Chapter 11
Assessment Methodologies for Potentially Polluting Wrecks: The Need for a Common Approach

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11.1 Introduction

There are believed to be more than 8500 Potentially Polluting Wrecks (PPW) lying on the seabed around the world, including many oil tankers, which potentially still contain very large quantities of oil. With many of these wrecks having been submerged for nearly 80 years (and sometimes more), the condition of their hulls is continuing to deteriorate, which combined with the increase in the frequency of severe weather events, means that the risk of significant pollution is increasing, particularly for wrecks in shallower waters.

The release of large quantities of oil from the catastrophic collapse of these wrecks is therefore an increasing risk. The resulting major pollution incidents would cause significant damage to the ocean environment, biodiversity and blue economies. The impact on the Global South coastal states, where there is a higher reliance on fishing communities and ocean economies, would be acute, as there is very limited capacity to deal with these events in those areas.

To understand the risk of pollution emanating from any wreck, the wreck must be assessed to determine its condition, the rate of deterioration, the likely pollutants remaining on board, the impact of any pollution and what methods might be feasible for preventing a release of pollutants into the ocean environment. From this assessment, viable management plans and intervention strategies for each wreck can be developed. The management and intervention of wrecks can then be prioritised according to the risk they present.

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11.2 Current Status of Wreck Assessment Methods

A number of nations have developed methods for the risk assessment and management of PPW, including comparison between different wrecks in order to prioritise the need for intervention, according to the risk of the wreck releasing hydrocarbons and the potential environmental impact of a release.[1]

However, the methods developed to date are considered to be limited in certain areas and lack key components when evaluated against an international standard on risk management (e.g., ISO 31000: 2009). Few methods are considered to take into account the uncertain nature of many of these wrecks, or the risk of continuous low levels of oil release into the marine environment and there is little in the way of standardisation in terms of the methodology. The existing methods have tended to be national or regional only, and their deployment to actual wreck management and intervention projects has been sporadic. In our view, this is primarily due to budget constraints and the challenges of cross-border responsibility.

There is an absence of common standards and protocols for the assessment and prioritisation of PPW which can inhibit proactive risk management. This also inhibits funding for the management and intervention of PPW. Proactive management and intervention of PPW will reduce, and aims to eliminate, the risk of serious pollution incidents from PPW. This also significantly reduces costs; the cost of proactively removing pollutants from a wreck can be orders of magnitude less than dealing with an emergency pollution clean-up and response, let alone the environmental and socio-economic impacts of spills.

This chapter outlines the experience that we have gained at Waves Group in the assessment of PPW and illustrates how the technologies and methodologies used for assessment can be effective and can be standardised but are also readily adapted.

11.3 Our Experience in the Assessment of Potentially Polluting Wrecks

The assessment of PPW requires a range of technical disciplines, including a combination of high-resolution survey data acquisition, naval architecture, marine engineering, modern ship salvage and pollution expertise, together with maritime archaeology expertise to address the pollution risks and the cultural heritage aspects. We have integrated this combination of expertise, regularly deploying it on modern, commercial salvage and wreck removal projects. Removal of pollutants and managing pollution risks is at the heart of modern ship salvage and so the techniques used are directly applicable to PPW and therefore provide a proven, state-of-the-art capability to meet the PPW challenge. Applying adaptions of proven commercial

[1]Particular examples include VRAKA (Sweden), NOAA (USA), South Pacific Regional Environment Program (SPREP), SWERA (Finland).

technology, such as non-intrusive sampling for hydrocarbons, has enabled the development of methods that considerably reduce the risks of the destabilisation of the wreck and the unintended release of hydrocarbons into the marine environment.

We are working internationally with Governments and their Agencies, together with other stakeholders and experts in the PPW field, and have built experience across PPW projects in UK, US, Finnish and Pacific Island waters, and modern salvage projects worldwide, including many environmentally and socio-economically sensitive regions from the high Arctic to South Pacific islands. This includes both planned PPW assessments and emergency response interventions. Our experiences to date have enabled us to consider what is 'best practice' for the management of PPW and the technologies and methodologies used for their assessment, and also highlight the gaps and future needs for proactive wreck management and intervention. Here, we summarise some of the aspects of the methodologies that we have deployed and experienced.

The approach to the assessment of PPW is driven by the need to achieve the best possible certainty, whilst having the lowest environmental risk, and to ensure that the assessment can be conducted cost-effectively. The stakeholders to any PPW require a clear and accurate understanding of the risk presented by the wreck to justify the intervention strategy. The decisions required to be made are significant and clear, accurate data underpins this.

For a planned (i.e., proactive) wreck assessment, a comprehensive desktop scoping exercise is undertaken before any fieldwork. This includes detailed archival research to source all available technical data and documentation for the wreck (e.g., plans and drawings), details of the voyage and events surrounding the sinking, location specific information, including ocean data, environmentally sensitive areas near the wreck and geological information on the nature of the surrounding seabed. Any previously available data that may have been acquired is also integrated to this assessment, which is then used to assess the nature of the assets and equipment best suited to undertake the offshore elements of the assessment, safely and cost effectively.

To assess the potential for oil (or other pollutants) to remain in a wreck, it is critical to be able to identify the internal compartments of the wreck and to assess those that would be holding the pollutants. Using a combination of the archival research and state-of-the-art 3D digital models derived from vessel plans and lines drawings, with expert Naval Architect input, the internal arrangement and compartments of the vessel can be modeled and used to identify the potential sources of pollutants. Figure 11.1 shows the digital model of SS *Derbent* assessed on behalf of the UK MOD (see Hill et al., Chap. 6, this volume). The model has been derived from ships plans of the vessel class of tanker. The model clearly defines the internal structure of the vessel and the location of the cargo holds.

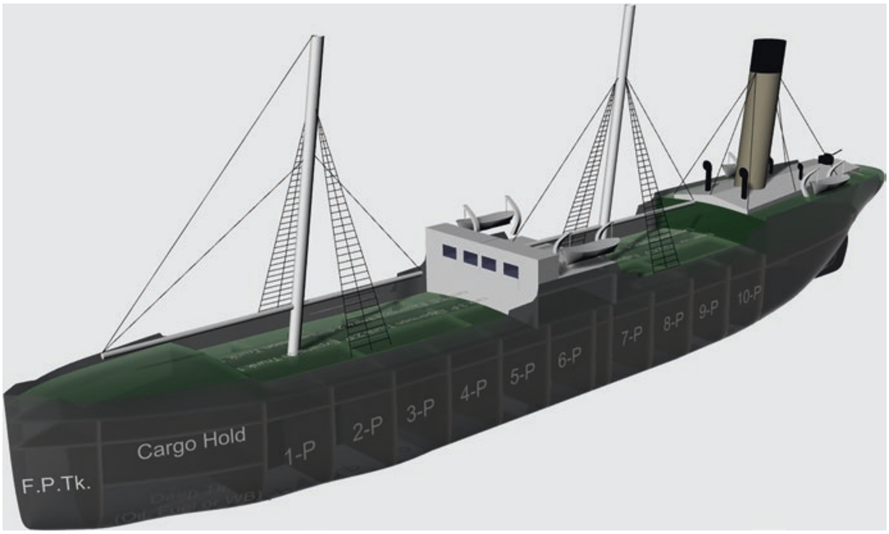

Fig. 11.1 Digital model of SS *Derbent* showing internal cargo tank structure

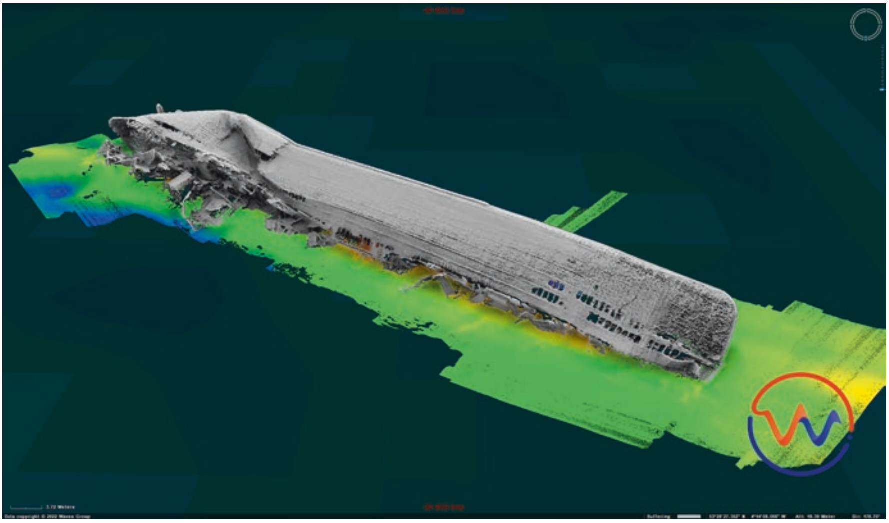

Fig. 11.2 High-resolution multibeam bathymetry data of the *Derbent* wreck. (Hill et al., Chap. 6, this volume)

High-resolution geospatial surveys are used to obtain an accurate representation of the wreck in three dimensions *in situ* on the seabed. A combination of subsea data acquisition techniques, including side-scan sonar, multibeam sonar and photogrammetry is used to obtain the data and integrated to create a high-resolution 3D model of the wreck (Fig. 11.2). Other measurements, such as hull thickness, can be used to determine the residual dimensions of the shell plating to help assess the potential for further structural degradation and hence the risk of pollutant release.

To produce the model, high-resolution survey data and hull thickness measurements are then integrated into a 3D digital environment to provide a better understanding of the wreck on the seabed and the likely locations of the pollutants within the wreck. This enables a 'virtual' structural inspection of the wreck, which can identify breaches in the hull and the presence of potential egress points for any pollutants. Figure 11.3 shows the integration of the digital model of the *Derbent* wreck highlighting the internal structure of the wreck and the locations of the cargo tanks. The integration of the data is critical to understanding the structural collapse that can be seen at the stern, noting that the structural failure is in line with the transverse bulkheads.

The integration of all these data provides a qualitative assessment, from which a range of possibilities of oil volumes remaining in the wreck can be estimated. To determine the oil volumes remaining within a wreck, some form of sampling regime is necessary, which means either intrusive or non-intrusive sampling must be undertaken. The 3D virtual model of the wreck also allows detailed planning of sample points for quantifying the pollutants remaining in the wreck.

Non-intrusive sampling uses specialised systems such as a Neutron Backscatter System (NBS), which can identify the level of hydrocarbons contained within a compartment, therefore enabling an assessment of the volume and location of hydrocarbons remaining in a wreck. The successful application of such systems, typically with an ROV, depends on the condition and orientation of the wreck, and it must be calibrated against known compartment conditions to provide results of sufficient veracity. Being non-intrusive, this method greatly reduces the risk of oil spills during the wreck assessment phase (therefore negating costly clean-up

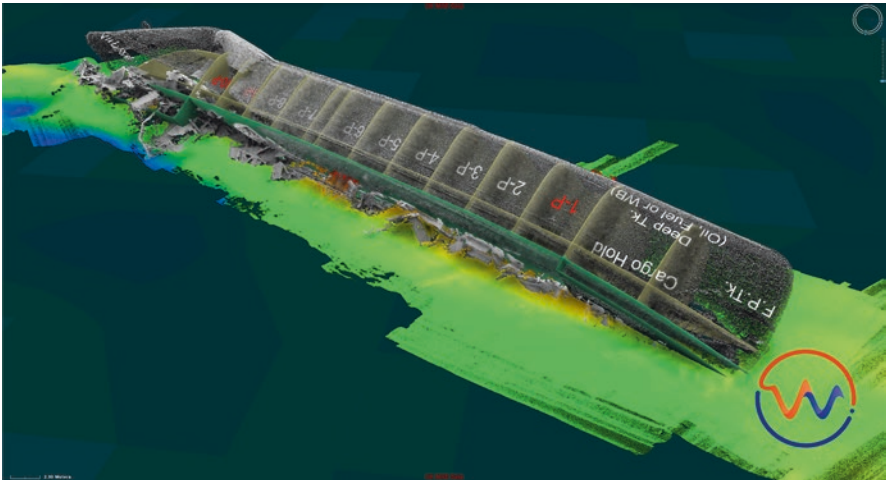

Fig. 11.3 Image of the *Derbent* showing the digital model integrated with the multibeam sonar data

Fig. 11.4 NBS sampling regime and results overlaid on the integrated data model of the *Derbent*

resources and response) and has no impact on the structure of the wreck. Figure 11.4 shows the NBS readings on the wreck of SS *Derbent* (Hill et al., Chap. 6, this volume). The sampling regime has been designed to identify the water/oil interface within cargo tanks that have been identified as potentially containing hydrocarbons from the structural assessment.

Intrusive sampling requires tanks to be drilled and physically sampled. This can be helpful for any eventual oil removal operation, as valves can be installed that will provide samples and, if oil is identified, can then be used for the oil removal. Alternatively, for assessing the PPW, smaller scale sampling techniques can be used drilling small holes to ‘tap off’ relatively small volumes of oil from the tank, which are then sealed after sampling. Any intrusive sampling has a higher impact on the hull of the wreck, increasing the risk of an uncontrolled release of oil. The advantage of intrusive sampling is that the results provide positive, visual, confirmation of the existence of pollutants and samples collected can be sent for analysis to inform the intervention planning.

To help understand the application of the assessment methodology in practice, here we summarise two case studies for PPW assessments that we have carried out. Please also see the summaries of the assessments of the SS *Derbent* wreck and the RFA *War Mehtar* wreck by Hill and colleagues earlier in this volume (Chap. 6).

11.4 Case Study: Tug *Simson*

The tug *Simson* sank in the Finnish archipelago in Baltic Sea in 1978, after striking a submerged rock whilst towing a rock barge. The assessment of the *Simson* wreck was part of the PPW management programme being undertaken by the Finnish Environment Institute. The wreck was classified as potentially polluting as it contained an estimated 1000 litres of diesel fuel, and the wreck site is located within the Finnish Archipelago which is a conservation area protected under Finnish and European law. It was chosen as a test case to apply the proposed methodology, being smaller in size, accessible and with a lower intervention risk than other larger wrecks.

Waves Group undertook the wreck assessment to inform the future management plan and assess whether remediation of the wreck was necessary. On initial survey, it was found that the wreck had sunk into the mud in an upright position and was buried up to its gunwales. It was therefore not possible to collect high-resolution imagery of the hull and as such, the methodology had to be adapted, whilst on site.

The 3D wreck model, built using derived plans for the vessel and the initial survey data, became the data reference point. Instrumental in this was also interviews with the surviving Chief Engineer!

Detailed video footage of the wreck was fused into the 3D model to create an immersive model from which the above-seabed features of the wreck could be interrogated and assessed. Water and sediment samples were also taken to assess whether any diesel was leeching into the seabed or water column. Using this methodology, we were able to assess the condition of the wreck and assess whether the wreck was leaking hydrocarbon and the viability of further remediation measures. Figure 11.5 shows a view of the combined 3D model.

Based on these adapted data, the survey concluded there was likely to be only small amounts of the diesel oil remaining in the wreck. The methodology adopted demonstrates how the integration of data with the relevant salvage experience can be adapted and used rapidly to produce results with high confidence to inform the future management plan for the wreck.

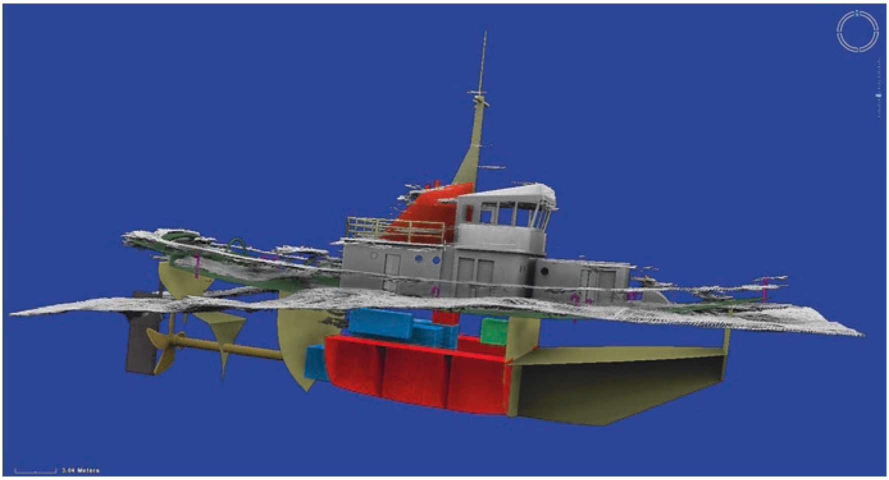

Fig. 11.5 Tug *Simson* composite 3D model comprising multibeam sonar data and aligned solid modelling of the internal layout

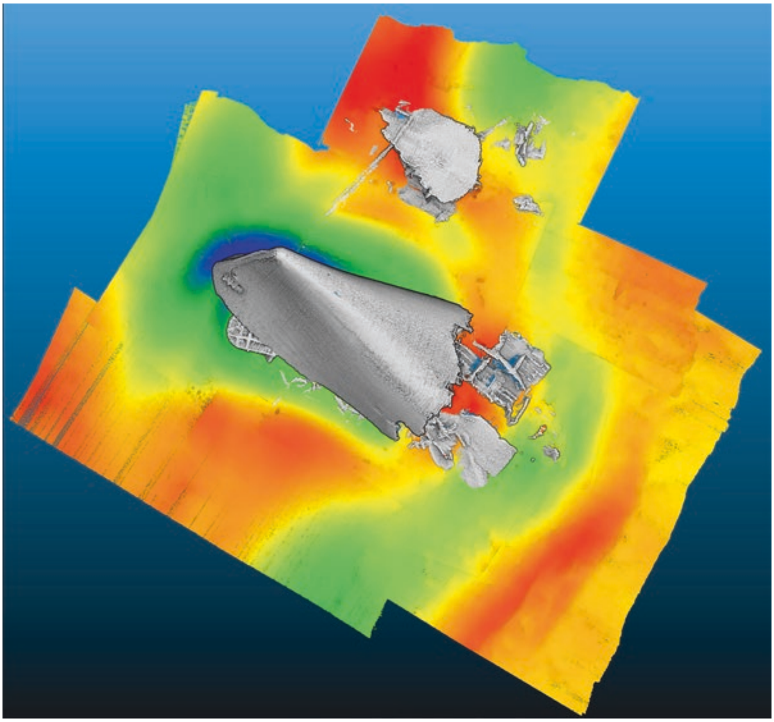

Fig. 11.6 Multibeam sonar image of unidentified vessel

11.4.1 Case Study: Emergency Response Assessment

It is, of course, preferred to conduct assessments of PPW in a proactive and planned manner. However, there are, and will be, occasions where a wreck starts to release pollutants before the planned assessment has been conducted.

Waves Group recently conducted a PPW assessment as an emergency response after significant oil was observed on the surface in a busy shipping area. Due to the rapid response required, the normal scoping phase could not be fully completed and mobilisation to site was conducted 'blind' with the consequence that the survey methodology had to be developed on site and evolved as findings were obtained.

The surface oil was traced to a wreck which was charted but unidentified (Fig.11.6). Temporary patching was installed to stop the release of oil and the wreck was surveyed using high-resolution multibeam sonar and combined with photo and video footage to create the 3D wreck model. An investigation was then undertaken to identify the vessel type, using archival data to compare and match key features to the survey data. Based on this, the vessel type was identified and the internal structural arrangement and compartments were incorporated into the 3D model (Fig 11.7). An analysis of the structural condition of the wreck was then

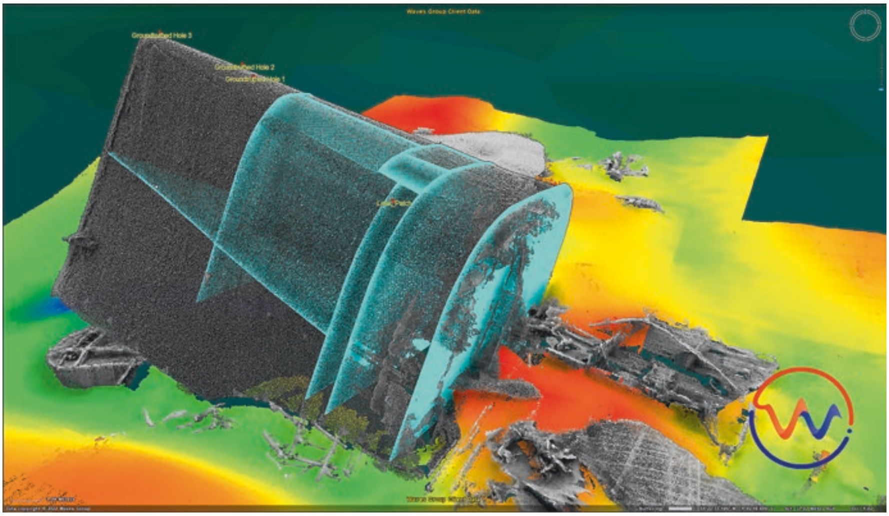

Fig. 11.7 Composite model comprising multibeam point cloud data a digital model of unidentified wreck showing internal compartments

conducted. Non-intrusive sampling of the oil was planned but could not be undertaken due to the poor condition of the wreck structure which could have resulted in the significant unintended release of oil.

An assessment of the risk of future release of hydrocarbons was then conducted, considering a range of factors. This assessment considered the potential volume of hydrocarbons in each tank (and their maximum capacity), the volumes reported in the pollution reports, the potential for material volumes to be recovered in the event of a further release and the condition of each compartment and whether it was already breached (i.e., was any oil already lost to sea). With the potential volume of oil remaining, an intervention strategy was recommended.

Emergency responses operations like this serve to highlight the need for a more proactive approach in the future, where PPW can be assessed, and the risks identified in a planned campaign. By using the similarities between vessel designs, assessments can be made with good confidence, even in rapid response cases without the time to plan the assessment. At the core of this, is the ability to adapt the assessment methodology.

11.5 Wreck Assessment Methodologies—The Future

The work that Waves Group has completed on PPW has brought a standardised approach to the assessment of PPW that has enabled stakeholders to obtain a clear understanding of the risks presented by a wreck, providing increased certainty on the risks it presents, and the intervention and management strategy needed. This methodology has proven to be readily adaptable between planned wreck assessments and rapid (or emergency) response cases. Figure 11.8 below sets out this methodology.

Phase one is typically a desk-based study undertaken to create a wreck inventory that identifies all the known PPW in the area of concern, followed by an appraisal of risk to prioritise further work on specific wrecks. Phase two is the assessment of the wrecks to establish whether the risk identified at the desk-based phase is appropriate. This phase will include the onsite survey work and is where our methodology has been effectively utilised. Phase three is the management and intervention phase which may include pollutant removal operations, containment, monitoring and the ongoing management of the cultural heritage, noting that many PPW are designated war graves.

As outlined here, there are a number of PPW risk assessment methodologies being utilised by different nations, with some regional approaches also in existence. However, the approaches between them differ, in terms of prioritisation of the wrecks, data acquisition and analysis for wreck assessments, and in intervention strategies. Moreover, there is no common approach between nations (and in particular, between those that have responsibility for the majority of PPW) on how to deal with the increasing pollution risk arising from PPW and who pays for it.

As the condition of PPW continues to deteriorate, there is an increasing need for a common approach to reduce the risk of serious marine pollution from PPW, with the potentially devastating effects that this will have on the ocean environment, as well as the socio-economic impacts.

Proactive management of PPW will require funding. Presently, even developed nations have limited budgets for managing PPWs and despite the increased awareness of the growing risk, are still reactive in dealing with those wrecks that are their responsibility. The wreck management programs that do exist are budget limited and so, are constrained in their ability to proactively manage the number of wrecks necessary.

Therefore, opening up pathways for alternative sources of funding will be critical to enabling the proactive management of PPW. For funding to become available, there will need to be certainty of the outcome; that is, what are the costs and what do the funders get for their money?

An international standardised methodology for the assessment and management of PPW, supported by appropriate international standards and guidelines, will provide that certainty and the confidence that the methodology being used represents best practice. That is, it enhances the due diligence for the funding. It allows the costs of PPW assessments to be more easily predicted and reduced (e.g., by sharing resources and undertaking assessments in campaigns, to a standard methodology). A standardised methodology will also support the aims of international treaties and regulations (e.g., the Nairobi Wreck Removal Convention 2007) and is directly linked to international treaties and targets such as:

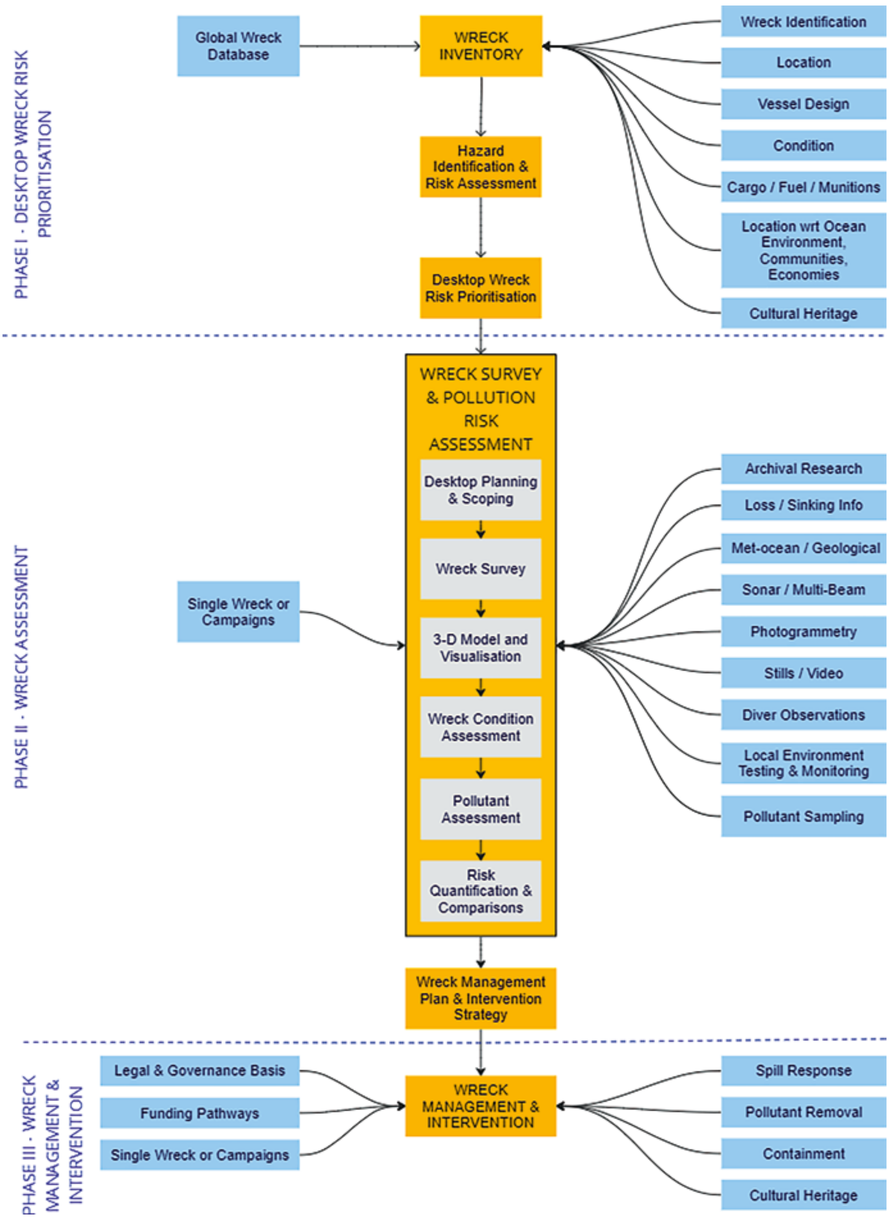

Fig. 11.8 Potentially polluting wreck assessment methodology

- The UN Sustainable Development Goal 14 targets to “prevent and significantly reduce marine pollution of all kinds by 2025”.
- The UN Decade of Ocean Science (2021–2030), where an objective is “a clean ocean where sources of pollution are identified and reduced or removed”.

- The UN High Seas Treaty (BBNJ), ratified in June 2023, which aims to protect the biodiversity of the ocean, through the creation of Marine Protected Areas (30% of the High Seas by 2030).

It is our goal to see the increased awareness of the PPW problem catalyse global action to develop an international standard and appropriate methodologies, drawing on existing international expertise, experience, and bringing technological innovation to help solve the problem. As we write this action has already commenced with the start of a project with Lloyd's Register Foundation, The Ocean Foundation and Waves Group called "*A Global Framework for the Near and Long Term Assessment, Intervention and Sharing of Data for Potentially Polluting Wrecks*".

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