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## Marine oil spill risk assessment in the Arctic: Combining species distribution models, oil spreading calculations and expert knowledge

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Climate change lengthens the ice-free period in the Arctic, which opens new opportunities for maritime traffic and oil drilling operations. These activities pose a major threat to Arctic marine ecosystems in the form of accidental oil spills. Developing effective management strategies calls for risk assessment methods that can cope with limited data and high uncertainties typical for the Arctic. Here we present a probabilistic approach for ecological oil spill risk assessment for such cases. The method estimates the proportion of the population that will die due to oiling (hereafter OSI) within two weeks after an accident. It combines information on three components: 1) spatiotemporally varying species' densities (estimated with probabilistic species distribution models); 2) spreading of oil in varying ice conditions (estimated with Fay-type equations); and 3) species-specific exposure potentials and sensitivities to oil (elicited from experts and literature). We used the Kara Sea as a case study, and included five navigation routes, three seasons, and four oil types in the analysis. We estimated OSI for three arctic marine mammal species: polar bear, ringed seal, and walrus. The results show that OSI varies between species, locations, seasons, and oil types. Further, associated uncertainties are high. It is essential that these uncertainties are shown explicitly, if the results are to be used to support decision-making related e.g. to marine spatial planning. The method provides quantitative risk estimates with explicit uncertainty estimates, and a relatively simple way to make justifiable risk comparisons over large spatial areas.

Keywords: oil spills, uncertainty, arctic marine mammals, ecological risk assessment, species distribution modeling, Arctic, the Kara Sea

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