Executive Summary

Introduction

During the past 30 years Alaska's Arctic Coastal Region has experienced increased anthropogenic activities following mining and petroleum-related development, and increased urbanization of coastal communities. Integration and synthesis of observations and development of new monitoring programs are needed to evaluate the cumulative success of current policies and programs for identifying potential problems before they become widespread or irreversible (Nusser and Goebel, 1997; Nusser et al., 1998; Urquhart et al., 1998). The Alaska Department of Environmental Conservation (ADEC) Alaska Monitoring and Assessment Program (AKMAP) is adapting the U. S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) statistical sampling survey approach to help meet the challenge of assessing Alaska's vast coastal waters (ADEC, 2005a and b; US EPA, 2010). AKMAP assessments have sampled a number of regions in Alaska but it will be years before resource managers can use "new" AKMAP data to understand trends and changes in status over time in most areas.

This pilot project evaluated the feasibility of conducting *post hoc* EMAP assessment using historic long-term marine environmental datasets to provide insights in trends of sediment variables within the western Beaufort Sea. Objectives of this study were to compile historic data to be made publicly available online and to perform an assessment of temporal trends. In addition, an assessment of this historic data, by and of itself is important to determining the most applicable and efficient design and techniques for future Beufort Sea and other Alaska coastal assessments.

Data Capture

Highlighting the problem at hand, numerous marine environmental datasets have been collected by various agencies and others in monitoring the oil and gas development activities on Alaska's North Slope creating a poorly integrated array of physical and chemical data sets for the western Beaufort Sea (Naidu et al., 2001; Naidu et al., in press).

Our effort reviewed and recovered, electronic data sets and in some cases just hard copies of reports and data, for a large group of historic Alaska Beufort Sea datasets. Data from 5 decades, 1960 to 2000, covering the western Beaufort Sea from Point Barrow eastward to the Demarcation Point was recovered. This dataset contains sediment grain-size, trace metals concentrations, and to a limited extent, some chemical information such as total of selected aromatic hydrocarbons (PAH) and total organic carbon (TOC). The data encompassed 78 variables totaling 112 stations over 5 decades. Data for the 1960s, however, were extremely limited and that data were not included in our analyses. The entire data collection, some of which consists of non-electronic data sets, is being submitted to the US Environmental Protection Agency (EPA), Alaska Department of Environmental Conservation (DEC), and the University of Alaska Fairbanks Geographic Information Network of Alaska (GINA).

Retrospective EMAP Analysis

First, a Quality Assurance Plan (QAP) was developed by the UAF and DEC team and approved by EPA. Data sets for 4 variables percent mud, copper, chromium, and zinc, was deemed of complete and sufficient quality to use for performing the retrospective analysis. Data records for the other variables compiled were incomplete for a retrospective analysis and the variables were not analyzed.

Next a determination was made of the temporal and spatial distribution of the data robustness for conducting post *hoc* temporal and spatial assessments of status and trends using Aquatic Resource Monitoring sampling survey methods (US EPA, 2010). The planned approach was to use a probabilistic sampling design based on the generalized random tessellation survey (GRTS) design (Stevens and Olsen, 2004) to perform a retrospective analysis of the historical data using EMAP-style summary methods. This methodology was used to generate within the region of interest 50 sites for each decade. Next it was envisioned that the selected decadal sample sites combined with a nearest-neighbor approach would be used to randomly select historic data points for status assessment. Unfortunately, the historic data were spatially sparse with very low numbers of unique sampling locations in some decades which was problematic for *post hoc* sampling using this proposed method.

Instead, an alternate approach was developed where geostatistical methods (Cressie, 1993) were applied to simulate predicted values for the variable of interest for the GRTS sample locations. Shifting support from year-to-year (changing numbers of stations and station locations) is a problem in retrospective analyses and the geostatistical method used is robust to varying sample locations within the region of interest.

Discussion of Results

The retrospective analysis of the four variables indicated no temporal trend (i.e., net increasing or decreasing trend) but it is clearly indicated that 1980 was punctuated by significantly higher mean concentrations of copper ($\alpha = 0.10$) and chromium and zinc ($\alpha = 0.05$) in sediments.

It is possible that increased mud content in the 1980 sediments resulted in higher contents of copper, chromium and zinc, because finer particles have greater potential capacity to sequester the metals by adsorption and/or metal-clay complex formation. However, this is not demonstrated by a parallel increase in mud in 1980. The other possibility is that there was an episodic increased flux and deposition of the three metals from the terrestrial natural source to the marine study area. This explanation also seems unlikely as there is no evidence to support an episodic flux. One hypothesize for this 1980 anomaly in sediment copper, chromium and zinc reflects higher input of the metals from petroleum-related industrial activities. Figure 1 and 2 provides an example of chromium. In this context, it is interesting to note that the higher mean concentrations of the above metals are consistent with significant spikes in the levels of several metals (V, Cr, Cu, Ni, Zn, As, Cd, Pb and methyl Hg) in 1980 as demonstrated in the stratigraphy of a 210Pb-based dated sediment core from Prudhoe Bay, Alaska (Naidu et al., 2001; Naidu et al., in press).

Presumably, the trace metal concentrations in 1970 reflect the natural variability in sediment chemistry in the dynamic nearshore environment of the Beaufort Sea resulting from local and regional processes and spatial trends (Naidu et al., in press). The data suggests the trace metals concentrations in sediments of the western Beaufort Sea sampled in 1990 and 2000 were so within the range of natural variability.

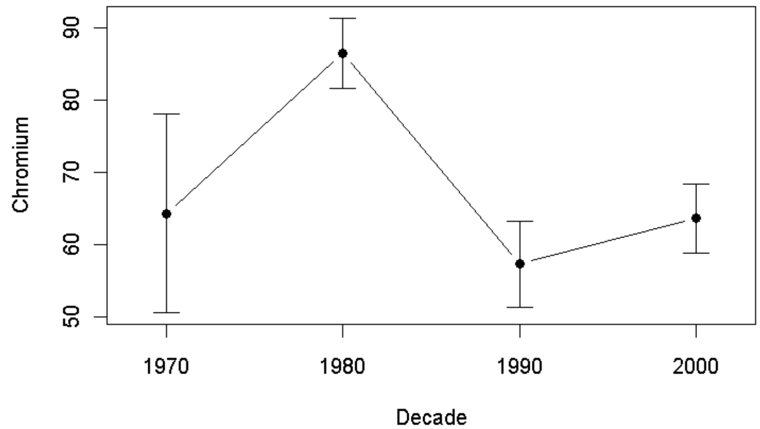

Figure 1 -- Line plot with 95% confidence intervals for chromium by decade.

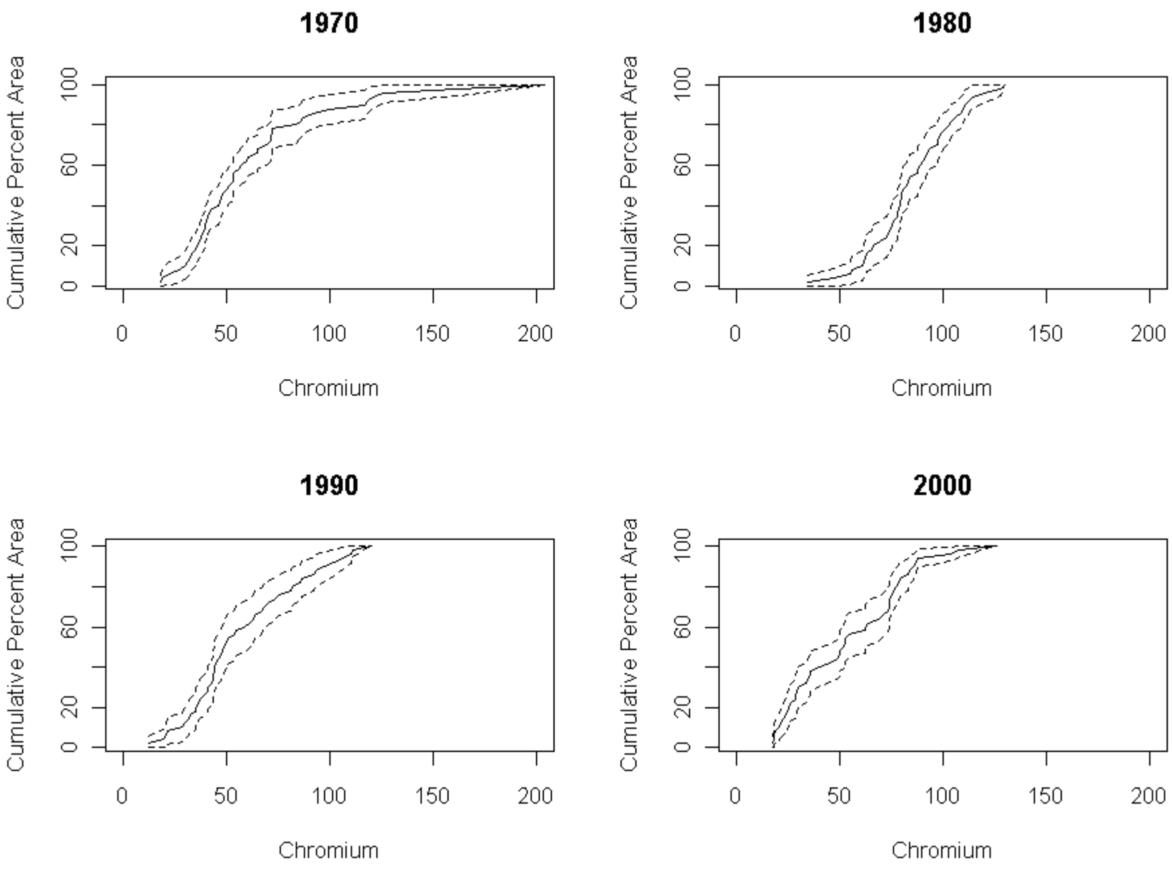

Figure 2 -- Cumulative percent of study area and 95% confidence intervals of Beaufort Sea coastal zone vs. chromium (ug g^{-1}) from simulated sampling.

Conclusions

One way to address the problem of sparse data and the lack of a random sample is demonstrated by using geostatistical modeling to simulate data for an EMAP-style analysis. In the context of the present study, strengths of geostatistical modeling include the ability for data from different sampling designs to be incorporated into data sets. The models generated are only as detailed as the data provided and in the present study, large scale trends could reasonably be predicted. The more extensive the data set, the better the model predictions.

The method provides a reasonable and comparatively simple approach to deal with the specific problem presented by this compiled data set. It provides insight into regional, rather than site specific, spatial and temporal distribution of a variable of concern, such a lead in the sediments. Ignoring historic data sets wastes a valuable resource that can provide resource managers a better understanding of changes taking place in the environment. Such insights can help in planning a more refined long-term assessment strategy and, as such, are being incorporated into our planning for a future ADEC Alaska Monitoring and Assessment Program Beufort Sea coastal assessment. It is clear that greater effort needs to undertaken to refine data mining efforts to utilize historic datasets, while clearly demonstrating the need to carefully develop a watershed to larger regional reasoned multi-faceted monitoring effort.