For Response Planning: Predicted Environmental Contamination Resulting from Oil Leakage from Sunken Vessels

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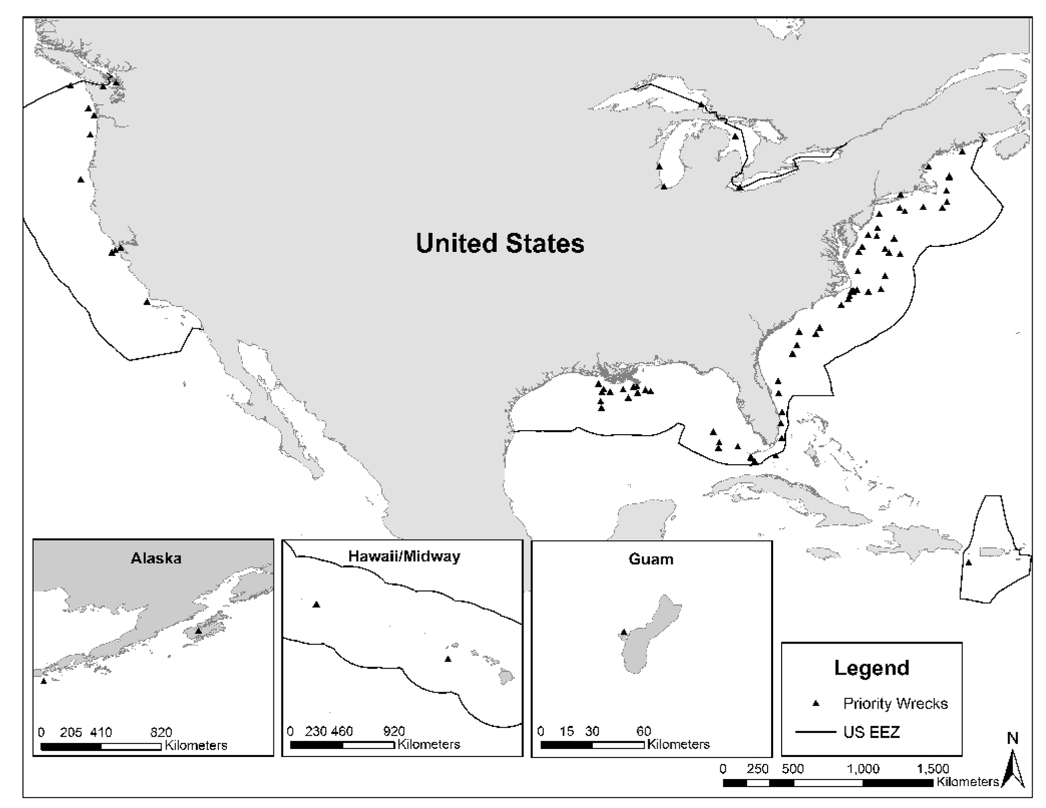
ABSTRACT 300108

An evaluation was made of the amounts and types of oil potentially released from sunken vessels in U.S. waters, where oil would be transported, how rapidly it would reach sensitive resources, and magnitudes of impacts on surface water and shorelines. Oil spill modeling was performed as part of a screening analysis to identify those sunken vessels of highest risk for environmental and socioeconomic impacts, with the expectation that those identified will be subject to more detailed analysis. The modeling provides estimates of the locations of oiling, as well as areas of water surface, lengths of shoreline, and volumes of water exposed above potential effects thresholds (oil thickness or concentrations). We developed regression models of the resulting indices of oil impacts as a function of spill volume, allowing for predictions of water surface area, shoreline extent, and water volume affected for any potential (partial or entire) release volume from the sunken vessel. We ran RPS ASA's SIMAP model in probabilistic mode, i.e., long-term wind and current records were sampled at random and model runs performed for each of 200 selected spill dates and times. The model results provide a statistical description of the probabilities and potential locations and magnitudes of oil-related impacts. This consequence analysis may be used to assign priorities for potential salvage of sunken vessels based on relative risk. The resultant analysis may be used by decision-makers to evaluate response needs, such as response equipment capacities, timing of deployment required to protect sensitive resources, and possible time windows and areas for dispersant use.

INTRODUCTION

Many of the approximately 20,000 known shipwrecks in U.S. coastal waters still contain significant volumes of oil, which potentially pose a substantial pollution threat as the wrecks corrode and disintegrate. The National Oceanic and Atmospheric Administration's (NOAA) Remediation of Underwater Legacy Environmental Threats (RULET) effort aims to prioritize potential threats to coastal resources and assess the historical and cultural significance of these wrecks. Based on an initial risk screening conducted by NOAA, 87 wrecks were identified as likely to contain harmful quantities of oil. RPS ASA subsequently conducted oil spill fate and effects modeling for these priority wrecks in a variety of environments along the U.S. coast.



The sinking tanker *U.S.S. Mississinewa AO-59*. Ulithi Lagoon, November 20, 1944. Photo courtesy of Simon (Sid) Harris.

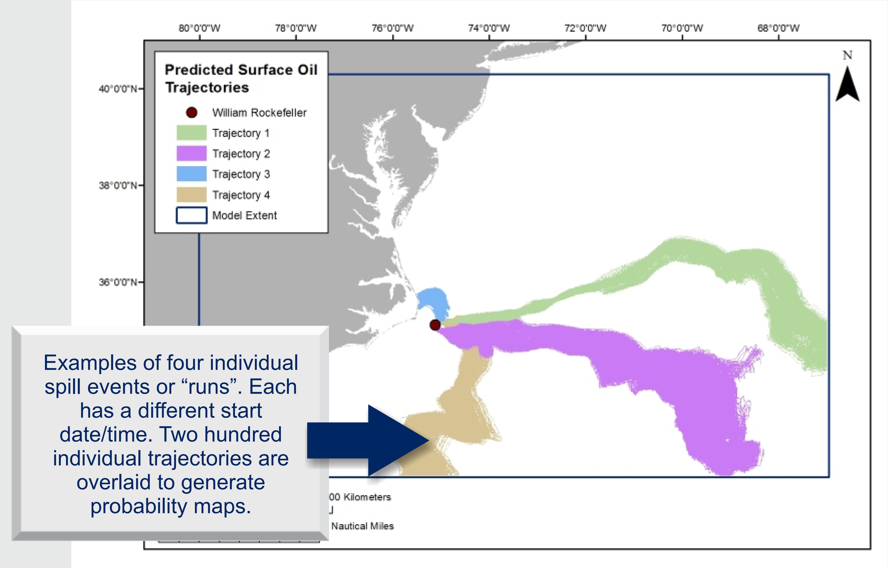
Oil leaking from the *U.S.S. Mississinewa AO-59*. Oil was removed in 2003. Photo Credit: U.S. Navy.

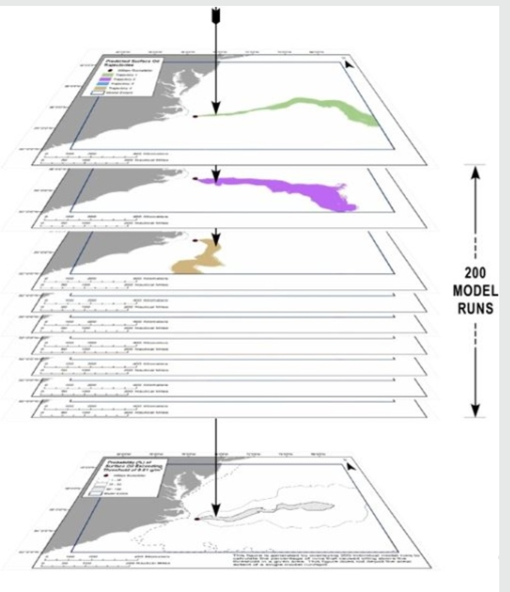
METHODS

Our general approach was to use an existing, well-vetted and validated oil-spill impact model system, RPS ASA's Spill Impact Model Application Package (SIMAP) model (described in French McCay, 2004, 2009), to simulate potential consequences associated with releases from the priority wrecks. We estimated the areas of water surface, lengths of shoreline, and volumes of water exposed above effects thresholds and developed regression models for each wreck fit to the resulting impacts as a function of spill volume.

Consequence	Impact Measure	Impact Threshold (1 g/m² ≈ 1 µm)	Oil Appearance*	Rationale
Impact to ecological resources - water surface	Water surface area exposed to floating oil	10 g/m^2	Dark brown sheen	This level of oiling has been observed to mortally impact birds and other wildlife (French et al., 1996; French McCay, 2009)
Impact to socio-economic resources – water surface	Water surface area exposed to floating oil	0.01 g/m^2	Colorless and silver sheen	Fishing may be prohibited in areas with any visible oil to prevent contamination of fishing gear and catch
Impact to ecological resources - shoreline	Shore length exposed	100 g/m^2	100 g/m^2	Based on a literature synthesis, this level of oiling may affect shoreline life (French et al., 1996; French McCay, 2009)
Impact to socio-economic resources - shoreline	Shore length exposed	1 g/m^2	1 g/m^2	This amount of oil would conservatively trigger the need for shoreline cleanup on amenity beaches

* Oil appearance listed in the table is for a continuous area of oil of the same thickness. In reality, the degree of oiling in the model is based on the amount of oil averaged over a large area (dependent on the resolution of the model). For example, 0.01 g/m^2 of oil on the water surface could appear as a barely visible sheen, oil patches of various amounts of oil, and/or scattered tarballs.

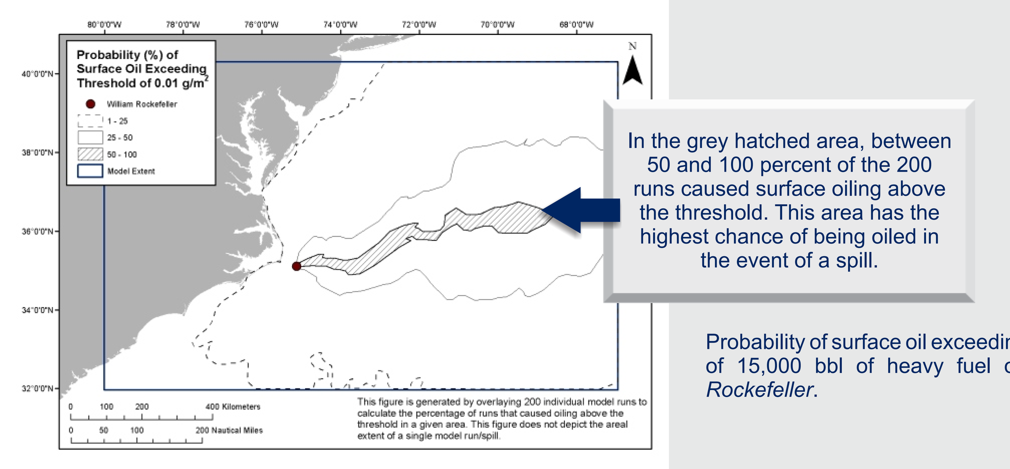




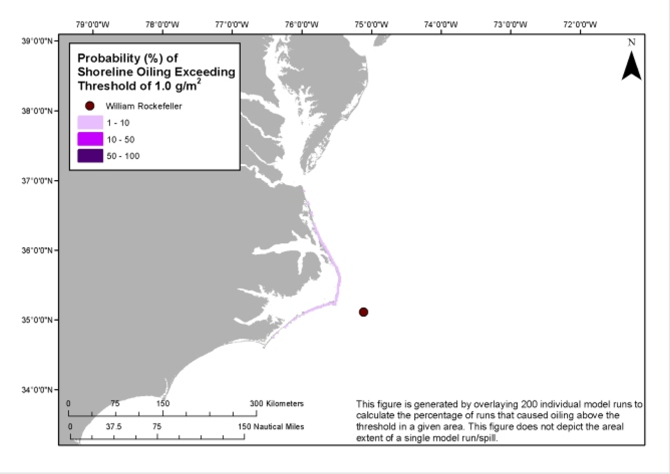
Because a spill from a wreck could occur during any time of the year, modeling was conducted using SIMAP's stochastic model to determine the range of distances and directions hypothetical oil spills are likely to travel from a wreck, given historical wind and current data. These results provide a statistical description of the potential likelihoods and magnitudes of oil spill-related impacts that would be expected, which can be used by decision-makers to evaluate response needs, such as response equipment capacities, timing of deployment required to protect sensitive resources, and possible time windows and areas for dispersant use.

RESULTS

Example results are shown for a spill of 15,000 bbl of heavy fuel oil from the *William Rockefeller*, a tanker that was torpedoed offshore of Cape Hatteras in June, 1942. Similar outputs were generated for each of the 87 wrecks.



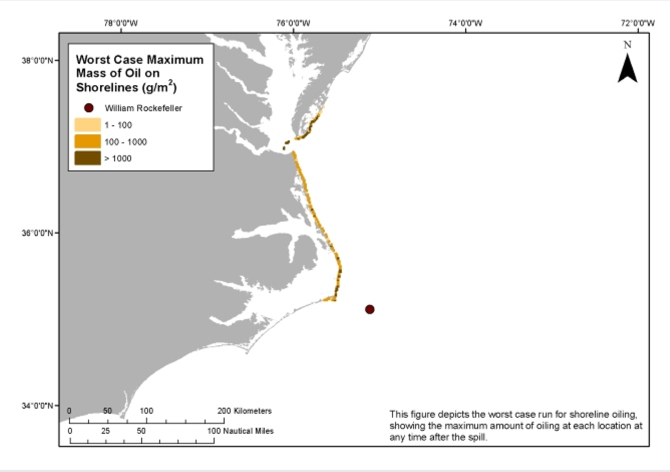
Probability of surface oil exceeding 0.01 g/m^2 for a spill of 15,000 bbl of heavy fuel oil from the *William Rockefeller*.



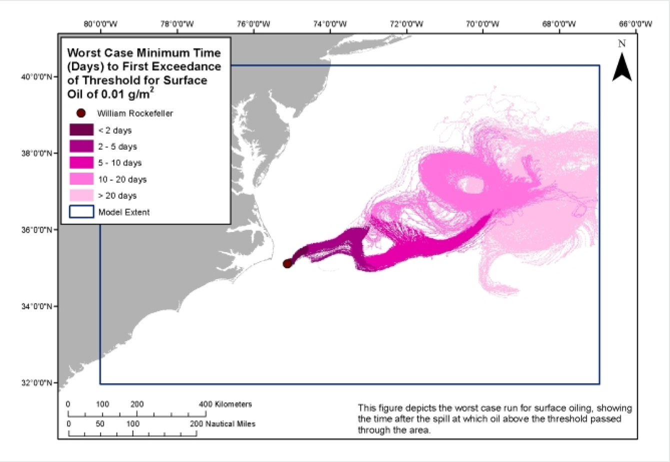
Probability of shoreline oiling exceeding 1 g/m^2 for a discharge of 15,000 bbl of heavy fuel oil from the *William Rockefeller*. The overall probability of shoreline oiling is low, but the results indicate where shoreline oiling is most likely to occur. This information can be used to help inform response planning.

The table below shows average lengths of shoreline oiled above 1 g/m^2, estimated from the stochastic analysis of different release volumes from the *William Rockefeller*. For this particular wreck, the highest risk of oiling is for sandy beaches.

	Length Oiled (mi.) above 1 g/m2, by Shore Type			
Release Volume (bbl)	Rock, Gravel, & Artificial	Sand	Wetland & Mudflat	Total
150	0	15	0	16
1,500	0	23	0	23
15,000	0	24	0	25
75,000	0	25	0	25
150,000	0	29	1	29

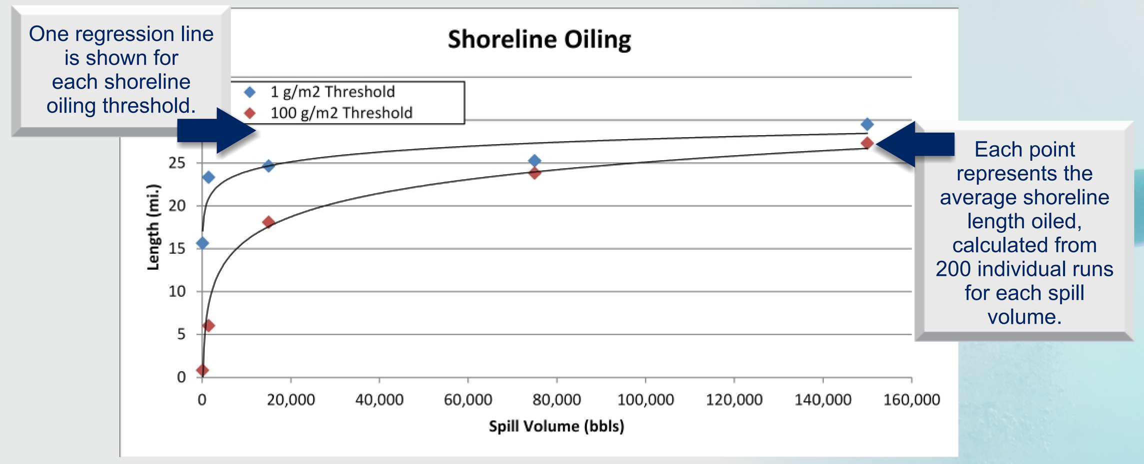


Worst case shoreline oiling from a discharge of 15,000 bbl of heavy fuel oil from the *William Rockefeller*. Results indicate the location and expected maximum concentration of oil on the shoreline.

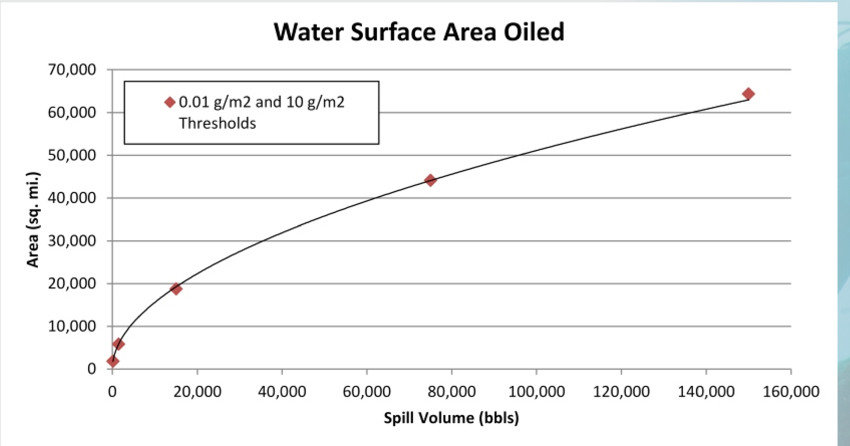


Worst case water surface oiling from a discharge of 15,000 bbl of heavy fuel oil from the *William Rockefeller*, shown as the time to first exceed a threshold of 0.01 g/m^2. The projected location of a spill at varying times after a release is important information for response planning and activities.

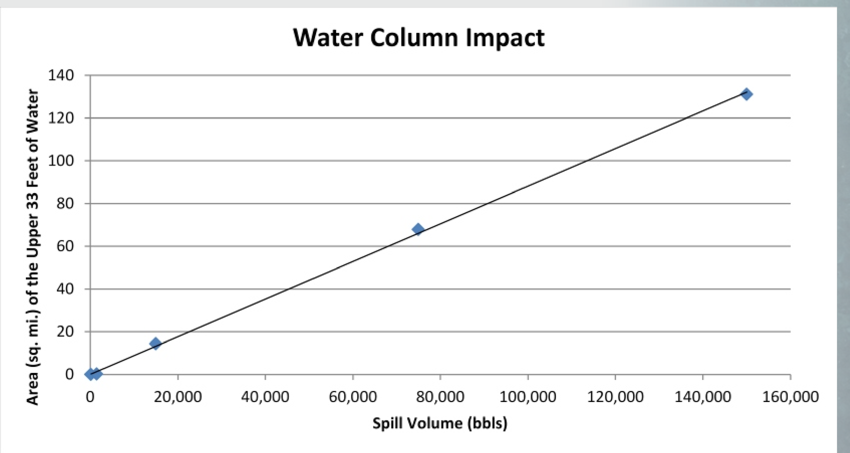
To generate regression models, average results are calculated for areas of water surface, lengths of shoreline, and volumes of water oiled and then plotted graphically. Regression models fitted to the data then allow for prediction of impacts for any potential (partial or entire) release volume from the wreck, or other nearby wrecks.



Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *William Rockefeller*.



Regression curve for estimating the extent of water surface oiling as a function of spill volume for the *William Rockefeller*.



Regression curve for estimating the extent of water column contamination (1 ppb threshold) as a function of spill volume for the *William Rockefeller*.

Dixie Arrow – Photo Credit: Joe Hoyt, NOAA

S.S. William Beaumont – Photo Credit: National Archives

British Splendour – Photo Credit: Doug Kesling, UNCW

CONCLUSIONS

- This oil consequence analysis quantified where oil would be transported, how rapidly it would reach sensitive resources such as shorelines, the areas oiled, and the magnitudes of those potential impacts.
- The results may be used to:
  - Justify further analysis and potentially salvage operations, assign priorities to sunken vessels for such operations, and identify sunken vessels of low risk for spill consequences;
  - Inform decision-makers regarding the risks of impacts from low-energy subsurface oil releases generally; and
  - Evaluate response needs, such as response equipment capacities, timing of deployment required to protect sensitive resources, and possible time windows and areas for dispersant use.
- In May 2013, NOAA released a national (U.S.) report detailing the results of the completed assessment of potentially polluting wrecks (NOAA, 2013). The report determined that of the 87 wrecks, 36 were ranked as having the highest risk of oil pollution and 17 were recommended for further assessment and potential removal of both fuel oil and oil cargo.
- More site-and event-specific modeling analyses may be performed to refine and provide further detail on the expected impacts of oil releases from these higher risk vessels.

REFERENCES

French, D., M. Reed, K. Jayko, S. Feng, H. Rines, S. Pavignano, T. Isaji, S. Puckett, A. Keller, F. W. French III, D. Gifford, J. McCue, G. Brown, E. MacDonald, J. Quirk, S. Natzke, R. Bishop, M. Welsh, M. Phillips and B.S. Ingram. 1996. The CERCLA type A natural resource damage assessment model for coastal and marine environments (NRDAM/CME), Technical Documentation, Vol. I-V. Final Report, submitted to the Office of Environmental Policy and Compliance, U.S. Dept. of the Interior, Washington, DC. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, PB96-501788.

French McCay, D.P. 2004. Oil spill impact modeling: development and validation. Environmental Toxicology and Chemistry. 23(10): 2441-2456. doi: http://dx.doi.org/10.1897/03-382

French McCay, D.P. 2009. State-of-the-art and research needs for oil spill impact assessment modeling. In: Proceedings of the 32nd AMOP Technical Seminar on Environmental Contamination and Response, Environment Canada. Ottawa, ON, pp. 601-653.

National Oceanic and Atmospheric Administation. 2013. Risk assessment for potentially polluting wrecks in U.S. waters. National Oceanic and Atmospheric Administation, Silver Spring, MD, 127 pp. + App. http://sanctuaries.noaa.gov/protect/ppw/