

SEA ICE, HYDROCARBON EXTRACTION, RAIN-ON-SNOW AND TUNDRA REINDEER NOMADISM IN ARCTIC RUSSIA

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It is assumed that retreating sea ice in the Eurasian Arctic will accelerate hydrocarbon development and associated tanker traffic along Russia's Northern Sea Route. However, oil and gas extraction along the Kara and Barents Sea coasts (Fig. 1) will likely keep developing rapidly regardless of whether the Northwest Eurasian climate continues to warm (Forbes et al. 2014). Less certain are the real and potential linkages to regional biota and social-ecological systems. Reindeer nomadism (Fig. 2) continues to be a vitally important livelihood for indigenous tundra Nenets and their large herds of semi-domestic reindeer (Forbes 2013).

Warming summer air temperatures over the NW Russian Arctic have been linked to increases in tundra productivity, longer growing seasons, and accelerated growth of tall deciduous shrubs (Fig. 3). These temperature increases have, in turn, been linked to more frequent and sustained summer high-pressure systems over West Siberia, but not to sea ice retreat (Macias-Fauria et al. 2012). At the same time, winters have been warming and rain-on-snow (ROS) events have become more frequent and intense, leading to record-breaking winter and spring mortality of reindeer (Bartsch et al. 2010). What is driving this increase in ROS frequency and intensity is not clear, but we may have some clues.



Fig. 4. Dead reindeer calf, Yamal Peninsula, Siberian Times, 20 March 2014



Fig. 5. Two ice layers from rain-on-snow, Yamal Peninsula



Recent modelling and simulation by Screen et al. (2014) have found statistically significant near-surface atmospheric warming and precipitation increases during autumn and winter over Arctic coastal lands in proximity to regions of sea-ice loss. Another team evaluating re-analyses of seasonal atmospheric data products from around the Arctic Ocean found winter heat fluxes were greatest over the Barents Sea (Lindsay et al. 2014). On the other hand, recent GCM simulations by Petoukhov and Semenov (2010) indicate that decrease of the wintertime sea ice cover in the Barents and Kara (BK) Seas does not always result in *a priori* expected warming over adjacent continental areas. During the winter of 2013-14 an extensive and lasting ROS event led to the starvation of 61,000 reindeer out of a population of ca. 300,000 animals on Yamal Peninsula, West Siberia (Figs. 4-5). Historically, this is the region's largest recorded mass mortality episode.

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Participatory mapping fieldwork (Fig. 6) with nomadic herders during summer 2014 and spring-summer 2015 revealed that the ecological and socio-economic impacts from this extreme event will unfold for years to come. Some Nenets nomads lost all of their reindeer and will need to rebuild their herds from scratch, subsisting on fish (Fig. 7) year-round and unable to





Fig. 6. Mapping the 2013-14 ROS event with Yamal herder



Key literature:

migrate until they do so. There is an urgent need to understand whether and how ongoing BK sea ice retreat may affect the region's ancient and unique social-ecological systems. Re-analyses of BK winter atmospheric feedback data by Kim et al. (2015) project that BK sea ice could completely disappear by 2022. If recent sea ice retreat is contributing to increasingly severe ROS events and high reindeer mortality, it has major implications for the future of reindeer nomadism. At the same time, rapid oil and gas infrastructure expansion has strong potential to limit the movement of large herds during extreme events. Using participatory methods, Nenets can contribute expert knowledge and skills to the study of BK climate change (Barnes et al. 2015).



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