Characteristics of two coastal regimes (Churchill River plume and adjoining marine waters) during the winter-spring transition


(1) University of Helsinki & Fisheries and Oceans, Freshwater Institute (FWI), 301 University Crescent, Winnipeg MB, R3T 2N6; (2) Centre for Earth Observation Science, Department of Environment and Geographics, Wallace Bldg, University of Manitoba, Winnipeg, MB R3T 2N2; (3) Fisheries and Oceans, Institute of Ocean Sciences (I0S), PO Box 9550, Sidney BC, V8L 4B2; (4) University of Calgary, Centre for Alpine and Arctic Climate Research, Department of Geography, Earth Sciences 430 2500 University Drive N.W. Calgary, AB T2N 1N4

Introduction

Freshwater plumes have significant effects on coastal marine ecosystems, altering nearshore stratification, circulation patterns, nutrient and particle dynamics, and the offshore transport and dispersal of materials. Ice further alters these patterns by preventing wind mixing and plume spreading, causing the plume to become much larger under the ice than in open water conditions [1-5]. Extensive study has been conducted around estuaries in southeastern Hudson Bay, especially the Great Whale River [5-8]. There, the dynamics of the Churchill River plume and the adjacent coastal waters are strongly influenced by the seasonal freeze up and melt back of the ice cover [5, 6, 8].

To address this gap, we conducted a pilot study of the physical and chemical oceanography and aquatic biota of the Churchill River plume - August, 1993, North/South Consultants Inc.: Winnipeg. p. 33 pp.

3. Nutrients, Particulate Matter and Organic Carbon

The freshwater plume associated with much higher CDOM and turbidity (Figure 6) and high concentrations of DOC (Figure 7). Salinity was positively correlated with phosphate but negatively correlated with silicate and, at times, nitrate (Figure 6). Because of nutrients or perhaps stratification, and in spite of turbidity, the estuarine had higher phytoplankton biomass (as indicated by chlorophyll a) at high-salinity areas. Figure 8 then either Button Bay or the river. The composition of the particulate material was distinct in each environment (Table 1) reflecting the input of terrestrial and possibly freshwater (biogenic) organic matter from the river.

Methods

Water column profiles were made with a Sea-Bird SBE 19plus CTD equipped with a transmissometer (providing beam attenuation coefficient 1/1 m at 660 nm, Waterlight C-Star, 25 cm path length) and coloured dissolved organic matter (CDOM) fluorescence sensor (WETStar). Water samples were obtained from the same hole using a submersible pump dissolved organic matter (CDOM) fluorescence sensor (WETStar).

Results and Discussion

1. Ice Conditions and Hydrology

From winter through May 12, the ice cover over Button Bay and the estuary (Figure 1). The seaward edge was defined by ice ridges and rubble up to 1 meters thick (R. Gale, unpub., some of it apparently grounded. Beyond that, a lead opened and closed as mobile pack ice was moved about by the wind. River discharges were very low (<100 m^3/s) in Figure 2) and the Churchill River plume appeared to be contained inside the rubble at the estuary. On May 12, warm temperatures, persistent resuspension and a SW wind coincided with parts of the rubble field in the estuary breaking off, which allowed river waters to flow out into the open lead. Freezing conditions returned briefly, then from May 17 to 28, the nearshore ice in the estuary began to thin in place. From May 19 onward, the estuary was flowing through the ice. May 20, the ice in the mouth of the estuary had completely ablated and river water was flowing unimpeded into the Bay.

2. Water Mass Characteristics

Based on the observation of the ice conditions and the pattern of river discharge, our observations are divided into three periods: pre-melt (mid-March to mid-April), early melt (late April to early May) and spring freshet (late May). In Figure 3):

- Pre-melt: well mixed water column in Button Bay. Brash ice surface plume in the estuary
- Early melt: little change in Button Bay, freshening of the plume in the estuary and strong halocline at 5-6 m; shift in S0 in river water and plume water (Figure 4) indicates altered composition, presumably increased meltwater; shift in S0 in
- Spring freshet: slight freshening in Button Bay, apparent river influence; very fresh surface layer in the estuary, about 3-4 m thick

Conclusions and Future Directions

Figure 10 summarizes our preliminary impressions of the seasonal dynamics of the Churchill River plume and the adjacent coastal waters. Despite large tides (>4.5 m), strong currents (+0 cm/s), and low river discharge, we saw a distinct plume develop and evolve inside the ice rubble boundary. The plume influenced water turbidity, nutrients, phytoplankton biomass, and particulate/carbonization. Spring freshet and a breach in the rubble allowed the plume to spread and influence surface waters more than 7 km away. Future study should consider the influence of large rivers entering western Hudson Bay (e.g., the Nelson River) and also build on the present work to develop a more thorough biogeochemical understanding of the Churchill River and estuary system.