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Estimation of the impact of prevailing weather conditions on the occurrence of oil-contaminated dead birds on the German North Sea coast

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Prevailing weather conditions have a significant impact on the occurrence of beached oil-contaminated sea birds.

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ABSTRACT

Chronic oil pollution by illegal oil dumping in the North Sea is difficult to quantify. Beached, oil-contaminated sea birds, however, may be used as an indirect indicator. Reconstructing the drift of oil slicks and sea bird corpses in the southern North Sea for the period 1992–2003 by means of a two-dimensional numerical transport model driven by re-analysed weather data, we show with an example of two common sea bird species that the variability observed within the number of corpses registered during beached bird surveys for the German coast primarily reflects the inter-annual variability of prevailing weather conditions. This should be taken into account when interpreting the data. We propose normalisation of beached bird survey data based on numerical drift simulations to improve the recognition of trends in the level of chronic oil pollution.

1. Introduction

While oil spills resulting from ship accidents attract much public interest, less dramatic, ongoing sources of oil pollution receive less attention. However, major oil pollution of the marine environment is caused by accidental discharges that occur during normal shipping operations or by illegal oil dumping, such as tank washing or the disposal of bilge water (Dahlmann and Theobald, 1988; Dahlmann et al., 1994). Shipping routes in the North Sea are among the busiest worldwide and the vast traffic in this area causes damage to the marine biota (Bernem van and Lübbe, 1997; Bundesamt für Seeschifffahrt und Hydrographie, 2008; Lozán et al., 2003; Reineking, 2005). The amount of oil spilled into the sea, however, is difficult to estimate, as chronic oil pollution often goes undetected (Schallier et al., 1996). To approximate trends in the magnitude of chronic oil pollution, continuous surveys of oil-contaminated sea birds, typical victims of oil pollution, are conducted. However, the number of beached birds is also influenced by other factors including, for instance, wind conditions (Camphuysen et al., 2005; Fleet and Reineking, 2000, 2001). This complicates the interpretation of beached bird surveys.

In this study, we show that neglecting the impact of changing weather conditions could for some species lead to a misinterpretation of beached bird survey data. For the investigation, results from beached bird surveys carried out on the German coast during the period 1992–2003 are utilized. We focus on two common sea bird species, namely Guillemot (*Uria aalge*) and Common Scoter (*Melanitta nigra*). Based on our results presented herein, an approach for normalisation is proposed. This efficiently reduces the meteorological signal and allows for a better assessment of possible trends in the number of corpses found during the surveys and hence in the general level of chronic oil pollution.

2. Data and methods

2.1. Beached bird survey data

Beached, oil-contaminated sea birds have been used as an indicator of chronic oil pollution since the 1960s (Fleet and Reineking, 2000). With the increasing recognition of the problem of oil pollution in the marine environment, the monitoring area has been enlarged and the beached bird surveys have been improved. On the German North Sea coast, surveys have been performed by volunteers twice a month during the winter season (October–March) since 1984. The results of beached bird surveys are used as an indirect measurement of chronic oil pollution. Analyses of oil samples indicate that the majority of birds are contaminated by heavy fuel oil from shipping (Fleet and Reineking, 2001).

Fig. 1a illustrates the annual number of oil-contaminated Guillemot (*U. aalge*, solid line) and Common Scoter (*M. nigra*, dashed) beached on the German North Sea coast for 1992–2003. These are relatively numerous bird species that are vulnerable to oil pollution (Fleet and Reineking, 2001, 2004; Garthe, 2003). During the winter,

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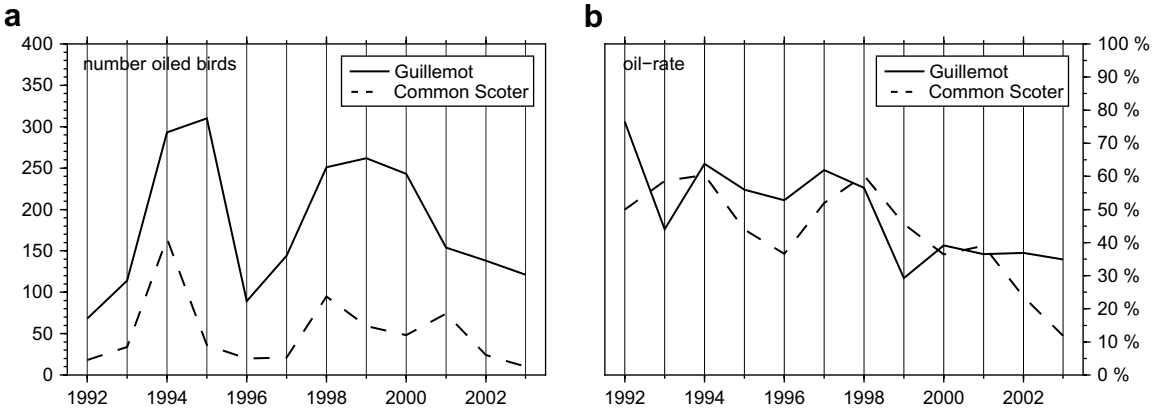

Fig. 1. (a) Number of beached, oiled Guillemot (solid line) and Common Scoter (dashed) at Germany's North Sea coast and (b) the percentage of beached Guillemot (solid) and Common Scoter (dashed) that were oiled within the period 1992–2003 (Jan.–Mar. and Oct.–Dec).

the Guillemots are distributed predominantly offshore in and around busy shipping routes (Stefan Garthe, personal communication). For this reason this species is preferred for the indication of chronic oil pollution (Fleet and Reineking, 2000). Common Scoters live at or near the coast.

Of note is the huge variability in the data presented in Fig. 1. In addition to oil pollution several other factors affect the number of birds recorded. For example, the number of oiled birds depends on the distribution and the size of their population (Camphuysen and Heubeck, 2001). To normalise the results, the percentage of beached sea birds that were oiled, denoted as the oil-rate, is used as an indicator (Fleet and Reineking, 2001) (Fig. 1b). However, circumstances such as mass mortality as a result of either extremely low temperatures, avian diseases or nutrition deficiencies also influence the oil-rate (Camphuysen et al., 2005; Fleet and Reineking, 2000, 2001). In addition, wind conditions regulate the number of beached sea birds and in some circumstances the oil-rate. To our knowledge, the quantification of the impact of weather conditions on beached bird data has not been studied systematically.

2.2. Modelling approach

Although aware that wind influenced the number of corpses recorded on the German North Sea coast, there was no attempt to standardise its effect in the past (Fleet and Reineking, 2004). In our study we exploit model based high resolution information about past atmospheric winds and North Sea currents (www.coastdat.de) to improve the quantitative handling of wind effects on beached bird survey data. Based on Lagrangian drift simulations (cf. Section 2.3) we attempt to produce a detailed picture of weather related annual variability within the beached bird survey data.

Given oil pollution at a certain location, it is impossible to say exactly when and where contaminated birds will die. Therefore, as wind drift factors happen to be similar for oil slicks and bird corpses (Bibby and Lloyd, 1977; Dick and Soetje, 1988), tracer particles are considered to be representative for drift behaviour of both items. In order to describe ship related chronic oil pollution, source regions for tracer particles are defined to contain the major shipping routes in the North Sea (Golchert and Benshausen, 1987; Reineking, 2005) (Fig. 2). For each source region the number of simulated tracer particles reaching the German coast is re-weighted according to (a) the estimated density of ship traffic and (b) particle travel time, assuming an exponentially decreasing particle weight. The latter emphasizes the particles originating from regions closer to the coast.

2.3. Numerical simulation of wind drift effects

The Lagrangian trajectories of passive tracers were calculated based on state-of-the-art re-analyses of past atmospheric and sea state conditions in the North Sea. Detailed hindcasts of shelf sea currents with hourly resolution were taken from the coastDat database (www.coastdat.org). They are the result from running a two-dimensional finite element model (TELEMAC-2D (Hervouet and van Haren, 1996)) on a triangular grid with a variable spatial resolution between a couple of kilometres offshore and about 100 m near the coast (Plüß, 2004). Hence, the model represents all relevant transport processes including both tidal and weather driven residual currents. Regional atmospheric fields stored in coastDat and employed to force the marine model at its upper boundary were produced based on NCEP re-analyses (Kistler et al., 2001), using the regional climate model SN-REMO (Meinke et al., 2004) for dynamic downscaling. Displacements of tracer particles contain a vertical and horizontal random component. For particles at the water surface, an additional drift of 1.8% of the 10 m wind was superimposed (Bibby and Lloyd, 1977; Dick and Soetje, 1988). This additional drift component was assumed to decrease with water depth if particles submerge. To properly resolve the history of weather related drift processes in 1958–2003 in the German Bight, drift simulations for ensembles of 2700 particles each were initialized every 28 h in the vicinity of the major shipping routes. Tracing particle travel times allowed for a statistical re-weighting of the drift simulations assuming particle weights exponentially decrease with a time constant of 21 days, which is clearly smaller than the maximum integration time of 60 days.

3. Results and discussion

3.1. Wind signals in beached bird survey data

The weighted numbers of stranded tracer particles are compared with the survey data already pictured in Fig. 1. The comparison is illustrated in Fig. 3. Simulations are restricted to the winter months when the surveys are conducted. Inter-annual

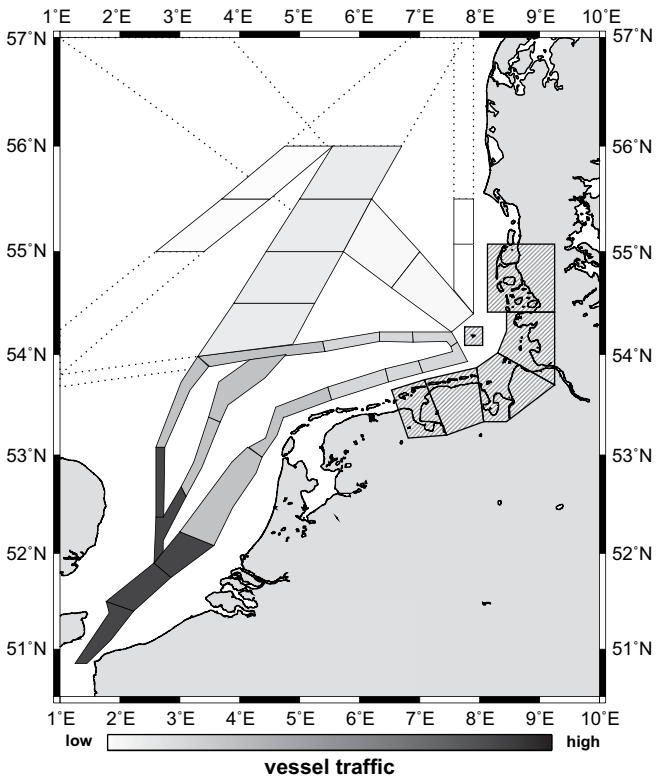

Fig. 2. Particle source regions containing all major shipping routes (different levels of grey shading represent different densities of shipping traffic (Golchert and Benshausen, 1987; Reineking, 2005)) and target regions along the German coast (hatched).