BOEM ENVIRONMENTAL STUDIES PROGRAM: Ongoing Studies

Study Area(s): Beaufort Sea, Chukchi Sea

Administered By: Alaska OCS Region

Title: Crude Oil Infiltration and Movement in First-year Sea Ice: Impacts on Ice-associated Biota and Physical Constraints (AK-13-03-06)

BOEM Information Need(s) to be Addressed: This project will address some of the questions related to infiltration of oil into sea ice and its biological impacts. This is much needed information with regard to the analysis of potential oil spills in the Arctic, particularly during winter months when ice cover is unavoidable. BOEM analysts and decision-makers will use this information in NEPA analysis and documentation for lease sales, EPs, and DPPs.

Total Cost: $298,214
plus Joint Funding ($298,214)

Period of Performance: FY 2014-2018

Conducting Organization: CMI, UAF

BOEM Contact: Dr. Heather Crowley

Description:

Background: Sea ice plays a critical role in the physics, chemistry and biology of polar seas. Increased oil and gas exploration and development, along with increased shipping in Arctic seas, are increasing the likelihood of oil spill events during periods of ice cover in these areas. Oil spilled under sea ice will initially accumulate under the ice but will then be redistributed through various physical processes, including entrainment into the brine channel system of the sea ice. The extent to which this movement occurs depends on the porosity of the ice, which is temperature and salinity dependent. In addition, the highly variable abundances of biota can substantially alter the characteristics of the brine channel network.

Sea ice provides a habitat for a wide range of biota that inhabit the surface, interior, and bottom ice layers including single-celled organisms such as diatom algae as well as multi-cellular taxa such as nematode round worms, various crustaceans and Arctic cod. These ice biota fuel Arctic food webs by providing an early and, for some taxa, nutritiously superior food pulse to pelagic and benthic fauna before the onset of pelagic production. Depressed sea-ice derived production caused by toxic or mechanical effects of oil would cascade up the food chain both in the pelagic and benthic realms.

Objectives:

- Adapt and apply potentially suitable, simple analytical and fluid dynamics numerical models to the small-scale movement of oil in ice.

- Compare results from mesocosm experiments conducted in nearly sterile versus highly populated biomass of sea ice to assess the effects on oil migration.
- Assess changes in sea ice flora and fauna composition in association with exposure to oil.
- Analyze the dependence of the volume fraction of ice impacted by oil on the small scale, as well as the mobilization of oil, on the evolution of ice microstructure during spring warming.

Methods: Field work will be conducted off Barrow, Alaska, during the sea ice-covered season in 2014 and 2015. Geophysical and biological measurements, as well samples of ice biota will be collected during different seasons, spring (April 2014) and early spring (Feb/March 2015), because physical and biological properties of sea ice change with increasing temperature and irradiance. Sections from at least three ice cores per sampling period and site will be melted directly in the dark and divided for measurements of algal pigment concentrations and measurement of particulate organic carbon (POC) and nitrogen (PON). Sea-ice geophysics data obtained in the field will include continuous measurements of ice temperature, thickness and snow-depth evolution with automated sensor. During field visits, ice cores will be extracted for analysis of ice stratigraphy, salinity, temperature and oxygen stable-isotope composition. On-ice thickness surveys will provide information on spatial variability of ice and snow thickness.

Ice tank experiments will be conducted at UAF. Two tanks each will be dedicated for each of three treatments: 1) an abiotic control (-biota, +oil); 2) a biotic control (+biota, –oil); and 3) an experimental treatment (+biota, +oil). Prior to collection of sea ice biota, the experimental design will be tested with an abiotic control to compare microstructure of artificial and natural sea ice. Natural sea ice biota collected from Barrow (see above) will be concentrated in biomass and inserted into treatments 2 and 3 after the initial sea ice cover has reached a thickness of ~5 cm. Crude oil will be released into treatments 1 and 3 under the ice, and after incubation for 2, 10 and 20 days after the oil release, small ice cores (5 cm diameter) will be taken to quantify biological parameters. Biological parameters to be quantified include ice algal pigment concentration, mass of particulate organic carbon and nitrogen, abundance of ice meiofauna, and extracellular polymeric substances as well as bulk salinity, porosity, and oil concentration.

Current Status: Awaiting final report

Final Report Due: December 2017

Publications Completed: None

Affiliated WWW Sites: http://www.boem.gov/akstudies/
http://www.sfos.uaf.edu/cmi/

Revised Date: July 3, 2017

ESPIS: Environmental Studies Program Information System
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