Oil spill probability map as a tool for environmental management

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Marine ecosystems are rich and diverse ecosystems composed of estuaries, sandy beaches, rocky shore, coral reefs, mangroves, deep sea and sea floor. A healthy marine environment has critical importance for life on Earth.

As a highly efficient mode of transportation, marine navigation plays a key role in world trade. Compared to other transportation modes, marine navigation has a relatively low carbon footprint. However, with the growing volume of marine traffic, marine navigation presents risks to the marine environment that could have potentially catastrophic ecological consequences.

Therefore marine ecosystems are rich and diverse ecosystems composed of estuaries, sandy beaches, rocky shore, coral reefs, mangroves, deep sea and sea floor. A healthy marine environment has critical importance for life on Earth. To minimize or eliminate the negative impact of marine navigation on the environment, environmental management is required. Examples of environmental management in marine navigation include using clean fuel, using renewable resources, and reducing oil pollution. An important aspect of environmental management associated with oil transportation traffic is the management of risks. These risks include oil spills due to ship collision, illegal releases of ballast water, and leakages of waste from ports and other navigation facilities.

For effective risk management it is important to recognize the exposure of the marine ecosystem to oil pollution. Having accurate maps and data on oil pollution exposure can help environmental managers with more suitable placement of oil spill emergency response facilities. Using the oil pollution exposure maps, environmental management authorities can develop local guidelines for preventing or minimizing the negative effects of oil spills.

This presentation introduces a new methodology and tools for creating oil pollution exposure maps for any region using readily available data sources. The inputs for creating the map are the locations with presence of oil spill incidents, locations with absence of recorded oil spill, and several explanatory variables, including, 1) distance to oil platform, 2) distance to oil facility, 3) distance to coastline and 4) distance to high-density ship tanker traffic route. The oil tanker traffic density can be estimated from the automated identification system (AIS) for recording vessel tracks (marinetraffic.org). and we categorized that map to 1 very low ,2 low,3 moderate , 4 high and 5 very high (Fig 1).

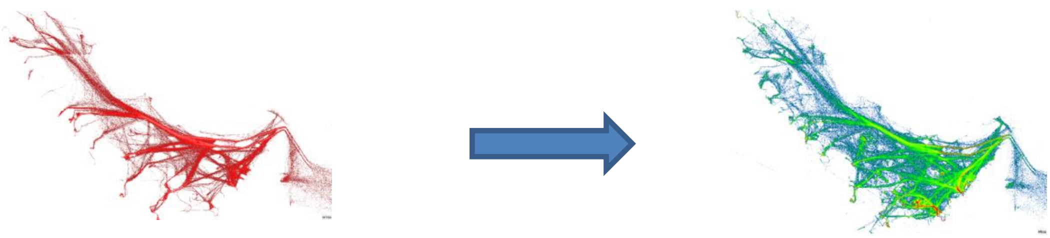

Fig 1: classified Persian Gulf tanker density map

The locations of recorded oil spill incidents have been detected by airplane surveillance, satellite surveillance or local report(Fig 2). The locations with absence of oil spill are randomly drawn from the areas that were environmentally and geographically far from the presence locations.

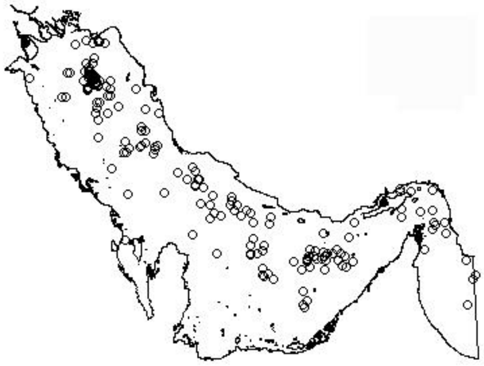

Fig 2: oil spills location map

The spatial prediction model is a generalized linear model (GLM) where the explanatory variables are used as predictors of the presence or absence of an oil spill event. The model has two main outputs. The first output is provided in the form of a probability map – for any point in the study area, a value of oil spill probability between 0 and 100% is provided. , indicating a relative risk of an oil spill incident occurring at that point.

Other open-access data sources such as the global ERA5 high-resolution wind speed and wind speed reanalysis grid and the maps of coastal zone ecological sensitivity, more detailed local analysis of oil pollution exposure can be created. The second output is a table showing the relative importance of the explanatory variables and their effect on the spatial distribution of oil spills.

For environmental management in navigation, the probability map and other model outputs can be used to pinpoint heavy-traffic areas where increased caution and surveillance of vessels may be needed. The map can also aid in decision where to place emergency response resources and in identification of sensitive coastal areas that have high oil pollution exposure and are in need of special protection. Finally, by learning about the causal factors of previous oil spill events, the map can be used as a resource for environmental management to develop local guidelines for preventing or minimizing the negative effects of oil spills from marine navigation.

The oil spill probability map and statistical model presented here are based on the location of previous events. Other factors such as the amount of oil and the time could be added to improve the predictive power of the model.

While the presented map does not take into account the movement of oil by wind and currents, it can be used as a pre-requisite for more detailed simulations of oil spill scenarios. Multiple scenarios locations of oil spill events at different times of year can be selected based on the probability map. Combined together, the results of these simulations can give us season-specific information about oil pollution exposure in the coastal zone and can be used as a decision support system in environmental management. (Fig 3).

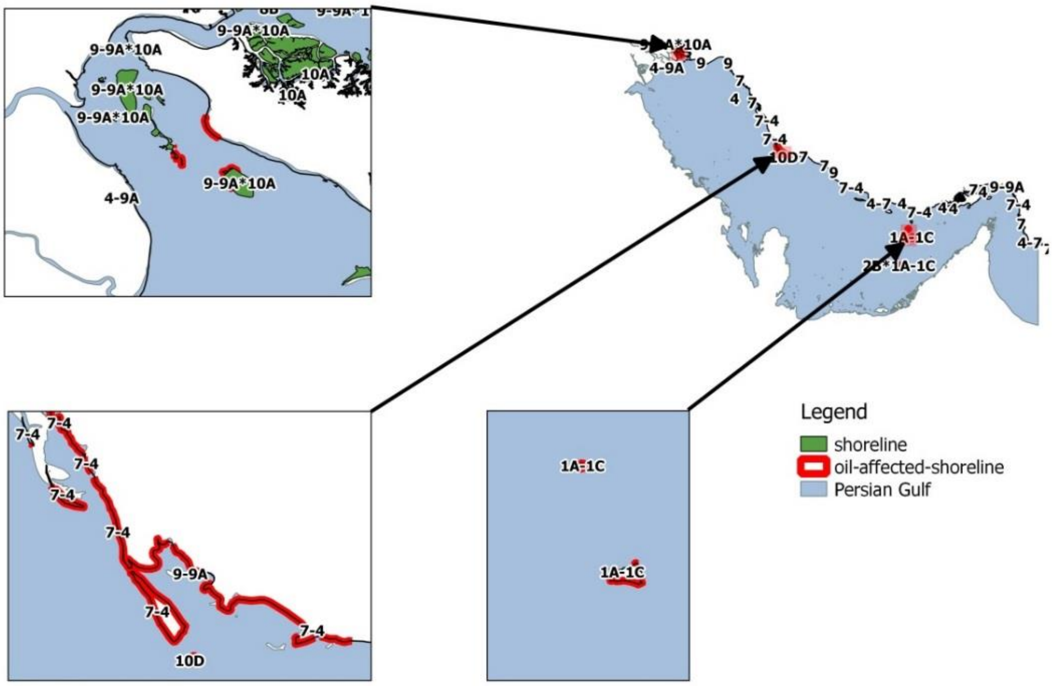

Fig 3: some part of probability of oil spill exposure locations based on scenarios

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