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THE STABILITY OF BEAM TRAWLERS

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SUMMARY

A study of the stability characteristics of the UK fleet of beam trawlers is presented, with the results of calculations to determine the effects of handling the fishing gear from derricks. The heavy gear and long derricks give rise to the potential for serious reductions in the stability, and large heeling moments. The effects of gear handling on the ability of these vessels to comply with the stability regulations is discussed, together with some suggestions for alternative methods of assessment.

AUTHOR'S BIOGRAPHY

Barry Deakin has been a consultant naval architect with the Wolfson Unit since 1978. He has always had an interest in the stability of small vessels, and has conducted a number of model testing programmes for the MCA and MAIB to investigate trawler capsize and sinking. He has also conducted substantial research projects for the MCA to develop stability standards for sailing vessels, standards which have now been adopted by other authorities overseas.

1 INTRODUCTION

Beam trawlers are uniquely equipped to lift heavy gear from twin derricks. Because normal operations maintain approximately symmetric loading, their vulnerability may not be appreciated fully by their crews. There have been a number of vessel losses without survivors which may have been the result of inadequate stability, and a number of incidents with reliable evidence of such inadequacy.

This paper describes a study conducted for the Maritime and Coastguard Agency (MCA), on the advice of the Marine Accident Investigation Branch (MAIB), following an inquiry into the loss of the beam trawler Margaretha Maria, Ref. 1. Gear handling was believed to have been cause of the loss, the vessel having been equipped to lift large weights via derricks, to the detriment of her stability.

Another beam trawling casualty recently investigated by the MAIB was the Pescado, Ref. 2. It is believed that her scallop dredges became entangled while attempting to free one of them from an obstruction, and the vessel capsized as a result of lifting the weight of both sets of gear on one side.

The MAIB suspected that other vessels might be vulnerable, and recommended an investigation with two principal objectives: to determine the influence of gear handling on the stability characteristics of UK registered beam trawlers, and to suggest alternative methods of assessment.

Whilst other aspects of the beam trawling operation were addressed in the study, space limitations precluded their inclusion in this paper.

2 OUTLINE OF BEAM TRAWLING OPERATIONS

The remit of this study was to include both beam trawls and scallop dredges, and vessels operating both types were included.

Scallop dredges comprise a number of steel dredges attached to a transverse beam, with two sets of gear towed on the sea bed.

Twin beam trawling involves towing two nets over the sea bed. The mouth of each net is spread by a steel beam, with chains to disturb the bottom dwelling fish, and there are two distinct configurations. On clean ground a number of transverse 'tickler' chains are used, and over rocky ground, to minimise the quantity of large stones entering the trawl, a grid of chain mat is used.

The fishing gear is handled from the ends of pivoted derricks to enable it to be brought alongside or on board the vessel. There is an obvious incentive to maximise the size of the gear but, with high rates of wear and breakage, the gear is necessarily heavy.

3 GEAR HANDLING PROCEDURES

3.1 SHOOTING THE GEAR

The gear is deployed on arrival at the grounds, when the vessel has a large quantity of fuel and a relatively high displacement, so the righting moments are generally at their highest level during the fishing period.

Scallop dredging gear must be brought aboard the bulwark to empty the dredges, and so shooting and boarding the gear is carried out throughout the fishing period.

3.2 TRAWLING

The gear is towed, typically at 4 to 6 knots, from the ends of the horizontal derricks. The loads may be high, but are angled well aft rather than vertical. If a load increases as a result of debris in nets, or a fastener, a change in the helm or heading of the vessel are the first indications rather than heeling of the vessel. Much research has focused on on this perceived hazard, for example Ref. 3, but it does not appear to be the cause of stability casualties and is not seen as a danger by the skippers.

3.3 RAISING THE GEAR

The gear is raised periodically to board the catch. Initially the warps are hauled with the derricks in the horizontal position and they are topped to about 30 - 45° when a certain length of warp remains to be hauled. The purpose of topping the derricks at this stage is unclear, with varying reasons given by the skippers. It may save some time in the hauling operation.

From the stability point of view this aspect of the procedure appears to be undesirable, because it transfers the loads to a higher location than perhaps is necessary, but none of the skippers indicated it to be a potential hazard.

3.4 BOARDING THE COD END

With the beams at the surface and the derricks topped to 30 - 45°, a secondary line hauls the cod end aboard via a block at the gantry or mast head. The weight of the gear is thus distributed between the derrick end and the gantry head, and this is not a particularly hazardous part of the operation.

3.5 RETRIEVING HEAVY GEAR

At times the trawls may become fouled with stones, sand, weed, shells, starfish, or other debris. In many cases the net fails when raised from the sea bed. If it remains intact, various methods are employed to remove such loads from the gear, and they may involve loss of the catch which will be of little value in such circumstances.

If the load is not excessive the cod end, or scallop dredges, may be retrieved and boarded, opened over the side, or held fast while the beam is lowered to invert the net.

The beams may be brought above the surface with the derricks topped to about 45°, and the cod ends streamed at speed to wash out sand.

It may be possible to wash out sand with the gear raised just above the bottom, in which case the derricks may remain horizontal.

The gear may be raised from the sea bed then lowered upside down, and towed over rough ground to chafe out the weaker top section of the net. Repairing the net is a relatively simple process and not regarded as a serious drawback.

Retrieving abnormally loaded gear in heavy weather was cited by some skippers as a procedure which might render the vessel relatively vulnerable. Three of the Dutch casualties occurred when lifting heavy loads, and the opposite topped derrick, with raised gear, swung across to the low side.

3.6 FREEING FASTENED GEAR

If the gear comes fast on an obstruction, the vessel is stopped, then hauled over the obstruction on the winch. The gear on the free side is raised and suspended in the water with the derrick horizontal. (The advice given in a Department of Trade, Merchant Shipping Notice M1657, states that the gear on the free side should be raised and suspended close to the vessel's side, but all skippers considered this procedure to be less safe.) Attempts are then made to free the gear by hauling, or by steaming in the opposite direction to that in which the obstruction was fouled.

Attempts are made with the towing block at the derrick head, and in very rare circumstances the slip hook may be released to drop the towing block and take the load on the shoulder block to minimise the heeling moment. Typically the skippers interviewed had released the block from the derrick on one occasion in their career.

Attempting to free fastened gear in a strong tidal stream and heavy weather was regarded as potentially hazardous by most skippers.

3.7 BOARDING THE GEAR

At the end of the fishing trip, with the cod end aboard, the derrick is topped up so that the beam is above bulwark height, and the gear is swung aboard using the roll motion of the vessel. It is lowered to the deck and made fast, then the gear on the other side is boarded.

Because the weight of a beam trawler's catch is considerably less than that of fuel consumed in a typical trip, the righting moment is at its lowest level at the end of the trip. This may come as a surprise to those familiar with the stability booklet presentation of righting arms, because the GZ values typically are greater at the end of the trip, because of the greater freeboard. It is, however, recognised by the skippers, and lifting the gear from the topped derricks was cited by most skippers as perhaps the most vulnerable procedure in the normal fishing operation. If the weather is severe, the vessel may steam with the gear towed from the derricks until calmer conditions are reached.

4 STABILITY REQUIREMENTS

4.1 UK REQUIREMENTS

UK fishing vessels are required to meet the same criteria as most other commercial vessels. It is recognised that beam trawlers require greater stability and, for them, the minimum stability criteria are increased by 20%. Some older vessels are exempt from the requirements for an inclining experiment and full stability analysis, and are assessed with a roll test.

4.2 DUTCH REQUIREMENTS

The Dutch have a significant fleet of beam trawlers, and revised their stability regulations as a result of extensive research which began around 1967. Many vessels were modified by ballasting or lengthening, and some of those for which the modifications were not viable were sold into the UK registry.

The Dutch require the stability criteria to be increased by the ratio of installed power to limiting power, if propulsion power is greater than a limit defined as:

Limiting Power = $0.6(LOA)^2$
for vessels of LOA less than 35m.

Limiting Power = $0.7(LOA)^2$
for vessels of LOA more than 37m.

With a linear interpolation between these lengths.

Despite these increased requirements, 8 vessels between 15 and 24m capsized between 1985 and 1999.

All new vessels are required to be equipped with warp tension monitoring equipment, and about 90% of the older vessels have been retro fitted. The skippers appreciate its value, perhaps in terms of reducing wear and damage to the gear rather than safety, and tend not to sail if the equipment is faulty.

All new vessels are required to have the towing block release cable led permanently to a winch which is controlled from the wheelhouse. To attempt to free a fastened trawl with the towing block at the derrick head contravenes their operational regulations, but this does not prevent crews from making initial attempts at freeing the gear in this configuration.

5 OPERATIONAL GUIDANCE

A number of documents have been issued by the UK authorities, advising caution when attempting to free gear fastened on the sea bed, in particular on the need to remove the towing warp lead from the derrick head. Prior to this study, little or no advice has been given regarding other aspects of gear handling however.

6 VESSEL SURVEYS

A number of beam trawlers were surveyed to gather data which were not available in stability booklets. These data included the derrick and winch arrangement, and the type and size of gear in use. Each visit was arranged with the skipper present to enable a discussion of the gear handling procedures.

Fig. 1 illustrates the range of vessels included in the study in terms of their length.

7 STABILITY INFORMATION

7.1 ACQUISITION OF DATA

Extracts from MCA stability files were made available for those vessels surveyed, and for a selection of additional vessels. A summary is provided in Table 1.

It is usual to conduct the inclining experiment with the derricks topped and fishing gear on deck, although in deriving the lightship condition, the derrick position frequently is adjusted to 45°. This is beneficial to the assessment of a vessel, and has been allowed following the argument that the derricks are at 45° when on passage, and horizontal when trawling.

The operations of most concern were gear handling during, or at the end of, the fishing period. The 'Arrive Grounds', and 'Depart Grounds with 20% Catch' conditions were taken as most representative. In the latter case the relatively low catch is representative of beam trawling operations because the catch typically is a low volume of high value fish.

7.2 CHARACTERISTICS OF THE DATA

7.2(a) Margin of Stability over the UK Criteria

The stability data are generally very similar in character with small margins over the minimum criteria. In . 2 each vessel's stability is compared against the criteria, with the most marginal characteristic shown as a percentage of the appropriate criterion. Many vessels are within 10% of the minimum requirement. In most cases the critical criterion was that the maximum righting lever must exceed 0.25 m. Only the 'Arrive Grounds' and 'Depart Grounds with 20% Catch' conditions were considered, the worst case being presented.

There is a general trend of increasing stability with size, with a some significant exceptions. For one vessel of 25m the most marginal characteristic is 100% in excess of the minimum criterion for fishing vessels, and 80% in excess of the beam trawling criterion. This vessel has relatively wide beam and a transom stern, with GM 40% greater than its nearest rival, but its range of stability is not particularly high.

Some of the small vessels compare favourably. In some cases this is attributed to a relatively high freeboard, and results in a relatively large range of stability.

The larger vessels are not exceptional in any way. They have GMs a little above average, with moderately high freeboard, and this combination of good proportions accounts for their relatively good stability. Their size may enable a favourable combination of parameters and arrangement, and the data suggest a trend of increasing stability margin with size.

The casualty presented with the small stability margin is the Margaretha Maria, and the one which fails to comply is the Pescado. The latter was approved on the basis of a roll test. It is important to note that the stability data for the Margaretha Maria are those used for approval of the vessel, and include the aft shelter as a watertight contribution. The vessel was found with the doors to this space fastened open however, and the range of stability was substantially less in that configuration.

7.2(b) Stability Variation with Age of Vessel

The study indicated that there may be a general trend for the more recent vessels to achieve better stability, but there are some recent vessels which comply by the smallest of margins. The tendency for vessels to become heavier and less stable with age, because of increased lightship weight or heavier fishing gear, may contribute to this trend. Pescado and Margaretha Maria were built in the 1950s.

TABLE 1 Summary of Vessel Dimensions and Characteristics

Registered Length metres	Year Built	LOA metres	Max Beam metres	L/B	Displace-ment tonnes	Gear Type	Beam Length metres	Gear Weight tonnes	Derrick Length metres	Derrick Weight tonnes	Topped Angle degrees	Engine Power kW	GM Arrive Grounds metres	GM Depart Grounds metres
21.54	1958	22.80	5.82	3.92	138	Mat	7.00	2.05	7.36	1.01		221	0.68	
21.55	1956	22.00	5.83	3.77	125	Scallop	8.84	1.84	9.20	1.10		400	0.67	
25.05	1968	28.60	6.40	4.47	235	Mat	8.00	3.13	10.40	1.82	70	492	0.79	0.80
29.37	1971	32.82	7.50	4.38	435	Mat	9.85	3.50	11.85	1.60	80	671	0.81	0.84
37.08	1974	39.10	7.70	5.08	513	Mat	11.90	5.75	13.10	2.88	70	1850	0.81	0.72
29.21	1973	31.80	7.60	4.18	388	Scallop	12.90	3.50	12.00	2.30	65	671	0.77	0.74
23.91	1977	25.31	7.32	3.46	229	Mat	9.00	3.50	9.45	1.26	70	615	1.20	1.14
25.82	1968	27.00	6.40	4.22	229	Mat	8.40	2.50	10.00	1.60	85	537	0.78	0.75
26.46	1968	28.00	7.00	4.00	262	Ticklers	9.00	3.00	10.00	1.60	65	597	0.81	0.85
26.18	1964	30.00	6.50	4.62	260	Mat	8.30	4.00	9.00	1.15	85	596	0.70	0.76
32.00	1981	35.67	7.50	4.76	479	Ticklers	12.00	5.42	12.50	2.50	80	1044	0.72	0.64
34.52	1980	35.90	7.50	4.79	556	Ticklers	12.00	4.75	11.00	2.10	65	1177	0.83	0.73
34.85	1987	36.50	8.00	4.56	546	Ticklers	12.00	5.50	12.80	2.80	80	1343	0.64	0.54
33.02	1988	37.75	8.50	4.44	679	Ticklers	12.00	6.30	12.40	2.50	80	1492	0.75	0.75
24.30	1970	26.25	6.60	3.98	225	Mat	8.70	3.32	9.00	1.58	70	597	0.76	
29.00	1974	33.53	7.50	4.47	341	Scallop	11.00	2.50	10.80	1.80	65	746	0.66	0.59
16.49	1962	18.37	5.10	3.60	66	Scallop	4.00	0.50	7.30	0.75	60	179	0.84	0.86
25.82	1968	27.50	6.30	4.37	214	Mat	8.00	2.50	8.50	1.00	70	596	0.68	0.69
15.24	1984	15.24	5.14	2.96	70	Mat	4.00	0.50	6.50	0.60	70	186	0.71	0.70
15.24	1984	15.24	5.14	2.96	67	Scallop	4.00	0.81	6.50	0.60	70	186	0.66	0.66
40.00	1999	42.35	8.50	4.98	796	Ticklers	12.00	6.00	13.00	2.75	80	1490	0.75	0.69
14.77	1969	15.57	4.85	3.21	62	Shrimp	8.00	1.25	6.50			177	0.78	0.79
34.04	1974	35.40	7.80	4.54	477							1044	0.72	0.72
14.10	1982	14.67	4.33	3.39	46	Shrimp							1.01	1.01
14.96	1966	15.72	5.16	3.05	66	Scallop		1.50					0.80	0.75
16.44	1989	18.25	6.50	2.81	142				7.10				0.93	0.90
20.93	1991	23.20	6.28	3.69	190			3.00	7.80			223	0.70	0.68
32.43	1968	29.95	7.00	4.28	359			4.00					0.86	0.87
32.58	1981	36.45	8.00	4.56	524								0.66	0.64
27.49	1972	28.90	6.63	4.36		Mat	9.50	4.50			70	671		
22.90	1962	23.98	6.00	4.00		Mat	4.00				65	221		

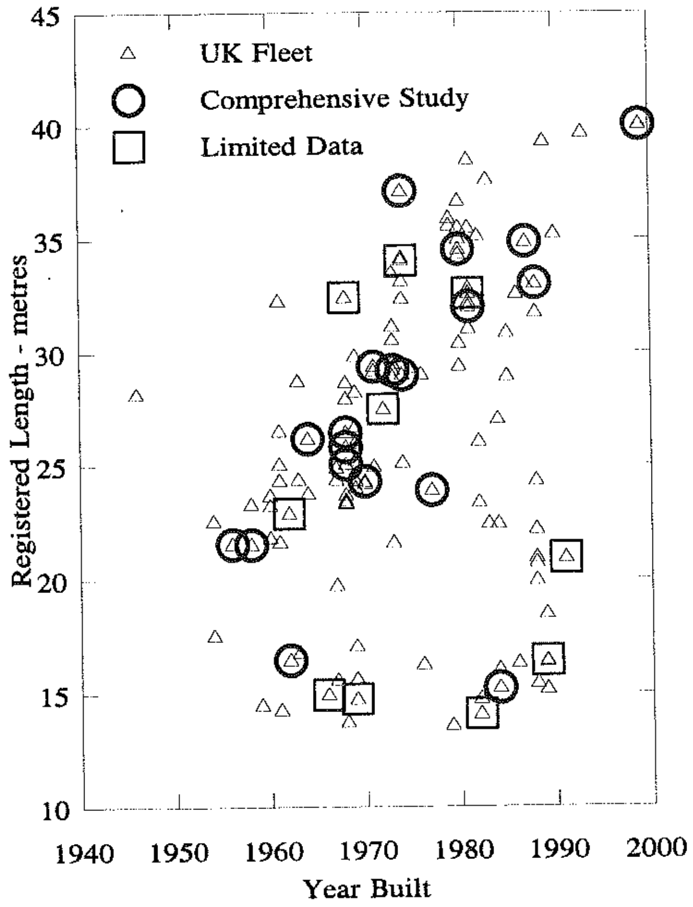

Fig. 1 Distribution of Vessels included in the Study

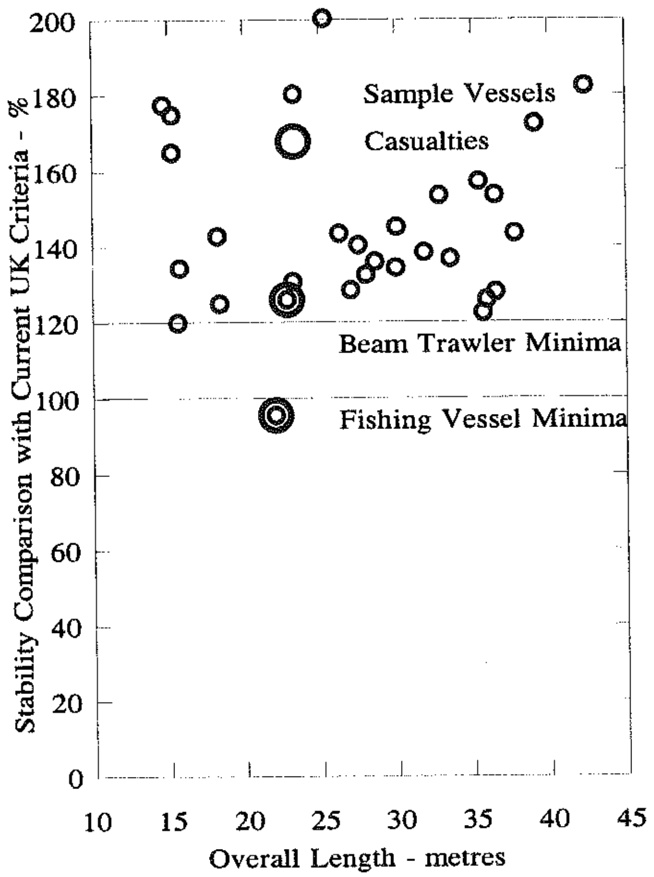

Fig. 2 Comparison of the Stability of the Sample Vessels with the UK Criteria

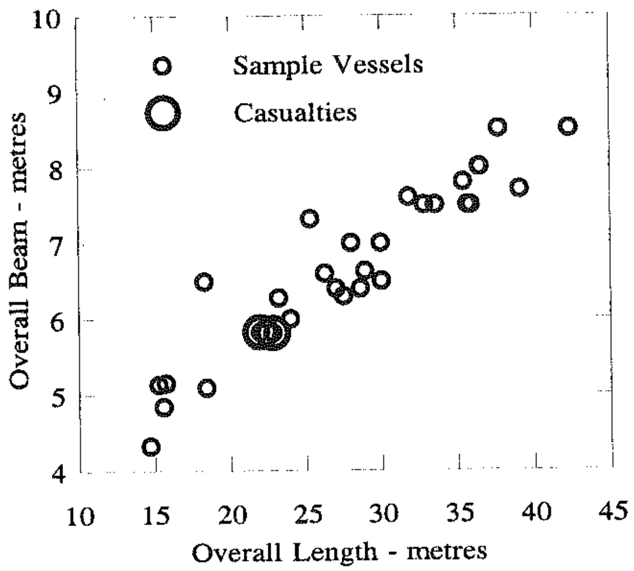

Fig. 3 Variation of Vessel Beam with Length

7.2(c) Variation of Beam and GM

Fig. 3 shows the variation of overall beam with the length of the vessels studied. The data lie within a narrow band, in which the beam/length ratio decreases with length. Two vessels stand out with relatively wide beam for their size. One of these, at 25m, is referred to above and its GM is significantly higher than the others.

It is interesting that the smallest vessel in this sample also has a relatively high GM of 1m, despite a relatively narrow beam. It has only a small wheelhouse, gantry and derricks above the deck, where the larger vessels have accommodation and other structures, and this may account for the difference.

Apart from these exceptions, the sample vessels lie within a narrow GM range of 0.6 to 0.9m, and reveal no trend of GM variation with size.

7.2(d) The Effect of Displacement on Righting Moment

The use of righting arms can be misleading because the variation in displacement may have a greater effect on the righting moment than the GZ variation during the voyage cycle. For the samples considered the GM change between the two conditions varies from an increase of 9% to a decrease of 16%, but the displacement decreases during the voyage by 3% to 14%. The increased freeboard at the end of the voyage gives improved large angle stability, with higher maximum GZ values, and this gives the impression of improved stability in the conventional presentation.

8 OTHER SOURCES OF DATA

The Sea Fish Industry Authority made available a summary of data derived from a survey of UK beam trawlers which they conducted ca.1992, Ref.4. Stability was not addressed, and the accuracy of the data could not be verified but the increased number of samples enabled a better statistical study of some relationships, such as gear weight, or engine power, to vessel size.

9 DATA ANALYSIS

9.1 EFFECT OF DERRICK POSITION

Derrick weight is substantial, up to 3 tonnes for a 13m derrick, and their position will affect the stability. During the vessel surveys it was noted that a number of derricks had been strengthened by welding one or more webs along the length, thus increasing their weight.

The angle of the derricks when topped to board the gear is dependent on their length and pivot location. Some skippers top the derricks fully when boarding the gear to prevent any movement after the gear weight is transferred to the deck.

9.2 GEAR WEIGHT AND POSITION

Gear weights vary with type. For a given beam length, scallop dredges tend to be lighter, and tickler chains are lighter chain mat. Quoted weights for a single set of gear range from less than 1 tonne for a 4m beam to 7 tonnes for a 12m beam. The weight varies considerably over a period of time because of the wear of steel chains and other components, and their sequential replacement.

The weight of the smallest beam trawl was quoted in the stability booklet as 0.5 tonnes, but comparison with the Seafish data suggests that this may be a substantial underestimate. Such an inaccuracy would have serious implications for any assessment of the heeling moments induced by gear handling. Further data on trawls was provided by MAIB for vessels under 12m which had been stability casualties. Their weights were 0.9 and 1.2 tonnes with 4m beams, and 1.8 tonnes with 4.5m beams.

The stability booklet presentation and assessment assume gear on deck, as inclined.

9.3 ENGINE POWER AND ITS IMPLICATIONS

There has been a trend in recent years for increased engine power. This enables the vessel to tow longer beams and heavier gear, and maintain an effective towing speed or cover more ground in a given time. The use of longer beams requires longer derricks, and so increased engine power gives the potential for increased heeling moments.

The variation of installed power with length is presented in Fig. 4, with the limiting value used in the Dutch regulations. Figure 5 presents their stability compared with the factored Dutch criteria. It is notable that the Margaretha Maria would have met the Dutch criteria, while more than half of the sample vessels would not.

10 EFFECTS OF GEAR HANDLING ON STABILITY

10.1 LIFTING CAPACITY

Beam trawlers are equipped with powerful winches and strong lifting gear, with capacity to lift one or both trawls, plus substantial additional weight, with derricks at various attitudes. Under normal circumstances the gear weight is reduced, being suspended in water for much of the time, but this is offset by the presence of additional material within the trawls.

Fish are neutrally buoyant so their weight becomes a consideration only when they are lifted clear of the water, and this is not done from the derrick. Other material such as sand, stones and shells add to the gear weight and increase the potential heeling moments. Trawls and dredges have capacity to carry considerable weights, although the nets frequently fail under abnormal loading. The report on the Margaretha Maria casualty indicates that the weight of sand in her trawls may have been up to twice the gear weight. Examination of the data for the sample vessels indicates that very few of them would have the stability to lift such a weight on one side only, even when offset with the opposite gear at the end of the horizontal derrick.

It is clear that many, and perhaps all, of these vessels have sufficient capacity in their lifting gear to generate a heeling moment sufficient to cause capsize. This supports the comment offered by most of the skippers that substantial experience is required to operate a beam trawler winch system safely.

10.2 THE EFFECTS OF DERRICK ANGLES

Considering the gear weight alone, the stability of three vessels was calculated with various combinations of port and starboard derrick angles. Those selected were: A, the 25m vessel revealed in Fig. 2 as having particularly good stability characteristics; B, a typical vessel of 29m which meets the UK criteria with a 10% margin; and the Margaretha Maria. For the latter, the stability data are for the approved configuration with the aft shelter watertight, and this accounts for the increase in the GZ values above 40°.

The results are presented in Fig. 6 for the case of the port derrick topped to 80°, with starboard derrick angles of 0, 30, 45 and 80°. These angles represent derricks horizontal, typical angles used when washing out sand or boarding the cod end, and fully topped for boarding the gear. The stability booklet curve, with the gear stowed on deck, is included for comparison.

When freely suspended, the effective centre of gravity of the gear is at its point of suspension, that is the derrick head. As the derricks are topped, the centre of gravity rises, and the stability is reduced dramatically in all three cases.

With the derricks raised asymmetrically, the curves show the angle of list and the fact that the stability to the side of the list is reduced, while that to the side away from the list is increased. Although the maximum value of GZ and the range of stability are affected, the angle of maximum GZ remains roughly constant.

With the port derrick topped and the starboard derrick horizontal, there will be an angle of list, and substantially reduced stability to starboard. This helps to explain the casualties experienced in the Dutch fleet, where the derrick swung across the vessel towards the low side. If the port derrick is topped to 80°, a list of 10° will put the derrick vertical, and gear suspended above the water surface will be liable to swing to starboard, where there is little stability reserve. This suggests that it is safer to lift the gear with both derricks at the same angle, although this is likely to be contradictory to the perception on board, where a list against the lift will be perceived as a benefit.

10.3 THE EFFECT OF TOPPING BOTH DERRICKS ON KG AND STABILITY

To quantify the decrease in stability for the sample vessels when handling the gear symmetrically, two configurations were considered. The first assumed that both derricks are at 45°, to simulate the situation where beams are raised prior to boarding the cod ends. The second assumed that both derricks are topped up to board the gear. The latter gives the minimum symmetric stability condition without additional weight in the gear.

The results for derricks at 45° are presented in Fig. 7, using the same format as Fig. 2. Only 7 samples comply with the criteria. With the derricks fully topped the situation is rather worse, and only 4 of the samples comply. It may be comforting that the two casualties fare particularly badly in this assessment.

Evidence of the dramatic effect on stability was the capsize of the small beam trawler Sally Jane, while alongside in harbour, when the gear was lifted from topped derricks. Ref. 5.

10.4 ANGLE OF LIST WITH GEAR DEPLOYED ONE SIDE ONLY

To quantify and compare the effects of asymmetry, the angle of heel was calculated for the configuration of one derrick horizontal with the gear suspended from it, and the other derrick fully topped with the gear on deck.

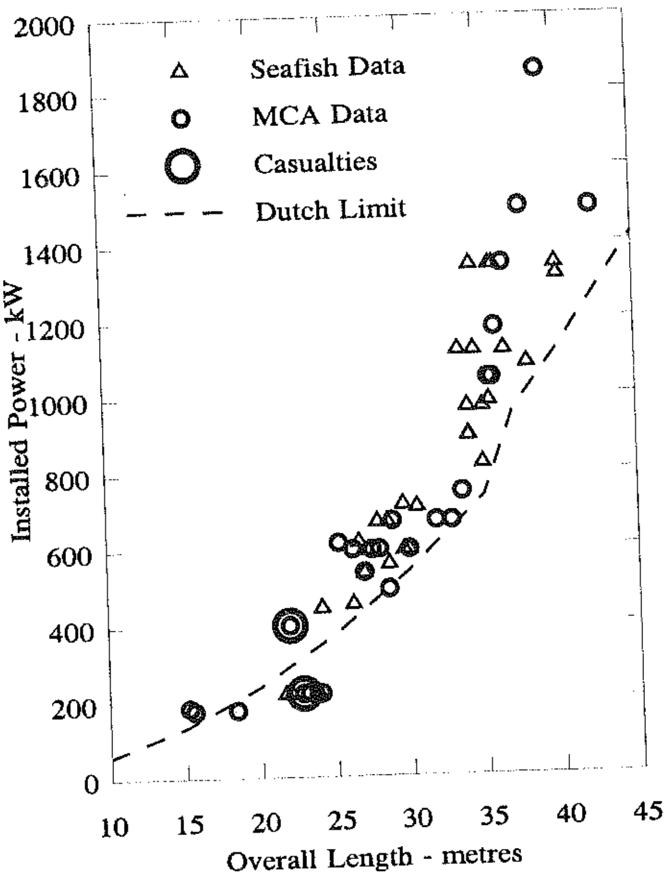

Fig. 4 Variation of Engine Power with Length (*Dutch vessels above the line require more stability*)

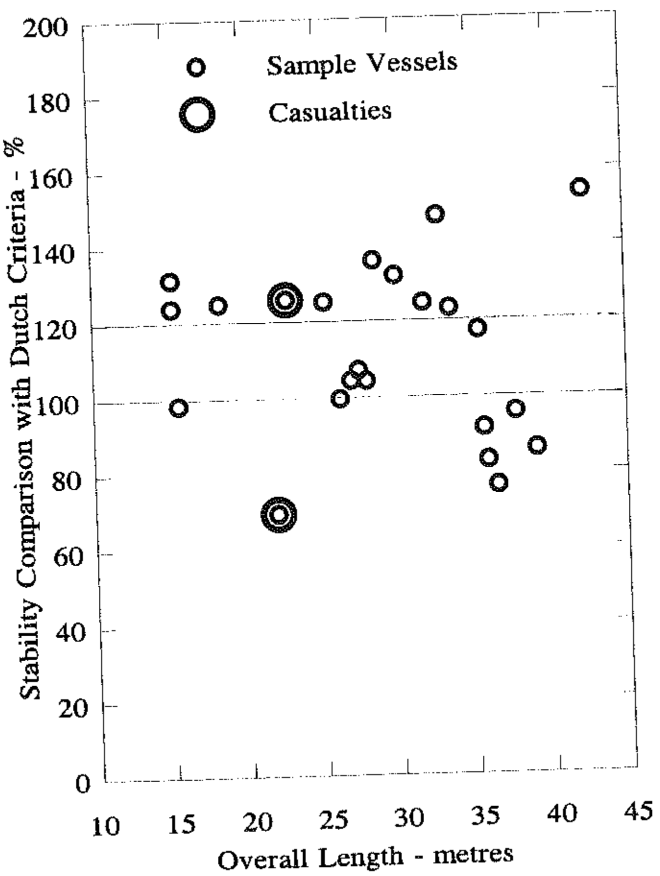

Fig. 5 Comparison of the Stability of the Sample UK Vessels with the Dutch Criteria

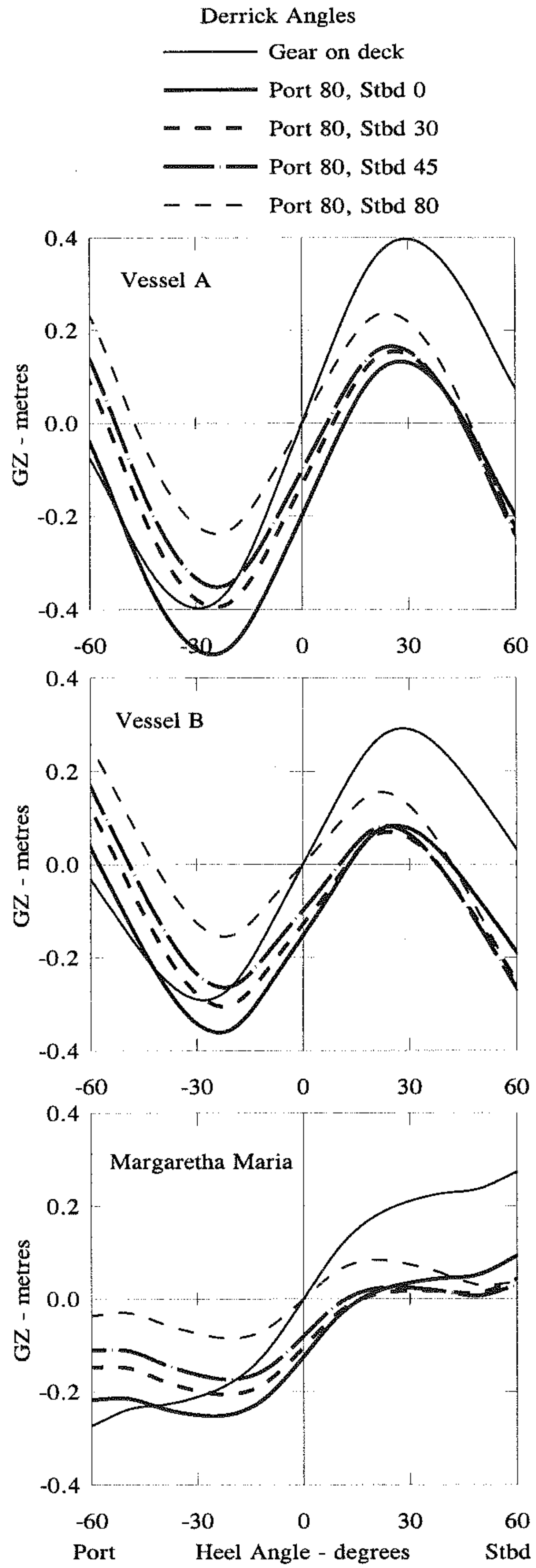

Fig. 6 Effect of Derrick Angle and Gear Weight on Stability of three sample Vessels

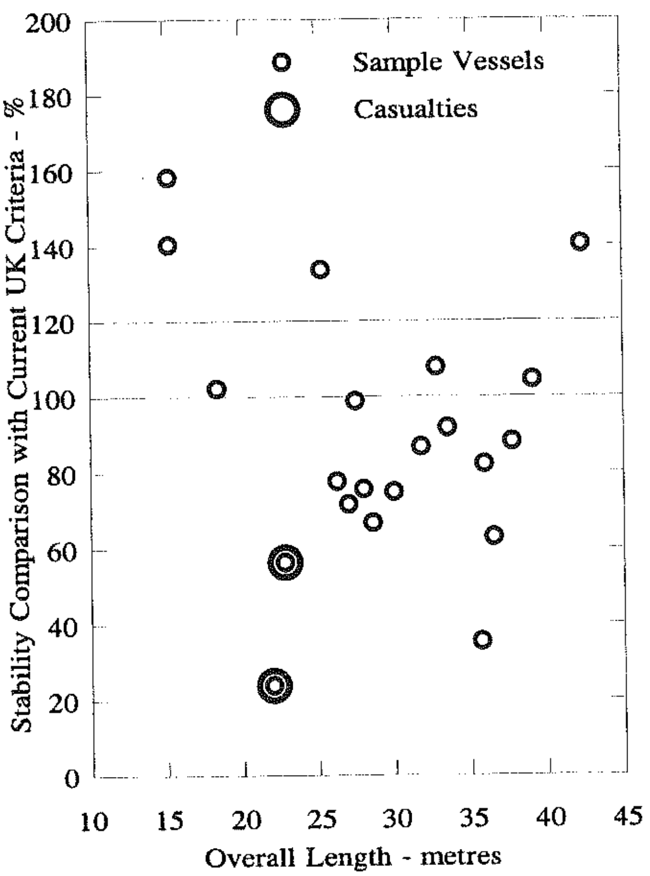

Fig. 7 Comparison of the Stability, with the Gear Raised, with the UK Criteria *(Derricks at 45°)*

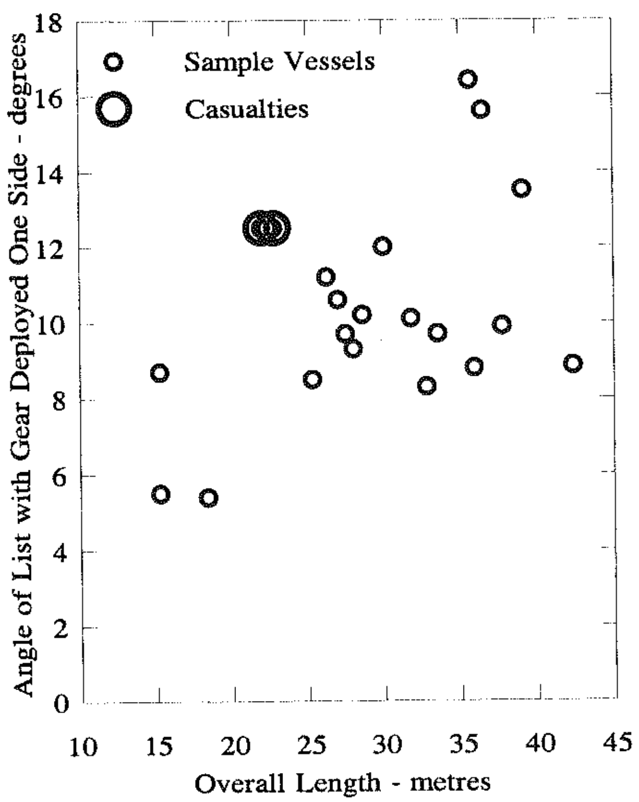

Fig. 8 Angle of List with Gear Deployed on One Side Only

Whilst this might not represent a normal operational configuration, it could be achieved readily in port if it were considered to be a relevant means of assessment. Fig. 8 presents the results in terms of the angle of list in each case. They vary between 5 and 15°, with the majority between 8 and 12°, and the casualties both at 12.5°.

10.5 THE EFFECTS OF LIFTING ADDITIONAL WEIGHT ON STABILITY

Fig. 9 illustrates the effects of lifting additional weight, such as when washing out sand with the derricks topped to 45°. It is assumed that an additional weight equal to the weight of the gear is being lifted on each side, and the stability is compared with a standard condition illustrated in the stability booklet, with gear on deck. Because these calculations have been conducted by adjustment of the stability curves presented in the booklet, full account has not been taken of the additional displacement, which will result in earlier immersion of the deck edge. The derived curves therefore may be a little optimistic.

The calculations are presented for the three sample vessels used previously. The additional load on the topped derricks is severely detrimental because of its effect on the VCG. The GZ values are reduced to less than half of the original values, on which the vessel is assessed.

The third curve presented represents an asymmetric loading scenario, such as, when washing out sand on both sides, one net fails and its load is released. For vessel A this would result in a list of 12° and a residual range of stability of 25°. On the more typical vessel B, the list would be 13°, but the residual range only 19°, and the maximum residual GZ only 0.04m. Margaretha Maria could not sustain such an asymmetric moment, and would capsize, even with the aft shelter assumed intact.

It appears that beam trawlers handle weights in excess of those used in this illustration and, while they are approximately symmetric, the list of the vessel will be negligible, and the potential danger may not be apparent to the skipper. The characteristic most likely to indicate a substantial reduction in stability will be the roll period.

10.6 THE EFFECTS OF GEAR HANDLING ON ROLL PERIOD

The roll period is proportional to the roll inertia, and inversely proportional to the square root of GM. With gear suspended from the derricks the inertia will be increased because of the increased inertia of the gear. With empty gear and derricks at 45°, the roll inertia of vessel B is increased by 50%, and the roll period will be increased by the same amount. The decrease in GM would be 30%, which would increase the roll period by a further 14%.

With an additional weight of debris in the gear, the roll period would increase again. These estimates do not include the effects of the added inertia of water entrained within and around the fishing gear, which is expected to be significant. The roll period therefore may be two or three times that with gear on deck.

The effects of GM on the roll period are relatively small and, while they may be detectable, are likely to be masked by the inertial effects.

The skippers and crews regard a long roll period as a benefit because it facilitates working on board. Some understand that a slow roll may be indicative of low stability, but it seems unlikely that they will use this knowledge to good effect in a critical situation. They are likely to interpret the dramatic effect of the deployed gear on increasing the roll period, and the very large roll damping effects that immersed gear will have, as stabilising influences on the vessel. The vessel will be far more comfortable, and a more stable working platform with the gear deployed, particularly if it contains additional weight.

11 COMPARISON WITH OTHER VESSEL TYPES

Vessels which are equipped to lift loads over the side generally are required to demonstrate by calculation that their lifting capacity will not overcome the stability, or have limitations on lifting based on a limiting heel angle. This may be an option for beam trawlers, using a technique such as described in section 10.4.

The operation of beam trawlers differs from most commercial vessels, where the stability is sufficient to counter any heeling moment imposed by the vessel's own equipment. In this respect they resemble sailing dinghies, sailboards or kayaks, the stability of which is totally dependent on the actions and expertise of the crew. It has not been possible to develop satisfactory stability criteria for such craft because of this dependence on the crew ability.

12 POSSIBLE ASSESSMENT ALTERNATIVES

12.1 MODIFY THE EXISTING MINIMA

The values of the criteria could be modified to ensure that beam trawlers comply with the standard stability criteria in all operating conditions but, even with unloaded trawls, this might require an adjustment of the criteria by a factor of 2 rather than the current 1.2. With a few exceptions, the existing fleet could not be adapted to meet such a standard.

A disadvantage of such a method is that it does not allow for a general development of fishing gear which may result in heavier loads being applied over a period of time. It is believed that such a development in beam trawling over the past 20 or 30 years has led to the present situation.

12.2 ADOPT AN ENGINE POWER FACTOR

The use of the engine power is a simple attempt to take into account the potential to handle heavy gear. This study suggests that it is not a sufficiently accurate quantification of the gear weight. The Margaretha Maria casualty indicates that the Dutch criteria may not be set at a sufficiently high level, or may not address the situation adequately.

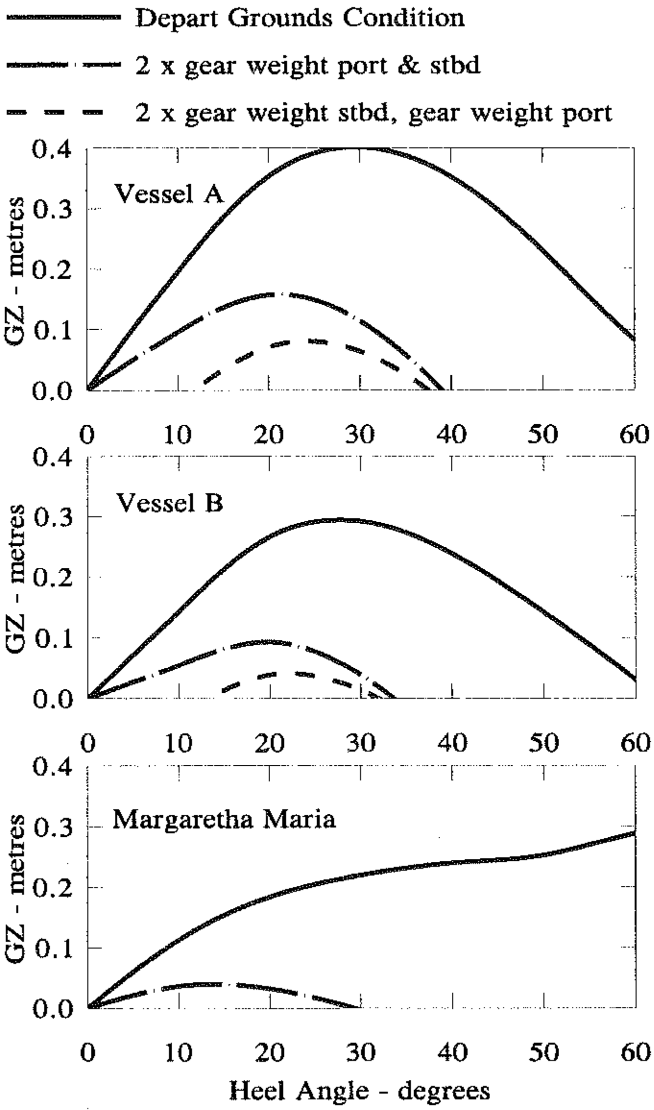

Fig. 9 The Effects of Lifting Additional Weight with Derricks at 45°

Many people in the industry are of the opinion that the quoted engine power may not be sufficiently representative for assessment purposes. If it were to be adopted as a factor, this problem could be addressed, but it is not considered the appropriate option.

12.3 TAKE ACCOUNT OF RAISED GEAR

It would appear to be more precise to assess vessels on the basis of their actual weight of gear and derrick arrangement, rather than some statistical assessment of the fleet in general. The derrick length is readily measured, and it is not unreasonable to expect the maximum weight of gear to be determined with some accuracy, in view of its significance to the stability.

The minimum level of stability could be set in some operational configuration, such as with the derricks fully topped, but very few of the existing fleet could be adapted to comply with the standard fishing vessel criteria in such a configuration.

The casualties fare poorly on this assessment, as indicated in Fig. 7, and this supports its potential value.

12.4 TAKE ACCOUNT OF OFFSET MOMENTS

Using the technique described in section 10.4, a maximum limit could be set on the heel angle with the gear deployed on one side only.

This technique could use the vessel to check the gear weight, if a heeling test were undertaken at the time of the inclining experiment. The result could be used to determine the angle of heel in the Arrive Grounds and Depart Grounds conditions.

This technique may be of particular benefit in assessing vessels for which full stability data are not available. Fig. 10 presents a correlation between the ordinates of Figs. 7 and 8. This represents a comparison of an assessment against the standard criteria with a heeling test. Both methods incorporate the gear weight and derrick length into the stability, but the angle of list incorporates only the initial stability, while the criteria also assess stability at larger angles.

One would expect some correlation between the two methods, and this is confirmed here. The bold lines at 10° heel and 80% highlight the level of correlation. With only one exception, vessels which heel to less than 10° have more than 80% of the required stability, while, with two exceptions, vessels which heel to more than 10° have less than 80%. This demonstrates that a simple heeling test could be introduced, with an appropriate limit, to screen out particularly good or bad vessels. Marginal vessels could be subjected to the more rigorous conventional assessment.

12.5 REQUIRE LOAD MONITORING INSTRUMENTATION

If the trawl warp loads were monitored routinely, it would be possible to advise the skippers of maximum safe working loads, based on some stability safety margin. This margin could be set with regard to the possibility of offset loading of the derricks, and the rise in KG associated with topping the derricks to enable operations such as washing out sand, boarding the load, or accessing the cod end to invert the net.

In addition to monitoring warp loads, the system can be configured to pay out warp, and reduce propeller pitch or revolutions, in the event of a sudden load increase. By detecting smaller load increases, the system will warn of debris accumulating in the nets at an early stage.

Information from the equipment supplier reveals that their system is in very widespread use throughout the world, but had been supplied to only five UK vessels. The reason for this is not known, but the general consensus among the UK skippers and owners appeared to be that load monitoring equipment could not be maintained reliably in their working environment. The experience of the Dutch fleet appears to contradict this opinion.

13 RECOMMENDATIONS

13.1 GEAR HANDLING

No beam trawler should be operated without experienced crew available to control the winch system. It is understood that there is no formal requirement for qualifications or experience in this aspect of the operation, and no training courses are offered in the UK. Most of the skippers interviewed had considerable experience, and provide informal instruction to crew members at sea.

13.2 STABILITY ASSESSMENT

The inclining experiment should be conducted with the derricks fully topped, and the allowance of an adjustment of VCG for derricks lowered to 45° should be discontinued. Whilst they may not be fully topped during normal operation, the difference between the VCG when fully topped, and when topped for boarding the gear is negligible.

Gear weight, beam length and derrick length should be determined accurately, and presented prominently in the stability booklet. The gear weight may vary considerably with wear, and the weight presented should reflect the maximum for new gear. If a vessel is fitted with warp tension monitoring equipment, the gear weight could be checked during any inspection of the vessel.

13.3 STABILITY REQUIREMENTS

The legal requirement for all fishing vessels to meet the standard minimum criteria '*in all foreseeable operating conditions*' is not met in the case of most beam trawlers. Fig. 7 illustrates that fewer than 40% of those surveyed comply with the requirements when the gear is deployed with derricks at 45°, and fewer still will comply with additional weight in the gear or with derricks topped. It was the technical and practical aspects which were the subject of this study, however, rather than the legal implications.

The stability characteristics of some vessels may be considered to be inadequate for their operation and it may be preferable to increase the minimum requirements. To increase the level of stability of the fleet to ensure fail safe operation of the lifting gear is not considered practical. Similarly, to reduce the derrick lengths or gear weights to ensure fail safe operation would render the existing fleet uneconomic.

It is unclear, therefore, what level of increase can be justified. The number of well documented casualties is insufficient to enable a new minimum level of stability to be selected on statistical grounds, and the level cannot be increased to ensure fail safe operation. In view of the political implications it may be preferable to maintain the current stability criteria and to concentrate any new regulatory effort on the operational aspects.

If it is considered appropriate to adopt a revised method of assessment, it is recommended that this should address the effects of gear handling by incorporating gear weight and derrick length. This may be by calculating the stability with the gear raised, as illustrated in Fig. 7, and by applying some relaxation of one or more of the standard criteria, such as the maximum value of GZ which is most frequently the critical criterion. The minimum level might be set at, say, 75% of the standard value, justified with the assumption that this situation would not occur in severe weather conditions.

An alternative method might use the angle of heel with an offset load, as illustrated in Fig. 8, with a maximum allowable angle of, say, 12°.

These assessments would need to be made in the worst operating conditions, which might be either 'Arrive Grounds' or 'Depart Grounds'.

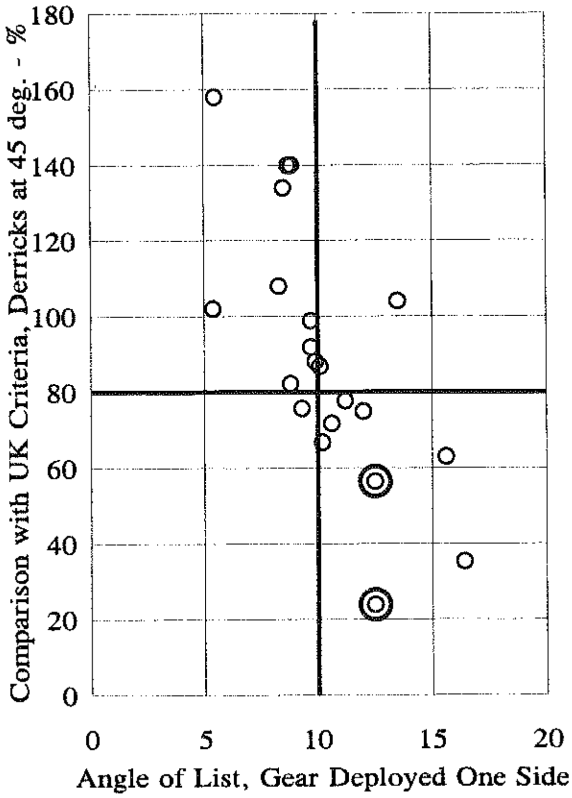

Fig. 10 Correlation of Angle of List with Stability Assessment Against Criteria

13.4 VESSEL EQUIPMENT

The requirement for warp tension monitoring equipment to be fitted should be considered, particularly on new vessels, and its value should be demonstrated to the owners of UK vessels. It is likely that the economic benefits will be perceived as more valuable than the safety benefits, and therefore the involvement of Seafish may assist in delivering a convincing argument.

13.5 INFORMATION FOR SKIPPERS

The existing stability booklet presentation is not generally understood or used by fishermen. The loading condition of the vessel does not deviate substantially from the standard voyage cycle, and so there is no requirement to calculate the stability as there may be on a cargo vessel. The booklet contains information which may be useful to the consultant considering possible modifications to the vessel, or the authority assessing the stability, but is not suitable as an on board safety reference document.

A standard, single page presentation, which shows the relative level of safety of the vessel during gear handling operations, might be posted in the wheelhouse and memorised or referred to on a daily basis. It might state the maximum safe warp load if monitoring equipment is fitted, or be in the form of a stability diagram such as in Fig. 9. In the latter case, a standard set of configurations should be adopted, with which fishermen may become familiar. They might use standard gear loads with an indication of their effect on stability, or use selected stability criteria to determine the maximum safe loads. It is unclear from the interviews conducted, whether skippers are sufficiently familiar with the conventional GZ curve presentation, or whether some alternative presentation would be preferable.

A Marine Guidance Note entitled 'Hazards Associated with Trawling, Including Beam Trawling and Scallop Dredging' is under preparation by the MCA.

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