Valuation of environmental damage from the Penglai 19-3 oil spill, China
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Abstract
The most recent Penglai 19-3 oil spill has not only devastating economic impact on local aquaculture, but also leads to a severe consequence of environmental damages in the Chinese Bohai Sea. Nearly 840 km\textsuperscript{2} coastal water and 154 km beach were polluted by spilled oil. In this paper, we transferred our previous valuation result in the Bohai Sea to the Penglai 19-3 oil spill, which was estimated to be ¥1066.5 Millions in a conservative way.

Results

A. Oil spill simulations

Table 1. Inputs to the models. Model starts at 0:00AM 2 June, while spill starts at 0:00AM 4 June 2011. The two days' lag is for stability of currents developed in the model.

| Attribute | Description | Value
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Offshore</td>
<td>90m</td>
</tr>
<tr>
<td>Density</td>
<td>Heavy-thick</td>
<td>0.862 g/cm\textsuperscript{3}</td>
</tr>
<tr>
<td>Spill size</td>
<td>Linear</td>
<td>1,989,270 m$^3$</td>
</tr>
<tr>
<td>Spill rate</td>
<td>Linear</td>
<td>2,681 m$^3$/s</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Linear</td>
<td>14.0 m/s</td>
</tr>
<tr>
<td>Current</td>
<td>Linear</td>
<td>0.46 m/s</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Linear</td>
<td>10.0 m$^2$/s</td>
</tr>
<tr>
<td>Dispersion</td>
<td>Linear</td>
<td>10.0 m$^2$/s</td>
</tr>
<tr>
<td>Duration</td>
<td>Linear</td>
<td>15 days</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Linear</td>
<td>0.00001</td>
</tr>
<tr>
<td>Water depth</td>
<td>Linear</td>
<td>18 m</td>
</tr>
</tbody>
</table>


1. Introduction

On 4 June 2011, oil was observed on the surface of coastal waters near platform B, latitude 38.4° N longitude 120.1° E, in a nearshore oil drilling field named Penglai 19-3 operated by ConocoPhillips China Inc. (COPC). Specific spill site was shown in Figure 1. This accident was identified as a consequence of geological fault that opened slightly because of pressure from water injection into a subsurface reservoir during production activities. According to COPC, a sum of approximate 723 barrels (115 cubic meters) of oil and 2,620 barrels (416 cubic meters) of mineral oil-based drilling mud seeping into the Chinese Bohai Sea. The Chinese Bohai Sea is semi-closed with an average water depth of 18 meters. Its significant ecosystem and important economy make the Chinese Bohai Sea be highly vulnerable to any size of oil spills. This Penglai 19-3 spill containing toxic substances and heavy metals, that threatened ecosystem and the livelihood of people on the Bohai coast. Dead seaweed and rotting fish have been seen and reported by XinHua News.

B. Determining value for coastal resources

Table 2. conditional logistic model with interactions for oil spill combat service attributes.

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C. Valuation of environmental damage

840m$^2$ Water: Loss of 100% function→ ¥2069.76 Million; Loss of 50% function→ ¥1035 Million; 154.26km Beach: Loss of 100% function→ ¥63 Million; Loss of 50% function→ ¥31.5 Million. So a conservative estimation is: CNY 1066.5 Millions.

2. Methods

1. Oil spill simulation for coverage of environmental damage:

Following the tragic Penglai 19-3 oil spill, oil particle trajectory simulations were developed to estimate how and where the oil might spread under the combined driving forces of currents and winds. Oil spill simulation consists of two major parts: hydrodynamic modeling and particle tracking. A hydrodynamic model for the Chinese Bohai Sea was fully established by using ECOM (Estuary, Coastal and Ocean Model) with a set up of bathymetry, initially condition, open boundary and gridding. More details on ECOM can be referred by the HydroQual’s website. To simulate the drift of oil slicks, a three dimensional oil transport model including a variety of processes such as spreading, stranding, evaporation and emulsion was then developed on the basis of both hydrodynamics and Lagrangian discrete particle algorithm.

2. Valuating coastal resources by a conjoint analysis:

To asses values that Chinese might hold for coastal resources prevented from oil pollution, a questionnaire was designed and followed by a pilot survey. The questionnaire consists of a set of choice cards as shown in the following Figure 2. The random utility approach underlying the choice analysis technique provides the theoretical underpinning for integrating choice behaviour with economic valuation. The random utility approach postulates that the utility of a choice alternative includes an explainable part as well as a random part.

![Figure 2. A sample choice set from the choice experiments. Pictograms represent the attributes sea water, beaches, birds (Eider ducks), oil removal and payment, respectively.](image)

Conclusions

We have shown that the simulation model coupled with a conjoint analysis from environmental economics is capable of predicting coverage area of environmental damage by oil spill by a case study of Penglai 19-3, China. A conservative estimation for the Penglai 19-3 oil spill in the Chinese Bohai Sea is CNY 1066.5 Millions.

Acknowledgments

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