The environmental risk assessment of potentially polluting wrecks: From desk to the field

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Introduction

Oil can cause significant damage to the environment due to its chemical composition and persistent nature. There are a few sources from which oil can enter the marine environment, which are typically the natural slow release of oil from the sea floor, offshore oil extraction, shipping incidents and terrestrial based activities (i.e. run off and discharges).

There is increasing concern over pollution risk from potentially polluting wrecks, which are estimated to contain between 2.5 and 20.4 million metric tonnes of bunkers and/or cargo oil (Michel *et al*., 2005). A large proportion of these are World War II shipwrecks, which have been submerged for over 70 years (Monfils, 2005). The oil types present in wrecks range from heavy persistent oils (e.g. bunker oils) to lighter oils (e.g. diesels and petrols). Hydrocarbons have varying environmental impacts, and can cause acute and chronic toxicological effects.

The potential of a wreck to release oil depends on several factors including the structural integrity of the wreck, the type of incident which resulted in the sinking of the vessel, how long the wreck has been submerged, and the environment in which the wreck lies (i.e. depth, exposure to currents and other external variables). The type and scale of oil leaks will vary between wrecks, occurring as sporadic events or continuous releases of differing magnitudes. It is difficult to predict the potential quantity and rate of release of oil. What is more certain is that, as the condition of a wreck deteriorates over time, the likelihood of remaining oil being released will increase (Monfils, 2005).

Some national authorities have begun investigating the potential pollution risks posed by wrecks within their waters. Depending on the perceived level of risk, mitigation measures range from doing nothing to monitoring the wreck and carrying out environmental surveys, to removing the oil. Removing oil from wrecks is not always cost effective (Etkin *et al.*, 2009), so a proactive approach is recommended to identify wrecks that pose the greatest risk to sensitive marine ecosystems and local economies and communities. This requires a robust, standardised environmental risk assessment approach to determine the likelihood of an oil release and the severity of its impact on the marine environment. This enables direct comparison of wrecks and prioritisation for appropriate management.

The UK Ministry of Defence (MoD) commissioned a programme of work to assess the oil pollution risks from several historic wrecks for which the MoD is responsible under the UK Wreck Removal Bill (2011) and other national and international legislation which protect the marine environment. A three-stage methodology for overall risk assessment has been defined. Stage I is subdivided into historical and environmental desk-based assessments (H-DBA and E-DBA, respectively). Stage II includes an on-site ROV survey of wreck integrity and environmental survey. Stage III (remediation) involves more detailed surveys, if required, and could include the removal of oil or an ongoing monitoring programme. This presentation presents Stage I (E-DBA) and Stage II (on-site environmental survey) of the three-staged process.

Main Results

Environmental Desk Based Assessment (E-DBA)

A standardised E-DBA for potentially polluting wrecks was developed, which considers the risk of oil releases from wrecks in a multi staged approach (Figure 1):

1. The likelihood that a wreck will release oil is assessed as low, medium or high, based on the information provided by the H-DBA (archived information, including survivor reports from the time of sinking, and dive reports).

2. The likelihood of ecological and socio-economic receptors being exposed to released oil is assessed using spatially resolved modelled outputs of spill trajectory and fate, carried out using DREAM and OSCAR models.

3. The overall risk posed by the wreck is assessed by generating risk scores based on *likelihood of exposure* x *severity of potential impact* for each ecological and socio-economic receptor.

The approach uses two predetermined scenarios, which can be applied to any wreck:

1. Chronic - long-term release of oil.

2. Acute - instantaneous release of oil.

Oil spill modelling gave an estimate of potential sea surface, water column, sediment and shoreline contamination from the wrecks, which was used to assess the potential impacts to sensitive ecological and socio-economic marine receptors (Figure 2). The standardised approach has been developed to ensure that the relative environmental risks of individual wrecks can be compared as an aid to environmental management, decision making and prioritisation for salvage, intervention or remediation purposes. Furthermore, the approach considers the confidence of the assessment, to identify any areas of uncertainty.

On-site Environmental Survey

This presentation also presents the Stage II on-site environmental survey protocol. The foundations of the survey protocol decision process are underpinned by information provided by:

1. the Stage I assessments (H-DBA and E-DBA);
2. the Stage II ROV wreck integrity survey; and
3. any existing habitat and feature information available for the wreck in question (e.g., modelled sediment type or existing habitat maps and information on population distribution).

It is assumed that any Stage III actions will involve a degree of environmental monitoring and thus the information collected during the Stage II on-site wreck integrity and environmental surveys will support the decision-making process relating to remediation requirements, and associated options at each wreck site.

An on-site environmental survey requires robust design and implementation to deliver the necessary information regarding site characterisation and a baseline assessment of contaminants present. Model outputs generated in the Stage I E-DBA are used to tailor site selection and sample collection. Verification of any previously conducted wreck integrity assessments (whether the wreck is structurally intact) will provide a more complete understanding of the risk posed by the wreck in question at the time of survey.

Characterisation of the physical habitat and associated ecosystem enables a comprehensive description of the area and provides a baseline of sensitive receptors for comparison with future assessments. Similarly, contaminant concentrations in water, sediment and biota indicate historic chronic release and

exposure (from the wreck or other sources) and provides a baseline for future assessment and comparison. The environmental survey protocol applies a modular approach, consisting of fixed survey objectives for each element of the survey. This ensures a consistent approach to data collection and interpretation (e.g., risk based apportioning of survey effort), thereby allowing a degree of comparison between wreck sites.

Supporting Images or Graphs

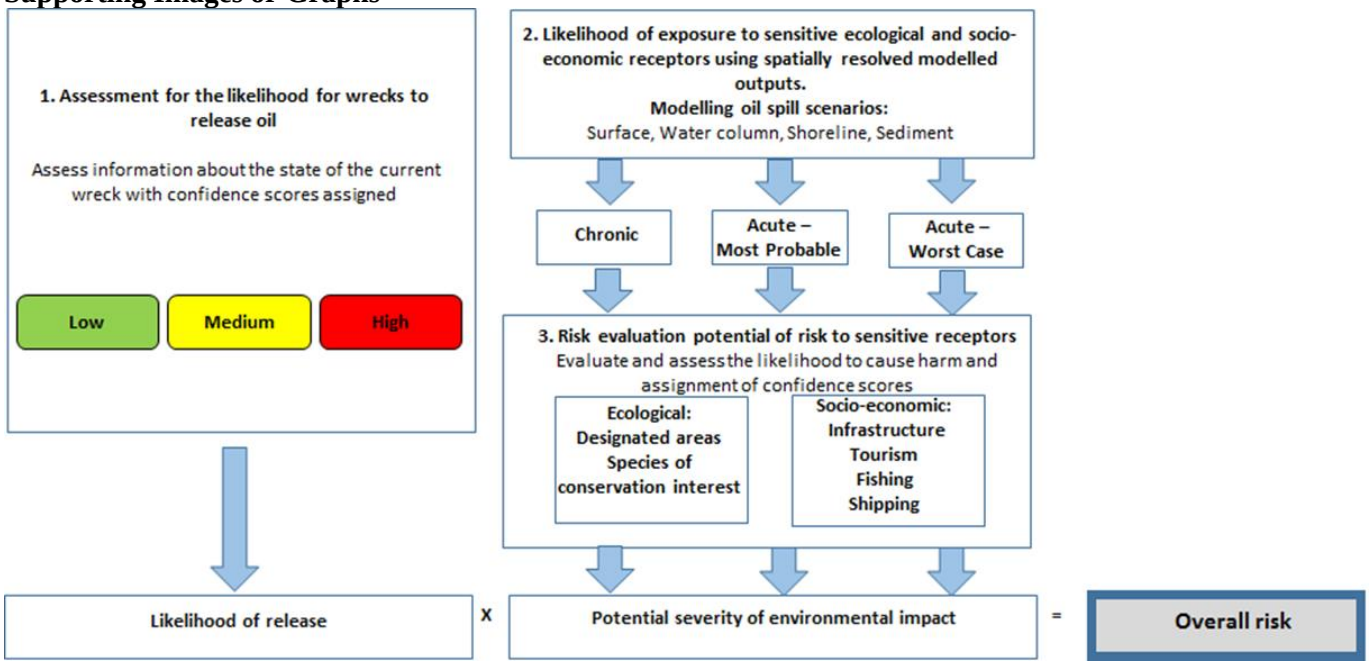

Figure 1: Flow diagram illustrating the E-DBA process).

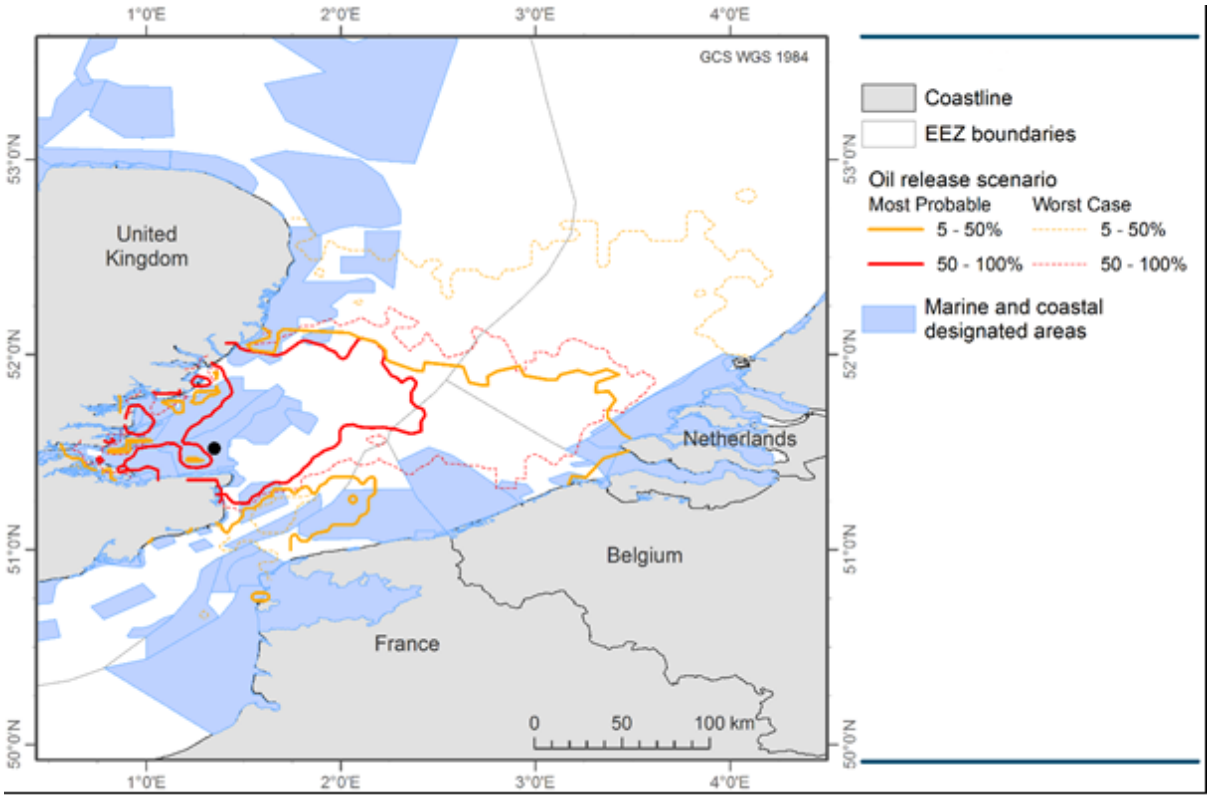

Figure 2: Probability of acute oil release scenarios impacting marine and coastal protected areas. Water surface, water column and sediment models are considered. The largest footprint of probability was

derived from the sediment impact, which is presented. The probability measure has been generated by overlaying 12 sediment models to calculate the percentage of runs that caused any contamination for a given area. The extent of any single model run is not depicted in this figure.

Conclusion

This paper presents an approach for the risk assessment of potentially polluting wrecks and the risk posed to sensitive marine receptors, using chronic and acute oil release modelling scenarios. Risk scores are applied using a bespoke model and scoring system. Wrecks which pose the greatest risk of releasing oil are fully assessed and the potential impacts on sensitive marine receptors investigated. Furthermore, the approach considers the confidence of the assessment, to identify any areas of uncertainty.

The approach is based on the best available data at the time of the assessment. High resolution multibeam echosounder and ROV surveys of structural integrity and hull plating damage (i.e. how many tanks remain intact) inform more realistic oil release modelling scenarios, which gives higher confidence to the wreck assessments. All oil-containing wrecks pose a risk to the environment, and this approach enables authorities to highlight those which pose the greatest risk and prioritise funding accordingly.

This work addresses some of the shortfall in environmental risk assessment methodology of MOD owned wrecks.

References

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