CASE STUDY

SEA EMPRESS: How the latest MarineAware tools could have helped

The availability of data and accurate modelling is crucial to forming a rapid and effective response in an emergency. MarineAware enables this in the world of marine pollution. Bringing together a range of capabilities, it provides more accessible and integral decision support to improve users’ preparedness to respond to potentially catastrophic oil spills at sea.

Through their collaboration with 4 Earth Intelligence (4EI), developers at Riskaware have incorporated Environmental Sensitivity Index (ESI) datasets into MarineAware. The ESIs that 4EI produce use automated satellite image classification methods aligned with international standards to rank the areas of coastline in terms of their sensitivity to marine pollution such as oil spills.
By combining ESI datasets produced by 4EI, and probabilistic modelling based on statistical Monte Carlo methods, MarineAware produces detailed oil spill risk assessments. These assessments can be used to identify the dangers of both real-world and potential oil spills. This uniquely provides users with a prioritisation strategy for dealing with at-risk coastlines, allowing for rapid, well-informed decision-making. By prioritising the protection and clean-up of the most vulnerable areas, users are able to save time, money and resources.

To demonstrate these integrated capabilities, we examine the Sea Empress oil spill which devastated large parts of the coastline of South Wales in 1996. This incident was one of several test cases recently used to validate the accuracy of MarineAware’s oil spill model as part of an Innovate UK funded project, in collaboration with the Science and Technology Facilities Council (STFC). At the time, the Sea Empress was also used as a testbed for early oil spill models which were used to predict the fate, trajectory, and beaching of oil but didn’t offer prioritisation capabilities.

Today, MarineAware takes oil spill modelling to the next level. This article revisits the Sea Empress spill with a new perspective, to determine how MarineAware’s prioritisation strategy could reduce the impact if a similar disaster occurred today.

On the 15th February 1996, the Sea Empress oil tanker grounded in the Milford Haven Waterway in Pembrokeshire, Wales. The ship was stranded and damage to its hull caused the ship to begin to spill its cargo of crude oil into the sea. Attempts to re-float the ship only exacerbated the damage to the vessel, and caused more oil to be released. Following this, authorities from Wales, England and Ireland collaborated and initiated a combined, large-scale mitigation effort. However, despite the methods deployed, including beach washing and dispersants, the slick spread throughout Pembrokeshire Coast National Park. Over the course of the next week, 72,000 tonnes of crude oil and 370 tonnes of heavy fuel oil were released into the ocean, and in total 200km of coastline was affected. Marine life and ecosystems were heavily impacted, several thousand seabirds were killed, and the local economy suffered enormously. Overall, the event incurred over £120m in costs and wildlife took years to recover. Despite this, the impact was far less severe than it could otherwise have been, due the time of year and stormy weather conditions which naturally dispersed much of the oil. [1,2,3]

How can MarineAware Help?

We applied the MarineAware solution to a theoretical incident replicating the original Sea Empress oil spill at low tide on the 25th March 2020. This was the same day that the satellite imagery was captured to generate 4EI’s ESI dataset.

MarineAware makes use of high-quality, up-to-date ocean and wind forecasts to run simulations. Additionally, it takes uncertainty in these forecasts into account using Monte Carlo methods to assess the probability of oil reaching different areas of the sea and coastline. Using these probabilistic outputs, responders can be fully prepared for a range of possible outcomes rather than relying on a single prediction, which is vulnerable to potential inaccuracies in the forecast data.
The Pembrokeshire Coastline – An important Marine Habitat

The environment surrounding the Sea Empress spill forms part of an ecologically significant marine ecosystem containing diverse habitats such as tidal creeks, saltmarshes and wetlands which are home to a number of endangered species. Islands such as Skokholm and Skomer also provide important nesting grounds for sea birds such as cormorants, razorbills and puffins, and the nearby waters are home to marine mammals such as dolphins and seals. [1]

At the same time, local industry and shipping puts the area under continued threat from oil spills and other disasters. In fact, the area has a long historical association with major oil spills, with one taking place at the Pembroke Refinery as recently as last year [2]. Other notable spills include the Christos Bitas spill which occurred close by in 1978 [3], and the Torrey Canyon in 1976 - the worst oil spill the UK has ever experienced - which did not affect this area but was caused by a ship that was on route to Milford Haven [4].

With this area set to play an ever more important role in the UK’s petrochemical industry [5], the marine environment will continue to be at risk of disasters like the Sea Empress.

[1] https://www.welshwildlife.org/

The MarineAware Simulation

The results of the simulation showed that if the incident occurred on the 25th March, large areas of the South Wales coastline would be at risk from the oil spill. This includes several important marine habitats, such as the nearby islands of Skomer and Skokholm which are Sites of Scientific Interest (SSI) and surrounded by marine nature reserves.

Furthermore, the modelling shows the potential for oil to spread farther out to sea where it could pose additional threats to the coasts of North Devon and Cornwall, or even the east coast of Ireland.

We focus our analysis at the mouth of the Milford Haven Waterway, which our model shows would be at high risk from such an oil spill. The varied ecology and environmental sensitivity along this part of the coastline demonstrates why having access to high resolution modelling and detailed ESI data can be hugely beneficial.

Probability of oil reaching certain parts of the coastline calculated by the MarineAware model

Modern Environmental Sensitivity Index for coastlines near where the Sea Empress was stranded
Coastal Impact Risk Scoring

To produce its coastline risk scores, MarineAware classifies the likelihood that each segment of coastline will be affected by oil with a score between 1 and 5 – with scores of 5 representing the highest probability. In addition, the sensitivity to marine pollution of each segment is determined based on its ESI.

The ESI data produced by 4EI is classified using international standards, generating rankings between 1 and 5 – with the most sensitive areas represented by a score of 5. Using an approach based on the traditional Risk Rating table, MarineAware combines the scores of probability and sensitivity to suggest the priority that should be given to each segment of coastline.

Modern technologies, like MarineAware and 4EI’s datasets, can play a key role in ensuring authorities are fully prepared, better equipping them to deal with the challenges they face when disaster strikes again.
The suggested priorities can be displayed through MarineAware’s intuitive, web-based user interface. Through this, responders can clearly see on the integrated maps and charts where the system recommends they prioritise their clean-up efforts. In addition to planning live responses, potential incidents can also be modelled to allow a better understanding of the areas at most risk from future oil spills.

Providing Actionable Intelligence

In events like the Sea Empress accident, where resources are stretched, knowing which areas to prioritise is vital to organising an efficient mitigation response.

In our simulation the beach of Whitedole Bay is given the highest priority because of its sensitivity and likelihood of being impacted by the oil.

Other nearby beaches, such as West Angle Beach and Freshwater West, are also given a high priority due to their sensitivity despite having a lower probability of being affected. In contrast, there is a high likelihood the oil will reach the surrounding rocky cliffs, but they are given a lower priority because the impact of the oil will be less severe, with most of the oil that reaches them washing back off the cliffs into the sea again.

Using this simple, but highly effective method to combine probability and sensitivity, MarineAware is able to provide its users with clear and easy-to-understand actionable intelligence, allowing them to quickly and effectively target and deploy resources.

Oil spills continue to threaten the marine environment of Milford Haven and other coastlines around the world. It is vital we put systems in-place before disasters like the Sea Empress spill occur again, so that we prepare more appropriate and impactful responses. Modern technologies, like MarineAware and 4EI’s datasets, can play a key role in ensuring authorities are fully prepared, better equipping them to deal with the challenges they face when disaster strikes again.
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