State-of-Science of Dispersants & Dispersed Oil in U.S. Arctic Waters

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KEY ARCTIC ENVIRONMENTAL FACTORS:

1. Large river systems introduce freshwater and suspended and dissolved materials to Arctic Ocean waters representing highly effective horizontal modes of transport during oil spills.
2. Seasonal ice melting and large river systems contribute to low salinity surface waters and create a near-surface pycnocline, which inhibits mixing.
3. All types of sea ice, create mixing from the relative motion between ice floes, due to wave penetration caused by the wind.
4. Frequent large storms occur in winter in the Bering-Aleutian system.

A recent SONS Arctic oil spill drill identified the need for a detailed evaluation of the state-of- science of dispersants and dispersed oil (DDO) as it applies to Arctic waters. The Coastal Response Research Center (CRRC) worked with NOAA, other government, academic and private sector representatives to determine the state of DDO science, specifically the 'knowns' and 'uncertainties'. The five topics evaluated were: Efficacy and Effectiveness; Physical Transport and Chemical Behavior; Degradation and Fate Public Health and Food Security; and Eco-toxicity and Sublethal Impacts. Highlights from first three topic areas include:

Efficacy & Effectiveness
Oil that is dispersed in warmer regions is expected to remain dispersible in colder regions if it is warm enough for the oil to remain fluid.
Subsea dispersant effectiveness in the Arctic will be equivalent to effectiveness elsewhere given the same conditions at depth.
Key factors affecting Arctic effectiveness include: temperature; mixing energy and the impacts of ice; oil type (viscosity, weathering); emulsification; dispersant formulation; dispersant to oil ratio; salinity, and dilution potential (open ocean vs tide pools).
Uncertainties for the Arctic effectiveness include: complex interaction of factors driving dispersion at cold temperatures; dispersability of higher viscosity oils; effects of different ice forms on surface mixing; and effects of different dispersant formulations.

Physical Transport & Chemical Behavior
In the Arctic, transport processes are similar to other regions of the world when considering open water conditions; once oil is frozen into ice, open ocean transport processes are no longer dominant, and the encapsulated oil will move with the ice.
Spreading of dispersant-treated oil in ice-infested water is difficult to predict.
Water-soluble constituents in the oil can be released to the brine and be transported to the water underneath the ice during melting.
The weathering process is slowed in Arctic conditions. The dispersant application window can be as long as seven days.
Lower temperatures result in higher viscosity and reduced oil spreading rates when compared to more temperate waters.

Degradation & Fate of Oil / Dispersed Oil
Oil may sink as a result of OMA or OSA which are impacted by factors such as oil type, suspended material, water column depth, salinity, and mixing energy.
Marine snow captures oil and other materials and sinks. There is an uncertainty about whether microbial-derived marine snow formation is inhibited by dispersants
Oil degrading microbes are ubiquitous and will actively degrade constituents in crude oil at -1°C in Arctic near-shore and offshore waters.
Lower molecular weight hydrocarbons in oil degrade faster than higher molecular weight hydrocarbons in the Arctic.

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