Annex A

Wolfson Unit stability analysis report

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Marine Accident Investigation Branch

F/V Joanna C Stability Analysis

1 INTRODUCTION

The following report describes an intact stability analysis conducted on F/V Joanna C (BM-265), a 14 metre scallop dredger that capsized and sank off the Sussex coast on 21st November 2020. The capsize resulted in the loss of two of the three crew on board.

This work is in support of the MAIB investigation into the loss and was commissioned by the MAIB following Wolfson Unit proposal ref. 5062ms.

The work was broken down into three phases, hence the reporting structure is as follows:

- Phase 1: definition of original 14.9m hull form and validation against approved stability book [1];
- Phase 2: definition of shortened 14.0m hull form, definition and validation of tanks and analysis of 2019 inclining experiment;
- Phase 3: intact stability analysis of 14.0m hull form in standard loading conditions.

2 PHASE 1 – ORIGINAL HULL FORM, 14.9m OVERALL LENGTH

2.1 Lines definition and validation

Software tools:

- Rhino 6
- Wolfson Unit DXF to LFH converter
- Wolfson Unit Hydrostatics and Stability suite HST

Modelling approach:

- Scanned lines plan converted to .png and imported into Rhino 6 as a background image
- Lines plan realigned to booklet datums and rotated to achieve horizontal baseline
- Plan view coordinate system adjusted to correct for hogged centreline
- Lines plan re-scaled by appropriate longitudinal and vertical scale factors to achieve 1:10 scale
- Stations 0-10 digitised and additional transverse sections lifted as appropriate
- Sections spaced longitudinally as appropriate to obtain 3d hull definition
- Rhino stations converted to Wolfson .lfh format, imported into HST and scaled to 1:1 scale
- 14.9m ‘1980 hull’ split into two adjacent HST elements, see Figure 1a
  14.0m ‘2019 hull’ (38 sections up to top of bulwark), and
  ‘1980 stern’ (4 sections up to deck edge)

- Ship properties, datums and draught marks set
- Level trim hydrostatics and 15 loading conditions defined, see Table 1

Validation against approved stability data over 1.8 – 2.3m draught and at level trim:

- Figure 2 - Variation of Displacement, LCB and KMT with Draught
- Figure 3 - Variation of Displacement Ratio with Draught
- Figure 4 - Variation of KMT Ratio with Draught
- Figure 5 - Variation of Draught with Displacement at 15 Loading Conditions
- Figure 6 - Variation of Trim with Displacement at 15 Loading Conditions

3 PHASE 2 – SHORTENED HULL FORM, 14.0m OVERALL LENGTH

3.1 Coordinate system and draught datum

Two sets of datums are used in the Joanna C stability documentation:

a) 1980 datums, defined in the shipbuilders' lines plan [2] and used throughout the stability booklet [1];
b) 2019 datums, described in the inclining experiment notes [3]

The HST stability model and the data presented in this report use the 1980 origin and baseline for consistency with the weights' positions and other measurements presented in [1]. The HST draught datum is at the 1980 baseline to simplify the trim calculation like so:
trim (m) = draught aft (m ab. base) – draught fwd (m ab. base).

3.2 Definition of cambered deck and 2019 whaleback focsle

The cambered deck and whaleback focsle presented in [2] and [4] were added to the lines shown in Figure 1a, to enable stability calculations at large angles of heel. This lines definition, shown in Figure 1b, has been used to assess the intact stability characteristics of the shortened, 14.0m hull form.

3.3 Definition of fuel tanks and fresh water tanks

Modelling approach:

- The fuel tanks were modelled in accordance with [6] and their HST steel percentages adjusted to match the total capacities stated in the stability booklet, Section IV page 82 'Capacities, CGs and FSMs' [1].
- The fresh water tanks were modelled in accordance with [5] and their HST steel percentages adjusted to match their 1166 lt total capacity.
- The stability booklet [1] assumes that opposing tanks always have the same fill percentage (eg both are 98% full at departure). Since the fuel wing tanks are asymmetrical and the starboard tank has approximately 5% greater capacity than the port tank, this should result in a starboard TCG and, therefore, a starboard side down heeling moment of approximately 0.2 tonnes.metre at 100% fill.
- The stability booklet, however, assumes TCG=0 throughout the analysis ie at all loading conditions the deadweight is arranged to achieve zero heel at equilibrium. To ensure consistency with the booklet, the analysis described in this report has also been conducted at TCG=0 unless otherwise stated.
- The stability booklet assumes constant LCG for fuel and fresh water at all levels of fill eg 1.16m (port fuel tank) and 1.75m (starboard fuel tank) and irrespective of the vessel's trim. Conversely, the fluid LCGs presented in this report vary with tank fill and trim, as this approach enables closer modelling of the stability characteristics of the vessel.

3.4 Analysis of 2019 inclining experiment

The lengths and deflections of the two pendula, weights on/off list and as-inclined draughts are supplied in [3]. These data were processed in HST and the 2019 lightship was calculated. Table 6 presents a comparison between the 1994 lightship of the 14.9m vessel and the 2019 lightship of the 14 m vessel. The full inclining report is given in Appendix A.

4 PHASE 3 – INTACT STABILITY ANALYSIS OF SHORTENED HULL FORM

4.1 Standard loading conditions

The lightship derived from the 2019 inclining experiment was combined with the weights presented in the 'standard' loading conditions LC1 to LC7 of the approved stability booklet [1], see Table 1. At each loading condition the two, 582 litres fresh water tanks described in Section 2 were filled at the same percentage levels as the original, 980 litres centreline fresh water tank. The resulting loading conditions are detailed in Appendix B.

4.2 Stability criteria

To enable a direct comparison with the stability booklet [1], the 'standard' loading conditions were assessed against the intact stability criteria set forth in The Fishing Vessels (Safety Provisions) 1975 for vessels engaged in twin boom fishing. The calculated maximum KGs and pass/fail results are detailed in Appendix C.

The 'standard' loading conditions were also assessed against the 'Wolfson freeboard guidance' formulated in MGN 526 (F) 'Stability Guidance for Fishing Vessels - Using the Wolfson Method', that provides stability guidance based on an assessment of residual freeboard when loaded or lifting. The results are summarized in Table 7 and the vessel's Stability Notice and Freeboard Guidance Mark are shown in Figure 7.

5 DISCUSSION AND CONCLUSIONS

5.1 Lines definition and validation

a) At a shell thickness of zero, the calculated displacement exceeds the displacement stated in the booklet by 0.3% or less over the range 1.80 to 2.30m draught and at level trim. Such a deviation reduces to 0.1% or less over the range of operational draughts 2.05m to 2.29m and at level trim.

b) At the draughts and trims of the seagoing loading conditions presented in the stability booklet (nos. 2 to 14) the calculated displacement is within 0.1% of the approved displacement. The corresponding draught and trim ranges are: 2.05m to 2.29m and 0.12m bow down to 0.39m stern down.

c) Displacement deviations up to 0.5% are deemed acceptable by the Wolfson Unit when validating stability models against approved results, therefore the Joanna C model used for this stability analysis is deemed valid.

d) Whilst no trimmed hydrostatics are presented in the stability booklet [1], validation of the HST trimmed results was conducted by inputting into HST the loading conditions of Table 1 and comparing the calculated draught and trim at equilibrium with those presented in the booklet. Figures 4 and 5 confirm the agreement between the original lines definition and the HST model.

5.2 Tanks
The calculated capacity tables are shown in Tables 2 to 4.

5.3 Coordinate system and draught datum
Table 5 shows the 1980, 2019 and HST datums. The HST datums are also presented graphically in Figure 1a and 1b.

5.4 Inclining experiment
The lightship displacement of the 14.0m vessel inclined in July 2019 is 19.8% greater than that of the 14.9m vessel inclined in 1994. The lightship VCG and GM of the 14.0m vessel are respectively 11.4% higher and 54.5% smaller than those of the 14.9m vessel.

5.5 Intact stability assessment of the shortened, 14.0m vessel
The stability and maximum KG results presented in Appendix C demonstrate that the 14.0m vessel in the standard loading conditions LC1 to LC7 fails to comply with the Fishing Vessel (Safety Provisions) 1975 and in particular:

a) none of the 1975 twin boom fishing vessel stability criteria are met;
b) the stability criterion failed by the greatest margin ie the 'critical' criterion is consistently 'No.5 - GZ shall be at least 0.24 metres at angles of 30 degrees or more'
c) the vessel's fluid VCG exceeds the critical maximum KG by 9.8% or more.

The Wolfson Guidance indicates a low level of safety for the 14.0m vessel in the standard seagoing conditions LC2 to LC7.

6 REFERENCES

[1] Joanna C, approved stability booklet ref. RJM/96/007
[2] Pembroke 48 lines plan dated 16-2-1979, with 2019 additions and further annotations
[3] Joanna C inclining experiment notes dated 25-7-2019
[4] Context letter dated 26-7-2019
[5] Fresh Water tank photos and notes, dimensions lifted in 2019
[6] Pembroke 48 structural drawings Fr. 16, 21, 23 and 25 dated 11-4-1979

Table 1 Loading Conditions Formulated in the Stability Booklet

No.	Description	Disp	LCG	VCG	TCG
		tonnes	m fwd midships	m above base	m
0	As inclined @ SG 1.025	61.31	-0.088	2.379	0.000
1	Lightship incl. fishing gear	55.67	-0.351	2.478	0.000
2	Depart Port	64.14	-0.240	2.388	0.000
3	Arrival Gnds	63.64	-0.253	2.386	0.000
4	Depart Gnds 100% Catch	61.56	-0.377	2.400	0.000
5	Arrival Port 100% Catch	61.06	-0.392	2.410	0.000
6	Depart Gnds 20% Catch	59.40	-0.388	2.421	0.000
7	Arrival Port 20% Catch	58.91	-0.403	2.432	0.000
8	Depart Port Beam Trawl Day 1	62.56	-0.165	2.394	0.000
9	Depart Port Beam Trawl Day 3	60.45	-0.249	2.394	0.000
10	Depart Port Beam Trawl Day 4	59.93	-0.254	2.406	0.000
11	Arrival Port Beam Trawl Day 6	57.84	-0.344	2.440	0.000
12	Depart Port Bulk Fishing Day 1	61.03	-0.142	2.401	0.000
13	Arrival Port Bulk Fishing Day 1	72.12	-0.360	2.301	0.000
14	Arrival Port Bulk Fishing Day 6	67.78	-0.501	2.346	0.000

Table 2 Capacity Data, 2 x Fresh Water Tanks

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Ship and Tank Particulars

Steel deduction factor	8.900 %
LCG reference point	0.000 metres
VCG reference point	0.000 metres
Capacity at 100%	1.165 metres³
LCG at 100% capacity	3.615 metres
VCG at 100% capacity	1.810 metres
Second moment of free surface	3.892 metres^4 at 2.000 metres above datum
Free surface moment for SG=1.000	3.892 tonnes.m at 2.000 metres above datum

Sounding metres	Capacity metres³	Weight for SG=1.000 tonnes	LCG metres	VCG metres	TCG metres	2nd Moment metres^4	FSM for SG=1.000 tonnes.metre
1.400	0.040	0.040	3.606	1.382	0.000	1.915	1.915
1.500	0.159	0.159	3.609	1.434	0.000	2.319	2.319
1.600	0.291	0.291	3.611	1.487	0.000	2.753	2.753
1.700	0.436	0.436	3.612	1.541	0.000	3.232	3.232
1.800	0.592	0.592	3.613	1.596	0.000	3.613	3.613
1.900	0.755	0.755	3.615	1.651	0.000	3.791	3.791
2.000	0.921	0.921	3.616	1.705	0.000	3.892	3.892
2.100	1.000	1.000	3.616	1.732	0.000	2.226	2.226
2.200	1.055	1.055	3.616	1.754	0.000	1.931	1.931
2.300	1.099	1.099	3.616	1.773	0.000	1.589	1.589
2.400	1.132	1.132	3.616	1.790	0.000	1.196	1.196
2.500	1.154	1.154	3.616	1.802	0.000	0.749	0.749
2.600	1.164	1.164	3.616	1.809	0.000	0.246	0.246
2.700	1.165	1.165	3.615	1.810	0.000	0.000	0.000

Table 3 Capacity Data, Starboard Side Fuel Tank

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Ship and Tank Particulars

Steel deduction factor	-7.000 %
LCG reference point	0.000 metres
VCG reference point	0.000 metres
Capacity at 100%	2.985 metres^3
LCG at 100% capacity	1.748 metres
VCG at 100% capacity	1.806 metres
TCG at 100% capacity	2.022 metres
Second moment of free surface	0.120 metres^4 at 2.500 metres above datum
Free surface moment for SG=0.850	0.102 tonnes.m at 2.500 metres above datum

Sounding metres	Capacity metres^3	Weight for SG=0.850 tonnes	LCG metres	VCG metres	TCG metres	2nd Moment metres^4	FSM for SG=0.850 tonnes.metre
0.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.800	0.008	0.007	0.915	0.776	1.773	0.001	0.001
1.000	0.103	0.088	1.184	0.907	1.840	0.012	0.010
1.200	0.310	0.263	1.368	1.042	1.893	0.047	0.040
1.400	0.628	0.534	1.499	1.175	1.942	0.078	0.066
1.600	1.012	0.860	1.597	1.299	1.971	0.088	0.075
1.800	1.423	1.210	1.659	1.415	1.989	0.095	0.081
2.000	1.846	1.569	1.696	1.526	2.001	0.102	0.086
2.200	2.280	1.938	1.721	1.636	2.010	0.108	0.092
2.400	2.725	2.316	1.740	1.744	2.018	0.116	0.098
2.600	2.985	2.537	1.748	1.806	2.022	0.000	0.000

Table 4 Capacity Data, Port Side Fuel Tank

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Ship and Tank Particulars

Steel deduction factor	-5.900 %
LCG reference point	0.000 metres
VCG reference point	0.000 metres
Capacity at 100%	2.838 metres³
LCG at 100% capacity	1.158 metres
VCG at 100% capacity	1.759 metres
TCG at 100% capacity	-2.042 metres
Second moment of free surface	0.114 metres^4 at 2.500 metres above datum
Free surface moment for SG=0.850	0.097 tonnes.m at 2.500 metres above datum

Sounding metres	Capacity metres³	Weight for SG=0.850 tonnes	LCG metres	VCG metres	TCG metres	2nd Moment metres^4	FSM for SG=0.850 tonnes.metre
0.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.800	0.017	0.014	0.526	0.768	-1.789	0.002	0.002
1.000	0.149	0.126	0.876	0.899	-1.849	0.018	0.015
1.200	0.395	0.335	0.999	1.029	-1.911	0.058	0.049
1.400	0.728	0.619	1.063	1.154	-1.965	0.081	0.069
1.600	1.088	0.925	1.103	1.269	-1.993	0.088	0.075
1.800	1.457	1.239	1.125	1.378	-2.010	0.093	0.079
2.000	1.834	1.559	1.138	1.485	-2.021	0.099	0.084
2.200	2.218	1.886	1.148	1.592	-2.030	0.105	0.089
2.400	2.610	2.219	1.155	1.698	-2.038	0.111	0.094
2.600	2.838	2.412	1.158	1.759	-2.042	0.000	0.000

Table 5 Datums

	Position Name		Longitudinal Position metres fwd HST origin		Baseline m above HST origin	Draught datum m above HST origin
1980	AP & Aft Marks	Station 10	Aft Marks X	-6.858	0	-0.153 (USK)
	Midships	Station 5	Midships X	0	0	0.398 (USK)
	FP & Fwd Marks	Station 0	Fwd Marks X	6.858	0	0.949 (USK)
2019	AP & Aft Marks	Fr 2	Aft Marks X	-5.867	0.442	-0.073 (USK)
	Midships	Fr 16	Midships X	0.533	0.442	0.442 (USK)
	FP & Fwd Marks	Fr 30	Fwd Marks X	6.934	0.442	0.957 (USK)
HST	AP & Aft Marks	Station 10	Aft Marks X	-6.858	0	0
	Midships	Station 5	Midships X	0	0	0
	FP & Fwd Marks	Station 0	Fwd Marks X	6.858	0	0

Table 6 Lightship Comparison

	1994 Lightship	2019 Lightship	% variation
Displacement, t	52.28	62.65	19.8 % increase
VCG, m above baseline	2.423	2.699	11.4 % increase
GMt, m	0.920	0.419	54.5 % reduction

Table 7 Vessel's Freeboard at Wolfson Mark, 25% LOA

Safety Zone	Minimum Freeboard cm	Freeboard at Standard Loading Conditions cm						
		LC1	LC2	LC3	LC4	LC5	LC6	LC7
Good margin of safety	At least 58	0.64						
Low level of safety	29 to 58		0.52	0.53	0.53	0.54	0.57	0.57
Danger of capsize	Less than 29							

LC1 - Lightship Including Fishing Gear (not a seagoing condition)
LC2 - Departure from Port
LC3 - Arrival at Grounds
LC4 - Departure from Grounds 100% Catch
LC5 - Arrival in Port 100% Catch
LC6 - Departure from Grounds 20% Catch
LC7 - Arrival in Port 100% Catch

Figure 1a **HST lines definition, original 14.9m hull to top of bulwarks (52.28t lightship waterline in blue, surveyed 1994)**

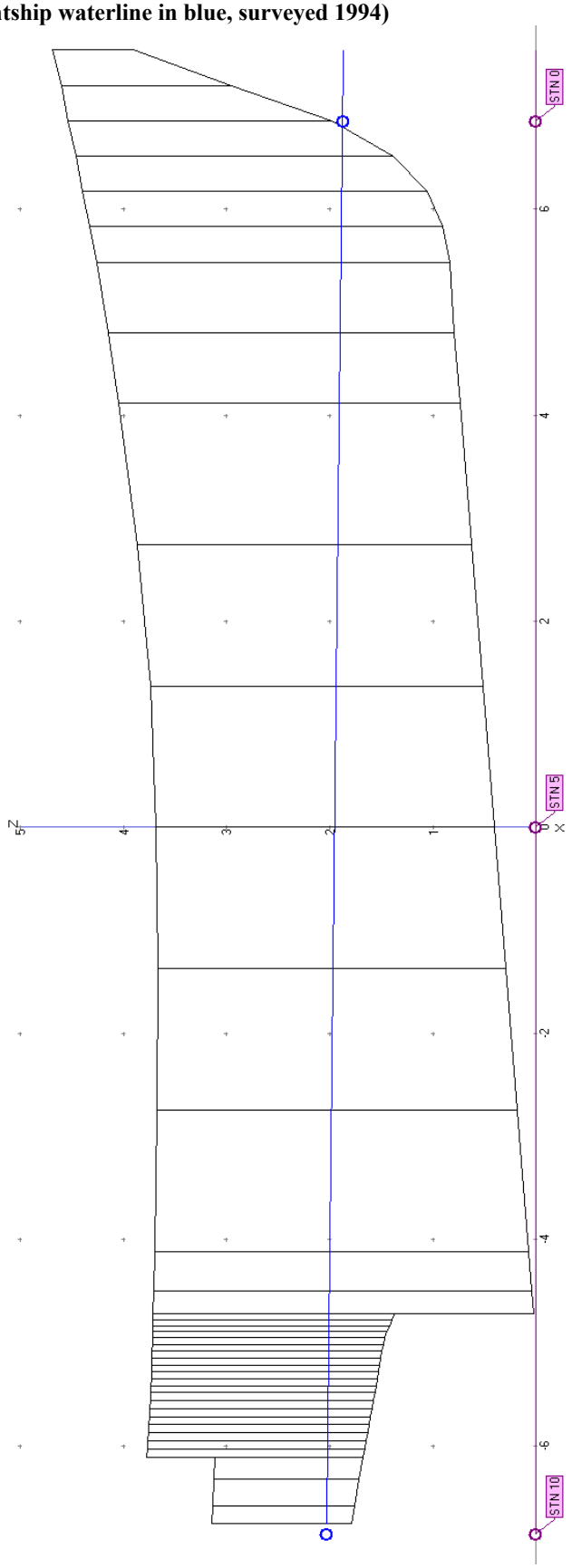


Figure 1b **HST lines definition, shortened 14.0m hull to cambered deck, with whaleback focsle (62.65t lightship waterline in blue, surveyed 2019)**

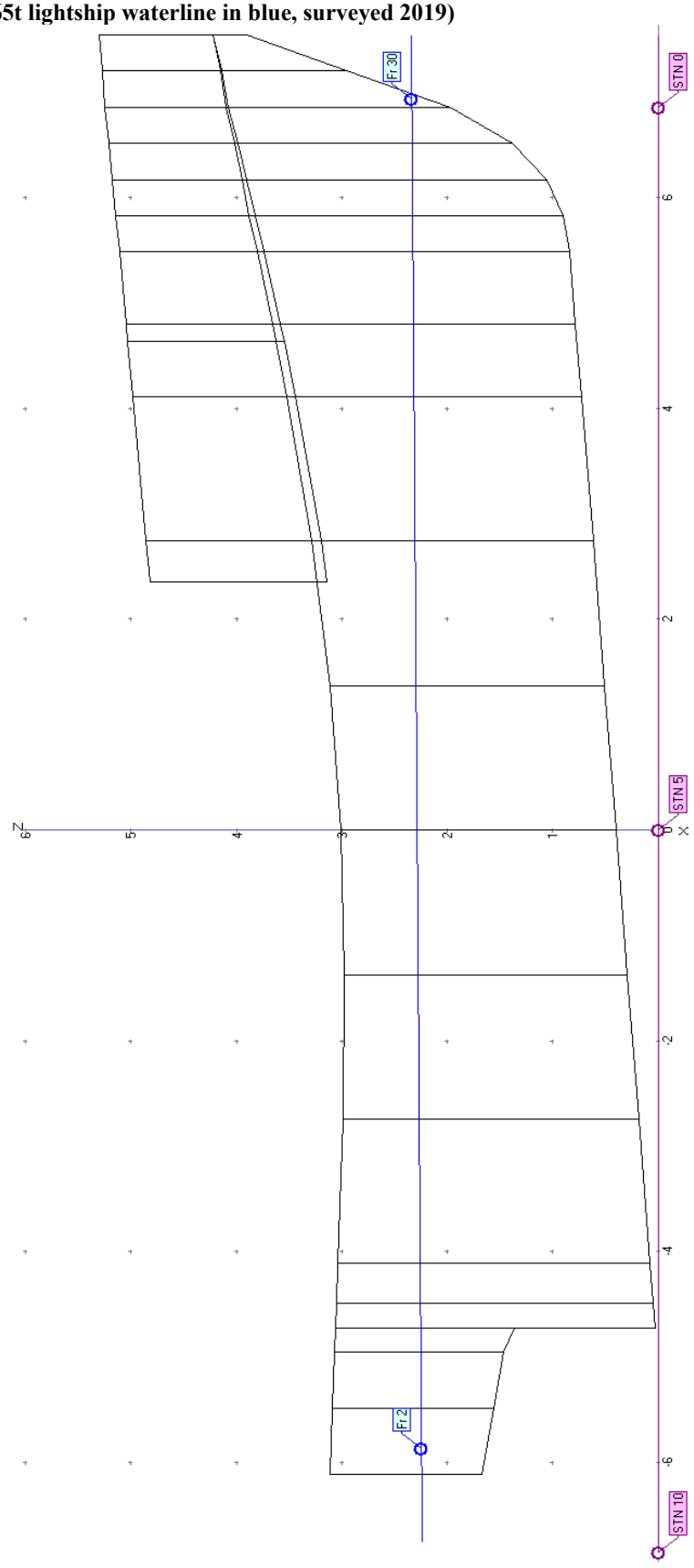


Figure 2 - Variation of Displacement, LCB and KMT with Draught

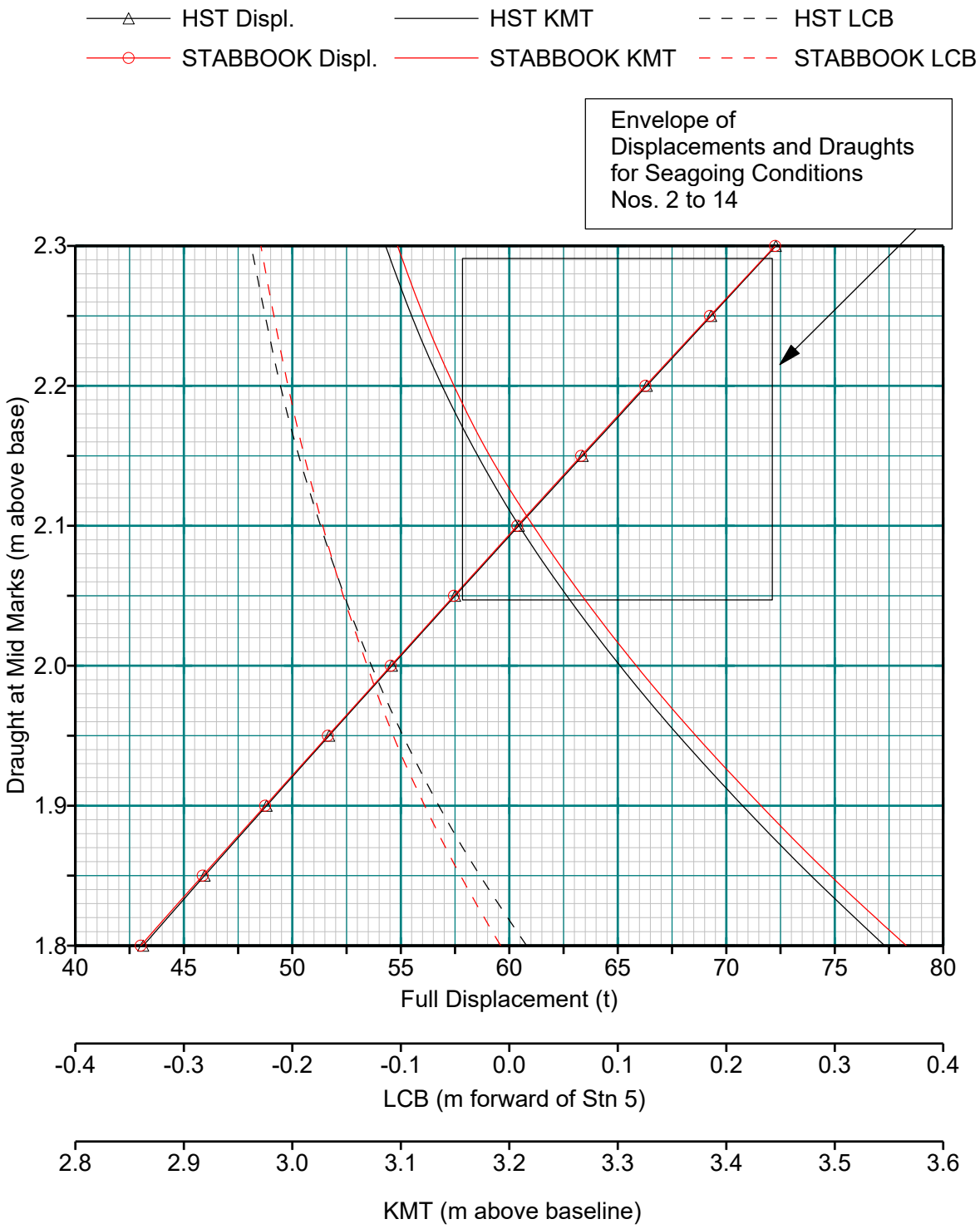


Figure 3 - Variation of Displacement Ratio with Draught
all data at level trim

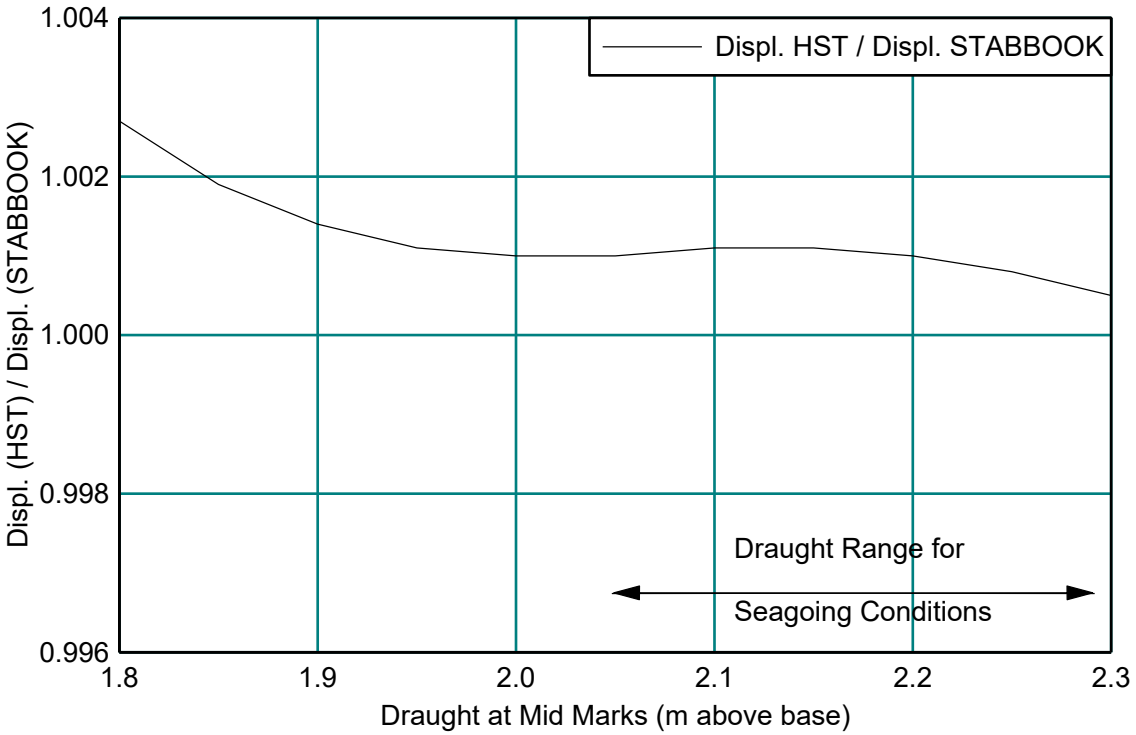


Figure 4 - Variation of KMT Ratio with Draught
all data at level trim

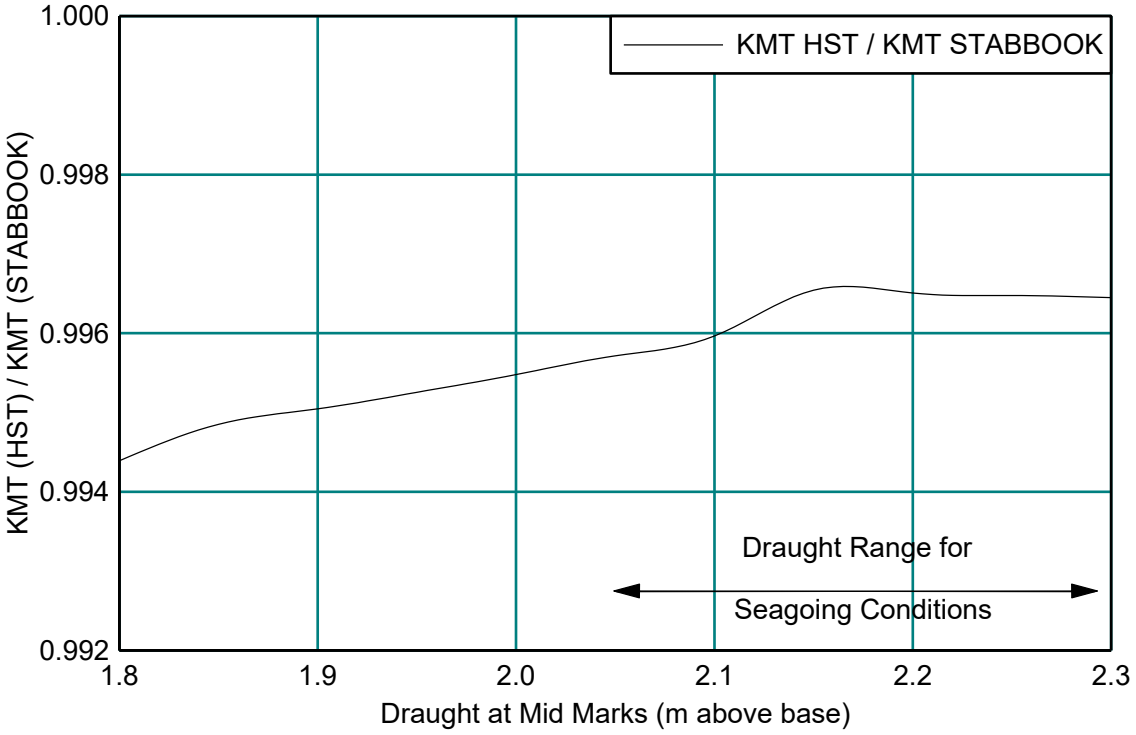


Figure 5 - Variation of Draught with Displacement at Loading Conditions

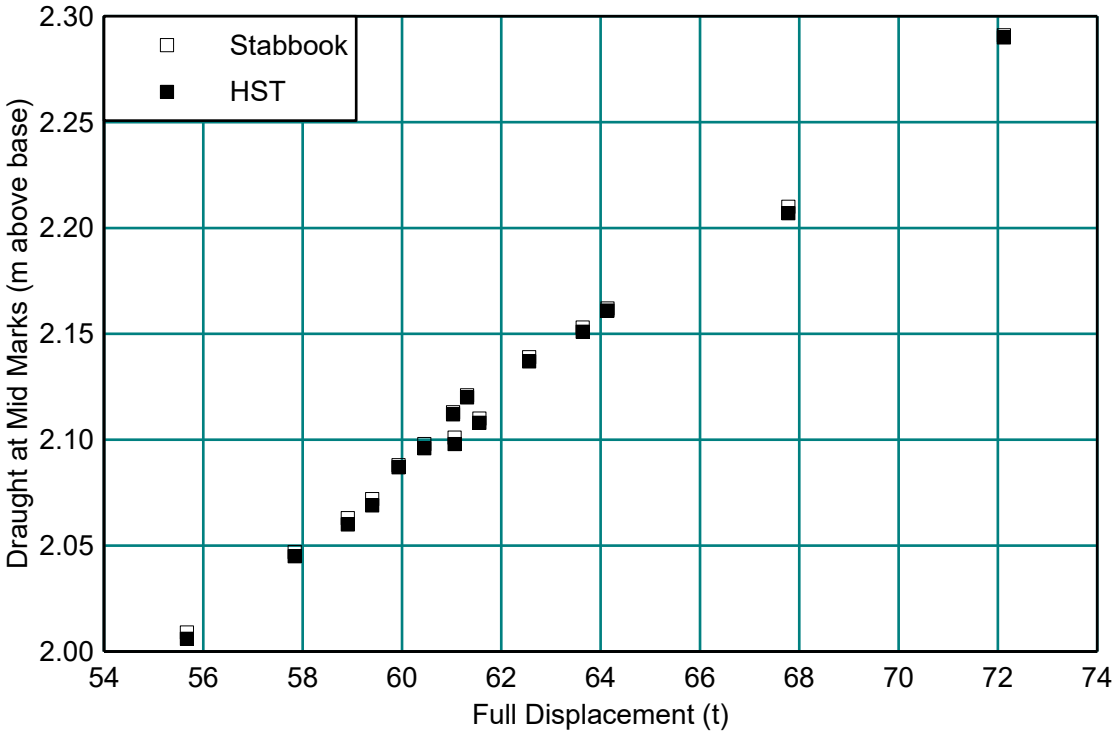


Figure 6 - Variation of Trim with Displacement at Loading Conditions
+ve stern trim, -ve bow trim

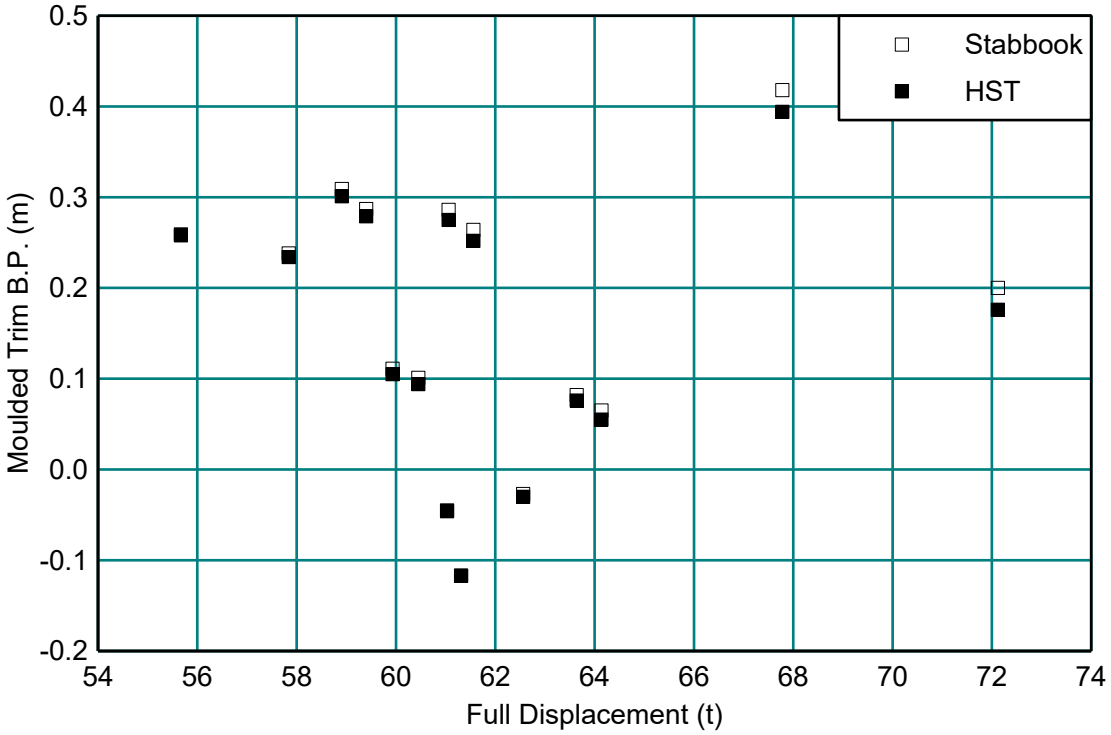
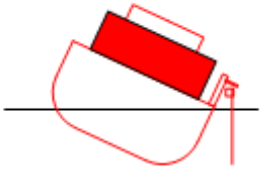
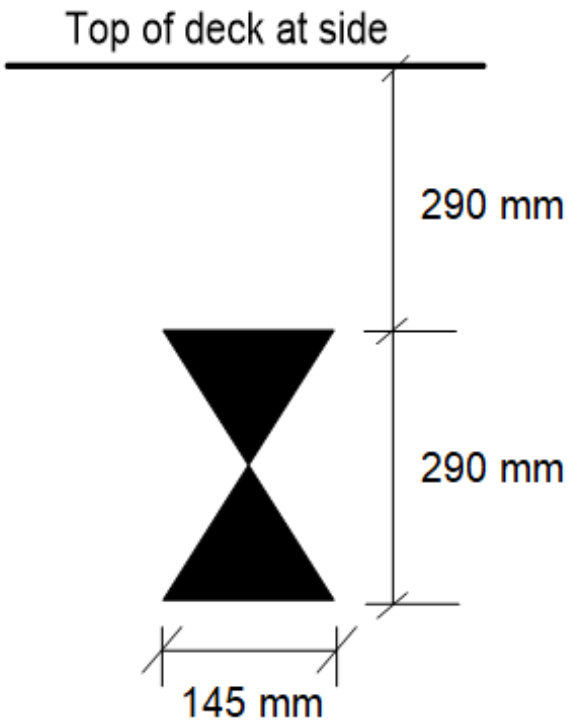


Figure 7 **Stability Notice and Freeboard Guidance Mark for F/V Joanna C**

STABILITY NOTICE				
Name **Joanna C** No. **BM 265** Owner **0** Length **14 metres** Beam **5.175 metres**	**Loading & Lifting Guidance**	**Safety Zone**	**Minimum Freeboard**	**Maximum Recommended Seastate**
	Good margin of residual freeboard	**Good margin of safety**	At least 58 cm	
	Loading or lifting reduces minimum freeboard to less than 58 cm	**Low level of safety**	29 to 58 cm	1.6 metres
	Excessive loading or lifting reduces minimum freeboard to less than 29 cm	**Danger of capsize**	Less than 29 cm	0.8 metres

Freeboard Guidance Mark - size and location



APPENDIX A INCLINING EXPERIMENT RESULTS

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Mean Shell Thickness	0.0000 metres
Longitudinal Datum	Stn 5
Vertical Datum	1980 Baseline
Trim Length	12.801 metres

Draught Marks	Name	X metres	Z metres
Aft Marks	STN 10	-6.858	0.000
Mid Marks	STN 5	0.000	0.000
Fwd Marks	STN 0	6.858	0.000

Weight Shifts

No.	Direction	Weight tonnes	Distance metres	Deflection P1, mm	Rate P1, Deflection/Moment	Deflection P2, mm	Rate P2, Deflection/Moment
1	Starboard	0.254	3.000	54.0	70.866	52.0	68.241
2	Starboard	0.254	3.000	53.0	69.554	51.0	66.929
3	Port	0.254	3.000	53.0	69.554	51.0	66.929
4	Port	0.254	3.000	54.0	70.866	52.0	68.241
5	Port	0.254	3.000	53.0	69.554	51.0	66.929
6	Port	0.254	3.000	54.0	70.866	53.0	69.554
7	Starboard	0.254	3.000	54.0	70.866	53.0	69.554
8	Starboard	0.254	3.000	53.0	69.554	51.0	66.929

Pendulum Data

No.	Position	Length metres	GM metres
1	Fishroom Hatch Port	2.115	0.431
2	Fishroom Hatch Stbd	2.112	0.445

Draught readings

No.	Position	X Value metres	Draught metres
1	Fr 2	-5.867	2.247
2	Fr 30	6.934	2.337

As Inclined Condition

Displacement	69.939 tonnes
LCG	-0.047 metres
VCG	2.619 metres
KMT	3.057 metres
GMT	0.438 metres
LCB	-0.040 metres
VCB	1.597 metres

Specific Gravity at Inclining 1.0240

Mid Marks Draught 2.288 metres
Trim Between Marks 0.096 metres by the bow

Items to be added to calculate lightship

Item	Weight tonnes	LCG metres	VCG metres	TCG metres	FSM tonnes.m
Catch Conveyor Belts	0.150	-2.761	3.566	0.000	0.000
Total	**0.150**	**-2.761**	**3.566**	**0.000**	**0.000**

Items to be removed to calculate lightship

Item	Weight tonnes	LCG metres	VCG metres	TCG metres	FSM tonnes.m
4 x inclining wt	1.016	-2.856	2.817	0.000	0.000
2 x personnel in fishroom, kneeling	0.160	-1.290	1.462	0.000	0.000
3 x personnel on deck, standing	0.240	0.000	3.645	0.000	0.000
Fuel Oil Tk Port	2.370	1.160	1.720	0.000	0.000
Fuel Oil Tk Stbd	2.490	1.750	1.780	0.000	0.000
Fresh Water Tk (2019) PS	0.583	3.615	1.810	-1.518	0.000
Fresh Water Tk (2019) SS	0.583	3.615	1.810	1.518	0.000
Total	**7.441**	**1.104**	**1.960**	**0.000**	**0.000**

Lightship Condition

Specific Gravity 1.0250

Displacement	62.648 tonnes
LCG	-0.190 metres
VCG (uncorrected for fluids)	2.699 metres
VCG	2.699 metres
GM	0.419 metres

Draught	Aft	2.236 metres
	Mid	2.153 metres
	Fwd	2.070 metres

Trim Between Marks 0.166 metres by the stern

APPENDIX B LOADING CONDITIONS AND STABILITY DATA

Filename: Z:\Projects\3917 FV Joanna C Stability Analysis\lines definition\JoannaC_09.02.21(0).hst
Date : 10/02/2021
Time :16:35:52

Specific Gravity of Water	1.0250
Mean Shell Thickness	0.0000 metres
Longitudinal Datum	Stn 5
Vertical Datum	1980 Baseline
Trim Length	13.716 metres

Draught Marks	**Name**	**X metres**	**Z metres**
Aft Marks	STN 10	-6.858	0.000
Mid Marks	STN 5	0.000	0.000
Fwd Marks	STN 0	6.858	0.000

Conditions

Condition 1: LC1 - Lightship Including Fishing Gear

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	0.000	--	--	--	--	--	0.000	0.0
Fuel Tk SS	0.000	--	--	--	--	--	0.000	0.0
FW Tk PS	0.000	--	--	--	--	--	0.000	0.0
FW Tk SS	0.000	--	--	--	--	--	0.000	0.0
Provisions	0.000	--	--	--	--	--	0.000	--
Crew and Effects	0.000	--	--	--	--	--	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.000	--	--	--	--	--	0.000	--
Ice (Unused)	0.000	--	--	--	--	--	0.000	--
Fish and Ice Boxed	0.000	--	--	--	--	--	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**3.390**	**-2.015**	**-6.83**	**3.236**	**10.97**	**0.000**	**0.000**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**66.038**	**-0.284**	**-18.73**	**2.727**	**180.09**	**0.000**	**0.000**	

Draught Aft 2.366 metres
Mid 2.210 metres
Fwd 2.053 metres

Trim Between Marks 0.313 metres by the stern

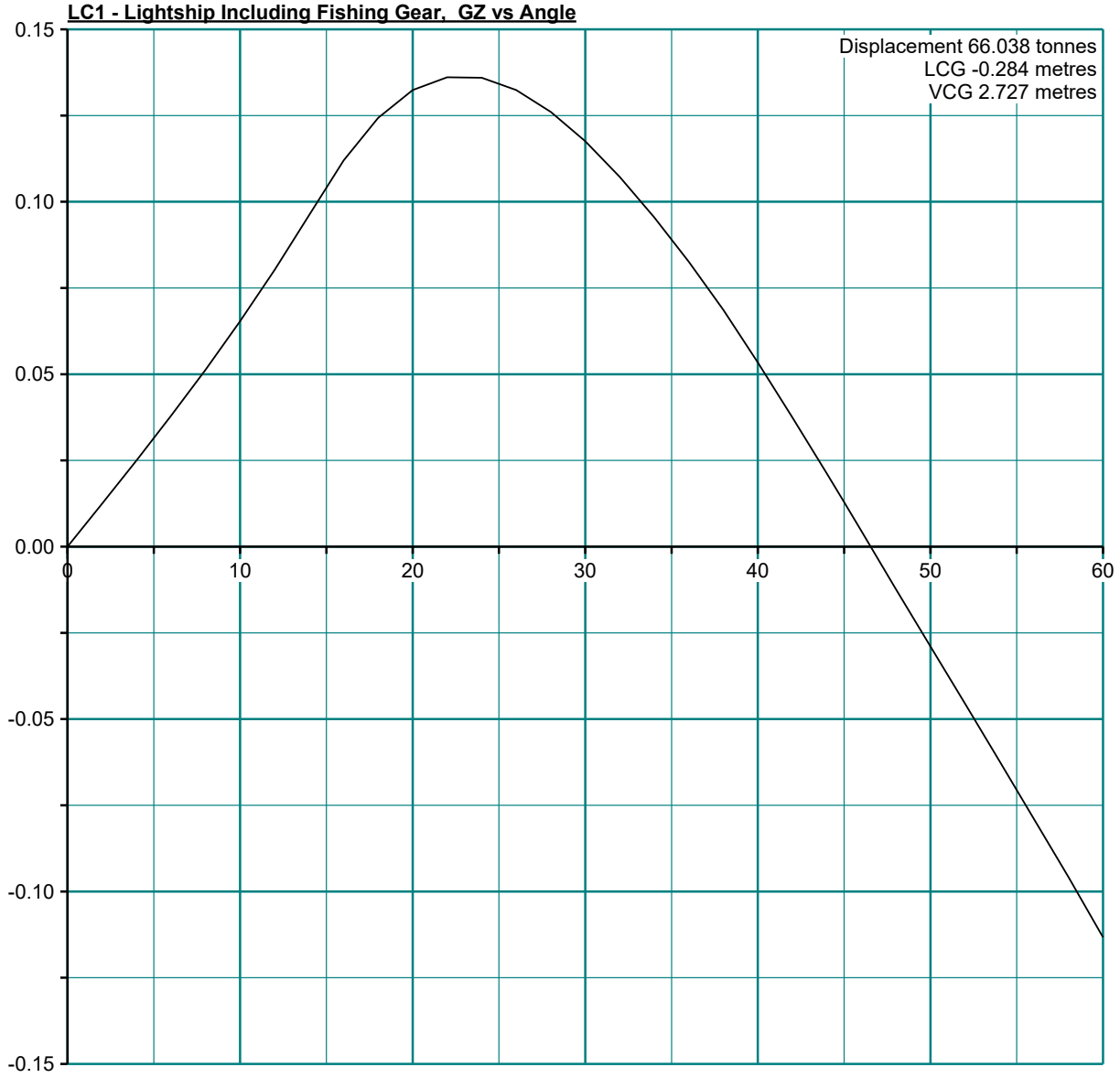
GM Solid 0.355 metres
GM Fluid 0.355 metres
Effective VCG 2.727 metres

Angle of Vanishing Stability 46.5 degrees to stbd 46.5 degrees to port
Maximum GZ 0.136 metres to stbd 0.136 metres to port
Maximum GZ Angle 22.8 degrees to stbd 22.8 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.210	0.313	1.560	0.000
10.0	0.065	0.539	2.232	0.317	1.584	0.006
20.0	0.132	1.065	2.305	0.348	1.654	0.023
30.0	0.118	1.481	2.454	0.511	1.736	0.046
45.0	0.013	1.941	2.774	0.944	1.867	0.065
60.0	-0.113	2.248	3.153	1.520	2.022	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.669	16.9	120.1	DE Tr
-5.486	2.249	3.000	0.665	16.5	125.8	DE S9
-4.115	2.387	2.952	0.648	15.3	138.7	DE S8
-2.743	2.500	2.916	0.644	14.6	149.7	DE S7
-2.611	2.506	2.913	0.644	14.5	150.6	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.645	14.3	159.2	DE S6
0.000	2.570	2.926	0.716	15.8	166.5	DE S5
1.372	2.546	3.021	0.843	18.7	172.5	DE S4

LC1 - Lightship Including Fishing Gear, GZ vs Angle



Condition 2: LC2 - Departure from Port

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	2.364	1.157	2.74	1.744	4.12	-2.041	0.097	98.0
Fuel Tk SS	2.486	1.747	4.34	1.792	4.46	2.021	0.101	98.0
FW Tk PS	0.583	3.615	2.11	1.810	1.05	-1.518	0.000	100.0
FW Tk SS	0.582	3.615	2.11	1.809	1.05	1.518	0.000	100.0
Provisions	0.100	2.500	0.25	3.500	0.35	0.000	0.000	--
Crew and Effects	0.250	3.000	0.75	4.250	1.06	0.000	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.280	-2.300	-0.64	1.900	0.53	0.000	0.000	--
Ice (Unused)	2.000	-3.500	-7.00	2.000	4.00	0.000	0.000	--
Fish and Ice Boxed	0.000	--	--	--	--	--	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**12.035**	**-0.181**	**-2.18**	**2.293**	**27.60**	**0.017**	**0.198**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**74.684**	**-0.189**	**-14.08**	**2.634**	**196.72**	**0.003**	**0.198**	

Draught Aft 2.434 metres
Mid 2.366 metres
Fwd 2.298 metres

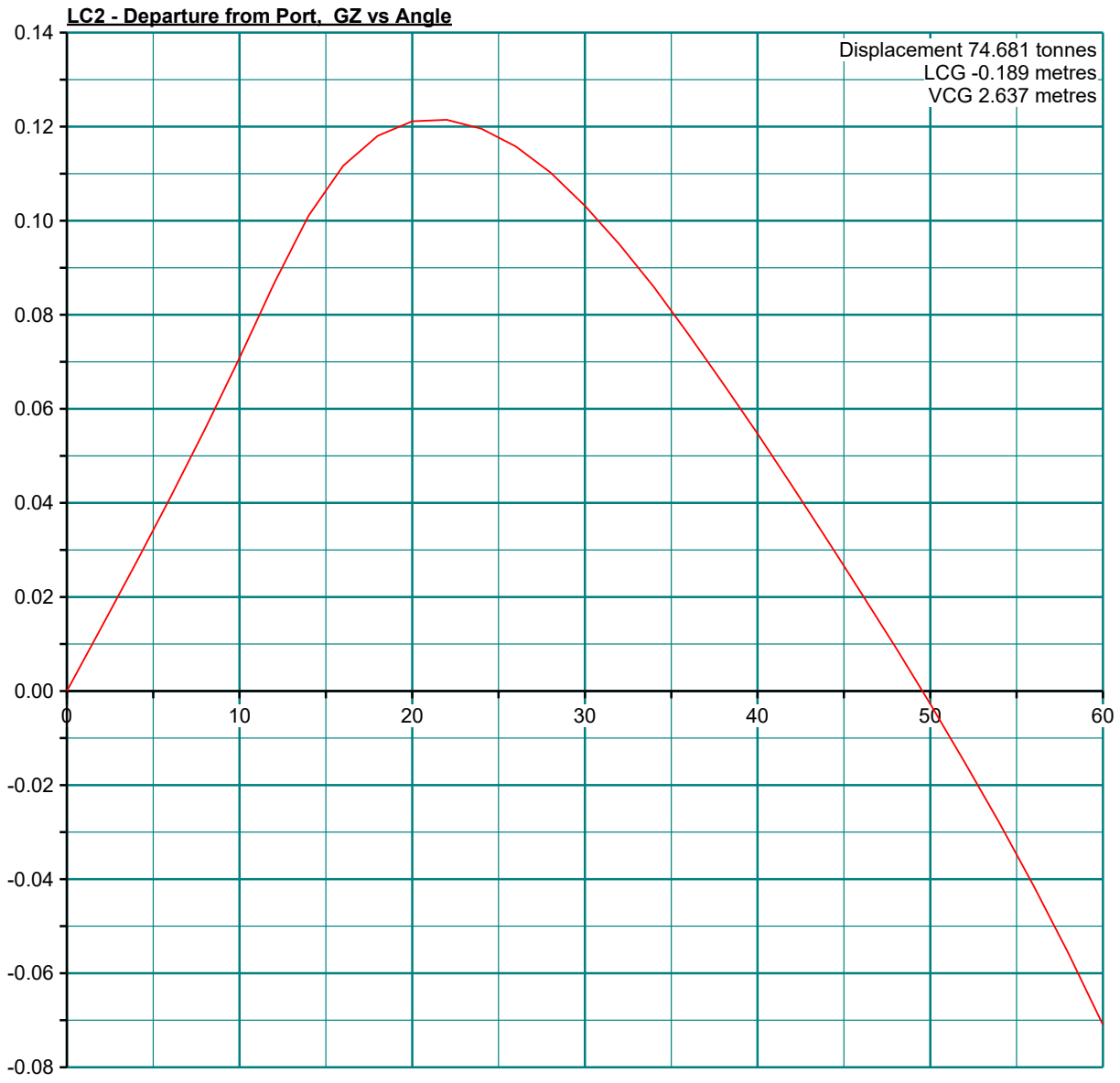
Trim Between Marks 0.136 metres by the stern

GM Solid 0.389 metres
GM Fluid 0.387 metres
Effective VCG 2.637 metres

Angle of Vanishing Stability 49.5 degrees to stbd 49.5 degrees to port
Maximum GZ 0.122 metres to stbd 0.122 metres to port
Maximum GZ Angle 21.4 degrees to stbd 21.4 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.366	0.136	1.643	0.000
10.0	0.071	0.529	2.387	0.141	1.665	0.006
20.0	0.121	1.023	2.468	0.211	1.722	0.024
30.0	0.103	1.422	2.637	0.444	1.790	0.044
45.0	0.027	1.891	2.985	1.004	1.911	0.062
60.0	-0.071	2.212	3.396	1.674	2.052	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.591	14.9	111.0	DE Tr
-5.486	2.249	3.000	0.579	14.4	117.4	DE S9
-4.115	2.387	2.952	0.545	12.9	131.6	DE S8
-2.743	2.500	2.916	0.523	11.9	143.8	DE S7
-2.611	2.506	2.913	0.521	11.8	144.8	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.506	11.3	154.2	DE S6
0.000	2.570	2.926	0.560	12.4	162.1	DE S5
1.372	2.546	3.021	0.669	14.9	168.5	DE S4


LC2 - Departure from Port, GZ vs Angle
Displacement 74.681 tonnes
LCG -0.189 metres
VCG 2.637 metres
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
0
10
20
30
40
50
60

Condition 3: LC3 - Arrival at Grounds

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	2.171	1.154	2.50	1.683	3.65	-2.037	0.094	90.0
Fuel Tk SS	2.283	1.738	3.97	1.735	3.96	2.018	0.098	90.0
FW Tk PS	0.542	3.616	1.96	1.766	0.96	-1.475	0.002	93.0
FW Tk SS	0.542	3.616	1.96	1.766	0.96	1.475	0.002	93.0
Provisions	0.090	2.500	0.22	3.500	0.32	0.000	0.000	--
Crew and Effects	0.250	3.000	0.75	4.250	1.06	0.000	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.280	-2.300	-0.64	1.900	0.53	0.000	0.000	--
Ice (Unused)	1.960	-3.500	-6.86	2.000	3.92	0.000	0.000	--
Fish and Ice Boxed	0.000	--	--	--	--	--	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**11.508**	**-0.258**	**-2.97**	**2.288**	**26.33**	**0.016**	**0.196**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**74.156**	**-0.200**	**-14.86**	**2.636**	**195.45**	**0.002**	**0.196**	

Draught Aft 2.436 metres
Mid 2.356 metres
Fwd 2.277 metres

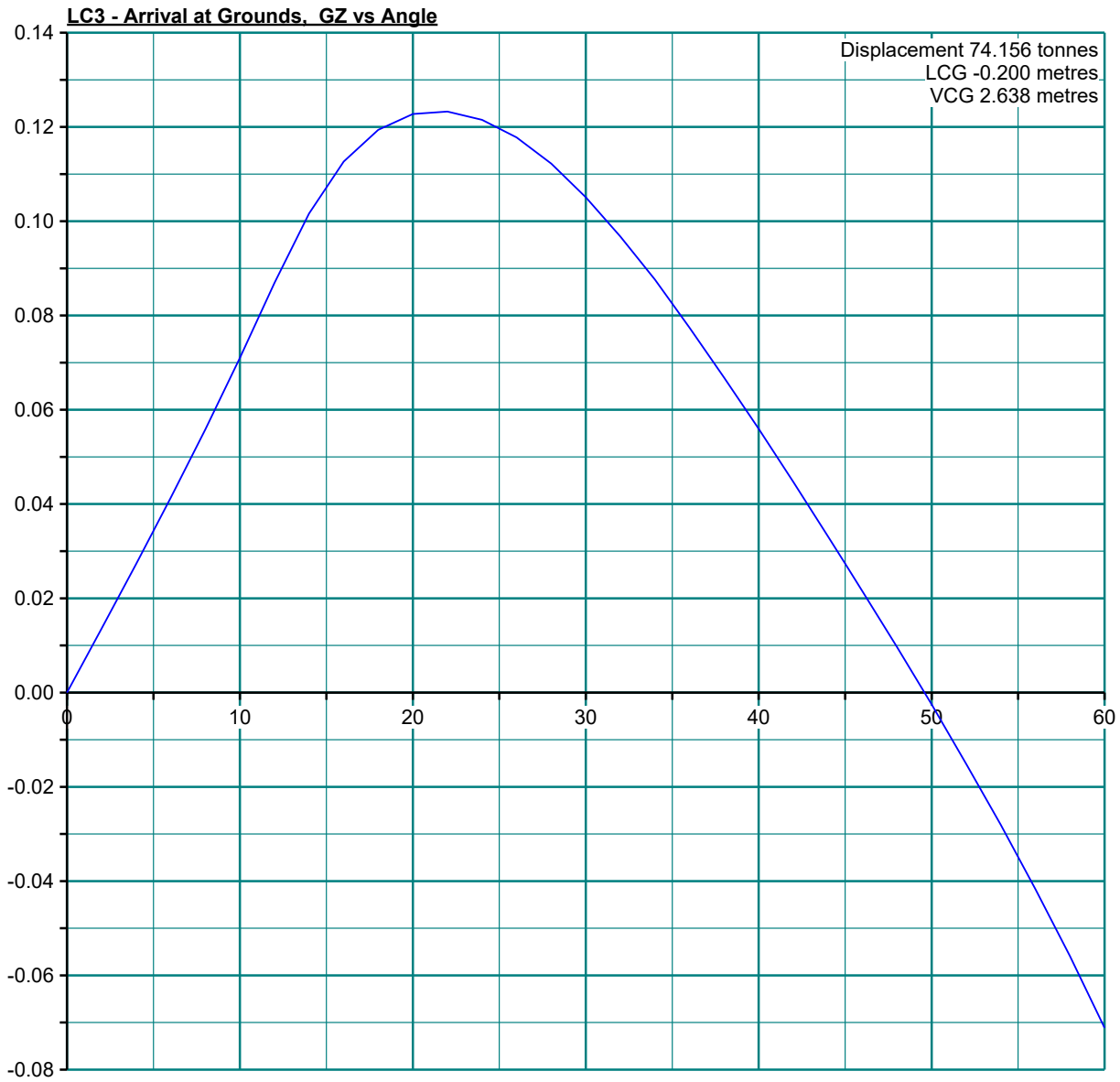
Trim Between Marks 0.158 metres by the stern

GM Solid 0.390 metres
GM Fluid 0.388 metres
Effective VCG 2.638 metres

Angle of Vanishing Stability 49.6 degrees to stbd 49.6 degrees to port
Maximum GZ 0.123 metres to stbd 0.123 metres to port
Maximum GZ Angle 21.6 degrees to stbd 21.6 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.356	0.158	1.638	0.000
10.0	0.071	0.529	2.377	0.163	1.660	0.006
20.0	0.123	1.025	2.458	0.230	1.718	0.024
30.0	0.105	1.424	2.626	0.460	1.786	0.045
45.0	0.027	1.893	2.973	1.015	1.908	0.063
60.0	-0.071	2.214	3.383	1.679	2.050	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.591	14.9	111.4	DE Tr
-5.486	2.249	3.000	0.580	14.4	117.8	DE S9
-4.115	2.387	2.952	0.548	13.0	132.0	DE S8
-2.743	2.500	2.916	0.528	12.0	144.1	DE S7
-2.611	2.506	2.913	0.526	12.0	145.1	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.514	11.4	154.5	DE S6
0.000	2.570	2.926	0.570	12.6	162.4	DE S5
1.372	2.546	3.021	0.680	15.2	168.8	DE S4


LC3 - Arrival at Grounds, GZ vs Angle
Displacement 74.156 tonnes
LCG -0.200 metres
VCG 2.638 metres
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
0
10
20
30
40
50
60

Condition 4: LC4 - Departure from Grounds 100% Catch

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	0.434	1.024	0.44	1.076	0.47	-1.934	0.061	18.0
Fuel Tk SS	0.457	1.467	0.67	1.142	0.52	1.932	0.061	18.0
FW Tk PS	0.099	3.610	0.36	1.450	0.14	-1.301	0.058	17.0
FW Tk SS	0.099	3.610	0.36	1.450	0.14	1.301	0.058	17.0
Provisions	0.020	2.500	0.05	3.500	0.07	0.000	0.000	--
Crew and Effects	0.250	3.000	0.75	4.250	1.06	0.000	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.000	--	--	--	--	--	0.000	--
Ice (Unused)	0.710	-3.500	-2.48	1.750	1.24	0.000	0.000	--
Fish and Ice Boxed	3.860	-1.000	-3.86	1.750	6.75	0.000	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**9.319**	**-1.132**	**-10.55**	**2.294**	**21.38**	**0.005**	**0.238**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**71.967**	**-0.312**	**-22.44**	**2.647**	**190.49**	**0.001**	**0.238**	

Draught Aft 2.493 metres
Mid 2.314 metres
Fwd 2.134 metres

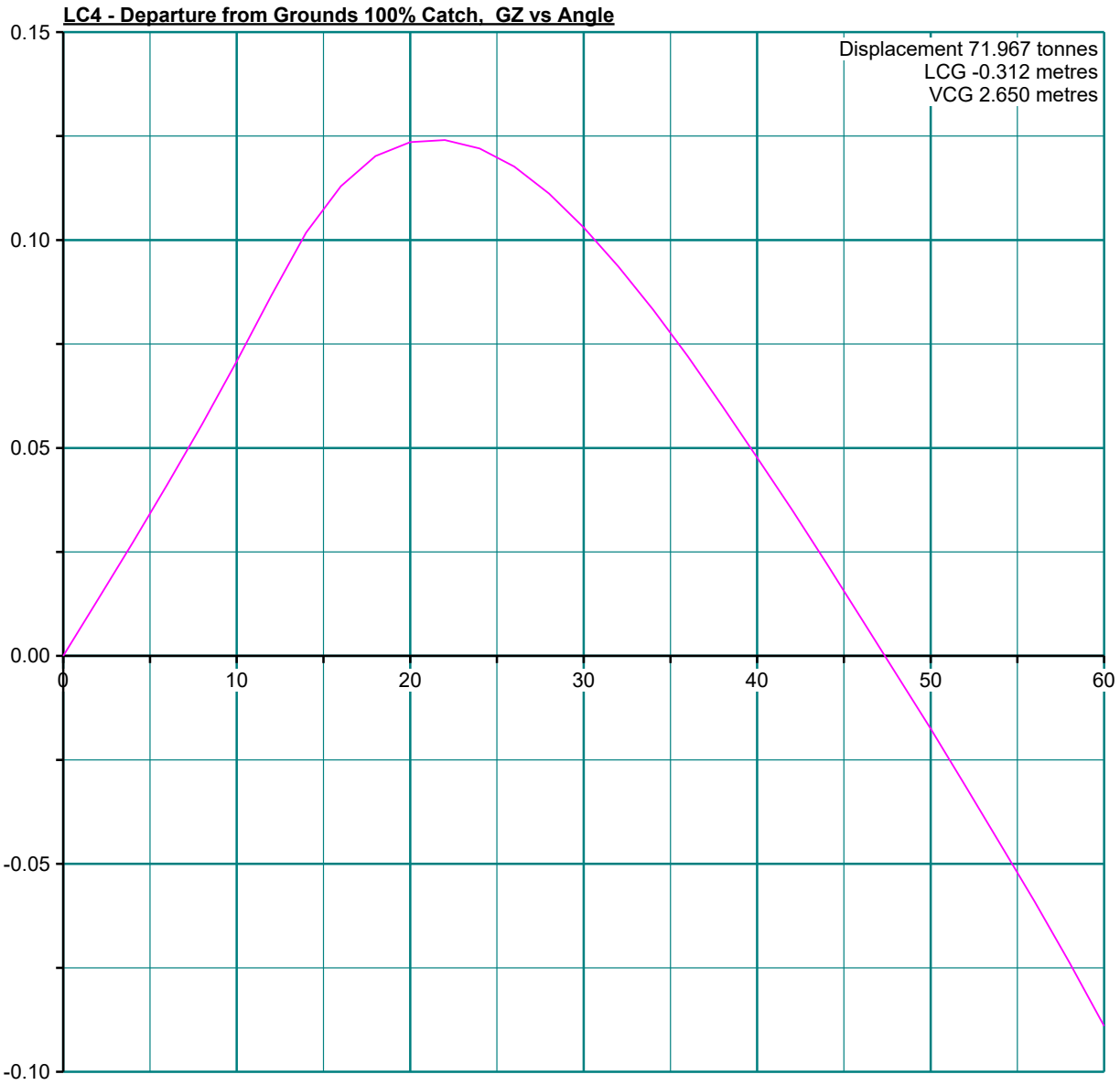
Trim Between Marks 0.359 metres by the stern

GM Solid 0.390 metres
GM Fluid 0.387 metres
Effective VCG 2.650 metres

Angle of Vanishing Stability 47.4 degrees to stbd 47.4 degrees to port
Maximum GZ 0.124 metres to stbd 0.124 metres to port
Maximum GZ Angle 21.5 degrees to stbd 21.5 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.314	0.359	1.619	0.000
10.0	0.071	0.531	2.335	0.360	1.641	0.006
20.0	0.124	1.030	2.416	0.429	1.701	0.024
30.0	0.103	1.428	2.584	0.660	1.771	0.045
45.0	0.016	1.890	2.932	1.204	1.891	0.061
60.0	-0.089	2.206	3.339	1.860	2.034	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.544	13.9	110.4	DE Tr
-5.486	2.249	3.000	0.543	13.6	117.1	DE S9
-4.115	2.387	2.952	0.531	12.6	131.8	DE S8
-2.743	2.500	2.916	0.530	12.1	144.3	DE S7
-2.611	2.506	2.913	0.531	12.1	145.3	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.536	11.9	154.9	DE S6
0.000	2.570	2.926	0.612	13.6	163.1	DE S5
1.372	2.546	3.021	0.743	16.5	169.8	DE S4


LC4 - Departure from Grounds 100% Catch, GZ vs Angle
Displacement 71.967 tonnes
LCG -0.312 metres
VCG 2.650 metres
0.15
0.10
0.05
0.00
-0.05
-0.10
0
10
20
30
40
50
60

Condition 5: LC5 - Arrival in Port 100% Catch

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	0.241	0.964	0.23	0.977	0.24	-1.886	0.033	10.0
Fuel Tk SS	0.254	1.362	0.35	1.037	0.26	1.891	0.038	10.0
FW Tk PS	0.058	3.609	0.21	1.416	0.08	-1.284	0.048	10.0
FW Tk SS	0.058	3.609	0.21	1.416	0.08	1.284	0.048	10.0
Provisions	0.010	2.500	0.03	3.500	0.04	0.000	0.000	--
Crew and Effects	0.250	3.000	0.75	4.250	1.06	0.000	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.000	--	--	--	--	--	0.000	--
Ice (Unused)	0.700	-3.500	-2.45	1.750	1.22	0.000	0.000	--
Fish and Ice Boxed	3.830	-1.000	-3.83	1.750	6.70	0.000	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**8.792**	**-1.290**	**-11.34**	**2.350**	**20.66**	**0.003**	**0.166**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**71.440**	**-0.325**	**-23.23**	**2.656**	**189.78**	**0.000**	**0.166**	

Draught Aft 2.495 metres
Mid 2.304 metres
Fwd 2.113 metres

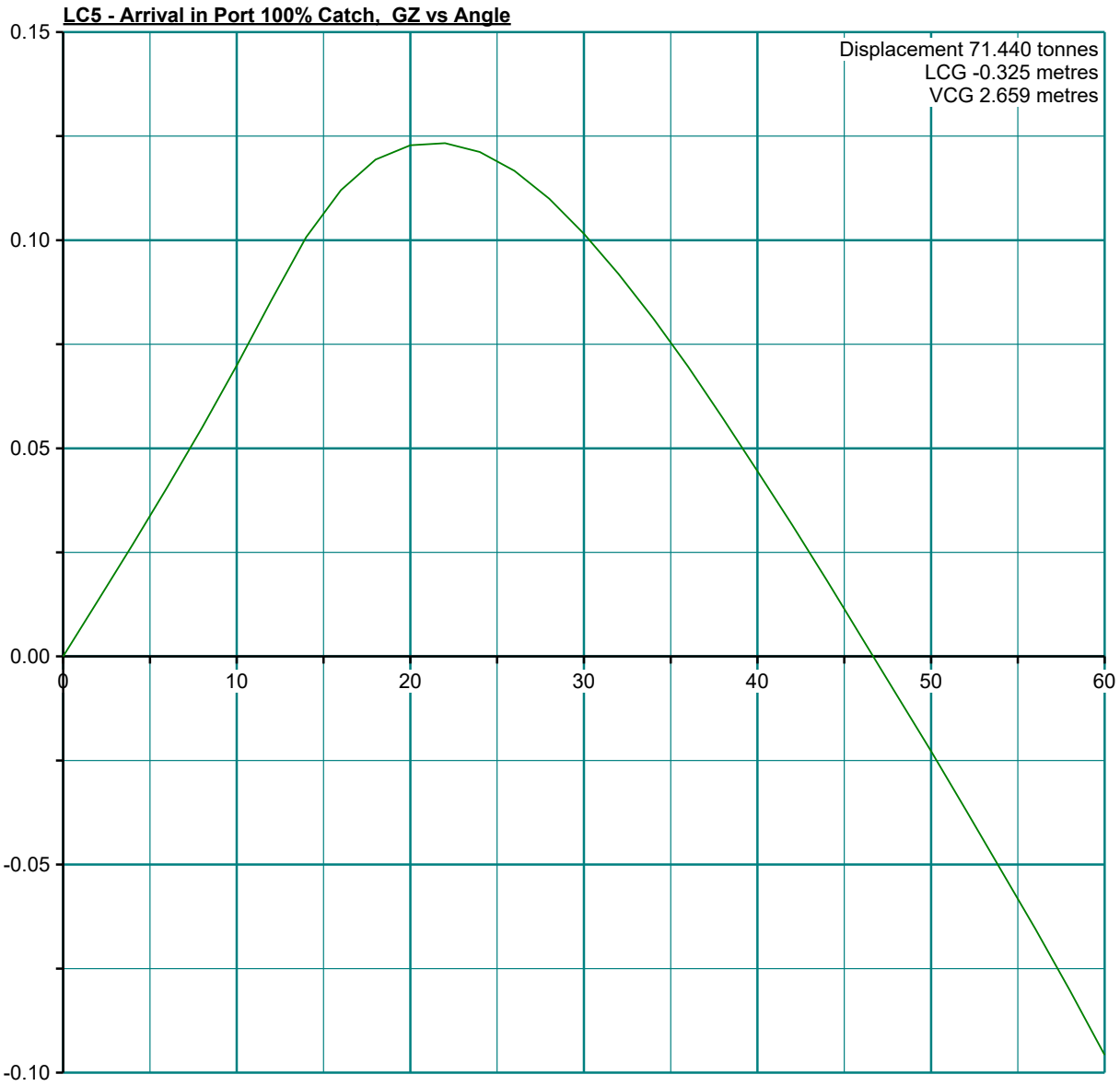
Trim Between Marks 0.383 metres by the stern

GM Solid 0.384 metres
GM Fluid 0.382 metres
Effective VCG 2.659 metres

Angle of Vanishing Stability 46.7 degrees to stbd 46.7 degrees to port
Maximum GZ 0.123 metres to stbd 0.123 metres to port
Maximum GZ Angle 21.5 degrees to stbd 21.5 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.304	0.383	1.615	0.000
10.0	0.070	0.532	2.325	0.384	1.637	0.006
20.0	0.123	1.032	2.406	0.451	1.697	0.024
30.0	0.102	1.431	2.573	0.680	1.768	0.044
45.0	0.011	1.891	2.920	1.219	1.888	0.060
60.0	-0.096	2.207	3.325	1.871	2.032	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.544	13.9	110.7	DE Tr
-5.486	2.249	3.000	0.543	13.6	117.4	DE S9
-4.115	2.387	2.952	0.533	12.7	132.1	DE S8
-2.743	2.500	2.916	0.536	12.2	144.5	DE S7
-2.611	2.506	2.913	0.536	12.2	145.6	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.544	12.1	155.2	DE S6
0.000	2.570	2.926	0.622	13.8	163.3	DE S5
1.372	2.546	3.021	0.755	16.8	170.0	DE S4


LC5 - Arrival in Port 100% Catch, GZ vs Angle
Displacement 71.440 tonnes
LCG -0.325 metres
VCG 2.659 metres
0.15
0.10
0.05
0.00
-0.05
-0.10
0
10
20
30
40
50
60

Condition 6: LC6 - Departure from Grounds 20% Catch

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	0.434	1.024	0.44	1.076	0.47	-1.934	0.061	18.0
Fuel Tk SS	0.457	1.467	0.67	1.142	0.52	1.932	0.061	18.0
FW Tk PS	0.099	3.610	0.36	1.450	0.14	-1.301	0.058	17.0
FW Tk SS	0.099	3.610	0.36	1.450	0.14	1.301	0.058	17.0
Provisions	0.020	2.500	0.05	3.500	0.07	0.000	0.000	--
Crew and Effects	0.250	3.000	0.75	4.250	1.06	0.000	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.220	-2.300	-0.51	1.900	0.42	0.000	0.000	--
Ice (Unused)	1.420	-3.500	-4.97	1.900	2.70	0.000	0.000	--
Fish and Ice Boxed	0.770	-0.900	-0.69	1.250	0.96	0.000	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**7.159**	**-1.448**	**-10.37**	**2.438**	**17.46**	**0.006**	**0.238**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**69.807**	**-0.319**	**-22.27**	**2.673**	**186.57**	**0.001**	**0.238**	

Draught Aft 2.461 metres
Mid 2.275 metres
Fwd 2.090 metres

Trim Between Marks 0.371 metres by the stern

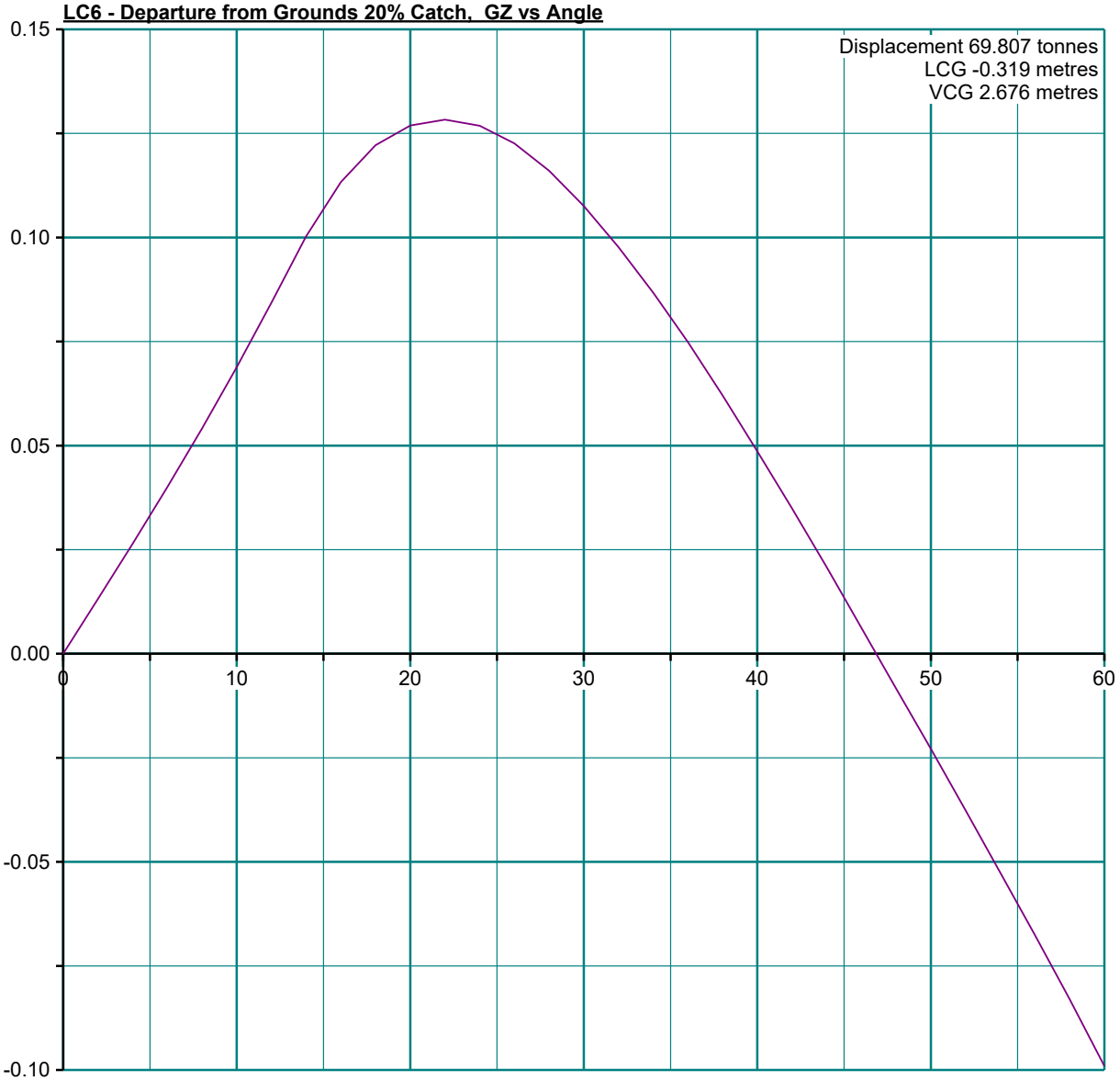
GM Solid 0.379 metres
GM Fluid 0.376 metres
Effective VCG 2.676 metres

Angle of Vanishing Stability 46.8 degrees to stbd 46.9 degrees to port
Maximum GZ 0.128 metres to stbd 0.128 metres to port
Maximum GZ Angle 22.0 degrees to stbd 22.0 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.275	0.371	1.599	0.000
10.0	0.069	0.534	2.297	0.373	1.621	0.006
20.0	0.127	1.042	2.375	0.428	1.684	0.024
30.0	0.108	1.446	2.537	0.639	1.758	0.045
45.0	0.014	1.906	2.876	1.148	1.881	0.062
60.0	-0.099	2.219	3.274	1.779	2.028	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.577	14.7	113.7	DE Tr
-5.486	2.249	3.000	0.576	14.4	120.0	DE S9
-4.115	2.387	2.952	0.565	13.4	134.1	DE S8
-2.743	2.500	2.916	0.566	12.9	146.1	DE S7
-2.611	2.506	2.913	0.567	12.9	147.2	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.574	12.7	156.4	DE S6
0.000	2.570	2.926	0.651	14.4	164.3	DE S5
1.372	2.546	3.021	0.783	17.4	170.8	DE S4

LC6 - Departure from Grounds 20% Catch, GZ vs Angle



Condition 7: LC7 - Arrival in Port 20% Catch

Item	Weight	LCG	LMom	VCG	VMom	TCG	FSM	Perc.Full
Fuel Tk PS	0.241	0.964	0.23	0.977	0.24	-1.886	0.033	10.0
Fuel Tk SS	0.254	1.362	0.35	1.037	0.26	1.891	0.038	10.0
FW Tk PS	0.058	3.609	0.21	1.416	0.08	-1.284	0.048	10.0
Fuel Tk SS	0.298	1.362	0.41	1.037	0.31	1.891	0.045	10.0
Provisions	0.010	2.500	0.03	3.500	0.04	0.000	0.000	--
Crew and Effects	0.250	3.000	0.75	4.250	1.06	0.000	0.000	--
Fishing Gear	3.390	-2.015	-6.83	3.236	10.97	0.000	0.000	--
Fish Boxes (Unused)	0.220	-2.300	-0.51	1.900	0.42	0.000	0.000	--
Ice (Unused)	1.390	-3.500	-4.86	1.900	2.64	0.000	0.000	--
Fish and Ice Boxed	0.770	-0.900	-0.69	1.250	0.96	0.000	0.000	--
Bulk Fish in Pounds	0.000	--	--	--	--	--	0.000	--
Deadweight	**6.882**	**-1.588**	**-10.92**	**2.467**	**16.98**	**0.075**	**0.163**	
Lightship	**62.648**	**-0.190**	**-11.90**	**2.699**	**169.12**	**0.000**	**0.000**	
Displacement	**69.530**	**-0.328**	**-22.82**	**2.677**	**186.10**	**0.007**	**0.163**	

Draught Aft 2.464 metres
Mid 2.270 metres
Fwd 2.076 metres

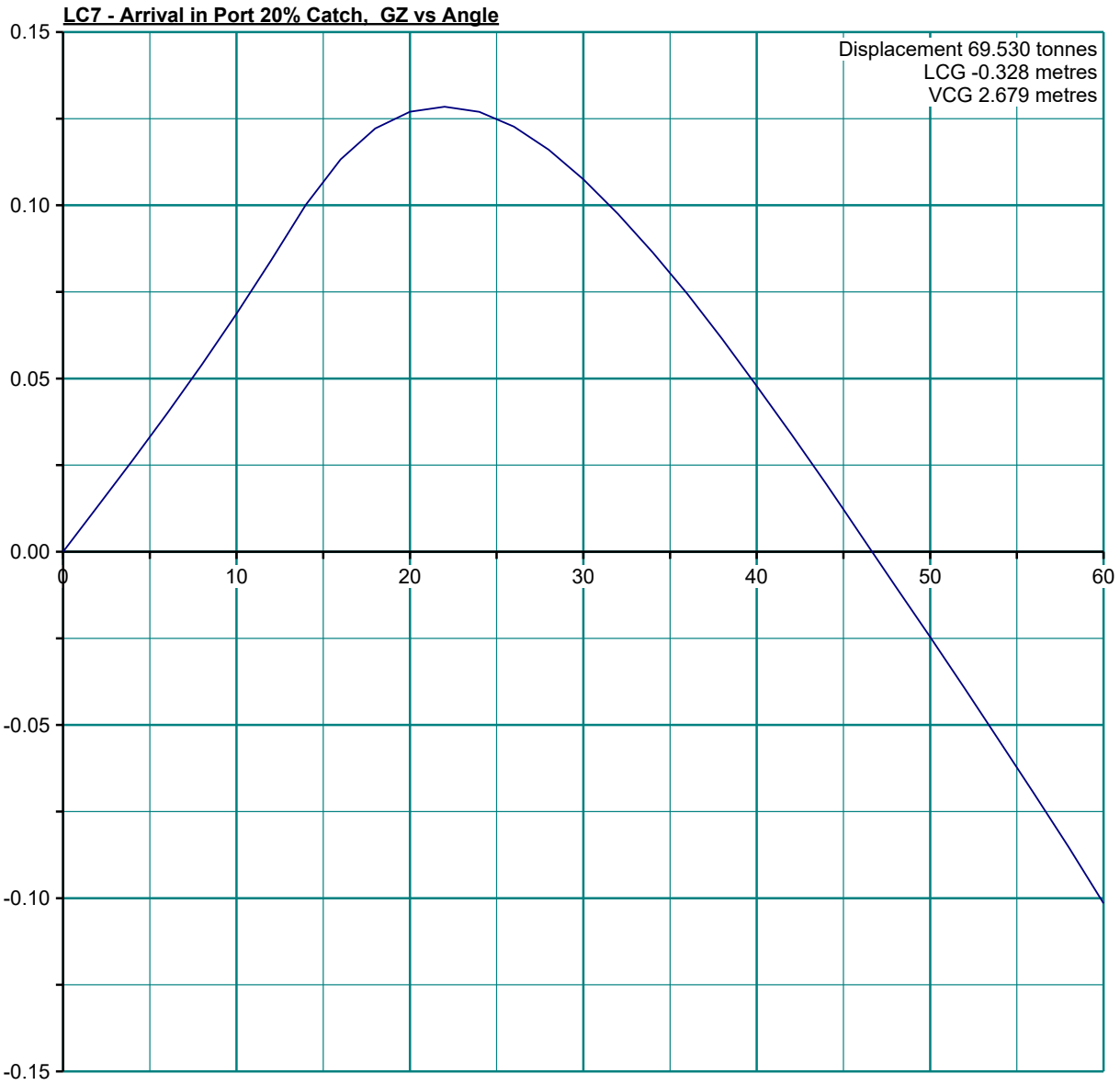
Trim Between Marks 0.388 metres by the stern

GM Solid 0.377 metres
GM Fluid 0.375 metres
Effective VCG 2.679 metres

Angle of Vanishing Stability 46.7 degrees to stbd 46.7 degrees to port
Maximum GZ 0.128 metres to stbd 0.128 metres to port
Maximum GZ Angle 22.0 degrees to stbd 22.0 degrees to port

Heel Angle degrees	Righting GZ metres	Lever KN metres	Waterline metres	Trim metres	VCB metres	GZ Curve Area metres.rad
0.0	0.000	0.000	2.270	0.388	1.596	0.000
10.0	0.069	0.534	2.292	0.389	1.619	0.006
20.0	0.127	1.043	2.369	0.444	1.682	0.024
30.0	0.107	1.447	2.531	0.653	1.756	0.045
45.0	0.012	1.906	2.870	1.160	1.880	0.062
60.0	-0.101	2.218	3.267	1.789	2.027	--

Deck Edge Points			Freeboard	Stbd Angle	Port Angle	Description
X	Y	Z	metres	degrees		
-6.111	2.201	3.018	0.575	14.7	113.8	DE Tr
-5.486	2.249	3.000	0.575	14.4	120.0	DE S9
-4.115	2.387	2.952	0.566	13.4	134.2	DE S8
-2.743	2.500	2.916	0.569	12.9	146.3	DE S7
-2.611	2.506	2.913	0.569	12.9	147.3	25% LOA (Wolfson Mark)
-1.372	2.565	2.886	0.577	12.8	156.5	DE S6
0.000	2.570	2.926	0.656	14.5	164.4	DE S5
1.372	2.546	3.021	0.790	17.5	170.9	DE S4


LC7 - Arrival in Port 20% Catch, GZ vs Angle
Displacement 69.530 tonnes
LCG -0.328 metres
VCG 2.679 metres
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0
10
20
30
40
50
60

APPENDIX C INTACT STABILITY CRITERIA AND MAXIMUM KG RESULTS

Filename: Z:\Projects\3917 FV Joanna C Stability Analysis\lines definition\JoannaC_09.02.21(0).hst
Date : 10/02/2021
Time :16:52:57

Mean Shell Thickness	0.0000 metres
Longitudinal Datum	Stn 5
Vertical Datum	1980 Baseline
Trim Length	13.716 metres

Draught Marks	Name	X metres	Z metres
Aft Marks	STN 10	-6.858	0.000
Mid Marks	STN 5	0.000	0.000
Fwd Marks	STN 0	6.858	0.000

Maximum KG Data

Calculated with heel to starboard

Criteria:

1: The area up to 30 degrees shall be 0.066 m.rad

2: The area up to 40 degrees shall be 0.108 m.rad

3: The area from 30 - 40 degrees or downflooding angle shall be 0.036 m.rad

4: The angle of maximum GZ shall not be less than 25 degrees

5: GZ shall be at least 0.24 metres at angles of 30 degrees or more

6: GM shall be at least 0.42 metres

Maximum KG Values

Condition	Criteria No. 1 metres	2 metres	3 metres	4 metres	5 metres	6 metres
1: LC1 - Lightship Including Fishing Gear	2.580	2.530	2.522	2.616	2.484	2.662
2: LC2 - Departure from Port	2.475	2.425	2.419	2.519	2.365	2.603
3: LC3 - Arrival at Grounds	2.480	2.430	2.424	2.523	2.371	2.606
4: LC4 - Departure from Grounds 100% Catch	2.492	2.439	2.428	2.515	2.379	2.617
5: LC5 - Arrival in Port 100% Catch	2.498	2.444	2.433	2.518	2.385	2.621
6: LC6 - Departure from Grounds 20% Catch	2.523	2.470	2.459	2.544	2.414	2.632
7: LC7 - Arrival in Port 20% Catch	2.525	2.472	2.461	2.546	2.417	2.634

Condition No.	Displacement tonnes	LCG metres	VCG metres	TCG metres	Maximum KG metres	Deadweight Moment tonnes.metres	Critical Number	Pass/Fail
1	66.04	-0.284	2.727	0.000	2.484	-5.10	5	fail
2	74.68	-0.189	2.637	0.000	2.365	7.55	5	fail
3	74.16	-0.200	2.638	0.000	2.371	6.69	5	fail
4	71.97	-0.312	2.650	0.000	2.379	2.13	5	fail
5	71.44	-0.325	2.659	0.000	2.385	1.28	5	fail
6	69.81	-0.319	2.676	0.000	2.414	-0.60	5	fail
7	69.53	-0.328	2.679	0.000	2.417	-1.09	5	fail

Maximum KG Summary Data

Calculated with heel to starboard

LC1 - Lightship Including Fishing Gear

Displacement 66.04 tonnes
LCG -0.284 metres
VCG 2.727 metres
TCG 0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.046 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.062 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.015 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	22.8 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.118 metres	0.24 metres	fail
6	The value of the upright GM	0.355 metres	0.42 metres	fail

LC2 - Departure from Port

Displacement 74.68 tonnes
LCG -0.189 metres
VCG 2.637 metres
TCG 0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.044 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.058 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.014 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	21.4 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.103 metres	0.24 metres	fail
6	The value of the upright GM	0.386 metres	0.42 metres	fail

LC3 - Arrival at Grounds

Displacement 74.16 tonnes
LCG -0.200 metres
VCG 2.638 metres
TCG 0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.045 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.059 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.014 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	21.6 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.105 metres	0.24 metres	fail
6	The value of the upright GM	0.388 metres	0.42 metres	fail

LC4 - Departure from Grounds 100% Catch

Displacement 71.97 tonnes
LCG -0.312 metres
VCG 2.650 metres
TCG 0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.045 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.058 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.013 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	21.5 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.103 metres	0.24 metres	fail
6	The value of the upright GM	0.387 metres	0.42 metres	fail

LC5 - Arrival in Port 100% Catch

Displacement 71.44 tonnes
LCG -0.325 metres
VCG 2.659 metres
TCG 0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.044 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.057 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.013 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	21.5 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.101 metres	0.24 metres	fail
6	The value of the upright GM	0.382 metres	0.42 metres	fail

LC6 - Departure from Grounds 20% Catch

Displacement 69.81 tonnes
LCG -0.319 metres
VCG 2.676 metres
TCG 0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.045 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.059 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.014 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	22.0 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.108 metres	0.24 metres	fail
6	The value of the upright GM	0.376 metres	0.42 metres	fail

LC7 - Arrival in Port 20% Catch

Displacement	69.53 tonnes
LCG	-0.328 metres
VCG	2.679 metres
TCG	0.000 metres

No.	Criteria	Actual	Requirement	Pass/Fail
1	The area under the GZ curve from 0.0 degrees to 30 degrees	0.045 m.rad	0.066 m.rad	fail
2	The area under the GZ curve from 0.0 degrees to 40 degrees	0.059 m.rad	0.108 m.rad	fail
3	The area under the GZ curve from 30.0 degrees to 40.0 degrees	0.014 m.rad	0.036 m.rad	fail
4	The maximum value of GZ occurs at	22.0 degrees	25 degrees	fail
5	The value of GZ at an angle of heel of 30.0 degrees	0.107 metres	0.24 metres	fail
6	The value of the upright GM	0.375 metres	0.42 metres	fail

Fleetwood Test House liferaft report

DB/FTL/3319
28th April 2021

FLEETWOOD TESTING LABORATORY

TEST OF

WAYPOINT COASTAL
FOUR MAN LEISURE LIFERAFT

IN ACCORDANCE WITH

MAIB SPECIFICATION OF WORKS
(DATED 19.03.2021)

ON BEHALF OF

MARINE ACCIDENT INVESTIGATION BRANCH (MAIB)
FIRST FLOOR SPRING PLACE
105 COMMERCIAL ROAD
SOUTHAMPTON
SO15 1GH
UNITED KINGDOM

THIS REPORT CONTAINS SIX PAGES

REPORT ORIGINATOR

[redacted]

REPORT CHECKER

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UKAS TESTING LABORATORY NUMBER 1559

Results stated in this report are only representative of the samples submitted for testing at Fleetwood Testing Laboratory. Uncertainty applied is based on a standard uncertainty multiplied by a coverage factor of k=2, which relates to a coverage probability of approximately 95%. Decision rule ILAC G8:2009 applied with Guard band (1U) which has a specific risk of <2.5% probability for a false accept or false reject with the following conformity decision rules applied:

PASS:	***Results ± expanded uncertainty meet the criteria/specification.***
FAIL:	***Results ± expanded uncertainty do not meet the criteria/specification.***
INDETERMINATE:	***Results fall within the area of expanded uncertainty for the criteria/specification and so it is not possible to determine compliance/non-compliance based on a 95% level of confidence.***

A satisfactory test report does not imply that the product tested has been approved to the relevant standard.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

This test report shall not be published or reproduced in any form without written approval of Fleetwood Testing Laboratory.

Date of tests: The tests were carried out at Fleetwood Testing Laboratory on 28.04.2021.

Samples tested: Two samples of the Waypoint 'Coastal' Four Man Liferaft delivered on 27.04.2021 by the Marine Accident Investigation Branch (MAIB) as follows:
Sample 1: Recovered liferaft, which had been returned to the manufacturer, repacked, and secured with polypropylene straps in the existing canister.
Marked: Serial No. W16L300, Next service date 12/2019
Sample 2: New unconditioned liferaft purchased by the MAIB (tape sealed around canister and secured with polypropylene straps).
Marked: Serial No. W21D076, Next service date 04/2024.

Pictures:

Fig.1. Waypoint Liferaft – Recovered. Serial No. W16L300, as received.

Fig.2. Waypoint Liferaft – New sample. Serial No. W21D076, as received.

Present during testing:

[redacted]

MAIB Inspector
MAIB Technical Support Specialist
FTH Technical Manager
FTH Testing Engineer
FTH Testing Engineer
FTH Testing Engineer
FTH Testing Engineer

Tests carried out:

Tests carried out in accordance with the requirements of the MAIB Specification of Works (Dated 19.03.2021) as follows:

Test 1: Buoyancy test
(Test method and equipment carried out in accordance with EN ISO 12402-9:2020 for PFDs.)
Scope of test: To determine any variation in buoyancy after time immersed in water for both liferaft samples. Initial buoyancy measurement followed by load cell readings at intervals of 15 minutes over a period of at least an hour.

Test 2: Force to inflate test
Scope of test: Dry test to determine force required to initiate inflation of the liferaft. (The design requirement of the liferaft is ≤ 150N).

Equipment used:

The following equipment was used to conduct testing:

Equipment ref.	Description	Uncertainty of measure
F01/13	Digital Thermometer	± 0.42 ºC (at 20 ºC)
F04/7	100kg Load Cell (Buoyancy Tank)	± 7.4 g
F04/14	300kg Load Cell	± 37 g
F05/9	Digital Air Pressure Manometer	± 1.3 mbar
F08/9	Steel Tape Measure	± 0.97 mm

Results:

Test 1: Buoyancy test
(Test method and equipment carried out in accordance with EN ISO 12402-9:2020 for PFDs.)
Scope of test: To determine any variation in buoyancy after time immersed in water for both liferaft samples. Initial buoyancy measurement followed by load cell readings at intervals of 15 minutes over a period of at least an hour. Additional load cell readings were taken at the direction of the MAIB representatives.

Note: All buoyancy measurements conducted in fresh water. The reported measurements have been corrected to account for water temperature and air pressure. Buoyancy value conversion for salt-water value assumes a relative density of 1.025 kg/m³.

Sample 1: Waypoint 'Coastal' Leisure Liferaft – Recovered sample (Serial No. W16L300)

Time	Observations	Buoyancy measured (N)	Buoyancy in salt water (N)
9:00	Sample placed into the buoyancy tank (marked information facing upwards). The sample was not manually manipulated to remove trapped air in order to obtain a buoyancy measurement of the product including trapped air. A significant amount of trapped air observed escaping from beneath sample and the lip of the container.	302.06	309.61
9:15	No adjustment to sample. No bubbles of trapped air observed escaping.	207.29	212.47
9:30	No adjustment to sample. No bubbles of trapped air observed escaping.	206.47	211.63
9:45	No adjustment to sample. No bubbles of trapped air observed escaping.	206.35	211.51
9:49	The liferaft was inverted whilst remaining submerged to allow all remaining trapped air to escape from air holes in the base of the container and obtain a buoyancy measurement without trapped air. A significant amount of trapped air was observed escaping from inside the canister through the lip of the container	98.06	100.51
10:04	No adjustment to sample. No bubbles of trapped air observed escaping.	98.13	100.58

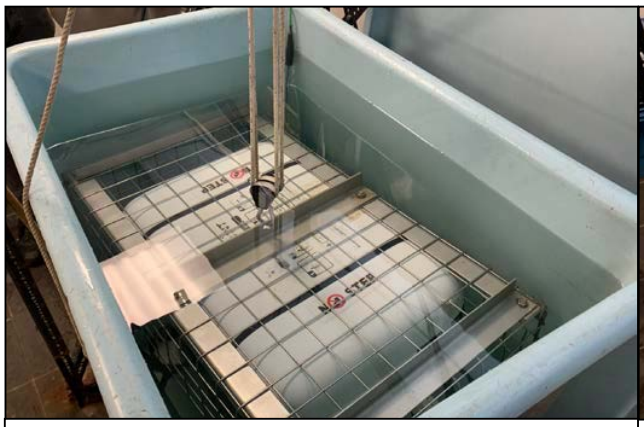

Fig.3. Waypoint Liferaft – Recovered. Serial No. W16L300 submerged in buoyancy tank (marked side up).

Fig.4. Waypoint Liferaft – Recovered. Serial No. W16L300, submerged in buoyancy tank (marked side down).

Sample 2: Waypoint 'Coastal' Leisure Liferaft – New sample (Serial No. W21D076)

Time	Observations	Buoyancy measured (N)	Buoyancy in salt water (N)
10:12	Sample placed into the buoyancy tank (marked information facing upwards). The sample was not manually manipulated to remove trapped air in order to obtain a buoyancy measurement of the product including trapped air. Bubbles of trapped air observed escaping from beneath sample. Note. This was significantly less than in the previous liferaft (Serial No. W16L300) that did not have tape around the seal. The sample was listing in the water due to significant trapped air.	409.40	419.64
10:27	No adjustment to sample. Bubbles of trapped air observed escaping from beneath sample.	338.54	347.00
10:33	Sample repositioned to a level position while remaining submerged. Bubbles of trapped air observed escaping.	282.38	289.44
10:48	No adjustment to sample. No bubbles of trapped air observed escaping.	281.92	288.97
10:50	The liferaft was inverted whilst remaining submerged to allow all remaining trapped air to escape from air holes in the base of the container. Bubbles of trapped air observed escaping.	176.82	181.24
11:05	No adjustment to sample. No bubbles of trapped air observed escaping.	113.87	116.72
11:09	Sample repositioned while remaining submerged. Bubbles of trapped air observed escaping.	113.27	116.10
11:24	No adjustment to sample. No bubbles of trapped air observed escaping.	112.58	115.39

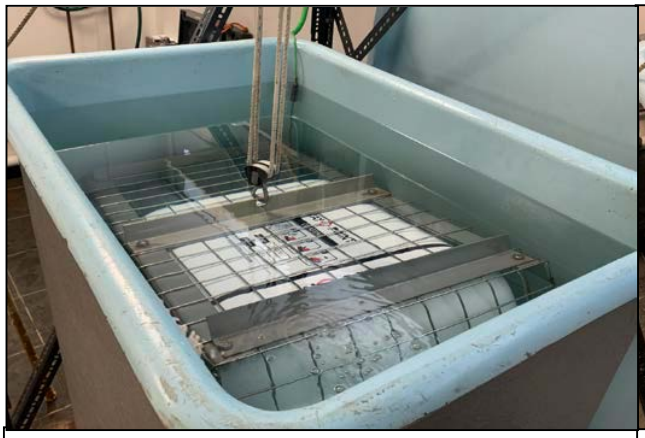

Fig.5. Waypoint Liferaft – New Sample. Serial No. W21D076 submerged in buoyancy tank (marked side up).

Fig.6. Waypoint Liferaft – New Sample. Serial No. W21D076 submerged in buoyancy tank (marked side down).

Test 2: Force to inflate test

Scope of test: Dry test to determine force required to initiate inflation of the liferaft. (The design requirement of the liferaft is ≤ 150N).

Prior to activation, the length of the released painter line was recorded at the point at which tension occurred. Each liferaft sample was then activated by pulling the painter line attached to a load cell and the maximum force measured was recorded.

Sample 1: Waypoint 'Coastal' Leisure Liferaft – Recovered sample (Serial No. W16L300)

Observations	Length of line at point of tension (cm)	Force required to activate (N)
During activation, the black grommet did not pull out with the loop handle of the painter line due to it being caught against the lip of the outer canister. The force required was greater as the knot on the painter line had to be pulled through the smaller hole of the grommet (which was subsequently damaged by the forced pull). The liferaft activated, but failed to deploy and inflate due to existing damage to the inflatable chambers.	352	247.0

Sample 2: Waypoint 'Coastal' Leisure Liferaft – New sample (Serial No. W21D076)

Observations	Length of line at point of tension (cm)	Force required to activate (N)
The black grommet pulled out with the loop handle of the painter line. The liferaft activated and inflated correctly as intended. Note: On initial inflation, the painter line was trapped around the middle of the raft, however it released soon after allowing full and correct inflation. No visual signs of damage to the liferaft following inflation.	377	137.8

Fig.7. Waypoint Liferaft – Recovered. Serial No. W16L300 following activation. Note the grommet not released with painter line loop handle.

Fig.8. Waypoint Liferaft – New sample. Serial No. W21D076 following activation and inflation.

Conclusion

Results were reported to the customer for information.

- End of Report -

MAIB safety flyer to the fishing industry

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

SAFETY FLYER TO THE FISHING INDUSTRY

Capsize and sinking of the scallop dredger, *Joanna C* (BM 265), with the loss of two lives, on 21 November 2020

Narrative

Image courtesy of Fishing News

Joanna C

Early in the morning on 21 November 2020, in darkness and windy conditions, the crew of the scallop dredger, *Joanna C*, was recovering the dredges, full of catch, back on board. As the gear emerged out of the water, the skipper realised that the starboard dredge bar was snagged on a potting line. At the same time, *Joanna C* started to heel to starboard and then rapidly capsized.

The mate, who was on deck, was thrown into the sea, but the skipper and deckhand were initially trapped inside the floating, upturned hull. After about 40 minutes, the skipper managed to escape as *Joanna C* sank, but the deckhand remained trapped inside. Once at the surface, the skipper found the mate, who was very cold and tangled in a rope.

Only the skipper survived this accident. The deckhand was unable to escape from the upturned boat and his body was recovered from the wreck by divers the following day; the mate's body washed up ashore sometime later.

Safety lessons

1. Modifications will alter a vessel's stability characteristics. *Joanna C* capsized because it had insufficient reserve of stability to counter the effect of the heel created by the starboard dredge becoming snagged. Post-accident analysis identified that multiple modifications over many years had eroded *Joanna C*'s stability condition from one of being very satisfactory, to that of failing the required criteria by a wide margin. When considering any modifications to a fishing vessel, it is vital that the potential effect on stability is considered.

2. Professional advice from a naval architect and informing the Maritime and Coastguard Agency (MCA) of your modification plans are key processes to ensure that fishing boats are operating safely with a sufficient margin of static stability to counter the dynamic effects of wind, waves or, as on this occasion, heeling as a result of snagging. It is potentially unsafe to continue fishing operations if there is any uncertainty over a vessel's stability characteristic, such as awaiting the results of a post-modification inclining experiment.

3. Automatic lifesaving appliances need to be arranged so that they float free and aid survivors. After *Joanna C* sank, the float free liferaft was released from its cradle by the Hydrostatic Release Unit (HRU) but did not subsequently inflate **(see figure)**. This meant that it did not come to the surface to provide refuge for the skipper and mate, adversely affecting their chances of survival.

4. The liferaft did not inflate because it was a model intended for use in the leisure industry and was not manufactured to meet any design standard. This meant that there was no guarantee that the liferaft would have sufficient buoyancy to overcome the pull required on the painter to initiate the inflation mechanism.

5. At the time of this accident, the carriage of a liferaft that did not meet any industry standard was acceptable under the small fishing vessel regulations. However, the safety lesson from this accident is that it is vital to check that, where 'float free' arrangements are in place, the buoyancy of the liferaft will be sufficient to overcome the inflation mechanism, when released from the cradle.

Figure: *Joanna C*'s uninflated liferaft floating mid-water, seen during a dive survey of the wreck

This flyer and the MAIB's investigation report are posted on our website: www.gov.uk/maib

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Extract from The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an such investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This safety flyer is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.