MARITIME & COASTGUARD AGENCY

Research Project 433 - Final Report

The Deployment of Liferafts Carried on UK Registered Fising Vessels - Phase 1

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UNIVERSITY OF SOUTHAMPTON
SOUTHAMPTON, ENGLAND, SO17 1BJ
TEL: (01703) 595044
FAX: (01703) 671532 (National)
+ 44 1703 671532 (International)

WOLFSON UNIT
FOR MARINE TECHNOLOGY
AND INDUSTRIAL AERODYNAMICS

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1. INTRODUCTION

The following report describes a programme of tests, using models of two types of fishing vessel, to study the release and subsequent behaviour of liferaft canisters following capsize and sinking. In a number of capsize incidents which have resulted in loss of life, liferafts have not deployed satisfactorily, sometimes because of fouling of the canister or its painter.

The objectives of the work were to ensure that liferafts, through correct operation of their hydrostatic release units, can be deployed automatically in the event of a vessel capsizing, and to find the optimum positions for liferaft stowage.

The work was commissioned as Research Project 443 on the 15th October 1998. Some of the tests were witnessed by Mr. Neil Atkinson, the MCA project officer, and other visitors to the test facility included MCA surveyors, representatives of the fishing industry and a representative of the liferaft manufacturing industry.

2. TRAWLER MODELS

Two fishing vessel models were used for the tests, one represented a typical beam trawler of 24 metres in length, and the other a 20 metre Scottish trawler. Both were constructed at a scale of 1:15.

The beam trawler model had been constructed for a previous programme of work conducted for the Marine Accident Investigation Branch in 1993. That work involved tests to study the behaviour of the vessel during capsize and sinking in a number of different scenarios. A liferaft canister was modelled and released, but this aspect of the work was secondary to the behaviour of the vessel. The work was reported in Wolfson Unit report numbers 1116, March 1993; and 1126, July 1993. The model hull and superstructure were based on the lines plan and general arrangement drawings of two different vessels, stretched and scaled to the same proportions and size. It was intended to be representative of a typical beam trawler of about 24 metres overall length, and similar to the F.V. Pescado which capsized and sank with the loss of all six crew in 1991. The model was refurbished and fitted with more detailed representation of the fishing gear, masts, aerials and other equipment of relevance to this project.

A second model was constructed, based on the Scottish F.V. Westhaven which capsized and sank with the loss of all four crew in 1997. A lines plan was made available by the MCA, but no general arrangement drawings were supplied. Details of the internal arrangement, superstructure and deck gear were estimated from surveyors notes and photographs of the vessel. The accuracy of the model therefore is limited.

Both models should be regarded as being typical of a type of fishing vessel rather than an accurate model of a specific vessel. Photographs showing their external arrangement and outfit are presented in Figures 2 to 7.

The models incorporated watertight bulkheads, hatches, doors and vents in order that the flooding process, and therefore the sinking attitude, would be representative. They were ballasted to the required displacement by weighing, and the ballast was adjusted longitudinally to float the model to the required draught marks. An inclining experiment was conducted on each model, and ballast adjustments were made until the required VCG and GM were obtained. The Westhaven model was ballasted to represent the estimated condition of the vessel prior to sinking, as described in Ref.1, and the beam trawler was ballasted to a condition which just met the UK stability requirements.

The principal dimensions and loading conditions of the models are presented in Table 1, and their stability curves in Figure 1. The stability curves were calculated for the hulls alone, and it should be noted that they give no indication of the attitude which the vessel will adopt following capsize.

Previous tests demonstrated that if a vessel capsizes to an angle of 90 degrees or greater, venting of the air from the hull may be very slow, and dependant on minor leaks or wave action. Since the models incorporated a totally watertight hull, and the aim was to conduct a large number of sinking tests, each principal compartment was vented with two 5 mm holes in the hull, one each to port and starboard. These were fitted with a polythene cover hinged to one side of the hole on the outer surface of the hull. These formed simple one way valves enabling air to vent from the models but with minimal leakage of water when upright. For some tests two or more valves were closed to ensure that the model would sink with the required bow or stern trim, enabling some variation of the sinking attitude.

3. LIFERAFT MODELS AND RELEASE MECHANISM

Two models were constructed in accordance with drawings of a six man Dunlop Beaufort Seafarer Mk. 4 liferaft canister. The models were turned from mahogany, drilled out to obtain the appropriate weight, and ballasted with an offset weight to represent the offset centre of gravity of the full scale canister.

Hydrostatic release mechanisms are designed to cut a loop holding the restraining strap around the canister at a depth of between 1.5 and 4 metres. The liferaft should float free from a sinking vessel with its painter attached to the vessel and paying out from the canister. When the painter is fully extended the tension should trigger the liferaft inflation system, and the increased buoyancy should then break a weak link between the painter and the vessel.

Attempts were made to release the model liferafts at the appropriate depth by withdrawal of a retaining pin by a float on a lanyard. Fouling of the float and its lanyard reduced the success rate to such an extent that this method was abandoned. Instead the retaining pins were withdrawn manually using a light lanyard led to the tank side. This method enabled the liferafts to be released as desired, for a range of situations with the model inverted, on its side, or upright, during the capsize or the sinking phase of the test.

Each liferaft was fitted with a painter fixed to the canister, and for the initial tests it was led through a fairlead in the deck. As the liferaft floated off the vessel the painter payed out through the deck. Following problems with the painter becoming tangled inside the model, it was stowed inside a plastic pen cap fixed alongside the liferaft. No tangling of the painter occurred using this system. The system differed from that at full scale because the model painter payed out from the ship structure, whereas the full scale painter is fixed to the structure and pays out from the canister. This change sometimes led to fouling of the painter on the structure which prevented full deployment of the painter. The implications of this are discussed in section 8.3.

Initially the canisters were painted white as at full scale but this resulted in difficulties of visualisation against aluminium structural components or escaping bubbles. The canisters were painted day glow orange after run 5. For the same reason the painters were also painted orange after run 14.

4. FISHING GEAR MODELS

Models of appropriate fishing gear were supplied by the Sea Fish Industry Authority. The Westhaven model was equipped with the components of the twin rig gear believed to be aboard when it sank. This comprised a net wound on the drum, the starboard trawl door slung from the gallows, and the clump weight on the aft deck.

The beam trawler was equipped with twin beam trawls complete with beams, tickler chains and nets. The beams were 8 metres long and the total weight of one trawl was 2.24 tonnes. One or both of these were suspended from the booms as required to represent various configurations.

5. TEST FACILITY

The tests were conducted in the flume tank operated by the Sea Fish Industry Authority in Hull. The working section of the tank is 17 metres long by 5 metres wide by 2.5 metres deep. To protect the conveyor belt on the bottom of the tank, sections of old wind tunnel conveyor belting were used to cover the bottom over a section of tank about 7 metres long. This protective covering precluded running of the flume tank to simulate the effects of a tidal stream.

The tank incorporates large viewing windows on one side, enabling adequate views of the models' behaviour while sinking.

6. TEST TECHNIQUE

For most of the tests the requirement was to simulate capsizing as a result of hauling on a trawl warp in an attempt to release fishing gear from a fastener. To simulate this a line was led from the appropriate block on the model, through a pulley attached to a weight on the tank bottom, and back to the tank side where an experimenter tensioned the line as required. On the Westhaven model the trawl warp was led through a block on the gallows. On the beam trawler the block was at the end of the boom, the location normally used when attempting to free a fastener, except for runs 51 to 54, when the lead was brought inboard to the block on the side of the whaleback to simulate the recommended procedure.

Other simulations included: hauling the trawl warp taught then using the main engine to break the gear free; and the loss of one loaded beam trawl when both had been raised to the surface supported by the horizontal booms. The former was simulated by pulling the model with a painter, the tension in which was measured by a spring balance. The latter was achieved by releasing the trawl from the boom by pulling a retaining pin in a similar way to the liferaft release.

The beam trawler was capsized both to port and starboard because the openings in the deckhouses differed on the two sides, and this offered additional variation in the mode of capsize and sinking. The engine room escape hatch was low on the starboard side and flooded at a relatively low angle of heel, while a deckhouse door to port enabled rapid venting of air.

For some of the tests a simple model of an EPIRB was also deployed using a similar release mechanism to that for the liferafts. The EPIRB was represented by a wooden dowel which could float free and unrestrained when released. This was incorporated at the request of the client during the test programme in order to highlight any problems with its deployment from the sinking vessel.

A video record of each test was made using one camera positioned on the tank side and another viewing through the underwater window. In order to present the model favourably for viewing of the liferaft release through the underwater window, tension was sometimes applied to the bow painter. When viewing the video it appears that this may have affected the sinking attitude, but the tension applied was small in relation to the model displacement.

7. TEST CONDITIONS AND RESULTS

A brief resume of the tests is presented in Tables 2 and 3, for Westhaven and the beam trawler respectively, with a brief description of the model behaviour and liferaft deployment. In some cases, detailed observations during the tests and subsequent study of the video record indicated that failure of the model painters to deploy from their containers was a direct function of modelling detail, and these cases have not been interpreted as failures of deployment.

Table 4 summarises the tests and presents data showing the number of occurrences of the canister becoming jammed or the painter snagged with respect to the number of releases of the liferafts. These are tabulated by vessel and attitude of sinking for each stowage location tested. The last column summarises as a percentage the failures per number of releases.

Figures 8 to 13 present photographs of selected tests to illustrate the problems of canister and painter snagging. The quality of these photographs is poor because they are taken viewing through the underwater window in low light conditions. The video images give a clearer visualisation of details such as the painter.

An edited video programme of selected tests is supplied to accompany this report. The video shows highlights of selected runs using a mix of views from above and below the surface, and does not necessarily show the complete duration, particularly where the sinking was slow. To visualise the motions of the vessels or liferafts at full scale speed the video recording should be viewed in slow motion, ideally slowed by the square root of the model scale, that is about a quarter of the original speed. The runs included are indicated on Tables 2 and 3. On the video programme they are in chronological, or run number order.

8. DISCUSSION OF RESULTS

8.1 Model Behaviour

Comparison of the stability curves for the two models in Figure 1 indicates that the Westhaven has greater intact stability, but their ranges of stability are similar. Following capsize, however, the beam trawler typically lay on its side while sinking slowly, whereas the Westhaven model turned upside down. The different behaviour is due to the air trapped in the deckhouses, which have a greater volume and lever on the beam trawler. The Westhaven's shelter appears to have a large volume but has large openings forward and no aft bulkhead. When the models sank they turned and released substantial volumes of air from the deckhouses and hull.

If the retained air was predominantly at one end of the model it would start to sink vertically stern or bow down, and this air would be released progressively with the changing attitude. As the models sank further they generally rotated such that they would settle upright on the bottom, albeit resting finally on the keel and one bilge. The limited tank depth of about 1.7 times the ship length was not always sufficient for the model to adopt the upright attitude, but the model trajectories, and previous tests in deeper water, indicate that these types of vessel will tend to turn upright as they sink.

Apparently small changes to the loading condition or to the venting, and hence the flooded buoyancy configuration, can result in very different attitudes when sinking. This is because the trim and stability of the flooded vessel is more sensitive than when intact, and this sensitivity increases further when the vessel submerges and has no waterplane.

These observations imply that attempts to predict the attitude which a particular vessel will adopt if it capsizes or sinks will be unreliable, as will attempts to place liferafts in such a position that they can be guaranteed a clear trajectory through the ship's structure and rig when sinking.

These tests were not required to address the subject of trawler stability, and no measurements of trawl warp loads were made. When simulating the use of the Westhaven's main engines to break out of the fastener, the maximum tension on the painter pulling ahead was measured at 0.7 kg prior to capsize. This represents a force at full scale of 2.4 tonnes, about 50% greater than that estimated in the MAIB report on the casualty. This difference may be due to a combination of differences in parameters including the loading condition, gallows block location, and warp pre-tension. The difference does not affect the MAIB conclusion that the propulsion force is small in comparison with the warp tension required to capsize.

Figure 14 presents simple estimates of the heeling moments required to capsize the two vessels represented in these tests by hauling on their trawl warps. For the beam trawler the lead is assumed to be at the outboard end of the horizontal boom, and for Westhaven at the gallows. The effect of the applied load on the effective VCG and GZ have been neglected in this simple analysis, which takes account only of the movement of the warp lead position with heel angle. The beam trawler would capsize at about 30 degrees and the heeling moment remains virtually constant because of the large transverse lever of 10.9 metres. The tension in the trawl warp would be about

3 tonnes. Westhaven would capsize at about 24 degrees with the heeling moment increasing with heel angle because of the relatively high position of the gallows block. With the gallows block 3 metres off the centreline, the trawl warp tension would be about 10 tonnes, as suggested in the MAIB report.

In both instances the trawler crew would have little indication that they were heeling the vessel to the point of capsize since, at lower heel angles, the GZ curves are virtually linear and the heel angle would increase slowly as the warp tension was increased, until the point of capsize.

8.2 Liferaft Canister Deployment

In some notable instances a liferaft canister was prevented from floating free of the model because it became fouled against the structure, for example the aft face of the wheelhouse or adjacent guardrails, or in the trawl net.

These instances were in a small minority but warrant consideration to minimise the problem. The location of the liferaft adjacent to a bulkhead, guardrails, or other vertical structures, or beneath some structural element such as a gantry or shelter, may hinder deployment of the liferaft temporarily or completely, depending on the attitude while sinking. Even if the fouling is only temporary the canister may be taken down to a depth at which inflation will be affected.

In run 12 a liferaft floated into the forecastle as the model sank by the stern, and was carried into the forward net store by the water flowing through the hatch. Close observation of the video record reveals this event.

8.3 Liferaft Painter Deployment

For the tests with the painters stowed in a container adjacent to the liferaft, a substantial proportion resulted in fouling of the painter to the extent that it did not deploy fully from the container. In the full scale arrangement the painter deployment from the canister would not be affected by such fouling, but this aspect of the model tests provided valuable information on painter fouling.

Subsequent tests with these components revealed that the force required to deploy the painters was 0.12 N, compared with the net buoyancy force of a submerged canister model of 0.27 N. When the painter did not deploy because it passed around elements of rigging or structure therefore, the friction had reduced the tension in the painter by at least 56%. The relationship is complicated, being dependant on the angle to which the painter is deflected around each item, their roughness, and the tension in the line. Relating this result to full scale should be done with caution, since no attempt was made to scale the painter stiffness or roughness, or the roughness of the trawler structure or rigging.

The result demonstrates the significant effect of passing the painter over other items, and the serious implications for the breakage of the weak link. The six man liferaft modelled would have a net buoyancy of 4748 N, at full size, when inflated. A representative of the liferaft industry advised that the breaking strength of the weak link is 1.5 kN. Assuming that this value is correct, a reduction in the painter tension of more than 68% would prevent breakage of the weak link by the inflated six man liferaft.

These values of percentage reduction in the tension due to friction are sufficiently close to suggest that, when a model liferaft did not deploy because of friction on the painter, deployment of the full scale liferaft would be affected or prevented.

The model painters were terminated with two links of chain in an attempt to model the hard eye and shackle which would be fitted on the full scale painter at its connection to the weak link. There were no instances of this component snagging, but it is envisaged that this might be a problem at full scale, if the painter is drawn into a small opening or an acute angle such as where a warp passes around a block, or if the painter passes beneath a net.

8.4 Liferaft Deployment Failures

It can be seen in Table 4, for Westhaven, that whilst overall the failure rate for deployment is 19%, for the stowage location used on the vessel the failure rate is 27%, of which 3 out of the 6 failures were due to the canister becoming jammed. A significant number of tests were carried out for the liferafts positioned on the gallows, which position is known to be used on some vessels, this resulted in a decrease in deployment failures to 7%.

The deployment failure rate for the beam trawler is far greater than that of the Westhaven, as might be expected, owing to a significant increase in above deck rigging, nets etc. Overall the failure rate for deployment was found to be 48%. Most failures were due to the painter being snagged, but in the vessel modelled where the liferafts were stowed forward on the galley roof, there were 3 occurrences of the canister jamming compared with 1 occurrence of the painter snagging giving an overall failure rate of 50%. Of these 8 releases, only 2 were with the model sinking by the stern, and in both cases the canister jammed. With the liferafts released from the aft end of the galley there was an 80% failure rate with 5 releases while sinking by the stern. In all 4 of these cases the painter snagged. Being in a slightly more open area, the canister was less prone to jamming.

On the Westhaven model one liferaft was stowed on the shelter in front of the wheelhouse. While this location was less encumbered by local structure, and there was no hindrance to canister deployment, the failure rate due to painter fouling was 29%. This is twice the painter fouling rate for the liferafts on the galley roof.

On the beam trawler model one liferaft was stowed on top of the wheelhouse. Again, with no adjacent structures, there were no instances of the canister becoming jammed but the failure rate remained high at 50%.

Stowage of the liferafts outboard aft of the galley resulted in a 53% failure rate. On all but one occasion the liferaft located on the low side at release failed to deploy. Conversely, on all but one occasion, the liferaft on the high side deployed successfully.

There was no evidence of failure when the liferafts were stowed on the forecastle for either the Westhaven or the beam trawler. But other considerations may preclude using this region for liferaft stowage.

8.5 EPIRB Deployment

The EPIRB model was fitted on top of the wheelhouse and deployed in about half of the tests, using both models, and in all but one test deployed satisfactorily. In run 25, with the beam trawler sinking on its side by the stern, the EPIRB floated from the top of the wheelhouse along the deck following the inside of the bulwark, and remained under the whaleback at the end of the test. Close observation of the video recording reveals its trajectory.

9. POSSIBLE METHODS OF LIFERAFT DEPLOYMENT

In making any changes to the existing method of liferaft deployment from a capsized vessel, it should be noted that there are many more incidents involving manual deployment from a slowly sinking vessel. It follows that changes made to facilitate automatic deployment should not compromise unduly, if at all, manual deployment. The following sub-sections comprise discussion of suggestions made by a number of people without necessarily taking into account manual deployment or the practicality of the proposed system.

Some of the proposed options result in the liferaft arriving at the surface uninflated in the event of a sudden sinking. It is not clear whether this is an advantage or disadvantage. It is likely that an inflated liferaft will be more easy to see than a white canister, however to enhance their visibility canisters could be another colour, eg. day glow orange. Without evidence from tests to the contrary, it is expected that the drift rate of inflated liferafts may be in excess of that of unopened canisters owing to their greater windage to submergence ratio. If this is the case it would be an advantage to have the liferaft uninflated until manual intervention.

9.1 Existing System

The existing system comprises an HRU which incorporates a weak link that connects the painter and restraining straps of the liferaft to the vessel. When used with a 6 man liferaft the stated breaking strength of the weak link is about one third of the net buoyancy of the inflated liferaft, whereas with a 100 man liferaft it is about a sixtieth. This implies that the weak link could be reduced to a fraction of its current size, particularly for small liferafts, and this could be accomplished if it were supplied with the liferaft rather than the HRU.

The minimum size for the weak link is governed by the force required to trigger inflation of the liferaft, and it is not clear why such a strong link is fitted.

Advantages

In the event of a slow sinking the liferaft can be thrown overboard and remain attached to the vessel by the painter until it is cut free. In the event of a sudden sinking the liferaft will float free and be inflated automatically as the painter reaches its full length, and then break free from the ship for the crew to board from the water.

Disadvantages

There are many instances of incorrect connection of the painter and HRU to the vessel, such that the weak link is by-passed. In the event of a sudden sinking the liferaft will go down with the vessel.

The amount of top hamper of a fishing vessel results in the painter creating a lot of friction as it passes round rigging etc., as it deploys. The strength of the weak link in relation to the fully inflated buoyancy and induced friction may prevent breakage of the weak link.

The parting of the weak link leaves the end of the painter with an eye and shackle attached, and the painter is often of an open braided nylon construction. These two features give the painter every chance of snagging in nets and acute angles between fittings and rigging, or on rough sections of structure or wires.

9.2 Unrestrained in a Deep Cradle

It has been suggested that the canister might be contained within a cradle deep enough to prevent accidental loss, and otherwise unrestrained. Such a system would alleviate the need for a hydrostatic release mechanism.

Advantages

In the event of sudden sinking the liferaft would have a good chance of floating free, since there is no painter to be snagged.

Disadvantages

In the event of a slow sinking the crew would need to remember to attach the painter before throwing over the liferaft.

The roll motions and accelerations of small fishing vessels probably would demand the use of a cradle at least as deep as the canister diameter, and such a deep cradle would reduce the ease of manual deployment. It may not be possible to lift the liferaft out of the cradle, so the cradle would need to incorporate some moving parts.

9.3 Incorporating the Very Weak Link Into the Painter

At present liferafts and their hydrostatic release units are supplied by different manufacturers. The weak link is supplied with the HRU, and is said to be suitable for any size of liferaft. A very weak link of the correct size to trigger inflation only could be used if it were supplied by the liferaft manufacturer.

Incorporation of this feature would reduce the number of occurrences where friction in the painter resulted in the weak link not parting. In all other respects the advantages and disadvantages are the same as those for the existing system.

9.4 Splicing the Very Weak Link to the Painter

The very weak link could be attached to the painter by a short splice or similar to provide a smooth transition from one to the other. Only the eye of the very weak link would be joined to the HRU loop, along with the restraining strap.

Advantages

The painter would have a smooth end and its propensity to jam would be much reduced.

Disadvantages

In the event of a slow sinking the crew would need to remember to attach the bitter end of the painter to the vessel before throwing over the liferaft. This may not be obvious in an emergency since apparently the painter would be already attached to the vessel by the very weak link.

9.5 Locating the Weak Link at the Liferaft

Placing the weak link at the liferaft end of the painter would ensure that the full buoyancy force of the inflated liferaft was always available to break the weak link, regardless of whether the painter was fouled. The strength of the weak link could be matched to the buoyancy of the inflated liferaft.

Advantages

The effect of friction and jamming of the painter would be avoided and the full buoyancy of the liferaft would be available to break the weak link.

Disadvantages

When the liferaft is deployed manually in severe conditions the wind or wave action might break the weak link with subsequent loss of the liferaft prior to embarkation.

9.6 Using a Very Weak Painter

A development of the previous modification would be to use only a light line to connect the liferaft to the vessel, and this would break regardless of snagging. In the event of a slow sinking, the painter would be attached to the vessel and it would be deployed as normal.

Advantages

In the event of sudden sinking, providing the canister was not jammed, and inflation took place clear of the vessel, the liferaft would come to the surface inflated.

Disadvantages

In the event of manual deployment, the painter would need to be attached to the vessel prior to deployment over the side. Since there would apparently be a painter attached to the liferaft, albeit a very light one, attaching the proper sized painter may be neglected in an emergency.

9.7 Deploying Without a Painter

The liferaft could be stowed without the painter attached, and in the event of a sudden sinking the HRU would cut the restraining straps and the canister would deploy to the surface uninflated. Once on the surface it would be inflated manually. In the event of a slow sinking, the painter would be attached to the vessel and it would be deployed as normal.

Advantages

In the event of sudden sinking, providing the canister was not jammed, the liferaft would come to the surface uninflated.

Disadvantages

In the event of a slow sinking the painter would need to be connected manually to the liferaft before deployment.

9.8 Using the HRU to Cut the Painter

If the HRU could be configured to cut both the canister restraint and the painter, the canister would float free without the encumbrance of the painter. This would require manual triggering of the inflation by a survivor in the water, but would ensure that the painter was secure when launched manually.

Advantages

In the event of sudden sinking, providing the canister was not jammed, the liferaft would come to the surface uninflated.

9.9 Using the HRU to Cut the Painter with an Additional Very Weak Painter

This is similar to the configuration in 9.8 with an additional very weak painter rigged to trigger the inflation. The very weak painter would be sufficiently strong to trigger inflation but weaker than the buoyancy of the liferaft canister.

Advantages

In the event of sudden sinking, providing the canister was not jammed, the liferaft would come to the surface inflated.

10. DISCUSSION OF PROPOSED LIFERAFT DEPLOYMENT

Table 5 summarises the advantages and disadvantages of proposed modifications to the liferaft deployment systems discussed.

The deployment ratings were arrived at by considering the good and bad features of a system and ascribing a numerical value to them. For example in the event of sudden sinking, three types of painter were identified: no painter, smooth painter, painter and shackle; and these were ascribed values of 1, 0, and -1 respectively. In addition where the system had an oversized weak link, as in the existing system, this was given a value of -1.

In can be seen in Table 5 that, in the event of sudden sinking, the existing system is rated as the worst and several other options appear to be equally the best. In the event of slow sinking the existing system is the best along with three other possibilities.

There exist two proposals that appear to be best in both categories, these are described in sections 9.8 and 9.9 and both require the HRU to cut both the painter and restraining strap. Option 9.8 deploys the raft uninflated, and option 9.9 deploys the raft inflated.

The choice for deployment of the uninflated canister or the inflated liferaft should be made with consideration of the potential for fouling of the liferaft after inflation. If inflation is triggered in close proximity to the vessel there is a danger that it might foul on, or be damaged by, the vessel or its gear.

11. CONCLUSIONS

11.1 In a small number of cases the liferaft canister may become jammed in such a way that it cannot deploy from the vessel.

11.2 In some cases the liferaft canister may become snagged temporarily so that it might be taken to such a depth that inflation is affected or prevented.

11.3 In many cases the painter may become fouled to the extent that inflation is affected or prevented, or breakage of the weak link is prevented.

11.4 Due to the variability and unpredictability of the attitude of a vessel when sinking, it is not possible to site liferaft stowage with confidence that deployment will be unhindered.

11.5 It is likely that one of the two liferafts will be released while beneath the capsized or sinking vessel. Its trajectory will pass around or through several items of structure, rigging or gear during its deployment.

11.6 When a vessel capsizes it may remain at the surface for a significant period, when it is likely that at least one of the liferafts will be released by the HRU. In this situation the painter will be susceptible to fouling by wave action on the painter and canister. This may prevent subsequent breakage of the weak link following sinking of the vessel.

12. RECOMMENDATIONS

12.1 The liferaft stowage locations should be as far apart as practical. This may entail port and starboard, or fore and aft locations.

12.2 The liferafts should be stowed in a location which is free from overhead obstructions, and as far from bulkheads, railings and other vertical structures as practicable.

12.3 The possibility of local structures hindering the canister deployment should be minimised by careful local detailing. For example, where a liferaft is stowed alongside guardrails, the cradle or rails should incorporate angled stanchions to guide the canister's trajectory clear of the rails.

12.4 If the existing system of painter and weak link are used, the painter should be manufactured from as smooth a material as possible commensurate with its other requirements, the joint between the painter and the weak link should be as smooth as possible, and the strength of the weak link should be reduced.

12.5 If a system of automatic inflation is incorporated, the painter or trigger line should be of sufficient length to ensure that inflation occurs clear of the vessel, bearing in mind that the vessel may sink with a vertical attitude.

12.6 Consideration should be given to an alternative system of deployment. Of those discussed in section 9, options 9.8 or 9.9 appear to be preferable.

12.7 Consideration should be given to the benefits of deploying the uninflated canister for manual inflation at the surface, compared to those of deploying the inflated liferaft.

12.8 Every effort should be made to simplify the deployment mechanism in order to eliminate the possibility of deployment failure resulting from incorrect installation by untrained.

12.9 Discussions should take place between the Wolfson Unit, the liferaft and HRU manufacturers, the MCA, and the fishing industry to identify the optimum liferaft deployment and inflation mechanism.

ACKNOWLEDGEMENTS

These tests were conducted over a period of five days at the Sea Fish flume tank, for which two and a half days were donated free of charge by Sea Fish. In addition to this donation, the enthusiastic help of the flume tank staff is gratefully acknowledged by the Wolfson Unit.

REFERENCES

1. Report of the Inspector's Inquiry into the loss of the Fishing Vessel 'Westhaven' AH190 with four lives on 10 March 1997 in the North Sea. MAIB Marine Accident Report 4/98, November 1998.

TABLE 1

TRAWLER PARAMETERS MODELLED

Parameter	Westhaven	Beam Trawler
Length Overall	19.96	23.7
Length BP	19.32	20.5
Beam	6.26	6.0
Depth Amidships	3.56	3.1
Draught Aft	3.18	2.98
Draught Fwd	2.31	1.72
Displacement	133	150
LCG fwd stn 5	-0.54	-0.2
VCG above USK @ stn 5	2.97	2.72
GM	0.92	0.53

TABLE 2

SINKING TESTS ON WESTHAVEN

Run	Liferaft Position	Attitude at Release	Attitude of Sinking	Canister Snagged	Painter Snagged
1	Galley roof	Port, upside down Stbd, on port side	By stern vertical	S	
2	Galley roof	***no release***	By stern vertical		
3	Galley roof	180° to port	40° by bow		S
4	Galley roof	180° to port	60° by bow	P	S
5 *	Galley roof	180° to port	By bow vertical		
6	Galley roof	100° to port	By stern vertical		
7 *	Galley roof	S 130° to port P upright on bottom	By stern vertical		
8	Gallows	180° to port	By stern vertical		S
9	Gallows	150° to port	By stern vertical		
10	Gallows	110° to port	45° by stern		
11 *	Gallows	170° to port	By stern vertical		
12 *	Shelter Aft	120° to port	By stern vertical	P	
13	Shelter Aft	150° to port	80° by stern		
14	Focsle & shelter	120° to port	By stern vertical		
15	Focsle & shelter	170° to port	By stern vertical		A
16	Galley roof	170° to port	70° by stern	S	
17	Galley roof	120° to port	By bow vertical		
40 *	Galley roof	200° to port	By bow vertical		P
41	Galley roof	200° to port	By bow vertical		
42	Gallows	120° to port	By bow vertical		
43	Gallows	200° to port	By stern vertical		
44 *	Gallows	250° to port	By bow vertical		
45 *	Galley roof	260° to port	By stern vertical		
46 *	Focsle & shelter	260° to port	By stern vertical		
47 *	Focsle & shelter	140° to port	By stern vertical		A
48 *	Focsle & shelter	240° to port	By bow vertical		
49	Focsle & shelter	190° to port	By bow vertical		
50	Focsle & shelter	180° to port	By bow vertical		

* Indicates that the run is included on the video programme.

TABLE 3

SINKING TESTS ON A BEAM TRAWLER

Run	Liferaft Position	Attitude at Release	Attitude of Sinking	Canister Snagged	Painter Snagged
18 *	Galley fwd	120° to port	By stern vertical	P,S	
19	Galley fwd	By bow vertical	70° by bow		P
20	Galley fwd	135° by bow	70° by bow		
21	Galley fwd	90° to port	Even keel	S	
22	Galley aft	90° to stbd	By stern vertical		S
23	Galley aft	***no release***	By stern vertical		
24	Galley aft	S 80° to stbd ***no release P***	By stern vertical		S
25 *	Galley aft	***no release***	By stern vertical		
26 *	Galley aft	90° to stbd	By stern vertical		P,S
27 *	Focsle & WH	90° to stbd	By stern vertical		A
28	Focsle & WH	90° to stbd	By stern vertical		
29	Focsle & WH	90° to stbd	By stern vertical		
30	Focsle & WH	80° to port	70° by bow		A
31	Focsle & WH	***sank early***	50° by bow		
32	Focsle & WH	40° by bow	30° by bow		A
33	Focsle & WH	90° to port	40° by bow		
34	OB aft galley	90° to port	80° by stern		P
35 *	OB aft galley	90° to stbd	By stern vertical		S
36	OB aft galley	***no capsize***			
37	OB aft galley	90° to stbd	By stern vertical		S
38	OB aft galley	S 100° to stbd ***no release P***	By stern vertical	S	
39 *	OB aft galley	110° to stbd	By stern vertical	S	
51 *	OB aft galley	90° to stbd	By stern vertical		S
52	OB aft galley	90° to stbd	By stern vertical		S
53 *	OB aft galley	P 90° to stbd S 80° to stbd	By stern vertical	S	P
54	OB aft galley	P 100° to stbd S 90° to stbd	By stern vertical		

* Indicates that the run is included on the video programme.

TABLE 4

SUMMARY OF LIFERAFT DEPLOYMENTS

	Number of releases		Canister snagged		Painter snagged		Failure per number of releases
Attitude of sinking	By bow /even keel	By stern	By bow /even keel	By stern	By bow /even keel	By stern	
Liferaft Posn.	**WESTHAVEN**						
Galley	12	10	1	2	3	0	27%
Gallows	4	10	0	0	0	1	7%
Shelter aft	0	4	0	1	0	0	25%
Shelter fwd	3	4	0	0	0	2	29%
Focsle	3	4	0	0	0	0	0%
All locations	22	32	1	3	3	3	19%
	BEAM TRAWLER						
Galley aft	0	5	0	0	0	4	80%
Galley fwd	6	2	1	2	1	0	50%
OB aft galley	0	17	0	3	0	6	53%
Focsle	3	3	0	0	0	0	0%
Wheelhouse	3	3	0	0	2	1	50%
All locations	12	30	1	5	3	11	48%

Total number of releases for both models: 96
Total number of failures: 30
Overall failure rate: 31%

TABLE 5

SUMMARY OF LIFERAFT DEPLOYMENT SYSTEMS

Proposal discussed in section	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.8	9.9
IN THE EVENT OF SUDDEN SINKING									
Deployment rating	-3	1	-2	0	1	1	1	1	1
Method of inflation Automatic or Manual	A	M	A	A	A	A	M	M	A
IN THE EVENT OF MANUAL DEPLOYMENT DUE TO SLOW SINKING									
Deployment rating	1	-1	1	-1	-2	-1	0	1	1

9.1 Existing System

9.2 Unrestrained in a Deep Cradle

9.3 Incorporating the Very Weak Link into the Painter

9.4 Splicing the Very Weak Link to the Painter

9.5 Locating the Weak Link at the Liferaft

9.6 Using a Very Weak Painter

9.7 Deploying Without a Painter

9.8 Using the HRU to Cut the Painter

9.9 Using the HRU to Cut the Painter with an Additional Very Weak Painter

Figure 1

GZ curves for the models in their intact condition

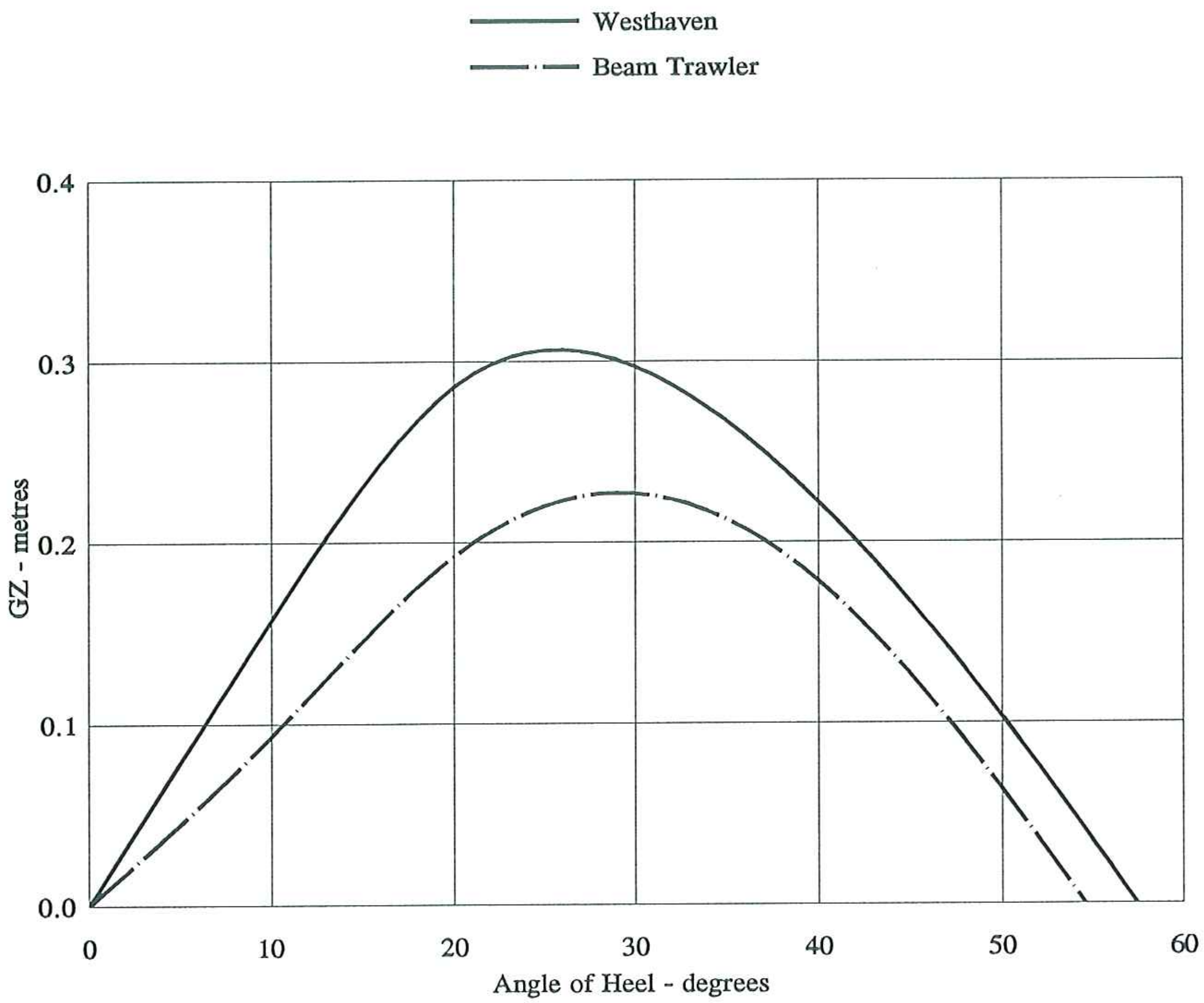

Figure 2. Westhaven model with liferafts located as on Westhaven.

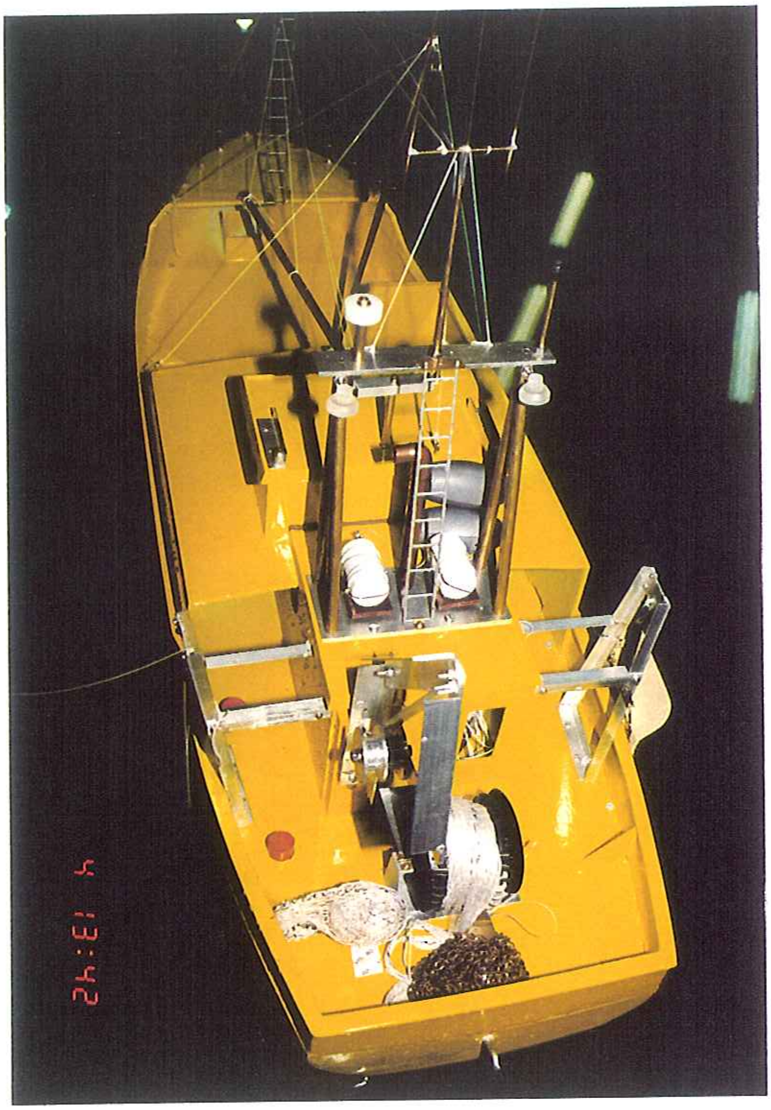

Figure 3. Westhaven model with liferafts on the focsle and shelter.

Figure 4. Beam trawler model with liferafts forward on the galley roof. Preparing to haul on port trawl warp.

Figure 5. Beam trawler model with liferafts aft on the galley roof. Preparing to haul on starboard trawl warp.

Figure 6. Beam trawler model with liferafts on wheelhouse and focsle. Preparing to haul on starboard trawl warp.

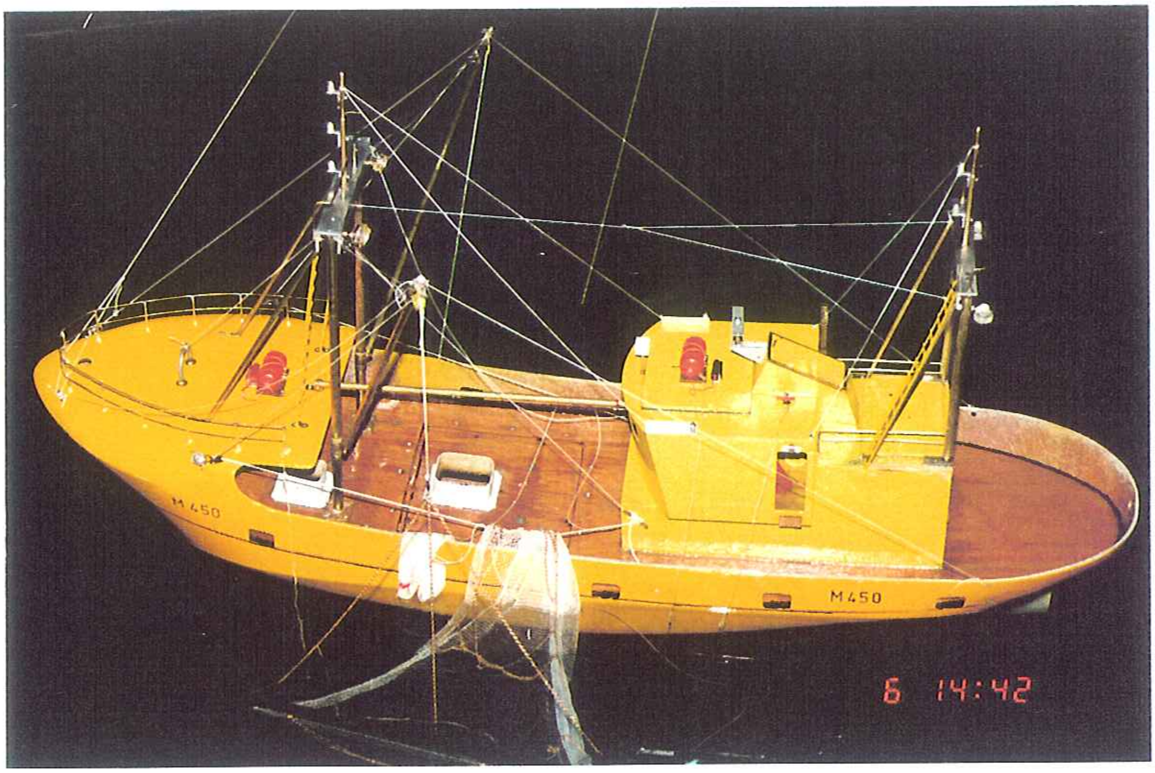

Figure 7. Beam trawler model with liferafts on brackets outboard of the galley. Preparing to haul on starboard trawl warp.

Figure 8. Westhaven model on the tank bottom.
Port liferaft released from galley roof and painter fouled by cod end

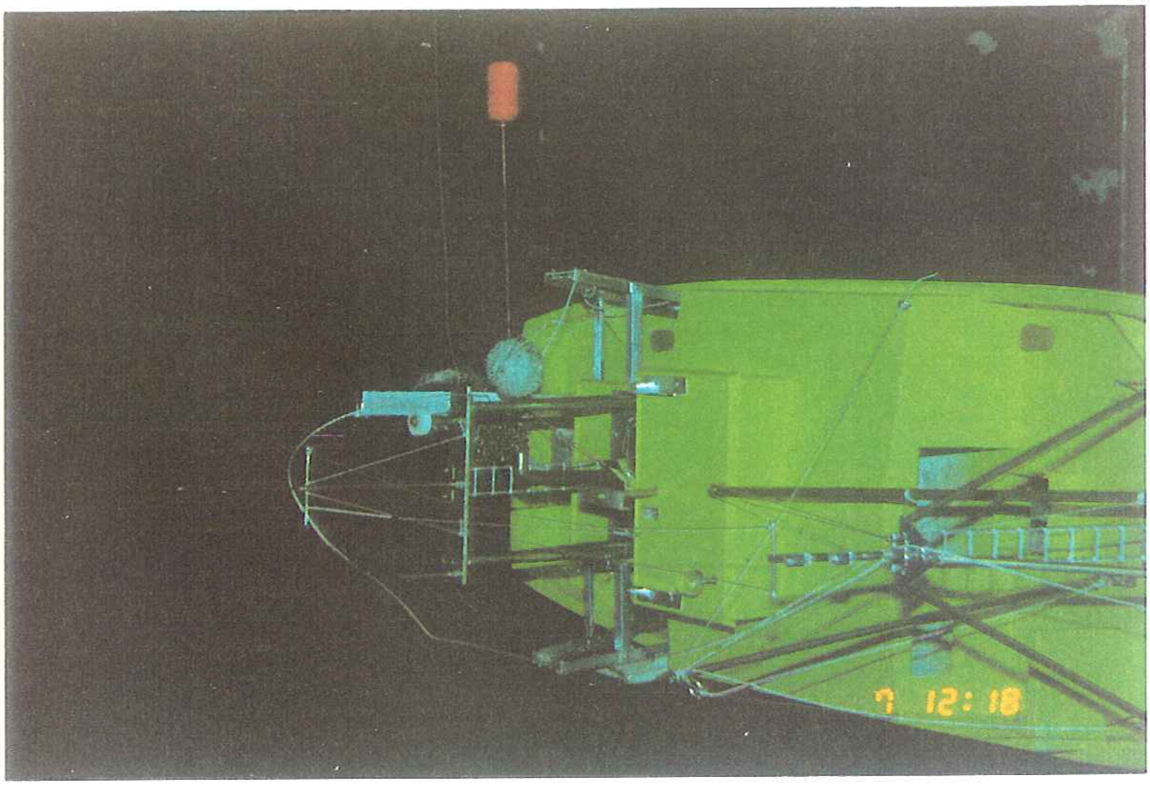

Figure 9. Westhaven model on the tank bottom.
Liferaft released from shelter roof in front of wheelhouse, and passed through forward tripod mast.

Figure 10. Beam trawler model on the tank bottom.
Liferafts released from forward on galley roof. Port raft fouled in starboard trawl. Starboard canister jammed by railings.

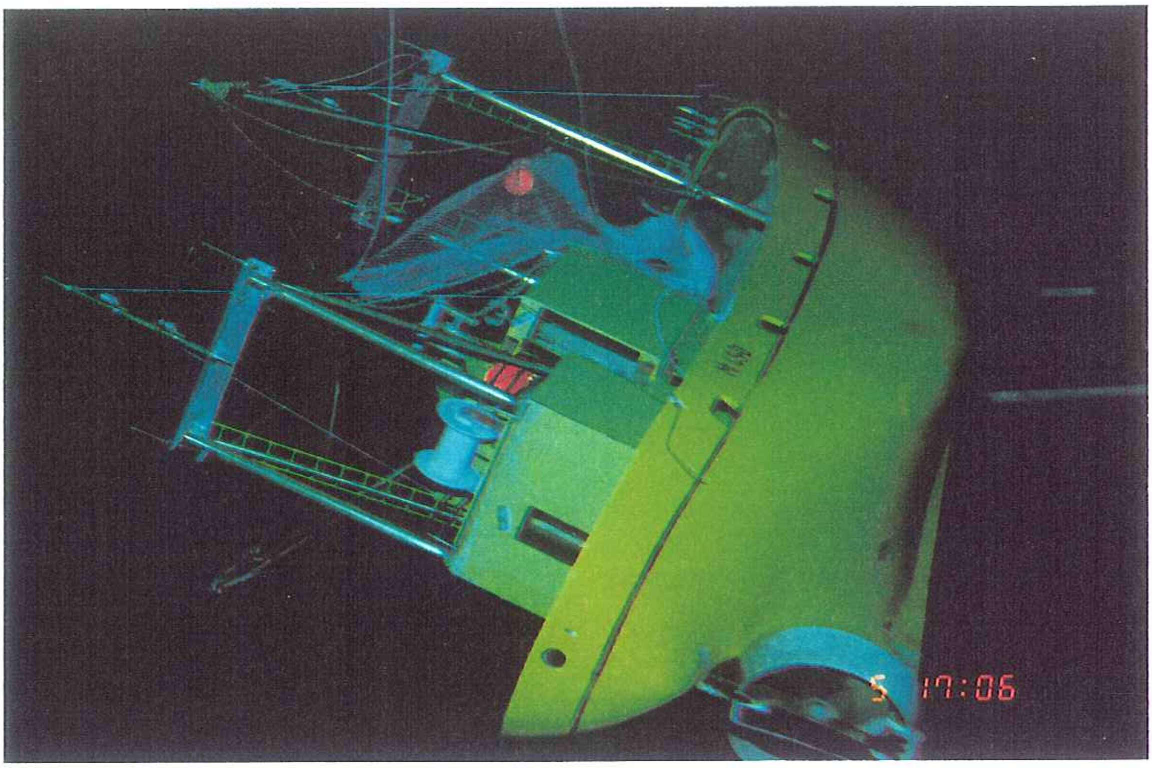

Figure 11. Beam trawler model on the tank bottom.
Liferafts released from brackets outboard of galley. Starboard canister jammed in wheelhouse door.

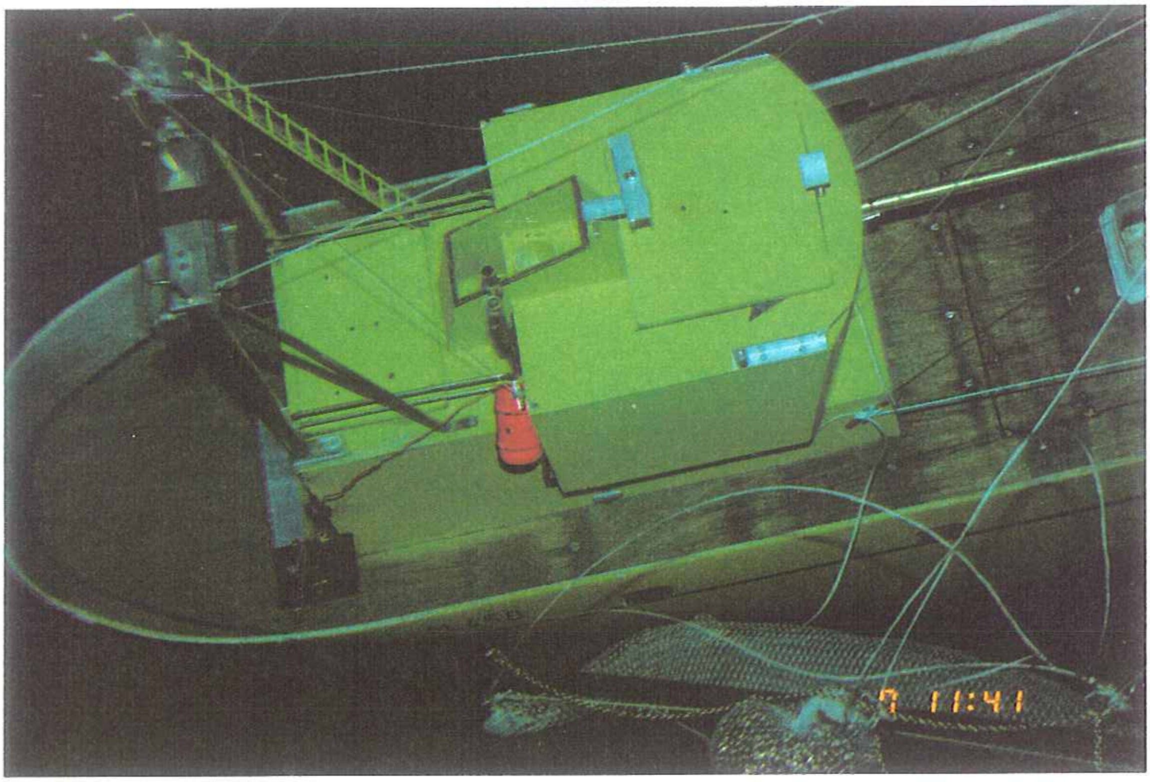

Figure 12. Beam trawler model on the tank bottom.
Liferafts released from aft on galley roof. Starboard painter fouled on port trawl bridle.

Figure 13. Beam trawler model on the tank bottom.
Liferafts released from brackets outboard of galley. Starboard painter fouled on aft gantry. Port painter fouled on port boom, trawl warp and tickler chains.

Figure 14

An Illustration of the Heeling Moments Required to Capsize with Constant Warp Tension