Research for the IPY

Title: Rapid transport of pollutants in drift ice to melting fronts.
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At the end of the 19th century, Fridtjof Nansen reported "dirty ice" in the Arctic, far from the civilized world. The ice contained mineral particles from the near shore regions of Siberia and layers of plankton from the periods of summer growth, being supported, in part, from the natural deposition of nutrients from the atmosphere. In those days, pollution of the Arctic was an unknown concept. Sea ice as a transport medium for the redistribution of long-range atmospheric transport of *pollutants* has not been fully appreciated. The pollutants of interest are primarily persistent organic pollutant (e.g. PCBs, PBDEs) and heavy metals (e.g. mercury, cadmium). Ice may gather contaminants from the atmosphere, the water column, shallow sea beds, when sediments are resuspended during ice formation, and from the surface micro layer, during ice drift. There are few direct measurements available to quantify the *transport* of contaminants deposited on ice floes.

During the winter and spring, both seasonal, first-year ice and drifting multi-year ice melt at the Polar Front where it meets the warm Atlantic water. These are regions of high primary production and potentially increased exposure to and uptake of contaminants by biota. They occur near Svalbard and Iceland. Cod caught to the northwest of Iceland, near the East Greenland Current show higher concentrations of cadmium than those caught in the North Icelandic Irminger Current (Atlantic water), suggesting an enhancement of contaminant levels due to exposure from the drifting sea ice. This cadmium anomaly has also been observed in the Barents Sea. The combination of high biological production and concentrations of pollutants may explain the higher concentrations of polychlorinated biphenyls in Svalbard polar bears and other top predators compared to other Arctic regions.

In the Arctic regions, fish and animal fats are an important source of food for human diets. The indigenous peoples of the Arctic have survived by consuming nutritious fatty foods and polar fractionation makes them particularly vulnerable to the fat-soluble contaminants injected into the environment from other regions of the world. Several of these issues and reference material are presented in publications from the Arctic Monitoring and Assessment Program (AMAP).

The ice transport is an abiotic precursor to the better-known bioaccumulation in the food web. It can be viewed as inverse entropy. There are a few scattered measurements of organic pollutants and trace metals in arctic drift ice, but not enough to test hypotheses on the ice as a significant conveyor belt for both abiotic and biotic components.

There remain questions on:

- how different contaminants behave during freezing and melting of sea ice,
- how snow and ice affect the partitions,
- how different contaminants behave during drift,
- how much export of pollutants occurs through brine rejection and sedimentation of particles during drift,
- how large the seasonal variations can be,
- why there may be a general cadmium anomaly in the Arctic,
- how much loss of methyl-mercury occurs during drift,
- whether the contaminant accumulation followed by release from sea ice is important for the distribution and flux in the marine food web,
- how sampling can be improved to account for seasonal variability, and
- how chemical analyses, standardization and intercalibration can be improved.

Furthermore, is our understanding sufficient to model transports correctly?

There is a high need for interdisciplinary research to answer the above questions, including amongst others oceanographers, glaciologists, analytical chemists, modelers and biologists. An increased understanding of these processes is important, not only in the perspective of the above research disciplines, but also from a human health (exposure to contaminants from food) and economics (trade with seafood) perspective.

It is recognized that the levels of contaminants in Arctic air, water and sea ice are relatively low, making both sampling and quantification complicated. Recent advances in CG-MS techniques make possible more accurate measurements, but sampling methods still need improvement. There is a need to develop convenient and reliable sampling methods and strategies to improve the cost/benefit ratio of field studies/monitoring. In particular, there is a need to provide a better approach to monitor contaminants in snow and ice, and give AMAP an improved basis for their assessments of the state of Arctic contamination issues.

The remoteness of the drift ice makes such research very expensive to carry out on its own. A coordinated program, together with other modules in an integrated polar research program will make this feasible. The expected results are:

- a better understanding of the role of sea-ice in redistributing long-range transports of pollutants,
- reliable methods for monitoring changes in the environment, and
- results that may be used to regulate the use of particular substances.

The plight of the arctic peoples faced with increased levels of pollutants in their food is a serious issue that must be addressed on a broad front. To gain understanding of the transport dynamics, it pays to focus on a few substances that are manageable in terms of available knowledge and their ease and quality of sampling and analysis.