RRS 'Discovery'

The 2007 – 2009 Restoration and Conservation Project

Introduction

Dundee Heritage Trust (DHT) began preparations to further restore and conserve the *RRS 'Discovery'* at the end of 2004. The ship was dry-docked and a full structural survey was carried out by Three Quays Marine Consultants, London. This survey and subsequent conservation plan was part funded by the Heritage Lottery Fund (HLF). When the consultant's final report was studied it suggested that Toredo Worm could be active in the lower hull planks. It also found what was deemed to be large areas of decay in the underwater Elm planks and recommended that a number of these should be removed and replaced. Elsewhere the ingress of fresh water was reported to have caused decay to areas of the inner hull. All in all the ship had become in need of serious restoration and conservation measures.

Since *Discovery* arrived in Dundee in 1986 a great deal of restoration and conservation work had been done. Apart from physical works to the ship's structure, a custom built dock and support complex had been completed in 1992 with *Discovery* being relocated there during mid 1992. It was and is DHT's Policy that the ship should remain afloat and with this in mind the new dock was designed to be used to dry-dock the ship from time to time when the need arose.

Using the final survey report that linked directly to a new conservation plan, a restoration and conservation project was agreed by DHT. An application was prepared seeking support funding from the HLF in order to complete the project. This was successful and the Fund agreed support in November 2006. Administrative matters were concluded between DHT's operating company, Dundee Industrial Heritage Limited (DIHL) and the HLF and a start date agreed as the 15th of March 2007. The total project cost was set at £700,000.

The Project

When the specification was drawn up for the tender for a main works, care was taken to allow deviation away from the detail of the works that if, during the works operations. Actual fact was found to be at variance with that recommended in the final structural survey report. Changes to the works schedule had to be agreed between the HLF Project Monitor, the Project Manager and the Main Contractor.
This arrangement proved, during the course of the project, to be of substantial value in conservation terms (and indeed in financial terms) to the final outcome.
The areas identified as being infested by the Worm were to be restored, the decayed planks replaced (originally approximately 14 strakes of Elm 30 feet long, 7 inches wide and up to 9 inches deep) using Opepe timber. A decision was taken to investigate first the reported Toredo activity. This was done by removing a 6 foot long section of what was

believed to be the worst affected Elm plank. Close examination found that while there was some evidence of past worm activity, it was not of the Toredo variety, no longer active and penetrated to no more than 1 inch from the outer surface of the plank. Equally when those bottom Elm planks reported as decayed and in need of replacement were examined, it was found that the decay penetrated no more than 1 inch below the planks outer surface. This meant that on average after any decay was routed out and the particular plank treated with appropriate conservation measures, 6 inches of the original 7 inch deep plank (8 inches of the deepest) remained sound and in more or less the same condition it had been when the ship was refitted in 1924..

While savings were made in not replacing bottom planks, this was offset by the discovery that almost 90% of the whole of the plank seams in the ships outer hull had to be routed out, recaulked and sealed. The original specification required only 50% to be thus treated. Given that the original sealant used was a mixture of red lead powder and linseed oil putty and that red lead could no longer be used, it was decided to investigate what other, near original, suitable material was available on the narrow supply market. *Traditional Boat Supplies of Suffolk* came up with its own aptly named *'Black Pudding Mix'*. It is a derivative of coal tar with other ingredients added. It is mixed with a little cement powder to form stiff dough that can be inserted into the seams using a trowel or gun. It does not set hard but remains flexible and retains its integrity even when the seams 'work'.

Electrolytic Corrosion

When the 6 foot section of Elm plank was removed for examination, it was noted that the original steel 'dumps' or fastenings showed signs of corrosion. On further examination of the underwater hull and particularly the area 1/3rd of the length of the ship forward from the sternpost, when the ship was dry and the bottom thoroughly cleaned; thick black gunge was found to be oozing from the sides of the dowels covering the recessed dump heads fastenings in the Elm planks in many locations. Originally these steel fastenings were 18 inches long and about 7/8ths of an inch in diameter, pointed at one end for driving and round headed at the other for finishing. When the dowels were removed it was found that many fastenings had corroded away completely, others were so severely corroded that they could be removed with ease using finger force. Others were found to have severe corrosion at half-length tapering to less at each end. All told 92 fastenings were renewed using oversized replacements, a near equal number on the port and starboard sides. Cotton twine was wound round the head of each before they were driven home in order to provide an additional seal. New dowels were inserted into the dump recesses to finish the work in traditional style.

Discussion between the main contractor and project manager concluded that the zinc anodes at the stern of the ship had not been replaced for more than eight years. To remain effective anodes should be renewed at least every 18 – 24 months. Fresh water had been allowed to accumulate in the bilge areas above the worst affected sites for some time past. This water had found the path of least resistance down the sides of some of the bottom fastenings. Electrolytic forces within the enclosed dock when filled with water were such as to inflict severe corrosive damage to the steel fastenings. However, the effect was so severe in certain areas that further investigation proved to be necessary. Earth leakage from the ships main supply was the first to be considered. The absence of a safety isolating transformer fitted to the mains shore-side electricity supply where it entered the hull of the ship to minimize earth leakage was considered desirable. The fitting of such a unit is included early in the new computerized maintenance schedule.

When the dock was originally designed in the late 1980s the electrolytic currents set up in the water of the dock that might do harm to the underwater steel fastenings and fittings may not have been sufficiently recognized at the time by the designers. Electrical mains supply cables to the Discovery Point complex to the west, mains cables running west/east to the north and the Olympic center swimming complex to the east must all add to the electrolytic currents generated in the dock. Dundee City Council, as owners of the dock, will wish to investigate this further and introduce measures to reduce the effect.

The fact is that such corrosion may develop and continue unseen for many years since such fastenings are not visible to ordinary eyeball inspection. In the meantime, new zinc anodes were fitted to the aft end of the ship and in addition, others have been fitted to the forward steel ice protection plates. This was done after advice was taken from experts in galvanic protection.

The Inner Hull

The heavy construction of the inner hull along with interpretive features introduced during the late 80s and early 90s in the hold areas of the ship meant that the 2004 survey team was restricted to examining only those areas that were accessible without recourse to expensive dismantling and rebuilding.

During the course of the works schedule the project manager was able to conduct a more thorough survey of the inner hull. When the spaces behind the interpretation panels were examined it was found that the inner ceiling and associated timbers had suffered badly from surface decay. This was wholly due to the accumulation of condensation through lack of adequate ventilation and air control. Further, in the bilge areas throughout the ship fresh water had been allowed to gather. This fresh water had seeped down the ship's side from the upper deck because of inadequate maintenance of the deck planking and seals. Moreover, of the original 16 bilge pumps located in different compartments, only 2 were operable, 6 were so badly corroded that they had to be scrapped the remaining 8 were missing.

Electrical circuit wires, plug boxes and associated electrical fittings, including heaters and a forced ventilation unit fitted in 1991, were all found to be in a state that left no alternative but to introduce a completely new system.

All of the above caused the project manager to report his negative findings and recommend solutions. The report was written in September of 2007 and the recommendations agreed by DIHL and the HLF before the end of that year.

Additional Works to the Inner Hull

The amount of additional works that could be undertaken were restricted by fact that it had been made clear that the original cost of the project set at £700k could not be exceeded. This decision was taken and agreed by DIHL in consultation with the HLF.

The additional works had to be completed within the timescale of the original agreed works schedule. The main contractor had been appointed on a fixed price contract. A contingency sum set at 12.5% of the total project cost had been agreed and this could only be drawn down in controlled amounts requested by DIHL during a regular HLF Project Monitor's meeting and subsequently agreed by the HLF. Extensions to the original main contractors fixed price contract were discussed and agreed between DIHL and the HLF in two separate stages.

All of the above forced the introduction of further innovation, discussion and technology into the plans for successful completion within budget.

Renovation of the engine room of the ship, never before open to the public, was set out within the original works schedule. The plans for this were developed in-house and formed the basis of what had to be done to the whole of the hold spaces including the boiler room. All of the old interpretation panels were removed completely and air flows again established. It took a full 6 months for the inner hull to dry sufficiently to enable the timbers to be treated using traditional means. Of course there are many modern wood preservation treatments available on the market, each laying claim to be better than the other. It is a fact that the use of hot Boron solution sprayed onto bare timbers proved positive in the 12 years since the inner forecastle of the ship was treated. Boron in powder form continues to be used through the salt boxes built into the inner hull and is now seeded in the bilge areas on either side of the keelson. The effectiveness of common or garden raw linseed oil, liberally applied to bare timbers that have suffered recent surface decay, been dried out, decay removed and then the oil applied and allowed to soak into the timber. It brings the wood back to life and has been used effectively for many past decades. It is cheap in comparison to modern treatments and, in the author's opinion, outlasts these in its effectiveness. The latter treatment was used extensively in the boiler room.

New ring mains, bilge pumps, heating, humidity, lighting, information and control measures were planned and installed but not before a great deal of consultation with local qualified marine electrical engineers, heating and dehumidifier suppliers, bilge pump manufacturers and developers and suppliers of computer soft and hardware. Uppermost in the final decision making process were three main criteria; One, longevity and guarantee of future parts supply. Two; nothing could be used that could be considered as intrusive to the structure of the ship and three; final cost. It should be noted that cost, while highly important in the final analysis, was considered to be the least important in the list of criteria. The philosophy behind this was simple. During the course of the project, it was established that during the restoration and conservation of the ship from 1980 to about 1998, cost absolutely dominated what could be achieved within the finances available at the time. This is understandable but also questionable. It could be that because past projects involving ship maintenance after 1992 were also linked to the support facility's annual budgets and not as a separate unit. It is true that each needs the other for the long term survival of both. So in order to make the available finance stretch further, items such as bilge pumps, heating and ventilation units, lighting and control measures that were fitted during the period highlighted, may have been the most cost effective in budget terms, but were certainly not fit for long term purpose. Equally, the quality of protective coatings, especially those on the whole of the outer hull, must have been suspect. Again, the mindset of seeking donations of equipment and materials required during any one project may have resulted in apparent success and financial savings, but take, for example, protective coatings that have been stored in a warehouse for 20 odd years or so, these do deteriorate during time. When finally applied they are no longer effective. Such donations may be well meant and equally well received but a question-mark must hang over their value in the longer term.

So the philosophy adopted during the 2007 – 2009 project ensured that whatever was replaced, renewed or introduced would provide the comfort of being durable and fit for purpose in the long term.

A Brief Description of Fixtures and Fittings Introduced or Replaced

The 16 new bilge pumps were over-designed on purpose. The pumps themselves were not fitted into the bilge but mounted, unobtrusively, on the deck immediately above. Discharge pipes with float switches set at a low level were fitted in the bilge directly below each pump. The machinery was therefore installed in a dry environment where maintenance can be done with ease. The ring circuits and associated fixtures and fittings were installed using high quality materials suited to the marine environment, and certified by a qualified electrical marine engineer.

The main lighting was provided by using long life bulbs. The lighting used to highlight the many features, new and old, in the hold, boiler room and engine room spaces is provided using LED units. Low cost, low maintenance and above all economical in electricity cost.

12 independent dehumidifying units were fitted in the different compartments throughout the ship. These units can be operated manually or automatically, each is fitted with a manually operated humidistat fitted to allow for the variances experienced in the different compartments from time to time. The moisture removed from the surrounding air during operation is piped from each unit directly into the bilges.

14 independent, fan convector heaters were likewis located in the different compartments. Each fitted with its own thermostat and can be operated manually or automatically.

Monitoring and Control

The electrical control room on board the ship is located more or less amidships on the starboard side of the hold. A new bilge pump control panel was installed with each pump being able to be operated by its own isolating switch. All pumps are on the ON position

24/7 and monitoring of activity is achieved by equipment developed and installed by *Omni Instruments,* a Dundee based company. Briefly, the equipment consists of a *GPRS Data Logger* with *email* and *SMX text function.* Simply configured with a menu style set up program it can text an alarm message activated by any of the inputs. Relays are fitted to each pump connection on the control panel. All information gathered is stored and can be downloaded via the internet. The activity of each pump can be viewed around the clock. A humidity and temperature transmitter was fitted in the control room and another fitted outside on the bridge deck, each linked to the data recorder.

Temperature and humidity monitoring equipment was developed, produced, supplied and installed by *Meaco Measurement and Control of Newcastle, Staffordshire*. It comprises a five-point telemetry sensor system transmitting data to a central receiver. The system utilizes *Meaco Sensia* software operated on a PC. It monitors temperature in degrees Celcius and humidity in percentage relative humidity. Each point has a specific address and sensors are accurate to +/-1% on humidity and +/- 0.3 degrees C on temperature @ 23 degrees C. There are 5 separate battery powered monitoring transmitters located in different compartments throughout the ship and linked to a receiver located in Discovery Point. All information recorded is available using an internet connection. Current and historical information for each compartment appears on a PC in graph form. Alterations to the settings of both the dehumidifiers and heaters in the different compartments monitored in order to achieve the best air control, can therefore be done with ease by simple reference to the information on screen.

The total cost of the bilge pump and temperature/humidity monitoring equipment was less than £6,000. Further technical information will be available from the suppliers.

Waste Water

The pump room is located in the port side of the hold area and discharges from each bilge pump location was received in a holding tank in this compartment. A kitchen and a separate wash up room are located immediately above and the waste water from these locations is gathered in the same holding tank as the bilge water. The latter two rooms service the wardroom and open areas when weddings, dinners or functions are held. While such occasions may gather much needed revenue, they do have a down side. The waste water collected during the clearing and washing up process is impregnated with liquid fats. This water collected in the holding tank cools and the fats solidify on the surface of the water, they then start to ferment and give off gasses that create both an obnoxious odour and a Health and Safety risk. During an examination of the system the holding tank was found to be of a heavy plastic material, open at the top. The bilge and waste water filling pipes entered the open top free from any containment. The discharge semi submersible pump was operated by a float valve that became contaminated by the sludge and therefore at times inoperable. A new stainless steel tank was designed whereby the filling pipes entered the tank through airtight flanges. An airtight inspection/cleaning opening was fitted to the tank top, easily removed for that purpose. The discharge pump was fitted immediately beside the outside of the tank, bolted to the deck and it's suction pipe fitted with a filter unit to enable easy maintenance. The suction

pipe entering the tank was fitted with a clapper valve inside the tank. So the system became airtight and environmentally friendly. The water discharged from the tank is collected, along with waste water from the toilets in the forecastle, to holding tanks in the chain locker. When the water in these tanks reaches a regulated level it is then automatically pumped into the waste water system ashore using a semi-submersible shredder pump.
The tanks were opened, thoroughly cleaned, the insides provided with a protective coating, the pump serviced and the system resealed. Care was taken to confirm that the stench pipes provided adequate air flows to avoid vacuums forming.

Completion of Agreed Works Schedule

This paper will not attempt to include all of the works that were completed within the scope of the Project. This information can be found on the *RRS 'Discovery'* web site: www.rrsdiscovery.com in Appendix III of the new conservation plan. Such information includes recommendations for future actions that could be of value to others involved in historic wooden ship restoration and conservation.

Observations

- The author has great difficulty in understanding why such vast sums of money have been required in the restoration and conservation of other historic ships in the United Kingdom, with perhaps the exception of the *'Mary Rose'*, when so much was achieved during the *2007 – 2009 Discovery Project* for **£700,000**.

- Value Added Tax (VAT) paid during the project amounted to nearly £90,000 or 12.6% of total project costs. The fact that DIHL opted for exemption from VAT on admission charges rather than on project costs when presented with that ultimatum by the Revenue, is understandable given the need to preserve annual cash flows. What is hard to swallow is that for every £1.00 that is gathered by DHT to be expended on the protection of our National Maritime Heritage, only 0.82p can be allocated to that cause.
  It has been said by some that it is of little consequence since, in the case of HLF funded projects, HLF meets its share of the VAT liability be that 50, 60 or whatever percentage of the project cost the HLF provided. This is a very hollow approach to a tax that reduces the ability of organizations such as DHT to meet their obligation to protect our National Maritime Heritage.
  The tax is, to use a political expression, a 'double whammy'. It decreases the HLF's ability to provide the net finance required to support our heritage, and, penalizes those who work tirelessly to support the work .
  The National Historic Ships Unit has been in place since 2006. It would be useful to learn whether it has formed its own opinion on the issue. Perhaps it already has, if so one would hope that it is making sympathetic progress in its efforts to have the burden removed.

- Credit must be given to the Scottish area HLF office in Edinburgh whose staff provided sound advice before, during and in the completion of the project. Changes to the HLF national guidelines were made in April 2008, exactly halfway through the project. The advice provided to DIHL thereafter allowed the project to continue seamlessly and to reach a satisfactory conclusion.

Statement on the Content of this Paper

The opinions expressed in this paper are the author's alone. The information provided is factual in so far as memory allows. Neither DHT nor DIHL were or have been consulted in regards to the content and therefore should be excluded from any negative comment that may be forthcoming as a result.

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