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跨越界限 共创价值

Valuation of environmental damage from the Penglai 19-3 oil spill, China

Xin LIU[1] and Guangchen PAN [2]*
[1]Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences
[2]The University of Yantai, 264005, P.R.China

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^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 coastal waters and beaches to estimate the short-term economic cost for environmental damages. The environmental damages arising from the Penglai 19-3 oil spill was estimated to be ￥1066.5 Millions in a conservative way.

Results

A. Oil spill simulations

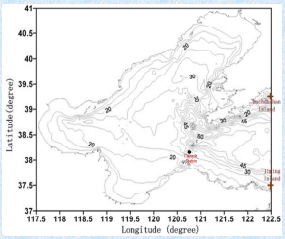

Figure 3. Bathymetry data is in meter for the Bohai Sea, China. One meteorological station at the Bohai Strait and two hydrological stations along the open boundary at 122.5 Longitude are all marked in red. Water depth was measured in meter.

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.

Name	Description	Value(s)
Oil type	Heavy oil released	Statfjord
Oil density	Density of oil released	0.832 *g/cm*^{3}
Spill site	Latitude and longitude of the release	120.1° E, 38.4° N
Release depth	Depth below the water surface (m)for spill	23 meters
Spill start	Hours over which the release occurs	0:00AM at 4 June 2011
Spill end	Hours over which the release ends	8:00AM at 4 June 2011
Model time step	Time step used for model calculations	180 seconds
Model duration	Length of each model simulation	46.5 days
Model start	Time over which the model runs	0:00AM at 2 June2011
Tidal constituents	Amplitudes and phases of major constituents included	M2, S2, K1, O1
Number of oil particles	Number of particles released	16000
Wind data	Wind velocity	Hourly varied wind data from local hydro-station

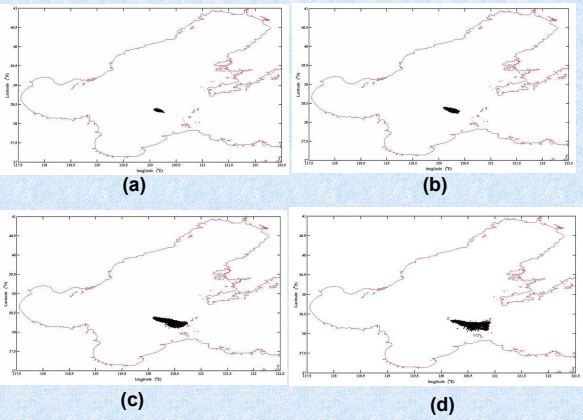

Figure 4. (a) Horizontal projection of simulated trajectory of spilled oil at 0:00AM on 11 June 2011; (b) Horizontal projection of simulated trajectory of spilled oil at 6:00AM on 19 June 2011; (c) Horizontal projection of simulated trajectory of spilled oil at 0:00AM on 8 July 2011; (d) Horizontal projection of simulated trajectory of spilled oil at 12:00AM on 18 July 2011.

1. Introduction

On 4 June 2011, oil was observed on the surface of coastal waters near platform B, latitude 38.4° N longitude120.1° 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.

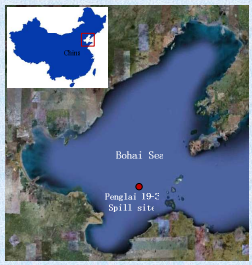

Figure 1. The Chinese Bohai Sea with a reference of Penglai 19-3 oil spill site (Note: Google map downloaded was modified).

B. Determining value for coastal resources

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

Variable Symbol	Definition	Coefficient	SE
WAT	Saved coastal waters (km^2) during the combat. Numerical variable	0.003***	0001
BEA	Saved beaches in km during the combat. Numerical variable	0.004**	0002
DUC	Saved Eider ducks during the combat. Numerical variable	2.43E-5***	8.76E-6
OIL	Collected oil in tons during the combat. Numerical variable	0.009**	0004
PAY	Yearly payments made by each household for using strategy to respond to the spill. Numerical variable	-0.030***	0007
ORG'PAY	Membership of any environmental organization. Dummy variable: yes = 1; no = 0	0.005**	0002
EDU'PAY	Education attainment (university degree and above = 1, 0 otherwise)	-0.005**	0002
ADU'PAY	Continuous variable indicating the total number of adults in the household	0.004**	0001
INC'PAY	Ordinal variable represents monthly net income of household. 1 = less than €1000; 2 = between €1001 and €2000; 3 = between €2001 and €3000; 4 = between €3001 and €4000; 5 = between €4001 and €5000; 6 = more than €5000	0.002***	0001
BID'PAY	Have you observed birds during your visits? Dummy variable: yes=1; no=0	0.004***	0001
KNO'PAY	Have you ever seen an oil spill from TV or newspaper? Dummy variable: yes = 1; no = 0	0.012**	0006
MEE'PAY	Is an oil spill one of major threats to sea water? Ordinal variable: Strongly agree = 1; Agree = 2; No idea = 3; Disagree = 4	-0.002*	0001

$\chi^2(12) = 1648$ (significant at 0.000 level)
Sample size = 1920 (120*8*2)

SE, standard error.
* Statistically significant at 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

C. Valuation of environmental damage

840km^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 assess 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.

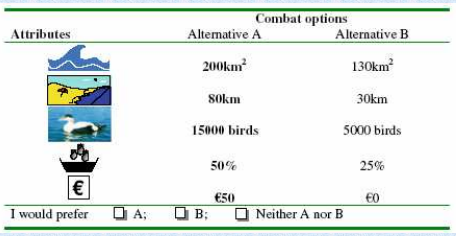

Figure 2. A sample choice set from the choice experiments. Pictograms represent the attributes sea water, beaches, birds (Eider ducks), oil removal and payment, respectively.

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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