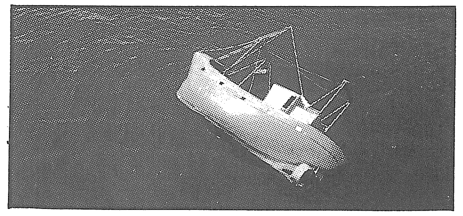
RESEARCH

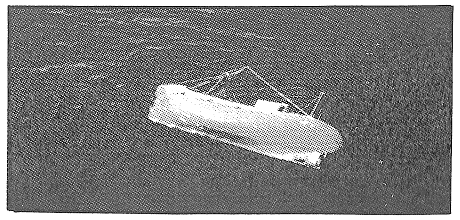
Trawler sinking tests at the Wolfson Unit

Recent losses of small beam trawlers have prompted questions regarding their behaviour during capsize, sinking and settling on the sea bed.

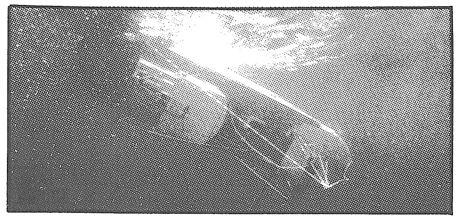
A. *Starboard gear snagged on the bottom, port gear (represented by a weight) raised to bulwark height with the port derrick lowered. Tension being increased in the trawl warp.*



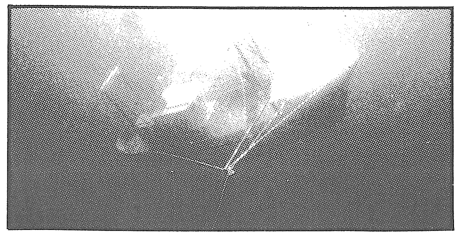
Model hauled over to immerse the engine room hatch and fish hold hatch. The port gear and derrick have swung across to starboard.



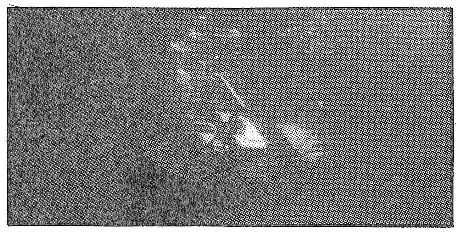
Model stable at 90 degrees and flooding rapidly.



Model now heeled to approximately 134 degrees with only the stern above water. Flooding slowly.



Sinking to the bottom, righting and venting air.



Striking the sea bed with the starboard bilge and still venting air.

The Marine Accident Investigation Branch of the Department of Transport sought to determine whether the attitude and condition of a vessel on the sea bed could provide any clues to the way in which it sank. To this end they commissioned the Wolfson Unit at the University of Southampton to conduct a series of tests, sinking a model trawler in a variety of ways and filming its behaviour throughout. Barry Deakin of the Wolfson Unit reports on the tests and conclusions.

The objectives of the tests were two fold. Primarily the MAIB hoped for evidence in support of investigations being conducted into a number of trawler losses. In addition there was a desire to learn more about the dynamics of a capsizing and sinking vessel with the possibility of such knowledge enabling an increase in their safety.

With no pre-conceived ideas about how the latter might be achieved, a test specification was prepared by MAIB which they hoped would fulfil their primary objective.

The cause of capsize which most concerned the MAIB was a result of snagging of the gear on a seabed obstruction, when the trawler would stop and haul on the warp to recover the gear. Several vessels had been lost whilst engaged in such an operation.

A model was constructed to represent a typical beam trawler of 24 metres in length at a scale of 1:15. The internal arrangement included watertight bulkheads, and blocks of ballast or buoyant material were located to represent regions of intact buoyancy such as the engine, tanks and double bottom. All doorways and hatches were provided with closures so that downflooding arrangements could be varied. The propeller, nozzle and rudder were fitted so that any influence they might have on the vessel's descent would be modelled. The model weight was 46kg, representing 154 tonnes full scale. It was ballasted to a loading condition which corresponded to the minimum aft freeboard required by the Department of Transport's Merchant Shipping Notice M975, and such that its stability just met the minimum requirements for beam trawlers. Provision was made for adjusting the stability by movement of ballast.

Portal frames were mounted fore and aft, and derricks were attached by universal joints to the forward frame. Lines representing the trawl warps were led via blocks at the outboard ends of the derricks and made fast on the model. A weight representative of a beam trawl was tied into one of the warps. The other was led through a block attached to a weight on the sea bed and back to the surface. By hauling on this line the model could be held against a current or capsized in a controlled way.

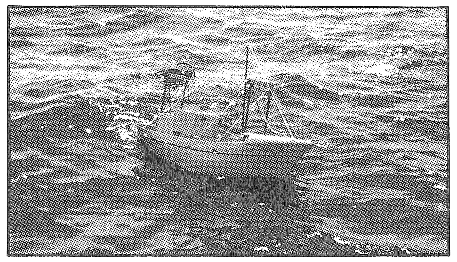
Initial tests were carried out in the controlled environment of a 5 metre deep indoor tank at the University. Later tests took place in the same depth of water in Swanage Bay on the Dorset Coast. This location offered exceptional water clarity and a sandy bottom, with an opportunity to observe the effects of tidal stream and a variety of representative model sea states.

All tests were monitored by Hi8 video cameras above and below the surface, the underwater filming being carried out by divers with hand held cameras.

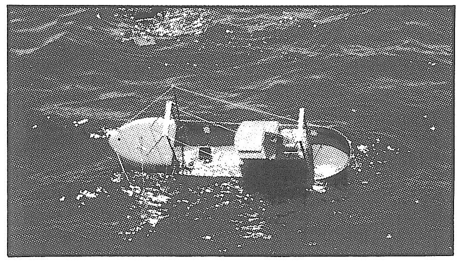
During the two sessions the model was subjected to 30 separate tests. The majority of these concentrated on capsizing caused by hauling on the trawl warp, with the warp led via the end of the derrick, or brought inboard to the bulwark rail in accordance with recommended procedures. Investigations were also conducted into the effects of flooding of the engine room and/or the fish hold as a result of a leak rather than downflooding.

Whilst the specification called for observations only, with no instrumentation to monitor load in the warp or response of the model, by pulling manually on the warp one was able to gain a good feel for the residual stability during capsize and flooding. By releasing the tension one could observe whether the model was able to recover or continue to flood at some angle of list.

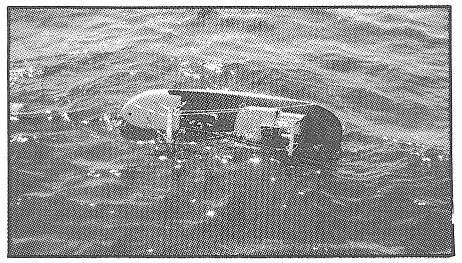
With the model ballasted to meet he Department of Transport's minimum stability requirements it proved very difficult to capsize. in order to sustain sufficient flooding to sink the model, warp tension have to be maintained to hold the model at a sufficiently large heel angle for flooding to take place. It is hard to imagine a trawler crew maintaining warp tension on their winch while the vessel floods through a doorway or hatch. If operating in a tidal stream however, and with a malfunction in the winch preventing release of the warp, the vessel's drag, when anchored by the snagged trawl, may be sufficient to cause this situation. Tidal flow in Swanage Bay gave the opportunity to model this scenario and supported the advice of skippers given by the Department of Transport.: "When attempting to free fishing gear fouled on the bottom, fishermen should exercise every care and where possible endeavour to free the gear while bow or stern to strong tides or heavy whether of if possible wait for slack water or the weather to abate".



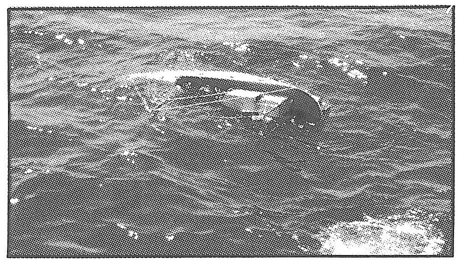
B. *Port gear snagged on the bottom, starboard gear on deck, starboard derrick raised. Tension being taken up on the trawl warp.*



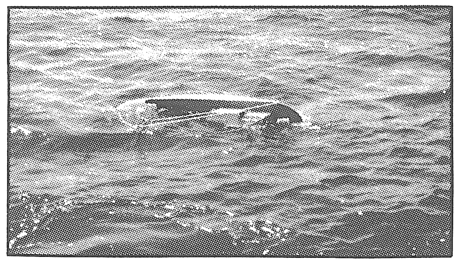
Model hauled over to immerse the net store hatch (under the whaleback), and intermittent flooding through the deckhouse door.



Flooding increased with the fish hold hatch and wheelhouse window submerged.



The rate of flooding reduces as the hatches become totally submerged.



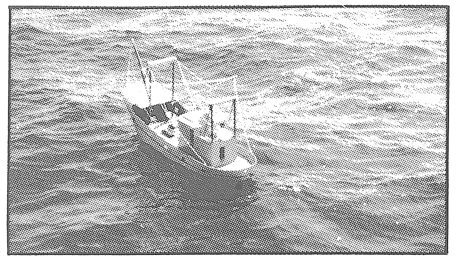
Model stable at 90 degrees and flooding slowly.

It was noticeable that the warp tension restricted the model's response to the waves with the result that the rate of downflooding was greater than that of the unrestrained model at a corresponding angle of heel. With stability reduced by movement of ballast, it was found that the model naturally settled on its side after some initial downflooding, and the rate of progressive flooding was then dependent upon the arrangement of openings. In some cases flooding was extremely slow, there being no openings in the high sides of some compartments through which the entrapped air could vent. Repeated wave action resulted in intermittent venting and the model gradually changed its orientation until a significant amount of air could be released and the model then sank.

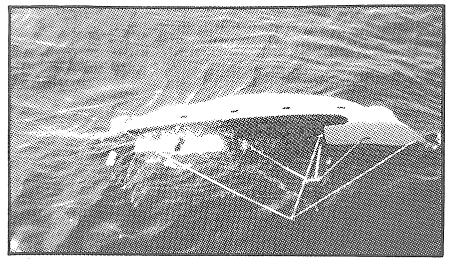
With the stability reduced still further, capsize induced by the trawl warp resulted in inversion of the model, to an angle of 110 degrees or greater. At such angles, with a totally sealed model hull, no venting could take place and the flooding was not able to progress, the model remaining stubbornly at the surface despite wave action or varying the tension in the warp. In reality trawlers may have small holes at skin fittings, stern glands, or hull joins which would permit a slow but continuous bleed of air and the vessel might sink very slowly. There have been such incidents reported where vessels have remained afloat but inverted for many hours.

As a vessel sinks below the surface its stability becomes dependent solely upon the locations of the centres of buoyancy and gravity, there being no intact waterplane to provide stability in the normal way. During the last moments on the surface and during the descent therefore, the attitude of the model often changed dramatically. The centre of gravity of the model's structure and ballast remained relatively constant throughout the programme, but the spaces remaining intact, or containing small amounts of floodwater, varied depending on the openings and model of capsize. The centre of intact buoyancy therefore changed between tests.

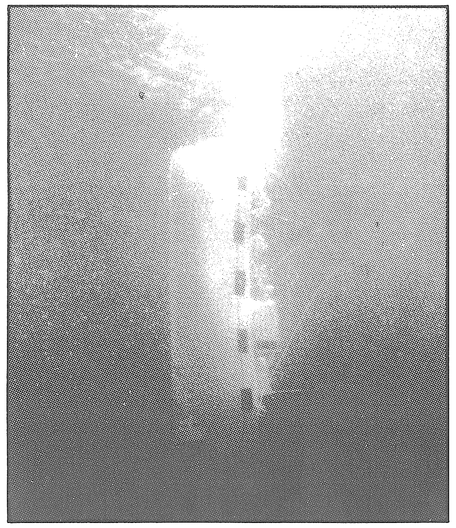
The model was observed to sink in various attitudes, often with the keel vertical and the tip of the bow being the last part to submerge. As its attitude changed on sinking, the general tendency was for it to return to upright, its centre of gravity being below the centre of the buoyant structure.



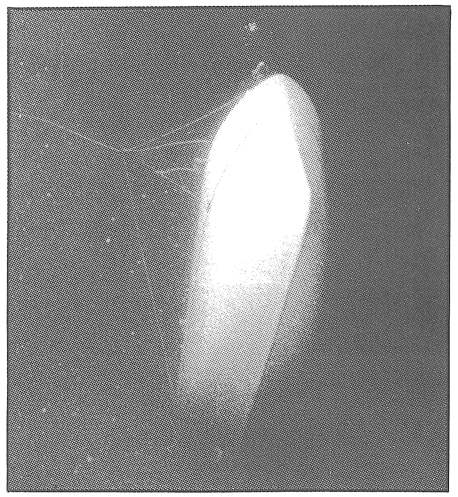
C. *Starboard gear snagged on the bottom, port gear on deck, port derrick raised. Model prepared for testing, tension being taken up on the trawl warp.*



Model flooding fast, venting the aft compartments through the deckhouse openings.



Model descending stern first and accelerating, venting fast through the wheelhouse windows.



Model striking the bottom with the rudder.

This brought the openings uppermost and released large volumes of air which caused to accelerate in its descent, perhaps changing its attitude further, and the impact with the bottom was always hard. Frequent on the spot repairs were required to the model's sterngear, deckhouse and derricks.

With regard to the primary objective the tests provided the conclusion that, in this water depth of three times the ship length, it is not possible to derive conclusive evidence of the mode of capsize from the attitude of the vessel on the sea bed, or from damage sustained as a result of impact with the sea bed. Its attitude did however give an indiction of its stability, the low stability tests resulting in a greater likelihood of the model settling on its side on the sea bed.

Observation of this physical model, and subsequent examination of the video records, enabled the secondary objective, of studying some aspects of trawler safety, to be addressed in a unique way.

The effects of sudden changes in the heeling moment were examined in two ways. The freeing ports were sealed and the vessel hauled over such that the bulwark rail was submerged. Water flooding onto the deck thus caused a sudden change in the stability but did not appear to cause any dramatic change in the vessel's attitude.

With the fishing gear on one side snagged, the gear on the other side was raised to the surface, and the derrick held at about 30 degrees to the vertical. When the model was hauled over, the raised gear swung across the model, transferring the load to increase the heeling moment on the snagged side. This sudden swing, while resulting in an increase in the heel angle, did not appear to have any adverse dynamic effect.

With the model ballasted to reduce the minimum freeboard to zero it was held with the snagged trawl cable over the bulwark rail. The seastate represented waves of 3 metre significant height, such as might be expected in Beaufort Force 6 conditions. Despite the low freeboard and substantial deck wetting, little flooding occurred through any of the openings, all of which had sills corresponding to 600 mm above the deck full scale. These sill heights were therefore demonstrated to be effective in these conditions despite negligible freeboard.

The tests did not result in any great surprises regarding the behaviour of the trawlers, but they did reinforce the advice given to fishermen. They also served to stress the importance of maintaining watertight integrity of the hull, particularly when embarking on a hazardous exercise such as freeing snagged gear, when all doors and hatches should be closed.

Effective subdivision of the hull is an obvious advantage, since it is most likely that downflooding will take place through just one or two openings, and some compartments will then remain intact, perhaps providing sufficient stability to enable recovery.

As a result of conducting this work, engineers at the Wolfson Unit have been prompted to consider the safety of small trawlers and have been in contact with the Department of Transport and an industry member of the Department's Fishing Industry Safety Group on methods of assessment which might assist the future operation of these vessels.

The findings from this research work were presented in the UK Fishing Vessel Safety Group in November, 1993. When comparing some of the modes of sinking and model contact with the seabed, good correlations with observations of actual FV sinking cases have been found. Furthermore, the damage observed on a number of fishing vessel wrecks is entirely consistent with the results of the heavy seabed impacts which were experienced by the model used in this research project.