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The potential for dispersant use as a maritime oil spill response measure in German waters☆

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A R T I C L E I N F O

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A B S T R A C T

In case of an oil spill, dispersant application represents a response option, which enhances the natural dispersion of oil and thus reduces coating of seabirds and coastal areas. However, as oil is transferred to the water phase, a trade-off of potential harmful effects shifted to other compartments must be performed. This paper summarizes the results of a workshop on the current knowledge on risks and benefits of the use of dispersants with respect to specific conditions encountered at the German sea areas. The German North Sea coast is a sensitive ecosystem characterised by tidal flats, barrier islands and salt marshes. Many prerequisites for a potential integration of dispersants as spill response option are available in Germany, including sensitivity maps and tools for drift modelling of dispersed and undispersed oil. However, open scientific questions remain concerning the persistence of dispersed oil trapped in the sediments and potential health effects.

1. Introduction

Oil spills can seriously affect the marine environment both as a result of physical smothering and toxic effects. The severity of an impact typically depends on the quantity and type of oil spilled, the ambient conditions and the sensitivity of the affected organisms and their habitats to the oil (Boyd et al., 2001). In case of an oil spill at sea, spill managers have to decide on the most effective spill response to minimize damage. In addition to mechanical containment and recovery using booms and skimmers, application of dispersants on the oil slick is another response option, which enhances the natural break-up of floating oil into small droplets in the water column. In this way, coating

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of coastal areas and oiling of sea birds and mammals can be reduced (IPIECA-OGP, 2015a). Furthermore, by enlarging the overall surface of the oil, many experts provide evidence that the bio-degradation of oil by naturally-occurring marine microorganisms is enhanced (Prince et al., 2013) although these findings have been challenged (Kleindienst et al., 2015). Anyway, due to the increased concentration of oil components within the water column resulting from the oil dispersion, toxic effects on pelagic, demersal and benthic living organisms can potentially be increased (Claireaux et al., 2013).

There are conflicting views concerning the potential risks and benefits for human health and the environment generated by the use of dispersants during oil spills (Bostrom et al., 2015; Prince, 2015). Up to now, no comprehensive assessment of risk associated with the use of chemical dispersants has been developed for German marine waters, which could provide guidance for the national response organisation. Therefore, a workshop was held in November 2015 to bring together experts from authorities, research institutions and international organisations to summarize and discuss the current scientific knowledge on risks and benefits of this response strategy.

The objectives of the workshop were:

- to identify pros and cons for use of dispersants as an option for oil spill response in Germany,
- to identify options to balance risks and benefits of different treatment options, and
- to identify open scientific questions concerning the risks of dispersant application in Germany.

Summaries of the individual presentations excluding discussions held at the two day event are provided in the workshop proceedings (Grote et al., 2016). The aim of the present paper is to summarize the main results of the workshop and to lay down a common understanding and interpretation of the situation and the scientific challenges of a conceptual framework for applying dispersants in a large scale after oil spills under German responsibility. This includes

- to give an overview on current practice, guidance on and operational experience concerning dispersant use,
- to present the relevant information concerning specificities of German marine waters (geography, ecosystems, meteorology, hydrodynamics etc.), and
- to discuss specific risks and benefits of a potential dispersant application in German waters and to identify open scientific questions.

2. Current practice, guidance, effects of dispersants and operational experience

2.1. What are dispersants and how do they work?

Dispersion of oil, i.e. the break-up of larger oil volumes into little droplets, is a naturally occurring process, which depends on the oil characteristics, its weathering stage and environmental parameters such as wave energy, salinity, temperature etc. (Zeinstra-Helfrich et al., 2015). This process can be enhanced by application of specific chemical formulations, so called dispersants. Dispersants are mixtures of surfactants in one or more solvents, designed for application onto oil slicks aiming to reduce the interfacial tension between the oil and the water phase and thus increase the natural dispersion of the oil. In order to promote dispersion and work as a successful spill response measure, the dispersant must get into the oil layer, i.e. the surfactant must be able to physically mix with the polluting oil (IPIECA-OGP, 2015b). Therefore, the efficacy of a dispersant formulation will not only depend on its chemical composition but also on the chemical characteristic of the oil, environmental parameters, the application technique and the quantity of the dispersant spread onto the slick (Dispersant – Oil Ratio, DOR). If the oil is overly viscous and therefore no physical mixing is possible, chemical dispersion will not be possible in most circumstances. Dispersion is most efficient on light oil which has a low viscosity. As a general rule, the higher the oil viscosity, which is typically increased by weathering processes and by low ambient temperatures, the less efficient is the dispersion. Weathering processes encompass all chemical (dissolution, evaporation, photo oxidation) and physical (natural dispersion, emulsification) processes which will occur immediately after the release of the oil at sea and which will induce chemical and physical modification of this oil, e.g. the increase of its viscosity. Furthermore, as dispersant formulations are typically optimised for use in marine waters and in temperate climate, they prove to be less efficient in brackish or fresh water and at low temperature. However, recent work to Arctic spill response indicated that even at low temperatures dispersants can still effectively applied. Viscosity might increase, but as weathering slows down, the window of opportunity might be larger at low temperatures (Lewis and Daling, 2007).

2.2. Important guidelines concerning dispersant use (e.g. IMO, EMSA)

One major objective of dispersant use is the transfer of oil from the water surface into the water column. As a result, exposure for surface dwelling and intertidal species and contamination of coastal habitats is potentially decreased, while it is increased for pelagic and benthic organisms. Thus, inherent to the decision whether or not to use dispersants is the implicit trade-off among different habitats and species with different ecological, social, and economic values. The methodology for a predictive comparison of estimated beneficial and harmful effects of different response options is typically referred to as Net Environmental Benefit Analysis (NEBA) (IPIECA-OGP, 2015a). A NEBA is always based on the comparison of different oil spill response options which will result in specific scenarios of environmental damage to biology and ecosystem services but also includes the potential for recovery. It mainly focusses on the environment. However, as typically other aspects such as economic, cultural and human health impacts have to be considered when taking a decision on spill response measures, the term Spill Impact Mitigation Assessment (SIMA) has recently been introduced (IPIECA-OGP, 2017). These terms are not always used in a consistent way. Here we use NEBA for assessment of environmental effects and SIMA for a broader assessment incorporating other aspects.

Internationally, the use of dispersants has gained wide acceptance as one of several response options for oil spill response. The International Maritime Organisation (IMO) is currently working on revising guidelines for dispersant use providing guidance for the decision process whether or not to use dispersants in a specific case (decision tree) (IMO, 2014). Furthermore the European Maritime Safety Agency (EMSA) has published a *Manual on the Applicability of Oil Spill Dispersants* (EMSA, 2010) in European waters. Comprehensive overviews on the authorisation, preparedness and use of dispersants are provided by the *International Tanker Owners Pollution Federation* (ITOPF) and the *Global Oil and Gas Industry Association for Environmental and Social Issues* (IPIECA) (IPIECA-OGP, 2015a,b; ITOPF, 2011).

If an incident occurs, different response options are usually evaluated and may potentially be applied in parallel. The overall purpose of a practical and operational decision process is to enable relevant authorities to check swiftly whether dispersant use is an appropriate option, i.e. to verify that conditions are met to achieve satisfactory results. Considering that chemical dispersants are most efficient during the early stages/hours after the spill, it is of utmost importance that a decision is taken as quickly as possible.

It is proposed that for the decision whether to apply dispersants to a specific oil spill, the following issues should be addressed by successively answering three questions:

1. Is dispersion possible? (i.e., is the specific oil type dispersible from a physico-chemical point of view at the given environmental conditions?)