Title: Impact of Spilled Oil in Sea-Ice Communities

Task Leaders and Participants: Coastal Response Research Center (CRRC) and National Oceanic and Atmospheric Administration (NOAA)

Anticipated Start: Mid 2010 Estimated Completion: Mid 2009 Duration: 2 years

Date: 20 July 2006

1. Background and Justification

Recent research demonstrates that diverse microbial communities, including heterotrophic bacteria, unicellular algae and protists, exist in association with the sea-ice interface, and as in all ecosystems, form the basis of the food web. Through photo-synthesis, the biomass production by micro-algae is on the order of 2 – 3 mg-C/m^2 (Rysgaard et al., 2001) in areas comparable to the proposed experimental spill (SINTEF, 2006). Protists and other organisms such as zooplankton graze on the algae and bacteria controlling overall biomass production. The composition of the community changes with the amount of sunlight and temperature. The microbial communities live on the sea-ice surface, within the ice in pore spaces and brine channels, and on the bottom of the ice (at the seawater-ice interface), and is patchy in its horizontal and vertical distributions. The sea-ice algae are grazed by zooplankton, which in turn are consumed by deep-water fish that migrate to the underside of the ice (secondary production). This also results in the migration of seals, seabirds and whales to these zones as top level predators of the system.

Hence, accumulation of spilled oil on the underside of sea-ice could impact the marine ecosystem in several ways. First, direct effects of oil toxicity to primary production have potential repercussions on the food web. Secondly, bioaccumulation of petroleum compounds (i.e., PAHs) provides a vector for transferring contaminants into the pelagic food web. Thirdly, consumers that congregate at the sea-ice interface to feed may be exposed directly by the oil phases (dissolved, particulate, and bulk oil). Thus, there is a current limitation in understanding biological effects of spills under oil-in-ice field conditions. Additionally, there is limited information on the rates of biodegradation of oil constituents by the sea-ice heterotrophic bacteria.

This proposal outlines several avenues of biological research that could enhance understanding of the impacts that spilled oil accumulated under ice may have on the sea-ice communities or the higher organisms that graze upon them. These research ideas are designed to complement the larger Joint Industry Project (JIP) for "Oil Spill Contingency for Arctic and Ice-infested Waters" (SINTEF, 2006).

2. Objective

The overall objective of the biological component to the JIP is to monitor the bottom sea-ice microbial community before and after it is exposed to spilled oil and compare the results to a control sea-ice community (not exposed) to predict how the community will

respond to oil exposure and how the impacts may be translated through the arctic food web.

3. Deliverables

Deliverables will include peer-reviewed publications and technical documentation to enhance future decision-making regarding resources at risk in ice-infested waters.

4. Scope of Work

Response of Microbial Community Structure to Oil Exposure
Samples of sea bottom ice will be taken prior to the planned spill and then after the spilled oil has coated the bottom of the ice. After the experimental spill, samples will be collected over time. Microbial community structure (algae, bacteria and protists) will be characterized using molecular techniques, with particular attention to species diversity and abundance. Concentrations of the suite of alkanes and PAHs associated with the bottom of the sea ice and adjacent water column will be monitored over time to determine the exposure concentrations and weathering fingerprints of the oil constituents.

Impact of oil exposure on sea-ice primary production and biodegradation rates
1) Sea-ice samples will be collected in the field and used to as a source of microbes for laboratory microcosms where primary production and biodegradation rates are estimated. The algae, bacteria and protists isolated from the collected sea-ice samples will be used to seed the bottom of ice created by freezing sterile seawater. These laboratory sea-ice samples will be used in the microcosms.
2) The photosynthetic rates of the algae in the laboratory sea-ice samples will be monitored as a function of typical boreal summer light levels for replicates of control (no oil), and oiled ice. These tests will be conducted at various light levels and temperatures over time along with detailed PAH analysis.
3) Biodegradation rates of the PAHs by the microbial community associated with the laboratory sea-ice samples will be assessed in microcosms. These samples will be exposed to oil or non-oiled conditions.

Characterizing Exposure of Community to Oil Constituents
Passive samples will be deployed on, and below the bottom ice surface as surrogates for organisms. These will be sampled to estimate exposure of organisms to specific oil constituents over time.

5. Time Schedule

It is anticipated that CRRC and NOAA would assemble a peer-reviewed team of scientists to perform the proposed work staring in mid-2007 and finishing in mid-2009.

6. Cost Estimate

$200,000 to $300,000 (US) to be covered by CRRC.

7. Interdependencies with Other Tasks

Task 6. Preparation of Generic Oil Spill Contingency Plan
Task 8. Field Experiments