Report on the investigation of

the capsize and sinking of the fishing vessel

Chelaris J (GU323)

and loss of all crew members

Banc de la Schôle (near Alderney)

1 October 2003

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Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999

The fundamental purpose of investigating an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 1999 is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

NOTE

This report is not written with liability in mind and is not intended to be used in court for the purpose of litigation. It endeavours to identify and analyse the relevant safety issues pertaining to the specific accident, and to make recommendations aimed at preventing similar accidents in the future.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

BV	-	Bureau Veritas (classification society)
CPP	-	Controllable pitch (propeller)
DSC	-	Digital Selective Calling
EPIRB	-	Emergency Position Indicating Radio Beacon
GM	-	Metacentric height – measure of performance of small angle stability
GZ curve	-	Diagram showing vessel righting lever at each angle of heel
kg	-	kilogram
m	-	metre
MCA	-	Maritime and Coastguard Agency
MOU	-	Memorandum of Understanding
NRV	-	Non return valve
NVQ	-	National Vocational Qualification
ROV	-	Remotely operated vehicle
UTC	-	Universal co-ordinated time
VCG	-	Vertical centre of gravity
VHF	-	Very High Frequency

SYNOPSIS

On 1 October 2003, the Guernsey-registered fishing vessel *Chelaris J* was lost suddenly with her four crew while fishing on the Banc de la Schôle, a sandbank lying 6 miles to the south of Alderney.

The MAIB was asked by the States of Guernsey Board of Administration to conduct an investigation into the accident, in accordance with the MOU between it and the MAIB.

Chelaris J had left Cherbourg around midnight on 30 September 2003, fully fuelled and carrying ice. On board was the Guernsey skipper/owner and three French crew members. They headed for the Banc de la Schôle to fish in the area of the sandbank.

On arrival at the fishing grounds, the single trawl was shot away and they began fishing. About 4 hours later, the net was hauled on board and the catch stowed below in the fish hold. The fishing gear was shot away once again. Around that time, the wind was east-north-east force 6 and the tide was running north-east at about 3.5 knots. Not long before their second haul was due, *Chelaris J*'s EPIRB started to transmit at 1114 UTC.

St Peter Port Radio mounted a search and rescue operation, locating the EPIRB and debris, but no survivors. *Chelaris J*'s liferaft was recovered, inflated, the following morning. The wreck was located on the seabed, and divers retrieved the bodies of 2 crew members from the accommodation space.

Two video surveys were conducted of *Chelaris J* on the seabed, before she was raised for further examination and testing in Guernsey. She was raised because there were concerns about her condition, and in particular her stability, given her incomplete survey history at the time of her loss.

It was established that the vessel capsized while trawling. The MAIB has concluded that, given the weather at the time of the accident, a combination of the trawl gear becoming snagged in the sandbank, some water on deck, a little internal flooding and wave action caused *Chelaris J* to capsize.

Several safety issues have arisen as a result of this investigation. These included the hazards of snagging, in particular on the Banc de la Schôle, survey and safety approval, fishing vessel maintenance concerns and, finally, crew training and safety awareness issues.

Recommendations are made to the States of Guernsey Board of Administration on the introduction of fishing vessel codes of practice and guidance, the establishment of an effective regime for the survey of fishing vessels and the introduction of mandatory safety training for fishermen sailing on Guernsey registered fishing vessels. The MCA is also recommended to develop a stability awareness course as a matter of urgency.

Figure 1

Chelaris J

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *CHELARIS J* AND ACCIDENT

Vessel details

Registered owner	:	Chelaris Fishing Company
Port of registry	:	St Peter Port
Flag	:	Guernsey
Type	:	Stern trawler
Built	:	1979, Ingrandes, Breheret, France
Classification society	:	BV at build not maintained in class
Construction	:	Steel
Length overall	:	16.8m
Registered length	:	16.0m
Gross tonnage	:	40.03
Engine power and/or type	:	305 kW, Poyaud
Service speed	:	8 knots
Other relevant info	:	Single screw CPP

Accident details

Time and date	:	1100, 1 October 2003
Location of wreck	:	49° 36'.23N 2° 12'.51W
Persons on board	:	4
Fatalities	:	4
Damage	:	Vessel foundered and was later salvaged

1.2 BACKGROUND

The fishing vessel *Chelaris J* was a stern trawler, registered under the Guernsey flag. She had been owned since the summer of 2000 by the Chelaris Fishing Company in Guernsey. The director of the company was Martyn Lane, who was also the vessel's skipper. The vessel had three other crew members, who were all French nationals.

The vessel was constructed in France in 1979, and initially fished under the French flag as *L'Ogien*, and then as *Simbad*. In July 1997, she changed ownership again and fished under the Irish Flag, with the name *Celtic Rose*. Chelaris Fishing Company bought the vessel after she had been laid up in Ireland for approximately 6 months. She then underwent a refit in the UK before fishing once again.

Chelaris J fished mainly in the waters around the Channel Islands, and latterly had used Cherbourg as her main port. Trips lasted 3 to 5 days and, roughly once a month, she would call into Guernsey.

1.3 CREW

Chelaris J was manned with a skipper and three crew:

Martyn Lane, the skipper, had fished from an early age on various vessels, including his father's. He had skippered his own vessel before his company, Chelaris Fishing Company, purchased *Chelaris J* in the summer of 2000. Martyn Lane had been her skipper since then. He had attended Banff and Buchan College in Scotland, where he obtained a level 2 NVQ in Marine Operations. While there, he attended a one day sea survival course on 20 March 1996. The fishing grounds in which *Chelaris J* was lost were well known to him.

Pierre Duflot was an experienced fisherman and was a qualified engineer. Prior to the final voyage, he had been *Chelaris J*'s shore-based engineer in Cherbourg. This trip to sea was the first he had made on the vessel.

Yvan Regnier, crewman, was a qualified and very experienced fisherman. He had been on board the vessel for about a month and a half.

Romain Ouitre, crewman, was the least experienced crew member. He joined *Chelaris J* at the same time as Yvan Regnier.

1.4 NARRATIVE

(All times are UTC)

The fishing vessel *Chelaris J* set out from Cherbourg around midnight of Tuesday 30 September 2003 with the skipper and 3 crew on board. She was fully fuelled, and had taken 3 tonnes of ice into her fish hold. The vessel headed towards the Banc de la Schôle, a sandbank lying south of Alderney **(see chart 1)**. On arrival at the fishing grounds, the trawl gear was shot away and fishing began. Some time later, the cod end was hauled on board and the catch stowed in the fish hold. Trawling then continued for a second tow. At 0910, a call was made to the skipper's mobile telephone, and a crew member answered it. He said that the skipper was down below, resting, but that he would be up again in about 2 hours. A phone call was also made to Pierre Duflot by his son at 1000, in which the former said that the fishing was good and that he hoped he would be returning to port sooner than had been expected. Around that time, the wind was east-north-east force 6, and the tide was running in a north-easterly direction.

At 1114, Falmouth Coastguard informed St Peter Port Radio that the EPIRB for *Chelaris J* had been activated. Initial efforts to contact the vessel were unsuccessful. At 1122, a position for the EPIRB was received. This was 49°36.8'N 002°13.6'W. A search and rescue operation, co-ordinated by the St Peter Port authorities, then began. At 1314, Alderney lifeboat located the EPIRB, along with a large amount of debris. No survivors were found.

The search continued for the rest of the day, and resumed the following morning. Various items, including fish boxes, baskets and buoys were recovered from the sea. The liferaft was found afloat, but empty, the morning after the accident. A French navy mine-hunter joined in the search and, using its sonar, managed to locate the wreck of *Chelaris J* on the seabed in position 49°36.385'N 002°12.87'W.

A French navy diving corvette was on-scene the morning of 3 October 2003. Her divers recovered the bodies of Martyn Lane and Romain Ouitre from *Chelaris J*'s accommodation space. The skipper was dressed only in boxer shorts and a cotton top. Romain Ouitre was wearing jeans, trainers and a wind-proof smock. The divers also carried out a video survey of the wreck. At the time of writing this report, the bodies of the other two crew members have not been found.

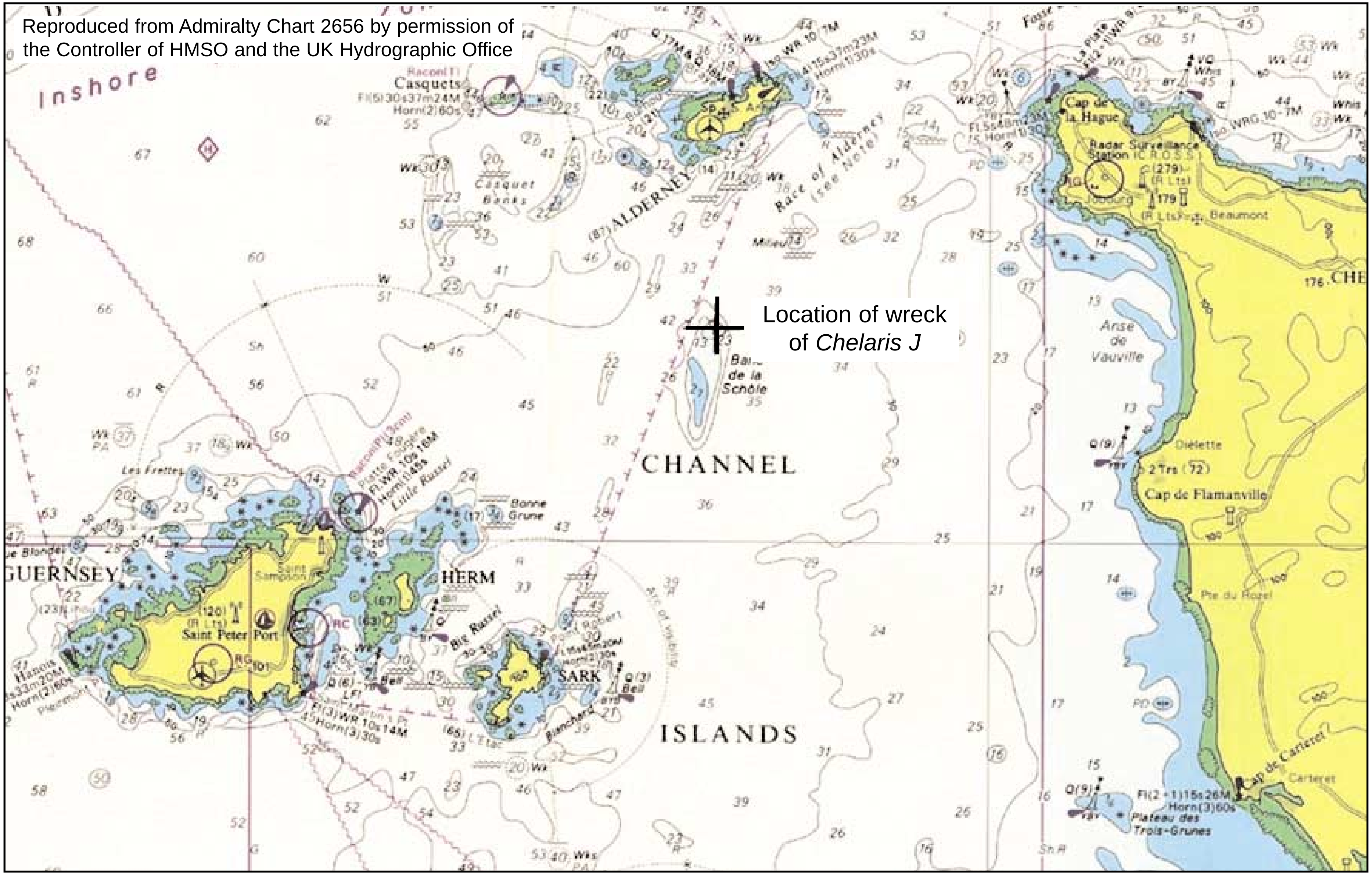
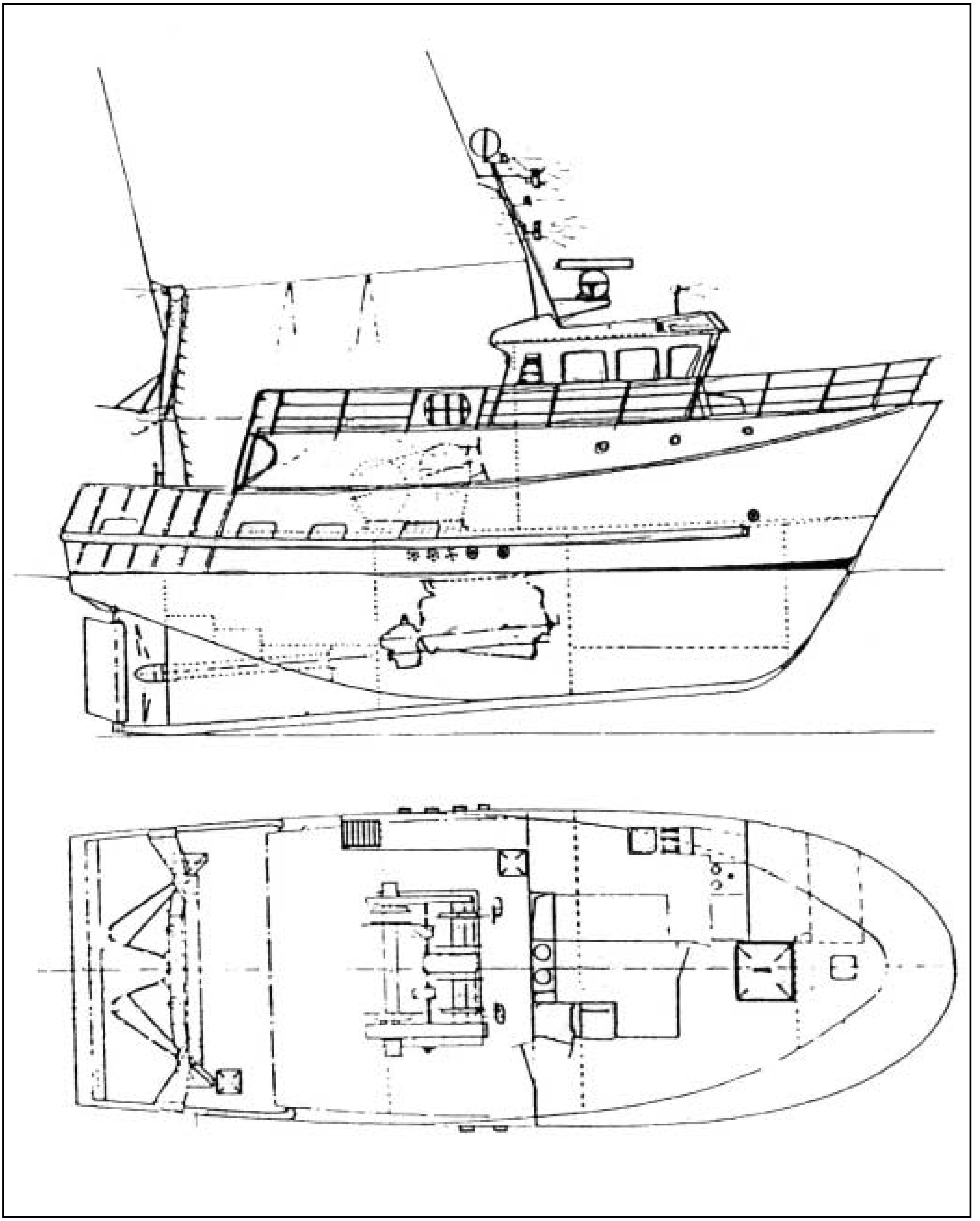

Reproduced from Admiralty Chart 2656 by permission of the Controller of HMSO and the UK Hydrographic Office
Location of wreck of *Chelaris J*
Inshore
Casquets
Casquet Banks
ALDERNEY
Race of Alderney (see Note)
Cap de la Hague
Radar Surveillance Station
Beaumont
Anse de Vauville
Banc de la Schôle
CHANNEL
ISLANDS
Diélette
Cap de Flamanville
Carteret
Plateau des Trois-Grunes
GUERNSEY
Saint Peter Port
Saint Sampson
Les Fretes
Little Russel
Big Russel
HERM
SARK
Bonne Grune

Chart 1



General arrangement of *Chelaris J*

1.5 VESSEL DESCRIPTION

A general arrangement of *Chelaris J* is shown in **Figure 2**.

1.5.1 Propulsion and steering

The main engine drove a single shaft fitted with a CP propeller. A single plate, semi-balanced rudder, was sited directly behind the propeller. The rudder was hydraulically-operated. An autopilot was fitted, which had a watch alarm incorporated when the unit was in use. This would sound an alarm in the wheelhouse every 4 minutes until reset. If the initial alarm was not reset within one minute of activation, a second, much louder alarm would sound in the wheelhouse, which could also be heard down below in the mess area.

1.5.2 Deck machinery

The main winch and a net drum were situated on the main deck. The winch was hydraulically-driven, with pneumatically-controlled dog clutches and brakes. There were two net drums on the gantry which were also hydraulically-powered. The controls for the trawl winches were situated in the aft end of the wheelhouse, where there were gratings to allow the operator to see the winches through the deck.

1.5.3 Fishing gear

The trawl wires passed through the top of the shelter and out to the two trawl blocks, which were hung from the gantry 2.1m above the deck. Two sets of trawl doors were on board the vessel when she sailed from Cherbourg on the last trip. Larger doors were used with the two hopper trawls stowed on the split net drum on the gantry. Smaller doors were used with the ‘bank’ net, which was normally stowed on the net drum that was integrated with the trawl winches. The ‘bank’ net was smaller than the hopper trawls and only had 5.5m (3 fathom) bridles.

1.5.4 Pumping arrangement

There was a fixed bilge pumping system on the vessel, with suctions in all compartments leading to a valve manifold in the engine room **(see Figure 3)**. This, in turn, was connected to an engine-driven bilge pump **(see Figure 4)**. The bilge pump was permanently engaged to the engine, and had two lines feeding into it to provide seawater cooling/lubrication when not pumping the bilge.

Each space was served by a single bilge suction that was sited at the valve manifold in the engine room **(see Figure 3b)**.

Figure 3a

Figure 3b

Bilge pumping Manifold

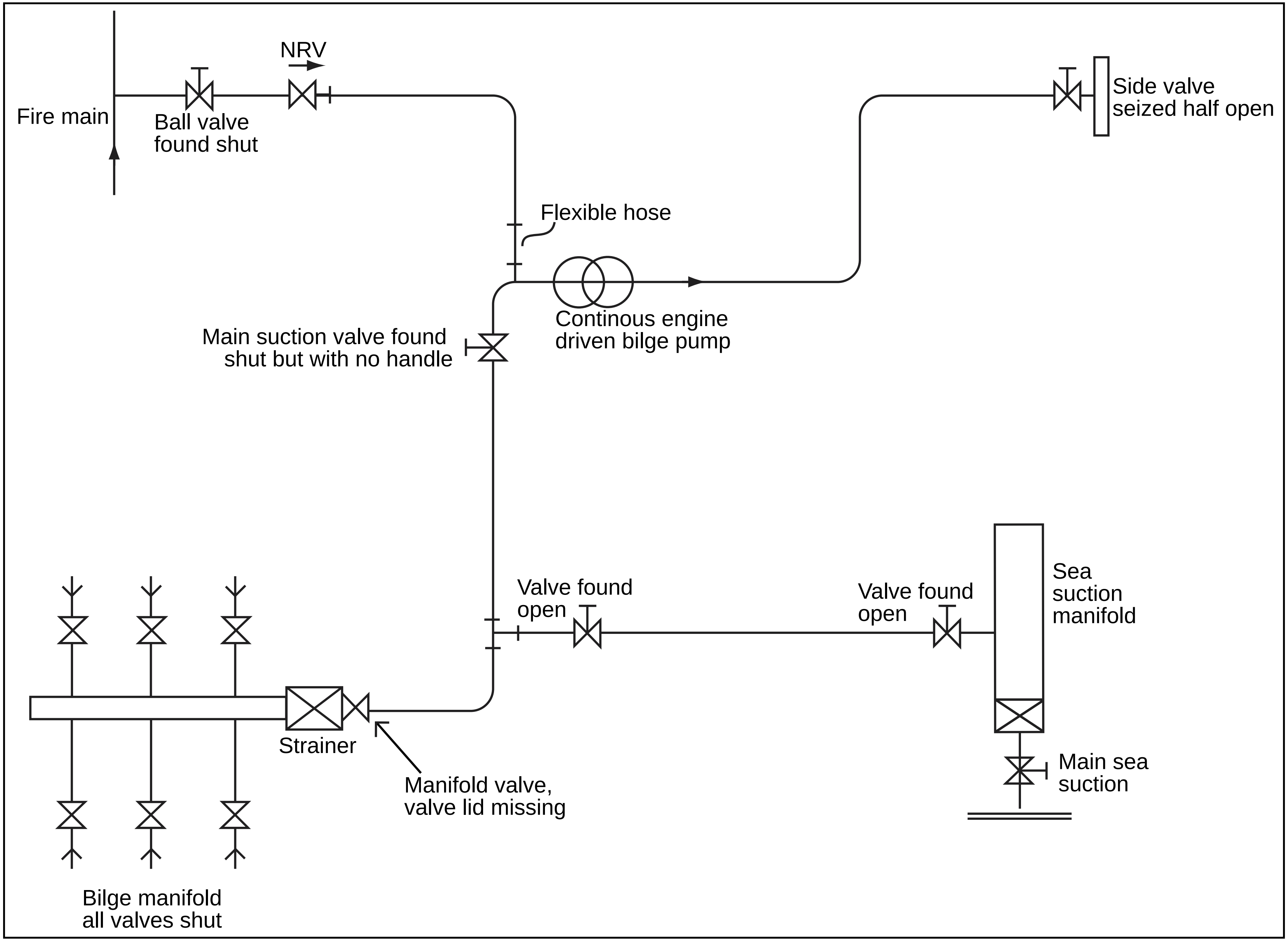


Figure 4

Diagrammatic sketch of bilge pumping arrangement

There was an engine-driven general service pump on the starboard side of the main engine, which serviced various systems, including the hydraulic cooling and the deck wash system. An electric fire pump was situated on the port side of the main engine.

There was also a portable electric bilge pump kept on board the vessel.

1.5.5 Bilge alarm

A bilge alarm was fitted to *Chelaris J*, with sensors in both the engine room and the fish hold. There was no automatic pump associated with the system, although this was an option with the type of bilge alarm fitted. The sensor in the engine room was inaccessible, rendering routine testing impossible, and the bilge alarm sensor in the fish hold was not routinely tested by the crew.

There was evidence to suggest the bilge alarm did not work, as it was never heard, even after a flooding incident in the fish hold had occurred. This flooding incident, and another in the accommodation, were thought to have been caused by back-siphoning through the bilge system when a valve on the valve bank was left open accidentally.

1.5.6 Watertight integrity

There was a weathertight door from the aft deck into the starboard passageway, which had a notice stating: 'To be closed at sea'. There was also a watertight hatch on the accommodation escape trunk to the aft deck. This hatch was always kept closed at sea. Forward, was a fish landing hatch on the upper deck directly above the hatch to the fish hold below. The forward superstructure had six portholes with closures. The wheelhouse had a weathertight door opening aft on to the upper deck. On the ship's sides, either side of the trawl winch, were two vents, one of which fed the engine room. Both were fitted with watertight closures.

1.5.7 Tanks

Two diesel tanks were sited, one either side of the engine room, running the length of the compartment. Two additional fuel tanks, in the wings of the steering gear compartment, were disused, and the associated pipework had been blanked off. The inspection covers for these tanks had been removed. The bottom of the starboard tank contained some solid ballast, consisting of steel washers and punchings. A freshwater tank was situated under the lower bunks on the centreline in the accommodation space.

1.6 BANC DE LA SCHÔLE

The Banc de la Schôle is a sandbank situated 6 miles south of Alderney. It is a fishing ground used almost exclusively by Guernsey fishermen catching skate, brill, turbot and ray. Vessels often fish off the bank during the day, and then on the bank at night. The tides in the waters around the Channel Islands are some of the strongest in the world. At the north end of the bank there can be 4.2 knots of tidal stream on a spring tide. Associated with this can be 6 to 7m of tidal range. The Sailing Directions state that in heavy weather, the sea can break dangerously on all parts of the shoal. **Chart 2** shows the estimated tidal direction and strength on the day of the accident. These tides dictate where fishing vessels can trawl as, if too strong, vessels of limited power can find it impossible to turn into tide while towing. Therefore, a good level of local knowledge of the bank is required to fish the grounds safely.

The sand around the bank forms ridges, which run east-west and can be very steep sided on one side. The term 'saw tooth shape' has been used to describe them. A trawler is more likely to snag her gear if she is trawling into the steep sides of the ridge. Therefore, vessels normally try and avoid this. Broadly speaking, fishing vessels in the area of Banc de la Schôle trawl south, down the east side of the bank, and north, up the west side. Some smaller, less powerful vessels tend to avoid fishing the north end of the bank because of the strong tides and the likelihood of becoming snagged.

1.7 TRAWLING OPERATIONS

When trawling, *Chelaris J* usually had only one crew member posted on watch, whose task was to ensure the vessel followed a pre-set track on the plotter. The autopilot was normally engaged, and the crewman altered the heading on it to keep to the track required. When trawling with the tide, the speed over the ground would usually vary between 2 and 4.5 knots. If trawling against the tide, the speed would normally only be 1 to 1.5 knots. This was to ensure the mouth of the net was kept open by the trawl doors. When fishing off the bank, the water is deeper, 40 to 50m, so 110m (60 fathoms) of trawl wire was generally used. When trawling the bank, in 20 to 30m of water depth, it was usual to use 73m (40 fathoms) of trawl wire.

Chelaris J was the most powerful fishing vessel in the Guernsey fleet. This meant she could fish areas of the Banc de la Schôle that others could not. Snagging occurred frequently when fishing on the bank.

There are two ways that gear can become snagged on the bank: the foot rope of the net digs into a large sandbank, or the trawl doors dig in. The latter is more likely when the vessel is turning, because the doors then fall over and the door on the inside of the turn may dig down into the seabed, causing the gear to snag.

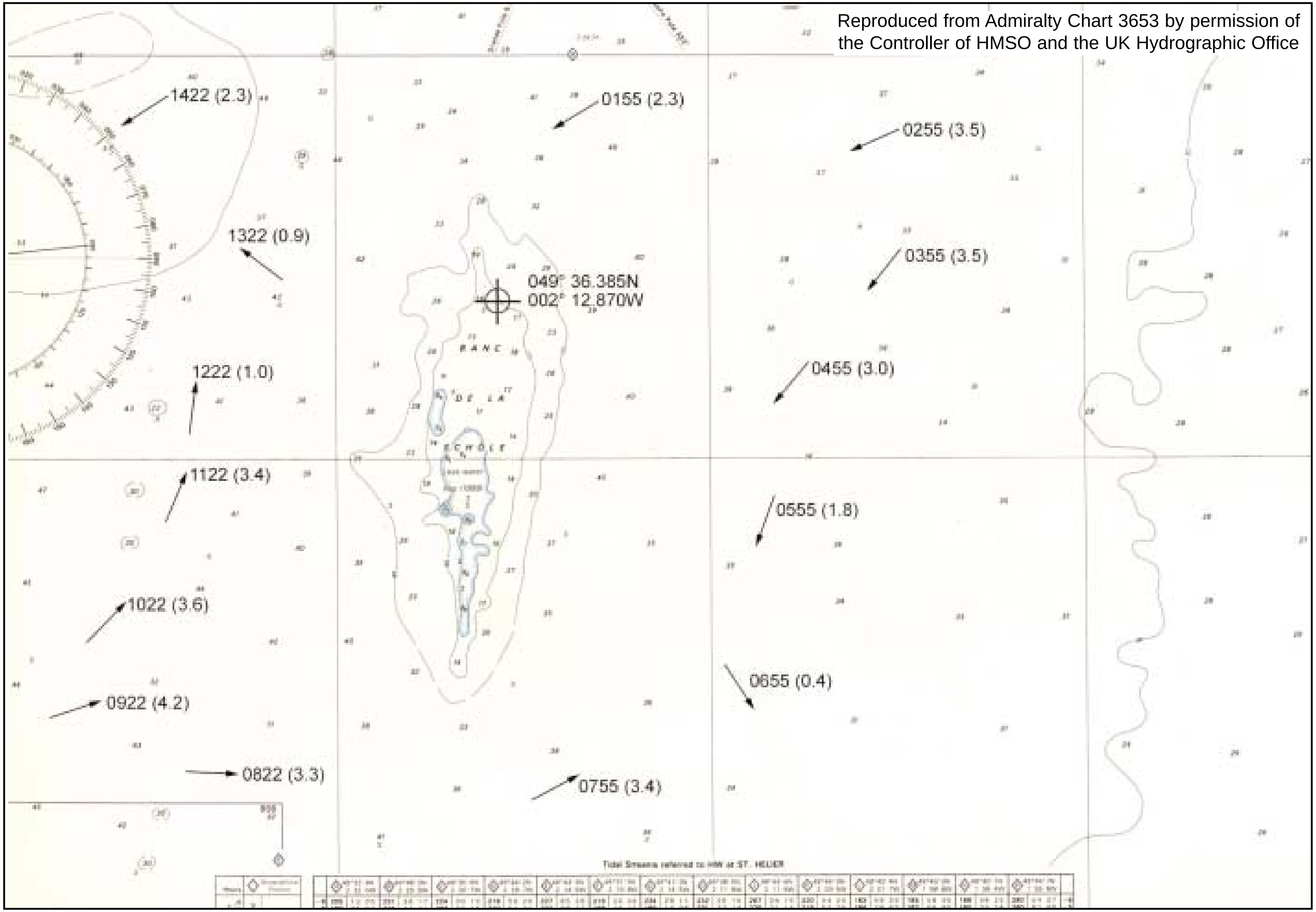


Chart showing tidal direction and speed in knots on 1 October 2003 - initial EPIRB at 1107 (all times are UTC)

Chart 2

Based on advice given by experienced fishing vessel skippers, the following progressive actions would normally be taken in the event that the fishing gear becomes snagged:

- More power would be applied in an attempt to pull the vessel clear.
- The autopilot would be disengaged, and manual steering applied to 'zig-zag', in an attempt to free the vessel.
- The engine speed would be reduced, the skipper would be called to the wheelhouse and the winch controls used to recover the fishing gear. Normally, on board *Chelaris J*, it was only the skipper who operated the winches.
- If the tide is astern of the vessel, the operation to free the snag becomes more urgent, to avoid fouling the nets.

1.8 STATES OF GUERNSEY HARBOURS AUTHORITY

The States of Guernsey Harbours Authority is responsible for the administration and operation of the ports of St Peter Port and St Sampsons. It also has other maritime responsibilities, including the licensing and regulation of commercial vessels in local waters.

The States of Guernsey Harbours Authority has its own Merchant Shipping Statutory Instruments, which are, in general, the same as UK Merchant Shipping Legislation with appropriate amendments. SI 990/2148, the fishing vessels (safety provisions) (Guernsey) order 1990, brought into force the UK SI 1975/330, the fishing vessel (safety provisions) Rules 1975, with some amendments. This is the extant standard for all fishing vessels under the Guernsey flag at the time of writing.

Although the flag state, the States of Guernsey Harbours Authority does not conduct its own surveys to ensure vessels meet the Rules. It is content for the MCA, or any company/organisation approved by the MCA, or any company nominated by the States of Guernsey, to conduct surveys on its behalf, in accordance with the 1975 Rules. There is also one approved local surveyor. Once surveyed by an approved body to their satisfaction, the flag state then issues the fishing vessel safety certificate.

Marine Guidance Notes, and other MCA publications, are made available to Guernsey-registered fishing vessels. There are no mandatory courses for fishermen to attend in Guernsey. In the UK, fishermen must undertake sea survival, fire-fighting and first-aid training before they go to sea. There is also a one day safety awareness course for experienced fishermen which will become mandatory from November 2004. As the vessel was below 16.5m registered length, there was no requirement for any of the personnel working on board *Chelaris J* to hold a certificate of competency.

1.9 VESSEL CERTIFICATION

When originally constructed, *Chelaris J* was surveyed by the French authorities, and sailed under the French Flag. Stability approval of the vessel at build appears to have been based on her being one of a class of vessels already built. No record of an inclining test could be found. The stability booklet produced in 1979 is based on her having a lightship value of 71.02 tonnes and a VCG of 3.08m above the baseline.

On 10 July 1997, the vessel was sold to a new owner, and she sailed under the Irish Flag, with the name *Celtic Rose*, until May 2000. No recorded surveys by the Irish Administration were conducted during that time, but it is known the net drums were added on the gantry. The vessel was laid up for roughly 6 months before being bought by Chelaris Fishing Company, and was renamed *Chelaris J*.

After purchase, *Chelaris J* underwent an extensive refit at Appledore Shipyard in Devon, which began on 2 August 2000. The owner decided to register the vessel under the Guernsey flag. The States of Guernsey Harbours Authority requested that the MCA conducted the necessary surveys in accordance with the Fishing Vessels (Safety Provisions) Rules 1975, SI 1975 330. Owing to her size, the Rules required *Chelaris J* to have valid stability information. The States of Guernsey Harbours Authority faxed the MCA on 7 August 2000 confirming the vessel should be inclined and full approved stability should be supplied. They also confirmed in another fax on 29 August 2000 that the stability data must comply with the requirements of the 1975 Rules. There was some limited stability information, produced by Bureau Veritas in 1979, provided with the vessel, but this needed to be corroborated.

A naval architect was employed to review the stability data for *Chelaris J*. Using the 1979 stability information, he calculated that 5 tonnes of ballast was required in the stern to trim her correctly. When she was refloated, it became apparent that this assessment was wrong, as she adopted a significant stern trim. An inclining test was carried out on 14 November 2000, in weather and sea conditions which were not ideal. However, it became apparent that the figures in the original French stability information bore no resemblance to those derived from the inclining test. The displacement seemed to have increased by 16 tonnes, having a VCG 3.85m above the baseline. From his calculations, the naval architect consultant became very concerned about *Chelaris J*'s stability, and advised that he could not even give a statement to say she was safe for the trip to Guernsey, let alone conduct fishing operations. He advised, at the very least, that solid ballast aft be removed, and 3.5 tonnes placed in the forepeak, if any attempt was to be made to cross the English Channel.

While in the UK, reports of survey were produced by the appointed MCA surveyors. The last report, dated 14 November 2000, identified several action points that needed to be completed before a safety certificate could be issued. The following two items were listed:

‘Full stability info’ to be submitted by naval architect’

‘Surveyor to approve inclining report to be submitted by naval architect. Provisional stability data to be placed on board for passage to Channel Islands’.

The skipper sailed *Chelaris J* from Appledore Shipyard on 15 November 2000, before completion of the MCA survey. Outstanding items included the production of approved stability information, and final system testing of the navigation lights, fire-fighting or bilge pumping system. *Chelaris J* fished for a short period, before the States of Guernsey Harbours Authority wrote to the owner on 21 November 2000 stating it was unable to grant him permission to operate until the outstanding survey items were completed. This was as a result of a fax from the MCA Principal Surveyor concerned stating:

‘*we do not consider that the vessel is safe to proceed to sea on fishing operations … I understand from the* [naval architect] *consultant concerned that the owner was fully advised regarding the stability of the vessel prior to his departure from Appledore’*.

Marine and General Engineers Ltd, of St Sampsons Harbour, Guernsey, were then employed by the owner. This contractor had been used for stability work before, including conducting inclining tests for passenger vessels, but sub-contracting the stability analysis to professional naval architects. MCA had been involved in the approval of inclining tests and stability booklets. Marine and General Engineers Ltd were only informed that the results from an attempted inclining test in Appledore were not acceptable due to the bad weather encountered and that the stability still needed to be checked. They were not aware of any of the concerns about stability that had arisen. They conducted a roll test and a lightship check during December 2000 and January 2001, the latter concluding the vessel was 5 tonnes heavier than detailed in the 1979 stability booklet. From the results of the roll test, the opinion offered by Marine and General Engineers Ltd, was that the vessel’s stability was satisfactory. They also concluded that the lightship check had confirmed that the vessel still complied with the Bureau Veritas stability information as long as the vessel’s deadweight was reduced by 5 tonnes.

For undetermined reasons, the States of Guernsey Harbours Authority sent a copy of Marine and General Engineer's roll test results to the MCA on 17 January 2001. This prompted the MCA to respond on 25 January 2001 stating:

'We do not accept roll tests for new flag in vessels and such vessels have to have fully approved stability based on an inclining experiment. Appledore Shipbuilders have advised me that they are no longer paying any fees to us for work carried out on this vessel. Consequentially I am not in a position to look at the stability information sent by fax last Wednesday as this is fee earning work. However I can advise yourself, (free of charge!) that the subject matter would not be accepted by myself as your fax of 29th August specifically states that the vessel must have stability data as per the requirements of the 1975 Rules. The only way to achieve this is for the vessel to be properly inclined and all calculations made based on the inclining experiment carried out. We do not accept roll tests for new or flag in vessels and such vessels have to have fully approved stability based on an inclining experiment.

In the fax, stability is based on calculations and a stability book compiled in 1979. My first question is 'how do we know that the vessel is the same now as when the stability book was produced so many years ago?'

A representative from the States of Guernsey Harbours Authority then visited *Chelaris J* and checked-off the items that had still been outstanding on the MCA survey report. This did not include items associated with stability, as Marine and General Ltd were dealing with this aspect. *Chelaris J* was then given verbal permission by the States of Guernsey Harbours Authority to continue fishing. No safety certificate was found during the MAIB's investigation, suggesting that one was never issued. This is believed to simply have been an oversight on the part of the States of Guernsey Harbours Authority.

Between 27 May and 18 July 2003, *Chelaris J* underwent a further small refit. Work included overhauling the main winch, replacing the auxiliary engine, servicing the main engine and replacing the aft escape hatch. Further work was also carried out on 8, 28 and 29 August 2003 on the hydraulics and main engine exhaust.

During the weekend before the accident, the crew replaced a general service pump in the engine room.

1.10 UNDERWATER SURVEYS AND SALVAGE

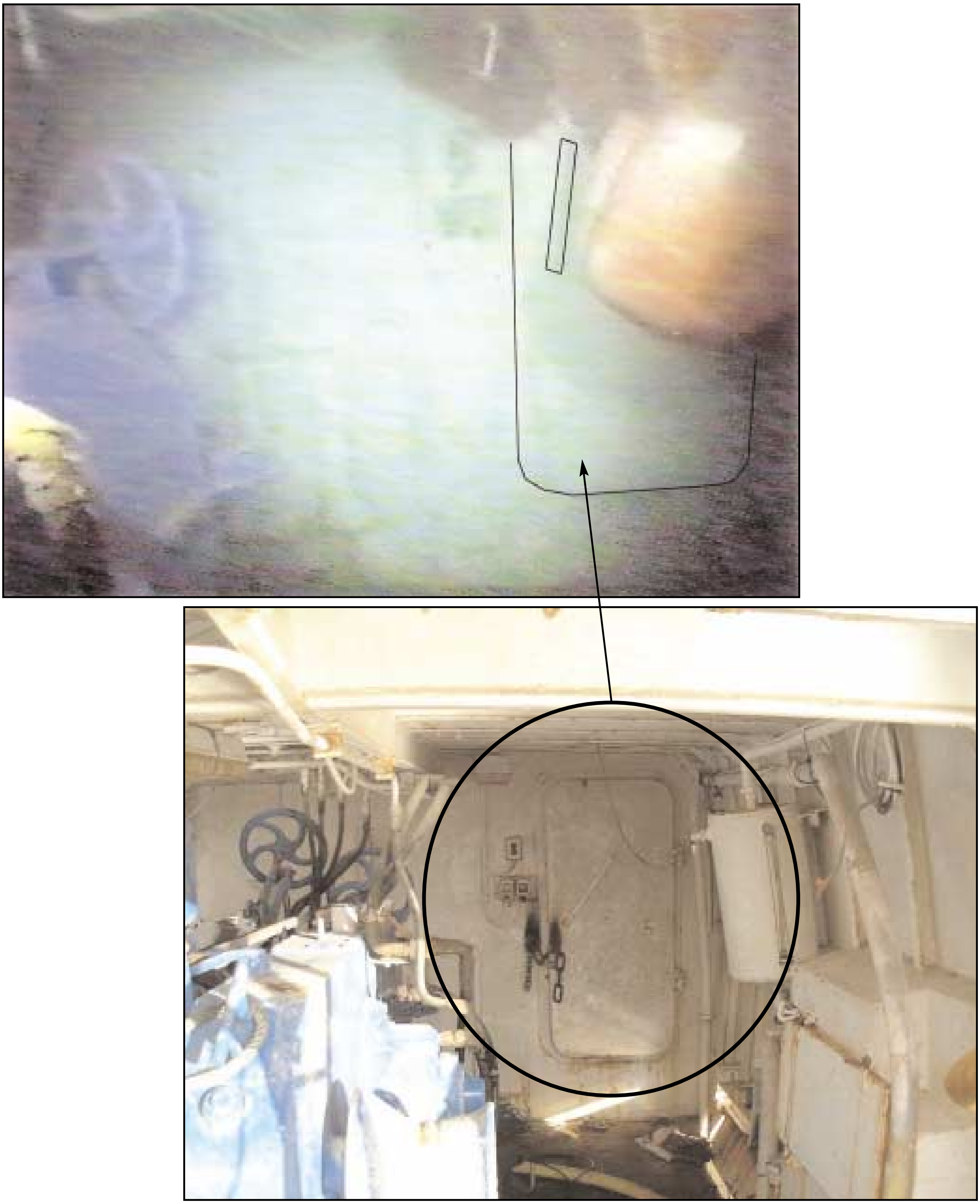
The French navy divers who recovered two of the crew members' bodies also conducted a video survey for the MAIB. They made the following key observations:

- All hatches, scuttles, and doors were open except the starboard passageway door **(see Figure 5)**. The accommodation escape hatch was open.
- The autopilot was found engaged on a course of 57° magnetic **(see Figure 6)**, and the rudder was virtually hard over to starboard.
- The main engine throttle was ahead at normal revolutions for the CPP.
- The CPP pitch indicator was at 10°.
- Two VHF radios were found in the wheelhouse, one of which had DSC.
- The starboard trawl wire was slack, while the port trawl wire was taut, passing through the trawl block up and then across the gantry before disappearing over the stern.
- The trawl winches were not in gear and the brakes appear to have been applied.
- 3 stripe markings were observed on the starboard trawl wire, indicating either 55m or 110m of trawl wire was out.
- The trawl wires and vessel were on a heading of approximately 015° to 020°.
- The net appeared to have slewed round to port, running parallel with the trawl wires.
- The liferaft painter weak link was still attached, with the painter heading off to port under the wheelhouse door.
- The fish hold hatch, and part of the hatch coaming, had suffered implosion damage **(see Figure 7)**.
- There was damage to the starboard side of the transom **(see Figure 8)**.
- The seabed was sand only.

The wreck was revisited on 21 October 2003, using divers and an ROV. Key observations from this visit were:

- The trawl wires were both bar tight.
- Galley equipment, tinned food, bedding and a fire extinguisher from the port side were all found next to the bunk on the starboard side of the accommodation space towards the stern.
- A radiator, which normally hung on the centre of the accommodation forward bulkhead, was found in the lower bunk on the starboard side, still attached to the wall by its flexible piping **(see Figure 9)**.
- The hatch into the steering gear compartment was not in place. It was found lying in the same bunk as the radiator.

Figure 5



Starboard passageway door

Figure 6

Autopilot control

Figure 7

Imploded fish hatch

Figure 8a

Figure 8b

Damage to starboard side of transom

Figure 8c

Starboard side

Figure 8d

Port side (scraping damage from salvage)

Figure 9a

Aft

Figure 9b

Radiator bracket

Radiator position after capsize

It was decided, exceptionally, to raise the wreck of *Chelaris J* because there were serious concerns about her condition, and in particular her stability, given her incomplete survey history at the time of her loss. On 21 November 2003, she was successfully raised and taken to St Peter Port. She was then refloated and taken to St Sampsons harbour for further examination. The following observations were made:

- The forepeak was found full of freshwater.
- Fish (approximately 200kg) were found in the fish hold.
- The ballast in the aft starboard disused fuel tank had corroded together.
- The main sea inlet strainers were found to be clear of debris, and the sea inlet valves moved freely.
- The bilge suction strainer in the steering gear compartment was cut off and was left lying in the bilge.
- The bilge suction valves on the valve manifold were all in the closed position.
- The main suction valve on the bilge pumping system was found closed with no handle **(see Figures 4 and 10)**.
- The rudder was found to be 35° to starboard.
- The fuse in the power supply to the bilge alarm and fire alarm panel had been pulled out, rendering these systems inoperable **(see Figure 11)**.
- The engine room bilge alarm sensor did not work, and the fish hold sensor was blocked with debris.

1.11 FURTHER WRECK EXAMINATION

1.11.1 Preparation

When refloated, *Chelaris J* had very little freeboard aft. This raised concerns about her short tow from St Peter Port to St Sampsons harbour. To improve her stability and freeboard, the aft gantry, complete with its two net drums, was cut off and lifted ashore. The removed structure was later weighed and found to be 5.1 tonnes. Once at the yard in St Sampsons, the vessel was slipped. The damaged transom was then cut out, and a watertight repair made to approximate the original hull shape. All fluids remaining in the vessel were pumped out. Compartments were cleared of sand and wet debris, and all ship's items stored in a container ashore.

1.11.2 Computer media analysis

In an attempt to recover any stored data, two hard drives, 4 zip drives and 9 floppy disks were removed from the vessel and sent to specialists in data recovery. This data might have enabled the vessel's position track at the time of the accident, or previously, to be examined. Unfortunately, the data storage units were found to be in poor condition, due to seawater immersion, and no data could be retrieved.

Figure 10

Main bilge suction valve

Figure 11

Fuse panel supplying bilge and fire alarms

1.11.3 Damage assessment

The damaged transom was closely examined, and plate thickness measurements taken. No evidence of plate thinning could be found. Photographs were then dispatched to an expert for closer examination. The expert concluded that the damage to the transom was consistent with an impact with the seabed when *Chelaris J* sank.

1.11.4 Autopilot examination

The autopilot control settings were recorded. The course set was 057°. The autopilot rudder and yaw settings were at minimum **(see Figure 6)**. The unit was then removed and taken to the manufacturers, to determine the internal gain settings. In conjunction with measurements taken in the steering gear compartment, a value of 0.5° rudder angle per degree of course error was derived. This means, for example, that for a requested course change of 20°, the autopilot would apply 10° of helm or, for a course change of 40°, 20° of helm would be applied, and so on. It was also found that the autopilot had been modified to take a GPS course input rather than the signal from the original magnetic heading sensor coil.

1.11.5 Liferaft examination

The liferaft was closely examined in St Peter Port **(see Figure 12)**. All associated lines were entangled. The painter had been severed and was frayed. The drogue line had also been severed, but the drogue was still entangled with the liferaft. The name 'MFV *Celtic Rose*' was still stencilled on the canopy. The service log was recovered, which detailed that a service had taken place in February 2002. The log also had the name 'MFV *Celtic Rose*' on it. This type of liferaft is required to be inspected/surveyed annually.

Figure 12a

Figure 12b

Liferaft from *Chelaris J*

1.11.6 Bilge pumping and pipework inspection

Figure 4 shows a schematic representation of the bilge pumping system as found on *Chelaris J*. The system was studied closely and valves were dismantled to establish their condition and position. The following was noted:

- The bilge manifold valve, adjacent to the strainer, was found without the valve lid, rendering the valve permanently in the open position.
- The bilge discharge hull side valve was found seized half open.
- The main suction valve **(Figure 10)** was found shut. It had no handle, but could be operated with a spanner.
- The two valves between the sea suction manifold and the bilge suction line were found to operate correctly.
- The only clear bilge suction line to the bilge manifold was to the midship fish room. With the system settings as found, it was very simple to flood the fish room by simply opening the fish room suction valve.
- The system, as found, appeared to have the engine-driven bilge pump running dry.
- No leaks were apparent in the engine room when all sea inlet valves were opened.

1.11.7 Examination of trawl gear

The trawl wires were cut during the salvage process, but at a later date an attempt was made to recover the gear for examination. Unfortunately, it was unsuccessful, because soft sand had covered the gear.

1.11.8 Stability investigation

On 22 December 2003, the MAIB conducted an inclining test to establish the stability characteristics of *Chelaris J*. The calculated results were used to predict the stability performance at the time of her loss. The stability was also calculated for various standard loading conditions, as required for a fishing vessel stability booklet. The stability investigation analysis summary is included in **Annex A**.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 CONTRIBUTORY FACTORS

The MAIB investigation considered several factors which might have contributed to the loss of *Chelaris J*. They are listed below:

- Snagging or coming fast.
- Stability.
- States of Guernsey Fishing Vessel Safety Approval.
- Bilge alarms and bilge pumping.
- Safety training.

2.3 SNAGGING OR COMING FAST

Fishing vessels' gear frequently becomes snagged on the seabed, and it is a hazard which can easily be underestimated. It is clear from the numerous snagging incidents that do occur, that the Banc de la Schôle is an area particularly prone to this problem, due to the large ridges in the sandy seabed and the significant tidal stream of 3 to 4 knots. Fishermen operating on the bank have had to learn to tow in certain directions, to minimise the risk of coming fast, hence towing south on the east side of the bank and north on the west side of the bank. Good local knowledge is essential when fishing on the Banc de la Schôle, requiring fishermen who are unfamiliar with the area to be supervised until they have acquired adequate experience.

Snagging of fishing gear will inevitably occur when trawling. The resulting force on the fishing vessel that is produced will increase the risk of capsizing. It is essential that the operators have an appreciation of the stability or heeling angle limits of their vessel and operate within them. Care must be taken when using past experience as an indicator of safe operation as no two snagging incidents will be the same.

Whenever a fishing vessel snags its nets, then frees them without problem, it is dangerous to simply assume a vessel can survive similar incidents in the future, given the variables involved. MGN 265 (F) **(Annex B)** is a useful reminder of the hazards and safety precautions that should be taken.

2.4 STABILITY

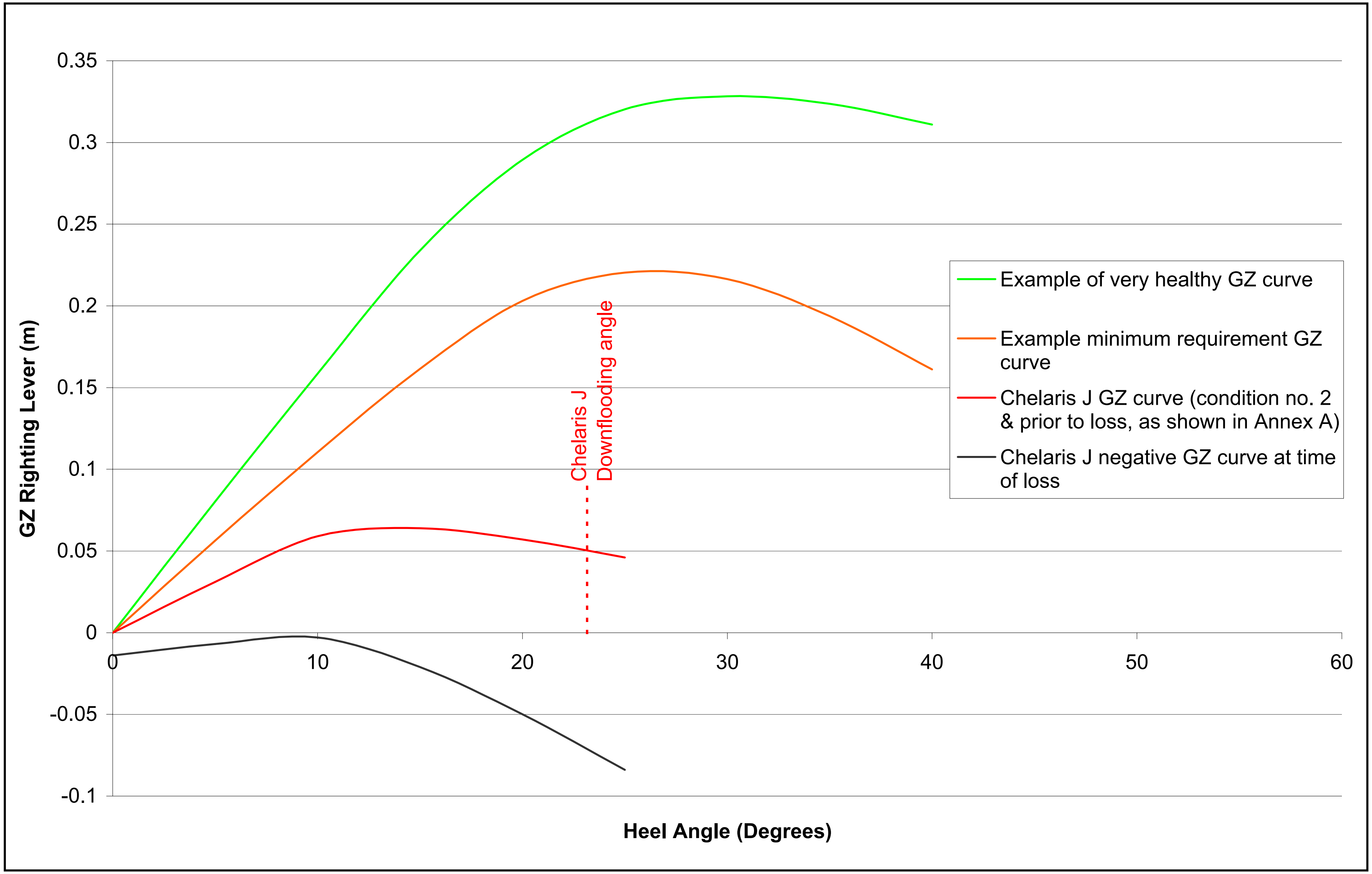
2.4.1 Stability performance

Annex A shows the stability performance of *Chelaris J* for standard conditions which would have been required for full stability approval. The estimated stability at the time of her loss is also presented. The inclining trial conducted at St Sampsons harbour on 23 December 2003, Appendix 1 of **Annex A**, has been used as the basis for these calculations.

Table 1 of **Annex A** shows that *Chelaris J* fails to meet the stability requirements of the Fishing Vessels (Safety Provisions) Rules 1975, SI 1975 330 in any of the standard conditions. Condition 2 (depart port 100 % consumables, 3.5 tonnes of ice and 4 crew) was the best seagoing condition, but it still falls well below the required standard. **Figure 13** includes four fishing vessel GZ curves. One is an example of a curve with a good healthy margin of safety. The next is an example of a GZ curve that just meets the requirements as detailed in Section 6 of **Annex A**. The next curve is for *Chelaris J*, condition 2. It can be seen that the engine room vent immerses at just over 20° of heel, causing downflooding, and effectively cutting off the GZ curve. Condition 2 also happened to be very similar to the derived condition immediately prior to the loss. The last GZ curve is for the loss condition, which was created by splitting the load between the trawl blocks 70:30 to starboard, adding 0.1 tonne of water in the engine room and fish hold bilges, and including 0.1 tonne of water on the aft deck. This last righting lever never becomes positive, indicating *Chelaris J* would have capsized.

The stability analysis has shown that *Chelaris J* had very poor stability, so why did she not capsize before? One factor may be the effect of the bulwarks and shelter aft of the watertight bulkhead. In reality, these would have provided extra righting lever, temporarily improving her stability, but only as long as the vessel was not held over at an angle of heel greater than deck edge immersion for more than a few seconds.

The analysis has shown that the concerns raised by the MCA, and the naval architect employed during the period in the Appledore Shipyard, were valid. The original lightship (i.e. the displacement of the vessel ready for sea, but without fuel, water and other consumables) assumed back in 1979 was 71.02 tonnes, at a VCG of 3.08m above base. From the analysis, it is estimated that the vessel, at the time of her loss, had a lightship of 91.57 tonnes, at a VCG of 3.44m above base. Although there are many factors in determining lightship values, this difference still represents a 29% increase in displacement, which would produce a loss of 0.3m freeboard. The lightship VCG has risen by 11.5% over the same period. Over the years, this would have degraded the stability performance significantly.



Fishing vessel GZ curve comparison

Figure 13

The analysis has further demonstrated that *Chelaris J*'s stability fell well below that required by the 1975 fishing vessel rules. This meant that her ability to resist any destabilising force, and return to upright, was minimal. Had this information been available before she left the Appledore Shipyard, she would not have been permitted to operate as a commercial fishing vessel.

2.4.2 Stability awareness

The stability work carried out to *Chelaris J,* at Appledore in 2000, had raised some initial concerns over her stability but, before any corrective action could take place, she sailed. The precise reason for the skipper/owner deciding to sail will never be known. It is clear, however, that he needed to start operating the vessel, so that he could gain a financial return. In hindsight, the skipper took a considerable risk when he sailed *Chelaris J* from the Appledore Shipyard before her stability had been approved. It could be inferred that he had insufficient knowledge about the potential consequences of his decision. This conclusion is a common theme in many other MAIB investigations, and it is of concern that there appears to be a general lack of awareness of stability issues among fishermen. However, *Chelaris J* managed to fish successfully for over 2½ years during the skipper's ownership. In many ways, his skill and experience, and that of his crew, prevented an accident such as this from happening during that time. Stability standards exist to ensure fishing vessels are safe through life if operated and maintained correctly. Not satisfying them reduces the margin of safety, leading to skippers unknowingly operating their vessels right at the limit of their vessel's capability, thus putting them at far greater risk.

During rough weather, water can collect on a fishing vessel's deck momentarily, before the freeing ports allow it to flood out. Water can also collect in a fish pound. The stability analysis has shown that only 2 tonnes of water were required on *Chelaris J*'s deck to render her unstable.

The seawater inlets opened when tested. This indicated that no leaks were present. However, some flooding might have occurred before the loss itself. This might have simply been existing bilge water and melt water from ice. The bilge alarm would have alerted the crew to significant flooding, had it been working. Any flood water in the engine room or fish hold would have possibly raised the centre of gravity by the free surface that it produced, and further degraded the vessel's stability performance.

The need to improve the understanding of stability, and associated hazards, among skippers and crews within the UK fishing fleet, is an issue which has arisen following several fishing vessel accidents. Some flag administrations have developed courses using practical, very visual and hands-on models, which demonstrate to fishermen the key elements of stability applicable to their vessel. A recommendation is made to the MCA and to the Seafish Industry Authority, to develop such a course for UK fishermen as quickly as possible.

2.4.3 Roll test and lightship check

Once notified by the States of Guernsey Harbours Authority that *Chelaris J* was not permitted to fish, the skipper employed a local company, Marine and General Engineers Ltd, to look at the outstanding stability issue. This approach had been agreed with the States of Guernsey Harbours Authority. A roll test and lightship survey were used to assess the stability of the vessel.

From the resulting analysis, Marine and General Engineers Ltd concluded that *Chelaris J*'s stability was satisfactory, and that she would still comply with BV's stability information if her deadweight was reduced by 5 tonnes. This was because the lightship check had indicated a 5 tonnes increase of displacement. The increase was less than had been suggested by the naval architect in the UK, when the vessel was at Appledore, who had calculated an increase of 16 tonnes. This is also less than was determined by MAIB's analysis, which indicated an increase of displacement of 20 tonnes. The differences between these figures can be attributed to numerous factors. One is the variety of definitions used in defining what items are to be included when calculating the lightship of a fishing vessel. Another is whether the draughts have been converted to displacement correctly using the stability information provided. However, even a 5 tonnes variance should have resulted in some cause for concern over the validity of the stability information provided with the vessel. Given the stability information showed a lightship weight of 71 tonnes, 5 tonnes represents a 7% increase in lightship. More importantly, the lightship check only highlighted the apparent increase in weight, not the position of the vertical centre of gravity about which the additional weight acts. Only an inclining test can do this. It is generally recognised that a 2% increase in lightship should necessitate an inclining test to be conducted, as there will be sufficient doubt over the position of the vertical centre of gravity, which is critical to the stability of a vessel. An inclining test, therefore, should have been carried out to establish the position of the vertical centre of gravity of the vessel, as well as the displacement.

Annex D provides some background on the roll test and its application in this case. The roll test is an internationally accepted [IMO Resolution A.749(18) refers] means of approximately determining stability when it is not practical to incline a vessel, but great care is required in its application. **Annex D** shows that the application of the roll test to *Chelaris J* was flawed because it failed 3 out of 4 criteria stipulated by the MCA for conducting a roll test. These included *Chelaris J* falling outside the breadth to depth ratio limit, no notice being taken of her full width superstructure, and averaging the roll period from only 2 roll oscillations. These criteria have been derived from the experience of the MCA in roll testing some of the UK fishing fleet. Additionally, the MCA refuses to accept roll testing for flag-in vessels due to their previously unknown stability history.

Another factor in this incident was that a mistake (detailed in **Annex D**) was made in carrying out the calculations required for the roll test. Thus, the problem caused by an inappropriate test was exacerbated further.

2.5 STATES OF GUERNSEY FISHING VESSEL SAFETY APPROVAL

The States of Guernsey Harbour Authority does not conduct its own surveys on fishing vessels. Instead, it delegates this task to authorised bodies. The MCA was used as the authorised survey body before *Chelaris J* sailed from the UK. In Guernsey, the owner chose to employ Marine and General Engineers Ltd to carry out work on the stability of his vessel. This was acceptable to the flag state, as Marine and General Engineers Ltd had conducted satisfactory survey work for the States of Guernsey Harbour Authority before.

Chelaris J left the UK with outstanding items from her last survey, which would have been known to the owner/skipper. These included the approval, by the MCA, of the inclining report and production of full stability information in accordance with regulations.

Marine and General Engineers Ltd were unaware of any particular stability concerns with *Chelaris J,* apart from the fact that the results of a previous attempt to incline her had been unacceptable due to the weather conditions at the time. The States of Guernsey Harbour Authority did not appreciate there may have been a serious problem with the vessel's stability given the brief information provided to them by the MCA, and their lack of expertise in the matter. Under the Guernsey safety approval process, the flag state is completely reliant on the expertise of the appointed surveyor, as there is no secondary check or audit made of the stability calculations.

A roll test and lightship check were conducted by Marine and General Engineers Ltd to assess the stability. Even though there was an apparent 5 tonne increase in lightship, the opinion was offered in a letter to the States of Guernsey Harbour Authority that the stability was satisfactory and that the vessel still complied with the BV stability booklet. The owner and the States of Guernsey Harbour Authority both believed, therefore, that the vessel was safe to operate and she was given verbal permission to fish. The MCA was sent a copy of the letter from Marine and General Engineers Ltd. This prompted the MCA Principal Fishing Vessel Surveyor to reply, expressing some concern over the use of the roll test to establish the ship's stability. Although this reply should have raised some concern, there was no further follow up action taken by either the States of Guernsey Harbour Authority or the MCA.

In this case, the flag state has been completely dependent on the flawed opinion of a single surveyor as proof of a vessel having adequate stability. Both the owner/skipper of *Chelaris J,* and the States of Guernsey Harbour Authority, believed that the vessel was safe to fish, even though the work conducted in the UK had indicated a problem. No internal check of the stability calculations, or the approach taken, was carried out by Marine and General Engineers Ltd. As they were unable to do so, no check was done by the States of Guernsey Harbour Authority either. This left the opportunity for any mistake to go undetected.

Basing the stability on the existing 1979 stability booklet was unsound, since there was evidence to suggest *Chelaris J* had changed considerably since 1979. Also, the stability booklet itself fell well short of meeting the requirements of the 1975 rules, as described in Schedule 3 of the legislation. The safety approval process, followed by the flag state for *Chelaris J,* allowed a single opinion to form the basis for the approval of the vessel's stability, even though concerns had been raised previously. It also allowed the vessel to fish for 2½ years without a safety certificate.

Given this tragic accident, it is clear that the stability problem, and associated issues of *Chelaris J,* had not been fully appreciated by the those involved in Guernsey. Safeguards should be introduced by the States of Guernsey Harbour Authority to ensure surveys are conducted correctly, and procedures are in place to detect and eliminate errors during the survey process.

Under the Fishing Vessels (Safety Provisions) Rules 1975, a periodic inspection by the certifying authority, mid-way through the 4 year certification cycle, is required. This was not carried out for *Chelaris J*. Under the 1975 regulations, fishing vessel skippers were required to request this inspection to keep their safety certificate valid. This did not always happen, and with the current UK fishing codes of safe working practice, an inspection is now enforced not less than 24 months, and no more than 36 months, after the initial survey during a 5 year certification cycle. Annual self-certification, by the owner, is also required to maintain validity of the fishing vessel safety certificate.

To assist in the process of improving safety approval for fishing vessels, it is recommended that the Guernsey Board of Administration introduces the codes of safe working practice and guidance for all Guernsey-registered fishing vessels, as currently applied in the UK. It should also ensure they are fully implemented. It is important that fishing federations fully support authorities with their implementation of safety procedures, such as this, to ensure they are effective.

2.6 BILGE ALARMS AND BILGE PUMPING

2.6.1 Bilge alarms

Chelaris J was fitted with a bilge alarm that was certified by the installer as operational before she left Appledore in November 2000. However, as far as can be determined, the bilge alarm was not operational at the time of the accident. The common fuse for the power supply to the bilge alarm and the fire alarm had been removed. The reason for this is unknown, but it is possible that a fault with either system might have led to the power supply being disconnected to prevent false alarms sounding. The fish hold sensor was blocked with debris, which might have been the problem, but this should have been a relatively simple job to rectify. Disconnecting a safety system, such as the bilge alarm or fire alarm, can put crews' lives at greater risk. Having the two systems on one fuse was short-sighted, considering the two systems were independent of each other and provided warnings of different hazards. The bilge system was also protected by an internal fuse and did not require additional protection.

Alarms are only of use to the operator when it is known that the system is working correctly. In the case of bilge alarms, regular testing of the system, before going to sea, informs the operator that it is functioning correctly. There was no regular testing of the bilge alarm system on board *Chelaris J*. The engine room sensor was impossible to test anyway, since it was inaccessibly positioned at the aft end of the engine room.

The bilge alarm sensors were also of a type difficult to test. They consisted of sealed units with a hole in the bottom. Although this prevents damage to the sensors, it also means the hole can become easily blocked. Additionally, the only way to test these sensors is to place them in a container of water, which is not always a practical option.

The reliability and required maintenance of bilge alarms has been a concern in the past, but much improved systems are now available[1]. Considering the likely outcome of a flooding incident, a good bilge alarm, that can be regularly and easily tested, is a sound investment for a fishing vessel owner.

2.6.2 Bilge pumping

The fixed bilge pumping system on *Chelaris J* appeared to be the original system fitted during construction in 1979. The skipper departed from Appledore in November 2000 before a test on the bilge system was carried out by the MCA, so its status was unknown. In principle, the engine-driven bilge pump could be used to suck from any compartment, simply by opening the corresponding valve sited at the valve manifold in the engine room. However, the system had deteriorated over the years, and had lacked proper maintenance.

The diagrammatic sketch **(Figure 4)** shows the bilge pumping arrangement as it was found, and it would appear that the system was completely ineffective at pumping the bilge. Only one of the suctions from the fish hold was found to be clear when tested. The strainer on the steering gear compartment had been cut off, and was lying near by. During testing, some of the pipework was found to be blocked, and this might have been indicative of the condition of other parts of the system.

[1] The Development of a Reliable Bilge Monitor and the Loss of UK Fishing Vessels rough Flooding, by David Cook & Bill West, December 2001, Banff & Buchan College of Further Education

The main suction valve, essential for pumping water over the side, had no handle and was shut. The manifold valve had no closure mechanism inside, and with the two valves linked to the main sea inlet open, it was very easy to fill the bilge with seawater by simply opening a valve on the valve manifold. This would account for the two flooding incidents detailed in section 1.5.5. The reason for having seawater inlets to the bilge pump, was to ensure adequate seawater lubrication and cooling of the pump. However, with the system as found, the pump was running dry, wearing it out, and dramatically reducing its effectiveness.

The maintenance of the fixed bilge pumping system might have been a low priority task for the skipper, possibly because he relied on the portable electric submersible pump he had on board. This pump had been used on occasions, and may have been seen as the main defence against flooding. It should have only been used as a back-up for when the main engine-driven bilge pump failed. Effectively only having a single bilge pumping system greatly reduces the chance of surviving a flooding incident.

2.6.3 Defence against flooding

Bilge alarms are an essential tool, which provide early warning of flooding. Having an effective, reliable bilge pumping system is also vital if any serious flooding is to be prevented. MGN 165 (F) was used to try and address this issue in July 2001 **(Annex C)**. All too frequently, fishing vessels are lost due to flooding, often because the ingress of water has been discovered too late, or because bilge pumps have had insufficient capacity. This inevitably leads to the conclusion that the general awareness of the risks of flooding is still poor.

2.7 VESSEL LOSS

Chelaris J left Cherbourg to fish the grounds of the Banc de la Schôle, with four crew. She had completed one trawl, and had stowed the catch in the fish hold. The vessel had nearly completed her second trawl when she was lost and her EPIRB started transmitting. At that time, the wind was east-north-easterly, force 6, and the tide was flooding at approximately 3.5 knots in a north-easterly direction. The skipper, Martyn Lane, and crewman Romain Ouitre, were subsequently found in the accommodation space of the vessel on the seabed. Therefore, either Pierre Duflot or Yvan Regnier was on watch. The reasons why the vessel capsized are discussed below:

2.7.1 Snagging of trawl gear

The MAIB analysis of *Chelaris J*'s stability after she had been raised showed that it would have taken very little to cause her to capsize, either through internal flooding, wave action, or because her trawl gear became snagged.

The lack of a distress call, and the discovery of trapped personnel in the accommodation space, confirmed that *Chelaris J* was lost suddenly by capsizing. The final resting place of the radiator, and other heavy items on the starboard side of the accommodation, indicated she capsized to starboard.

Chelaris J's heading, when she was lost, can only be assessed as somewhere between 020° and 060°. These were the flood tide heading and autopilot setting respectively. There was no evidence of hauling back on the fishing gear, as the skipper, who normally operated the winches, appears to have been in bed, and the winch controls were set for towing. To cause *Chelaris J* to capsize, a trawl door, or the net itself, might have dug hard into a large ridge of sand on the seabed. This might have been as a result of the vessel's relatively high speed (4 to 5 knots over the ground), because of the strong tide and/or possibly because of the length of trawl wire deployed, 110m in 25m of water depth. The markings on the trawl wire could have indicated 110m or 55m of wire out. The latter is thought unlikely, since 73m is the normal minimum used, and since estimates of the length of wire deployed, made by French navy divers, were much greater than this. The snag might have caused a greater loading at the starboard trawl block. This would have heeled the vessel to starboard and raised *Chelaris J*'s centre of gravity (the suspension point of the trawl blocks was 2.1m above the deck). The stability analysis has shown that very little external force would have been needed for *Chelaris J* to become unstable, and thus fail to right herself after an involuntary heel.

2.7.2 Loss scenarios

Two likely scenarios are suggested for the snag occurring:

Firstly, *Chelaris J* was not in a position expected by some local fishermen. The wreck was found on the east side of the Banc de la Schôle. As detailed in section 1.6, fishing vessels in the area of the bank trawl south down the east side of the bank, and north, up the west side of it. The wreck of *Chelaris J* was found apparently heading in a northerly direction, on the east side of the bank, contrary to normal practice. There is a possibility that the crewman on watch steered off the intended course and, due to his lack of local knowledge, he was unaware of the greater risk of fishing on the shallow part of the bank, especially with so much trawl wire out.

Secondly, a turn to starboard might have been initiated to head round and back south along the east side of the Banc de la Schôle. On the turn, the trawl doors might have fallen over because of the relatively low flow speed over them with the tide astern. The starboard door might have then dug hard into a large sand ridge, causing an asymmetric load on the trawl blocks.

2.7.3 Events following capsize

To cause *Chelaris J* to sink after capsizing, flooding must have occurred through portholes, open hatches, vents and scuppers. This would initially have occurred at 23° of heel, through the starboard engine room vent. After that, flooding would have occurred through the starboard portholes and then, eventually, the wheelhouse door and fish landing hatch, causing her to sink stern-first. The vessel was probably near vertical in her descent to the bottom, assisted by the buoyancy in the fish hold forward, until the fish hatch imploded **(Figure 7)**. Once the stern hit the seabed, her bow dropped down to the seabed. During the capsize and sinking, the port trawl wire became entangled around the stern gantry, and was pulled taut as the bow came down to rest on the seabed. Although normally closed, the accommodation escape hatch was found open. This might have been as a result of somebody trying to escape from the accommodation space.

2.8 OTHER FACTORS CONSIDERED

2.8.1 Wave action

Wave action alone might have contributed to the capsize of *Chelaris J*, as it was rough at the time of her loss. Rough seas would also have been responsible for swamping the deck, as discussed in section 2.4.2. However, during the 2½ years in which the Chelaris Fishing Company had operated her, she had met worse conditions, yet had not capsized as a result.

2.8.2 Cargo shift

Cargo shifting within the fish hold is not thought to have played a major part in this accident, mainly because of the small amount of catch and the adequate stowage arrangements.

2.8.3 Rudder

The rudder was found nearly hard over to starboard. There are three possibilities for this:

- The port trawl wire became snagged, steering the vessel's head to port, causing the autopilot to apply starboard helm in an attempt to bring the vessel back on track.
- The crew manually adjusted the autopilot to starboard, for a significant alteration of course. To produce a hard over response from the autopilot, this would have required at least a 70° course change to starboard, see section 1.11.4.
- The autopilot continued to try to steer a course as the vessel sank, until power was lost.

There is insufficient evidence to establish which of the above scenarios occurred.

2.9 STERN DAMAGE

The damage to the stern is substantial **(see Figure 8).** The welded joint on the underside of the hull is also split in way of the damaged area. The initial underwater survey indicated some corrosion in the area of the damage, even though she had only been on the seabed two days. After salvage, an internal inspection showed evidence of corrosion in the vicinity of the solid ballast fitted to the aft starboard disused fuel tank. The internal structure of the transom only consisted of 30mm angle bar and beam knees at top and bottom. However, thickness testing of the transom, as a whole, highlighted no areas of corrosion or reduced plating thickness.

Collision was considered as a possible cause of the damage, but no ships or submarines were reported to be in the area at the time of her loss. Additionally, further metal to metal contact damage would have been evident had a collision occurred, and this was not found **(see Figures 8c and 8d)**.

Photographs of the damage and associated welding were sent to an expert for closer examination. The expert's opinion concurred with that of the MAIB, in that the damage was consistent with a grounding impact on the seabed, with the transom starboard corner hitting the seabed first.

2.10 OTHER ISSUES

2.10.1 Liferaft

The Fishing Vessels (Safety Provisions) Rules 1975 require that a liferaft should be carried <u>and</u> correctly installed. To ensure there is every chance of a successful deployment of a liferaft, it must be positioned to avoid becoming entangled if the vessel sinks before it can be released manually. *Chelaris J* had her liferaft positioned in a clear area behind the wheelhouse, yet it still became entangled on deployment, and did not surface until the day after the accident. It is difficult to see how the liferaft on *Chelaris J* could have been better positioned.

A minor point worth noting from this accident is the ship's name stencilled on the canopy of the liferaft. To provide rescuers the maximum chance of finding survivors, and determining what has happened, it is important that the correct name is recorded on the liferaft. In this case, the vessel's name had been changed from *Simbad* to *Celtic Rose*, but no further effort was made to update the name to *Chelaris J*.

2.10.2 Safety training

No formal safety training of crews is mandated by the flag state for Guernsey fishing vessels. In the UK, it has become more widely recognised that training is an excellent way to improve fishermen's safety awareness, and a number of training courses are provided by the Seafish Industry Authority. The States of Guernsey Harbour Authority should consider introducing mandatory safety training for Guernsey fishermen, based on these courses. A recommendation has been made to this effect to the States of Guernsey Board of Administration.

Of particular note, is the one day safety awareness course for experienced fishermen that will become mandatory in the UK from 1 November 2004. Guernsey fishermen would benefit from attending it. The course will hopefully go some way towards raising awareness of:

- The risk of flooding.
- Stability, and the limitations it imposes on fishing vessels.
- The hazards of snagging while trawling.

SECTION 3 - CONCLUSIONS

The following are the safety issues which have been identified as a result of the investigation. They are not listed in any order of priority.

Snagging:

1. It is common for fishing vessel gear to become snagged when trawling on the Banc de la Schôle, due to the large ridges in the sandy seabed, and the significant tidal currents of 3 to 4 knots. (2.3)

2. Good local knowledge is essential when fishing on the Banc de la Schôle, requiring fishermen who are unfamiliar with the area to be supervised until they have acquired adequate experience. (2.3)

Survey and Safety Approval:

3. *Chelaris J*'s stability was poor, and fell well below that required by the 1975 fishing vessel Rules. Her ability to resist any destabilising force and return to upright was minimal. (2.4)

4. The safety approval process, as operated by the flag state for *Chelaris J*, allowed her to operate for 2½ years without a safety certificate. (2.5)

5. No periodical survey between certification surveys, as required by the 1975 fishing vessel Rules, had been conducted for *Chelaris J*. (2.5)

Maintenance:

6. A lack of awareness of the risks of flooding to the vessel was demonstrated by the non-operational bilge alarm, and the poor state of the fixed bilge pumping system. (2.6)

Training:

7. There appears to be a general lack of awareness of stability issues among fishermen. (2.4)

8. There are no mandatory training requirements for fishermen on Guernsey-registered fishing vessels. (2.10)

Other:

9. The liferaft did not surface until the day after the accident. (2.10)

SECTION 4 - RECOMMENDATIONS

The **States of Guernsey Board of Administration** is recommended to:

2004/183 Introduce the codes of safe working practice and guidance for all Guernsey-registered fishing vessels as currently applied in the UK, and to ensure they are fully implemented.

2004/184 Establish an effective regime for the survey of Guernsey fishing vessels, to ensure full compliance and certification in accordance with fishing rules.

2004/185 Introduce mandatory safety training for Guernsey fishermen based on that supplied in the UK by the Seafish Industry Authority.

The **Maritime and Coastguard Agency** and the **Seafish Industry Authority** are jointly recommended to:

2004/186
2004/187 Develop a mandatory course, which must include good visual and practical elements, to raise practical stability awareness among fishermen.

Marine Accident Investigation Branch
July 2004

ANNEX A

Stability Investigation of *Chelaris J*

Report on Stability Investigation - FV ‘Chelaris J’

1. Introduction

The objective of this report is to assess the stability of the fishing vessel ‘Chelaris J’ in the accident condition and in the set of conditions which would have been required for the compilation of a stability booklet for submission to the Maritime and Coastguard Agency (MCA).

Sections 2 and 3 of the report describes the generation of the computer model for the ‘Chelaris J’ and the calculation of her lightship displacement and centre of gravity utilising this model and the results of the inclining trial. Section 4 details the principal dimensions of the vessel and section 5 describes the background data required for the analysis. Section 6 details the stability and freeboard requirements with which any fishing vessel over 12 metres in length must comply. Section 7 describes the seven loading conditions which would usually have been included in a stability booklet and summarises the data computed for these conditions. Section 8 describes the accident loading condition immediately prior to the loss, proposes the additional factors which may have made the vessel capsize and assesses the resultant data. Section 9 comprises the report’s conclusion.

The information providing the analysis data is included in the Appendices at the back of the report.

2. Hull definition

Half breadth and height dimensions for thirty-five sections were taken from the hull definition produced by Bureau Veritas for the original stability booklet. Additional sections were inserted to improve the definition at the bow and at longitudinal discontinuities representing the aft ends of the watertight shelter and the keel. Appendix 4 is comprised of section, and isometric views of the hull form.

Longitudinal dimensions were taken about an Aft Perpendicular (AP) at the intersection of the design waterline with the transom centreline. The Forward Perpendicular (FP) was taken to be at the intersection of the design waterline with the stem on the centreline. The resultant length between perpendiculars (LBP) is 14.68 metres. The origin for the longitudinal dimensions, the LBP dimension and the location of both perpendiculars have all been taken from the original stability book produced by Bureau Veritas.

Vertical dimensions have been taken about a Base Line parallel with the design waterline and 0.03 metres below the lowest point of the keel as defined in the Bureau Veritas data. Again, the Base Line is the same as that used for the original stability book.

3. Inclining trial

An inclining trial was conducted to establish the vessel’s displacement and the location of its centre of gravity. Appendix 1 is comprised of a report of the trial conditions and results. The mean GM transverse value computed was 0.416 metres with a difference of 9 millimetres between the GM values obtained from the two pendulums.

Tables of items to come off and to go on to obtain the lightship condition are also included in the appendix along with a light ship summary.

4. Principal dimensions

The vessel's principal dimensions are as follows:

Length Overall (LOA):	16.80 metres
Length Between Perpendiculars (LBP):	14.68 metres
Beam moulded (at deck level):	5.59 metres
Depth (base line to deck edge at midships):	3.62 metres
Lightship displacement:	91.976 tonnes
Draft midships at lightship displacement:	2.848 metres
Keel rake:	0.983 metres in LBP

5. Hydrostatic, KN and Tank capacity data

[Hydrostatic, KN and tank capacity data was produced during the analysis but has been omitted from this Annex.]

6. Criteria used for assessment of stability and freeboards

The Fishing Vessel (Safety Provisions) Rules 1975 require that any fishing vessel of 12 metres in length or greater must comply with the following stability requirements:

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

- (a) 0.055 metre.radians up to an angle of 30 degrees;
- (b) 0.09 metre.radians up to an angle of 40 degrees or such lesser angle of heel at which the lower edges of any opening in the hull, superstructure, deckhouses, or companionways being openings which cannot be closed weather tight are immersed;
- (c) 0.030 metre.radians between the angles of heel of 30 degrees and 40 degrees or such lesser angle as defined in (b) above;

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

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

IV) In the upright position the transverse metacentric height (GM) shall not be less than 350 millimetres;

The Rules also specify that such vessels shall be designed and operated so as to maintain adequate freeboards in all foreseeable loading conditions. Merchant Shipping Notice No. M975 expands on the definition of adequate freeboard and provides tabulated values and formulae for the calculation of minimum freeboards under the Rules. These minima apply to the 'Chelaris J' as follows:

Forward freeboard ($H_{Bulwark}$) = $1 + L/16$ = 1.894 metres
Forward freeboard (H_{Deck}) = $0.8 + 7L/240$ = 1.217 metres
Aft freeboard ($H_{DeckAft}$) = $0.3 + L/30$ = 0.777 metres

Where L = 96% of overall length on waterline at 85% of least depth = 14.31 metres

Note that where a watertight forecastle extends more than 0.07 x L aft of the FP, as in this instance, both forward freeboards may be taken about the top of the shelterdeck at the side. The greater of the two values is used for the analysis.

7. *Assessment of loading conditions for stability booklet*

A fishing vessel is judged to comply with the requirements only if it exceeds the stability and freeboard criteria stated in Paragraph 6 in 'all foreseeable operating conditions'. It is usual practice, therefore, for any stability submission to the MCA relating to a fishing vessel to include an assessment of the stability and freeboard in a set of loading conditions representative of any voyage profile.

The following conditions form such a voyage profile and were created on the computer for the purposes of this report:

1. Lightship
2. Depart Port, 100% Consumables, 3.5 tonnes ice, 4 crew
3. Arrival Grounds, 90% Consumables, 3.3 tonnes ice, 4 crew
4. Depart Grounds, 50% Con's, 7.25t catch (5.75t F/R, 1.5t deck), 2t ice
5. Arrive Port, 10% Consumables, 7.25t catch (5.75t in fishroom, 1.5t on deck), 1.25t ice, 4 crew
6. Depart Grounds, 50% Consumables, 1.45t catch (20% max) on deck, 1t ice, 4 crew
7. Arrive Port, 10% Consumables, 1.45t catch (20% max) on deck, 0.75t ice, 4 crew

Sample trim and stability data computed for these loading conditions is to be found in Appendix 2. Note that transverse centres of gravity have not been included for the deadweight items in the deadweight tables for these conditions as it would be normal practice not to include these in a stability booklet for submission to the MCA. Note also that maximum values have been used for the tank content's VCG and free surface moment data regardless of the fluid level. Again, this is normal practice in a stability booklet as it simplifies manual calculation and produces results which will err on the safe side.

Table 1 below summarises the results and compares them with the requirements detailed in Section 6 above.

Table 1 – Stability and freeboard requirements and computed values

		Condition No.						
Requirement	***Min.***	***1***	***2***	***3***	***4***	***5***	***6***	***7***
Area to 30° heel (m.r.)	**0.055**	0.022	0.018	0.015	0.007	0.003	0.000	0.000
Area to 40° heel (m.r.)	**0.090**	0.022	0.018	0.015	0.007	0.003	0.000	0.000
Area 30°-40° heel (m.r.)	**0.030**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Min. GZ 30°-90° heel (m.)	**0.200**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Angle of GZ max. (degrees)	**25**	17.89	14.14	12.75	10.79	10.65	10.16	9.26
Min. GM fluid (m.)	**0.350**	0.233	0.419	0.300	0.213	0.123	0.096	0.002
Freeboard forward (m.)	**1.894**	3.573	2.761	3.012	2.961	3.077	3.257	3.260
Freeboard aft (m.)	**0.777**	0.481	0.446	0.414	0.434	0.487	0.366	0.328

Red underlined values fail the requirements

The tabulated data indicates that the vessel fails to comply with the stability or aft freeboard requirements by a wide margin in all conditions and has very little residual stability, again, in all conditions. Indeed, in conditions Nos. 6 and 7 with a reduced fuel load and with a catch on deck but none stowed in the fishroom, a negligible further influence would be required to capsize the vessel. A more positive influence, albeit small, would be required to have this effect in any condition similar to Nos. 1 to 5.

The stability of a vessel will be dramatically reduced when it heels to the point where significant quantities of seawater can flood through flooding points such as open doors or vents into the spaces that are assumed to be initially watertight. If a vessel is held over at such an angle for a period of time, there is the liklihood that such flooding will reduce the stability to the point where capsize will occur. The regulations therefore require that the righting lever, and thus the stability, is assumed to reduce to zero at the heel angle when the first flooding point is immersed.

On the ‘Chelaris J’, flooding could occur through the apertures noted in table 2 below; the heel angle at which seawater would flood into the vessel through these apertures and the heel angle at which the vessel would capsize with all the flooding points closed watertight are also noted for the conditions listed above.

Table 2 – Heel angles of flooding point immersion and capsize

	Condition Nos.						
	1	***2***	***3***	***4***	***5***	***6***	***7***
Flooding points	***Heel angles***						
Port engine room vent	46.6°	33.8°	36.9°	36.5°	39.4°	39.5°	42.1°
Starboard engine room vent	28.7°	21.6°	23.2°	23.1°	24.9°	24.3°	26.1°
Engine room vent in aft wheelhouse face	75.5°	66.8°	69.0°	68.7°	70.6°	70.8°	72.6°
Wheelhouse door	>90°	77.4°	80.6°	80.2°	82.9°	83.3°	>90°
Open wheelhouse window*	82.6°	73.3°	75.6°	75.4°	77.4°	77.6°	79.5°
Capsize angle – all flooding points closed	*33.1°*	*63.0°*	*31.6°*	*21.5°*	*18.8°*	*17.1°*	*14°*

Red underlined values are less than the capsize angle
*Aft wheelhouse window open at the time of the accident

It will be seen from the table that the three flooding points located in the wheelhouse structure would never be immersed until after the vessel had capsized. It may be assumed, therefore, that it is unlikely that water would have flooded through these points in sufficient volume to put the vessel in jeopardy. However, the data also indicates that the Port engine room vent would have been immersed in one condition and the Starboard vent would have been immersed in two operational conditions before the vessel capsized. In other words, if the vessel capsized to Starboard, for instance, in a condition similar to ‘Depart Port’ or ‘Arrival Grounds’, water would have been flooding into the engine room in large quantities before capsize occurred and would have acted to further reduce the stability in the process.

8. The accident condition

The loading condition of the ‘Chelaris J’ immediately prior to the accident was established from the refloated vessel. The detailed deadweight makeup and the resultant trim and stability data for the vessel in this condition are to be found in Appendix 3. Note that transverse centres of gravity have been included in the deadweight tables for the accident condition so as to model more accurately the possible causes of the loss. Note also, that actual vertical centres of gravity and free surface moments have been computed for the tank contents (as opposed to maximum values used for the conditions noted in Paragraph 7), again, so as to model the possible causes more accurately.

The stability analysis indicates that the vessel already had very low reserves of stability before the accident occurred. Nevertheless, the reserve was sufficient to suggest that an additional factor or combination of factors was necessary for the accident to have taken place, given that the loading condition indicates a vessel operating in a stable regime, albeit marginal.

Possible factors would include:

1. An uneven load on the trawl blocks caused, for example, by the vessel's movement in the seaway and/or a trawl door catching on the sea bed and/or the vessel turning
2. Seawater collecting in significant quantities on the open aft deck
3. Wave action
4. Bilge water in one or more major compartments

To model the effect of these factors in the context of the accident, Appendix 3 also includes trim and stability data analysing the stability of the vessel with the following loads superimposed on the accident loading condition:

- Load on trawl blocks split 70% to Port, 30% to Stbd
- 0.10 tonnes seawater on aft deck
- 0.10 tonnes bilge water in fishroom
- 0.10 tonnes bilge water in engine room

The stability data computed for this condition indicates that, given the vessel's very low level of stability, these factors alone would have been sufficient to move the vessel from a stable to an unstable regime, thereby initiating the capsize and loss.

9. *Conclusion*

It is probable that it took a combination of the factors listed in Paragraph 8 to initiate the accident. The vessel was working in a seaway when the accident occurred. It is known that a Force 6 wind was blowing from East North East against a strong tide at the time. Quantities of seawater, albeit perhaps small, will therefore have been coming through the freeing ports and/or over the bulwarks and collecting on the open aft deck. The free surface effect of even a small quantity of water in such an area would be very considerable indeed. The vessel will have been moving in response to the considerable seas that a strong wind against a fast running tide would have created. Even in their ordinary operation, the loads on the Port and Starboard trawl blocks will have been varying relative to one another as the vessel rolled, pitched and heaved in the seaway. Such varying loads on the trawl blocks will have been exacerbated by the known tendency for trawl doors to catch on the seabed in the area that the loss occurred, particularly if the vessel was turning. Quantities of bilge water will also have been present in the hull, particularly in the engine room and fish room. All four of these factors will therefore have been working to a variable extent to deplete the vessel's already very limited stability reserve.

It may be stated, therefore, that a very low level of stability was responsible for the accident occurring in the first place, but that it probably took a combination of the additional factors described in Paragraph 8 to make the vessel capsize.

Appendix 1

Inclining Trial Report

Inclining Experiment

Date:	Monday 22 December 2003
Time:	1630-1800
Place:	St Sampson Harbour, Guernsey
Weather:	Light Northerly Breeze
Mooring:	Bow line to quay side, Stern line centreline to quay side What breeze there was blew vessel off quay
Those present:	Nicholas Hance MAIB 2 Marine & General Staff Cliff Brand MAIB

Freeboards measured:

Waterline forward:	3.95	metres below upper deck measured down stem slope			
Waterline port aft:	0.64	metres below centre of freeing port at deck			
Waterline stbd aft:	0.76	metres below centre of freeing port at deck			
	Port	Starboard		Average	
Below midships loadline:	0.12	0.22	metres	0.17	metres

(Loadline 0.51 m below main deck)

Draughts:

Draught at forward marks:	1.97	1.98	metres	1.975	metres
Draught at aft marks:	3.03	2.95	metres	2.99	metres
Average draught at FP:	1.976	metres about keel line (2.506 metres about Base Line)			
Average draught at AP:	3.058	metres about keel line (3.102 metres about Base Line)			
Draught at midships LBP:	2.804	metres about Base Line			
Trim:	0.596	metres by stern			

Hydrostatics:

Mean sea water SG:	1.0280	(MAIB hydrometer)			
Displacement:	87.419	tonnes	KMT	3.698	metres
LCB:	6.702	metres	VCB	2.059	metres

Pendulum deflections and data:

Movement	*Weight in tonnes*	*Distance in metres*	*Applied Moment*	*Deflection fwd pend in mm*	*Deflection aft pend in mm*	*def/mom * forward*	*def/mom * aft*
A-port	0.281	2.80	0.787	77.0	67.0	97.865	85.155
C-port	0.290	2.80	0.812	94.5	72.0	116.379	88.670
C-stbd	0.290	2.80	0.812	94.5	72.0	116.379	88.670
A-stbd	0.281	2.80	0.787	77.0	67.0	97.865	85.155
B-stbd	0.281	2.80	0.787	78.0	80.0	99.136	101.678
D-stbd	0.270	2.80	0.756	93.0	79.0	123.016	104.497
D-port	0.270	2.80	0.756	93.0	79.0	123.016	104.497
B-port	0.281	2.80	0.787	78.0	80.0	99.136	101.678
						872.791	760.000

$$GM = \frac{l}{m\,\Delta}$$

where: l = Pendulum length
m = Change in deflection per unit change of moment
Δ = Displacement

Max angle of heel:	2.6	degrees			
Average def/mom forward:	109.099		Forward pendulum length:	3920	mm
Average def/mom aft:	95.000		Aft pendulum length:	3490	mm
GM forward:	0.411	metres	Mean GM:	0.416	metres
GM aft:	0.420	metres			

Displacement: **87.419** **tonnes**
VCG: **3.282** **metres above base line**
LCG: **6.752** **metres forward of AP, corrected for trim**

Items to go on to achieve Lightship

Items to go on	*Weight tonnes*	*LCG metres forward of AP*	*Long'l Moment Tonne. metres*	*VCG metres above Base Line*	*Vertical Moment Tonne. metres*
Structure					
Gantry	5.100	1.500	7.650	6.700	34.170
Ballast in old Stbd fuel tank	0.351	0.000	0.000	2.600	0.913
Steel lost in transom repair	0.075	-0.100	-0.008	2.900	0.218
Upper deck					
Liferaft	0.065	6.800	0.442	6.310	0.410
Lifebuoys	0.009	5.500	0.050	6.500	0.059
EPIRB + top case	0.006	7.800	0.047	7.350	0.044
Fish boxes on deck	0.271	8.000	2.171	6.520	1.770
Fish baskets	0.042	7.500	0.315	6.020	0.253
Ship's Bell	0.010	8.200	0.082	7.250	0.073
Radar	0.010	8.500	0.085	13.350	0.134
Wheelhouse					
2 PC's	0.015	10.000	0.150	6.450	0.097
Paperwork	0.030	9.750	0.293	6.400	0.192
Television	0.015	9.750	0.146	6.400	0.096
Compass & Binnacle	0.020	11.000	0.220	6.400	0.128
Miscellaneous (police)	0.030	9.750	0.293	6.500	0.195
Stbd Passageway/ Forward Store					
Nets/Rope/Wires	0.200	12.000	2.400	4.6	0.920
Speedline etc	0.025	13.500	0.338	5.000	0.125
Oilskins	0.010	13.300	0.133	4.600	0.046
Tools etc	0.030	13.300	0.399	4.500	0.135
Galley Area					
Removed insulation	0.006	8.200	0.049	4.600	0.028
General galley	0.040	12.000	0.480	4.100	0.164
Fire extinguisher	0.010	11.100	0.111	3.850	0.039
Videos	0.010	9.000	0.090	5.000	0.050
Personal effects (police)	0.100	9.500	0.950	4.600	0.460
Accommodation					
Mattresses	0.040	2.700	0.108	2.500	0.100
Personal effects/Bedding	0.070	3.350	0.235	2.400	0.168
Survival suits	0.045	3.300	0.149	2.000	0.090
Fish hold					
Pound Boards	0.220	11.200	2.464	2.440	0.537
2 shovels	0.004	11.200	0.045	2.400	0.010
Totals	***6.859***	***2.899***	***19.885***	***6.068***	***41.619***

Items to come off to achieve Lightship

Items to come off	*Weight tonnes*	*LCG metres forward of AP*	*Long'l Moment Tonne. metres*	*VCG metres above Base Line*	*Vertical Moment Tonne. metres*
Inclining weights	1.123	5.719	6.423	6.152	6.909
Spare weights (on centreline)	0.080	4.500	0.360	5.710	0.457
Aft inclining pendulum trough	0.239	3.200	0.765	4.100	0.980
Forward inclining pendulum trough	0.261	12.050	3.145	1.900	0.496
Aft pendulum	0.027	3.300	0.089	6.500	0.176
Forward pendulum	0.005	12.050	0.060	6.060	0.030
MAIB inspector 1	0.075	6.500	0.488	6.600	0.495
MAIB inspector 2	0.075	2.500	0.188	4.670	0.350
Boatyard staff 1	0.075	11.550	0.866	2.200	0.165
Boatyard staff 2	0.075	0.500	0.038	4.750	0.356
Portable electric bilge pump	0.005	4.700	0.024	3.650	0.018
Generator + fuel	0.320	4.700	1.504	4.300	1.376
Oil fuel in daily service tank	0.255	8.714	2.222	3.441	0.877
Power distribution box	0.020	4.700	0.094	4.300	0.086
Chain hoist	0.010	1.640	0.016	3.650	0.037
Chain hoist	0.010	8.500	0.085	5.650	0.057
Water in insulation - galley	0.023	10.000	0.230	4.900	0.113
Water in insulation - accommodation	0.019	3.300	0.063	2.760	0.052
Water in insulation - wheelhouse	0.010	9.750	0.098	7.050	0.071
Totals	***2.707***	***6.190***	***16.756***	***4.839***	***13.100***

Lightship Summary

Item	*Weight tonnes*	*LCG metres forward of AP*	*Long'l Moment Tonne. metres*	*VCG metres above Base Line*	*Vertical Moment Tonne. metres*
Inclining condition	87.419	6.752	590.253	3.282	286.909
Items to come off	-2.707	6.190	-16.756	4.839	-13.100
Items to go on	6.859	2.899	19.885	6.068	41.619
Lightship	*91.571*	*6.480*	*593.382*	*3.445*	*315.428*

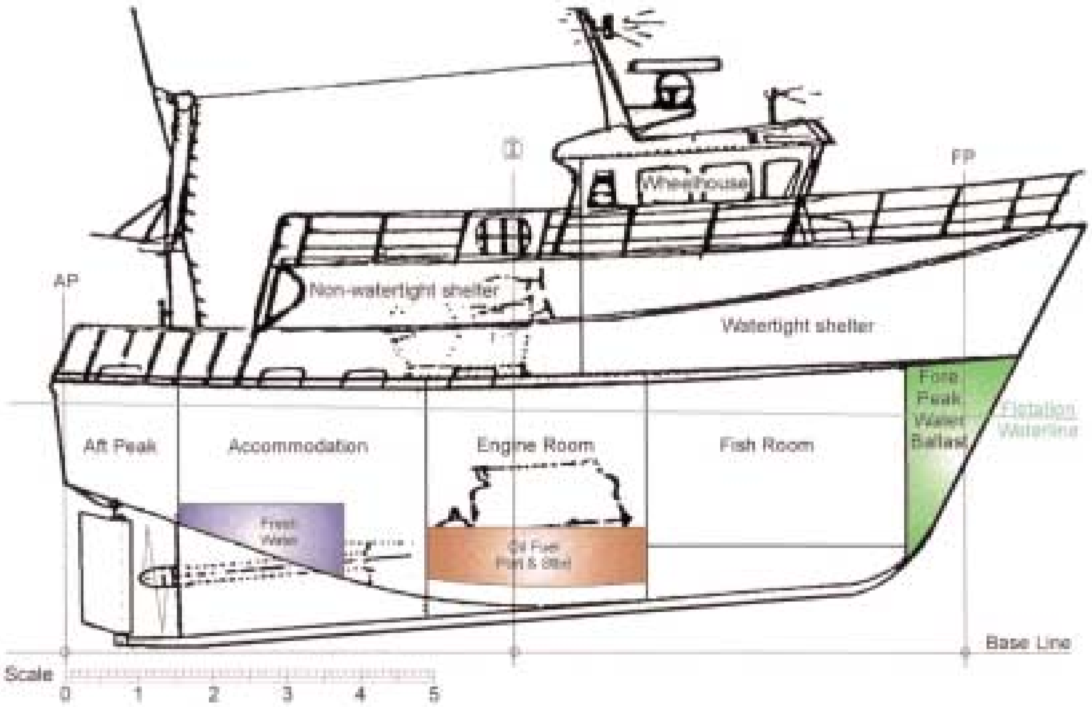
Appendix 2

Loading conditions with associated trim, stability and freeboard data for stability booklet

DEADWEIGHT TABLE

```
Vessel....: MFV 'Chelaris J'
Condition.: Depart Port, 100% Consumables, 3.5 tonnes ice
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about Aft Perpendicular (-ve aft, +ve forward)
Vertical dimensions about Base Line (+ve above, -ve below)
```



	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	Oil Fuel - Port	5.262	7.050	37.097	1.576	8.293	3.237
2	Oil Fuel - Stbd	5.262	7.050	37.097	1.576	8.293	3.237
3	Oil Fuel - Daily Service	0.255	8.714	2.222	3.441	0.877	0.073
	Total Oil Fuel	10.779	7.089	76.416	1.620	17.463	6.547
4	Water in Fore Peak	2.352	13.940	32.787	3.112	7.319	0.809
5	Fresh Water	2.007	3.023	6.067	2.075	4.165	0.718
6	Catch in fishroom	5.750	9.500	54.625	1.800	10.350	0.000
7	Catch on deck	0.000	0.000	0.000	0.000	0.000	0.000
8	Ice	3.500	11.500	40.250	2.000	7.000	0.000
9	Crew and effects (4)	0.400	9.500	3.800	6.750	2.700	-
10	Victuals	0.100	9.500	0.950	3.800	0.380	-
11	Trawl doors	0.700	1.500	1.050	4.500	3.150	-
12	Trawl wires	0.462	5.800	2.680	4.400	2.033	-
13	Trawl net	0.800	1.300	1.040	6.600	5.280	-
	DEADWEIGHT TOTAL	26.850	8.181	219.665	2.229	59.840	8.074
	LIGHTSHIP	91.571	6.480	593.380	3.445	315.462	-
	DISPLACEMENT	118.421	6.866	813.045	3.169	375.302	8.074

Free Surface Correction (Total Free Surface Moment/Displacement)	0.068
VCG fluid	3.237

SAILING STATE

Vessel....: MFV 'Chelaris J'
Condition.: Depart Port, 100% Consumables, 3.5 tonnes ice
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draught at FP about Base Line	-	3.197
Draught at midships on LBP about Base Line	-	3.276
Draught at AP about Base Line	-	3.352

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP about foredeck edge	1.894	2.761
Freeboard at midships LBP about main deck edge	-	0.344
Freeboard at AP about main deck edge	0.777	0.466

STABILITY DATA

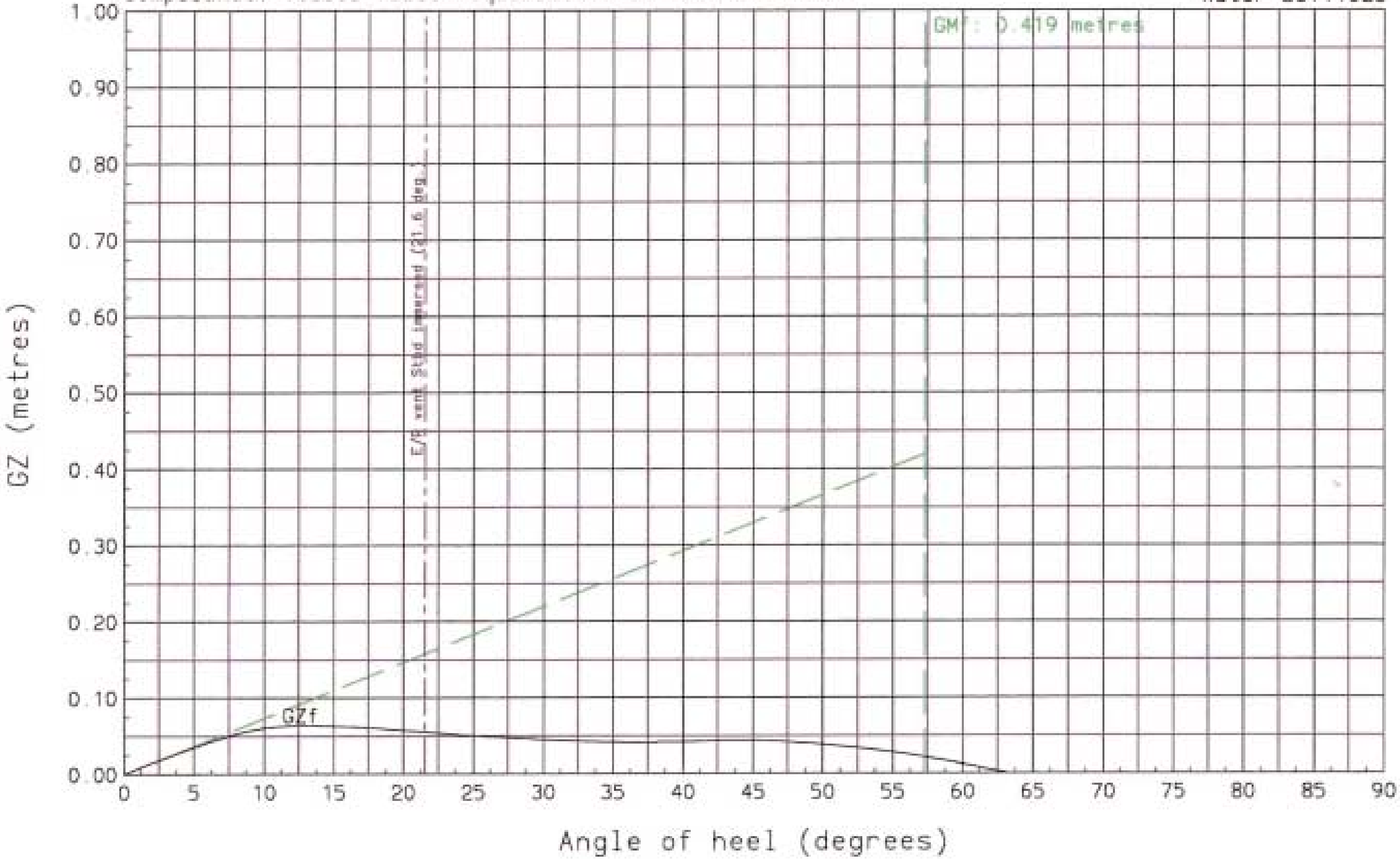
Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.155 by stern	3.275	0.000	0.000	0.000	0.000
5	0.128 ''	3.262	0.317	0.282	4.159	0.035
10	0.154 ''	3.228	0.623	0.562	7.147	0.060
15	0.236 ''	3.184	0.901	0.838	7.473	0.063
20	0.360 ''	3.124	1.165	1.107	6.806	0.057
25	0.520 ''	3.047	1.418	1.368	5.950	0.050
30	0.712 ''	2.949	1.664	1.619	5.340	0.045
35	0.929 ''	2.826	1.899	1.857	4.958	0.042
40	1.168 ''	2.678	2.123	2.081	4.988	0.042
45	1.426 ''	2.509	2.333	2.289	5.183	0.044
50	1.668 ''	2.319	2.518	2.480	4.499	0.038
55	1.933 ''	2.120	2.680	2.652	3.309	0.028
60	2.195 ''	1.909	2.816	2.804	1.431	0.012
65	2.444 ''	1.684	2.926	2.934	-0.903	-0.008
70	2.675 ''	1.450	3.011	3.042	-3.718	-0.031
75	2.892 ''	1.208	3.071	3.127	-6.680	-0.056
80	3.097 ''	0.958	3.105	3.188	-9.859	-0.083
85	3.265 ''	0.696	3.114	3.225	-13.149	-0.111
90	3.455 ''	0.438	3.097	3.237	-16.632	-0.140

STABILITY SUMMARY	Minimum	Actual
Angle of immersion of E/R vent Stbd (degrees)	-	21.561
Area under GZ curve between 0.00 and 21.56 degrees (metre.radians)	0.055	0.018
Area under GZ curve between 0.00 and 21.56 degrees (metre.radians)	0.090	0.018
Area under GZ curve between 30.00 and 21.56 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	-	0.063
Angle of heel at which maximum GZ occurs (degrees)	25.000	14.141
Maximum GZ between 30 and 90 degrees (metres)	0.200	0.000
Positive GZ heel range (degrees)	-	21.561
GM solid (metres) (upright)	-	0.488
Free Surface correction (metres)	-	0.068
GM fluid (metres) (upright)	0.350	0.419

GZ PLOT

MFV 'Chelaris J'

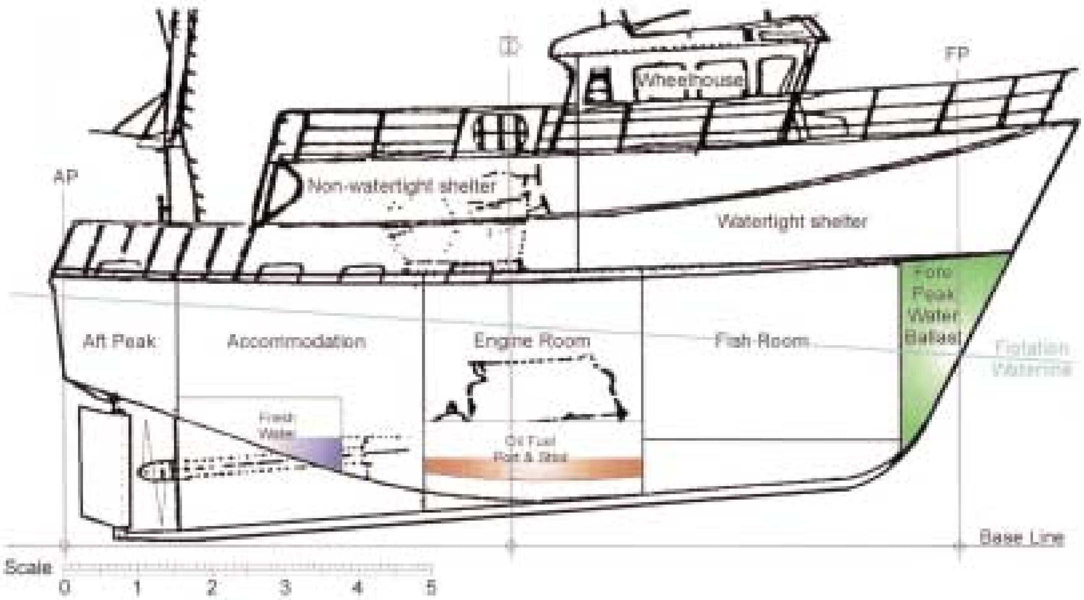
Condition : Depart Port, 100% Consumables, 3.5 tonnes ice
State : Intact inc. shelterdeck volume, exc. W/H volume
Compliance: Vessel fails requirements in this condition



DEADWEIGHT TABLE

Vessel....: MFV 'Chelaris J'
Condition.: Arrive Port, 10% Con's, Ice: 0.75t, Catch: 20% max (1.45t)
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about Aft Perpendicular (-ve aft, +ve forward)
Vertical dimensions about Base Line (+ve above, -ve below)



	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	Oil Fuel - Port	0.526	7.418	3.902	1.576	0.829	3.237
2	Oil Fuel - Stbd	0.526	7.418	3.902	1.576	0.829	3.237
3	Oil Fuel - Daily Service	0.256	8.714	2.231	3.441	0.881	0.720
	Total Oil Fuel	1.308	7.672	10.035	1.941	2.539	7.194
4	Water in Fore Peak	2.352	13.940	32.787	3.112	7.319	0.809
5	Fresh Water	0.201	3.651	0.734	2.075	0.417	0.718
6	Catch in fishroom	0.000	0.000	0.000	0.000	0.000	0.000
7	Catch on deck	1.450	1.529	2.217	3.920	5.684	7.838
	Total Catch	1.450	1.529	2.217	3.920	5.684	7.838
8	Ice	0.750	11.500	8.625	2.000	1.500	0.000
9	Crew and effects (4)	0.400	9.500	3.800	6.750	2.700	-
10	Victuals	0.100	9.500	0.950	3.800	0.380	-
11	Trawl doors	0.700	1.500	1.050	4.500	3.150	-
12	Trawl wires	0.462	5.800	2.680	4.400	2.033	-
13	Trawl net	0.800	1.300	1.040	6.600	5.280	-
	DEADWEIGHT TOTAL	8.523	7.499	63.917	3.637	31.002	16.559
	LIGHTSHIP	91.571	6.480	593.380	3.445	315.462	-
	DISPLACEMENT	100.094	6.567	657.297	3.461	346.464	16.559

Free Surface Correction (Total Free Surface Moment/Displacement)	0.165
VCG fluid	3.627

SAILING STATE

Vessel....: MFV 'Chelaris J'
Condition.: Arrive Port, 10% Con's, Ice: 0.75t, Catch: 20% max (1.45t)
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draught at FP about Base Line	-	2.601
Draught at midships on LBP about Base Line	-	2.978
Draught at AP about Base Line	-	3.355

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP about foredeck edge	1.894	3.260
Freeboard at midships LBP about main deck edge	-	0.512
Freeboard at AP about main deck edge	0.777	0.328

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.769 by stern	2.980	-0.000	0.000	-0.000	-0.000
5	0.742 ''	2.970	0.316	0.316	0.029	0.000
10	0.747 ''	2.934	0.632	0.630	0.212	0.002
15	0.766 ''	2.878	0.937	0.939	-0.123	-0.001
20	0.830 ''	2.811	1.213	1.240	-2.721	-0.027
25	0.926 ''	2.728	1.469	1.533	-6.405	-0.064
30	1.049 ''	2.625	1.707	1.813	-10.640	-0.106
35	1.196 ''	2.500	1.932	2.080	-14.826	-0.148
40	1.367 ''	2.351	2.146	2.331	-18.591	-0.186
45	1.561 ''	2.176	2.345	2.565	-21.945	-0.219
50	1.777 ''	1.984	2.529	2.778	-24.958	-0.249
55	2.000 ''	1.774	2.690	2.971	-28.136	-0.281
60	2.223 ''	1.552	2.826	3.141	-31.525	-0.315
65	2.443 ''	1.318	2.935	3.287	-35.223	-0.352
70	2.660 ''	1.076	3.018	3.408	-39.070	-0.390
75	2.875 ''	0.828	3.072	3.503	-43.127	-0.431
80	3.089 ''	0.573	3.099	3.572	-47.298	-0.473
85	3.290 ''	0.312	3.098	3.613	-51.502	-0.515
90	3.492 ''	0.053	3.072	3.627	-55.510	-0.555

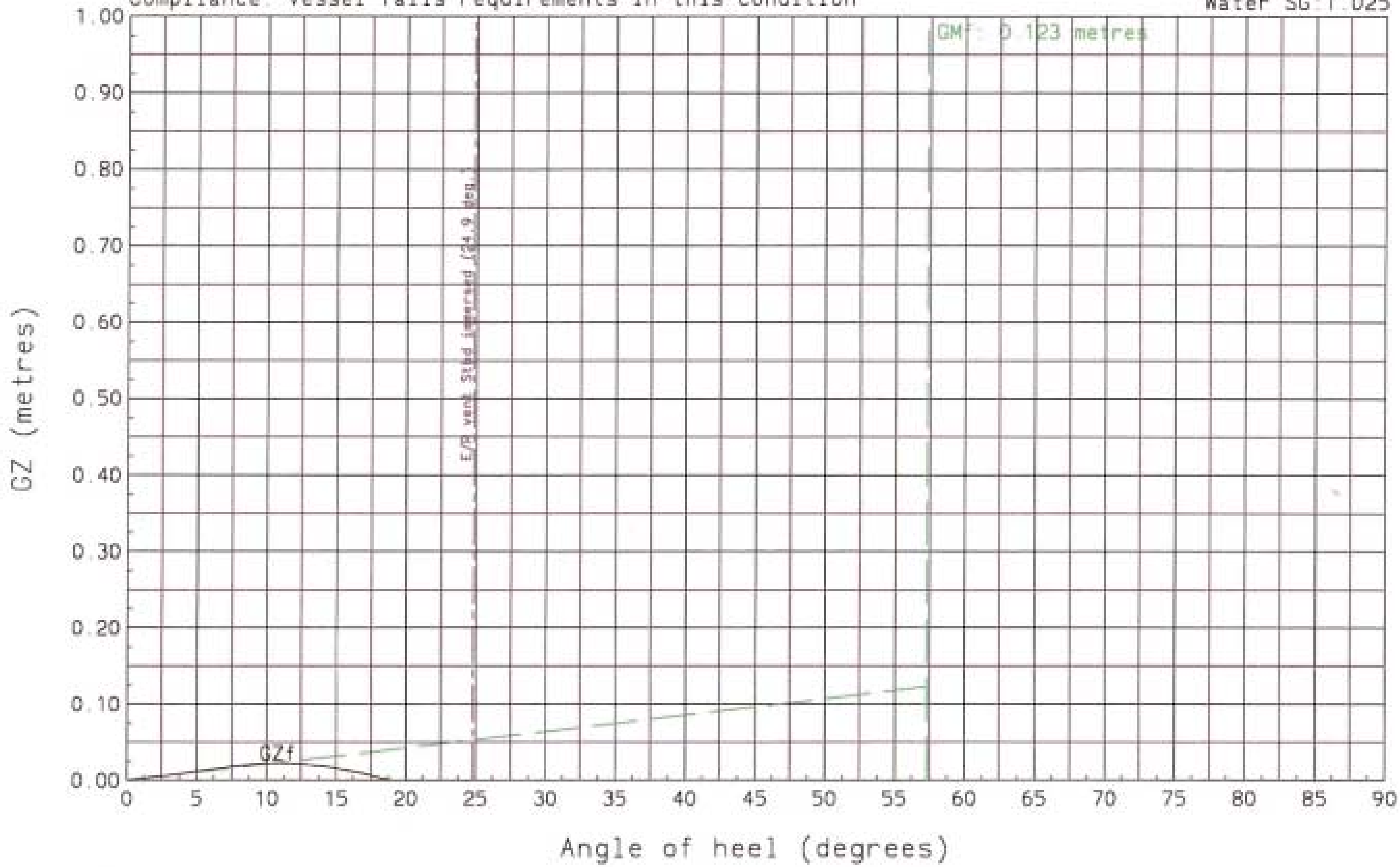
STABILITY SUMMARY	Minimum	Actual
Angle of immersion of E/R vent Stbd (degrees)	-	26.113
Area under GZ curve between 2.48 and 26.11 degrees (metre.radians)	0.055	0.000
Area under GZ curve between 2.48 and 26.11 degrees (metre.radians)	0.090	0.000
Area under GZ curve between 30.00 and 26.11 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	-	0.002
Angle of heel at which maximum GZ occurs (degrees)	25.000	9.264
Maximum GZ between 30 and 90 degrees (metres)	0.200	0.000
Positive GZ heel range (degrees)	-	12.014
GM solid (metres) (at angle of equilibrium)	-	0.167
Free Surface correction (metres)	-	0.165
GM fluid (metres) (at angle of equilibrium)	0.350	0.002

STABILITY SUMMARY (CONTINUED)	Maximum	Actual
Angle of equilibrium (degrees)	-	2.477

GZ PLOT

MFV 'Chelaris J'

Condition.: Arrive Port, 10% Con's, 1.25t Ice, Catch: 5.75t F/R, 1.5t deck
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Compliance: Vessel fails requirements in this condition



Appendix 3

Loading condition at accident with associated trim, stability and freeboard data

DEADWEIGHT TABLE

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Vessel....: MFV 'Chelaris J'
Condition.: Vessel condition immediately prior to accident
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

Longitudinal dimensions about Aft Perpendicular (-ve aft, +ve forward)
Vertical dimensions about Base Line (+ve above, -ve below)
Transverse dimensions about centreline (+ve Port, -ve Stbd)
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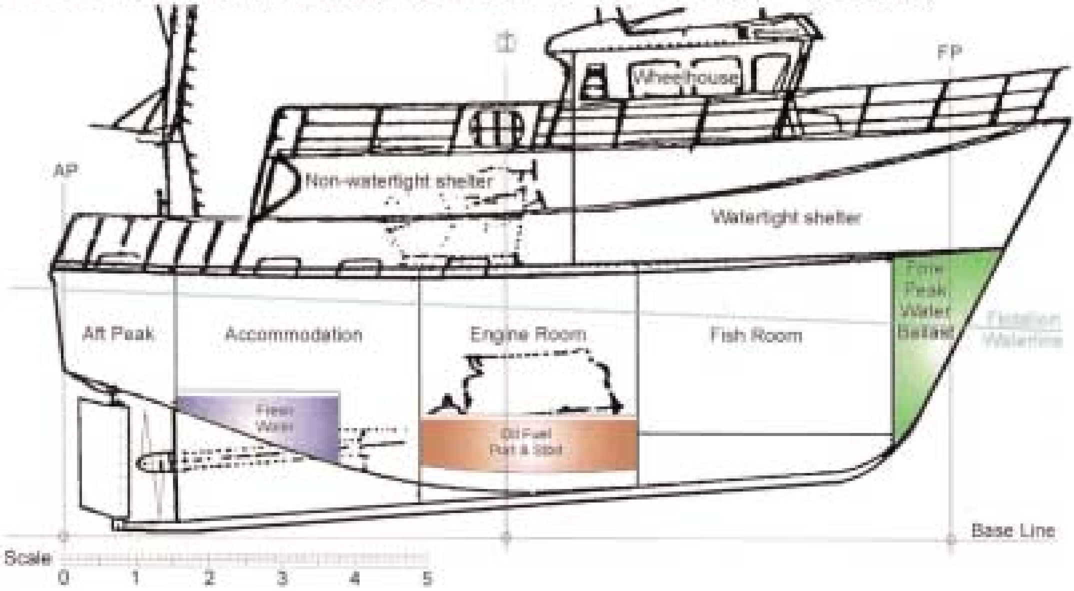


	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	TCG metres	Transverse moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	Oil Fuel - Port	4.913	7.060	34.686	1.507	7.404	1.538	7.556	2.196
2	Oil Fuel - Stbd	4.913	7.060	34.686	-1.507	-7.404	1.538	7.556	2.196
3	Oil Fuel - Daily Service	0.255	8.714	2.222	0.000	0.000	3.441	0.877	0.000
4	Water in Fore Peak	2.152	13.940	32.787	0.000	0.000	3.112	7.319	0.000
5	Fresh Water	1.990	3.023	6.016	0.000	0.000	2.075	4.129	0.000
6	Catch in fishroom	0.200	9.500	1.900	0.000	0.000	1.800	0.360	0.000
7	Catch on deck	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	Ice	3.000	11.500	34.500	0.000	0.000	2.000	6.000	0.000
9	2 crew in wheelhouse	0.200	9.900	1.980	0.000	0.000	6.750	1.350	-
10	2 crew in accommodation	0.200	3.600	0.720	0.000	0.000	2.600	0.520	-
11	Victuals	0.100	9.500	0.950	0.000	0.000	3.800	0.380	-
12	Trawl door on Port block	0.275	1.660	0.456	2.800	0.770	5.870	1.614	-
13	Trawl door on Stbd block	0.275	1.660	0.456	-2.800	-0.770	5.870	1.614	-
14	Trawl wire on Port block	0.180	1.660	0.299	2.800	0.504	5.870	1.057	-
15	Trawl wire on Stbd block	0.180	1.660	0.299	-2.800	-0.504	5.870	1.057	-
16	Trawl net on Port block	0.250	1.660	0.415	2.800	0.700	5.870	1.467	-
17	Trawl net on Stbd block	0.250	1.660	0.415	-2.800	-0.700	5.870	1.467	-
	DEADWEIGHT TOTAL	19.533	7.822	152.787	0.000	0.000	2.269	44.325	4.392
	LIGHTSHIP	91.571	6.480	593.380	0.000	0.000	3.445	315.462	-
	DISPLACEMENT	111.104	6.716	746.167	0.000	0.000	3.238	359.787	4.392

Free Surface Correction (Total Free Surface Moment/Displacement)	0.040
VCG fluid	3.278

SAILING STATE

Vessel....: MFV 'Chelaris J'
Condition.: Vessel condition immediately prior to accident
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draught at FP about Base Line	-	2.929
Draught at midships on LBP about Base Line	-	3.160
Draught at AP about Base Line	-	3.390

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP about foredeck edge	1.894	3.026
Freeboard at midships LBP about main deck edge	-	0.458
Freeboard at AP about main deck edge	0.777	0.406

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.462 by stern	3.160	0.000	0.000	0.000	0.000
5	0.440 "	3.147	0.317	0.286	3.459	0.031
10	0.450 "	3.109	0.628	0.569	6.525	0.059
15	0.511 "	3.060	0.913	0.848	7.145	0.064
20	0.614 "	2.999	1.178	1.121	6.374	0.057
25	0.752 "	2.921	1.431	1.385	5.109	0.046
30	0.919 "	2.822	1.673	1.639	3.801	0.034
35	1.110 "	2.699	1.903	1.880	2.590	0.023
40	1.324 "	2.552	2.123	2.107	1.762	0.016
45	1.545 "	2.377	2.329	2.318	1.214	0.011
50	1.800 "	2.191	2.515	2.511	0.489	0.004
55	2.056 "	1.988	2.677	2.685	-0.839	-0.008
60	2.303 "	1.772	2.813	2.839	-2.808	-0.025
65	2.540 "	1.545	2.923	2.971	-5.266	-0.047
70	2.764 "	1.308	3.008	3.080	-8.036	-0.072
75	2.979 "	1.063	3.066	3.166	-11.146	-0.100
80	3.188 "	0.813	3.098	3.228	-14.483	-0.130
85	3.371 "	0.551	3.103	3.265	-18.041	-0.162
90	3.568 "	0.293	3.082	3.278	-21.738	-0.196

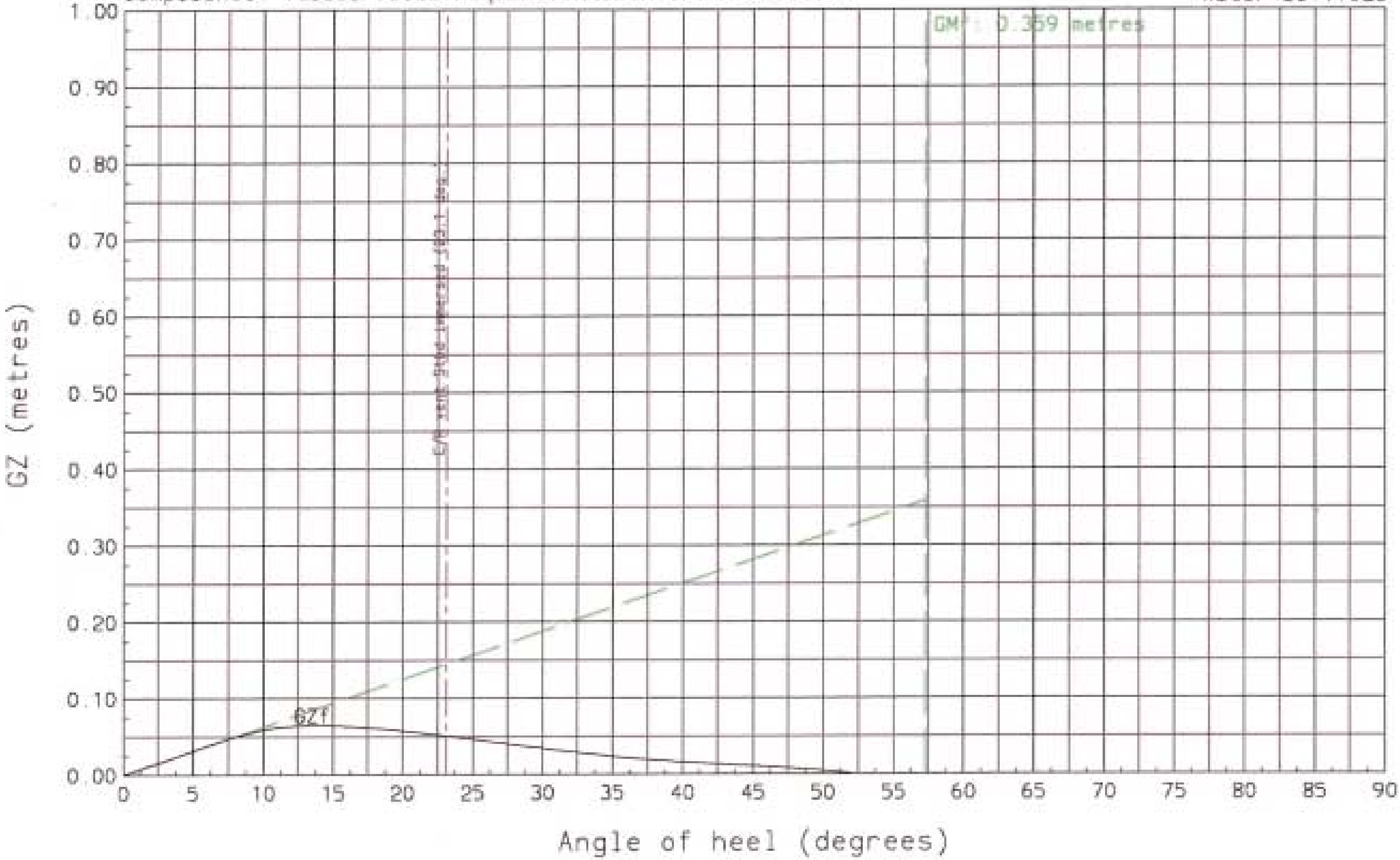
STABILITY SUMMARY	Minimum	Actual
Angle of immersion of E/R vent Stbd (degrees)	-	23.141
Area under GZ curve between 0.00 and 23.14 degrees (metre.radians)	0.055	0.019
Area under GZ curve between 0.00 and 23.14 degrees (metre.radians)	0.090	0.019
Area under GZ curve between 30.00 and 23.14 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	-	0.064
Angle of heel at which maximum GZ occurs (degrees)	25.000	14.729
Maximum GZ between 30 and 90 degrees (metres)	0.200	0.000
Positive GZ heel range (degrees)	-	23.141
GM solid (metres) (upright)	-	0.398
Free Surface correction (metres)	-	0.040
GM fluid (metres) (upright)	0.350	0.359

GZ PLOT

MFV 'Chelaris J'

Condition.: Vessel condition immediately prior to accident
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Compliance: Vessel fails requirements in this condition

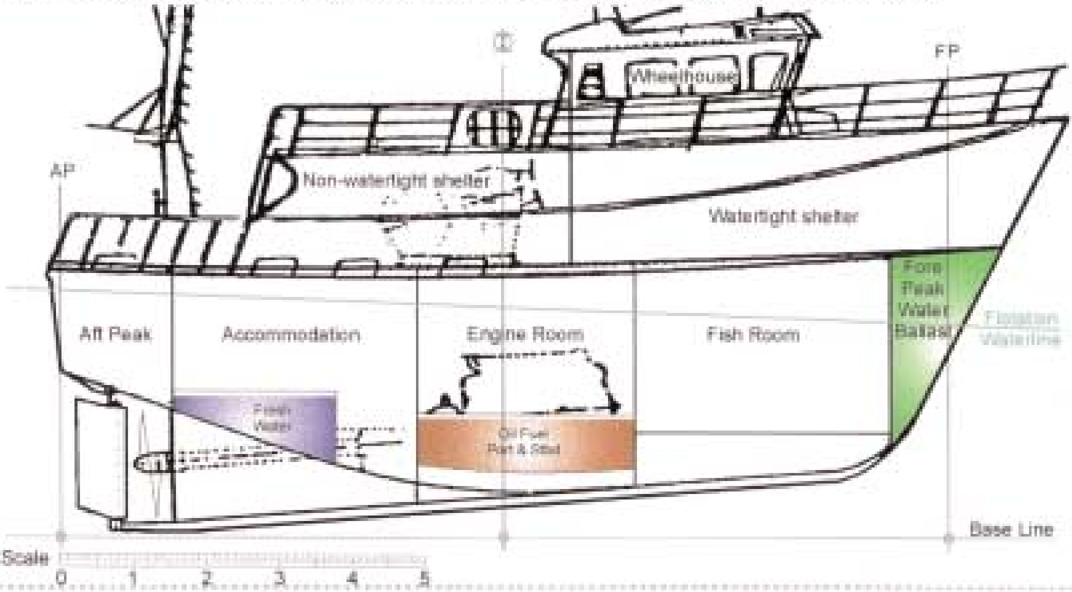
Water SG:1.025



DEADWEIGHT TABLE

Vessel....: MFV 'Chelaris J'
Condition.: Accident inc 70:30 trawl block load, aft deck and bilge water
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
WARNING...: Vessel capsizes in this condition

Longitudinal dimensions about Aft Perpendicular (-ve aft, +ve forward)
Vertical dimensions about Base Line (+ve above, -ve below)
Transverse dimensions about centreline (+ve Port, -ve Stbd)



	Deadweight Item	Weight tonnes	LCG metres	Longitudinal moment t.m	TCG metres	Transverse moment t.m	VCG metres	Vertical moment t.m	Free Surface moment t.m
1	Oil Fuel - Port	4.913	7.060	34.686	1.507	7.404	1.538	7.556	2.196
2	Oil Fuel - Stbd	4.913	7.060	34.686	-1.507	-7.404	1.538	7.556	2.196
3	Oil Fuel - Daily Service	0.255	8.714	2.222	0.000	0.000	3.441	0.877	0.000
4	Water in Fore Peak	2.352	13.940	32.787	0.000	0.000	3.112	7.319	0.000
5	Fresh Water	1.990	3.023	6.016	0.000	0.000	2.075	4.129	0.000
6	Catch in fishroom	0.200	9.500	1.900	0.000	0.000	1.800	0.360	0.000
7	Catch on deck	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	Ice	3.000	11.500	34.500	0.000	0.000	2.000	6.000	0.000
9	2 crew in wheelhouse	0.200	9.900	1.980	0.000	0.000	6.750	1.350	-
10	2 crew in accommodation	0.200	3.600	0.720	0.000	0.000	2.600	0.520	-
11	Victuals	0.100	9.500	0.950	0.000	0.000	3.800	0.380	-
12	Trawl door on Port block	0.385	1.660	0.639	2.800	1.078	5.870	2.260	-
13	Trawl door on Stbd block	0.165	1.660	0.274	-2.800	-0.462	5.870	0.969	-
14	Trawl wire on Port block	0.252	1.660	0.418	2.800	0.706	5.870	1.479	-
15	Trawl wire on Stbd block	0.108	1.660	0.179	-2.800	-0.302	5.870	0.634	-
16	Trawl net on Port block	0.350	1.660	0.581	2.800	0.980	5.870	2.054	-
17	Trawl net on Stbd block	0.150	1.660	0.249	-2.800	-0.420	5.870	0.881	-
18	Water on open aft deck	0.100	5.997	0.600	0.000	0.000	3.651	0.365	10.896
19	Bilge water in fishroom	0.100	9.984	0.998	0.000	0.000	0.714	0.071	0.063
20	Bilge water in engine room	0.100	5.906	0.591	0.000	0.000	0.381	0.038	0.004
	DEADWEIGHT TOTAL	19.833	7.814	154.976	0.080	1.579	2.259	44.800	15.355
	LIGHTSHIP	91.571	6.480	593.380	0.000	0.000	3.445	315.462	-
	DISPLACEMENT	111.404	6.717	748.356	0.014	1.579	3.234	360.262	15.355
	Free Surface Correction (Total Free Surface Moment/Displacement)						0.317		
						VCG fluid	3.551		

SAILING STATE

Vessel....: MFV 'Chelaris J'
Condition.: Accident inc 70:30 trawl block load, aft deck and bilge water
State.....: Intact inc. shelterdeck volume, exc. W/H volume
Water SG..: 1.025
WARNING...: Vessel capsizes in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draught at FP about Base Line	-	2.935
Draught at midships on LBP about Base Line	-	3.164
Draught at AP about Base Line	-	3.393

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP about foredeck edge	1.894	3.020
Freeboard at midships LBP about main deck edge	-	0.453
Freeboard at AP about main deck edge	0.777	0.403

STABILITY DATA

Heel angle degrees	Trim about Base Line metres on LBP	Draft at midships LBP about Base Line	KN metres	KGxSIN(Heel) metres	Righting moment tonne.metres	GZ fluid metres
0	0.458 by stern	3.164	-0.014	0.000	-1.579	-0.014
5	0.436 ''	3.151	0.303	0.310	-0.765	-0.007
10	0.446 ''	3.113	0.614	0.617	-0.337	-0.003
15	0.508 ''	3.065	0.898	0.919	-2.328	-0.021
20	0.613 ''	3.004	1.164	1.215	-5.625	-0.050
25	0.753 ''	2.926	1.417	1.501	-9.308	-0.084
30	0.921 ''	2.827	1.660	1.776	-12.910	-0.116
35	1.113 ''	2.705	1.891	2.037	-16.281	-0.146
40	1.329 ''	2.558	2.111	2.283	-19.121	-0.172
45	1.550 ''	2.383	2.318	2.511	-21.530	-0.193
50	1.806 ''	2.196	2.505	2.720	-23.947	-0.215
55	2.063 ''	1.994	2.669	2.909	-26.784	-0.240
60	2.311 ''	1.779	2.806	3.075	-30.087	-0.270
65	2.548 ''	1.551	2.917	3.218	-33.631	-0.302
70	2.773 ''	1.315	3.002	3.337	-37.292	-0.335
75	2.988 ''	1.070	3.062	3.430	-41.066	-0.369
80	3.175 ''	0.814	3.095	3.497	-44.813	-0.402
85	3.380 ''	0.558	3.101	3.538	-48.595	-0.436
90	3.577 ''	0.300	3.082	3.551	-52.261	-0.469

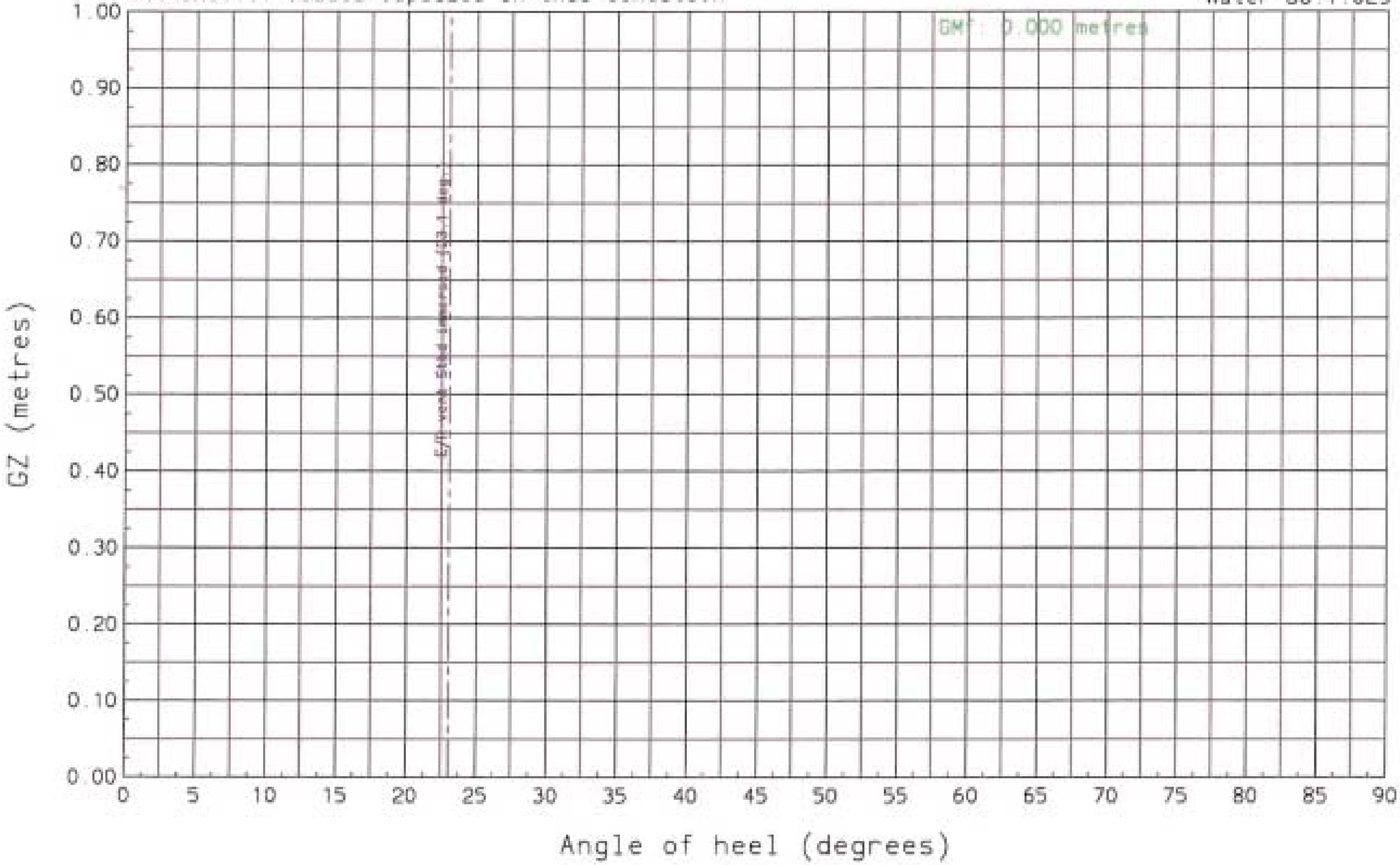
STABILITY SUMMARY	Minimum	Actual
Angle of immersion of E/R vent Stbd (degrees)	-	23.049
Area under GZ curve between 0.00 and 23.05 degrees (metre.radians)	0.055	-0.008
Area under GZ curve between 0.00 and 23.05 degrees (metre.radians)	0.090	-0.008
Area under GZ curve between 30.00 and 23.05 degrees (metre.radians)	0.030	0.000
Maximum GZ (metres)	-	0.000
Angle of heel at which maximum GZ occurs (degrees)	25.000	0.000
Maximum GZ between 30 and 90 degrees (metres)	0.200	0.000
GM solid (metres) (upright)	-	0.317
Free Surface correction (metres)	-	0.317
GM fluid (metres) (upright)	0.350	0.000

GZ PLOT

MFV 'Chelaris J'

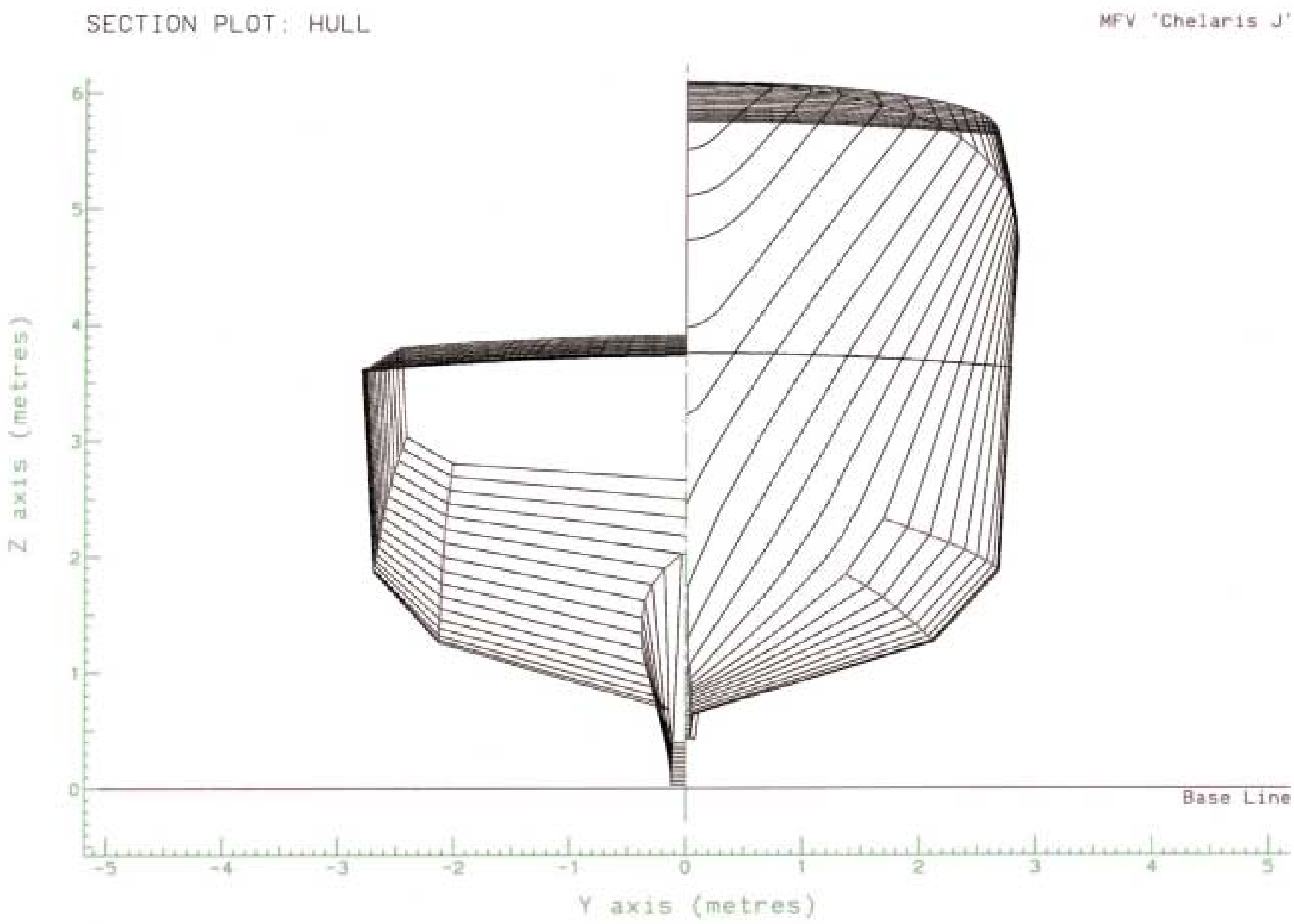
Condition..: Accident inc 70:30 trawl block load, aft deck and bilge water
State......: Intact inc. shelterdeck volume, exc. W/H volume
WARNING...: Vessel capsizes in this condition

Water SG:1.025



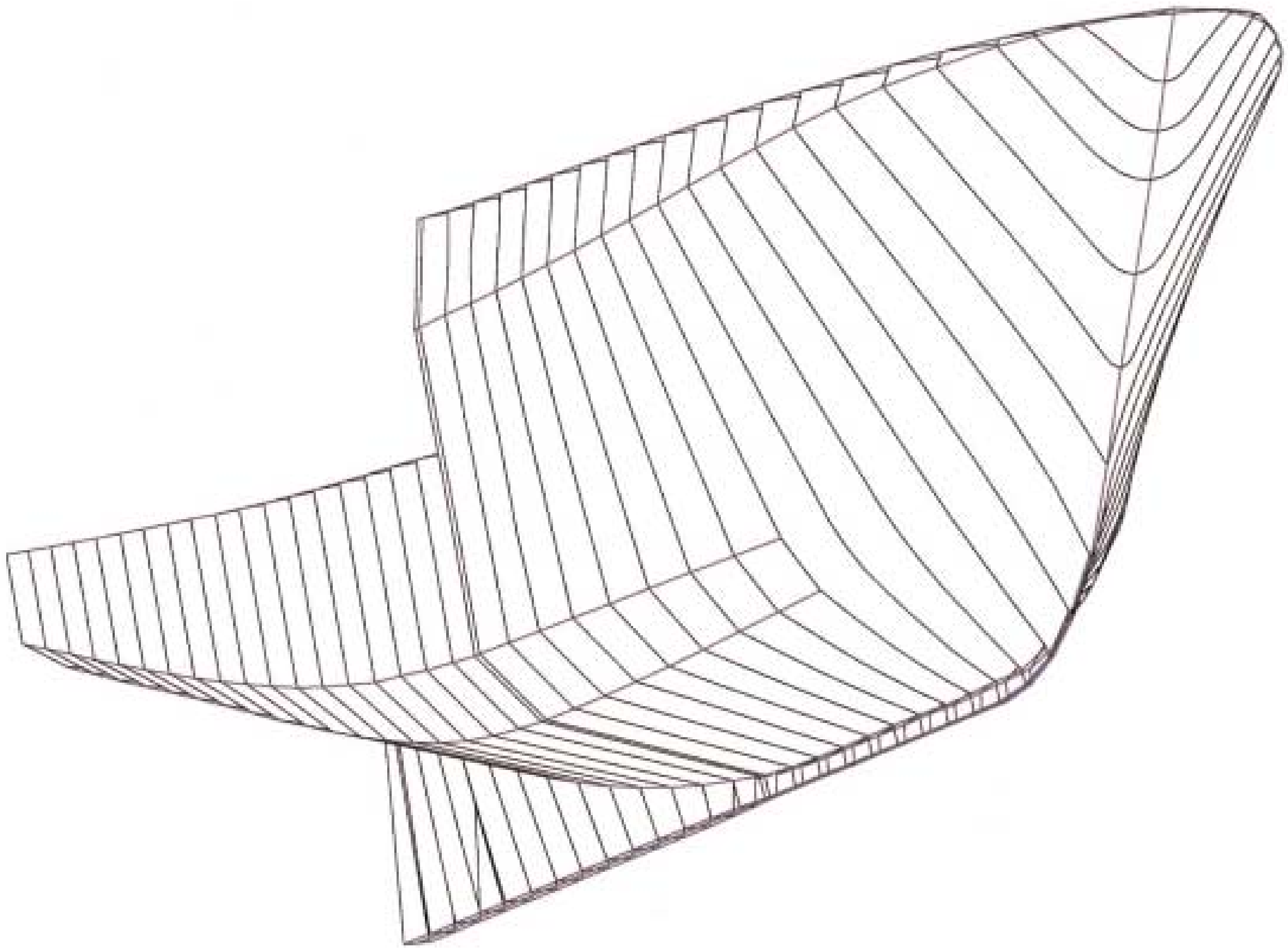
Appendix 4

Hull section plots


SECTION PLOT: HULL
MFV 'Chelaris J'
Base Line
Z axis (metres)
Y axis (metres)
-5
-4
-3
-2
-1
0
1
2
3
4
5
6

SECTION PLOT: HULL
Isometric view

MFV 'Chelaris J'



ANNEX B

MGN 265 (F) Fishing Vessels: The Hazards Associated with Trawling, Including Beam Trawling and Scallop Dredging

MARINE GUIDANCE NOTE

MGN 265 (F)

Fishing Vessels: The Hazards Associated with Trawling, Including Beam Trawling and Scallop Dredging

Notice to all Owners, Operators, Skippers, Crews, Managers, Gear Fitters, Shipbuilders and Designers.

This notice supersedes MGN181 (F)

Summary

- Provides guidance on the safe operation of fishing vessels engaged in trawling.
- Provides specific guidance on the safe operation of fishing vessels engaged in twin beam trawling, including scallop dredging with derricks or booms. Some of the risks identified for beam trawlers may also be applicable for other fishing vessels or fishing techniques that have similar characteristics.

1. THE DANGERS OF TRAWLING

1.1 The nature of trawling, especially beam trawling can result in serious accidents occurring at sea. Analysis of casualty data has shown that human error, failure of equipment, snagging of gear and loss of stability are recurring factors.

1.2 This notice provides general advice on safety matters related to the operation of fishing vessels. It is the responsibility of the owner and skipper to ensure that all procedures in use whilst fishing are suitable for the vessel, its equipment and its mode of fishing.

1.3 A video, 'Level Headed' looking at the risks involved in beam trawling is available from the Maritime and Coastguard Agency.

2. BEFORE GOING TO SEA…

Knowing the vessel

2.1 The skipper should ensure that only persons who are fully experienced in handling the vessel and competent in its fishing methods are on watch. All watch keepers and engineers should be aware of conditions that can reduce the stability reserves of the vessel including the use of fuel, stowage of fish and the effects of entrapped water when scuppers are restricted by debris or gear.

2.2 All crewmembers should be made aware of the procedures to follow in the event of an emergency, these should include the closing of weathertight doors and hatches to spaces which are needed to maintain the stability of the vessel. They should be made aware of the location and correct operation of all safety related equipment on board the vessel.

3. WHILST AT SEA…

3.1 Loose gear should be restrained or secured. In particular, booms, beams, nets, trawl doors and attached chains should always be securely lashed when not in use, even in fine weather. This safe working practice also helps to prevent inadvertent loss of gear, injuries to crew and the blockage of freeing ports and scuppers due to loose gear on deck.

3.2 Weathertight doors and hatches should be kept closed at sea when not in use. This reduces the number of vital tasks that need to be completed in the event of an emergency. They should not be left open to assist in ventilation. Inadequate ventilation should be rectified by improvements to the ventilation system. If possible, openings for winches or winch wires should be positioned well above the weather deck

4. WHEN SHOOTING AND RECOVERING GEAR…

4.1 Crew working on deck should be aware of the dangers of equipment failure and the simple precautions they may take to avoid injury. These include keeping out of the bights of ropes and keeping away from working machinery unless directly involved in its operation.

4.2 Sudden rolling of the vessel followed by a heavy list may arise when hauling or towing equipment fails or a load is lost from one side. This may happen whilst clearing sand, stone or weed from a trawl that is clear of the seabed.

4.3 Methods of restraining the net prior to release should not cause crew members to become fouled in bights of lifting ropes which are too stout to be made up on cleats. Sharp course alterations should be avoided whilst lifting the cod end.

4.4 On vessels where the winch controls are on deck, care should be taken to ensure good communications are maintained between the skipper and the winch operator, especially if the skipper has only a restricted view of the winch operator. This is particularly important on smaller vessels with powerful winches where there may be less time to react to a dangerous situation. If problems occur the load should be lowered as quickly and safely as possible to the deck or onto the seabed.

4.5 Be aware of the additional risk from use of dog-clutch type winches. Dog-clutch winches should always be de-clutched when fishing.

5. WHEN RECOVERING FOULED OR FASTENED GEAR

5.1 Recovery of fouled gear can impose extra loads on wires and machinery, particularly in adverse weather conditions. Failure of either may result in excessive rolling or a dangerous list to the vessel.

5.2 The vessel's stability reserves may be seriously reduced when hauling on fouled gear with the winches working hard. Additionally winches should not be braked and used in conjunction with a vessel's motions to free fouled gear, a heavier than normal swell may be sufficient to bring about the vessel's capsize in this condition. Dog-clutch winches are particularly hazardous in these circumstances.

5.3 Unusual or potentially dangerous operations should always be carried out under the supervision of the skipper.

5.4 There should be an emergency means for the fast release of snagged gear.

6. ADDITIONAL CONSIDERATIONS FOR BEAM TRAWLING

6.1 A recent study undertaken with the co-operation of the fishing industry has emphasised the particular risks of beam trawling. Appropriate precautions should be taken to ensure safe fishing. The study emphasised a number of other important safety issues.

6.2 Even with the increased stability reserves that are required for beam trawlers, the vessel's stability may not be adequate in some sea conditions when recovering the fishing gear and catch with the derricks raised.

6.3 No beam trawler should be operated without experienced crew in charge of the vessel and in control of the winch.

6.4 All winch operators should be fully trained and experienced.

6.5 The skipper's understanding of how stability is affected during fishing operations can be enhanced by the ready availability, in the wheelhouse, of simplified stability information.

6.6 A beam trawler at sea with gear deployed can behave differently to vessels using other fishing methods. The fishing gear has a damping effect on the roll of the vessel. This damping effect masks the signs that indicate the vessel's true stability state. A long roll period indicates reduced stability.

Risk Assessment

6.7 A thorough safety risk assessment should be carried out before fishing operations are commenced. The Seafish safety folder includes a risk assessment questionnaire that is excellent for this purpose. Guidance on carrying out risk assessment is also contained in Marine Guidance Note 20 (M+F). The following points are relevant to the particular risks associated with beam trawlers:

- Crew fully trained and experienced in beam trawler methods and familiar with the vessel and its operation.
- Bridge control of winches to include warp and topping lift as well as control of the engines.
- Bridge control or a suitable method for the release or lowering of derrick head blocks. This will enable controlled lowering of the point of suspension of the load from the head of the derrick down to the shoulder block. This can prevent a dangerous list or capsize occurring if the gear picks up an abnormal load.
- Warp-tension monitoring equipment.
- Sounding equipment that can reduce the possibility of the trawl picking up excess loads of sand and shells or snagging an obstruction on the bottom.
- Past experience of safe working with gear of similar sizes and weight.
- Particular care when working on fishing grounds where the features of the sea bed are not known.
- Past experience of safe working with a vessel whose structure, weight distribution and stability characteristics are substantially unchanged.
- Avoiding the use of systems with dogclutch winches. These winches often take considerable time to de-clutch and re-clutch preventing a rapid response to sudden load changes. Operators should be aware of these additional risks. Dogclutch winches should be de-clutched when trawling.

What the owner should do

6.8 Owners should note that possession of approved stability is no guarantee of satisfactory stability during fishing operations. An assessment of safety for beam trawling should be based on three principles:

History - Generally a beam trawler will continue to operate safely if it has a history of safe operation and its operating profile remains substantially unchanged. This includes factors such as the vessel's characteristics, its gear, the fishing grounds, its crew and the worst weather conditions in which the vessel operates.

Stability - On vessels newly acquired, or after structural alterations, or before working with a new arrangement of fishing gear, or on new vessels, an appraisal should be made of the vessel's stability during fishing operations. Such information should supplement the relevant sailing conditions that are contained in the approved stability book. For normal fishing operations the worst case is generally shown to be when the vessel is recovering her gear and catch.

Control - Control generally means control of winches in addition to engines and helm. A skipper's ability to respond and the speed of response is enhanced by full and immediate access to these separate controls.

General Operations

6.9 Every effort should be made to avoid an excessive list by ensuring uneven loads are kept to a minimum during recovery of the gear.

6.10 When hauling on snagged gear, this should ideally be carried out with the warp load acting as low and as close to the vessel's side as is possible and not from the derrick head.

6.11 Generally, when gear is stuck fast on an obstruction such as a rock or wreck, the vessel is stopped and hauled back over the obstruction. It is possible that the gear on the free side may be raised to act as a counterbalance to the snagged gear however this is a dangerous operation and capsize may occur if the snagged gear is suddenly released. All crew members should be advised when gear recovery operations commence and when they are completed. During recovery, they should be on deck with their lifejackets.

6.12 Great care should be exercised during adverse weather conditions or where there is a significant swell or tidal current. These conditions can impose a sudden increase in the loads that the trawl warps exert on the vessel.

6.13 Vessels sometimes pick up excess loads of sand, rocks, shells, weed or man-made debris from the seabed. Without warp-tension monitoring equipment it can be difficult to detect excess loads on the gear. Subtle indications may come from extra strain on the winch, changes in vessel handling or steering or from increased engine exhaust temperatures.

6.14 For beam trawlers, the use of a "weak link" near to the cod end can increase the chances of capsizing during trawling or gear recovery operations. The problem will arise if a "weak link" parts in one of the trawls when both trawls are laden and at or near the sea surface. The condition of these weak links is therefore very important and these should be inspected whenever the nets are onboard.
Care should be taken when cleaning heavy debris from nets and all crew members should be advised whenever an abnormal load has been trawled. In this situation they should be on deck with their lifejackets. Both trawls should have a freefall quick release.

6.15 Experienced skippers apply a range of methods to clear fouled gear of debris however care should be taken when raising heavy loads as this can have serious effects on the stability of the vessel. A vessel's centre of gravity rises proportionally to the magnitude of the weight that is being lifted and the vertical positioning of the derrick head lifting block. Vessels become less stable as the centre of gravity is raised so if there are any doubts about the ability of the vessel to raise a load safely, then the lift should not be attempted.

6.16 It is important that all weathertight doors and hatches are closed and freeing ports are checked free and clear, before the recovery operation takes place. Unless this is done and if the vessel heels suddenly, it is possible that water may downflood into the hull and this, if unchecked, will invariably lead to capsize and the loss of the vessel.

6.17 If snagged gear cannot be freed without hazarding the vessel, the safe course of action is to release the gear, mark it with a buoy and leave it until conditions improve or a more capable vessel can recover it.

6.18 All those involved in the catching operation should fully understand their role and be familiar with the equipment that is in use.

Experience and Training

6.19 It is essential that all crew members are aware of the particular risks of beam trawling. Special training by experienced beam trawler fishermen is necessary, the crew should have time to become accustomed to the work and equipment and be supervised whilst fishing is being undertaken.

Stability Information

6.20 It is recommended that the weights and positions of fishing gear and the lengths of beams and derricks should be recorded in all future revisions of beam trawler stability information. Changes in fishing gear can have significant and detrimental effects on a vessel's stability and unless such changes are investigated their effects will remain unknown.

Further information on the contents of this Notice can be obtained from:

Fishing Safety Branch
Maritime and Coastguard Agency
Spring Place
105 Commercial Road
SO15 1EG

Telephone: 023 8032 9130
Fax: 023 8032 9173

General Enquiries: 24 Hour Info Line
infoline@mcga.gov.uk
0870 600 6505

MCA Website Address: Internet:
http://www.mcga.gov.uk

File Ref: MS 088/001/00426

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Department for Transport

The MCA is an executive agency of the Department for Transport

Safer Lives, Safer Ships, Cleaner Seas

ANNEX C

MGN 165 (F) Fishing Vessels: The Risk of Flooding

MARINE GUIDANCE NOTE

Maritime and Coastguard Agency

MGN 165 (F)

Fishing Vessels: The Risk of Flooding

Notice to Owners, Builders, Employers, Skippers and Crews of Fishing Vessels.

This Notice replaces Marine Guidance Note No. MGN 49 (F).

Summary

This notice:

1. provides guidance on bilge systems, during construction and operation, to help reduce the number of vessels and lives lost as a result of flooding; and

2. recommends owners and skippers to consider using additional or alternative equipment, such as salvage pumps, propeller shaft-mounted pumps and secondary bilge alarms, to reduce the risk of catastrophic flooding.

1. INTRODUCTION

MAIB investigations into fishing vessel losses continue to show flooding as the primary cause. In 1999, 18 (out of a total of 33) vessels were lost for this reason.

Flooding is preventable, but if not prevented, in most cases can be controlled. If discovered early, leaking pipes can be isolated and the flooding controlled by pumping out the affected space. Flooding can be rapid and late discovery leaves no time to treat the cause. An efficient bilge alarm can be critical in providing early warning of flooding.

No alarm or pumping system, however efficient, is fully reliable on its own. Good practice requires regular checks and function tests of bilge alarms and pumps, together with regular checks of hull and pipework to prevent potential leaks or failures developing.

2. ARE THE PUMPS ON YOUR VESSEL ADEQUATE?

Statutory requirements provide for a minimum capacity for pumping bilges. There is no guarantee that the statutory minimum is adequate for dealing with serious hull or pipework failure. Alternative supplementary means of pumping bilges are available, such as salvage pumps and propeller-shaft mounted pumps. Use of such equipment is highly recommended.

3. CONSIDER CARRYING MORE EQUIPMENT THAN THE REGULATIONS REQUIRE

A range of bilge pumps and alarms are available. To help reduce the consequences of flooding, in addition to statutory requirements, consider one or more of the following options :-

- Install an efficient bilge alarm in the fish hold and any other compartment below the waterline.

- Fit secondary bilge alarms, positioned at a higher level to the main bilge alarm. This will reinforce the main alarm.

- Fit secondary bilge alarms, fed from a separate supply, that incorporate an alarm visible from outside the vessel (e.g. an orange "strobe" light).

- When available, fit electronic bilge level monitoring systems in addition to conventional "float switch" alarms.

- Fit "circuit healthy" indicators on bilge alarm circuits to ensure that the alarm system is working correctly (similar idea to navigation light failure alarms).

- Fit a propeller-shaft mounted pump; this type of pump runs continuously on the main propeller shaft and automatically attempts to pump out the engine room space in the event of flooding.

- Install "submersible" pumps, which continue to operate whilst submerged in water.

- Where practical, fit remotely operated clutches to engage engine driven bilge pumps.

- Carry a portable salvage pump. Extremely positive feedback has been received from Skippers who have sailed with this type of pump, which may "double-up" as a fire-fighting pump in a "dead ship" situation. However, a recent investigation attributed the death of one crew member to such a salvage pump. Unfortunately, he received fatal carbon monoxide poisoning whilst operating the pump inside the engine room.

<u>Such pumps should be:-</u>

i) Used in a well-ventilated space, preferably on deck, where the exhaust fumes will be released to outside the vessel.

ii) Permanently rigged, or readily available, with direct attachment to permanent suction lines (to prevent the need for hoses to be fed through open hatches/doors).

iii) Given due consideration concerning the storage of fuel, particularly petrol driven versions (i.e. adequate ventilation provided, fit for purpose storage canisters and away from sources of ignition).

4. PREVENTATIVE MEASURES – DURING CONSTRUCTION AND REFITS

Bulkheads/Openings

- Ensure that the main bulkheads are as watertight as practicable, to prevent (or at least delay) a flood from spreading to other compartments.

- DO NOT make additional penetrations through main bulkheads unless absolutely necessary.

- Clearly label ("TO BE KEPT CLOSED AT SEA") all doors which contribute to the watertight integrity of the vessel.

Sea Valves/Pipework

- Try to keep the number of sea inlet valves to a minimum.

- Valves and fittings should be manufactured from a suitable* material.

- Avoid unnecessary bends in sea water pipework.

- Position sea valves where they can be easily and quickly closed. Fit extended spindles if necessary, to ensure that sea intake valves can be closed without having to remove floor plates.

- Fit clear labels to identify sea valves.

- DO NOT fit flexible sections of piping in seawater lines unless designed and fitted to withstand vibration. Such sections should be made from reinforced neoprene rubber and secured with stainless steel clips (at least two at each end). The date of manufacture should be clearly marked to identify renewal dates in accordance with the manufacturers' instructions (typically every 5 years).

* "Suitable" means a ductile and corrosion resistant material e.g. bronze, gunmetal, stainless steel, alpha-brasses (containing 70% copper or more and effectively inhibited from de-zincification).

Bilge Alarms

- Position floats or level sensors to bilge alarm systems in accessible positions but where they cannot be damaged and low enough to provide early warning of flooding.

Bilge Valves/Strainers

- Fit bilge valves so they can easily be reached in an emergency.
- Fit clear labels to identify bilge valves.
- Fit and position all bilge strainers (mud boxes) in the engine room, so they can be cleaned easily.
- Fit grids over the fish hold slush well or some other form of coarse strainer.
- Fit a bilge isolating valve in the engine room for the fish hold, to allow cleaning of the strainer even if the hold is flooded.

Bilge Lines

- Avoid unnecessary bends in bilge lines, keeping them straight and direct.

Refits

- Inspect the outer hull closely each time the vessel is slipped, paying close attention to any signs of wastage, damage, caulking and fastenings.
- Inspect sea water pipework closely each time vessel is slipped, paying close attention to bends, "sumps" (e.g. the bottom of sea strainer boxes) and those pipes which are not easily accessible.
- If in doubt about the condition of the sea water pipework, have an ultrasonic inspection carried out and renew those pipes found to be wasted by more than 25-30% of the original wall thickness.

5. REDUCING THE RISK –
DURING OPERATION

- Always investigate i<u>mmediately</u> the cause of high bilge alarms.
- Ensure all watertight and weathertight doors are closed when not in use.
- Regularly (at least weekly) test the bilge pumps and bilge system.
- Test bilge alarms daily.
- Regularly (at least monthly) open and close all bilge and sea water valves, to ensure they don't "seize".
- Keep sea water valves closed when not in use.
- Permanently repair any leaking sea water pipe as soon as possible. Do not rely on temporary repairs and find out if the other sea water pipes are in a similar condition and require renewal.
- Ensure crew members are familiar with sea water side valves and bilge systems. As a reminder, keep a plan at the engine room entrance, identifying the position of sea inlet valves.
- Regularly (several times a day) check compartments not fitted with bilge alarms.
- Regularly (at least weekly) clean bilge. strainers
- Keep the engine room and fish hold free of rubbish, which could choke the bilge system.
- Check sea valves (including overboard non-return valves) whenever the vessel is slipped.

6. EFFECTIVE USE OF THE BILGE PUMPING SYSTEM

- Close the sea suction after any priming of bilge pumps.
- Stop the bilge pump when pumping bilges is finished.
- Close all bilge valves when not in use.

7. WHAT TO DO IN AN EMERGENCY

- Immediately try to find the cause of the flooding and shut the right sea valve. <u>If in doubt, close all sea valves until the flooding stops.</u>
- Start pumping the bilge as soon as possible.
- Do not concentrate on other matters, such as recovering the fishing gear. <u>Deal with the flooding first.</u>

8. PREVENTION AT ANCHOR OR IN HARBOUR

- Close all sea suction valves.

- Avoid "squeezing" wooden vessels in harbour, whenever practicable. This can damage the caulking and lead to a sprung plank.

9. FURTHER NOTES

1. Statutory requirements for fishing vessels of 12 metres in length and over are detailed in the Fishing Vessels (Safety Provisions) Rules 1975 as amended [currently under review]. New vessels 24 metres in length and over now need to comply with EC Directive 97/70/EC, in accordance with the Torremolinos Protocol.

2. This notice is considered relevant to all types of fishing vessels, regardless of size.

Enquiries relating to the content of this MGN should be addressed to:-

Fishing Vessel Safety Branch
The Maritime and Coastguard Agency
Spring Place
105 Commercial Road
SOUTHAMPTON SO15 1EG

Tel: 023 8032 9478
Fax: 023 8032 9173

General enquiries relating to the supply or availability of MSNs, MGNs, MINs or other subjects covered by MCA should be addressed to the Maritime Information Centre at the above address, or

Tel: 023 8032 9297
Fax: 023 8032 9298

File Numbers: MS 007_025_008
MS 088_001_0456

July 2001

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ANNEX D

Roll testing of *Chelaris J*

Roll Testing of *Chelaris J*

The roll test was a tool that was introduced by the UK authorities in the 1970s to enable a large proportion of older fishing vessels to have their stability assessed without having to go to the lengths of producing full stability information. It was based on:

- The vessel having a proven safety record,
- Her condition not varying greatly throughout the voyage cycle
- The original fishing method being maintained.

The roll test was conducted with the vessel ready for sea with fuel ice and fishing gear. The average roll period of the vessel was determined by forcing her to roll, and then some basic formulae were used to derive a GM required and actual GM. Due to the types of vessel for which the roll test was originally introduced, there were limitations on certain parameters:

- $0.04 \leq$ Minimum Freeboard/Breadth ≤ 0.2
- $1.75 \leq$ Breadth/Depth ≤ 2.15
- The vessel not having full beam wheelhouse/superstructure
- At least 5 oscillations (possibly 3 in extenuating circumstances) were achieved on each force roll.

In the case of *Chelaris J* she fails three of the criteria:

- Breadth/Depth=1.54,
- She had a full width superstructure,
- Only 2 roll oscillations were measured.

The application of a roll test to *Chelaris J* was not appropriate, and given her reported 5 tonne increase in lightship, which is greater than 2% of lightship, she should have been subject to an inclining test and production of full stability information.

When the roll test calculation was carried out by Marine and General Engineers Ltd, an error was made in the calculation of actual GM. This would actually have indicated her failing the roll test.

Correct Calculation

$$GM_{ACT} = \left(\frac{fB}{T}\right)^2$$

$$f = 0.8, B = 5.6\,\text{m}, \text{T} = 6\,\text{secs}$$

$$\Rightarrow GM_{ACT} = 0.557\,\text{m}$$

M&GE Calculation

$$GM_{ACT} = \left(\frac{fB}{T}\right)$$

$$f = 0.8, B = 5.6\,\text{m}, \text{T} = 6\,\text{secs}$$

$$\Rightarrow GM_{ACT} = 0.740\,\text{m}$$

$$GM_{REQ} = 0.6 + 0.05B - 0.25F_{MIN}\ ,\ B = 5.6\,\text{m}, F_{MIN} = 0.66\,\text{m}$$

$$\text{GM}_{\text{REQ}} = 0.715\,\text{m}$$

By missing out the squared term, Marine and General Engineers Ltd believed their actual GM was in excess of the GM required. With the correct calculation, the actual GM is much less than GM required.