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When Oil Meets Ice: Assessing the Capacity for Microbial Oil Biodegradation in the Arctic Ocean

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Rapid arctic warming and declining sea ice are opening northern waters to increased shipping and resource extraction. This raises the likelihood of accidental oil spills that pose serious risks to Inuit communities and Arctic marine ecosystems. Because the presence of sea ice limits access to oil contaminants for mechanical or chemical cleanup, biodegradation by natural microbial populations is the most viable response strategy. Despite its importance, our limited understanding of how microbial communities degrade petroleum oil in ice-laden waters continues to hinder the development of effective spill-response strategies. To address this gap, we conducted 8-week mesocosm experiments at the Ocean-Sea Ice Mesocosm (OSIM) Facility in Churchill, Manitoba. This state-of-the-art facility allows us to add large volumes (130 L) of diesel to expansive pools of ice-laden seawater (255 m^3 each) in a controlled setting. To track the response of microbial communities under realistic arctic conditions, we leveraged a combination of genomic and geochemical approaches. Specifically, metagenomics with longitudinal modeling was used to catalogue taxa and genes indicative of oil biodegradation. In parallel, extracellular enzyme assays were used to quantify the rates of microbial enzymatic activity based on the degradation of organic compounds. Preliminary results indicate that diesel-impacted communities exhibit slow (>20 days), but pronounced shifts in community composition, including substantial increases in known oil degraders (e.g., *Cycloclasticus*). Integration of genomic and enzymatic datasets is nearly complete and will further resolve the genes and pathways involved in oil degradation, while geochemical data will quantify rates of biodegradation within sea ice and the underlying waters. By generating a mechanistic framework for biodegradation in the Arctic Ocean, this work will provide new insights into the capacity and constraints of microbial oil biodegradation under ice-covered conditions.