Effects of oil spills on Arctic pelagic ecosystems - Winter exposure and variations in sensitivity

In a world where climate is changing faster than ever previously recorded, the Arctic is in the front line experiencing substantial environmental changes at accelerating speed. One of these changes, the declining sea ice cover, encourages exploration of the regions abundant offshore fossil fuel reserves. This has raised international concerns about emergency preparedness and oil spill prevention, because the time scale of ecosystem impact and recovery could be extensive in Arctic regions. The vulnerability of Arctic marine ecosystems to oil spills is influenced by a strong seasonal biological production and a number of unique species adaptations that result in variations in sensitivity over the annual cycle. A particular challenge for risk assessment of oil activities is that biological background data from the winter period often is insufficient. This thesis outlines my work on effects of oil spills on Arctic pelagic ecosystems, where I have focused on winter exposure and variations in sensitivity of the lower trophic levels – the microbial and copepod communities. These communities are fundamental to the function of the marine ecosystem because their interactions generate the high-energy lipids that upper trophic levels rely on for coping with strong seasonal variations in food availability. The thesis is based on four papers addressing two main questions; Firstly, how does a surface oil spill impact ice-associated plankton communities during the ice-covered period, and how is vulnerability affected by available oil spill response methods (paper I and II)? And secondly, how does an oil spill on deep water impact overwintering zooplankton communities, and how is species vulnerability affected by differences in reproduction strategy (paper III and IV)? Based on mesocosm studies, we first show that a surface oil spill in sea ice in winter can lead to alterations in the structure and function of ice-associated plankton communities in spring, and potentially cause indirect cascading ecosystem effects through trophic interactions in the Arctic marine food web. During the ice-covered period, these plankton communities are less vulnerable to an oil spill treated with in situ burning, and more vulnerable when chemical dispersant is used. Then, based on laboratory studies, we further show that an oil spill on deep water in winter can severely impact the two most important zooplankton species in Arctic ecosystems, which are important ecosystem components responsible for energy transfer to upper trophic levels of the marine food web. Both lipid content and reproduction strategy play an important role for determining the vulnerability to oil exposure during their overwintering. The findings of this thesis provides novel insights to the seasonal vulnerability of Arctic pelagic ecosystems to oil spills, which is important for improving risk assessment of oil activities in the Arctic

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