OBSERVATION OF THE PENGLAI 19-3 OIL LEAK AND ITS IMPACT ON THE SEA AREA ECOSYSTEM

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ABSTRACT

In this paper, we use ENVISAT ASAR data and the Estuary, Coastal and Ocean Model to analyze and compare characteristics of the Penglai 19-3 oil leak. The oil slicks have spread from the point of the oil spill to the east or north-western Bohai Sea. We make a comparison between the changes caused by the oil spill on the chlorophyll concentration and the sea surface temperature using MODIS data, which can be used to analyze the effect of the oil spill on the Bohai Sea ecosystem. We found that the Penglai 19-3 oil spill caused abnormal chlorophyll concentration distributions and caused red tide nearby area of oil spill in the Bohai Sea.

Index Terms : ENVISAT ASAR, MODIS, oil spill, chlorophyll, sea surface temperature

1. INTRODUCTION

The Bohai Sea is China's inland sea and it is surrounded by the Liaodong and Shandong peninsulas. It connects to the Yellow Sea and covers 77,000 square kilometers. The average depth of the Bohai Sea is 18 meters and is dominated by mud and silt-mud sediments. The Bohai Sea consists of Laizhou Bay, Bohai Bay, Liaodong Bay, and the central basin. The sea is nearly enclosed by shallow waters and has a high, rich-quality fishery, a harbor, petroleum, landscapes, and sea salt resources. However, its own water exchange is abnormally slow. On 4 June 2011, the oil spill appeared in the Penglai 19-3 oil field near latitude 38ºN, longitude 120.0ºE in the Bohai Sea. The oil spill accident lasted for some months. There was a great deal of concern because the oil spill occurred very close to shore. Synthetic aperture radar (SAR) is an effective microwave

sensor to detect oil spills, which can image ocean surfaces during the day and night with high resolution and large coverage, independent of cloud cover [1]. The semi-automatic and automatic detection algorithms based on neural networks, multi-scale image segmentation and fuzzy logic have been developed to detect oil slicks with SAR data [2, 3 and 4]. In this paper, we detected the oil slick of the Bohai Sea using ENVI and Nest4A software. We used ocean dynamic models, ASAR data and MODIS data to analyze of the characteristics of the oil spill and the potential impacts of the oil spill event on Bohai Sea ecological environment.

2. METHODS AND RESULTS

The region under investigation is located between longitude 117ºE and 122ºE, and latitude 37ºN and 40ºN. ENVISAT ASAR images data are used to detect this oil spill in this study.

We use ENVISAT ASAR data and the Estuary, Coastal and Ocean Model to analyze of characteristics of the Penglai 19-3 oil leak (Figure1, 2 and 3). We found that the oil slicks spread from the point of the oil spill to the north then to the east or west Bohai Sea (see Figure1). The oil slick drifted from east to west in the Bohai Sea, according to ASAR image observations on 11 June, 19 June, and 8 July 2011. Moreover, the oil slicks drifted from the west to northwest Bohai Sea as measured on 18

August, 21 August (wind speed >8m/s), and 3 September 2011. Some oil slicks drifted to the Bohai Strait (see Figure2). To simulate the drift of oil spilled from the seabed close to the points of Bohai Sea, a three-dimensional oil transport model including a variety of processes such as spreading, stranding, evaporation and emulsion was developed based on ECOM (Estuary, Coastal and Ocean Model). All simulations started on 4 June at 20:00 and ended on 21 July at 20:00. All simulations lasted 47 days. Wind field data came from the Penglai Meteorological station. The spill rate was simulated to be 100 particles every 180 seconds. In total, there were 10,000 particles representing 1500 barrels of heavy oil released during 5 hours. Using the Lagrangian algorithm, surface oil particles drifted by both wind and tidal currents [5]. Three dimensional simulations plus time as results are shown in the Figure 3. Figure 3(down) predicted that most of the oil had a southeastern trajectory and only tended west or northwest under a monthly-averaged mode of wind. Common to both simulations is that east and southeast are the dominant directions of oil pollution if no combat/recovery strategies were carried out.
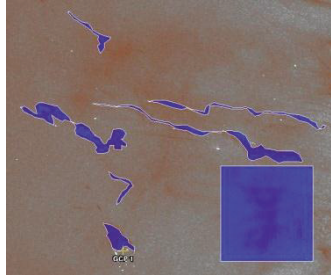
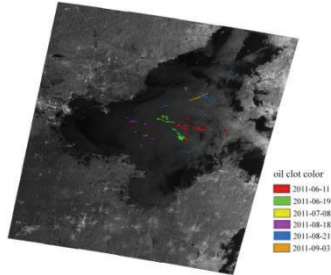Figure1 The irregular curve surrounding the area is the oil slick.

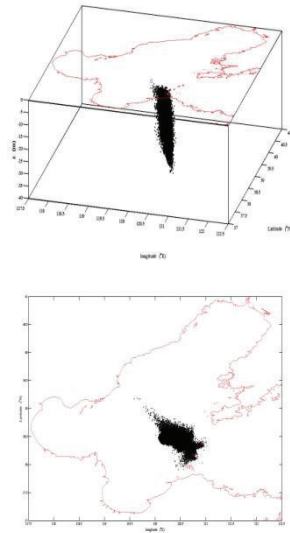Figure2 Oil slick distribution from six ENVISAT-ASAR images.

Figure3 Results of the simulations: (upper) three dimensional view of oil trajectory on 16 July 2011 with a vertical distribution of

oil in water column; (down) horizontal distribution of oil on 21 July 2011 driven by a monthly-averaged mode of wind. Oil mostly flowed southeast with only few scattered towards the northwest.
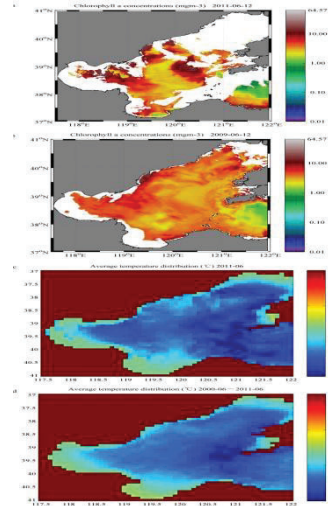

Figure4 Chlorophyll and sea surface temperature of Bohai Sea distributions for (a) Chlorophyll on 12 June 2011, (b) Chlorophyll on 12 June 2009, (c) Average temperature from in June 2011, and (d) Average temperature From June 2000 to June 2011(except 2003)
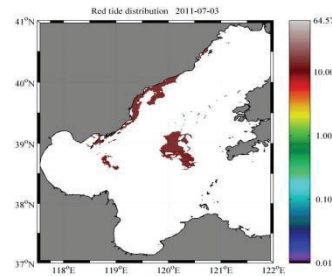

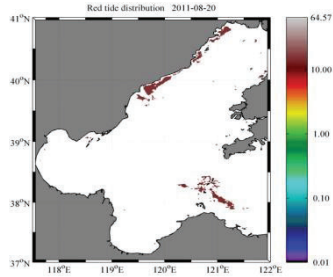Figure5 Red tide of Bohai Sea distribution on 03 July 2011

Figure6 Red tide of Bohai Sea distribution on 20 Aug 2011

3. CONCLUSIONS

From ENVISAT ASAR images observation and ECOM simulation, we found that some of oil slicks drifted from the point of the oil spill to the west or northwest Bohai Sea. Some slicks drifted to particular islands including Tuoji Island off the Yantai coastal zones, but most slicks remained near the point of the oil spill in the Bohai Sea. We found that the chlorophyll concentrations in a nearby area of the oil spill in Figure 4a were significantly increased and induced a red tide (see Figure 5 and 6).

4. ACKNOWNLODGYMENT

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