H.M.S. 'GUERNSEY'— GROUNDING AND SALVAGE

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ABSTRACT

H.M.S. *Guernsey* ran aground outside Aberdeen harbour on 17 April 1987. The extent of the flooding which resulted from this accident was recorded well enough to allow computer calculations of draught and stability for comparison with observations made at the time. Although the ship was successfully salvaged and returned to service with no apparent ill effects, the incident exposed some deficiencies in various aspects of design and maintenance, and in Damage Control information and practice.

Introduction

H.M.S. *Guernsey* is an ISLAND Class (FIG. 1) Offshore Patrol Vessel, built in 1977 by Hall Russell of Aberdeen, to a MOD specification. The ship ran aground on Girdleness at 1245 BST on 17 April 1987 while preparing to enter Aberdeen harbour. Weather was foggy with visibility of 200–400 yards, no wind and a calm sea. The consequent flooding and salvage presents a rare example of a ship which was flooded almost to the point of loss, which remained balanced on rocks in a steady state, and whose extent of flooding was fairly accurately recorded. This has allowed an assessment of the reserves of buoyancy and stability while the ship was balanced on the rocks. This accident also provides an opportunity to observe the adequacy of current practices in design, maintenance, and Damage Control training.

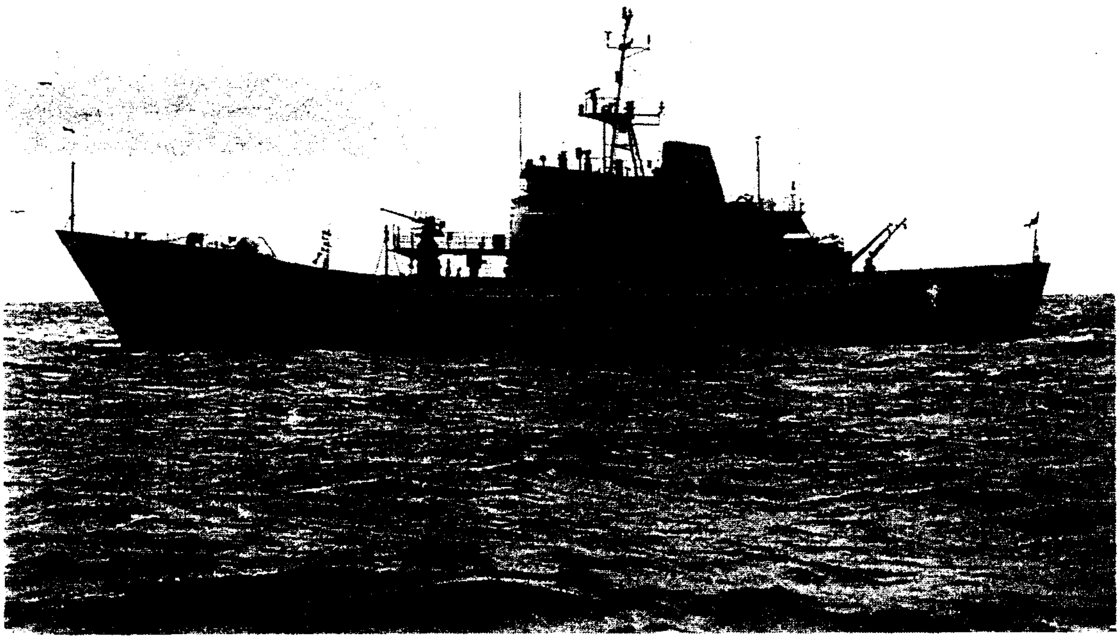

FIG. 1—AN 'ISLAND' CLASS OFFSHORE PATROL VESSEL, H.M.S. 'LINDISFARNE'

Design Standards

The narrative of grounding and flooding in this article describes flooding which was only to be expected from the size and location of the holing caused by the grounding; it also describes the additional spread of flooding which should have been contained by the watertight subdivision. The flooding, whether expected or unexpected, is perhaps best explained by describing the design standard which was adopted for this class when MOD prepared the build specification.

The ISLAND Class repeats the design of the Fisheries Protection Vessel *Jura* in respect of hull form and overall layout but not in respect of subdivision. *Jura* was required to meet the Department of Transport regulations for a Class VII Cargo Vessel, that is for a cargo vessel capable of unrestricted ocean operation. These regulations do not require the ship to be capable of remaining afloat if any one compartment is flooded. *Jura* was also built to Lloyds Rules, which impose an additional requirement for watertight bulkheads at each end of the machinery spaces. However these bulkheads need only extend as high as 2 Deck and need not give the ship the ability to survive flooding of any one compartment other than the space forward of the collision bulkhead. *Jura* is therefore incapable of surviving any holing aft of the collision bulkhead. This level of vulnerability was unacceptable to MOD, which exercised its right as ship-owner to require a higher standard.

The standard of survivability adopted by MOD for the ISLAND Class was appropriate to the peacetime risks of collision and grounding, and were that the ship should be capable of surviving in a Force 6 wind and corresponding sea state with any one compartment flooded. This in turn required reserves of stability, buoyancy and freeboard which could be specified as the starting

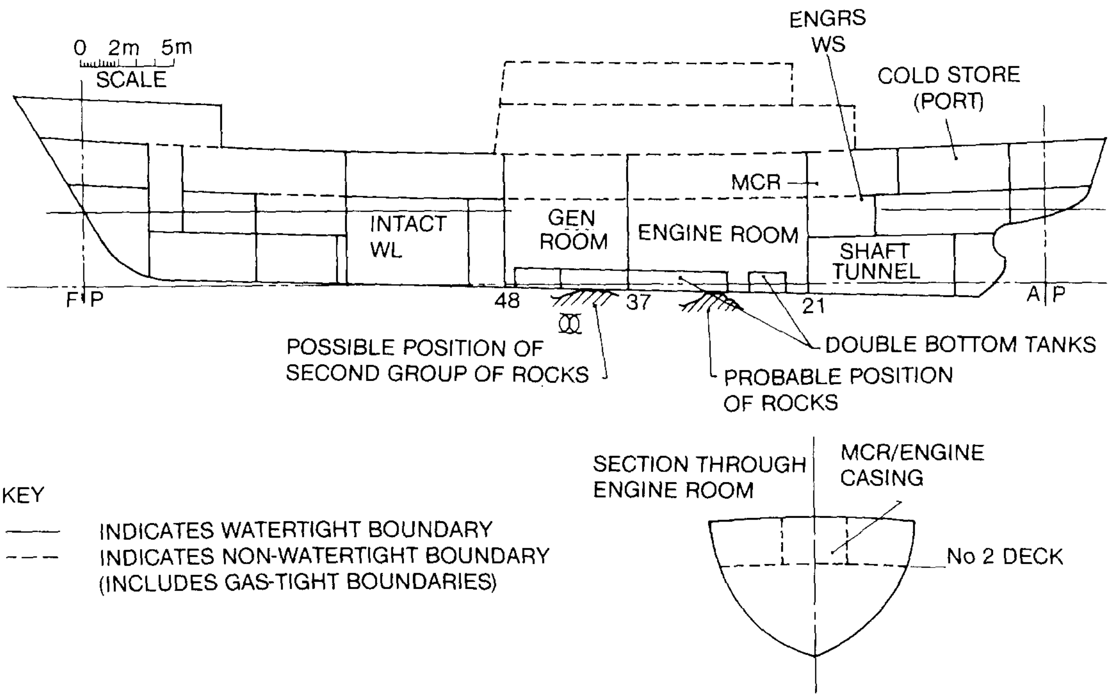

FIG. 2—H.M.S. 'GUERNSEY', PORT PROFILE

point for design and calculations. The required reserves of freeboard were achieved by the subdivision shown in FIG. 2. It will be seen that 2 Deck was not required to be watertight other than where required by tanks, and was gas-tight but not watertight over machinery spaces. Bulkheads were watertight to the underside of 1 Deck. Bulkhead doors were specified to MOD standards of watertightness; doors to machinery spaces were specified to commercial standards of gas-tightness. Systems were specified to commercial standards including the extent to which they were fitted with isolation valves at bulkheads and watertight decks (but not at non-watertight bulkheads and decks) to prevent secondary flooding. This sets the scene for the subsequent events in H.M.S. *Guernsey* on 17 April 1987.

Narrative

Running Aground

At about 1245 BST the ship was heading west towards the shore-line and at about right-angles to it, speed about 3 kt, in fog of about 200 yards visibility. It was a little before half-tide with the tide rising (high tide 1621 BST) and there was a southerly tidal current of about 1 to 2 kt. The ship was in Condition X-RAY. Proximity to the shore was detected on radar, the ship went full astern, and a rock was sighted on the starboard bow at about the same time. The ship lost directional control under astern power and yawed to starboard before gathering sternway. The southerly tide swept the ship port-side onto the submerged rocks immediately north of the Girdlestone. The hull made multiple contacts with one or more rocks as the ship was moving slowly astern. The engines were stopped and it became immediately evident that the ship was aground. The time was then about 1247. Subsequent analysis leads to the conclusion that the ship had come to rest on rocks about frame 27 to 32 and possibly on a second rock or group of rocks between frames 40 to 45, all to port of the keel. The position deduced for the ship on these rocks is shown on FIG. 2, with the intact waterline and the estimated height of tide above the rocks (4.305m) at the moment of grounding.

Damage and Holing

The full extent of structural damage was determined during the docking after salvage and is shown in FIG. 3 in plan and FIGS. 4, 5 and 6 in section. Some of the indentations may have been caused while the ship sat on the rocks before salvage at 1630 BST but there is no evidence that any additional holes were made during that period rather than at the time of grounding. The hull showed longitudinal score marks; some of these were consistent with astern motion at the time of grounding; others may have been caused during grounding or during salvage but evidence is insufficient to allow a conclusion. Again there is no evidence that any additional holes were made during the salvage at 1630.

Grounding holed the outer bottom as follows (shown in FIGS. 3 to 6):

(*a*) A gash about 0.7m wide across the bulkhead between the shaft tunnel and the engine room.

(*b*) A hole about 0.6m diameter into the water ballast tank in the engine room double bottom.

(*c*) A split about 2m long by 0.01m wide at the join of the vertical keel and the garboard strake into the same tank.

(*d*) 4 splits each about 0.15m × 0.01m at frames in the bottom of the gearbox lub oil drain tank.

(*e*) A split about 0.25m × 0.05m into the double bottom water ballast in the engine room.

The subsequent flooding was almost entirely due to the first of these holes. The splits under the gearbox lub oil drain tank would have contributed to flooding the engine room through the gearbox but their effect would have been small compared with the gash in the hull at the engine room/tunnel bulkhead. Flooding from the other holes was confined by the tank tops.

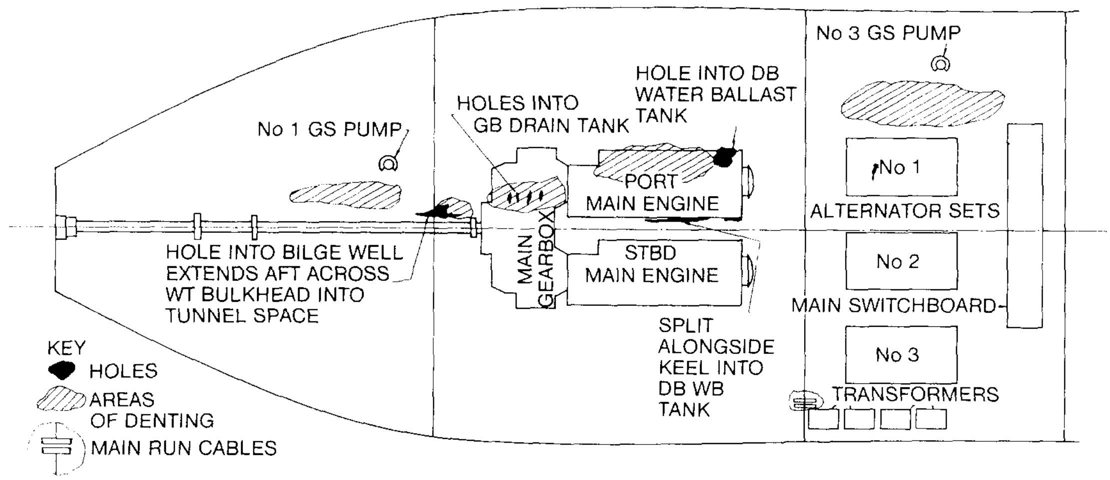

FIG. 3—LOCATION OF HOLES AND DENTS

Uncontrollable Flooding in the Tunnel and Engine Room

The engine room was immediately seen by the watchkeepers to flood from an area at the bottom of the aft bulkhead. One witness described the flood as 'a plume of water about 6 ft high'. The general service pump in the engine room was put to bilge suction but without observable effect on the rate of rise of water. The main engines were shut down before they were completely submerged a few minutes later.

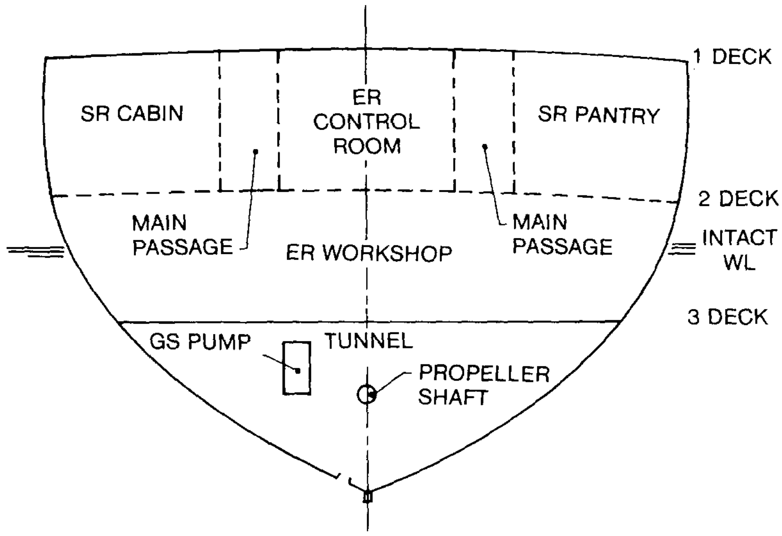

Fig. 4—Section aft of engine room, looking forward at frame 20

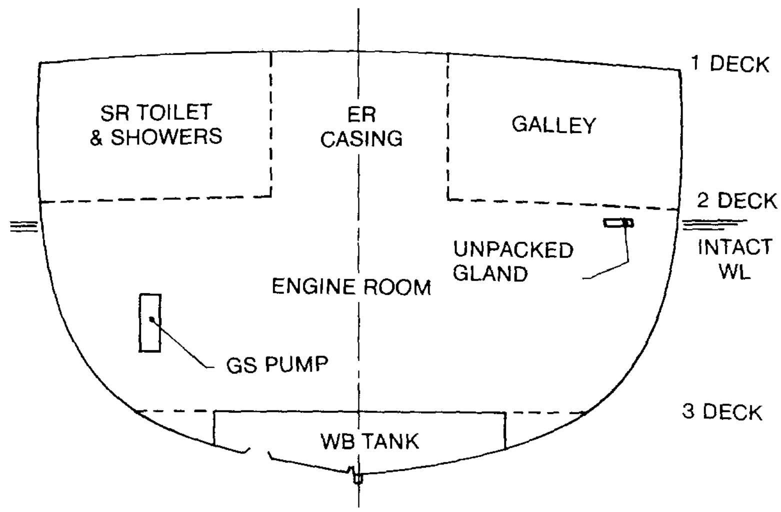

Fig. 5—Section through engine room, looking forward at frame 34

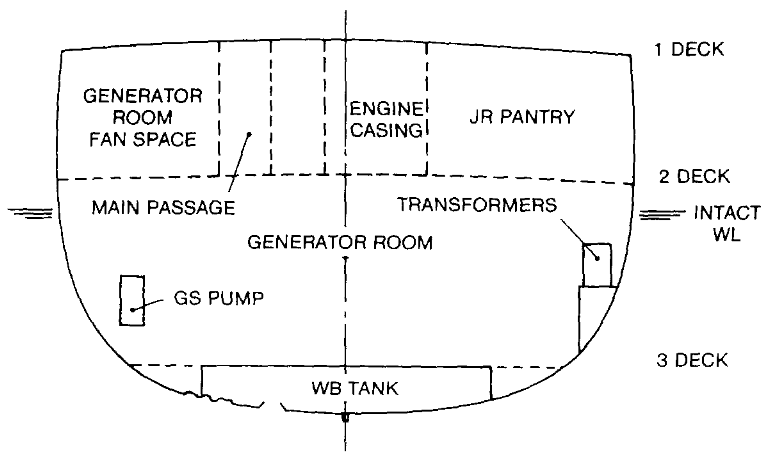

Fig. 6—Section through generator room, looking forward at frame 40

The tunnel was seen to flood by sighting down the access trunk from 2 Deck. A MEM(M) descended the trunk into the tunnel, waded through waist-deep and rising water to start the general service pump, and put it to bilge suction. On the way back up the trunk he shut and fully clipped the watertight door at 3 Deck level into the workshop. This should have stopped the workshop from flooding but it was later discovered that it had flooded.

The tide was rising at about 0.15m per 10 minutes and this may have clouded the observations of time taken to fully flood spaces. In any event it seems that the tunnel and engine room flooded to the waterline (at about 2 Deck) in 15 minutes or less, with flooding in the tunnel running its course quicker than the engine room, so that by 1300 fast flooding was complete and H.M.S. *Guernsey* sat firmly on the rocks. Subsequent changes in the water level of the tunnel and engine room were due solely to the rising tide and changes in trim.

Rates of Flooding

The tunnel has a volume of about $80m^3$ and the engine room about $360m^3$. These spaces fully flooded in 10–15 minutes giving a combined flooding rate of 1750–2500 tonnes/hr through the gash under the tunnel/engine room bulkhead. This vastly exceeded the capacity of the general service pumps in the tunnel and engine room (50 tons/hr each) and these shorted out as soon as the water reached the windings of the non-submersible motors. A Spate pump was quickly established in the engine room and another pumping the tunnel. Their combined capacity is about 70 tons/hr, which again is negligible compared with the flooding rate.

Stability at 1300

By the time uncontrollable flooding had run its course in the tunnel and engine room the depth of water over the rocks was about 4.515m and the tide was still rising. The ship had lost about 440 tonnes of buoyancy (assuming no flooding in the workshop yet). MOD has attempted to deduce the position of the rocks relative to the ship and their depth below chart datum. These deductions are shown in FIG. 7 for the tide at 1300. FIG. 7 also shows the extent of flooding observed at the time, assuming negligible flooding in the workshop.

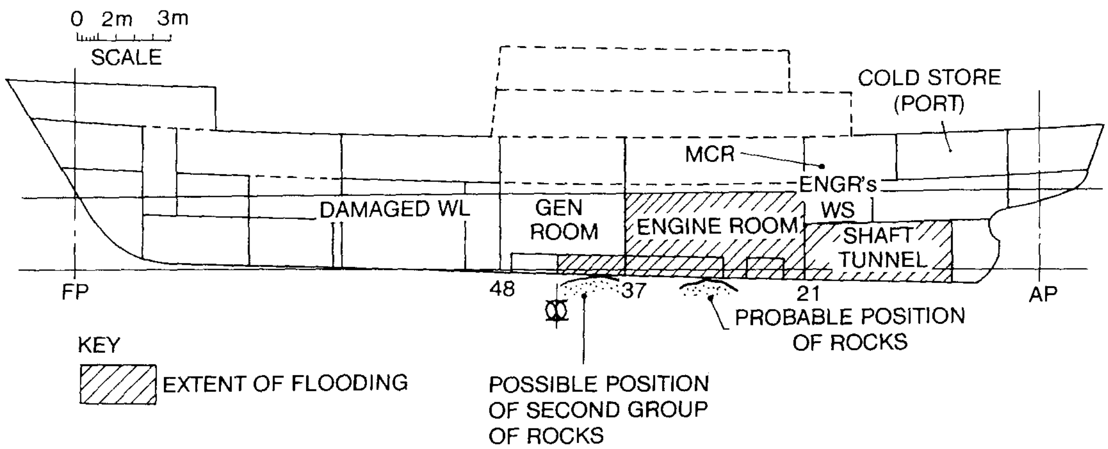

FIG. 7—SHIP CONDITION AT 1300

The stability of the damaged ship balanced on a rock is very sensitive to the assumed position of centre of gravity, to the assumed longitudinal position of the rocks, and to the immersion of the rocks below the waterline. Various estimates of upright stability were made and produced estimates of GM of between +0.7m and −0.55m. Since the ship remained upright in the condition shown in FIG. 7 then either GM was positive or the ship was cradled on the rocks. Since all the holes and indentations were in the port half of the hull the upward force exerted on the hull would lead to a heel to starboard. Since there was no heel to starboard it is a reasonable but not certain judgement that the ship was cradled on the rocks and may have been held in that position by the southerly tidal current acting on the starboard side. If the ship had not been cradled on the rocks she would have heeled to an angle noticeable by the ship's company. It is not possible to produce a GZ curve for the ship in this condition because of the sensitivity of GM and GZ to the assumed position of the rocks and because of the probable cradling of the hull by the rocks.

The Spread of Secondary Flooding

Fast, uncontrollable flooding via the holes in the outer bottom had run its course in the first ten minutes but had left the ship sitting safely and upright on a rock or rocks in a flat calm on a rising tide, with full generator capacity available and with salvage capacity undiminished other than by the loss of the fixed general service pumps in the flooded engine room and tunnel. The ship had been seriously damaged and extensively flooded but was still salvable. However worse was to come.

The watertight door to the engineers workshop had been shut by the quick and determined action taken by the MEM during his ascent from the tunnel. This effort was negated by flooding from the tunnel through either or both the vent valve between workshop and tunnel or the escape scuttle from the tunnel into the workshop at 3 Deck. The vent valve may have been open or not fully shut; the scuttle may have leaked. The cause of flooding in the workshop was never satisfactorily identified and the time to flood this space cannot be determined. It is reasonable to assume that the space fully flooded in no more than an hour, but it could have been rather less.

In the first half hour after grounding the gas-tight doors from the engine room and the tunnel trunk onto 2 Deck were taped over from the inside and shored from the outside. Despite this, 2 Deck aft of bulkhead 37 suffered secondary flooding from the engine room and tunnel through the gas-tight doors; from the tunnel into the cold and cool rooms through a drain into the tunnel and whose non-return valve returned; and from the sea into the galley and into wash-places through scuppers whose non-return valves to the sea also returned. The cold and cool rooms flooded to 1 m and other accommodation spaces flooded between 0.1 and 0.5 m by about 1545.

Most serious of all, at about 1325 the rise of the tide caused the water level in the engine room to reach an unpacked cable gland (FIG. 8) in bulkhead 37 just below 2 Deck. The unpacked opening was about 0.14 × 0.06 m and caused flooding at about 120 tonnes/hour in the form of a spray over the transformer bank (FIG. 3). The transformers did not short out but the generators were shut down for fear of short-circuits. This caused total loss of power throughout the ship, affecting lighting, communications and most importantly the general service pump in the generator room. The generator room was therefore deprived of the means of controlling the flood. Water level rose quickly. The generators were restarted and two senior rates tackled the leak with wooden wedges in the classic manner. This reduced the rate of flooding from about 120 tonnes/hr to about half that amount according to estimates by the senior rates involved (or approx 25 tonnes/hr according to the author's estimates from the reported levels of water in the generator room, the times to reach them and the capacity of the pumps used). In the meantime the rise of tide had raised the level of water in the machinery control room to the height of the remote controls for the general service pumps and shorted the controls 'off'. The general service pump in

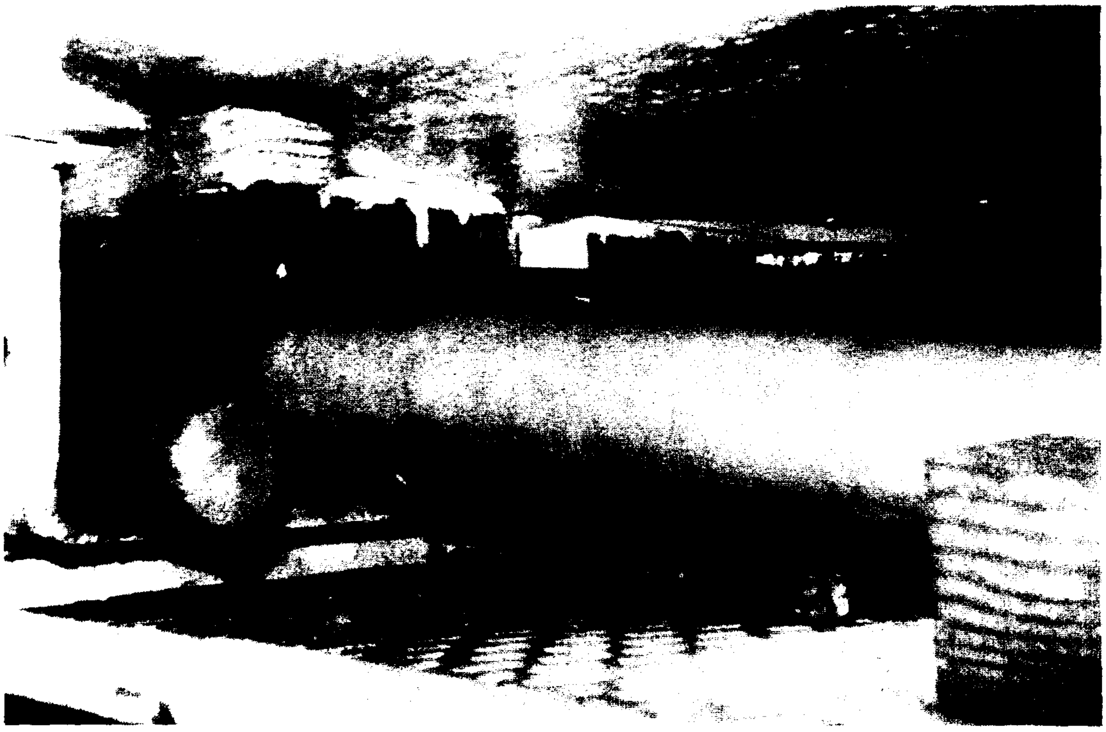

FIG. 8—PORT PACKED CABLE GLAND SHOWING SOME WOODEN WEDGING

the generator room stopped at about 1350. The water level in the generator room then rose steadily and all power was finally lost at about 1400.

By around 1400 the ship was in a parlous condition and the prospects for H.M.S. *Guernsey* were poor. The tunnel, engine room and workshop were fully flooded. The generator room was flooding at about 120 tonnes per hour and secondary floodwater was invading 2 Deck aft of 37 bulkhead. All electric power had been lost. Pump capacity consisted of one diesel Spate pump (one having seized) and the equivalent of a Spate pump brought by a lifeboat. Secondary flooding was winning. Spread of flooding probably reached its greatest extent at about 1530 before the pumps started to gain after leak-stopping. The ship's condition and extent of flooding is shown in FIG. 9, with the height of tide at that time.

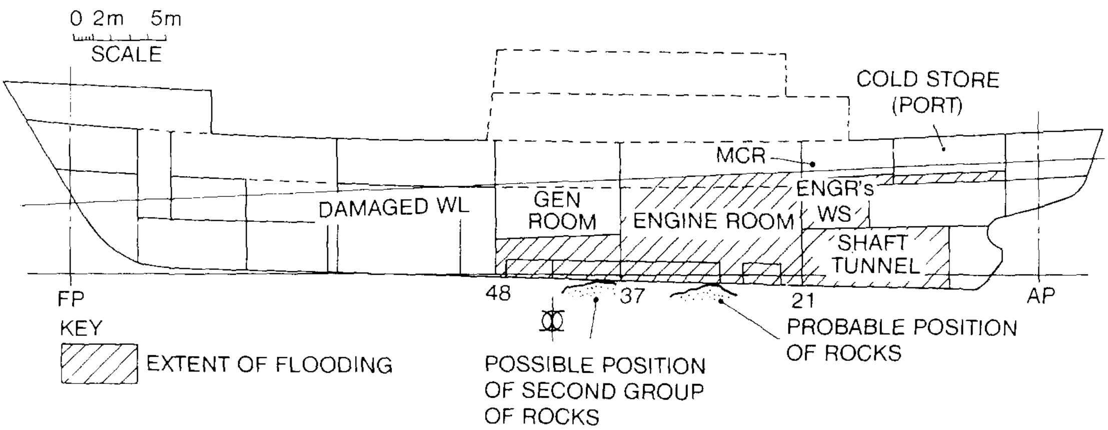

FIG. 9—SHIP CONDITION AT 1530

Counterflooding

The ISLAND Class are equipped for OILSAFE operations and have a 30 tonne tank forward for detergent. At about 1330 about 6 tonnes of water was pumped into this tank with the aim of reducing draught aft. This might have reduced trim but it lodged the vessel more firmly on the rocks. In

TABLE I—*H.M.S. 'Guernsey': employment of pumps during salvage*

Source of Pumps	*No. of Pumps*	*Pump Type*	*Motive Power*	*Capacity* tonne/hr	*Arrival Time*	*Space Pumped*	
Original 'Guernsey' Equipment	3	General Service	Electric	50		Tunnel Engine Room Generator Room	Shorted out immediately by floodwater Shorted out c. 1415
On-Board Portable Pump	2	Selwood 'Spate'	Diesel	30		Tunnel Engine Room	Seized c. 1330 Redirected to Gen Room c. 1345, No. 2 deck c. 1450
Lifeboat	1	'Spate'	Diesel	30	1334	Tunnel	
Tug (1st Delivery)	3	Fire Pump	Diesel	80	1450	Tunnel Engine Room Generator Room	
Tug (2nd Delivery)	4	Fire Pump	Diesel	80	1608	Tunnel Engine Room Generator Room Generator Room	(set up after a delay)

Note: The ISLAND Class are also provided with a Flygt Bibo submersible electric pump (34 tonne/hr) and an eductor (15 ton/hr). These were not used on the day of the grounding.

changing trim the ship may have pivoted on the rocks on which she had grounded and this may have been given the impression of a small reduction in water level in the engine room and tunnel.

Pumping

The ship's staff immediate response to the flooding in the tunnel and engine room was to put the general service pumps in these spaces to 'bilge suction'. This has already been described. The general service pump in the generator room was also put to engine room suction. The general service pumps in the tunnel and engine room were shorted out by flood water immediately. The ship's two Spate pumps were set up, one pumping the tunnel and one pumping the engine room. At about 1334 a lifeboat provided another diesel salvage pump similar to the Selwood Spate. At about 1450 a tug arrived with three fire pumps (80 tonne/hr each) provided by Aberdeen Fire Brigade and at about 1608 another four fire pumps arrived by the same means.

The ship was faced with unexpected floods breaking out in a variety of spaces (the generator room and on 2 Deck). Pumps arrived in three different batches for allocation as judged by the ship according to their assessment of the priorities at the time of arrival of each batch. Recollections of pump movements differ and TABLE I is the author's best attempt at reconstruction. It is quite clear that one of *Guernsey*'s Spate pumps seized and that a lot of effort was put into pumping the tunnel and engine room. These spaces were linked by the gash across the bottom of bulkhead 21 and were flooding at a combined rate of 1750–2500 tonnes/hr, so that all the effort in pumping these spaces was wasted. Secondary flooding into the generator room was capable of control by pumping after the leaks were stopped. Secondary flooding on 2 Deck was also capable of control by pumping because of the action taken to seal the gas-tight doors from the tunnel and engine room. Pumping started to win from about 1530 when enough pumping capacity was put onto the spaces subject to secondary flooding.

The Salvage

The incoming tide peaked in the period 1600 to 1640, with nominal high tide at 1621 BST. In this period the leak-stopping on 2 Deck and in the generator room allowed the pumps working on these spaces to reduce the level of water, particularly in the generator room where the level was reduced from about 1 m to about $\frac{1}{4}$ m. The height of tide over the rocks was not enough to float the ship off but bumping was felt, indicating that the ship was almost afloat. Lines were passed to the two tugs then in attendance and at 1630 H.M.S. *Guernsey* was simply pulled off the way she came, settling in the water by a few inches once clear of the rocks. The estimated draughts and extent of free and secondary flooding are shown in FIG. 10 and the

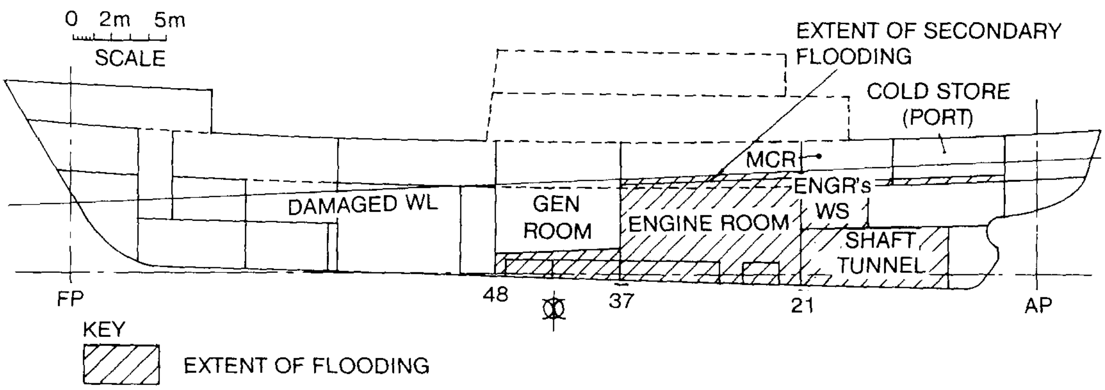

FIG. 10—SHIP CONDITION IMMEDIATELY AFTER SALVAGE

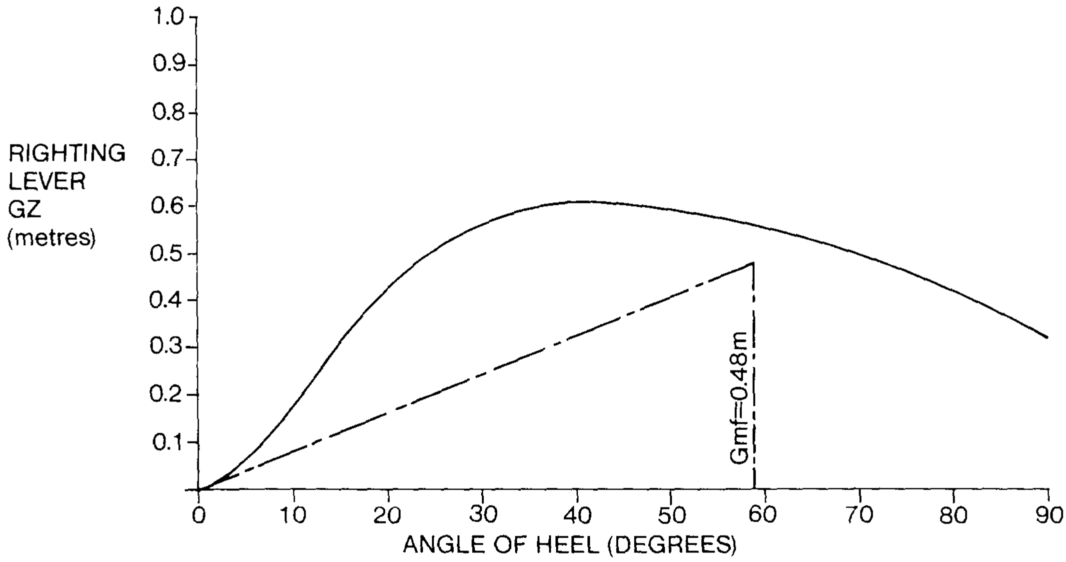

FIG. 11—STABILITY AT SALVAGE. THIS GZ CURVE TAKES ACCOUNT OF TRIM AND FREE SURFACE EFFECTS

estimated stability characteristics are shown in FIG. 11. The reserves of buoyancy before the loss of the ship would have been inevitable were about 700 tonnes. *Guernsey* was towed into Aberdeen harbour (FIG. 12) and she was secured alongside Hall Russell's yard where she was built ten years before.

Aftermath

H.M.S. *Guernsey* was docked in Hall Russell's yard on 18 April. Ammunition was landed, fuel was pumped out of tanks and provisions were landed from the flooded provision rooms and condemned. The flooded machinery spaces were pressure washed with fresh water and non-ionic detergent. Electric motors and the generators were removed for rewinding or replacement. Fuel injectors were removed from diesel engines for preservation and the diesel engines were flushed with oil. Hall Russell was contracted to repair the damage and *Guernsey* returned to service about five months after the accident which almost caused her loss. A year after the incident the ship shows no ill effects.

Post Mortem Conclusions

Overall H.M.S. *Guernsey*'s accident provided a very successful vindication of the design standards adopted by MOD and of damage control training and practice. There must inevitably be constructive lessons emerging from this incident which can be fed into future designs, into maintenance and into damage control training. These lessons should not take away from the overall success which *Guernsey*'s salvage represents, nor from the immense achievement by ship's staff in successfully combating floods which broke out in a wide range of unexpected locations.

Ship Design

The ISLAND Class was designed with subdivision in the form of watertight bulkheads but not with watertight decks. H.M.S. *Guernsey*'s incident reinforced the need for double bottoms or, where double bottoms are not necessary or practicable, the lowest deck should be watertight. In the case of the ISLAND Class there is a limited double bottom and 3 Deck is also watertight over its limited extent. In addition the deck on or nearest above the intact waterline (2 Deck in ships such as the ISLAND Class) should be designed to be watertight to limit the upward spread of flooding from damage below the waterline. This would preserve buoyancy and would ensure positive stability in all cases of underwater damage. In the ISLAND Class, 2 Deck is non-watertight unless required watertight in way of deep tanks, and the resulting penalty was unnecessary spread of flooding, unnecessary water damage, and an unnecessary proximity to loss of the ship. In warships policy results in the creation of the 'damage control deck'. The same design policy may be a good insurance against peace-time risks.

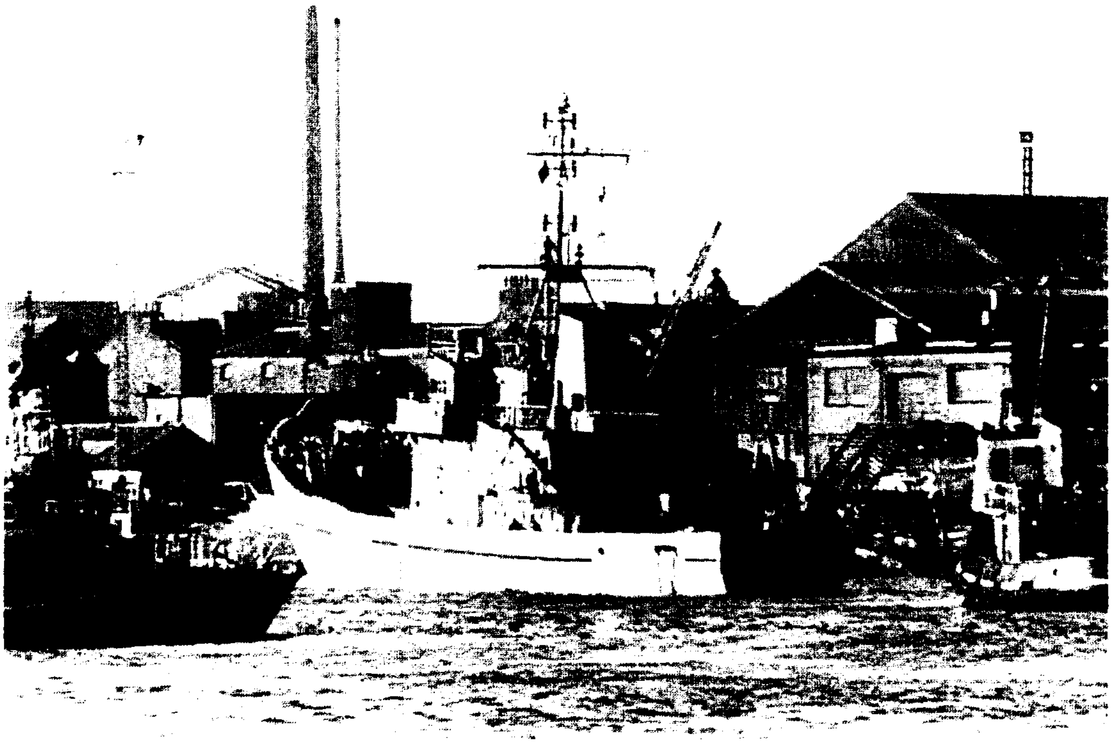

FIG. 12—H.M.S. 'GUERNSEY' BEING TOWED INTO ABERDEEN HARBOUR

Systems Design

Open-ended pipe systems such as scuppers penetrating watertight boundaries need to be capable of positive isolation above watertight decks or on either side of watertight bulkheads. Non-return valves are inadequate and should either be screw-down non-return valves or they should be supplemented by isolation valves at the watertight boundary. In the case of the ISLAND Class the scuppers were fitted with non-return valves which did return and no isolation valves were fitted at 2 Deck.

Watertight compartments below the waterline, which are at risk of spreading flooding through open-ended systems such as scuppers or vent, should be fitted with system isolation valves capable of remote operation from the 'damage control deck'. In *Guernsey* the workshop flooded unnecessarily, probably through a vent valve whose state could not be checked and which could not be shut remotely.

The general service pump in the generator room failed when the remote controls in the machinery control room flooded and shorted. Controls should be designed to ensure local control is not lost because of flooding remote controls.

Maintenance

Flooding through the unpacked cable gland into the generator room nearly converted a bad but survivable accident into the outright loss of H.M.S. *Guernsey*. It is not possible to say if this gland was left unpacked at build or at some later maintenance period but the evidence is that it had been left unpacked for some considerable time. BR 3000 Article 2808 and the Maintenance Management System (MMS) Schedule No. 1-2020-0000 Maint. Op. No. 1 (a starred item, see BR3000 Art. 0404 and App. 1) both state the requirement to air test watertight compartments and citadel boundaries. Where this is impracticable, e.g. where the vent system is not designed to be isolated at No. 1 deck, this requirement has not been met. Action has been initiated to amend the wording of BR3000 and MMS Schedule No. 1-2020-0000 to include a thorough survey of boundaries which cannot be air or vacuum tested.

In the meantime ships are encouraged to survey *all* watertight boundaries or to include full or partial surveys in defect lists.

Information Provided to Ship

Information on the likely responses of ship and systems to damage and flooding forms the main and most vital connection between design on the one hand, and training and ships' standing orders on the other. MOD policy has previously been for R.N. ships with a combattant role to be provided with NBCD Class Books, and these books are the main source of information to such vessels. This leaves a lot of naval auxiliaries which have wartime roles (but not combatant roles) without information on survivability, whether holed by damage in war or by peacetime collision or grounding. Three of the ships for which Section SS411 is design authority have been holed by grounding and one by collision in the three-year period June 1985 to June 1988, so that there is a calculable risk of such accidents.

In the case of H.M.S. *Guernsey*, which is typical of auxiliaries procured by design-and-build contracts, the ship had a valid Risk and Control Marking drawing but insufficient information to define the watertight boundaries. Coupled with ambiguous instructions on maintenance, this allowed watertight integrity to be degraded and it left ship's staff unaware that 2 Deck was non-watertight and at risk of flooding from below. The crew of H.M.S. *Guernsey* discovered this the hard way and it is very much to their credit that they did eventually succeed in controlling secondary flooding through a boundary designed to be non-watertight.

Guernsey was not provided with examples of damage and flooding. The ship therefore had no knowledge of extents of flooding which were readily survivable and no knowledge of extents of flooding which either began to present a risk of loss, depending on the weather, or which would certainly lead to loss. The ship had no guidance on the likely mode of loss—whether predictably by sinking or unpredictably by capsize. *Guernsey* worried a lot about free surface during the incident of 17 April 1987, but the ship was on the verge of sinking with no risk of capsize. The ship was not provided with a Jettison Bill and had no guidance on actions in the event of grounding rather than holing while afloat.

NBCD Training and Practice

NBCD training may be considered in two parts—general training on R.N. practice, and training in the behaviour of one's own ship after flooding and in the appropriate NBCD responses. The latter must be led by information provided by MOD and in the case of the ISLAND Class (which has no NBCD Class Book) the basis for on-board training was seriously deficient.

H.M.S. *Guernsey* put a lot of effort into pumping the engine room and tunnel although both had suffered fast free flooding through shell openings of a size large enough to defeat the ship's salvage pump capacity about 30 times over. Yet Phoenix training is very clear on the need to 'leak-stop first, then pump second'. Indeed this training was used with entire success in salvaging the generator room. It might be that we need not only to train DC teams to 'leak-stop, then pump' but also how to recognize when flooding is controllable and when it is not. The author suggests, for a starter, that if water level in a compartment is observably rising then flooding rate is enough to defeat salvage pumps.

Where Do We Go From Here?

One obvious need is to provide all naval auxiliaries with information on stability and buoyancy after particular types and extents of flooding. By itself this is not enough and ships should also be provided with guidance on which flooding is readily survivable and which flooding might not be survivable. Guidance should also be provided on the most likely mode of loss—sinking or capsize—for the extents of flooding which will lead to the loss of the ship, and guidance should also be provided to enable ships to judge if sinking or capsize might occur from the circumstances prevailing after damage. These actions are in hand in MOD, but it will take time for all naval auxiliaries to be provided with the information. H.M.S. *Endurance* has received the first set of guidance; another is being prepared for the 'H' Class Ocean Survey Vessels (June 1988) and books for the ISLAND and CASTLE Classes are also intended for issue in 1988. Feedback from the Fleet and from Phoenix on the first sets of guidance will be essential to ensure that the information provided is as useful as possible.

Another obvious need is to ensure higher standards of maintenance of watertight boundaries. Action is in hand to provide all ships with watertight integrity drawings and to amend BR 3000 Article 28.08 and Maintenance Management System Schedule 1-2020-0000 to clarify the requirements for visual inspection where air or vacuum testing is not possible.

The design standards for sub-division and for systems design were touched upon earlier. These standards are specified at the initial stages of procuring a ship in accordance with guidance from the Chief Naval Architect (CNA). The requirements for survivability are clearly specified for HM ships and auxiliaries; the required extent of subdivision at decks is currently under consideration. It is possible that ship projects based on commercial designs had too much discretion to accept non-watertight decks while complying with CNA's standards for survivability.

What If?

If H.M.S. *Guernsey*'s generator room had not been part-pumped out by the time of high tide (1630 BST) then the ship would have remained firmly on the rocks. The turn of tide brought a reduction in water level over the rocks and a reversal of the tidal current which would have borne on the port side. Any cradling effect of the rocks on the hull would be lost and the vessel would progressively heel to starboard as the tide fell. It is not possible to say how far the ship would heel before either coming to rest on more rocks or falling sideways off the rocks; nor is it possible to say if more holing would occur before the next high tide. The prospects for salvage would quickly become poorer, since the high tide of 1630 BST was the last of the spring tides.

Acknowledgements

This article was prepared from information provided to the author by the Ship's Staff of H.M.S. *Guernsey* at the time of the incident. The draft also attracted the support and interest of several members of DCW's staff. In particular the author is grateful to Mr Paul Greenman and Mr Tony Friday (both PTO(C)) for their help in building up the picture of *Guernsey*'s flooded conditions by a long series of calculations.