Idea492

Project Idea for the International Polar Year 2007/2008

Title: The biogeochemistry of methyl mercury in the Arctic Ocean and its relevance for humans

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Project description:
Several gaps exist in our understanding of mercury sources and its fate in marine food webs in the Arctic Ocean despite the fact that high levels of methyl mercury have been measured in marine fish and mammals which present an important food source for the local human population. This is especially critical because the Arctic Ocean is experiencing rapid changes due to global warming and associated changes in the hydrological cycle of the Arctic. It has been suggested that the global hydrological cycle is undergoing significant changes with increased evaporation at low latitudes and increased precipitation at high latitudes. This changing pattern could favor the long range transport of mercury from industrialized regions at mid northern latitudes to the Arctic thereby increasing the amount of mercury introduced to Arctic ecosystems.

Mercury is introduced into the environment by both natural and anthropogenic sources. It typically enters into aquatic systems in inorganic forms and is converted to monomethyl mercury (MMHg) by microorganisms, principally in surficial sediments. MMHg is the form of mercury that enters into aquatic food webs and bioaccumulates as it is transferred into higher trophic levels. MMHg is a neurotoxin, with the fetus being particularly sensitive. Humans can be exposed to mercury by several routes, but consumption of shellfish and finfish with elevated mercury contents is the dominant pathway. Exposure of MMHg to local human populations in the Artic from contaminated fish and mammals is well recognized as a significant health risk. Large vertebrates such as seals are especially important vectors since they are top level predators and are also long-lived. Not enough is known about the pathways of mercury from its input, bacterial transformation to MMHg, uptake by phytoplankton, zooplankton, and accumulation in fish and mammals in the Arctic Ocean. Measured levels of mercury in the diet of the local population significantly exceeded limits established by the FAO/WHO.

Several steps between the introduction of mercury to the Arctic ecosystem to the accumulation of MMHg in top predators are not at all understood and need to be investigated

within a multidisciplinary framework. Our main gaps in the understanding of mercury biogeochemistry include:

1. The role of organic matter for the introduction of mercury to the coastal environment.
2. The transport of mercury from surface waters to locations of mercury methylation.
3. The location, identity and activity of organisms responsible for mercury methylation.
4. The distribution and transfer of MMHg from solution into biological tissue.
5. The most effective trophic linkages, leading to MMHg accumulation in top predators.
6. The identification of the key species that seem to be most problematic for human consumption.

A unique feature of the Arctic Ocean are the large freshwater discharge and elevated levels of terrestrial-derived dissolved organic matter (DOM) which could act as an important transport agent for Hg and MMHg in the Arctic. Through our involvement in a funded project which is looking at the seasonal discharge of organic and inorganic matter by the 6 largest Arctic rivers we have access to a unique sample set which will allow us to determine the potential mercury input via rivers. Cooperations will be established with colleagues in atmospheric sciences to include the eolian input of mercury. Studies of the organic matter/mercury biogeochemistry on the Arctic coast and shelves will elucidate the mercury transport pathways in dependence of organic matter composition and mercury speciation. Mercury methylation will be determined by using a molecular microbiological approach to determine the prime locations and most important bacterial species involved in MMHg production.

The transport of MMHg from the location of production into the tissue of fish and mammals is also poorly understood. Potential mechanisms include turbulent mixing (through enhanced predator prey contact) and trophic transfer. Both of these pathways will be studied in order to quantify the rate of MMHg distribution on the shelves. The final link to human consumption will be addressed by close cooperation of our fisheries ecologist with the local population and fisherman/hunters which will supply important samples for MMHg determinations. We are also in contact with Anne Sweeney, an environmental epidemiologist, and will get her involved in the project for a more systematic investigation of the effects methyl mercury has on the local human population.

Through our past involvement in Arctic research we already have access to the quantitatively most important rivers and some coastal shelf ecosystems. More focused sampling programs will have to be developed in the most productive estuarine areas and locations where the hunting and consumption of fish and seals are high. International cooperations are already in place with groups in Germany, Sweden and Russia as well as with a group in Alaska to gain a pan-Arctic understanding of the mercury issue in the coming years.