Annex A

HM Coastguard operational procedures for SAR (CG3)

1.3 PROCEDURE AT CO-ORDINATING MRCC

On receiving the first information or a Casualty Action Message from an Initial Action Station, the WM at the co-ordinating MRCC is to:

a assess and initiate the required level of response;

b assume the duties of SMC and co-ordinate all subsequent action;

c if appropriate, pass incident details as required to the Duty Area Officer and inform him or her of action taken (See Chapter 2 - Section 3);

d pass the Casualty Action Message to all action addressees for which the co-ordinating MRCC is responsible;

e issue regular SITREPs to inform and update all authorities concerned, including information broadcasts to SRUs, SAR facilities and the casualty;

f inform the Initial Action Station and positively accept all responsibility for all further action required using the words "(name of MRCC) Coastguard Co-ordinating".

1.4 HANDING OVER CO-ORDINATION FROM ONE MRCC TO ANOTHER

1.4.1 Introduction

It is not normally desirable to change responsibility for the overall co-ordination of an incident that is in progress. Technology allows us to co-ordinate incidents in the partner MRCC's area of responsibility and future technology will almost certainly give us easy access to the non partner flank station. However, as described in 1.2, there are occasions when it will be necessary to transfer co-ordination.

1.4.2 Information to be Passed on Transferring Co-ordination

The circumstances under which co-ordination of an incident is transferred will depend largely on the length of time an incident has been running and its severity. If it is in the very early stages or a minor incident, a verbal transfer (formally confirmed by GD 92) between co-ordination centres may be sufficient.

In such circumstances, to ensure a comprehensive and effective transfer, the format in Annex A should be followed. This should form the basis of an orderly transfer of responsibilities. Before any transfer is finalised, the SMCs are to discuss any outstanding issues.

However, in the case of a major incident involving a large number of SRUs and/or complex plans, a more comprehensive approach to the handover is necessary. See Ch 2 - Section 6.12.

1.4.3 Other Considerations on Transferring Co-ordination

SAR units and any other participants are to be fully briefed before the changeover, and an agreed communications policy established.

As soon as practical, a SAR SITREP should be made, and an amendment to any broadcast action already taken, should be made by the outgoing co-ordination centre to advise of the change.

Once the changeover has been affected, a confirming message by GD92 or fax is to be sent from the co-ordination centre assuming co-ordination to the previous co-ordinating MRCC and is to be logged into the incident narrative at both stations. Both SMCs are responsible for ensuring that this happens, and that there can be no subsequent doubt as to when co-ordination was formally transferred.

There may well be further action required of the initial co-ordinating station and full use should be made of their resources and local contacts. Care should be taken to avoid duplication of effort particularly when dealing with outside agencies. Any significant devolvement of responsibility should when practical be backed up by a GD92 message or fax for reference.

HANDOVER OF SAR CO-ORDINATION PRO-FORMA

Handover should be initiated for operational reasons only (See Section 1.2). Close co-operation between the co-ordination centres involved should be conducted prior to the handover, and transfer should not occur before all participants have been informed. A formal signal accepting the responsibility for co-ordination is to be telexed immediately the changeover takes place. The following proforma may help to formulate this formal signal.

DTG	
From MRCC	
Fax:	
Phone:	
Telex:	
Point of Contact:	
To MRCC	
Fax:	
Phone:	
Telex:	
Info:- MRCC	
SAR Units	

HANDOVER OF SAR CO-ORDINATION **PAGE 1**

1	Reason for Handover	
2	Time of Handover	
3	Description of Incident Casualty	
4	Background Information	
5	SAR Strategy	
	a Previous	
	b Current	
	c Future	
6	Search Area	
	a Previous	
	b Current	
	c Future	

Annex B

Extract from stability report

Stability Assessment

Investigation into capsize of MFV 'Aquila'

Marine Accident Investigation Branch

December 2009

Report on Stability Investigation - FV ‘Aquila’

1. *Introduction*

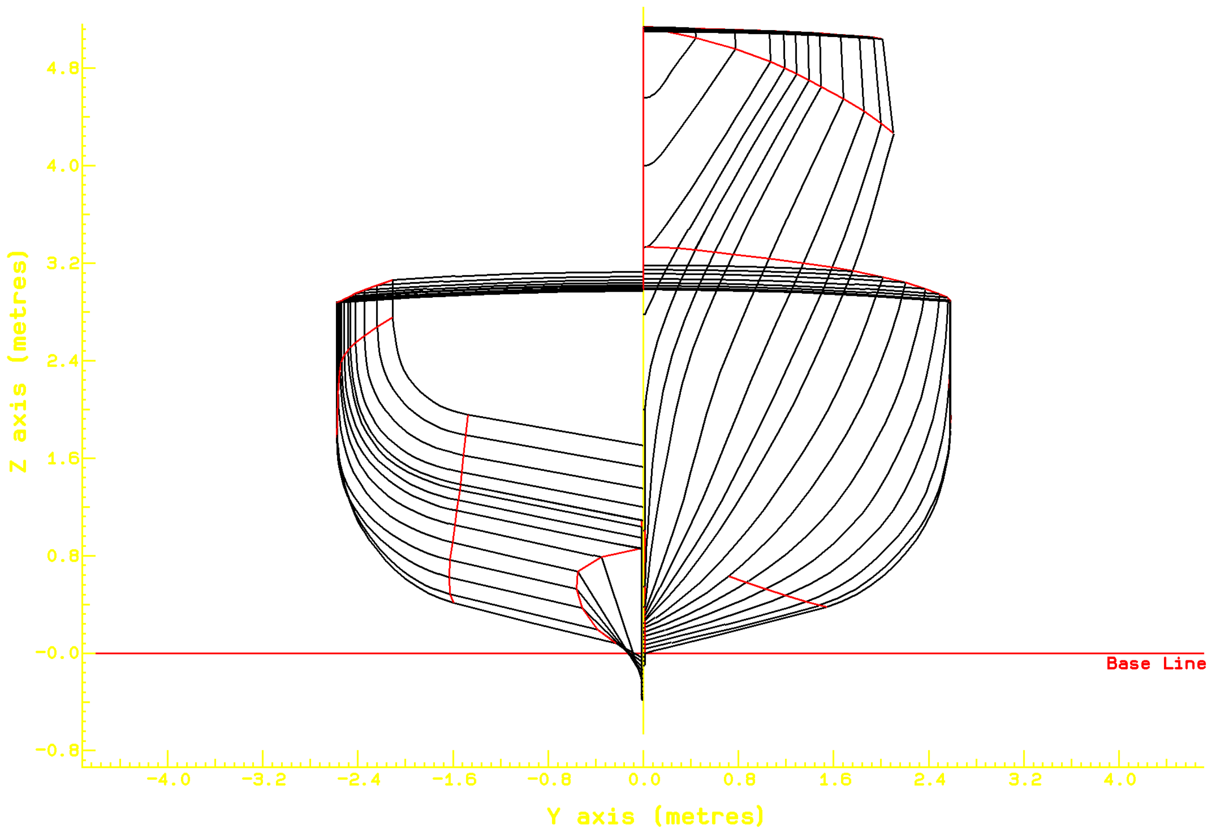
The objective of this report is firstly, to assess the general stability of the fishing vessel ‘Aquila’ in light of the data in the original stability information booklet (SIB) produced in 1988 and secondly, to assess the stability in the accident condition.

Section 2 explains the means by which the hull and compartments were defined for the analysis and Section 3 specifies the vessel’s principal dimensions. Section 4 illustrates the relationship between KN and righting lever values and outlines the assumptions made in the computation of this data. Section 5 details the stability and freeboard requirements in the 1975 Fishing Vessel Regulations. At less than 12 metres registered length, Aquila did not have to comply but many vessels of this size have been checked against the requirements over the years – for example, compliance was a Sea Fish Industry Authority requirement when grants were available for construction. Section 6 lists the seven loading conditions in the 1988 stability information booklet (SIB), compares that data with the information computed for this report and in light of this makes an assessment of the 1988 SIB. Section 7 describes the changes to the vessel after 1988 and the effect that these had on its stability. Section 8 examines the accident condition itself and discusses the nature of the capsize. Section 9 is comprised of the report conclusions. For brevity, some of the appendices which form the basis for the analysis have been removed from this report.

2. *Hull and compartment definition*

The shape of the vessel’s hull and its compartments and tanks were defined by measurements taken from the lines plan and the hull. Half breadth and height dimensions for 16 transverse sections through the hull were recorded on the computer to create a coordinate model of the hull shape. An additional 22 sections were interpolated automatically from the input section data to refine the model – see diagram 1 below. Appendix 1 is comprised of section, plan, profile and isometric views of this hull model.

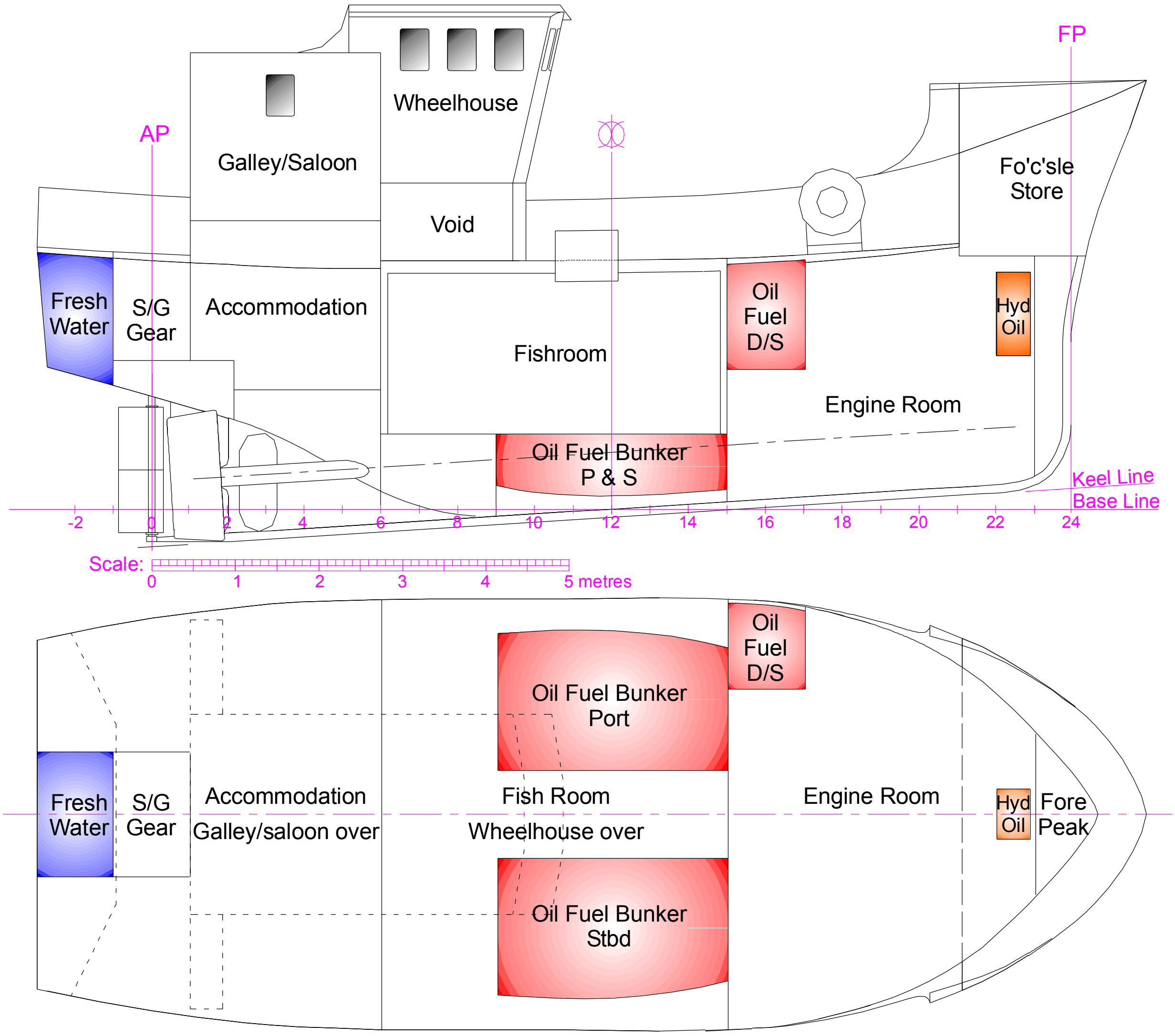
Diagram 1 – Hull sections of fishing vessel ‘Aquila’



The appendages modelled for this analysis were the centreline keel, the bilge keels and the propeller nozzle. The preamble to the KN data in the 1988 stability booklet indicates that the volumes of the deckhouse and forecastle were included. There is no indication whether the bilge keels and propeller nozzle were included in the stability booklet. Both these appendages have been included for analysis in this report.

All longitudinal dimensions are taken about an Aft Perpendicular (AP) located at the rudder stock. The Forward Perpendicular (FP) is located 11.00 metres forward of the AP at the intersection of the stem with the datum waterline. All vertical dimensions are taken about a moulded Base Line passing through the the intersection of the keel and bottom plating at midships on the LBP. The same horizontal and vertical datums were used in the 1988 SIB. These datums are shown on the general arrangement drawing below.

Diagram 2 – General Arrangement of fishing vessel 'Aquila'



The principal compartments are listed below with their related frame positions and lengths:

Table 1 – Compartment locations and lengths

No..	*Compartment*	*Frame Nos.*	*Length - metres*
1	Forepeak	Bow to 23 (WTB)	0.46
2	Forecastle store	Bow to 21 (WTB)	2.24
3	Engine room	23 (WTB) to 15 (WTB)	3.68
4	Fishroom	15 (WTB) to 6 (WTB)	4.14
5	Aft Accommodation	6 (WTB) to Transom	4.11
6	Deckhouse	6 (Non WT) to 1 (WT)	2.30
7	Wheelhouse (void under)	10 (WT) to 6 (WT)	1.84

The geometry of compartments Nos. 1 to 5 in the table 1 list were derived by the computer system from the hull model while compartments 6 and 7 were defined by measurement from the General Arrangement drawing.

The locations and capacities of the vessel's main tanks are listed in table 2 below:

Table 2 – Tank locations and capacities

No.	*Tank*	*Location Frames*	*Capacity metres^3*	*Content's SG*	*Capacity tonnes*	*Capacity in 1988 SIB - m^3 (% diff)*
1	Fuel Oil Bunker - Port	9 to 15	2.219	0.84	1.864	2.31 (+3.9%)
2	Fuel Oil Bunker - Stbd	9 to 15	2.219	0.84	1.864	2.31 (+3.9%)
3	Fuel Oil Daily Service	15 to 16.5	1.099	0.84	0.923	1.04 (-5.7%)
4	Fresh Water	-1 to transom	1.816	1.00	1.816	1.84 (+2.3%)
5	Hydraulic Oil	22 to 23	0.239	0.86	0.205	Not stated

Capacities calculated for this report differ from the 1988 SIB by between +3.9% and -5.7%. Such variations are small and can be justified by differing assumptions made for the permeability of the tanks. Further details on the tanks, including longitudinal and vertical centres of gravity and free surface moments calculated for this report are to be found in Appendix 4.

3. Principal dimensions

The vessel's principal dimensions are as follows:

Length Overall (LOA)................................. : 13.40 metres
Length Between Perpendiculars (LBP)....... : 11.00 metres
Maximum moulded beam (at deck level) .... : 5.15 metres
Depth (base line to deck edge at midships) : 2.85 metres
Lightship displacement .... : 50.28 tonnes (from inclining trial on 31/05/88)
Draught midships at lightship displacement : 1.90 metres (from inclining trial on 31/05/88)
Keel rake .... : 0.70 metres over LBP

4. Hydrostatic, KN and tank data

Appendices 2 and 3 are comprised of hydrostatic and free-trim KN data computed from the hull model for this report. The diagram below illustrates the relationship between KN values and righting levers (GZ):

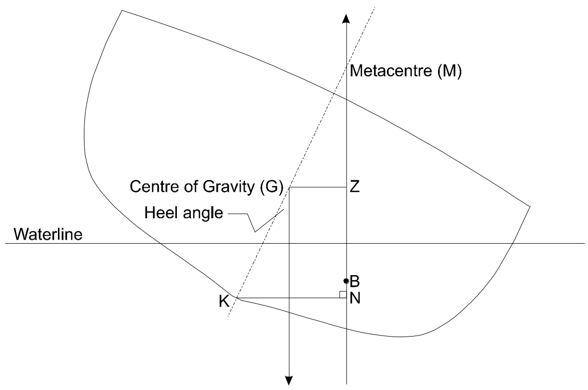


Diagram 3 – Relationship of KN to righting lever (GZ)

It should be noted that the KN data used for the calculation of the stability data discussed in Section 6 of this report includes the volume of the hull below the foredeck (i.e. including the fo'c'sle) and the main deck but excludes the volume of the deckhouse and wheelhouse. This is normal practice in compiling a stability booklet for submission to the MCA as these latter volumes may not be watertight – flooding through open doors and windows, for example, will remove any additional righting lever that might have been obtained. In the 1988 SIB the deckhouse was included in the KN data.

5. *Criteria used for assessment of stability and freeboards*

The Aquila was completed by the builders, Hepworths in 1988 and the stability booklet was produced in June 1988. At that time, the Fishing Vessel Safety Provisions Rules 1975 were in force, but these did not apply to a vessel with a registered length of less than 12 metres such as the Aquila. The 1975 Rules were superseded in 2001 by the Fishing Vessels (Code of Practice for the Safety of Small Fishing Vessels) Regulations 2001 and in 2002 by the Fishing Vessels 15 to 24 metres regulations. With regard to stability, the provisions of the 1975 rules were identical to the 2002 regulations for vessels of 15 metres in length or greater, with no stability requirements for vessels of less than 15 metres in length. Merchant Shipping Notice (MSN) 1770(F) draws attention to the provisions of the 2002 regulations and paragraph 3.1.2 states that any fishing vessel of 15 metres in length or greater must comply with the following stability requirements:

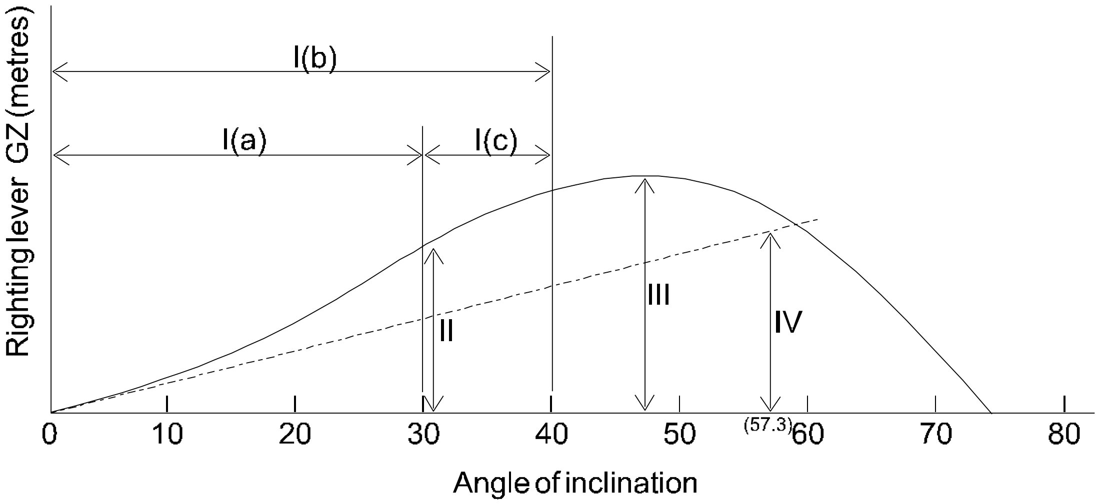


Diagram 4 – Example of righting lever curve with requirement key points

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;

In addition to the stability requirements, paragraph 3.2.1 of MSN 1770(F) specifies that fishing vessels of over 15 metres length shall be designed, constructed and operated so as to maintain adequate freeboards in all foreseeable operating conditions – paragraphs 3.2.2 to 3.2.7 define these minima which are applied at the FP, the AP and the point where the minimum freeboard occurs. Minimum freeboard requirements for fishing vessels with a registered length greater than 12 metres were also included in Rule 15(1) of the 1975 Safety Provisions Rules (Merchant Shipping Notice M975 issued in 1981 explained these requirements in greater detail), but these did not include a minimum at the point where the lowest freeboard occurred. In Aquila's case, the minimum freeboards would have been 1.15 metres forward and 0.65 metres aft if these requirements had been applicable to vessels with a registered length of less than 12 metres.

6. *Assessment of 1988 inclining trial report and SIB loading conditions*

An inclining experiment was conducted for the vessel in 1988 following build and the original report for this was included in the stability booklet. As part of the analysis for this investigation, the original inclining trial report was checked and re-analysed, with a number of minor variations identified. Some of these, the mean draught and trim for example, may be due to measurement from paper drawing copies which are subject to distortion. However, the net effect was that the 1988 report possibly underestimated the lightship displacement by a little over 1.5 tonnes and the lightship KG by about 66mm.

A fishing vessel is judged to comply with the requirements if it exceeds the stability and freeboard criteria stated in Section 5 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 these parameters in a sequence of loading conditions representative of a voyage profile. Additional conditions are also included where appropriate, examining the stability in intermediate loading conditions and with alternative loads on board.

The following seven loading conditions were created for the 1988 SIB and were recreated on the computer for this report:

1. Lightship
2. Depart Port
3. Arrive Shellfish Grounds
4. Depart Shellfish Grounds 100% Catch
5. Arrive Port 100% Catch
6. Depart Shellfish Grounds 20% Catch
7. Arrive Port 20% Catch

As noted in Section 4, the KN data used for these conditions does not include the volume of the deckhouse in this report. The deadweight make-up has been reproduced from the 1988 SIB so as to provide the best comparison with that data.

Table 3 on the next page summarises the differences between the 1988 SIB for the conditions listed above and the data obtained for the same conditions but using the lightship derived from the 2009 inclining trial (with and without reassessed deadweights).

Table 3 – Comparison between 1988 stability data and stability data derived from 2009 inclining trial (See Appendices 6 and 8)

		Condition No.																				
		1 Lightship			**2 Depart Port**			**3 Arrive Grounds**			**4 Depart Grounds 100% Catch**			**5 Arrive Port 100% Catch**			**6 Depart Grounds 20% Catch**			**7 Arrive Port 20% Catch**		
Stability, Draught and Freeboard	**Min.**	1988 SIB	1988 / 2009	% diff	1988 SIB	1988 / 2009	% diff	1988 SIB	1988 / 2009	% diff	1988 SIB	1988 / 2009	% diff	1988 SIB	1988 / 2009	% diff	1988 SIB	1988 / 2009	% diff	1988 SIB	1988 / 2009	% diff
Area under GZ to 30˚ heel (metre.radians)	0.055	0.082	0.080	31.3%	0.084	0.077	28.6%	0.083	0.076	27.6%	0.082	0.069	20.3%	0.084	0.072	23.6%	0.079	0.071	22.5%	0.081	0.074	25.7%
			0.081	32.1%		0.069	20.3%		0.068	19.1%		0.055	0.0%		0.055	0.0%		0.067	17.9%		0.066	16.7%
Area under GZ to 40˚ heel (metre.radians)	0.090	0.127	0.123	26.8%	0.13	0.113	20.4%	0.129	0.113	20.4%	0.127	0.098	8.2%	0.132	0.104	13.5%	0.121	0.105	14.3%	0.125	0.11	18.2%
			0.120	25.0%		0.094	4.3%		0.093	3.2%		0.066	-36.4%		0.068	-32.4%		0.091	1.1%		0.091	1.1%
Area under GZ 30˚ - 40˚ (metre.radians)	0.030	0.045	0.043	30.2%	0.046	0.037	18.9%	0.046	0.037	18.9%	0.045	0.029	-3.4%	0.048	0.031	3.2%	0.042	0.034	11.8%	0.044	0.037	18.9%
			0.039	23.1%		0.025	-20.0%		0.025	-20.0%		0.011	-172.7%		0.012	-150.0%		0.025	-20.0%		0.025	-20.0%
Maximum GZ 30˚ - 90˚ (metres)	0.200	0.280	0.260	23.1%	0.300	0.234	14.5%	0.290	0.236	15.3%	0.288	0.193	-3.6%	0.300	0.206	2.9%	0.280	0.219	8.7%	0.280	0.231	13.4%
			0.247	19.0%		0.172	-16.3%		0.172	-16.3%		0.111	-80.2%		0.114	-75.4%		0.170	-17.6%		0.173	-15.6%
Angle of maximum GZ (degrees)	25˚	30.00	30.20	17.2%	32.00	27.63	9.5%	30.00	27.850	10.2%	30.00	25.33	1.3%	30.00	25.90	3.5%	30.00	27.89	10.4%	30.00	28.49	12.2%
			27.69	9.7%		22.95	-8.9%		23.10	-8.2%		19.52	-28.1%		19.93	-25.4%		23.38	-6.9%		23.81	-5.0%
GM fluid (metres)	0.350	0.665	0.663	47.2%	0.629	0.608	42.4%	0.624	0.605	42.1%	0.596	0.583	40.0%	0.620	0.604	42.1%	0.601	0.571	38.7%	0.622	0.593	41.0%
			0.653	46.4%		0.622	43.7%		0.610	42.6%		0.574	39.0%		0.554	36.8%		0.580	39.7%		0.569	38.5%
Draught at FP about USK (metres)	N/A	1.320	1.360	N/A	1.530	1.554	N/A	1.520	1.546	N/A	1.830	1.847	N/A	1.810	1.832	N/A	1.570	1.596	N/A	1.550	1.580	N/A
			1.555	N/A		1.848	N/A		1.846	N/A		2.098	N/A		2.054	N/A		1.861	N/A		1.818	N/A
Mean draught about USK at amidships (metres)	N/A	1.900	1.892	N/A	2.070	2.065	N/A	2.050	2.048	N/A	2.230	2.245	N/A	2.210	2.227	N/A	2.030	2.039	N/A	2.010	2.021	N/A
			1.990	N/A		2.276	N/A		2.260	N/A		2.424	N/A		2.391	N/A		2.231	N/A		2.196	N/A
Draught at AP about USK (metres)	N/A	2.400	2.424	N/A	2.550	2.576	N/A	2.520	2.551	N/A	2.610	2.642	N/A	2.590	2.623	N/A	2.450	2.482	N/A	2.430	2.462	N/A
			2.668	N/A		2.943	N/A		2.912	N/A		2.968	N/A		2.948	N/A		2.829	N/A		2.803	N/A
Freeboard at FP about foredeck edge (metres)	1.150	3.500	3.481	67.0%	3.300	3.287	65.0%	3.300	3.296	65.1%	3.000	2.995	61.6%	3.020	3.011	61.8%	3.250	3.246	64.6%	3.270	3.262	64.7%
			3.286	65.0%		2.992	61.6%		2.995	61.6%		2.745	58.1%		2.788	58.8%		2.980	61.4%		3.024	62.0%
Freeboard midships about main deck edge (metres)	N/A	0.985	1.101	N/A	0.815	0.929	N/A	0.835	0.946	N/A	0.655	0.750	N/A	0.675	0.768	N/A	0.855	0.956	N/A	0.875	0.973	N/A
			0.903	N/A		0.618	N/A		0.634	N/A		0.470	N/A		0.504	N/A		0.663	N/A		0.698	N/A
Freeboard at AP about aft deck edge (metres)	0.650	1.090	1.012	35.8%	0.940	0.861	24.5%	0.970	0.886	26.6%	0.880	0.796	18.3%	0.900	0.815	20.2%	1.040	0.956	32.0%	1.060	0.976	33.4%
			0.768	15.4%		0.493	-31.8%		0.524	-24.0%		0.470	-38.3%		0.490	-32.7%		0.609	-6.7%		0.634	-2.5%

**** Loading conditions from 1988 SIB with amended lightship data from 1988 inclining trial (% differences relate to minimum values)***

**** Amended loading conditions with lightship from 2009 inclining trial and reassessed deadweights (% differences relate to minimum values)***

NB Table represents a comparison with current requirements for fishing vessels over 15 metres in length

7. Vessel condition prior to the accident

Appendix 7 is comprised of the report on the post accident inclining trial conducted in September 2009. Despite generally poor weather, this trial was conducted in good local sea and wind conditions as the tide was low and the vessel was well sheltered from the prevailing North-Westerly Force 2 to 3 wind by the quayside. Pendulum offsets varied by a maximum of 5.5mm on the 3.121 metre length forward pendulum and 6mm on the 3.052 metre length aft pendulum. No problems were experienced in carrying out the trial and the mean $GM_{transverse}$ values derived from the offsets at the two pendulums were consistent at 0.486 metres aft and 0.482 metres forward, i.e., a 4 millimetre difference.

Unfortunately, failure of both the two pumps which were hired to empty the bilges meant that the trial was conducted with a total of approximately 2.8 tonnes of sea water in the engine room, fishroom and accommodation spaces. The water depth in these compartments was measured by soundings which were then used to model the bilge water volumes on the computer as accurately as possible. A further quantity of approximately 1.5 tonnes seawater was later found the forepeak and in the rockwool insulation behind the linings whilst the Aquila was being broken up. The inclined condition was corrected for the resultant weights and centres, along with corrections for other items to be removed, added or moved to obtain the lightship condition – see table of items to come off in appendix 7.

The most notable aspect of the figures in this 2009 inclining report is the increase in lightship displacement. The 1988 inclining trial indicated a lightship displacement of 50.28 tonnes whilst the 2009 trial indicated a lightship of 62.46 tonnes, a 24% increase. At some time after completion the Aquila was fitted with about 3 tonnes of additional ballast located under the accommodation sole and in the steering flat. The object of this was to increase the propeller immersion and hence its thrust, but in so doing, the aft freeboards were significantly reduced. The additional ballast was located with its centre of gravity well above the base line so it increased the vessel's displacement but did not substantially reduce the height of the centre of gravity.

The weight of the fishing equipment and other items of deadweight had also increased; the assumption was made in the original SIB that the fishing equipment amounted to 2.03 tonnes but by the time of the accident this had more than doubled. The net effect of these weight increases was that the displacement in the 'Depart Port' loading condition was estimated in 1988 to be 59.2 tonnes, but by 2009, this figure was nearly 32% greater at 78.1 tonnes.

Appendix 8 is comprised of the same loading conditions as Appendix 6, but with amended lightship and deadweight figures reflecting the 2009 inclining trial and a detailed re-assessment of the deadweight items. It will be seen from the data in Appendix 8 that the vessel fails to comply with the stability requirements by a substantial margin in all but the lightship condition.

8. The capsize condition

The Aquila was towing two scallop dredge beams in a moderate following sea with waves of up to 2 metres in height at the time of the accident. The dredge beam wires were connected to the boat via blocks mounted on the jockey poles ends – the poles are shown in their deployed positions in diagrams 6 and 7. The engine speed was set at between 1450 and 1500 rpm – approximately 80% of maximum output. It has been estimated that propeller thrust with the engine running at this speed would have been between 2.2 and 2.5 tonnes.

The deadweight table in Appendix 9 is the estimated condition of the vessel at the time of the accident. It has been drawn up from information derived from the 2009 inclining trial, and from interviews with the accident survivor, equipment suppliers and individuals who had knowledge of the boat and its operation. It therefore represents the best estimate of the accident condition. Items 21 and 22 in the deadweight list represent the estimated 0.315 tonnes per side vertical element of the loads imposed on the port and starboard jockey pole ends by the dredge wires which were assumed to be running aft of the pole ends at about 15 degrees to the horizontal. The righting lever curve for the condition (curve 1) is reproduced in diagram 5 below. In this condition, the vessel did not comply with three of the six stability criteria - the minimum area under the righting lever curve between 30 and 40 degrees (0.03 metre.radians required, 0.029 metre.radians achieved), the angle of heel at which the maximum righting lever occurs (25 degrees required, 23.3 degrees achieved) and the maximum righting lever between 30 and 90 degrees (0.20 metres required, 0.193 metres achieved). For the purposes of comparison, a second righting lever (curve 2) is shown indicating the level of stability which would have complied, albeit marginally. Compliance has been achieved by lowering the condition KG by 0.087 metres from 2.305 metres to 2.218 metres. Note that the curves do not commence at the 0,0 origin because the vessel had a transverse centre of gravity approximately 18mm to port at the time of the accident and the righting levers shown assume heeling to starboard as in the accident.

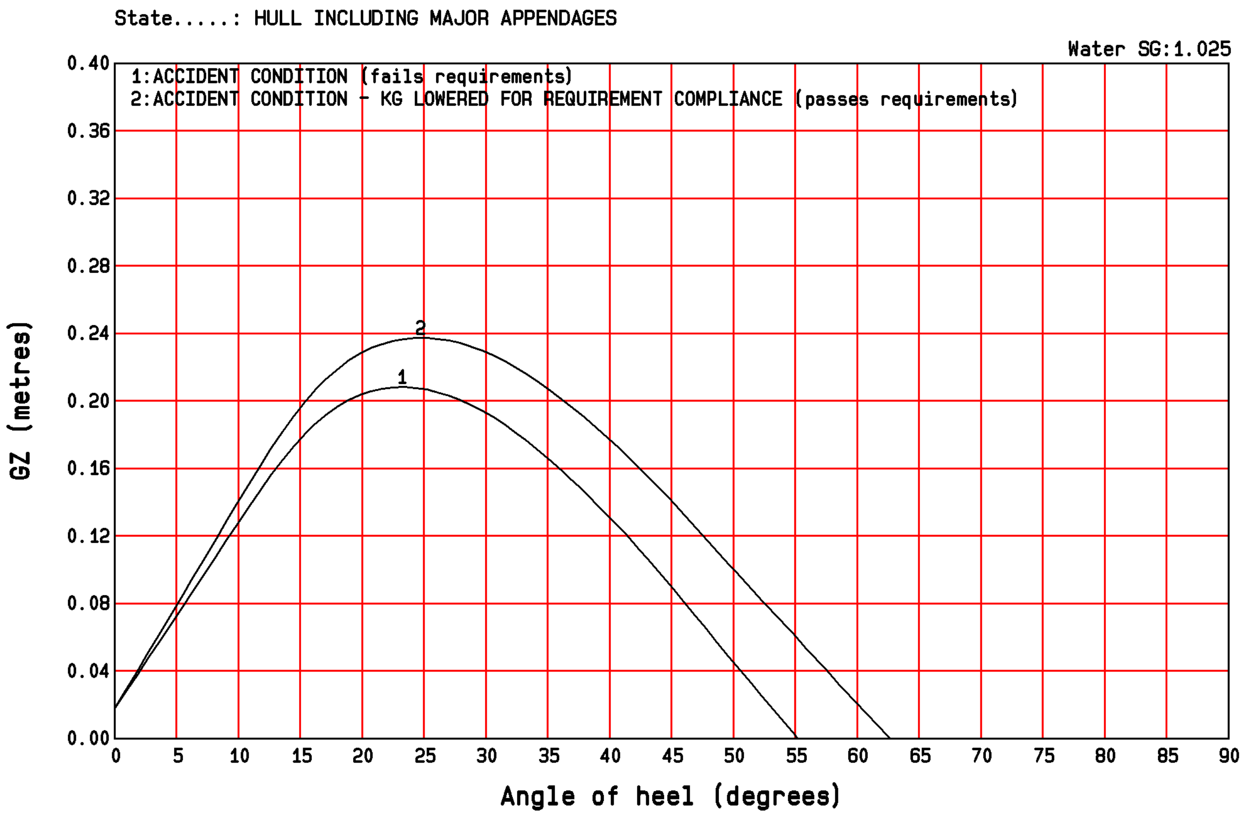


Diagram 5 – Righting lever plots for accident condition and with KG lowered to comply

Diagram 6a shows the Aquila at equilibrium before the accident occurred with the stern pulled down equally by the tension in the port and starboard dredge wires.

When the starboard dredge wire caught fast, the immediate effect would have been to heel and yaw the vessel to starboard (see diagrams 6b and 7b). The initial yawing moment (the horizontal element of the additional force imposed on the starboard jockey pole end times the normal distance from the line of action of this force to the centre of buoyancy) would have been greater than the heeling moment. However, since roll inertia (i.e. the tendency of a body to resist acceleration) is much lower than yaw inertia for conventional hull shapes, it is considered that heel would have increased more rapidly than yaw.

As the vessel heeled and yawed, the heeling (or capsizing) moment caused by the starboard dredge wire would have been growing as the heeling lever, measured about the centre of buoyancy, increased in length. At about 20 degrees heel the jockey pole end was at the same height as the centre of buoyancy and thereafter, the lever length and consequently the heeling moment would have reduced. Similarly, the righting moment from the port wire, albeit less because the dredge wire was not caught, would have been dropping and would have reduced to zero at about 50 to 55 degrees of heel. As heel increased beyond this angle, tension in the port wire would start to contribute to the heeling moment. Diagrams 6a and 6b illustrate the increasing heeling lever to starboard and the decreasing righting lever to port as heel increased.

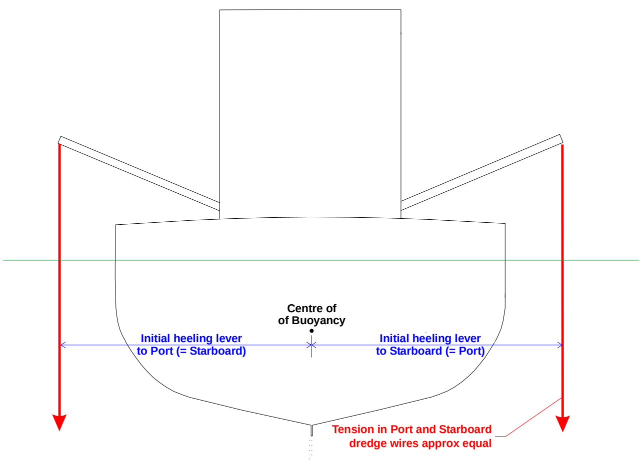


Diagram 6a – Dredge wire heeling and righting levers - vessel upright

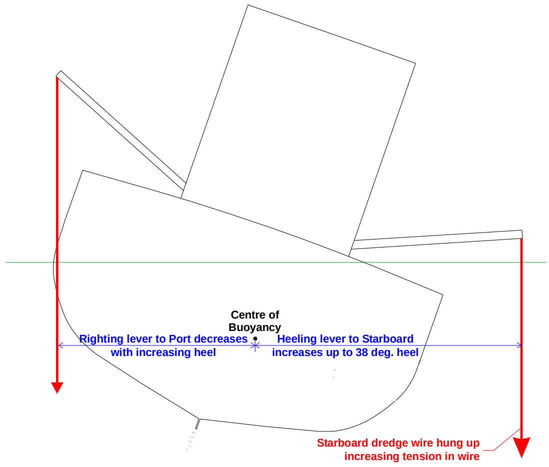


Diagram 6b – Dredge wire heeling and righting righting levers - vessel heeled

The net effect of an increasing heeling lever to the starboard dredge wire and a decreasing righting lever to the Port dredge wire was to increase the capsizing moment up to about 20 degrees of heel. Thereafter, as explained above, the moment would have started to decrease. Nevertheless, the righting and heeling lever data
and the plots of this data (reproduced in diagram 9) show that at 20 degrees heel,
the heeling lever was still greater than the righting moment inherent in the hull. In other words, without a reduction in the heeling lever, capsize was inevitable.

The yaw lever arms were also changing as the accident developed. The starboard yaw lever arm was reducing rapidly in length as the vessel yawed to starboard whilst the port lever arm lengthened - See diagrams 7a and 7b below.

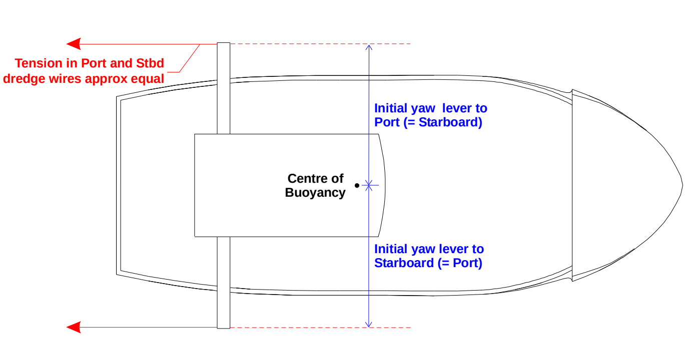


Diagram 7a – Dredge wire yaw levers before accident occurred

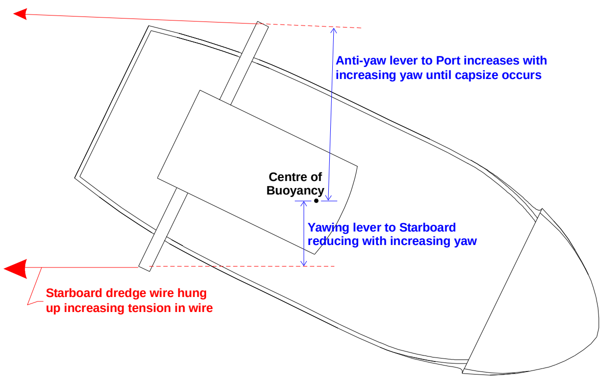


Diagram 7b – Dredge wire yaw levers changing as accident developed

Effectively, the vessel was pinned at the starboard jockey pole end, a point which although well off the centreline was also well aft of amidships. It is therefore considered that high yaw inertia (relative to roll inertia), coupled with decreasing yaw moment to starboard and an increasing 'anti-yaw' moment to port, albeit with lower tension in the port wire, would have resulted in capsize through the mechanism discussed above before the vessel had reached a high angle of yaw.

Diagrams 8a to 8f on the next page summarise the capsize sequence. Whether or not the engine had been throttled back by the time the situation had reached that shown in diagram 8e, the vessel would have been coming to a standstill with a very dangerous, if not irrevocable heel to starboard. In this already hazardous situation, any of the waves advancing from astern would have lifted the stern of the vessel, heeling it further about the anchored outboard end of the starboard jockey pole (see diagram 8e). By this time, the tension in both dredge wires (albeit less in the port wire, but with an increasing lever arm) would have been acting to heel the vessel and with the angle of vanishing stability (approximately 55 degrees - see righting lever plot - Appendix 9) past, capsize would inevitably have followed.

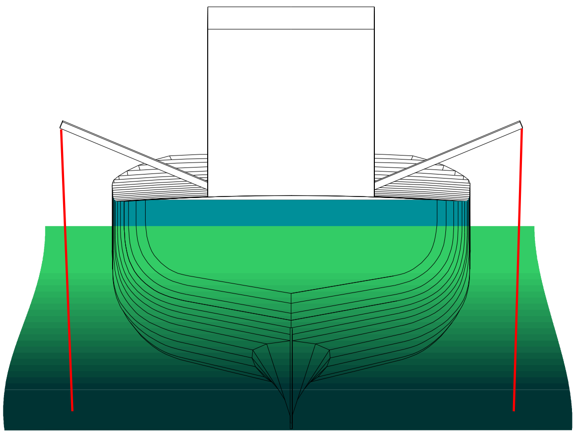


Diagram 8a – Aquila towing port and starboard dredges before accident. Waves coming from astern

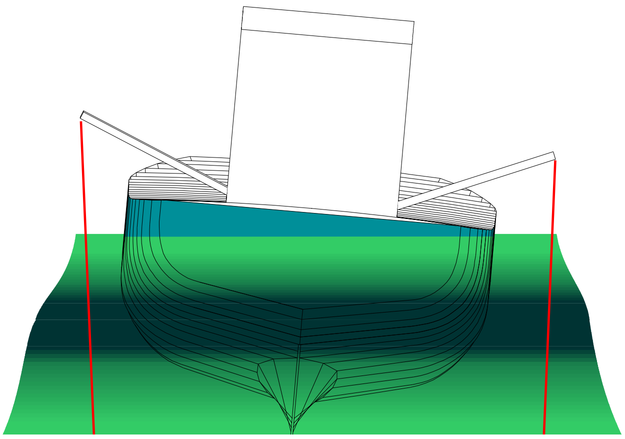


Diagram 8b – Starboard dredge wire becomes trapped. Vessel heels in response to increased tension in starboard wire

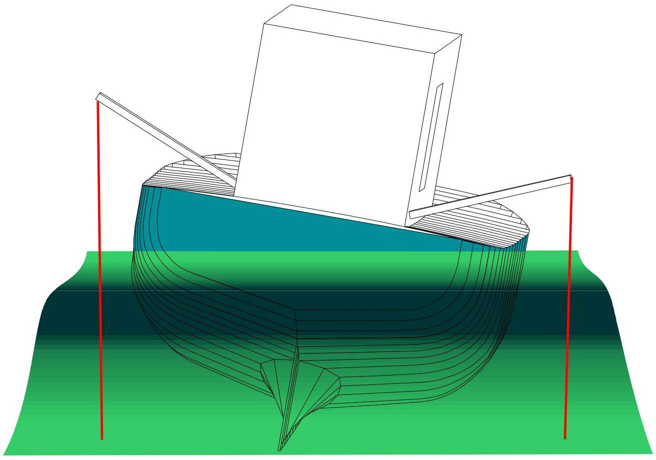


Diagram 8c - Heel to starboard increases and vessel starts to yaw to starboard, both in response to greater tension in starboard dredge wire

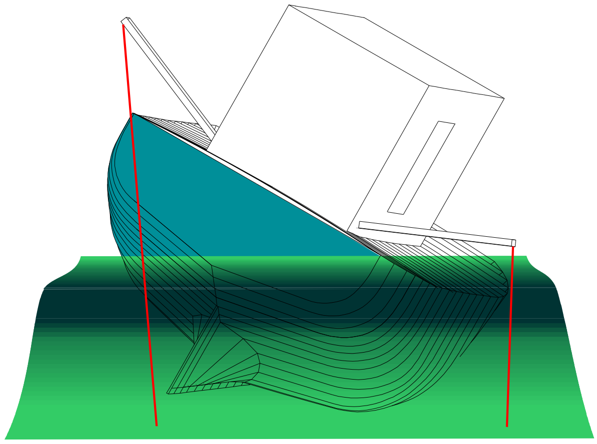


Diagram 8d - Heel and yaw to starboard increase. Righting moment from port dredge wire reduces with increasing heel

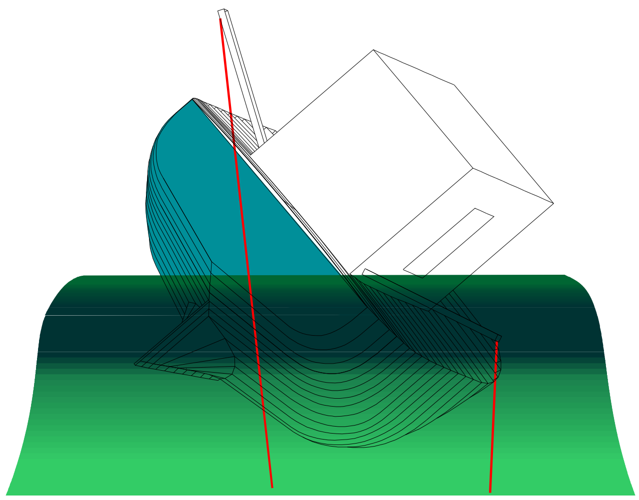


Diagram 8e - Vessel continues to heel and yaw to starboard. Wave from astern lifts stern sections increasing capsizing moment about starboard jockey pole end. Righting moment from port dredge wire reducing to zero as heel and yaw increase

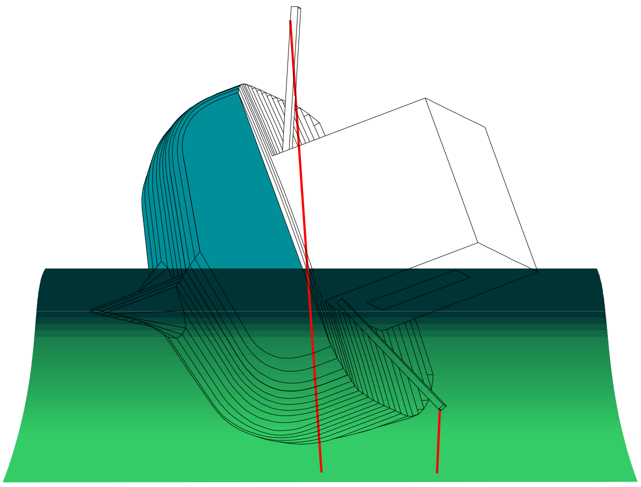


Diagram 8f - Tension in both port and starboard dredge wires now contributing to heeling moment. Vessel now beyond 54 degree angle of vanishing stability making capsize inevitable

The tension in the port dredge wire throughout the accident was that which was sufficient to drag the port scallop dredge along the bottom. Assuming the propeller was producing about 2.5 tonnes thrust, this would have resolved into about 1.3 tonnes tension for a wire at 15 degrees to the horizontal. However, the tension in the starboard dredge wire as the accident developed was much greater, comprised of a combination of propeller thrust, vessel momentum and increased buoyancy under the aft sections from a wave passing from astern. It is considered that the last of these would have been the most significant. Assuming that it started to pass along the hull when the dredge wire came fast (i.e. before heel commenced), a 1 metre high wave (i.e. half the maximum wave height reported) with the crest at the transom and extending about 4 metres along the hull could have provided a buoyancy upthrust in the aft sections of at least 10 tonnes. This would have reduced if the wave passed after the vessel had started to heel but nonetheless, it would have represented the largest component of the capsizing moment and more than sufficient, in itself, to capsize the vessel, given that it was pinned at the starboard jockey pole end.

The heeling lever analysis indicates that using a hydrostatic analysis the minimum load acting vertically downwards at the starboard jockey pole end would have to be at least 4.52 tonnes in magnitude to capsize the Aquila in flat water. The plot in appendix 9 ,reproduced in diagram 9 below, illustrates this minimum heeling lever superimposed on the righting (GZ) lever.

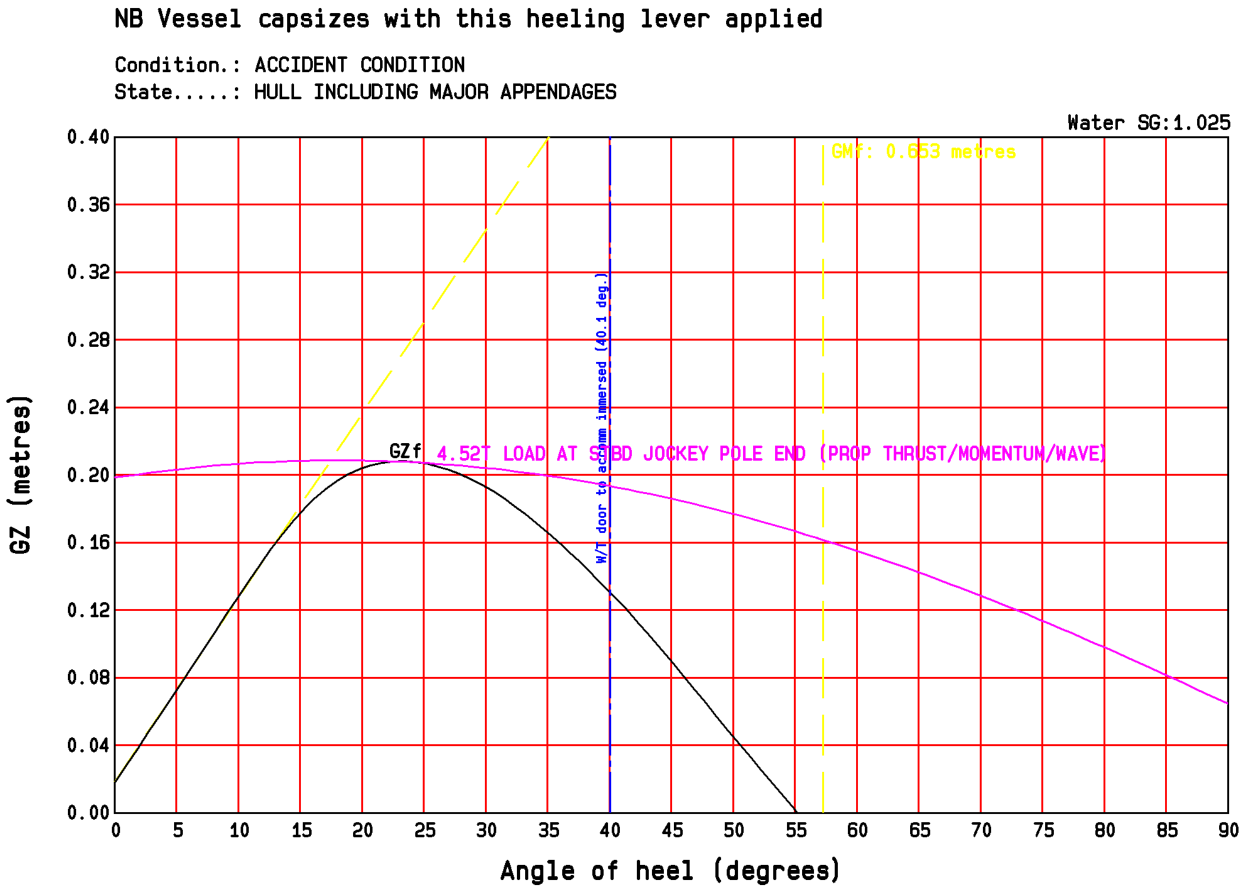


Diagram 9 – Righting and heeling lever curves for accident condition

It should be emphasised that the heeling lever shown in the plot is the minimum that would have been required to capsize the Aquila in the accident condition. It is very probable that the sum of the forces acting about the starboard pole end were in fact considerably greater than the 4.52 tonnes minimum. In light of this, a further heeling lever was assessed, using the righting lever shown in diagram 5 (curve 2) that would have complied with the requirements, i.e. with the KG at a reduced height of 2.218 metres rather than the 2.305 metres estimated. This analysis indicates that the vessel would have capsized in this condition if the sum of the forces acting about the starboard pole end were greater than 5.18 tonnes. This analysis is detailed in appendix 9 and the heeling and righting levers are plotted in appendix 9, reproduced in diagram 10 below.

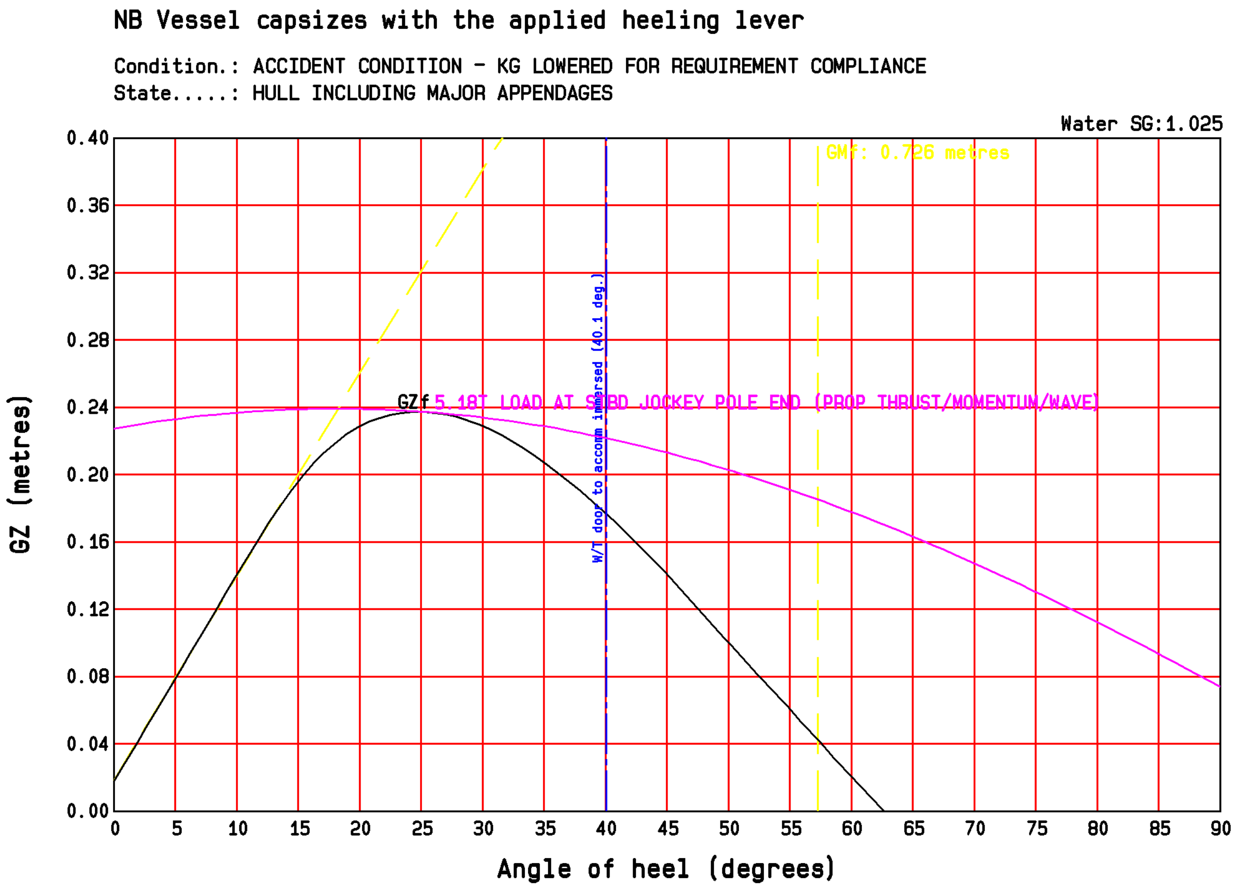


Diagram 10 – Righting and heeling lever curves for accident condition with KG lowered to comply

It is considered that the combination of forces acting at the starboard jockey pole end, particularly the buoyancy upthrust in the prevailing sea conditions, would have been in excess of the minimum 5.18 tonnes required to capsize the boat in this condition with a lowered KG. It follows that the Aquila would in all probability have capsized whether or not it complied with the stability requirements at the time of the accident.

It should be noted that cross-connect pipe between the two fuel tanks was found to be open during the investigation subsequent to the accident. This was a 50mm bore pipe which could have increased the free surface moment in the main fuel oil tanks to very dangerous levels, potentially raising the vessel's centre of gravity by over 160mm. However, in the circumstances it is not considered that this contributed significantly to the accident, partly because the tanks were little more than a third full at the time, the vessel had a substantial trim by the stern and the cross-connect pipe was at the front of the tanks; in other words, the fuel contents would have been largely below the level of the pipe. In addition, it is understood that the accident happened within a few seconds which would not have given time for sufficient fuel to flow between the tanks to affect the outcome significantly.

9. Conclusions

In 1988, the Aquila was designed and built to comply with the stability requirements for a vessel greater than 12 metres in registered length and the lightship data derived from the 1988 inclining trial confirmed that the vessel complied with these requirements in all the conditions in the stability booklet.

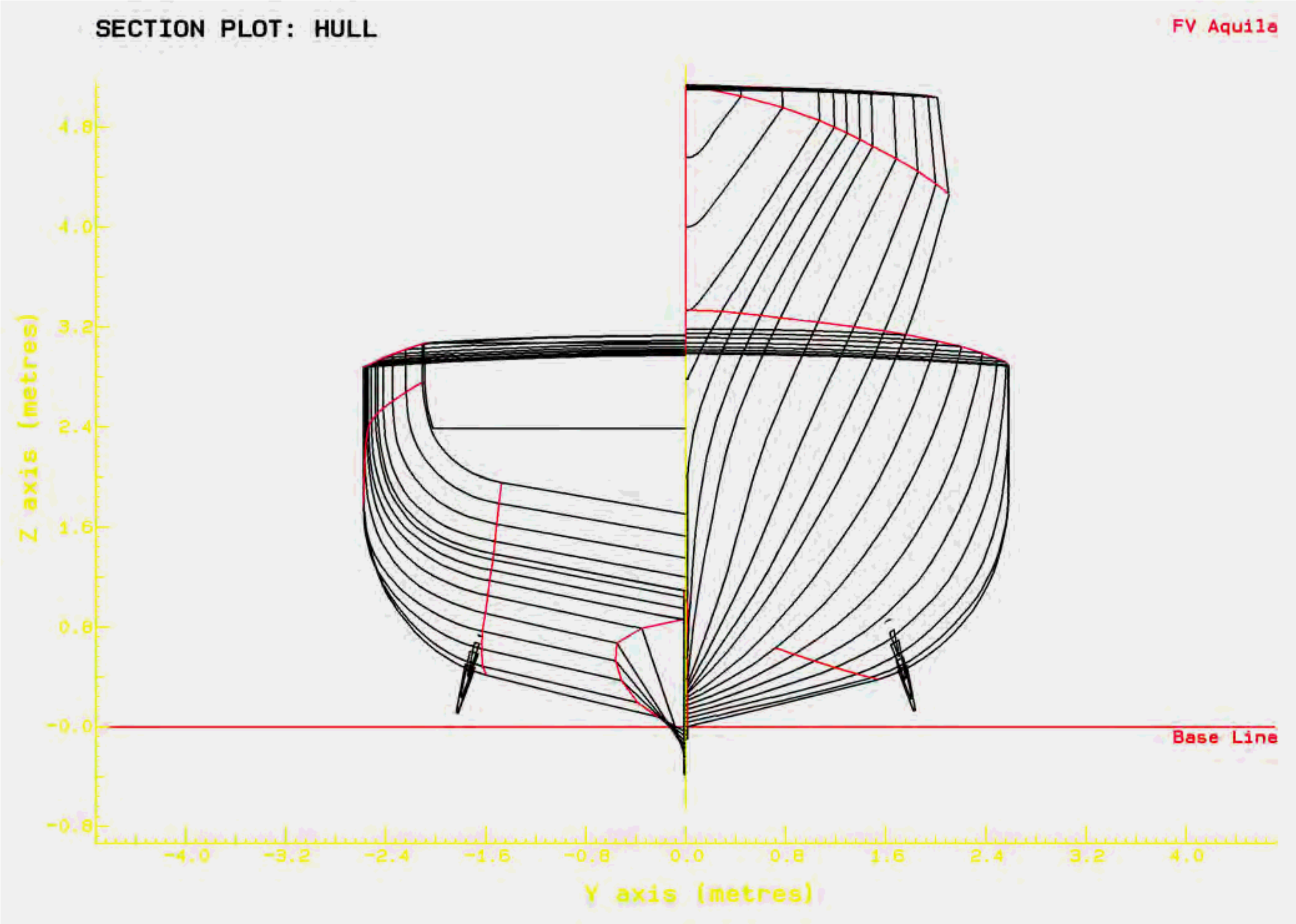
Between 1988 and 2009, however, the installation of additional ballast and other fit-out items had increased lightship weight by 24% without improving the stability. In addition, fishing gear weights had more than doubled from 2.03 tonnes to over 4.4 tonnes over the same period and the overall effect, as stated in Section 7, was to increase the 'Depart Port' displacement by 32% whilst reducing stability significantly below the levels required at the time for fishing vessels of over 12 metres length and recommended for those such as Aquila below this length.

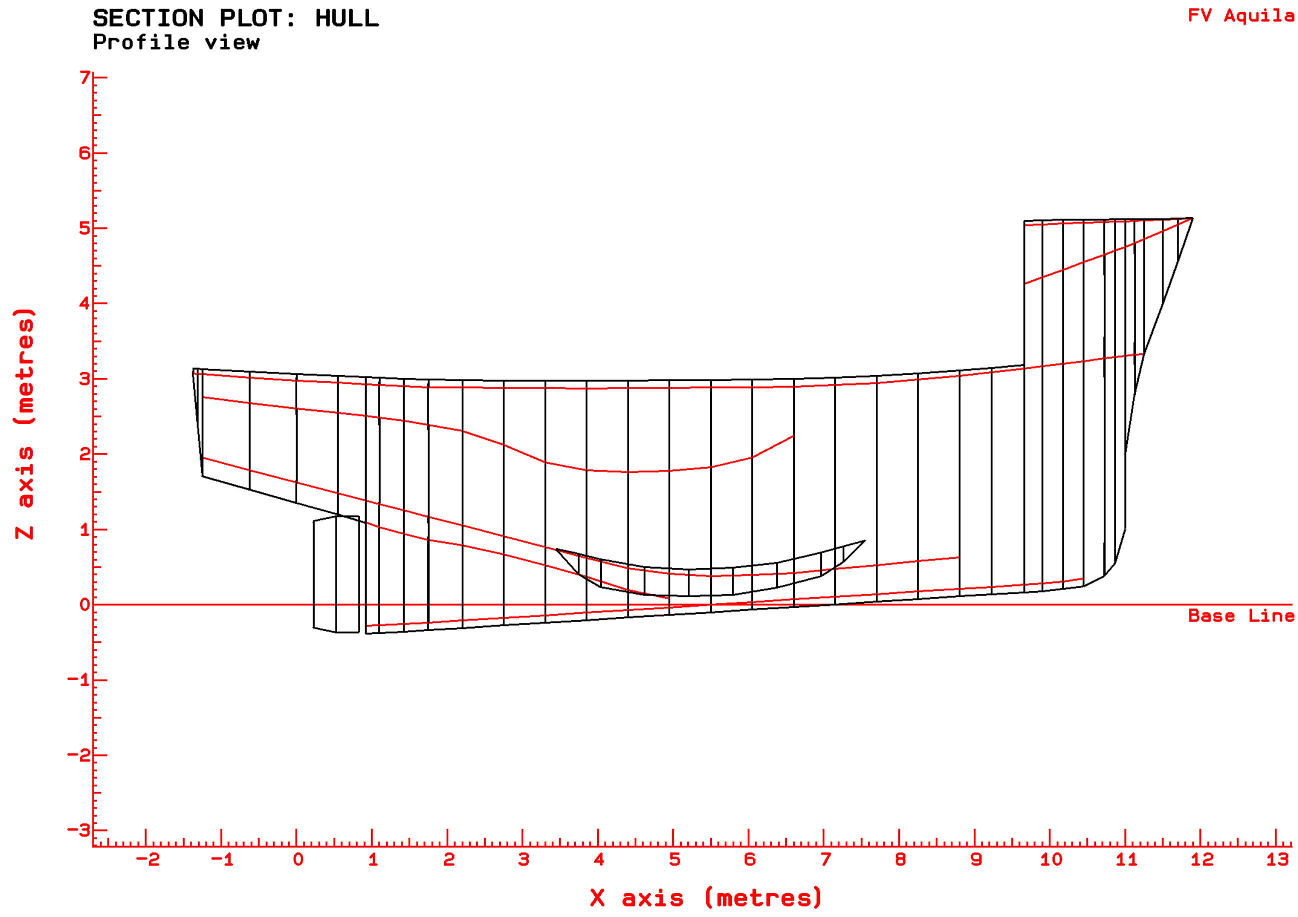
Any fishing vessel is at particular risk towing gear in a following sea. The plot and the associated data in appendix 9 indicate that when the starboard dredge wire came fast, a combined load of 4.52 tonnes working on the end of the jockey pole would have been sufficient to capsize the vessel. This load was the resultant partly of propeller thrust (which may have reduced if the throttle was pulled back as the accident developed) and the vessel's momentum, but predominantly of the buoyant force resulting from even a relatively small wave coming from astern, passing under and lifting the stern sections as the vessel heeled.

Further analysis indicated that even if the Aquila had fully complied with the stability requirements, it was very probable that capsize would still have occurred.

Appendix 1

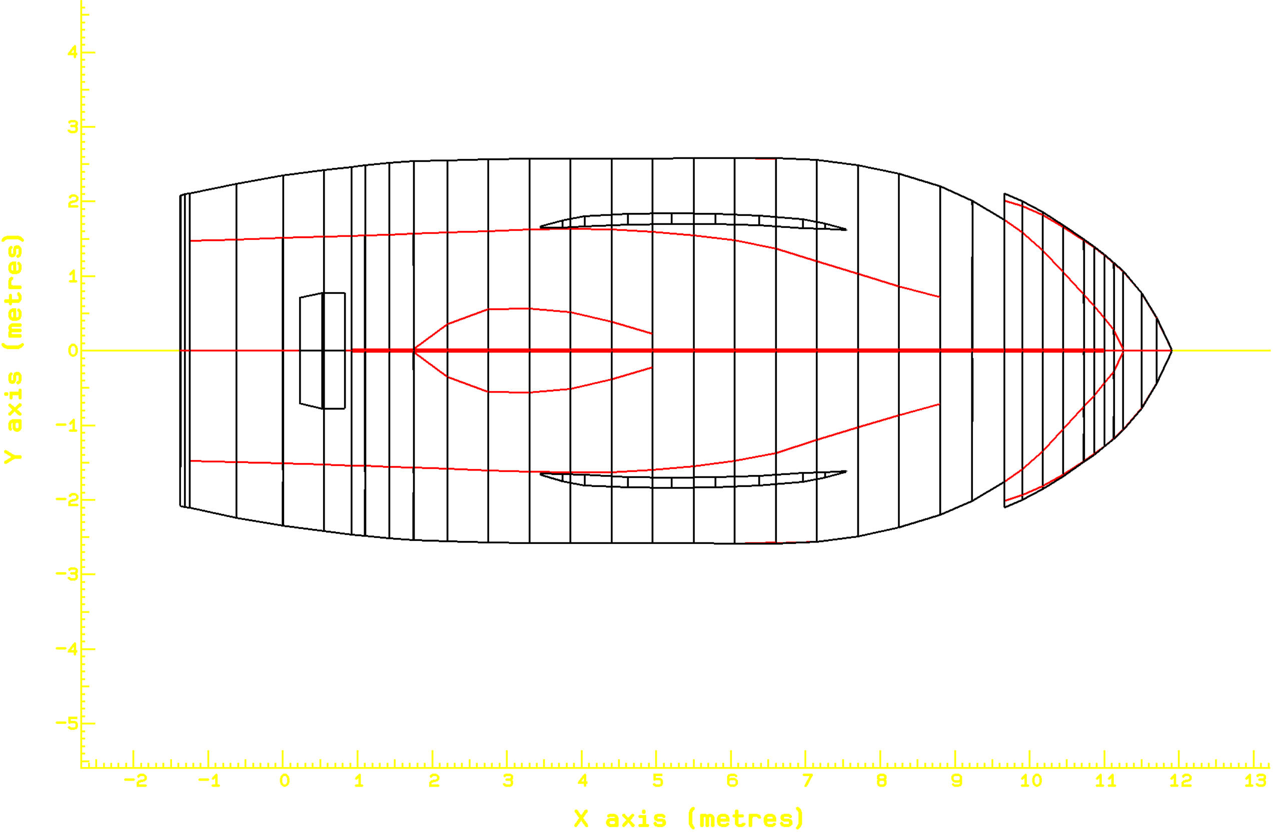
Hull section plots


SECTION PLOT: HULL
FV Aquila
Base Line
4.8
4.0
3.2
2.4
1.6
0.8
-0.0
-0.8
-4.0
-3.2
-2.4
-1.6
-0.8
0.0
0.8
1.6
2.4
3.2
4.0
Z axis (metres)
Y axis (metres)


SECTION PLOT: HULL
Profile view
FV Aquila
Base Line
7
6
5
4
3
2
1
0
-1
-2
-3
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Z axis (metres)
X axis (metres)

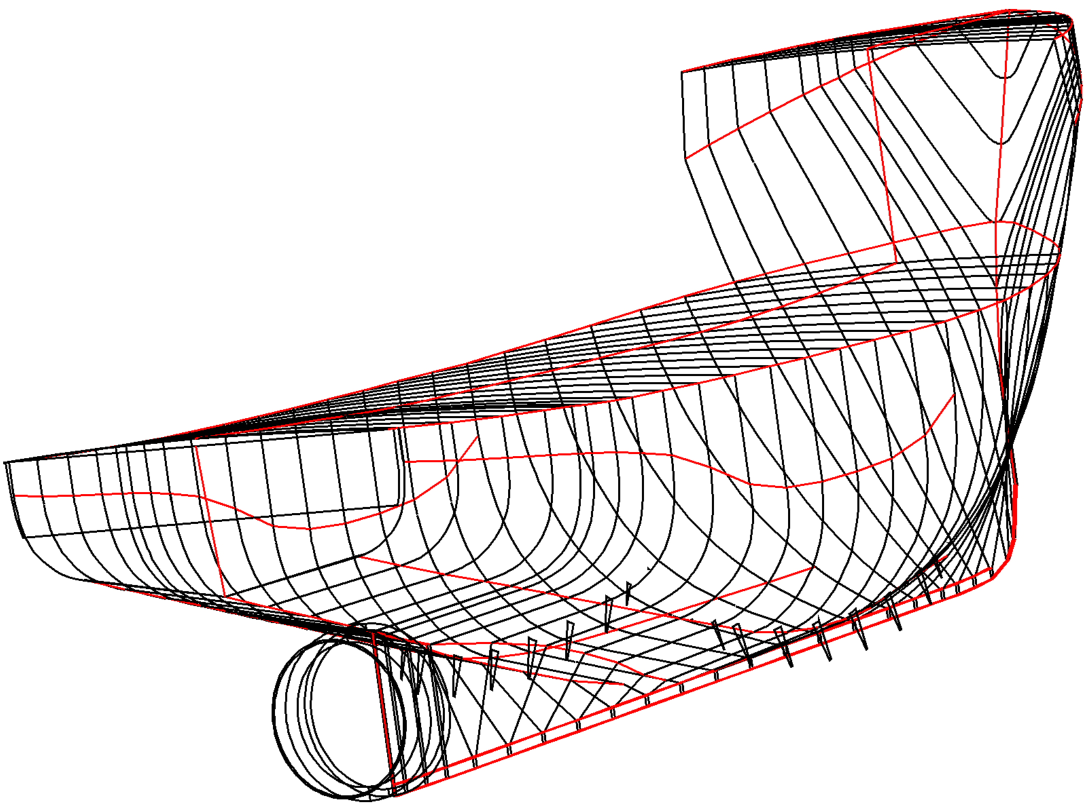
SECTION PLOT: HULL
Plan view

FV Aquila



SECTION PLOT: HULL
Isometric view

FV Aquila



Appendix 7

2009 investigation inclining trial report

Inclining Trial Report – September 2009

Vessel name/number..... :	Fishing Vessel 'Aquila'
Trial location.................. :	Quayside at BUTEC base, Kyle of Lochalsh
Trial date........................ :	23rd September, 2009
Weather conditions........ :	Low tide - sheltered from NW Force 2-3 wind by quayside
Sea conditions .... :	+/- 10mm wavelets
Specific gravity of water . :	1.026
Vessel condition............. :	Fuel oil bunkers pressed full, all other tanks empty, floodwater in E/R, fishroom and accommodation bilges - See table of items to come off and go on
Keel rake........................ :	0.700 metres over LBP
Draught at FP................. :	1.768m about keel line (2.015m about Base Line)
Draught at transom .... :	0.63 metres about transom base (measured up transom)
Draught at AP .... :	2.745m about keel line (2.295m about Base Line)
Mean draught midships.. :	2.255 metres about keel line
Trim over LBP .... :	0.280 metres by stern
Forward pendulum......... :	3.121 metres long, sited 10.1 metres forward of AP
Aft pendulum.................. :	3.052 metres long, sited 2.6 metres forward of AP
Inclining weights............. :	48 in number, each 20kg, totalling 960kg in weight
Personnel....................... :	[redacted]
Displacement .... :	70.898 + 0.173 (2 persons) = 71.071 tonnes

Pendulum deflection table

No.	*Shifts Direction*	*Weight Tonnes*	*Distance metres*	*Deflections Aft - mm*	*GM metres*	*Deflections Fore - mm*	*GM metres*
1	Stbd > Port	0.120	4.277	44.0	0.501	46.5	0.485
2	Stbd > Port	0.120	4.277	46.0	0.479	46.0	0.490
3	Stbd > Port	0.120	4.277	44.0	0.501	44.5	0.506
4	Stbd > Port	0.120	4.277	46.0	0.479	47.0	0.480
5	Port > Stbd	0.120	4.277	44.0	0.501	47.0	0.480
6	Port > Stbd	0.120	4.277	45.5	0.484	44.5	0.506
7	Port > Stbd	0.120	4.277	46.0	0.479	46.0	0.490
8	Port > Stbd	0.120	4.277	44.0	0.501	46.0	0.490
9	Stbd > Port	0.120	4.277	44.5	0.495	48.0	0.470
10	Stbd > Port	0.120	4.277	46.0	0.479	46.0	0.490
11	Stbd > Port	0.120	4.277	50.0	0.441	50.0	0.451
12	Stbd > Port	0.120	4.277	44.5	0.495	47.5	0.474
13	Port > Stbd	0.120	4.277	45.0	0.490	47.5	0.474
14	Port > Stbd	0.120	4.277	46.0	0.479	48.0	0.470
15	Port > Stbd	0.120	4.277	47.5	0.464	47.5	0.474
16	Port > Stbd	0.120	4.277	44.0	0.501	46.0	0.490
				Mean aft:	*0.486*	*Mean fore:*	*0.482*

Inclined condition

Displacement :	71.071 tonnes
KMT .... :	2.899 metres
GMT mean .... :	0.484 metres
KG................. :	2.415 metres above Base Line
LCB .... :	4.711 metres forward of AP
VCB .... :	1.419 metres above Base Line
LCG .... :	4.736 metres forward of AP

Items to come off to achieve lightship condition

Item	*Weight tonnes*	*LCG - m about AP*	*Long'l Moment t.m*	*VCG - m about Base Line*	*Vertical Moment t.m*	*FSM t.m*
Fuel - Port (1750 litres)	1.575	5.496	8.656	0.618	0.973	8.236*
Fuel - Stbd (1750 litres)	1.575	5.496	8.656	0.618	0.973	8.236*
Inclining weights	0.960	4.140	3.974	3.075	2.952	-
1 Person forward (Engine Room)	0.083	10.050	0.834	1.050	0.087	-
1 Person aft (Accommodation)	0.090	2.110	0.190	1.475	0.133	-
4 x holdalls personal effects (galley)	0.080	0.850	0.068	4.300	0.344	-
Ship's spares (Accommodation)	0.350	1.400	0.490	1.600	0.560	-
Fishing spares (Void under W/H)	0.300	3.500	1.050	3.200	0.960	-
Floodwater in insulation	0.875	3.000	2.625	2.600	2.275	-
Floodwater (Fore Peak)	0.646	10.767	6.955	2.520	1.628	0.000
Floodwater (Engine Room)	0.688	7.831	5.388	0.355	0.244	1.108
Floodwater (Fishroom)	0.949	5.014	4.758	0.202	0.192	0.329
Floodwater (Accommodation)	1.215	1.943	2.361	1.089	1.323	0.732
Total items to come off:	*9.386*	*4.902*	*46.006*	*1.347*	*12.645*	*18.641*

Items to go on to achieve lightship condition

Item	*Weight tonnes*	*LCG - m about AP*	*Long'l Moment t.m*	*VCG - m about Base Line*	*Vertical Moment t.m*	*FSM t.m*
Batteries (Engine Room)	0.320	7.700	2.464	2.010	0.643	-
Pound boards (Aft deck)	0.040	-0.415	-0.017	3.650	0.146	-
Pound boards (Fishroom)	0.100	4.830	0.483	1.250	0.125	-
Liferaft (Wheelhouse top)	0.100	3.700	0.370	6.200	0.620	-
Pyrotechnics (Accommodation)	0.040	2.000	0.080	1.650	0.066	-
EPIRB (Aft gantry)	0.010	1.400	0.014	7.100	0.071	-
Radio antennae (Aft gantry)	0.030	1.400	0.042	8.200	0.246	-
Deck lights - aft gantry	0.008	1.400	0.011	7.500	0.060	-
Radar scanner #1 (Forward gantry)	0.050	5.200	0.260	8.100	0.405	-
Radar scanner #2 -(Forward gantry)	0.050	5.200	0.260	8.700	0.435	-
Antenna (Forward gantry)	0.030	5.200	0.156	9.000	0.270	-
Total items to go on:	*0.778*	*5.300*	*4.124*	*3.968*	*3.087*	*0.000*

Items to move to achieve lightship condition

Item	*Weight tonnes*	*LCG change m*	*Long'l Moment t.m*	*VCG change m*	*Vertical Moment t.m*	*FSM t.m*
Fore mast top - raise 0.3m	0.010	0.000	0.000	0.300	0.003	-
Gantry over accomm - raise 0.8m	0.150	-0.500	-0.075	0.800	0.120	-
Scotch pole - raise part 3.1m	0.060	-0.800	-0.048	3.100	0.186	
Trawl block bracket (P) - raise 30mm	0.090	0.000	0.000	0.030	0.003	
Gilson block (S) - raise 5.5m	0.040	-3.000	-0.120	5.500	0.220	
Total items to move:	*0.350*	*-0.694*	*-0.243*	*1.519*	*0.532*	*0.000*

Lightship Summary

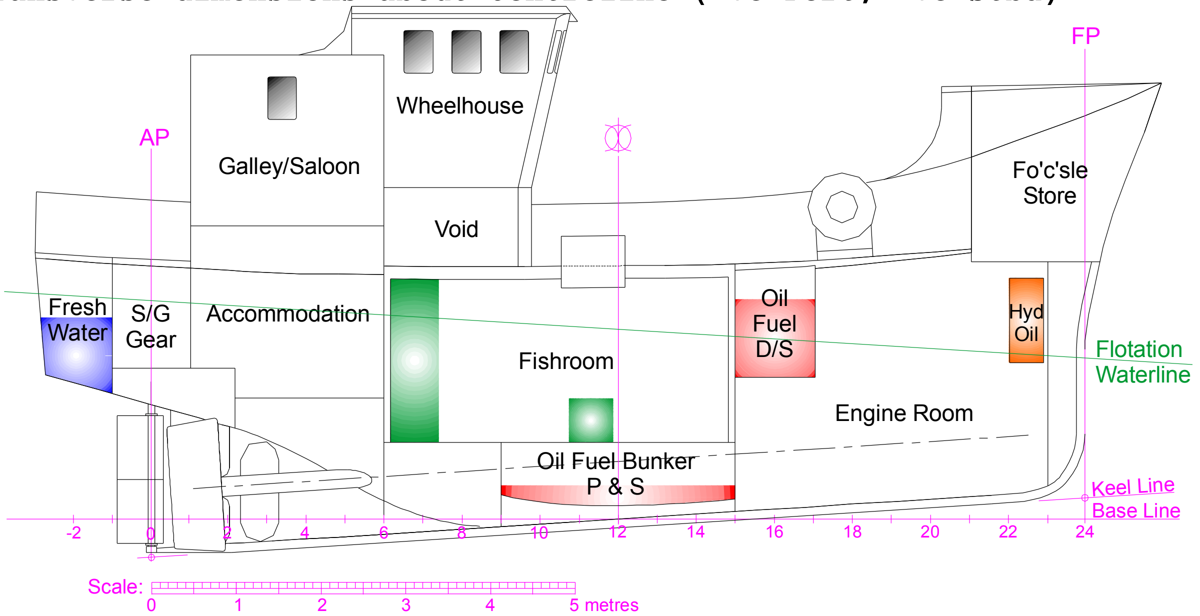
Item	*Weight tonnes*	*LCG - m about AP*	*Long'l Moment t.m*	*VCG - m about Base Line*	*Vertical Moment t.m*	*FSM t.m*
Condition at lightship trial	71.071	4.736	336.592	2.415	171.636	18.641
Total items to come off	-9.386	4.902	-46.006	1.347	-12.645	-18.641
Total items to go on	0.778	5.300	4.124	3.968	3.087	0.000
Total items to move	-	-	-0.243	-	0.532	-
Lightship:	*62.463*	*4.714*	*294.467*	2.603	*162.611*	
				FSM:	*-18.641*	
			VCG:	*2.305*	*143.970*	

* Valve in 50mm diameter cross-connect pipe open

DEADWEIGHT TABLE

Vessel....: FV Aquila
Condition.: ACCIDENT CONDITION
State.....: HULL INCLUDING MAJOR APPENDAGES
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)



	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 D/B - PORT (36%)	0.672	5.516	3.707	-1.007	-0.677	0.624	0.419	0.942
2	OIL FUEL D/B - STBD (36%)	0.672	5.516	3.707	1.007	0.677	0.624	0.419	0.942
3	OIL FUEL D/S (75%)	0.693	7.342	5.088	-1.965	-1.362	2.187	1.516	0.063
4	FRESH WATER (50%)	0.908	-0.844	-0.766	0.000	0.000	2.397	2.176	0.369
5	SCALLOPING GEAR DEPLOYED	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	SPARE SCALLOP DREDGES (2)	0.200	6.650	1.330	0.000	0.000	3.150	0.630	-
7	SPARE TOOTH BARS (136)	1.224	-0.900	-1.102	0.000	0.000	3.200	3.917	-
8	FISHING EQUIPMENT SPARES	0.300	3.500	1.050	0.000	0.000	3.200	0.960	-
9	GENERAL SPARES	0.350	1.400	0.490	0.000	0.000	1.600	0.560	-
10	CREW AND EFFECTS (4)	0.400	1.500	0.600	0.000	0.000	4.200	1.680	-
11	CONSUMABLES	0.100	1.610	0.161	0.000	0.000	3.950	0.395	-
12	CATCH IN F/R AFT (98 BAGS)	3.675	3.235	11.889	0.000	0.000	1.870	6.872	-
13	ICE WITH F/R AFT CATCH	0.290	3.235	0.938	0.000	0.000	1.870	0.542	-
14	CATCH IN F/R FWD (22 BAGS)	0.825	5.400	4.455	0.000	0.000	1.350	1.114	-
15	ICE WITH F/R FWD CATCH	0.065	5.400	0.351	0.000	0.000	1.350	0.088	-
16	ICE (10%/DAY MELT RATE)	2.245	5.200	11.674	0.000	0.000	1.200	2.694	-
17	JOCKEY POLES STOWED OFF	-0.310	1.175	-0.364	0.000	0.000	4.296	-1.332	-
18	JOCKEY POLES DEPLOYED ON	0.310	1.175	0.364	0.000	0.000	3.592	1.114	-
19	DREDGE BLOCKS STOWED OFF	-0.070	1.175	-0.082	0.000	0.000	5.345	-0.374	-
20	DREDGE BLOCKS DEPLOYED ON	0.070	1.175	0.082	0.000	0.000	3.938	0.276	-
21	V.LOAD AT DREDGE BLOCK P	0.315	1.175	0.370	-3.320	-1.046	3.938	1.240	-
22	V.LOAD AT DREDGE BLOCK S	0.315	1.175	0.370	3.320	1.046	3.938	1.240	-
	DEADWEIGHT TOTAL	13.249	3.345	44.312	-0.103	-1.362	1.973	26.147	2.316
	LIGHTSHIP	62.463	4.714	294.451	0.000	0.000	2.305	143.977	-
	DISPLACEMENT	75.712	4.474	338.762	-0.018	-1.362	2.247	170.124	2.316

Free Surface Correction (Total Free Surface Moment/Displacement)	0.031
VCG fluid	2.278

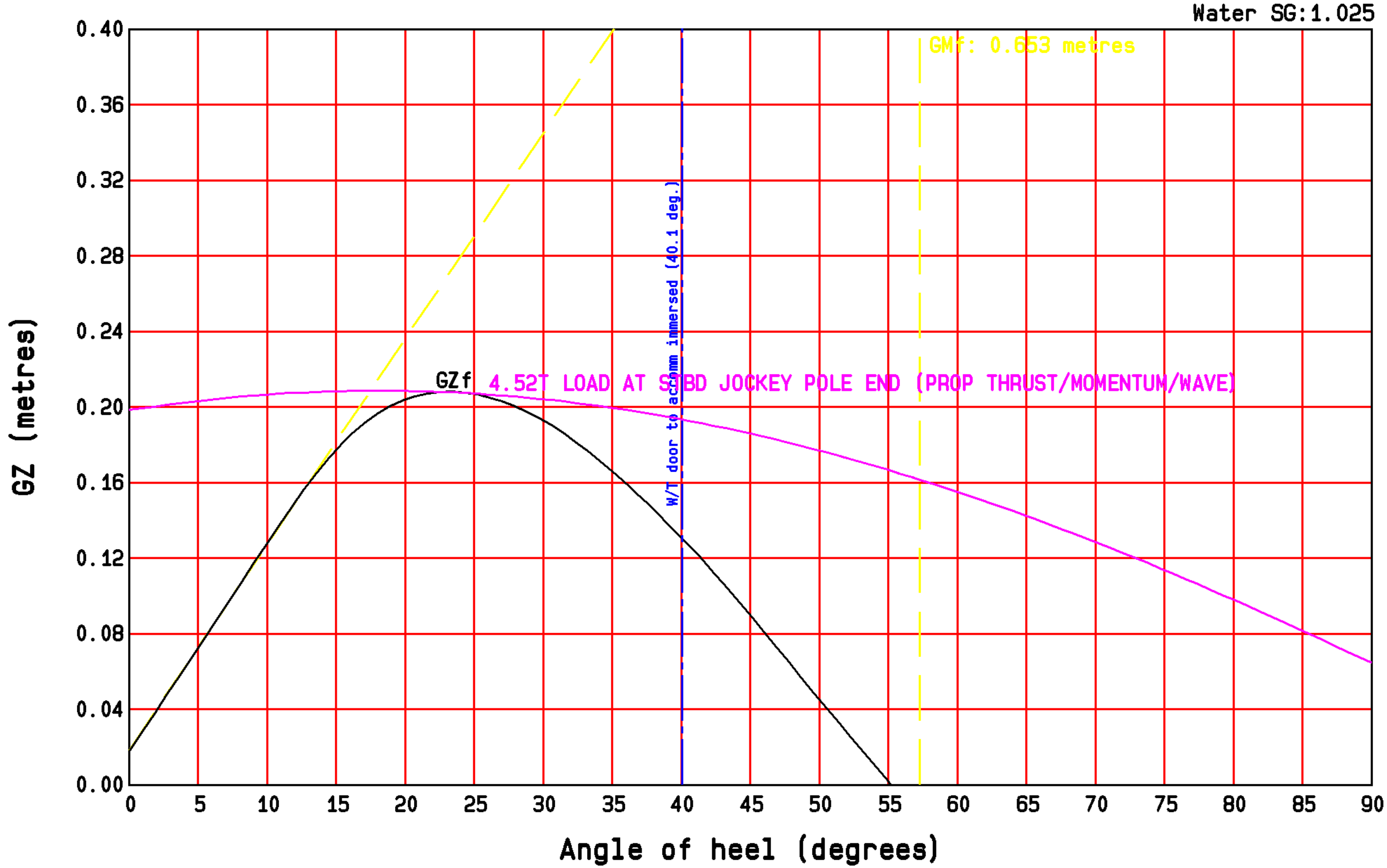
Appendix 9

Accident loading condition data

GZ PLOT

NB Vessel capsizes with this heeling lever applied

Condition.: ACCIDENT CONDITION
State.....: HULL INCLUDING MAJOR APPENDAGES



SAILING STATE

Vessel....: FV Aquila
Condition.: ACCIDENT CONDITION
State.....: HULL INCLUDING MAJOR APPENDAGES
Water SG..: 1.025
Compliance: Vessel fails requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draught at FP about keel line	-	1.653
Draught amidships about keel line	-	2.203
Draught at AP about keel line	-	3.020

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP about foredeck edge	-	3.183
Freeboard at amidships about deck edge	-	0.688
Freeboard at AP about deck edge	-	0.413

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	0.601 by stern	2.203	0.018	0.000	1.362	0.018
5	0.589 ''	2.204	0.271	0.199	5.509	0.073
10	0.588 ''	2.175	0.524	0.395	9.701	0.128
15	0.597 ''	2.130	0.767	0.589	13.445	0.178
20	0.635 ''	2.077	0.983	0.779	15.459	0.204
25	0.688 ''	2.019	1.170	0.963	15.671	0.207
30	0.745 ''	1.955	1.332	1.139	14.611	0.193
35	0.815 ''	1.883	1.472	1.306	12.560	0.166
40	0.855 ''	1.803	1.595	1.464	9.921	0.131
45	0.909 ''	1.713	1.700	1.610	6.796	0.090
50	0.986 ''	1.610	1.790	1.745	3.419	0.045
55	1.033 ''	1.496	1.867	1.866	0.121	0.002
60	1.112 ''	1.366	1.931	1.972	-3.146	-0.042
65	1.196 ''	1.225	1.981	2.064	-6.276	-0.083
70	1.280 ''	1.074	2.017	2.140	-9.315	-0.123
75	1.361 ''	0.917	2.038	2.200	-12.233	-0.162
80	1.436 ''	0.753	2.045	2.243	-14.963	-0.198
85	1.518 ''	0.585	2.037	2.269	-17.534	-0.232
90	1.564 ''	0.413	2.016	2.278	-19.830	-0.262

STABILITY SUMMARY	Minimum	Actual
Angle of immersion of W/T door to accomm (degrees)	-	40.050
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.079
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.107
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.029
Maximum GZ (metres)	-	0.208
Angle of heel at which maximum GZ occurs (degrees)	25.000	23.333
Maximum GZ between 30 and 90 degrees (metres)	0.200	0.193
Positive GZ heel range (degrees)	-	40.050
GM solid (metres) (upright)	-	0.684
Free Surface correction (metres)	-	0.031
GM fluid (metres) (upright)	0.350	0.653

HEELING LEVER DATA

NB Vessel capsizes with this heeling lever applied

Vessel....: FV Aquila
Condition.: ACCIDENT CONDITION
State.....: HULL INCLUDING MAJOR APPENDAGES
Heel lever: 4.52T LOAD AT STBD JOCKEY POLE END (PROP THRUST/MOMENTUM/WAVE)
Water SG..: 1.025
Expression: Lever = 4.52*((4.163*COS(37-HEEL))-(1.424*SIN(HEEL)))/DSPT

Heel angle degrees	Trim about Base Line metres on LBP	Heeling moment tonne.metres	Heeling lever metres
0	0.601 by stern	15.028	0.198
5	0.589 ''	15.397	0.203
10	0.588 ''	15.648	0.207
15	0.597 ''	15.781	0.208
20	0.635 ''	15.793	0.209
25	0.688 ''	15.685	0.207
30	0.745 ''	15.458	0.204
35	0.815 ''	15.113	0.200
40	0.855 ''	14.654	0.194
45	0.909 ''	14.082	0.186
50	0.986 ''	13.404	0.177
55	1.033 ''	12.623	0.167
60	1.112 ''	11.747	0.155
65	1.196 ''	10.781	0.142
70	1.280 ''	9.733	0.129
75	1.361 ''	8.611	0.114
80	1.436 ''	7.423	0.098
85	1.518 ''	6.179	0.082
90	1.564 ''	4.888	0.065

HEELING LEVER AND RIGHTING LEVER DATA	Maximum	Actual
Angle of heel at first curve intersection (degrees)	-	22.473
Heeling lever at first curve intersection (metres)	-	0.208
Angle of heel at second curve intersection (degrees)	-	24.685
Heeling lever at second curve intersection (metres)	-	0.207
Area under heeling lever to first curve intersection (metre.radians)	-	0.081
Area under heeling lever to second curve intersection (metre.radians)	-	0.089

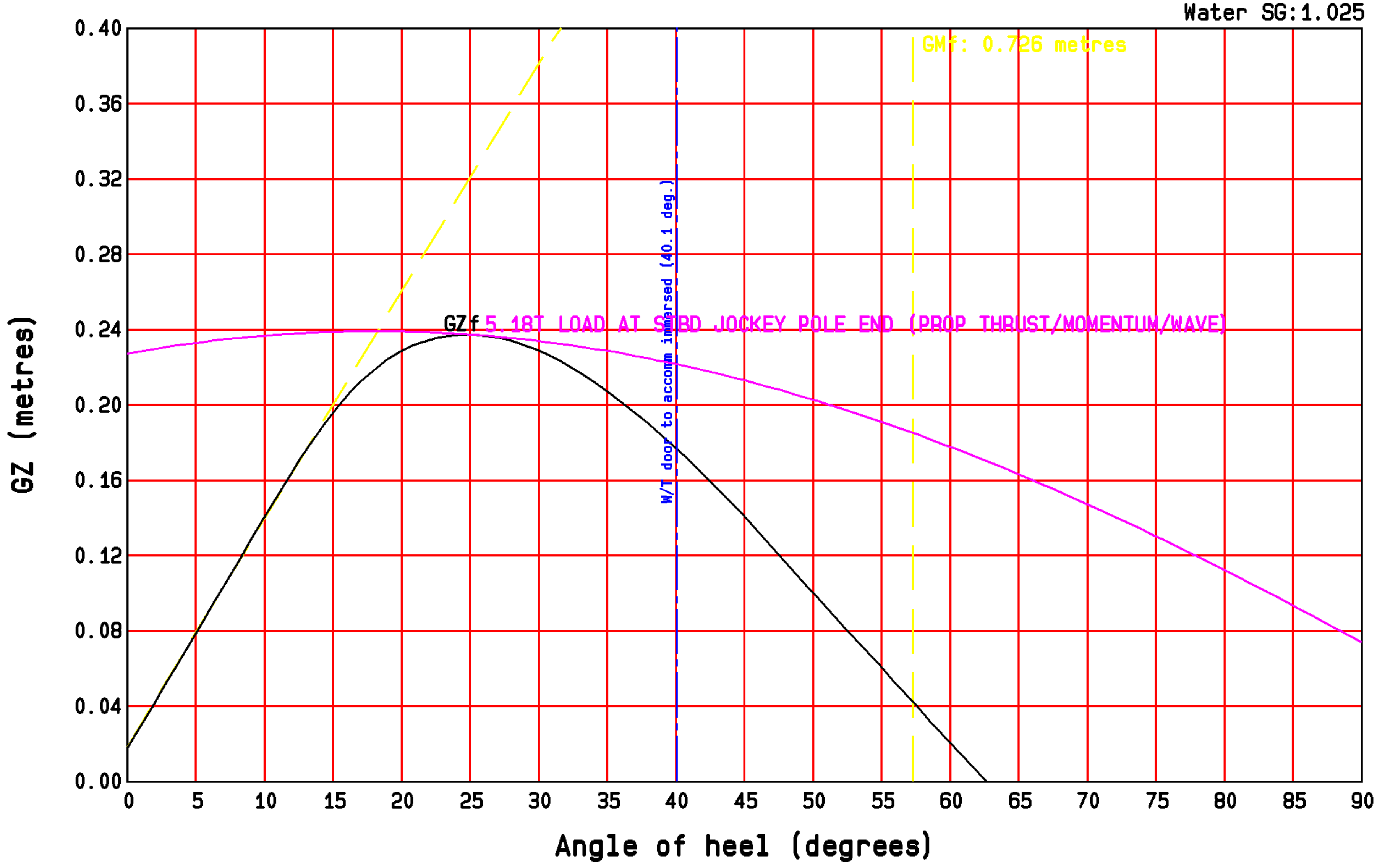
HEELING LEVER AND RIGHTING LEVER DATA (CONTINUED)	Minimum	Actual
Area under GZ curve to first curve intersection (metre.radians)	-	0.052
Area under GZ curve to second curve intersection (metre.radians)	-	0.060
Area between curves from 0 deg. heel to first curve intersection (metre.radians)	-	0.029
Area between curves in range 22.5 degrees to 24.7 degrees (metre.radians)	-	0.000

FV Aquila

GZ PLOT

NB Vessel capsizes with the applied heeling lever

Condition.: ACCIDENT CONDITION - KG LOWERED FOR REQUIREMENT COMPLIANCE
State.....: HULL INCLUDING MAJOR APPENDAGES



SAILING STATE

Vessel....: FV Aquila
Condition.: ACCIDENT CONDITION - KG LOWERED FOR REQUIREMENT COMPLIANCE
State.....: HULL INCLUDING MAJOR APPENDAGES
Water SG..: 1.025
Compliance: Vessel passes requirements in this condition

DRAFT SUMMARY (DIMENSIONS IN METRES)	Maximum	Actual
Draught at FP about keel line	-	1.653
Draught amidships about keel line	-	2.203
Draught at AP about keel line	-	3.020

FREEBOARD SUMMARY (DIMENSIONS IN METRES)	Minimum	Actual
Freeboard at FP about foredeck edge	-	3.183
Freeboard at amidships about deck edge	-	0.688
Freeboard at AP about deck edge	-	0.413

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	0.601 by stern	2.203	0.018	0.000	1.362	0.018
5	0.589 ''	2.204	0.271	0.192	5.983	0.079
10	0.588 ''	2.175	0.524	0.383	10.644	0.141
15	0.597 ''	2.130	0.767	0.571	14.852	0.196
20	0.635 ''	2.077	0.983	0.754	17.318	0.229
25	0.688 ''	2.019	1.170	0.932	17.968	0.237
30	0.745 ''	1.955	1.332	1.103	17.328	0.229
35	0.815 ''	1.883	1.472	1.265	15.677	0.207
40	0.855 ''	1.803	1.595	1.418	13.414	0.177
45	0.909 ''	1.713	1.700	1.560	10.639	0.141
50	0.986 ''	1.610	1.790	1.690	7.582	0.100
55	1.033 ''	1.496	1.867	1.807	4.572	0.060
60	1.112 ''	1.366	1.931	1.910	1.561	0.021
65	1.196 ''	1.225	1.981	1.999	-1.351	-0.018
70	1.280 ''	1.074	2.017	2.073	-4.208	-0.056
75	1.361 ''	0.917	2.038	2.131	-6.983	-0.092
80	1.436 ''	0.753	2.045	2.172	-9.611	-0.127
85	1.518 ''	0.585	2.037	2.197	-12.120	-0.160
90	1.564 ''	0.413	2.016	2.206	-14.395	-0.190

STABILITY SUMMARY	Minimum	Actual
Angle of immersion of W/T door to accomm (degrees)	-	40.050
Area under GZ curve between 0.00 and 30.00 degrees (metre.radians)	0.055	0.088
Area under GZ curve between 0.00 and 40.00 degrees (metre.radians)	0.090	0.124
Area under GZ curve between 30.00 and 40.00 degrees (metre.radians)	0.030	0.036
Maximum GZ (metres)	-	0.237
Angle of heel at which maximum GZ occurs (degrees)	25.000	25.019
Maximum GZ between 30 and 90 degrees (metres)	0.200	0.229
Positive GZ heel range (degrees)	-	40.050
GM solid (metres) (upright)	-	0.757
Free Surface correction (metres)	-	0.031
GM fluid (metres) (upright)	0.350	0.726

HEELING LEVER DATA

NB Vessel capsizes with this heeling lever applied

Vessel....: FV Aquila
Condition.: ACCIDENT CONDITION - KG LOWERED FOR REQUIREMENT COMPLIANCE
State.....: HULL INCLUDING MAJOR APPENDAGES
Heel lever: 5.18T LOAD AT STBD JOCKEY POLE END (PROP THRUST/MOMENTUM/WAVE)
Water SG..: 1.025
Expression: Lever = 5.18*((4.163*COS(37-HEEL))-(1.424*SIN(HEEL)))/DSPT

Heel angle degrees	Trim about Base Line metres on LBP	Heeling moment tonne.metres	Heeling lever metres
0	0.601 by stern	17.222	0.227
5	0.589 ''	17.645	0.233
10	0.588 ''	17.933	0.237
15	0.597 ''	18.085	0.239
20	0.635 ''	18.099	0.239
25	0.688 ''	17.976	0.237
30	0.745 ''	17.715	0.234
35	0.815 ''	17.320	0.229
40	0.855 ''	16.793	0.222
45	0.909 ''	16.139	0.213
50	0.986 ''	15.361	0.203
55	1.033 ''	14.467	0.191
60	1.112 ''	13.462	0.178
65	1.196 ''	12.355	0.163
70	1.280 ''	11.154	0.147
75	1.361 ''	9.868	0.130
80	1.436 ''	8.507	0.112
85	1.518 ''	7.081	0.094
90	1.564 ''	5.601	0.074

HEELING LEVER AND RIGHTING LEVER DATA	Maximum	Actual
Angle of heel at first curve intersection (degrees)	-	0.000
Heeling lever at first curve intersection (metres)	-	0.000
Area under heeling lever to first curve intersection (metre.radians)	-	0.000
Area under heeling lever to flood angle (40.1 degrees) (metre.radians)	-	0.000

HEELING LEVER AND RIGHTING LEVER DATA (CONTINUED)	Minimum	Actual
Area under GZ curve to first curve intersection (metre.radians)	-	0.000
Area under GZ curve to flood angle (40.1 degrees) (metre.radians)	-	0.000
Area between curves from 0 deg. heel to first curve intersection (metre.radians)	-	0.000
Area between curves in range 0.0 degrees to 40.1 degrees (metre.radians)	-	0.000

Marine Guidance Note MGN 267 (F)

MARINE GUIDANCE NOTE

MGN 267 (F)

The Location and Stowage of Liferafts and Emergency Positioning Radio Beacons (EPIRBs) on UK Registered Fishing Vessels

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

This notice should be read in conjunction with MGN 104 Stowage and Float Free Arrangements for Inflatable Liferafts, and supersedes MGN 130 (F).

Summary

- This note gives guidance on suitable stowage positions and other measures that will significantly reduce the possibility of a liferaft or an EPIRB becoming trapped or snagged when being deployed automatically from a sinking fishing vessel.

1. LIFERAFTS

1.1 To enhance the chances of successful deployment in an abandon ship emergency, the Maritime and Coastguard Agency strongly recommends that for liferaft containers:

(a) The owner/skipper should review the liferaft stowage arrangement on the vessel and consider:

(i) Are the liferaft containers stowed in an area that is free from overhead obstructions, and as far away from bulkheads, railings and other vertical structures as is possible?

(ii) Does the vessel have rigging, equipment or structure which could interfere with the deployment of a liferaft?

(b) A liferaft container may be released when the vessel is on its side or at some other extreme angle of heel and trim. A deep cradle should allow for this but be designed to avoid inadvertent release.

(c) Manual launching may also be necessary, and any arrangement should allow this to be easily achieved.

(d) The arrangement should allow easy access for crew from their normal working positions.

1.2 Of the 104 fatalities from vessel losses between 1992 and 2000, 69 were never found, and it is possible that a significant proportion of these losses were because of the incorrect operation of life saving equipment. As a result of one of these incidents the Maritime and Coastguard Agency commissioned a research project to find out:

(a) why some liferafts failed to reach the surface; and

(b) the optimum positions for the stowage of inflatable liferaft containers.

1.3 Phase 1 was undertaken by the Wolfson Unit for Marine Technology and Industrial Aerodynamics, and involved conducting a series of tank tests using two models of common fishing vessel types. This investigated the behaviour of a sinking vessel.

1.4 This work concluded that a liferaft positioned away from fishing gear and structures would have a much greater chance of reaching the surface from a sinking vessel than a more traditional aft mounted liferaft.

1.5 The research from Phase 1 showed that:

(a) Because of masts, rigging and fishing gear on beam trawlers, when compared with other fishing vessels, there is an increased likelihood of liferaft containers and/or painters becoming fouled and snagged on superstructure and/or fishing gear; and therefore being prevented from reaching the surface.

(b) Due to variations in fishing vessel design and operation, the attitude (angles to port, starboard, forward and aft) that the vessel takes up as it sinks is difficult to predict.

(c) In some cases the container may become so fouled or jammed that it cannot deploy automatically.

(d) More commonly, when the liferaft container is released by the Hydrostatic Release Unit, the painter becomes fouled as the liferaft ascends to the surface. As a result, the painter weak link does not break and the liferaft will not reach the surface.

1.6 Phase 2 was undertaken by the Inflatable Safety and Survival Equipment Trade Association (ISSETA), working with SEAFISH and the Maritime and Coastguard Agency.

1.7 A six person liferaft in a rectangular container was placed on the bow of a beam trawler for a trial period of two years, in addition to the existing liferafts, to prove that a liferaft could cope with the conditions encountered. (The report is attached).

1.8 The research from Phase 2 showed that:

(a) The trial of the liferaft on the bow showed that over the two years of service the case and liferaft itself remained in good condition with no degradation. The Hydrostatic Release Unit was also found to operate as required when tested. (The Hydrostatic Release Unit was of a type which would operate at 6-10 metres depth to avoid accidental operation caused by seas shipped over the bow).

(b) A liferaft stowed forward, properly fitted with a suitable Hydrostatic Release Unit and protection from waves will provide an effective alternative to stowing both liferafts aft.

1.9 For vessels with little rigging or obstruction, alternative actions could include:

(a) The possibility of local structures hindering the container's deployment can be minimised by incorporating angled stanchions to guide the container upwards and past the obstruction.

(b) To reduce the possibility of automatic deployment failure occurring as a result of the painter snagging on wires used for rigging etc., consideration should be given to the fitting of smooth sheathing over wires in areas close to where liferafts will float free.

2. EMERGENCY POSITIONING INDICATING RADIO BEACONS (EPIRBs).

2.1 Tank tests also provided information on the conditions for automatic deployment of EPIRBs. From this the following advice is given on the siting of this equipment:

2.2 To provide the best conditions for automatic deployment, the EPIRB should be sited so that it can float free and clear regardless of the attitude of the vessel during or following capsize. The wheelhouse top is the favoured position, although rigging, masts, equipment etc. could indicate that an alternative position should be found. Access should be easy so that the EPIRB can be manually activated and placed in the liferaft if abandoning ship.

2.3 If the EPIRB is placed on one side of the vessel, or immediately behind the wheelhouse then the likelihood of correct deployment is much reduced.

Further Information

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

Maritime and Coastguard Agency
Website Address: http://www.mcga.gov.uk

File Ref: MS/088/001/0390

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Department for Transport

The MCA is an executive agency of the Department for Transport

Safer Lives, Safer Ships, Cleaner Seas

MAIB Fishing Accident Flyer

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

FLYER TO THE FISHING INDUSTRY

Capsize of fishing vessel *Aquila* with three fatalities

Photo: Sean Mcilwraith

On 20 July 2009, at about 1540 UTC, the starboard warp of the scallop dredger *Aquila* became snagged on the seabed while she was trawling, downwind, in moderate to heavy seas near the isle of Eigg.

The vessel almost immediately veered and heeled over to starboard. The skipper was heard to pull the engine control back to neutral, but a succession of large waves then struck the vessel and she rapidly capsized. The three crewmen were initially trapped, and as water entered the mess room through the open accommodation door one of them dived down and out through the door to escape from the vessel.

When he surfaced, the wind and tide took him quickly away from the upturned hull, but he was able to grab two wooden planks which had floated free of the wreck. The man started swimming towards the shore, which was about 2 miles away. He had been in the water for more than an hour when he attracted the attention of a passing yacht and was rescued. A search and rescue operation was then commenced for the remaining men whose bodies were recovered from the sea over the next few hours.

Aquila was built in 1988 and had a registered length of less than 12m. Although not statutorily required, her stability was checked at the time of her build when she was found to comply with the stability requirements for larger vessels.

After the accident the vessel was salvaged and an analysis of her stability was undertaken. This found that additional ballast had been fitted to the vessel and, with the carriage of more fishing gear, her displacement tonnage was found to have increased by 32%.

The ballast had been placed under the accommodation floor and also below the steering flat, to increase the stern trim and thus the depth and thrust of the propeller. However, the resultant centre of gravity of the additional ballast was found to be 1.5m above the keel which meant that the vessel no longer met the stability requirements for larger fishing vessels.

The MAIB investigation found that there were delays in the deployment of Search and Rescue assets. While these delays are not considered to have affected the outcome of this tragic accident they are addressed in the Investigation report.

SAFETY ISSUES:

1. When planning to add ballast or making other modifications to a vessel, the effect of such action on a vessel's stability should be properly assessed by a competent person.

2. The risks of fishing gear becoming snagged, particularly when trawling downwind, should be fully assessed to ensure appropriate control measures are in place to prevent water ingress or capsize.

This accident was the subject of an MAIB Investigation report which can be found on MAIB's website at: www.maib.gov uk

A copy of the report and/or the flyer will be sent, on request, free of charge.

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SO15 2JU

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Email: maib@dft.gsi.gov.uk

April 2010