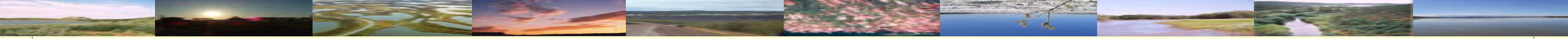

Downstream nutrient changes and vertical structure of the Mackenzie Estuary, NT: The Arctic River-Delta Experiment (ARDEX)

Craig A. Emmerton[1], Lance F.W. Lesack[1] and Warwick F. Vincent[2]

[1]*Depts. Of Geography & Biology, Simon Fraser University, Burnaby, BC V5A 1S6, Canada* [2]*Centre d'Études Nordiques, Université Laval, Québec City, Québec G1K 7P4, Canada*

Background

The Arctic Ocean is the world's most river-influenced marine region[1] (Fig. 1). Annual spring flooding of these rivers provides heat, nutrients and organic matter to coastal areas and coupled with nearly continuous irradiation, these conditions initiate a short and intensive growing season[2]. Both physical and biological processes within estuaries control the nutrient fluxes to the productive near coast. With climate-related changes in sea ice[3] and river hydrology[4] occurring throughout much of the Arctic, it is essential to study the current nutrient structure in order to understand how Arctic estuaries will respond.

Figure 1. The large riverine influence of the Arctic Ocean (from Holmes et al. 2001).

Figure 2. The Mackenzie Estuary and the extent of the river plume.

The Mackenzie Estuary (Fig. 2) is an important environment to investigate the nutrient structure of an Arctic estuary as the Mackenzie River is the largest source of nutrients, freshwater and sediment to the western Arctic Ocean.

Objectives

Within the context of the Arctic River-Delta Experiment (ARDEX), objectives of this study were:

1.) To test the hypothesis that nutrients will deviate from conservative behaviour across the transition from fresh to saltwater.

2.) To characterize the vertical structure of the Mackenzie Estuary from river to marine environments.

Study site and methods

Figure 3. CCGS *Nahidik*

The overarching goal of the ARDEX cruise was to evaluate processes controlling organic matter across the Mackenzie Estuary. The cruise was comprised of a 12 site transect (4 fresh; 4 estuarine; 4 marine; Fig. 3,4) sampled from 26-Jul. to 02-Aug. 2004.

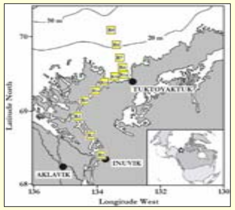

Figure 4. ARDEX cruise track and sampling sites.

Table 1. ARDEX cruise site, sampling and analyses information.

Site	Type	Layer Sampled	GF/C filtered nutrients sampled
R1-R4	River	Surface, bottom, column	→Inorganics (NO_3^-, NH_4, $Si(OH)_4$, PO_4^{3-})
R5x	Estuary	Surface,bottom, pynocline	→Organics (DOC, DON, DOP)
R6-R9	Marine	Surface, bottom, pynocline, chlorophyll-a max.	→Particulates (C, N, P, TSS) →Others (chl-a, SO_4^{2-}, Cl^-, salinity)

Water samples were collected at various sites and depths for nutrient analyses using clean methods (Table 1).

Downstream & Vertical Structure

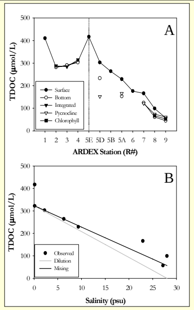

Figure 5. Downstream (A,B) and vertical (A) structure of TDOC.

Dissolved Organic Matter

The behaviour of DOM (C,N,P) in estuaries is generally variable[5,6]. TDOC steadily declined across the Mackenzie estuary and generally followed conservative behaviour similar to other Arctic estuaries (Fig. 5). DON and DOP increased across the estuary, possibly reflecting the progressive transition to phytoplankton-dominated communities offshore[2] and subsequent production-related organic matter release. Vertical structure in the estuary showed organic-depleted marine waters wedging underneath relatively richer river waters at depths of less than 5 meters at all non-river stations.

Dissolved Inorganic Nutrients

Dissolved inorganic nutrients are not normally conservative across estuaries due to high algal demand, denitrification or particle desorption. Nitrate showed removal below the dilution line, likely due to phytoplankton uptake (Fig. 6). Ammonium was largely below detection through the estuary and silica decreased across the estuary in a conservative pattern similar to other Arctic estuaries. Phosphate increased across the estuary likely due to mixing with the high seawater end member. The influence of a depleted shallow marine wedge and offshore nutrient-rich deep water was observed.

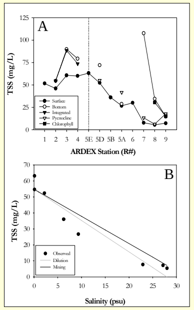

Figure 6. Downstream (A,B) and vertical (A) structure of nitrate.

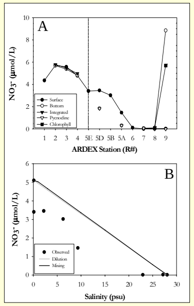

Figure 7. Downstream (A,B) and vertical (A) structure of TSS.

Particulates

Sediment and particulate organic matter are efficiently stripped from the water column in estuaries due largely to losses in river velocity when flow meets sea level. Organic particulates are also affected by the sharp increases in salinity (flocculation and coagulation). Particulate C, N and P paralleled total suspended solids (Fig. 7) showing sharp declines across the estuary. Each showed concentrations below the dilution line especially near shore, indicating intense particle settling. The turbulent sediment interface at the bottom of the water column increased in particulates in all cases, suggesting active bedload transport.

Conclusions

Vertical nutrient structure was well defined throughout the fresh-salt water transition zone during low flow conditions. Downstream nutrient changes through the estuary suggested that most did not exhibit conservative behaviour.

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