# HMS NOTTINGHAM
## FROM WOLF ROCK TO PORTSMOUTH

BY

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ABSTRACT

The article considers the recovery of HMS *Nottingham* following her grounding in July 2002 off Lord Howe Island, from the design authority and salvage team points of view. The article commences with a brief overview of the initial incident and considers the stabilization and tow to Newcastle, Australia. De-ammunitioning, de-fuelling and heavy lift in Australia are detailed, followed by the offload in Portsmouth, the dry-docking and subsequent repair.

### Introduction

*Scope*

This article summarizes the design authority and salvage team activities undertaken to recover HMS *Nottingham* to Portsmouth following her grounding off Lord Howe Island on the 7 July 2002. The article does not consider any aspects of the grounding itself, save for noting the crew's superb damage control efforts. The article commences with the initial support to the casualty, discusses the preparations for tow, the tow to Newcastle, selection of a Heavy Lift contractor, outload in Sydney Harbour and preparations for the voyage to the UK. The article concludes with the successful offload, dry-docking and repair in Portsmouth.

*Major Organizations*

Major Warships and Salvage & Marine Operations (S&MO) are two IPTs within the Warship Support Agency (WSA). MWIPT is the design and support authority responsible for the in-service support of 3 CVS class carriers, HMS *Ocean* and 11 Type 42 destroyers.

The S&MOIPT has a wide brief covering salvage of ships, ditched aircraft and lost equipment, along with mooring, towing and heavy lift on a worldwide basis. Many other organizations were also involved and are detailed later.

*The Incident*

HMS *Nottingham* completed her fourth major upkeep period, a full refit, in late 2000. During 2002, the vessel deployed to the Far East in support of the Five Powers Defence Agreement.

On the 7 July 2002, she was operating alone en route from Cairns, Australia to Dunedin, New Zealand, and had landed a small party (including a CASEVAC) onto Lord Howe Island (LHI) by helicopter. She departed LHI, recovered the helicopter and was manoeuvring to enable helicopter stowage. *Nottingham* grounded on Wolf Rock to the East of LHI at approximately 1300 BST. The ship was powered astern from the rock and made a slow speed passage to a more sheltered anchorage off Middle Beach, LHI (FIG.1). The ship had extensive forward flooding and the Forward Engine Room was also flooded via a Stabilizer Shaft. The MEO (LIEUTENANT COMMANDER Ian GROOM RN) described the grounding and ship's staff actions at Reference 1.

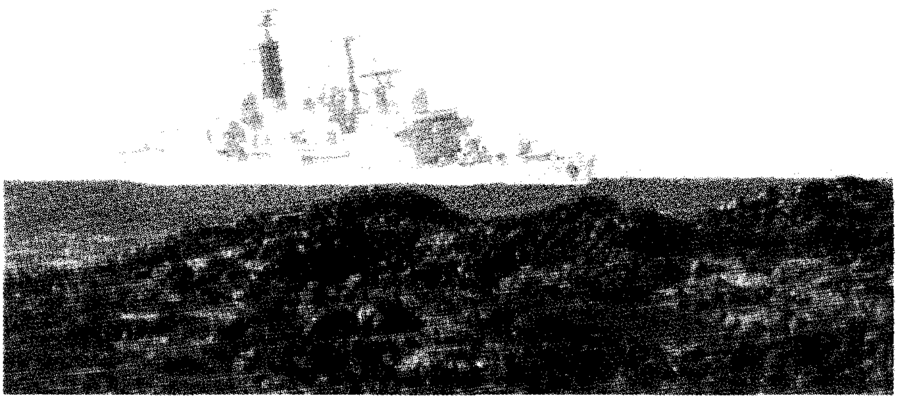


FIG.1 HMS NOTTINGHAM AT LORD HOWE ISLAND

## Initial Responses

*Supporting a Casualty*

Following the ship's casualty signal, the RN's Duty Fleet Controller contacted the WSA's Duty Technical Officer and CSALMO, following established practice. The WSA Duty Technical Officer rang Nigel HILLS (of the MWIPT) at about 1300 and passed an alert message. The MWIPT team leader (CAPTAIN Bob LOVE) and Chris DICKS were subsequently alerted and met at MoD Abbey Wood. Chris readied himself to undertake supporting stability analysis if required.

The Chief Salvage And Mooring Officer (CSALMO) met Steve QUINN at S&MO HQ and agreed that Steve should deploy to the casualty with an initial Salvage Response Team and alert salvage resources for future deployment as required

On arrival at Abbey Wood Chris and Nigel amended a general arrangement drawing to reflect the reported damage. The magnitude of flooding was of great concern, but was mostly at the bow, an area of good damage stability performance for the vessel. Of particular concern was the fact that that the Forward Engine Room was making water fast and a high flood level was quoted.

Within half an hour the first of four stability conditions was analysed. This was based on the worst possible liquid loading state,* the worst (least stable) distribution of flooding in those areas reported as uncertain and the reported flooding.

The initial case was much more pessimistic than the subsequent cases analysed as more information became available. All analyses showed that the vessel possessed a very healthy GZ curve, providing the flooding and structural situation remained as reported. However the Forward Engine Room (FER) bulkhead strength under hydrostatic load was only just adequate, as was the ability to maintain 2 Deck as the vertical boundary at all damaged locations.

The situation required a different school of thought from that of naval design authority business. We were no longer interested in analysis to identify the minimum possible failure point (based on pessimistic assumptions). We wanted exact points of failure, which current engineering tools and rules do not cater for, as there were severe potential penalties for overly pessimistic advice as well as for optimistic advice.

During the initial proceedings Fleet Operation Maintenance Officer announced that the vessel's MEO wanted to speak to Chris at which point the lack of an operational telephone or radio connection through to the vessel was discovered. By alternate routes we contacted the island administrator. He was able to pass to the MEO a request for further condition information. This was duly supplied and used to populate the fourth stability analysis. This showed even more clearly that the vessel possessed good stability, albeit with dramatically changed trim and reduced freeboard. As a result emphasis then shifted to the potential for loss of the vessel due to loss of structural strength and subsequent spread of flooding as well as the problems posed by a flooded SEA DART missile magazine.

Various elements of the MoD response were forming up and communicating with each other. CAPTAIN LOVE was in constant communication with CSALMO. It was decided that Chris would join Steve's Salvage team of 3 people on route to LHI, along with a Defence Munitions representative. Nigel would provide the UK based Naval Architecture focal point.

MWIPT assumed 24 hour watch keeping in an incident room with additional support from specialist areas such as the Defence Ordnance Safety Group and S&MO. A multitude of management briefings took place. The Military Coordination Authority (MCA) was set up at CINCFLEET and efforts turned to forming up dedicated action plans. At about 0400 the MEO rang Nigel and gave the first comprehensive damage report. It reinforced the incredible damage control effort that the ship's company had made.

RAN Divers from the RAN Clearance Diving Team 1 (AUSCDT1) had flown immediately to LHI. The MEO reported that the divers had managed to get a rope seal around the starboard forward stabilizer (the flood path into the Forward Engine Room) and he wanted to pump out. Nigel and the MEO agreed there was little chance of the bow sinking deeper (the damage control teams were struggling to contain flooding through loose deck cable glands) but agreed to counter flood watertight compartments further aft. A first underwater SITREP from the RAN divers was also passed. The scale of damage made it clear that the vessel would have to remain flooded at least until alongside a safe port or until any heavy lift or dry docking operation.

Ship's staff were working hard to restore systems. The major concern at this stage was munitions safety as the SEA DART and 4.5" Magazines were both flooded. It

* As the actual state was not available from the initial incident reports.

was imperative that the SEA DARTs remained wet, as the boost motors become unstable if subsequently allowed to dry out. Efforts were immediately made to establish a method of safe removal of the missiles, drawing on the experiences of the HMS *Southampton* collision in 1988.[2]

### Stabilization and Recovery

As parties became satisfied that the initial situation had stabilized, attention gradually turned to the recovery from LHI, which had no sheltered or repair facilities. The tow would involve a tow across 380nm of Open Ocean in the Austral winter. Uncertainty as to the residual bow strength later led to a decision to tow the vessel astern from the quarterdeck and a ban on rafting operations.

The tow would require:

- Safety cases.
- Structural reinforcement.
- Installation of towing brackets.
- Most of all formal permission to come alongside in mainland Australia and remove ammunition from flooded magazines.

On arrival at the vessel on the 9th, the salvage team was shown plate distortion in the weather deck plate, starboard side, by the forward breakwater from the centerline to the deck edge. This was of concern as this was also a longitudinal location of major keel damage. When opportunity was later available for structural reinforcements, Chris and the S&MO fabricator took the decision to weld two 10m long I beams onto the weather deck, one each side of the fwd breakwater, over three watertight zones. The final weight of each beam was 820 kg, limited by the civilian helicopter's lifting capacity. The beams would arrive later on the MV *Island Trader*, the Island's supply ship. Throughout the island based operations, the most limiting leg of the logistic chain was the final, Island to vessel, leg, particularly after the LYNX became unserviceable and the salvage effort became reliant on a civilian helicopter chartered by the Salvage team.

The S&MO team were developing the bigger picture, with Steve as the officer in command of the local salvage operation. Plans were developed for the number and type of tugs required (3) and the transport of the wider salvage team (later to number 18). Salvage resource requirements, such as contract welders, submersible pumps, plasma cutters and welding equipment were developed and passed to Inchcape to action. Timber for 60 additional shores and also to replenish ship's damage control stores was ordered. The incident reinforced the requirement for large damage control timber holdings.

Strategic and tactical transport plans were developed and enacted, including:

- Commercial airfreight.
- Helicopter.
- Light aircraft.
- Supply ship.
- Locally obtained boat transportation.

The following spaces were flooded at this stage:

3A, 5B, 5C, 5D, 5E, 5F, 5G.

At this stage the vessel had wooden shoring in the following spaces:

2A, 3B, 3C, 3D, 3E1, 3E2, 3F, 3G, 4H.

The ship had used all the timber available. Many spaces still had leaks, either from cable glands or from fixed firefighting nozzles built into the hatches. Some of these were cement boxed during the initial recovery but larger cement boxes would eventually replace almost all and many would never seal fully. 2 Deck was a mass of hoses and fire main extensions to support the numerous eductors operating.

Two underwater videos had been prepared by AUSCDT1 (Fig.2).

FIG.2 - AUSCDT1 INSPECT THE STEM

These formed the basis of the report Chris sent to Nigel, recreated as (FIG.3) and below:

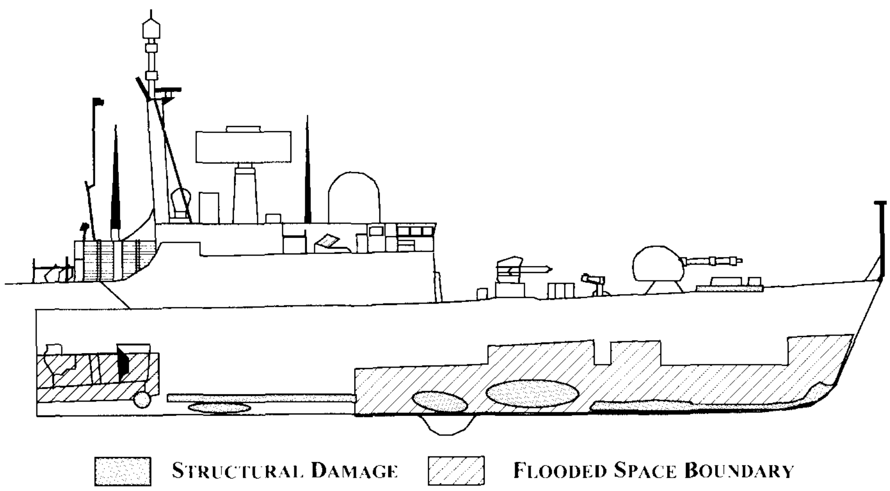



FIG.3 - EXTENT OF COLLISION DAMAGE

- Almost complete loss of the bow structure below the 6 foot draught mark, for the first 7 metres of the vessel from the bow. In this area much of the structure was unrecognizable.
- Extensive damage to the keel and surrounding structure on the starboard side in Zones C and D.
- Possible loss of solid ballast in Zones B and C indicated by disturbed ballast blocks at the mouth of the damaged plate.
- A major penetration into the SEA DART Spray Compartment.
- Limited distortion to the keel in Zones E-G.
- Many plate perforations, tears and major plate deformation in Zones E-G.
- Complete removal of the forward half of the Sonar Dome. Many Hydrophones were hanging.
- Aft of the Dome the keel was completely untouched but with damage to the turn of bilge.
- The Bilge Keel was heavily distorted and it was uncertain whether there was a leak into adjacent compensated tanks.
- The leaking, distorted and damaged stabilizer.

**Support from the UK and Mainland Australia**

UK support to the operations settled into a routine with a continuous flow of information being co-ordinated, disseminated and actioned. The main areas of contact were between MWIPT, S&MOIPT, the MCA, FLEET Logistics and various munitions experts. The scale and variation of the different detail was bewildering. The co-ordination of supply of Munitions Handling Equipment and Containers was particularly involved. Snippets of useful information filtered through, for example,

"Make sure you can confirm your kit is Foot and Mouth free?"

and,

"Can it be readily disinfected on arrival in Australia?"

Planning identified which military equipment would need to be removed from *Nottingham* and returned to the UK.

Most importantly, we had to develop a robust justification that *Nottingham* was safe to move, that all risks to the environment had adequate mitigation, and, that we had all the assets available for the de-ammunitioning. This safety case approach was developed to meet our own procedural requirements but also supported the presentation to the appropriate Australian authorities. The Australian authorities were very comprehensive in their appraisal but adopted a positive approach throughout and could not have been more helpful.

WSA's Director of Operations – Platforms led a preparatory team to Australia. This led to a remote berth in the Port of Newcastle being made available, after thorough consideration was given to several destinations along the coasts of New South Wales and Victoria, all of which had major risks in one or more safety or seamanship areas. A major effort from the S&MO commercial team in Australia led to an indemnity agreement which covered the potential munitions safety implications and also the financial and technical implications of postponing the demolition of the disused works immediately adjacent to the berth. Ministerial briefing was undertaken jointly by the WSA secretariat and CINCFLEET.

With a destination, plans for leaving LHI could be fully developed with final permission to come alongside and de-ammunition being received two days before the tow was scheduled to depart.

**Preparations for the Tow**

On board the vessel, each day commenced with a meeting between the ships' staff and the salvage team. This meeting was used to describe overnight developments as the time difference meant that the UK's thoughts dramatically changed during the Australian night.

Initially the vessel's Fresh Water was not potable, due to Dieso contamination. Chilled water had been restored to Hotel section. The aft fuel separator was able to polish fuel and uncontaminated fuel could be obtained from two tanks. The gearboxes required salt water purging but no shaft distortion had been noticed so the Aft Engine Room's Gas Turbines could be used to provide short-term propulsion if required.

HMNZShips *Te Mana*, and *Endeavour*, supported the local operation until the tugs arrived on the scene. The two RNZN vessels and the vast support provided by the RAN and RAAF, were initially tasked to protect life at sea. However both countries easily exceeded their obligations. They sailed for home upon the arrival of the MV *Pacific Chieftain*, the main rescue capable tug. A RNZN Rigid Inflatable Boat was left for use by the salvage team.

The superb reaction of the RNZN and RAN left us contemplating the implications if the incident had occurred in a region where such support was not available. A RN team conducted an incident investigation on board *Endeavour*.

*Naval Architecture issues*

*Nottingham*'s Certificate of Safety-Structural Strength had been suspended by the Sea Technology Group (STG), the MoD's Naval Authority.

Due to the uncertain residual strength, care was taken not to structurally load the bow in any unnecessary way. For example, the anchor cable was backed up to the 4.5 inch gun turret to relieve the strain on the usual chain arrangement of windlass and slips.

Given the bow damage, the salvage team wished to tow *Nottingham* astern. STG rapidly commissioned towing tank experiments at QinetiQ Haslar to correlate the analytical towing assessment. These indicated that *Nottingham* could be towed astern with acceptable directional stability, and the combination of analytical and experimental work also gave information on load/speed/sea state combinations.

The information being generated in the UK was compared with that received from Chris and Steve at the scene. A stern tow was complicated, but could be achieved with minimal risk to the hull girder. STG had also advised on an estimate of the total loading on the hull girder, this having increased because of the large amount of floodwater forward, and the strength reduced because of the tears in the plating on the starboard side. We took a pessimistic view as to what the damage may be, and provided information as to where steel reinforced shoring should be installed in place of wooden shoring.

Further damage stability scenarios for the tow evolution were studied to establish whether the vessel would be in danger of plunging or capsizing under tow due to collapsing bulkheads. We investigated the circumstances under which we might consider abandoning the tow. This information was included in the safety plan, and provided to Chris who briefed the MEO on site.

As the Design Authority, CAPTAIN LOVE and Nigel were soon in a position to sign the Naval Architecture Safety Case along with a covering letter of approval from the MoD's Chief Naval Architect.

*Munitions Safety and Pollution*

Pollution from the vessel had been very limited during the grounding. The main fuel tanks were all apparently intact with no evidence of further spillage. This was an area of great concern to the Australians and us. Precautions were taken to ensure that we could move the ship without risk of additional spillage. Mainland Port Authorities witnessed all fuel and sullage transfer operations.

An issue raised was the possibility of flood water contaminated with medical supplies penetrating cable penetrations in 3F Deck. The Medical store in 4F had prior to the incident contained $NO_x$ and $O_2$ cylinders as well as chemicals capable of forming noxious substances when exposed to water.

The SEA DART missile removal and disposal exercised everyone. The idea of using the ship's hydraulic ring main to achieve a local disposal using the SEA DART magazine hoist system was considered most favourable given the difficulties of all other 'forced removal' approaches. But this was dependent on whether the missiles were intact. It was proven using several independent methods including underwater visual survey that there was a crack in a magazine structural weld. All the missiles were found to be in place with no contamination noted but there was evidence of electrolytic effects on the aluminium screws. The option of removing the SEA DARTs at LHI was swiftly discounted, both in the UK and on LHI. For the duration of the tow preparations, and the tow itself, the damaged magazines remained flooded.

*Shoring Plan development*

A shoring plan was developed but could not be immediately implemented as timber stores had been exhausted during the incident. When fresh timber arrived 60 additional 2.8m long shores were added in 4 watertight zones. The shoring was concentrated in areas considered most likely to suffer local structural collapse of deck or bulkhead grillages and the shoring plan was informed by the analytical work undertaken on our behalf by STG.

3F's shoring was designed to fix the deck and bulkhead stiffeners in place using welded steel I beam shores. The design that evolved also had to consider the difficulties of fabricating a structure in a seaway such as the risk of flooding a dry compartment by accidentally burning through plating. The final design only allowed welding onto stiffeners or plating that did not form part of the flood-boundary

Seven Steel shores (FIG.4) were later introduced consisting of I beams laid longitudinally onto the deck, over a potentially damaged under-deck stiffener. Each beam was stiffened by two vertical steel pillars welded to the deckhead stiffening and angle connecting beams. Four pillars were connected to the forward bulkhead stiffening. Additional transverse beams linked the four shores and the forward bulkhead stiffeners to allow the shoring of bulkhead plate by wooden wedges.

The salvage team considered similarly shoring 3D and 3G. The deck screed and major equipment rendered this impractical and judicious wooden shoring was used.

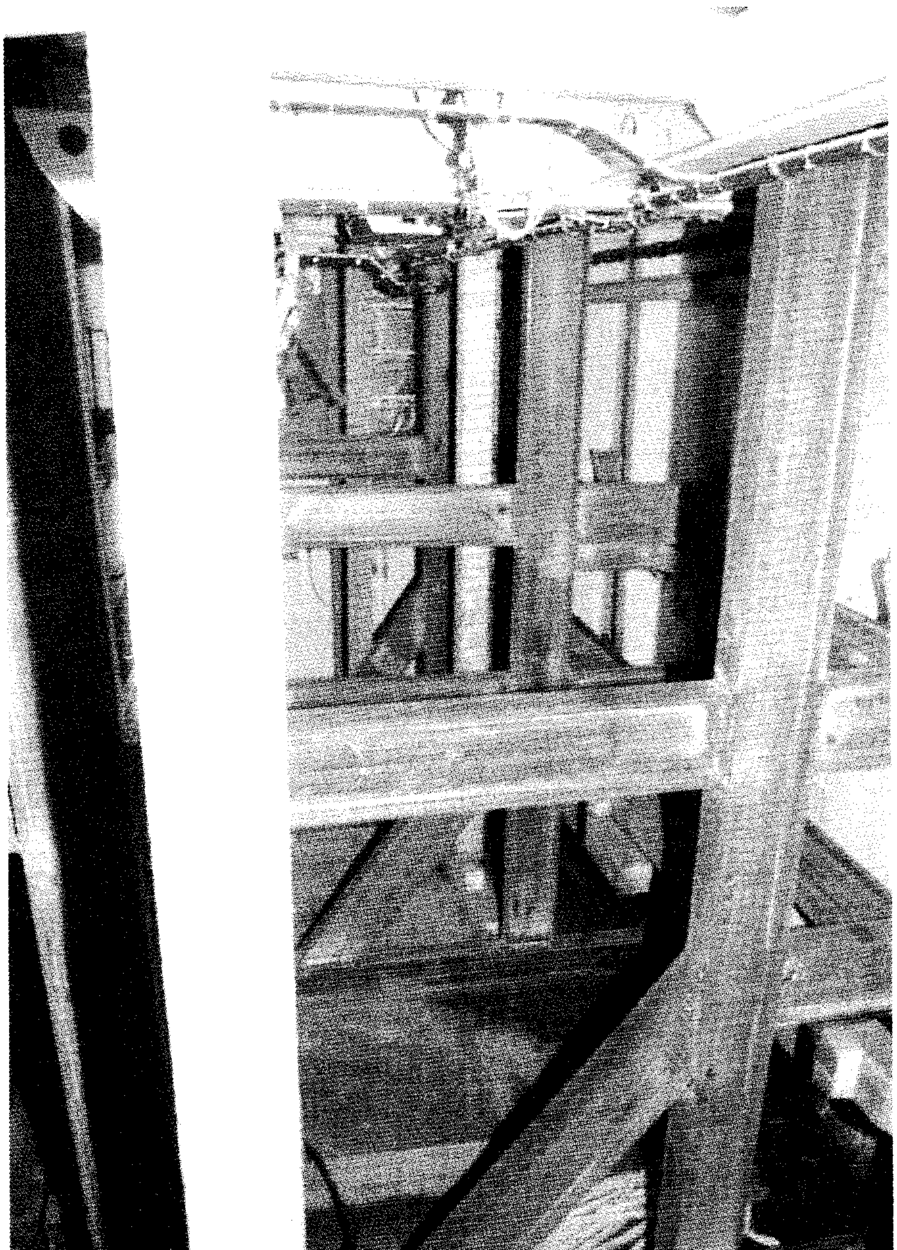


FIG.4 3F STEEL SHORES

*Preparing for the Tow*

The prospect of an aft tow required the consideration of the hangar watertight integrity. There was a risk that the hangar door would not withstand green seas during the tow, with consequential water accumulation in the hangar. A rigid hangar door was designed and later fitted. A flight deck breakwater was designed, to be installed at the last possible minute prior to the commencement of the tow to allow flight operations to continue unaffected as long as practicable. The availability of the flight deck was a significant factor in several of the safety contingencies. Stability analysis considered the impact of 2.5 metres of water in the hangar and freeing ports were fitted.

The salvage team agreed locations for pre-deployed submersible pumps and emergency Diesel Generators. This required an assessment of the priority for pumps, noting the effects on stability of losing further compartments. Suitable areas of weatherdeck were established for mounting 30 Tonnes of salvage equipment during the tow.

The daily S&MO/Ship staff meetings were very focused at this stage on the following topics:

- Command and Control during the tow. Development of contingency plans for further emergencies.
- Management of salvage equipment delivery, via the RAAF's HERCULES fleet or the MV *Island Trader*.
- Management of the forthcoming fabrication task.
- Development of the towing plan and safety case.
- Reducing the tow party to an acceptable minimum (35 RN and 18 S&MO personnel).
- Arranging the departure of the residual RN complement, to reduce the logistics associated with 230 personnel, while ensuring that sufficient manpower was available to complete the preparations.
- Development of sullage removal and refuelling plans using the *Pacific Chieftain*.

The towing plan evolved in response to the availability of equipment and tugs. A port side towing clench was intended for the quarterdeck, along with the standard fit Starboard towing clench, to allow a bridle tow rig. The Sonar 2070 towed array decoy bedplate was cannibalized for this purpose (FIG.5). A Panama fairlead was removed from forward of the bridge, fleeted down the vessel, and welded into position on the aft end of the quarterdeck for the port tow cable. Substantial additional stiffening was designed to assist load transmission into the deck structure.

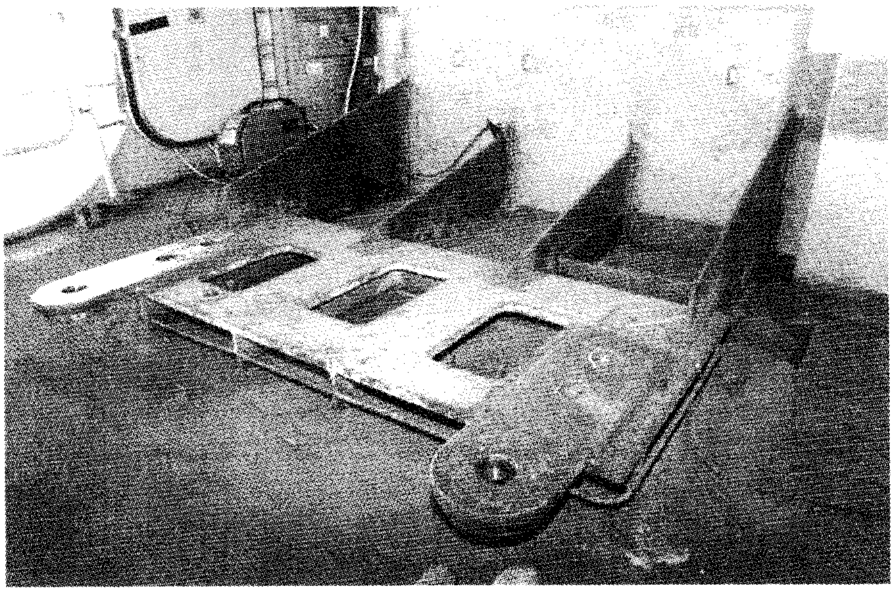


FIG.5 PORT TOWING CLENCH

The towing arrangement was based on a 35 Tonne predicted load in Sea State 6. The port side of the main towing bridle had a second bridle and fishplate to avoid the quarterdeck bollard and was connected to the Sonar 2070 bedplate via two shackles and in-situ fabricated towing arms. A load cell was installed. The tow safety case was predicated on a tow in conditions of up to Sea State 4 at about 5 knots.

A survey of down-flooding points was undertaken. All aft located valves would later be shut, all covers dogged into position, with the dogs tack welded. All quarter deck vents and the citadel pressure release valve would later have covers fabricated and welded in place.

The first tug to arrive was the *Austral Salvor* from Brisbane. The second tug to arrive was the *Pacific Chieftain*, from New Plymouth. The *Chieftain*'s role was pivotal as she had a large working deck, spare fuel, sullage capability and rescue facilities. Her presence also allowed lightering operations to commence. The more manoeuvrable *Austral Salvor*'s duties were to maintain readiness to move *Nottingham* away from the shore, if the anchor dragged. During the tow to Newcastle she was designated the escort tug, able to react rapidly to any changes.

*Countdown to the Tow*

By 19 July most of the steel had arrived along with the salvage equipment. Equipment was shuttled across by the commercial helicopter. Fabrication of steel shoring started. 8 contract welders joined the salvage team welders. Fabrication started on a 6 hour on and off watch basis.

By 24 July, steelwork was well underway with 3F's steel shores complete along with the majority of the two main deck beams fully welded in place. Towing equipment modifications were started. On the 25th the hangar door structure was started. On the 31st the hangar welding, the final major fabrication was completed. Simultaneously the towing equipment was rigged.

By the 3rd August the steering tug (*Yam-O*) had arrived and the *Nottingham* was ready in all respects for departure. The berth infrastructure had been established at Newcastle. All that was required was a weather window.

**Tow to Newcastle, NSW**

The weather dictated that the tow would start on the 6th August with landfall on the 9th (FIG.6). The operation began when the *Pacific Chieftain* began to recover *Nottingham*'s anchor cable, which had been deliberately slipped. As this occurred, the *Nottingham* was held by the *Yam O* at the bow and the *Austral Salvor* at the stern. After the *Pacific Chieftain* had recovered the chain she connected up to the primary tow position and *Austral Salvor* took up her escort role.

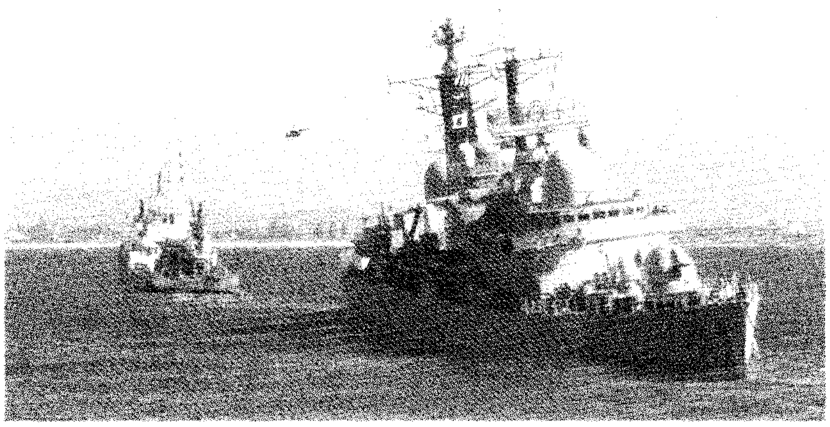


FIG.6 - ENTERING NEWCASTLE NSW

The *Nottingham* towed as predicted, with no directional instability, with an average of 5.5 knots through the water. The quarterdeck was goffered on many occasions but the flight deck was dry, in abnormally calm conditions.

**De-Ammunitioning**

*Preparation of the berth*

The berth at Newcastle was on the site of a disused steel works that was scheduled for demolition at the same time we were supposed to be there. The MoD rented and indemnified the site for 6 weeks and infrastructure was established.

The importance of an effective shipping agent and reliable sub-contractors was emphasised during the subsequent work. Under the direction of James and the second S&MO team, the berth was equipped with generating capacity and domestic infrastructure (including roads). A munitions processing site was established with appropriate secure zones. When *Nottingham* berthed, it was at a fully functioning berth, with all equipment required to carry out a complex de-ammunitioning and de-fuelling task. Following the safe arrival, the ship's company was incrementally reduced with some returning to the UK and the remainder being accommodated at RAAF *Williamstown* to provide an onboard duty watch and day working teams.

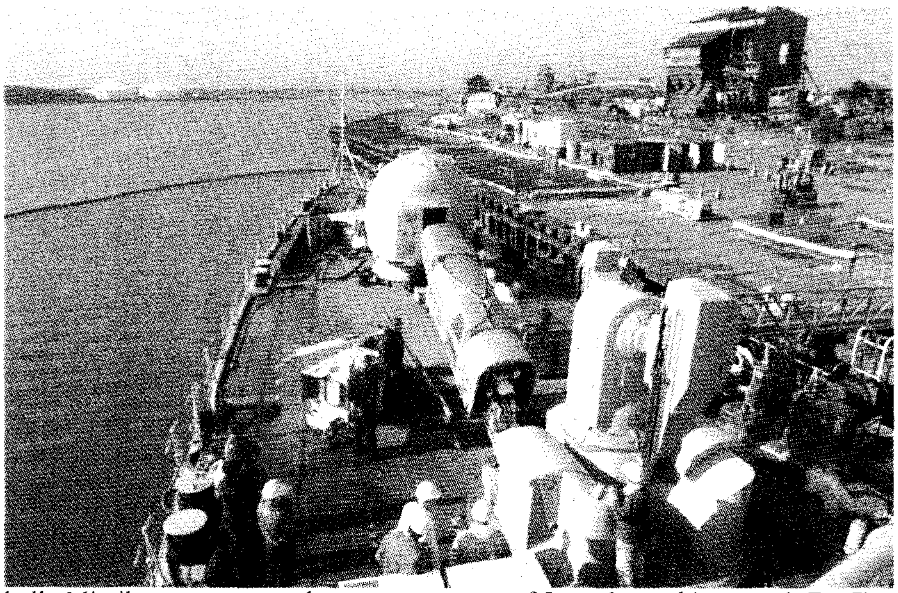
*De-Ammunitioning*

It was very important to move apace to establish a firm time line for the remainder of the recovery. COMMANDER Tony HOLBERRY (MWIPT) took scheduling authority for the ship from Steve. Operations began immediately to de-ammunition the vessel.

Munitions from intact magazines were removed conventionally into their standard containers and moved to safe storage in Australia to await transit home. The next phase was to progressively lower the Effective Net Explosive Quantity of damaged munitions in the vessel. The majority were immersed 4.5" shells. With the vessel in sheltered waters, 3D Mess deck was re-flooded to allow magazine access for divers. Royal Navy divers removed all of the ammunition by hand in a 36 hour evolution, an exceptional effort.

It was now possible to concentrate on the SEA DART missile removal. Of most concern was the means of removal of wet SEA DART missiles, by indexing (incrementally moving) the missiles around the magazine using jury rigged equipment, to the hoist positions for movement to weather deck level and into the waiting container. If missiles could be manipulated in this manner, the team could firmly plan this evolution and allow planning to solidify for successive evolutions, not least the contracting of a Heavy Lift Ship, without significant and expensive delays in using the contracted vessel.

To great relief, the indexing system was proved to work. The advantage of this cannot be overstated; it avoided cutting major access routes through the ship's



hull. Missiles were removed at an average rate of 5 per day and inspected (FIG.7).

FIG.7 SEA DART REMOVAL AND BERTH INFRASTRUCTURE

Water filled industrial dustbins moved the wetted boost motors about the site. The missiles were despatched to Singleton Army Base for controlled disposal. All munitions operations were undertaken with the oversight of the relevant Australian Explosive and Environmental specialists, within the confines of a busy commercial port with a safety exclusion zone being regularly lifted to allow passage of merchant shipping. The magazine flood water could not be pumped in to the harbour, because of the risk of environmental contamination and was therefore pumped to water bowsers for controlled disposal.

MoD specialist teams removed some equipment and the ship was de-fuelled and water ballasted to reduce environmental hazards without reducing stability. To protect propeller hubs and shafts during later heavy lift operations, the two lowest bolted propeller blades on each propeller hub were cropped to the root by divers. This also allowed a reduction in the number of pits to be cut in the heavy lift ship's deck.

**Letting a Heavy Lift Contract**

At this stage the formal decision had been made to return the vessel to the UK. The charter contract was let on a competitive basis. S&MOIPT are tasked to let charters of this nature and have extensive experience in dealing with the commercial maritime industry. MWIPT provided technical information on the state of *Nottingham* to support the Invitation To Tender (ITT) issued to industry. This information included the damaged condition of the vessel, stability information, lines plans and appendages information. In addition, MWIPT arranged for a detailed underwater survey to take place in Newcastle to try and accurately detail the local shape of the damaged hull.

There was a strong desire to complete the heavy lift evolution in Newcastle to avoid injecting additional risk into the operation by moving *Nottingham*. Additionally for this port entry permissions were already held. The limited water depth at Newcastle would be critical, and hopes were raised that a suitable draft heavy lift vessel could be selected. A bid was received from a company who were finishing refitting such a vessel, but unfortunately, following an inspection by S&MOIPT staff, the vessel was deemed not to be suitable.

Potential locations on the East Coast of Australia were examined for suitability of sheltered conditions coupled with deep water. The most suitable candidate was Sydney Harbour. This was very attractive for the heavy lift operation, but did introduce a second tow, along with the presentational issue of moving a damaged warship into the largest natural harbour in the world and a major tourist attraction. An MWIPT representative liased with local authorities to prepare the groundwork for using Sydney Harbour. Environmental issues were paramount and additional work was required to demonstrate that the condition of *Nottingham* had been improved with the removal of fuels and ammunition. The authorities asked many searching questions, but co-operation was outstanding. In short order, a lift location of Watson's Bay was identified, a temporary berth at Chowder Bay was made available, and importantly, we would be allowed to complete voyage preparations at Garden Island Naval Base at a secure berth.

S&MOIPT received several bids in response to the ITT. DOCKWISE were duly awarded a single contract to load *Nottingham* in Sydney and transport her to UK waters using MV *Swan*. DOCKWISE prepared a Transport Manual for the completion of the operation, and presented this for approval to representatives of S&MOIPT and MWIPT. S&MOIPT arranged the attendance of Warranty and On-Hire Surveyors. *Swan* completed her refit in Singapore, loaded with materials to manufacture deck cribbing and sea fastenings, and departed for Sydney (FIG.8).

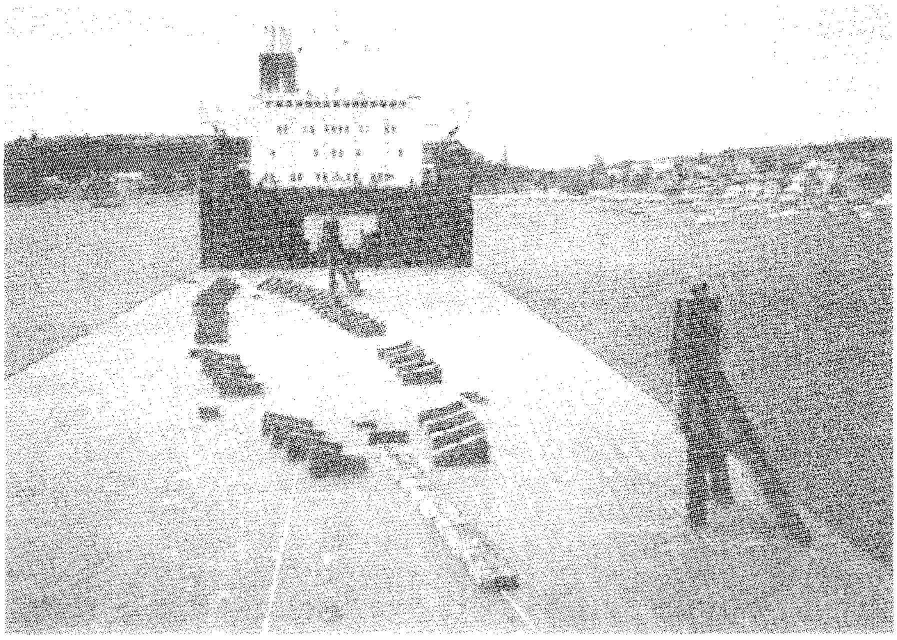


FIG.8 MV SWAN CRIBBING ARRANGEMENTS

With negotiations complete with the Sydney authorities, *Nottingham* was prepared for her move from Newcastle to Sydney Harbour. This was to be a short, coastal, tow. With all ammunition and virtually all fuel having been removed, there were fewer risks but all safety cases were reviewed. Stability was reassessed and new guidance produced. At all stages both the UK MoD and Australian Government safety authorities had a right of veto.

The departure from Newcastle was made with mixed feelings as the town had treated the ship enormously well. She was given a rousing send off on the 14 October. As events transpired, the tow was more a controlled drift in the southerly current. *Nottingham* was secured alongside Chowder Bay fuelling jetty on the north side of Sydney Harbour.

**Heavy Lift and return home**

*Heavy Lift operation*

At all stages of the Heavy Lift operation major emphasis was placed on satisfying the concerns of the local authorities particularly with respect to the environmental risk to Sydney Harbour. Pollution control equipment such as booms were widely used.

Prior to the arrival of *Swan*, the potential contamination to the Medical Store was investigated using the Salvage team's divers who drilled a hole in the ship's side and using a probe tested the atmosphere. A hazardous atmosphere was identified which was vented safely to atmosphere via a dedicated exhaust.

*Swan* arrived in Sydney on 20 October 2002, and anchored in deep water at Watson's Bay on the south side of the harbour. *Swan* underwent an On-Hire survey for charter purposes, and a Warranty Survey with respect to the technical details of the heavy lift operation, notably the cradle blocks, which would support *Nottingham* as she was lifted.

*Swan* ballasted over night on the 21 October and *Nottingham* started the move from Chowder Bay across the harbour at 0500 on the 22nd. Warps were passed and *Nottingham* was wound over the cradle by use of the *Swan*'s winches. A diver checked the relative location of the 3 remaining fin stabilisers and those recesses which had specifically been let into *Swan*'s deck for them. The diver initially reported a potential clash with the edge of one recess. There was limited freedom to move *Nottingham* fore and aft, as it was imperative that the cradle located onto the ships transverse frames. DOCKWISE's superintendent elected to gradually de-ballast *Swan* to match trims and fine tune the longitudinal position. *Nottingham* gradually moved to the correct location and final deballasting commenced. The forward port stabiliser fin was found to be extremely close to the edge of its pit in *Swan*'s deck, which had removed its Limpetite coating. This was due to an erroneous datum pack drawing.

*Nottingham* was sued at 0930, and the bow of *Swan* was de-ballasted to allow the forward port corner of her cargo deck to emerge first. This sequence was critical to ensure satisfactory levels of stability and to have a controllable water-plane throughout the operation, requiring at one stage a 7 meter trim (FIGS 9 & 10).

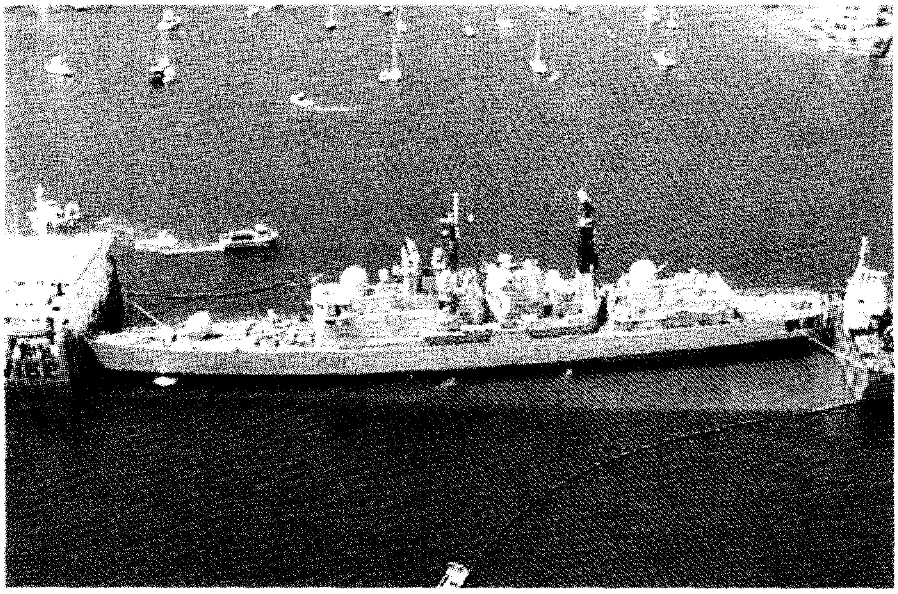


FIG.9 – HEAVY LIFT OPERATIONS IN SYDNEY HARBOUR

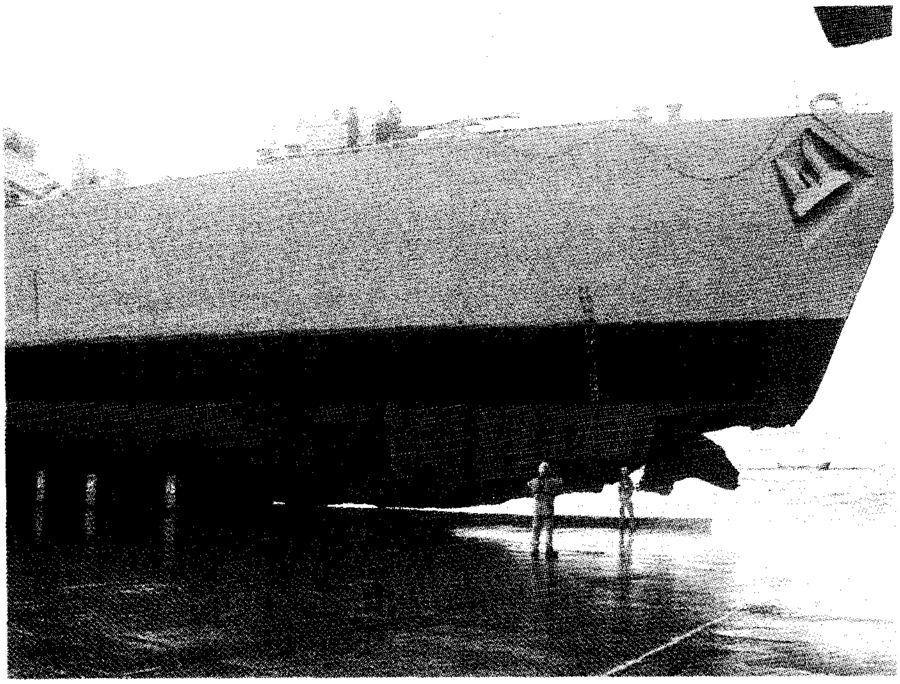


FIG.10 HMS NOTTINGHAM ON MV SWAN

The cargo deck was dry at about 1400 and the full extent of the underwater damage to *Nottingham* became apparent. The damage to the bow structure, whilst most spectacular was not that which caused the most concern (FIG.11).

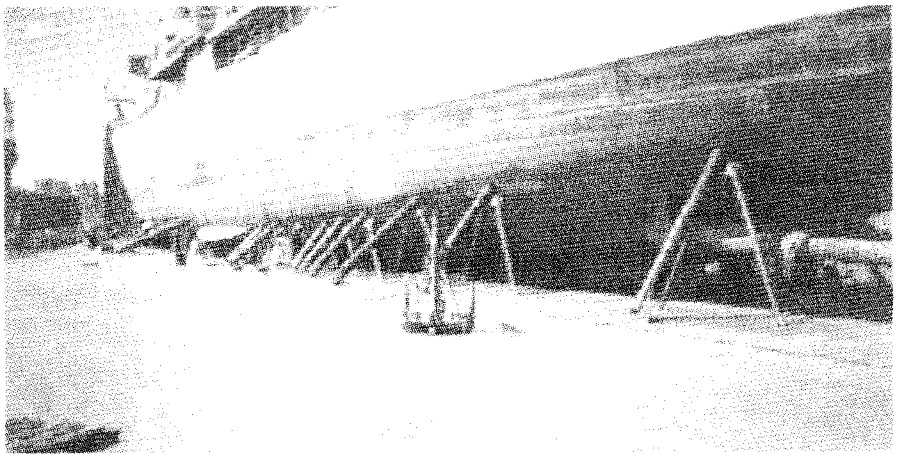


FIG.11 CLOSE UP OF SEA FASTENINGS

A more serious issue was the degree of buckled and split plating further aft. The Salvage Team would later seal several compartments to improve the offload trim. This would be critical for the ultimate safe dry-docking of the vessel in a graving dock.

Preparations were completed to effect compartment re-entry and to start the recovery of various flooded materials. The pharmaceutical contents of the medical store were successfully recovered and were carefully sealed into thick plastic bags for controlled disposal ashore. Because of the potential hazards a RAN doctor was on board for this evolution.

*Passage preparations*

*Swan* completed de-ballasting at 0100 on the 23rd and steamed to Garden Island Naval Base. A RAN Shore Services Team provided craneage to ship Quarantine Containers onto *Nottingham*'s forecastle.

The planned return route was via the Panama Canal, and thus the potential forces on the vessels had been established from the sea states likely to be encountered. The Transport Manual dictated that 19 pairs of angled sea fastenings would be required, along with a stern support frame. MWIPT also asked for additional supports at the bow. DOCKWISE devised a system of 3 pairs of vertical pillars supported off wedged hard points on the *Swan*'s cargo deck. *Nottingham* would be firmly supported but the arrangements were such that she would not be additionally loaded by any hogging or sagging of the *Swan*'s deck.

DOCKWISE advised a programme of 3-5 days for the Australian Defence Industries to complete the sea fastening work. This required considerable welding on the *Swan*'s cargo deck adjacent to both sides of *Nottingham*. Simultaneously, it was essential that the ship was cleansed and prepared for sea. Sea fastening preparations started aft, leaving the forward end free for compartment cleaning. The Salvage Team rigged ventilation and pumping systems so wastewater could be removed for disposal. The main concern was release of Hydrogen Sulphide as the contents of flooded compartments were disturbed. Once compartments had been cleared for safe entry, the cleansing team set to work with power washers. This was an example of how additional 'come in handy' stores carried by the vessel hindered the salvage effort. Conversely, in other areas such as timber, the additional stocks had greatly assisted the salvage effort.

The decision to repair the vessel led to the requirement to run a competitive repair contract. Access was given to survey teams from the three competing UK repair organisations. These needed to accurately assess the extent of damage to hull and systems for bidding purposes, should the decision be taken to repair *Nottingham*. A further scheduling conflict was the requirement to accurately map the damaged hull girder and plating. Babcock's Design and Technology Ltd were contracted separately to complete a laser scan of the hull plating. These, coupled with the steelwork fabrication of the sea fastenings dictated that it was a very congested main cargo deck for several days.

At 0230 on 29 October the *Swan* departed from Sydney Harbour with *Nottingham* on board.

**Arrival in the UK – Offload and Docking**

*Offload preparations*

*Nottingham* was to be delivered to the UK and unloaded from *Swan* in such a condition that she could be successfully docked down in a conventional dry dock, with limited modifications. Several factors were considered during the planning and all required flexibility until *Swan* arrived in UK waters. S&MOIPT reviewed the geography of the potential delivery locations and started comprehensively planning three offload options, one for each potential contractor's dockyard. Each would be challenging, because of the likely environmental conditions in the British winter. Two options would have required a short tow into the dockyard. One would have required a coastal tow of up to a day. Contingency planning was also required for different methods of adjusting the offload condition's bow trim into a stern trim for a conventional dry docking. Options considered included:-

- Deliberately flooding the tiller flat and aft deep magazines.
- Addition of weight to flight/hangar decks.
- Filling damaged Bow spaces with internal buoyancy bags.
- External buoyancy bags at the Bow.
- Internal ballast addition and removal.
- Internal and External water bags.
- Removal of ballast water from dieso tanks.

Each had difficulties but due to local strength and spatial concerns, more than one solution would need to be adopted. In particular flight deck ballast and bow buoyancy bags would be required, the exact amounts depending on actual trim and dock declivity. Options involving deliberate flooding of undamaged compartments were discounted to avoid future repair costs.

On 3 December Defence Ministers formally announced to parliament the decision to repair *Nottingham* and that FSL at Portsmouth was the chosen contractor. Arrangements were formalized for the entry of the *Swan* and *Nottingham* into HMNB Portsmouth, removal of sea fastenings, the offload in the Solent and the subsequent tow of the *Nottingham* into a Dry Dock.

A 14 strong detachment of *Nottingham*'s complement was aboard the *Swan* during the passage to provide security and maintain systems during the passage. They had also made minor changes to the tank state. This, in conjunction with the temporary repairs made to watertight compartments made in Sydney led to a subtly different offload condition. The Naval Architecture and port entry safety cases were developed prior to arrival in Portsmouth. Again revised stability guidance was prepared, covering the range of conditions from all repairs being effective to all being ineffective with the impact of new flooding incidents assessed.

*Offload*

Because of the prevailing conditions in December, the offload safety case required that once sea fastenings were removed, the *Swan* was to be at sea for the minimum possible time, with strict tide, sea state and wind limitations. As a result the offload was planned to include a period alongside in Portsmouth, both to prepare the ship for safe offload and also as a sheltered berth.

*Swan* arrived at Victory Jetty, Portsmouth on a grey and cold afternoon on the 8 December. DOCKWISE arranged for the removal of Sea Fastenings by FSL. DOCKWISE would give 24 hours notice that they would be ready to offload, so S&MOIPT and MWIPT set to work clearing fittings from the 4.5" Magazine and Chain Locker ready for the installation and inflation of 25 $m^3$ of buoyancy bags prior to offload. Local leak stopping was also attempted. The weather window for the offload became all important as the offload location, Stokes Bay, is weather dependant. It was crucial that *Swan* was ballasted so that *Nottingham* floated off without the cropped propellers touching the cargo deck as this would have risked distorting *Nottingham*'s shafts. Similarly there was to be minimal relative movement between *Nottingham* and *Swan* to avoid uncontrolled contact. Following delays for weather, the offload started over-night on the 12th, with *Nottingham* finally floating free at 0800 on the 13th.

She moved under harbour tug tow into the main basin at Portsmouth dockyard and then into D Lock ready for docking on 15 December. FSL completed rigging 14 external buoyancy bags of up to 10 $m^3$ size around the bow on the 16th. 80t of Weights were added to the flight deck, and the docking proper started on the 18th December, with *Nottingham* suing just after mid-day (FIG.12).

FIG.12 DRY DOCKING IN PORTSMOUTH

### Repair period

The repair period began on 6 January 2003 and *Nottingham* was successfully undocked on the 7 July 2003 (FIG.13). The sluice gates were opened almost exactly a year to the hour after she hit Wolf Rock. Work is proceeding to the overall plan and the ship is expected to return to service in late 2004.

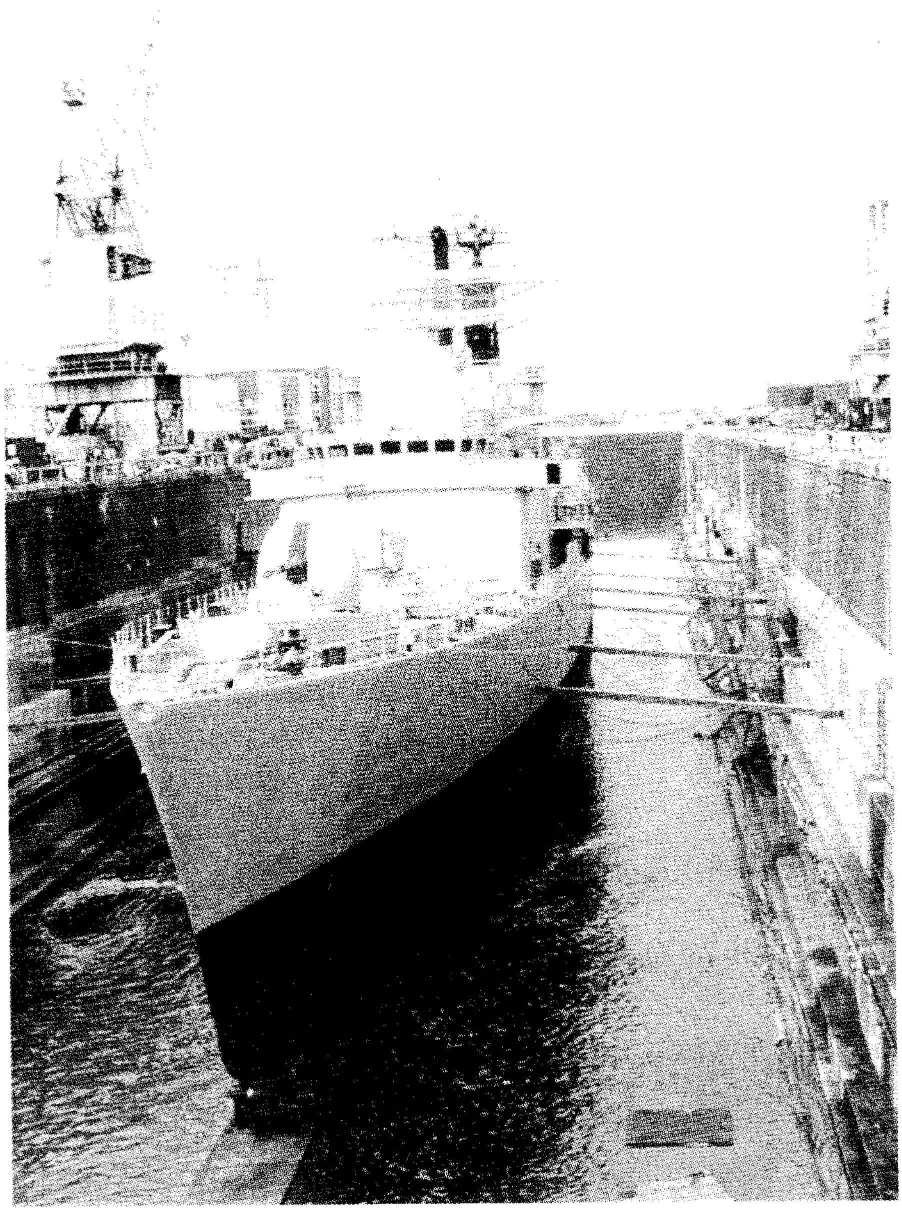


FIG.13 UNDOCKING ON 7 JULY 2003

The repair period has been undertaken in two stages, the first mainly concerned with repairing the structural (FIG.14) and major systems damage while in the Dry-dock. This has been achieved by fabrication of replacement structural modules, based on original drawings, for the major areas of structural damage. All major systems were inserted into these modules prior to undocking. A replacement forward port stabilizer mounting was installed in place of that wrecked during the grounding, using both stock items and major new construction. The sonar system and dome have been completely replaced. Solid ballast lost during the initial grounding has been replaced.

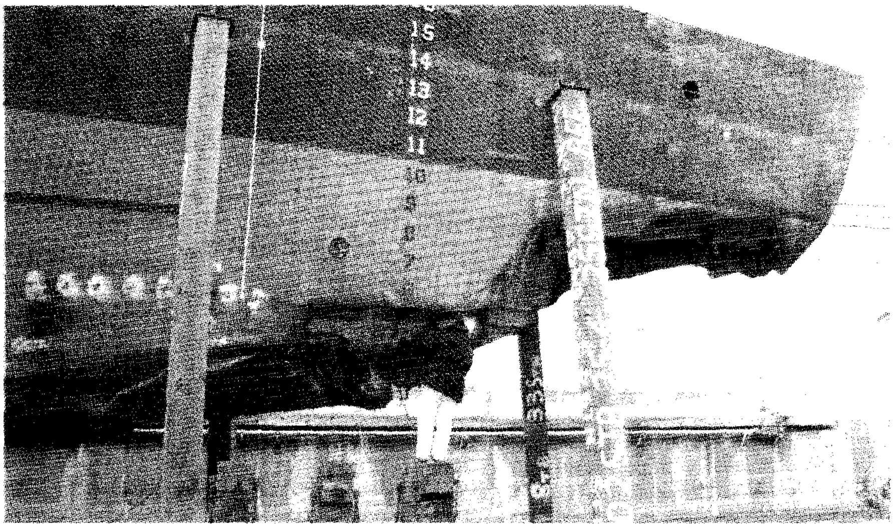


FIG.14 REPAIR IN PORTSMOUTH

The second, afloat, stage of the repair period is concentrating on the re-commissioning of the myriad of systems and cables that were affected or damaged by the grounding. A lesson learnt from the HMS *Southampton* incident in 1998 was to expect major salt water capillary action in cables well away from the damaged area and the replacement of cable has been planned accordingly.

Limited planned modifications and a full structural safety certificate hull survey and repair programme have been undertaken to allow deferral of the next planned docking period. At present *Nottingham* is programmed to remain in service until relieved by the Type 45 class.

## Conclusions

The main conclusion of the incident and subsequent recovery was reinforcement of the requirement for clear lines of communication and defined responsibility. Several of the most important signals issued were those formally handing over tactical command of the situation at the interface between the different recovery phases. With an organization as complex and diverse, with so many specialists, as the MoD, clear communications were paramount.

The salvage effort required all of the MWIPT and S&MO IPT personnel resources and fully justified the level of duplication in capabilities. At any one stage the teams in the UK and Australia contained duplicate specialists, able to manage the local situation as well as manage the corporate concerns in the UK. The managerial independence of the S&MO IPT and MW IPT generally meant that as both reported the same concerns, the corporate MoD more easily accepted the implications, for example the technical requirement to undertake operations in locations with potential adverse publicity.

The entire recovery operation depended upon the close co-operation of a multitude of teams and workstreams. The importance of having a defendable safety case for all the evolutions became very apparent, not only for ensuring the safe conduct of the operation, but also as a valuable aid to satisfying third party stakeholders as to the viability and validity of the tasks that were being undertaken.

The supply and exchange of information was absolutely crucial, and full benefit was taken of all modern means of communication, including Mobile Satellite Phones, Faxes , E-mail, digital imagery and video conferencing. A useful lesson identified was to have as much information prepared in an electronic format for ease of transmission and manipulation. However with the remote location of LHI and the ship motion, even the most modern of methods were not always reliable.

A great contributory factor to the recovery's modus operandi was the fact that we were in another country's waters, one that was keen to help but was rightly cautious of the potential environmental impact. The host nation had the right to ask any question, and the right to expect an answer that allayed their concerns.

From the project management viewpoint, clear and detailed planning with a robust timeline was all important. The nature of the recovery operation was that there was always potential for uncertainty over various aspects, despite the comprehensive project plans, which as a result had to remain live and flexible. By having a detailed project plan, any change due to an unexpected event was manageable, and all stakeholders were immediately aware of the implications.

**Acknowledgements**

The views expressed in this article are based on the author's direct experiences during the *Nottingham* incident. The article focuses directly on aspects of the salvage, tow, heavy lift and docking in which they were involved.

Ship Staff's immense contribution to the successful salvage and recovery should be recognized. Recognition should be made by the contributions made by other areas of the WSA, CINCFLEET, STG, DOSG and Defence Munitions. Several European contractors including BAE Systems, FSL and DOCKWISE, ably supported the operation.

The support of the following organizations in the southern hemisphere was extensive:

> The Lord Howe Island Authorities and people, DOD, RAAF, RAN, RNZN, many Australian Federal and New South Wales Authorities, Sydney and Newcastle Port Authorities, Inchcape Shipping Services, J-MAC marine services and ADI.

Without this support the safe recovery of the vessel would have been rendered much more difficult.

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