Spatial Statistical Analysis of Detected Illegal Vessel-Source Oil Discharges in Canada's Pacific Region.

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Abstract

We present the results in identifying possible hot spots of shipping-based oil pollution in Canada's Pacific Region, as well as a description of current research focus on exploratory spatial statistical analysis to relate the detected oil spill incidents with associated independent variables (e.g., shipping densities). This research provides an insight to understanding the spatial patterns of illegal oil spills detected by the National Aerial Surveillance Program (NASP) in Canada's Pacific Region to ultimately develop a predictive model that will allow mapping areas where these events are more likely to occur.

Background and Relevance

The National Aerial Surveillance Program (NASP) is the main tool used to monitor and prevent illegal discharges from marine vessels within Canada's Exclusive Economic Zone (CEEZ) (Transport Canada Marine Safety, 2004). On marine ecosystems, the ecological impact of these small chronic levels of oil pollution is shown to be greater than larger accidental oil spills (e.g., Exxon Valdez) (Burger, 1992; Wiese and Robertson, 2004). In the Pacific Region, marine pollution patrol flights are conducted routinely recording the location and time of each observed oil spill. However, monitoring and managing oil pollution resulting from small ship-source discharges can be challenging because of differences in spatial scale between the ship's level of operation, and complexity and immensity of the area to patrol. Our objective is to use multivariate statistical methods and exploratory spatial data methods to analyze patterns of oil spill data captured during NASP flights off Canada's West Coast.

Data and Methods

Spatial and temporal oil spill data collected by the NASP crew during fiscal years 1997/1998 to 2005/2006 were analyzed in this study. Flight path information also archived by the NASP program was used to calculate the total spatial coverage of surveillance effort (i.e., number of flights per unit area). Marine traffic related data were compiled from different sources: Information on the Traffic Separation Schemes (TSS) of Canada's Pacific Region was obtained from

Marine Safety Division of Transport Canada; Relative marine traffic densities for different vessel type groups (i.e., tugs, ferries, tankers, carriers, cruise ships and fishing vessels) were estimated from 2003 Vessel Traffic Operation Support System (VTOSS) data, courtesy of the Marine Traffic and Communication Services (MCTS) of Transport Canada.

Spatial patterns of documented oil spills were explored using three different techniques: the Quadrat Count method and the Kernel Density Estimation using a fixed and adaptive bandwidth (Worton, 1989; Bailey & Gatrell, 1995). Each density map was standardized by the number of flights in the study area to account for the uneven coverage of the surveillance effort; necessary measure for a correct interpretation of the spatial distribution of oil spills (Tufte et. al., 2004).

Current analyses are focused on: (1) exploring of the spatial relation between oil spills and the estimated number of vessel movements differentiating between vessel type classes; (2) identifying the number of oil spills that are present or absent within the limits of the main marine traffic lanes; (3) measuring the minimum distance between oil spills and shore, and the nearest port. The time dimension will be also incorporated into the analysis, to search variation of detected oil spills between seasons. These measurements expect to be important statistical indicators themselves, but they are aimed at the specification of a predictive model using spatial regression methods.

Results

The Kernel Density Estimation using an adaptive bandwidth was considered the most suitable method to represent the spatial pattern of detected oil spills. By standardizing oil spill density surface with surveillance effort a probability of detection map is obtained. Elevated detection values, or hot spots, are detected in the Strait of Georgia, Johnstone Strait and Barkley Sound, following the coastline and near harbours, such as Vancouver, Victoria, Nanaimo, Port Alberni, Campbell River, Port Hardy, Bella Bella, and Prince Rupert. Forthcoming analyses will incorporate a quantitative measure to the described oil spill pattern.

By relating oil spill patterns with different shipping activities and defined marine traffic zones we will investigate which shipping characteristics are possible drivers of the observed distribution of these illegal discharges. For example, the distribution of detected oil spills in relation with areas inside or outside shipping lanes could be an indicator of the type of vessels responsible for these oil discharges, since certain vessels are not committed to specific marine traffic routes (e.g. ferries, recreational vessels).

Conclusions

In conclusion, this study presents preliminary results of mapping illegal oil discharges and identifying possible hot spots, and ongoing analysis focuses on the incorporation of marine traffic related information and other measured variables into a spatial regression model aimed to explain the distribution of the observed oil pollution patterns.

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