USES OF GIS TO DETERMINE THE RELATIVE IMPORTANCE OF TRANSPORT PATHWAYS TO AND ACROSS THE ARCTIC SHELVES

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The Arctic Environmental Atlas, by K. Crane and J. Galasso, was published by the Office of Naval Research during the summer of 1999. An updated version of this atlas was published in Russia of 2000 by K. Crane and VNIIOkeangeologia for the World Wildlife Fund. The authors compiled the first trans-oceanic set of contamination and marine geological data collected from the years of 1950 to the present. Maps illustrate the sources, the intervals of contamination, the potential transport pathways and the sites of deposition of radionuclide, heavy metal, and persistent organic contaminants in the Arctic wide environment. Many of these contaminants emanate from the Former Soviet Union (FSU) and greater Eurasia, and either remain near their source, fall out onto the land of the FSU or are transmitted by the winds, rivers, currents, ice and biota across and around the Arctic. A key outstanding question that one should address is the relative importance of these transport pathways. Data contained within this atlas reside in a Geographic Information System (GIS) and thus contaminant concentrations in the sediment, water, biota (and to a lesser degree ice, air, snow) may be spatially compared to such physical and chemical environmental parameters as grain size of the sediment, clay type, total organic carbon, salinity of the water, proximity to currents, upwelling and downwelling zones, geomorphology of the source and deposition site and relationship to other key parameters that control the partitioning of inorganic and organic contaminants into the various media over space and time.

Although this is the first such comprehensive atlas of contamination in the Arctic, there are substantial data gaps both in the absolute concentrations and spatial distribution of both contaminants and physical, chemical and biological parameters in the Arctic shelf regions and its neighboring seas. Many gaps lie in the critical fisheries regions of the Arctic including the Bering Sea. The lack of data make it difficult to determine the relative importance of transport pathways for currents, bottom sediments, biota and contaminants in certain areas.

Many of these data gaps in the Arctic could be filled by rescuing previously collected data stored in Russian institutions, enabling Russian scientists to put these data in a GIS format and by measuring a suite of physical, chemical, biological and contaminant parameter.

Known data that exist and that could be included in a GIS of the Northern Pacific region through the Arctic shelves include:

BIOTA

Distribution of biomass (benthic fauna, phytoplankton, mesoplankton and bacteria)
Distribution and seasonal variation of fish stocks in the Arctic and the near Arctic regions,
Distribution of marine mammals,
Larval stage concentrations and distribution,
Migration Routes and Spawning Grounds,
Bioturbation,

Concentration depositional factors

MARINE GEOLOGY
Bathymetry,
Seafloor sediment type,
Recent sedimentation rates,
Seafloor sedimentary thickness,
Acoustic backscatter information (side-looking sonar data that reveal canyon locations and seafloor textural data),
Flux of suspended matter,
Distribution of particulate matter,
Seismic reflection information,
Gas hydrate distribution,
Permafrost distribution on the seafloor,
Other Greenhouse gas inventories in the sediments

PHYSICAL and CHEMICAL OCEANOGRAPHY
Physical properties of the sediments,
Transmissometry,
Salinity, temperature, density structure of the shelf seas,
Oxygen data,
Seasonal oceanographic and riverine infomation,
Salt wedge and flocculation zone distribution,
Ice movement and transport on a daily, monthly and yearly basis,
Ice thickness,
Bottom currents, shear velocities, sediment resuspension velocities,
Locations of winter water formation
Density stratification,
Geochemical tracers and basic geochemistry, of water and sediments,
Greenhouse Gas inventories in the water column

ATMOSPHERIC
Distribution of aerosols in Air/riverine and ocean environments,
Seasonal Winds, magnitudes, and average distributions,
Snowfall distributions

The pathways of transport in the Arctic, may change somewhat seasonally as well as over periods of years. Contaminants are excellent tracers for many types of transport mechanisms. They illustrate actually where the winds, waters and sediments originate and where they end up. The rates, frequency and timing of contaminant movement from one transport pathway to another are not well understood in the Arctic. Examples of focusing zones could include: regions where two or more transport pathways converge, places on the seafloor which have high concentrations of total organic carbon, a high percentage of clay (especially smectite) in the sediment, regions in estuaries at the transition between fresh and salt water, melting zones of ice and areas where there is a particular concentration of certain types of biota. Sediments may have very different characteristics based on varying grain sizes, organic matter, clay mineralogy, and a variety of other parameters. Some of these properties affect the ability of particulate matter to transfer contaminants from the water and concentrate them in the bottom sediments. By examining these characteristics, predictions can be made as to where pollutants such as heavy metals and organochlorines may concentrate. These areas may be of particular concern for bottom feeders, and potential sources of pollutants to the water column if resuspension should occur.

If the existing data were processed and put into a GIS format one could then be able to:

1) carry out a spatial analysis of the relationships between the concentrations of contaminants in the water and the sediment in open marine, near coastal, and estuarine environments;
2) illustrate where certain contaminants tend to move from one medium to another and from one transport pathway to another:
3) determine a "statistical goodness-of-fit" between actual "contaminated" locations and the type of substrate into which the contamination accumulates;
4) based on the results of (3), suggest whether regional contamination is a function of the substrate type or other focusing mechanism, (e.g fresh water/sea water interface) or in contrast, an indication that there is an additional source for the contamination in the region; or there are additional benthic currents, or other physical, chemical, biological phenomena in the Arctic which have not been previously noted;
5) determine which contaminants are transported into the currents, which are deposited at the mouths of rivers, which are transported via the continental margin canyons and troughs into the greater Arctic region, and which are primarily transported via the atmosphere; and
6) interfaces can be designed to provide data inputs to climate, ocean and ice circulation modelers.

Samples could be analyzed at many Russian institutions (with good GIS links to key scientific personnel in other countries), at a fraction of the cost it would take to hire purely American or Western European investigators. As an example, it took Crane and Galasso, over five years to find and compile data for the Arctic Environmental GIS, based at the Naval Research Lab. Outsourcing much of the work to Russian scientists, can alleviate many of the financial burdens, will accelerate the data retrieval and data entry process, will provide the global Arctic community with many valuable data from regions formerly and often presently out of bounds for scientists outside (and even inside) of the Former Soviet Union.

Data links should also be maintained at the following institutions outside of the United States:

CANADA:	Environment Canada, the Bedford Institution of Oceanography, Canada,
GERMANY:	GEOMAR, Germany, Alfred Wegener Institute for Polar Research, Germany, the Bundesamt fuer Seeschiffahrt und Hydrographie, Germany,
JAPAN:	the Ocean Research Institute, Japan.
KOREA:	KORDI, Korea,
NORWAY:	The Norwegian Polar Institute, GRID, Norway, NIVA, Norway,
RUSSIA:	VNIIOkeangeologia, Russia, The Shirshov Institution of Oceanology, Russia, AARI, Russia, The Vernadsky Institute, Russia, The Marine Biological Institute, Russia, The Kurchatov Institute, Russia