RISK ASSESSMENT OF THE WRECK OF THE HMS ROYAL OAK

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SUMMARY

HMS Royal Oak was a Royal Sovereign Class battleship sunk by the German U-boat U47 at Scapa Flow, Orkney on 14 October 1939. At the time of sinking, the vessel was fuelled, stored, and had a full load of ordnance. Previous studies have considered the environmental effect of oil loss from the wreck, and the probability of munitions explosion. These reports did not, however, evaluate the consequences of explosion, degradation of the structure, dispersion of munitions and dispersion of any other hazardous materials that may be on the wreck.

In order to address these issues during preparations for a large-scale operation to recover the fuel from the wreck, BMT Reliability Consultants Limited, along with several BMT subsidiaries and other organisations, conducted a comprehensive risk assessment, under contract to the MoD’s Salvage and Mooring Organisation. The study brought together safety, environmental, structural and operational assessments under a risk and cost benefit framework based on a Formal Safety Assessment Methodology (FSA).

By balancing the costs, risks and the benefits, the study has provided a major input to decisions relating to the short- and long-term management of the wreck. In particular, the assessment has informed the planning and preparation for the operation to recover fuel oil from the wreck. The paper describes the assessment and highlights its benefits for reducing risks to people, property and the environment.

AUTHORS’ BIOGRAPHIES

Ron Gerdes holds the current position of principal consultant and is the Professional Head of Risk Management with BMT Reliability Consultants Limited. He has been responsible for the development of BMT Reliability Consultants Limited’s capability in Risk Management including the development of methods and tools for project risk and safety studies. Ron’s qualifications include degrees in Cybernetics and Artificial Intelligence and he is a Chartered Engineer and a member of the Association for Project Management (APM). He is a co-author of the APM’s Risk Guide and has an interest in all aspects of Risk Management including effective risk management within organisations and Corporate Governance. His previous experience includes risk assessments for other wrecks, civil aircraft, military aircraft, industrial systems, rail systems and road vehicles.

Genevieve Martin holds the current position of Senior Consultant at BMT Cordah Limited. She carries out Environmental Risk Assessments focusing on the marine environment and offshore oil and gas related activities with specialist knowledge of UK marine legislation. Her previous experience includes other wreck risk assessments, many drilling and development risk assessments and decommissioning assessment work for offshore installations.

Dr David Sell holds the current position of Technical Director at BMT Cordah Limited. He specialises in environmental impact and risk assessment for marine engineering projects. His previous experience includes environmental risk assessments and advice for major decommissioning studies e.g. Shell’s Brent Spar and other oil and gas projects.

1. BACKGROUND TO THE SINKING AND PARTICIPATING ORGANISATIONS

HMS ROYAL OAK was a Royal Sovereign Class battleship sunk by the German U-boat U47 at Scapa Flow in the early hours of 14 October 1939 (see Figure 1). At the time of sinking, the vessel was fuelled and stored, including a full operational load of ordnance.

Since sinking there has been a slow leak of fuel from the wreck in amounts that have had minimal impact on the environment. Continuing deterioration of rivets and seams has allowed the leakage rate to increase in recent years and it is now considered to be unacceptable, requiring remedial action. Palliative measures to reduce and contain the leakage have had some success, but, because of the shallow depth, have proved vulnerable to the extreme weather and sea conditions to which the area is prone. Oil removal
operations in 2001 were successful in reducing the leak rate and further oil removal is planned for 2002.

Figure 1: Wreck of the HMS Royal Oak (image courtesy of Ocean Optics Ltd)

A number of studies have been previously carried out to better understand the problems associated with the Royal Oak. Those studies considered the effect of oil loss hazard on the environment and the probability of munitions explosion but did not consider the consequences of explosion, degradation of the structure, dispersion of munitions and dispersion of any other hazardous materials that may be on the wreck.

A comprehensive risk assessment of the wreck of **HMS Royal Oak** has been undertaken and managed, both technically and commercially, by BMT Reliability Consultants Limited, under contract to the MoD’s Salvage and Marine Operations Integrated Project Team.

The comprehensive risk assessment of the Royal Oak, undertaken by BMT, fills in the gaps in past assessments and brings together a variety of information under a risk and cost benefit assessment framework based on Formal Safety Assessment (FSA).

The study involved several BMT subsidiaries and other organisations and included safety, environmental, structural and operational assessment, brought together under a risk and cost benefit assessment framework based on the FSA methodology. FSA was previously developed in a joint project with the Maritime and Coastguard Agency.

2. **THE STUDY METHODOLOGY FSA EXPLAINED**

The FSA methodology was developed for the Maritime and Coastguard Agency. It is a framework, which combines risk assessment, cost benefit assessment and decision making.

![FSA Diagram](Image)

The methodology can be applied to any major problem or issue where there are a number of options to be considered to address the problem. The benefits resulting from each option and the associated costs are assessed. These costs and benefits can be assessed globally or from the perspective of stakeholder groups. The comparison of benefits and costs for each option enables the most cost effective option or options to be selected and recommendations to be made.

Overall, the methodology provides for logical and traceable decision making.

3. **THE KEY ISSUES INCLUDING ENVIRONMENTAL SENSITIVITY**

The key social, environmental and economic sensitivities in the area are:

- The environment within 16 miles of the wreck site has a high ecological importance (see Figure 3 at the end of the paper for wreck location).
- There are numerous designated conservation areas including Sites of Special Scientific Interest, Special Protection Areas, Special Areas of Conservation, RSPB reserves and Ramsar sites. Scapa Flow supports a number of nationally and internationally important populations of rare or vulnerable birds. Seaducks, divers and auks are particularly
vulnerable to oil spills. Scapa Flow also supports 9% of the UK population of common seals, which are vulnerable during their pupping season, when they are hauled out on beaches. Otters are also at risk as they are present on 57% of Scapa Flows coastline.

• In terms of socio-economic importance, the area supports activities and industries, which range from the Flotta Oil Terminal and associated shipping traffic, to tourist and amenity users including diver charter vessels. The area sustains a valuable shellfish industry. A number of salmon farms are also located in Scapa Flow.

• The most vulnerable period is over the winter months, October to April. Sensitive bird populations are present, the shellfish industry is most active and when weather conditions are most extreme. An unexpected and uncontrolled oil spill in this season could have significant environmental impacts. Containment methods such as booming, or the use of dispersants, are also least effective in strong wind and wave conditions

The issues associated with the wreck of the **HMS Royal Oak**:

• Loss of oil and damage to the environment and commerce (primarily tourism and fisheries). The present slow loss of oil is not resulting in any detectable change in marine life. The concern about oil loss stems from the possibility of the rate of loss increasing or there being a sudden loss of oil.

• Other hazardous materials such as are contained in antifoulings resulting in possible damage to the environment and commerce plus health effects. The concern is that the hazardous materials may be being dispersed.

• Migration of munitions away from the wreck and possibly on to beaches, and subsequent explosion. It should be noted that the migration of munitions is thought not possible because of the currents being less than 0.3 knots in the area

• Explosion of the munitions on the vessel resulting in casualties plus loss of oil and dispersion of hazardous materials.

4. ENVIRONMENTAL IMPACT ASSESSMENT

The study attempted to determine the environmental consequences of worst-case fuel spills from the wreck and the mass or partial detonation of the munitions cargo.

Assuming a worst case mass detonation, the environmental consequences of the explosion, water wave, underwater pressure wave and flying projectiles are forecast to occur mainly within a 1-mile radius of the wreck, but may occur to lesser degrees within 2.1 miles. Possible consequences are envisaged to be fatalities and injuries to people (primarily those personnel carrying out the hot tapping, or possibly divers in the vicinity of the wreck), loss of or damage to vessels, fatalities and injuries to fish, birds, and other wildlife.

The mass release of oil from an explosion is thought to be a greater threat to the environment compared to any blast or water wave resulting from the explosion. The effect of a mass detonation would be to disperse the heavy metals identified in the vicinity of the vessel. This would reduce the concentration in these areas but would result in a larger area being affected. The resulting levels of heavy metals and other toxic substances would require that monitoring of shellfish and other seafoods take place they are supplied for human consumption for human consumption.

The slow release of oil over time results in a negligible effect on the environment. However the uncertainty of the integrity of the hull of the wreck over time indicates removal of the oil would be environmentally beneficial.

5. SUMMARY OF RECOMMENDATIONS

Both short term and long term recommendations have been provided, highlighting the best long and short term options, balancing the costs, risks and the benefits. The results of the assessment have provided a major input to decisions relating to the long-term and the short-term management of the wreck. In particular the assessment has informed planning and preparation for a large scale operation to recover fuel oil from the wreck and guided decisions relating to long-term risk management, including reducing the probability of an incident and/or reducing its consequences on people, property and the environment.

The recommended approach of partial oil removal provides the optimum balance of risk and environmental impact both during oil removal operations and in the subsequent years.
6. CONCLUSIONS

- Persistence of the problem. The HMS Royal Oak sunk over 60 years ago. It is recognised that the problems resulting from marine incidents can last longer than the operational life of the vessel or vessels concerned.

- Perceptions change over time. Environmental and safety “goal posts” only get smaller over time. Increased awareness of environmental and safety issues suggests that we need to address issues that were previously considered unimportant.

- Planning pays. Before undertaking any remedial work it is important to consider the options and decide what is most beneficial (perhaps using Formal Safety Assessment).

- Other Applications. There are many other types of issues or problems that could benefit from a similar approach as outlined below:

  Marine environment: This methodology of formally identifying and managing environmental and safety issues could be applied to any salvage operation.

  In other spheres: Any major problem or issue where there are a number of options, a number of stakeholders, a number of technical issues, and there is a need to formalise decision making, for example:

    - Decommissioning;
    - Strategic environmental assessment;
    - Offshore renewable energy planning;
    - Transport planning; and
    - Even the options for managing major disease epidemics, such as Foot and Mouth Disease.

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Figure 3: Position of HMS Royal Oak in Scapa Flow