets empty. Shelter doors closed.

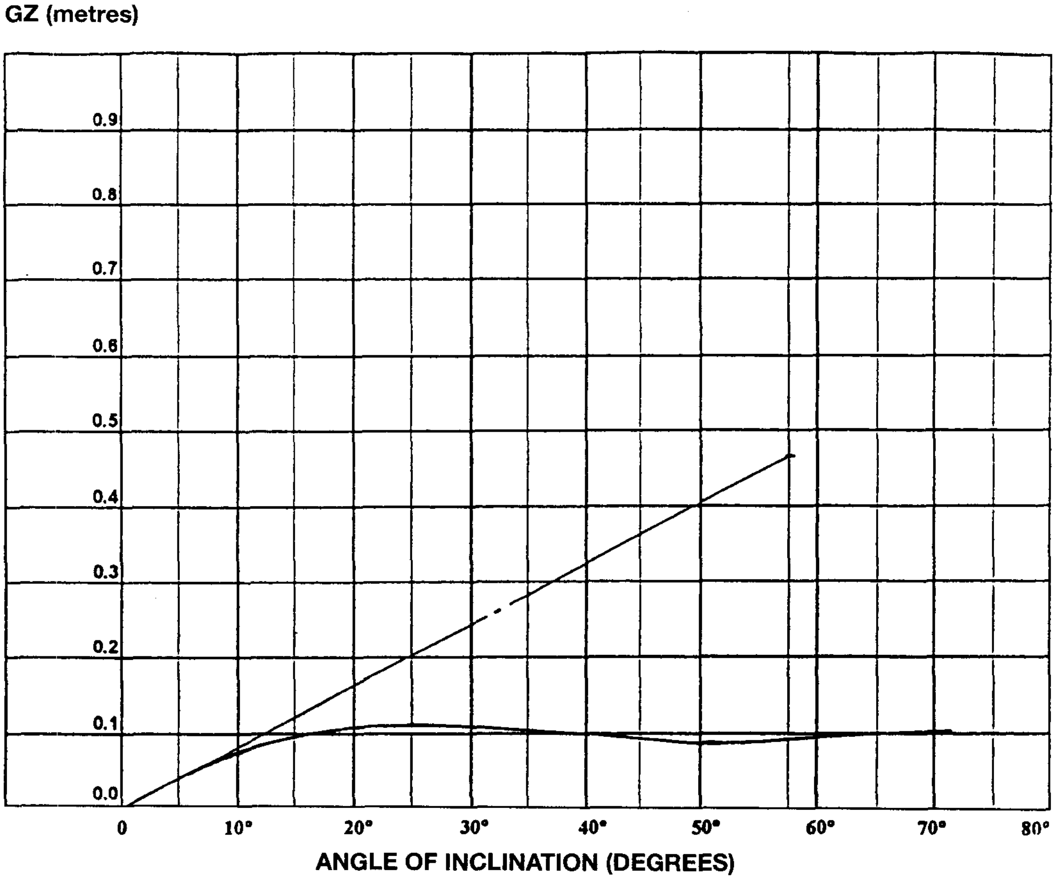


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.051*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.075*	0.108 M.Rads
Area Difference from 30° to 40°	0.024*	0.036 M.Rads
Angle at which Maximum GZ Occurs	OVER 70°	25 Degrees
GZ at 70°	0.158*	0.240 Metres
Initial GM (Fluid)	0.523	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS **In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel**	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	3.077	2.170
2. To Main Deck at Side at A.T. (HDA)	0.830	0.493
3. To Poop Deck at Side at A.T.	3.200	—
4. To Top of Main Deck Sheathing at Midships	0.398	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.387	—

Condition 10: **Both derricks topped 45° above horizontal, beams at derrick ends, nets empty. Shelter doors closed.**

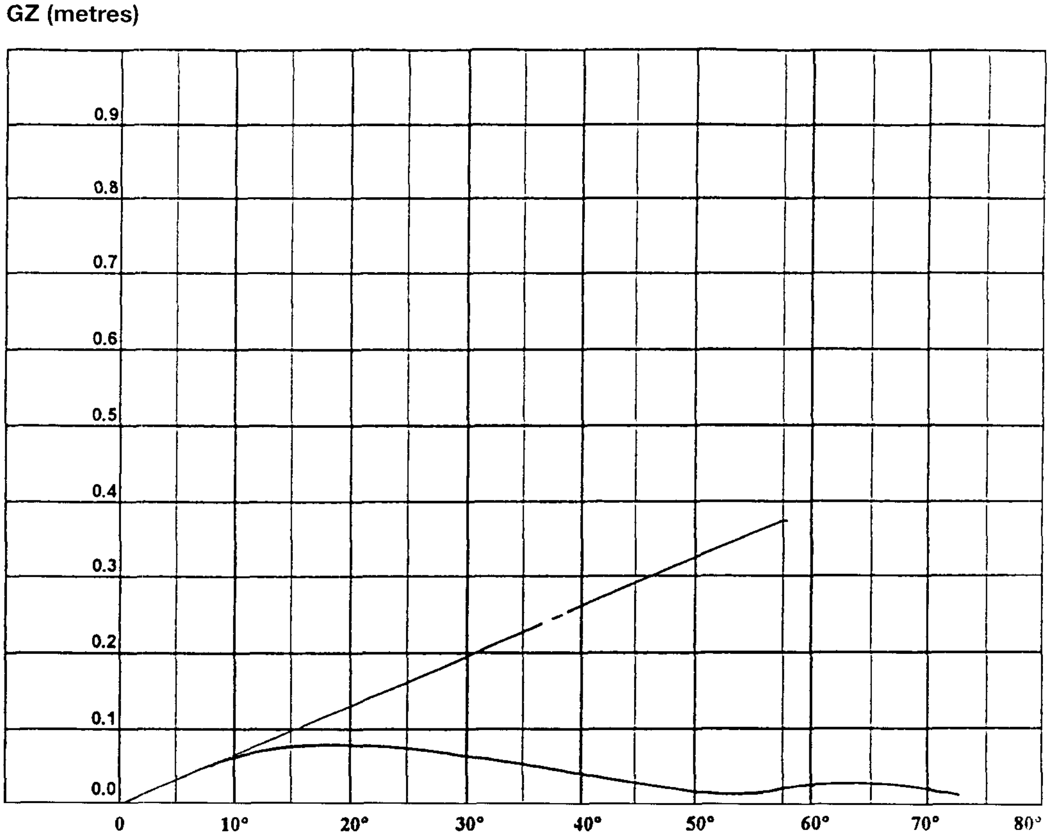


	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.043*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.062*	0.108 M.Rads
Area Difference from 30° to 40°	0.019*	0.036 M.Rads
Angle at which Maximum GZ Occurs	25°	25 Degrees
GZ at 70°	0.113*	0.240 Metres
Initial GM (Fluid)	0.465	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	3.077	2.170
2. To Main Deck at Side at A.T. (HDA)	0.830	0.493
3. To Poop Deck at Side at A.T.	3.200	—
4. To Top of Main Deck Sheathing at Midships	0.398	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.387	—

Condition 11: **Both derricks fully topped, beams at derrick ends, nets empty. Shelter doors closed.**



	Actual Value	Rule Minimum
Area Under Curve up to 30° (0.0654 × (1))	0.032*	0.066 M.Rads
Area Under Curve up to 40° (0.0581 × (2))	0.041*	0.108 M.Rads
Area Difference from 30° to 40°	0.009*	0.036 M.Rads
Angle at which Maximum GZ Occurs	18°*	25 Degrees
GZ at 70°	0.066*	0.240 Metres
Initial GM (Fluid)	0.375*	0.420 Metres

*Failure to satisfy minimum criteria

FREEBOARDS **In accordance with Merchant Shipping Notice M-975 and Survey Memorandum No 55 for an Existing Vessel**	**Actual Value (Metres)**	**Required Minimum (Metres)**
1. To Fo'c'sle Deck at Side at F.T. (HB & HD)	3.077	2.170
2. To Main Deck at Side at A.T. (HDA)	0.830	0.493
3. To Poop Deck at Side at A.T.	3.200	—
4. To Top of Main Deck Sheathing at Midships	0.398	—
5. To Top of Main Deck Sheathing at Bhd. 12	0.387	—