Use of the Wolfson stability guidance for appraising the operational stability of small fishing vessels

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ABSTRACT

This paper describes the use of the Wolfson guidance and other stability criteria in the context of two recent accident investigations on small fishing vessels: 11.4m scallop dredger JMT and 9.9m stern trawler Stella Maris. Both vessels capsized and sank whilst handling their catch in benign weather conditions. The Wolfson guidance, which is suitable for all types of fishing vessels including those with no stability information, enables estimation of the safe operational limits for both JMT and Stella Maris. Also, given the probable loss scenarios and residual stability characteristics, the Wolfson guidance predicted that both vessels were operating outside such limits at the time of each loss.

Keywords: *Stability, Safety, Wolfson Guidance, Stability Notice, Freeboard Mark.*

1. BACKGROUND

Statistics published by the Food and Agriculture Organisation show that 'fishing holds the record as the most dangerous occupation pursued by man' [1], which is underpinned by a fatality rate in excess of 24000/year worldwide [2]. Further statistics quoted in [3] show that the fatality rate in the UK fishing industry is 'of the order of 100 times higher than that of the general workforce'.

Although there are many causes of accidents, most of the fatalities are caused by capsize or swamping because they occur without warning and with little prospect of survival. Statistics of fishing vessel accidents investigated by Canada's Transportation Safety Board between 1990 and 2000 show that more than half the fatalities occurred in incidents where loss of stability was a known factor [4]. Data presented in [5] show that 10 fishing safety recommendations issued by the UK's Marine Accident Investigation Branch (MAIB) between 1992 and 2006 are attributed to stability issues that caused the loss of 6 fishing vessels with a total of 13 fatalities.

Safety is dependent on the stability and seaworthiness of the vessel and its size in relation to the seastate. Small vessels, therefore, are particularly vulnerable, but they are the ones for which no stability calculations are required. Existing UK fishing vessels under 15m overall length are not currently required to comply with statutory stability requirements. Whilst the proposed Small FV Code is re-introducing stability requirements for 12-15m fishing vessels joining the UK Register, the existing under 15m fleet and newly built craft under 12m registered length need not comply with any current or proposed stability standards. Should such vessels seek compliance on a voluntary basis, guidance is available and presented in MGN 427(F), which also states that 'it is not acceptable to do nothing and assume the vessel's stability is satisfactory' [6].

Figure 1 – Salvaged wreck of F/V JMT (Credit: MAIB)

2. AVAILABLE METHODS

MGN 427(F) describes five methods that may be used, on a voluntary basis, for assessing the stability of small fishing vessels. These are summarized below:

2.1 Full Stability Information

Currently, this requirement applies to all vessels of 15m overall length and over. It involves conducting an inclining experiment to derive the lightship displacement and centre of gravity, and the calculation of loading conditions representative of a fishing voyage.

Standard loading conditions (ie gear stowed and catch on/below deck) must be assessed against the stability criteria and beam trawlers have a 20% uplift with the criteria. Operating conditions, however, may be more onerous than standard conditions due to raised gear and heavy lifts, but are not normally assessed.

2.2 Small Commercial Vessel Code Heel Test

This method prescribes a maximum heel angle and adequate freeboard with a 1t load applied on deck at the maximum outboard position. The method may only be used for fishing vessels carrying up to 1t of catch.

2.3 Small Passenger Vessel Heel Test

This is an alternative method to 2.2 and assumes a 2/3 : 1/3 catch distribution on each side of the vessel. It prescribes a maximum heel angle and a minimum freeboard requirement, and may be used for fishing vessel carrying in excess of 1t of catch.

2.4 Wolfson Guidance

This method was formulated by Barry Deakin and is based on the findings of extensive model tests conducted for MCA Research Project 509 [7] combined with evidence from UK casualty statistics. The development of the Wolfson guidance is described in [8, 9], whilst [10] is an independent commentary undertaken at the request of RINA.

The Wolfson Guidance suits fishing vessels of any size and enables owners and skippers to produce a single page Stability Notice showing an indication of their vessel's level of safety. The Guidance consists of two separate formulations and assessment routes, depending on the availability of a full stability analysis for the vessel.

For vessels with stability information (typically 15m overall length or more) the Wolfson Guidance is based on an assessment of the residual stability when loaded or lifting.

For vessels with no stability information such as JMT or Stella Maris, the Guidance is based on the residual freeboard when loaded or lifting heavy loads, and the freeboards referred to in the Stability Notice should be marked on the side of the vessel using a standard Freeboard Guidance Mark ('Wolfson mark'). The mark should be positioned at the lowest freeboard, or where the freeboard becomes lowest when lifting.

The relevant formulae and example results are given in Annex 5 of MGN 427(F), which is intended for use by consultants tasked with the production of Stability Notices.

2.5 IMO Roll Period Approximation

This method enables skippers to monitor whether stability changes over time, on the basis of the vessel's measured roll period. It is an operational method rather than a stability criterion, so it was not taken into account in the accidents investigations discussed herein.

3. FV JMT INVESTIGATION

MAIB Report [11] describes an investigation into the capsize and sinking of 11.4m scallop dredger JMT. The accident occurred on 9th July 2015 and resulted in two fatalities.

Figure 2 – Lady Patricia (Credit: trawlerpictures.net)

Figure 3 – JMT following 2013 conversion (Credit: trawlerpictures.net)

3.1 Construction and modifications

JMT (previously Lady Patricia) was built in 1988 as a conventional stern trawler and was fitted with a forward wheelhouse, amidships 'scotch poles' and a stern gantry (Figure 2). Between 2003 and 2013 the vessel's stern gantry was raised and a port side shelterdeck was added. Subsequently, the vessel was converted for scallop dredging, which involved fitting winches and outriggers for handling the scallop gear, removing the shelter deck, raising the stern gantry further and replacing the scotch poles with a goalpost gantry. The latter vessel configuration (Figure 3) was approved by Seafish Marine Survey in 2013 and, subsequently, by the MCA.

The vessel had been fishing off Plymouth since May 2015 and usually operated in daylight. At the time of its loss, JMT carried two dredges weighing 750kg each, 0.5t of bagged catch on deck and very little fuel. An underwater survey identified that the starboard side dredges were empty and inverted, whilst the port side dredges were suspended from a goalpost block 5m above deck, unrestrained and full of 400kg of catch and debris.

3.2 Stability assessment

Initially the Wolfson Unit conducted a lines survey and an inclining experiment on the salvaged wreck. Then it prepared a stability model within Wolfson's hydrostatics and stability software HST and performed a stability analysis against MGN 427(F). Four standard loading conditions and three operational conditions representing the vessel at the time of its loss were formulated and assessed against methods 2.1 and 2.4 above. Heel tests 2.2 and 2.3 were conducted numerically, at the appropriate loading conditions. Table 1 gives the calculated load conditions. Readers are referred to Annex A of MAIB report [11] for the full stability assessment.

3.3 Results

The vessel failed the full stability assessment (method 2.1) required by larger fishing vessels, which indicates insufficient reserve stability. In particular, the six stability criteria are not met in any of the conditions. Also, the minimum freeboard of conditions 1 and 2 is below 300mm, which is the minimum recommended freeboard given in the Seafish Standard [12].

The vessel failed both numerical heel tests. It had no positive stability in the SCV heel test and failed the minimum freeboard requirement of the small passenger vessel heel test.

The vessel's Wolfson Stability Notice and Freeboard Mark are given in Figure 4 and its calculated level of safety in the various load conditions is given in Table 2. The Wolfson guidance indicated that the vessel had:

a. low residual freeboard due to loading in all the standard conditions and in two operational conditions, namely no.7 - tow lift, dredges just off seabed and no.8 - full dredges resting on bulwarks;

b. low residual freeboard due to lifting in the operational condition that probably triggered the capsize: no.9 - starboard dredges emptied on deck and port dredges suspended from goalpost gantry;

c. that the vessel was in danger of capsize in seastates exceeding 0.7m significant wave height (low end of Douglas seastate 3).

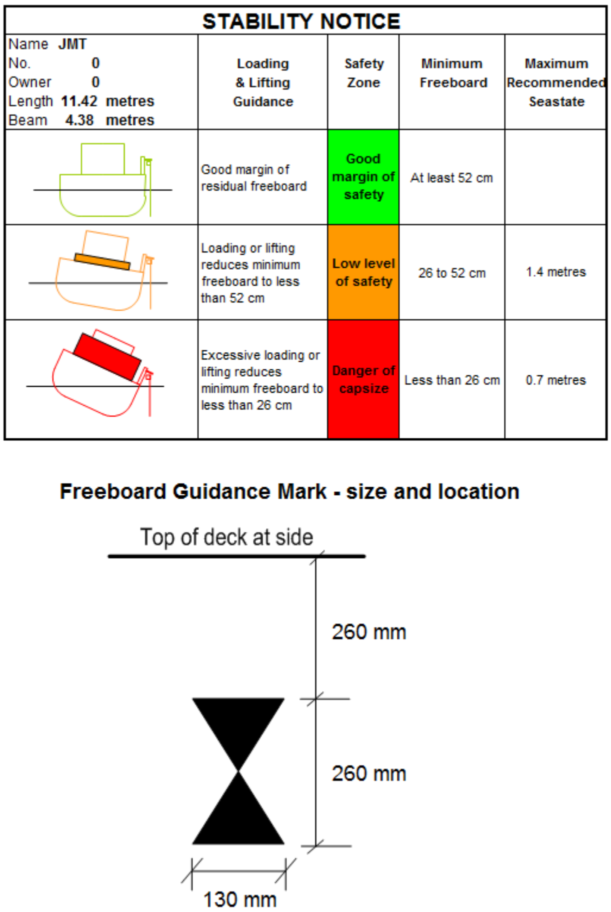

Figure 4 – Stability Notice and Freeboard Guidance Mark for FV JMT

Table 1: Loading conditions (S: standard, O: operational, H: heel test). No.9 is the probable loss condition.

Name	Displ. (t)	Minimum freeboard (mm)
1: S Departure Port	48.49	263
2: S Arrival Grounds	47.96	274
3: S Depart Grounds	44.88	322
4: S Arrival Port	44.29	331
5: H SCV Code Heel Test	49.49	submerged
6: H Small Pax Vessel Heel Test	49.04	14% of requirement
7: O Tow Block Lift & Full Dredges	43.75	261
8: O Full Dredges on Bwks	43.98	327
9: O SS Tipped, PS Full & Suspended	43.98	219

Table 2 – Vessel's freeboard at Freeboard Guidance Mark, 25% LOA

Safety Zone	Minimum Freeboard cm	Freeboard at Load Conditions cm						
		STD				OP		
		1	2	3	4	7	8	9
Good margin of safety	At least 52							
Low level of safety	26 to 52	31	31	32	33	28	33	
Danger of capsize	Less than 26							22

3.4 Conclusions

The MAIB report concludes that the capsize was probably triggered by the sudden release of the contents of the starboard side dredges, while the unrestrained port side dredges and their contents remained suspended from the 5m high 'goalpost' gantry.

It was also highlighted that 'of the alternative stability assessment methods detailed in MGN 427(F), only the Wolfson method would have provided an indication of the vessel's operational limits, and when caution was required' [11]. MAIB recommendation 2016/130 to the Maritime and Coastguard Agency emphasizes that 'all existing vessels of under 15m should be marked using the Wolfson Method, or assessed by use of another acceptable method'.

4. FV STELLA MARIS INVESTIGATION

MAIB Report [13] describes an investigation into the capsize and foundering of 9.96m stern trawler Stella Maris, on 28th July 2014. The two crew abandoned to a liferaft and were later rescued.

The Wolfson Unit was not involved in the accident investigation, which included a stability assessment against the Wolfson guidance and other simplified methods. Such an assessment concluded that 'the craft had a reasonable measure of stability'. It is the Author's opinion, however, that the Wolfson guidance would have predicted that the vessel was endangered, had it been applied correctly. Sections 4.3 to 4.5 below offer the Author's view on the application of the Wolfson guidance to Stella Maris.

4.1 Construction and modifications

Stella Maris was built in 1999 as a conventional stern trawler. Initially, it was equipped with a gilson derrick for performing cod end lifts over the side and releasing the catch on deck. In 2013 it underwent major modifications, see Figure 5, to enable lifting over the stern into a catch hopper, thus improving the quality of the catch. To that effect, the gilson derrick was removed and a stern gantry was fitted, which raised the lifting point by approximately 1m. Also, the cod end had to be raised by approximately 1.65m above the bulwark to clear the upper edge of the hopper, so it could be emptied in the hopper from an overhead position. The catch would then remain in the hopper and gradually feeding to the sorting area beneath the shelterdeck.

It is stated in [13] that 'no post-modification inspection by the MCA was required, or carried out, following the modernisation'.

Figure 5 – Stella Maris following 2013 modification (Credit: Jon Irwin)

4.2 Loss scenario

The vessel capsized and sank whilst attempting to lift a heavy cod end of fish and debris. The estimated weight in air of the cod end was 1.8t and the stern lift was performed using a 2.8t (first layer pull) rated winch and a gilson block fitted near the top of the stern gantry ie about 6m above deck.

As successive layers of wire built up during the lift, the winch pull reduced until the cod end could not be lifted any higher and remained suspended from the gilson block. The skipper then veered the winch in an attempt to lower the cod end back into the sea, but the net snagged on a guide pole fitted at the starboard transom corner. This caused the starboard transom quarter to submerge and, ultimately, resulted in a capsize.

4.3 Longitudinal position of the Wolfson mark

Figure 16 of Ref. [13] identifies the size and position of the Wolfson mark temporarily applied to Stella Maris' sister vessel. The estimated longitudinal position of the mark is 35% LOA forward of AP, assuming that the centreline of the mark coincides with that of the port side access door opening (see the GA presented in Annex B, page 13).

The vessel's GA indicate that 35% LOA forward of the transom is the minimum freeboard position for the 100% Port Departure condition given in Annex B. The vessel has approximately 30mm stern trim in this condition.

With regard to positioning the Wolfson mark, MGN 427(F) states that 'In selecting the location, the most likely reason for reduced freeboard should be borne in mind. If a large load is added well forward or aft, or is lifted from a point that is well forward or aft, the load might induce a large trim, resulting in the minimum freeboard being at a different longitudinal location compared with the upright case' [6].

The calculations presented in Annex B of Ref. [13] show that performing a centreline, 1.8t lift over the stern from the gilson block induces a large trim by the stern, about 8 times the port departure trim. This causes the minimum freeboard position to shift further aft than at port departure, by a distance between 5 and 10% LOA. Thus the Wolfson mark should be positioned between 25 and 30% LOA forward of transom, not at 35% LOA to represent the true residual stability of the vessel when lifting.

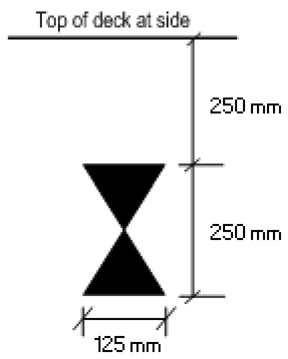

Figure 6 – Freeboard Guidance Mark for Stella Maris

4.4 Vertical position of the Wolfson Mark

The dimensions of the Wolfson mark may be calculated from the vessel's beam and overall length as per Appendix A, and are shown in Figure 6.

Section 1.9 of Ref. [13] describes the temporary application of the Wolfson mark to Stella Maris' sister vessel, during the post-accident stability assessment. Figure 16 of Ref. [13] shows the Wolfson mark affixed to the port side of the sister vessel in the as inclined condition, and Figure 7 below is MAIB's Figure 16 with tentative dimensions edited in.

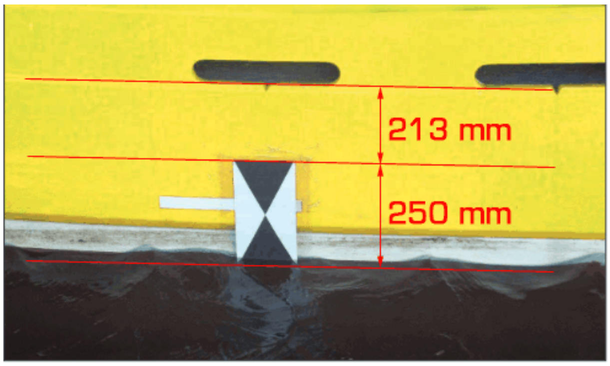

Figure 7 – Wolfson mark as applied in Ref. [12] with tentative dimensions added. As-inclined waterline.

As the sister vessel's calculated port departure freeboard was 40mm higher than at inclining, a small clearance was expected between the lower edge of the mark as applied to the sister vessel and its port departure waterline, so the MAIB Report concluded that the sister vessel would have been 'just in the Wolfson guidance mark green safety zone in the depart port condition' [13].

However, Figure 7 indicates that perhaps the mark should have been lowered by about 40mm to achieve the calculated 250mm separation between the deck at side and the top edge of the mark. Such a vertical shift would position the lower edge of the Wolfson mark at the port departure waterline, as shown in Figure 8. So the vessel in the port departure condition appears to be at the boundary of the green and amber safety zones.

4.5 Operational stability assessment

Figure 8 shows two waterlines derived from the vessel’s calculated draughts at FP and AP, as indicated in Annex B of Ref. [13]. The Wolfson mark is positioned as per MAIB report, but its correct position may be further aft and approximately 40mm lower than in the report, as discussed in Sections 4.3 and 4.4 above.

The red waterline of Figure 8 represents the 1.8t stern lift, zero heel condition described in Annex B, page 64. As the Wolfson mark is partially immersed, the Wolfson guidance indicates a ‘low level of safety’ for the vessel in that load condition.

The gilson winch is rated at 2.8t (first layer pull) so hoisting 1.8t should be regarded as a realistic operating condition that reduces the vessel’s freeboard to a level that, according to the Wolfson guidance, may endanger the vessel.

For the probable loss condition described in Annex B, page 69 the calculated equilibrium heel angle is 8.4 degrees to starboard. A simple calculation shows that a Wolfson mark affixed on the starboard side of the vessel would be submerged at that heel angle. Therefore, the Wolfson guidance predicts that the vessel’s residual stability is reduced to an unsafe level in such a condition, and the vessel is in danger of capsize.

According to the deadweight tables of Annex B Ref. [13], the heeling moment resulting in deck flooding and capsize was approximately 1t.m, that is a 1.8t point load (cod end) applied 0.55m from the centreline. It is reasonable to assume that heeling moments of such a magnitude may be applied whilst the vessel is in operation (eg. cod end retrieval in beam seas), thus reducing the vessel’s freeboard to an unsafe level due to the combined effect of trim and heel. Similarly to heavy lifts over the stern, these scenarios are also realistic and therefore should be assessed against the Wolfson guidance.

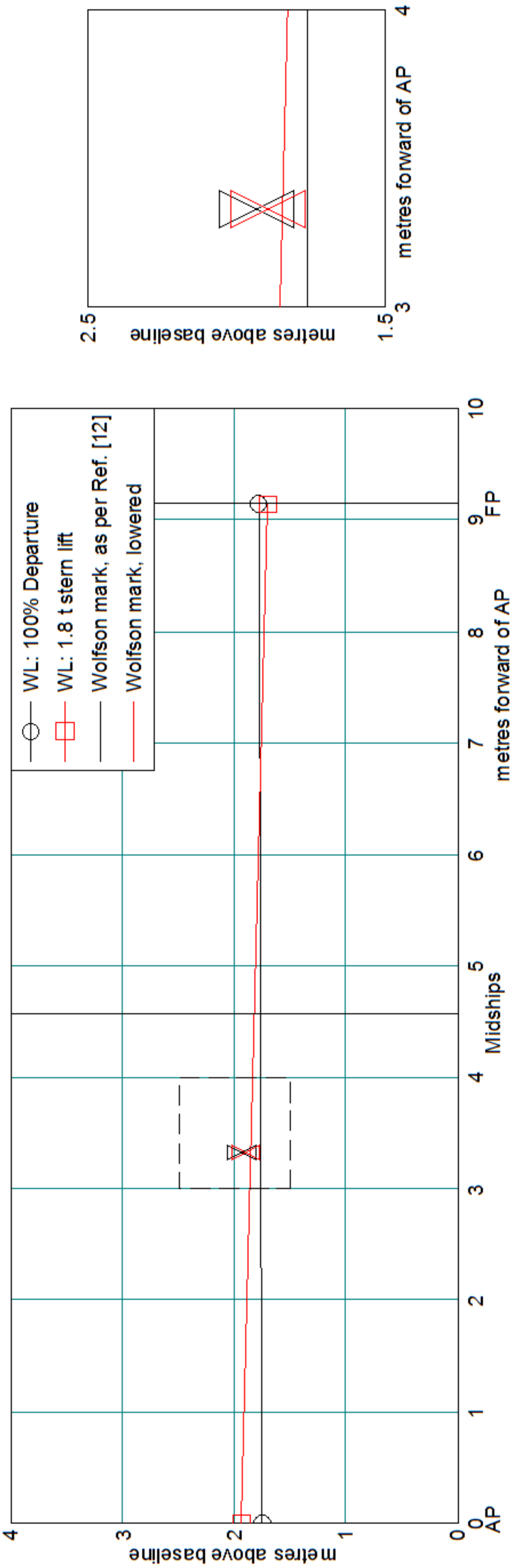

Figure 8 – 100% departure and 1.8t stern lift waterlines

4.6 Conclusions

Calculations based on the data presented in Ref. [13] suggest that the position of the freeboard mark applied to the sister vessel of FV Stella Maris was incorrect. In particular, the appropriate position of the mark appears to be approximately 40mm lower and further aft (at the minimum freeboard location when undertaking a heavy lift) than indicated in the report, resulting in a more onerous freeboard requirement for the vessel.

Section 2.3.3 of Ref. [13] states that 'Assessment of Stella Maris's sister vessel by Roll Test, Small Commercial Vessel Heel Test and Wolfson Guidance indicated that the craft had a reasonable measure of stability'. The Wolfson guidance, however, indicates that the vessel had a 'low level of safety' when lifting a 1.8 t cod end from the stern gantry and was probably 'unsafe, and in danger of capsize' had such load shifted transversely by about 0.5 metres.

Section 2.3.2 of Ref. [13] states that 'Any vessel can be capsized, and it is the duty of vessel's operators to work within the vessel's safe limits. However, this is not easily achieved when those limits are not known'. The Wolfson method is a simple guidance for identifying such limits and relate them to the vessel's operation, thus raising awareness on how certain loading or lifting operations will reduce the safety of the vessel, and on the limit seastates in which such operations should be conducted.

5. DISCUSSION

Currently, UK fishing vessels under 12m registered length such as JMT and Stella Maris, are not required to comply with statutory stability criteria and there is presently no intention to introduce such requirements. However, the stability methods presented in MGN 427(F) are available and the MCA recommend that small vessels are assessed against such methods to ensure that they have a satisfactory measure of stability [6]. These methods include a full stability assessment, which is mandatory for fishing vessels over 15m LOA, heel tests and the Wolfson Guidance.

The Wolfson Guidance is intended to provide fishermen with some indication of their vessel's level of safety. On a small fishing vessel such safe limits may not be exceeded in the port departure/arrival and grounds arrival/departure conditions normally assessed in stability booklets but, crucially, may be exceeded whilst the vessel is in operation and its residual stability is reduced due to heavy loading or lifting. Such operating conditions are often more onerous than the standard conditions and should be appraised.

MGN 526(F) is expected to replace MGN 427(F) and its current draft version [14] continues to present the Wolfson Guidance as a suitable method for assessing and maintaining stability on small fishing vessels, whilst the other methods are no longer discussed.

The draft Small Fishing Vessel Code [15] recommends that vessels up to 12m registered length carry stability information but it is unclear what it should consist of and no reference to MGNs 427 or 526 is made.

The draft Small Fishing Vessel Code reintroduces mandatory stability compliance for vessels between 12m registered length and 15m overall length entering the UK Register. But are stability books alone going to make such vessels safer? Or should simple stability guidance also be available to fishermen and adhered to? It should be borne in mind that:

a. Fishing vessels are not currently required to meet the standard stability criteria with the gear raised or deployed.

b. Currently it is not mandatory to assess the stability of a fishing vessel in the most onerous load case eg heaviest lift, furthest outboard, highest position.

c. The above is a stark contrast to other vessel types such as workboats, where vessels fitted with cranes must be assessed 'in the worst anticipated service condition for lifting operations' and against criteria prescribing the maximum heel angle, or minimum freeboard, whilst lifting [16].

d. Upgrading lifting gear and winches enables more onerous lifts, resulting in larger heeling moments applied and/or higher vessel VCG whilst lifting. This is unlikely to invalidate the approved lightship, or affect compliance with standard criteria unless operational conditions are assessed.

e. The preparation and updating of formal stability information is expensive, and not perceived as an asset by owners and skippers.

f. If a stability booklet was mandatory and available onboard, the skipper would still have no idea how safe he is. All he knows is the vessel has met the criteria so he assumes that it must be safe.

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APPENDIX A

Wolfson Freeboard Mark calculations for FV Stella Maris (overall length 10.14m, beam 4.09m) as per Ref. [5]:

$$Hs,amber = \sqrt{1 + 0.4 * LOA} - 1 = 1.25\ m \quad (1)$$

$$Hs,red = \frac{Hs,amber}{2} = 0.62\ m \quad (2)$$

where Hs,amber and Hs,red are the significant wave heights at the green/amber boundary and amber/red boundary respectively.

$$Freeboard,amber = \frac{Beam}{LOA} * Hs,amber = 0.5\ m \quad (3)$$

$$Freeboard,red = \frac{Freeboard,amber}{2} = 0.25\ m \quad (3)$$

where Freeboard, amber and Freeboard, red are the minimum freeboards at the green/amber boundary and amber/red boundary respectively.