Sources, Distribution and Fate of Organic Carbon in the Hudson Bay System and Implications for Contaminant Cycling

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Introduction

Organic carbon is supplied to marine systems by primary production in the marine waters (autochthonous carbon) and by input from terrestrial or freshwater aquatic sources (allochthonous carbon) via river runoff, coastal erosion, aeolian transfer, and groundwater discharge. Within a marine system, the carbon can be involved in numerous processes: it can be transferred to food webs and converted to new biomass, it can be transported (advected) out of the system, it can be broken down by respiration, or it can end up in long term burial in sediments (Figure 1).

With the exception of Hudson Bay, basic organic carbon budgets (or box models) have been constructed for most of the Arctic and sub-arctic marine systems [1]. The Arctic shelf seas generally have considerable supply of both terrigenous particulate organic carbon (t-POC) and marine organic carbon (m-POC), with the latter often much in excess [2, 3] (Table 1). There is generally very low burial and preservation of the marine material (2% or less) and relatively large burial of the t-POC (sometimes 65%).

A detailed understanding of the basic processes that control the organic carbon cycle in a marine system (of which a budget is a part) is critical to predict and detect the impacts of climate change [4-6]. The supply of marine and terrestrial carbon may be impacted very differently, the former by reductions in sea-ice cover and the latter by altered river run-off, changes in vegetation, or the destabilization of permafrost [1, 7]. Thus, the Hudson Bay system is an obvious critical data gap, considering it is expected to undergo relatively massive changes over a very short period of time [6, 8, 9]. Already, there is evidence suggesting that climate-related changes may have occurred [6].

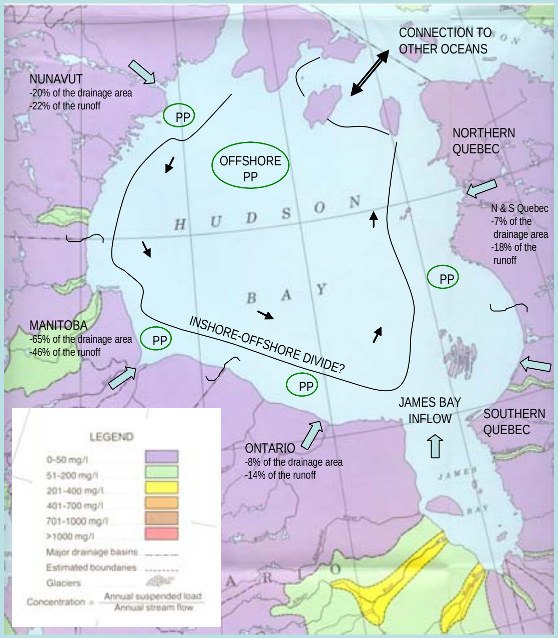

Figure 2. Potential factors influencing the organic carbon cycle in Hudson Bay, including river input from multiple drainage basins, limited exchange with other oceans, a counter-clockwise internal circulation pattern, and spatial variability in marine primary production (PP). Background map shows estimated river sediment discharge [19].

Hudson Bay is a unique system, for which it would be difficult to predict changes except from an understanding of the system itself. It is a large, shallow inland sea [10], which is relatively isolated from other oceans (Figure 2). It has an overall cyclonic circulation pattern but its oceanography is also strongly influenced by local factors. The rivers draining into the Bay derive their water from boreal forest watersheds in the south and east (parts of Manitoba, Ontario and Quebec), Prairie grasslands in the west, and tundra in the north [11]. The freshwater discharge into the system is tremendous and profoundly impacts stratification, circulation, nutrient distributions and primary productivity [12-14]. Ice melt is as or more significant for the seasonal freshwater budget [15] and is also a significant agent in sediment resuspension and transport [16]. Many of these factors probably influence the organic carbon budget of the Bay.

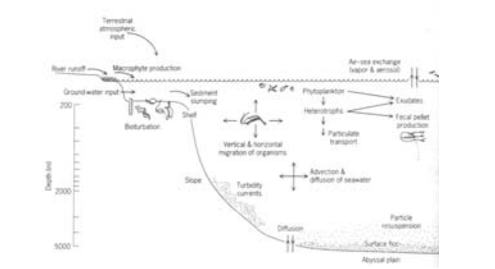

Figure 1. Schematic of POC in marine systems [20].

Description	Size ($x10^3$ km^2)	Organic Carbon ($x10^6$ t y^{-1}) Supply t-POC Rivers	Erosion	Eolian	t-DOC	m-POC	Burial t-POC	Burial m-POC	Export
Barents Sea									
-Atlantic water influence	1597	0.5	0.8	0.27	5.9	73	2.8-3.7 total		
-small river inflow									
-moderate ice formation									
-higher productivity									
Kara Sea									
-troughs to open ocean	926	0.9	1.0	0.17	9.7	37	1.15	0.23	0.2
-large river inflow (Ob & Yenisei)									
Laptev Sea									
-generally shallow	498	1.3	1.8	0.09	5.5	17.6	0.77	0.08	1.07
-high ice production									
-large river inflow (Lena)									
East Siberian Sea									
-generally shallow	987	0.48	2.2	0.18	1.42	17.3	0.96 total		
-ice bound									
Chukchi Sea									
-moderate ice formation	620	>0.13	0.8	0.11		42	0.23 total		
-continental boundaries									
-higher productivity									
Beaufort Sea - Mackenzie Shelf									
-large river inflow (Mackenzie)	60	2.1	0.08	0.03	1.3	3.16	1.36	<0.08	0.64

Table 1. Organic carbon budgets for Arctic Shelf Seas [1].

Project Objectives

As a starting point for understanding the sources, distribution and fate of organic carbon in the Hudson Bay system and the potential impacts of climate change, we will be applying a suite of techniques to characterize the carbon content of bed and suspended sediments collected during the Bay-wide ArcticNet cruise in September-October 2005 (Figure 3, Photos 1 and 2). Sediment cores provide large, time-integrated samples of known (temporal) sequence. They can serve as both 'passive recorders' of carbon cycling in the system, through for example, their time sequence of various carbon components, and 'dynamic recorders', through the vertical distributions of redox-sensitive elements [17, 18]. Suspended sediments can provide an instantaneous picture of the spatial variation in carbon source intensity and composition as they relate to regional conditions (e.g., water column stratification, circulation, depth). Sediments will be examined using both bulk analyses (C/N ratios, $\delta^{13}C$ compositions) and specific biomarker work (e.g., lignin, fatty acids, etc.).

The specific aims are to:

- Quantify the terrestrial and marine carbon preserved in the sediments of Hudson Bay
- Identify the factors that control carbon burial in this system
- Evaluate the internal evolution, in space and time, of the terrestrial carbon that is supplied to the system to gain insight into its role in the system.

A second objective of the project is to determine the distribution of contaminants such as persistent organic pollutants and heavy metals in the marine sediments of Hudson Bay and investigate how the distribution has been shaped by the sources, distribution and burial of organic carbon. A tight linkage between carbon and contaminants is to be expected because hydrophobic contaminants readily sorb to organic matter upon entering the marine system. Understanding the coupled behaviour of organic matter and contaminants should give us insight into possible climate-change effects on contaminants.

Photos 1 & 2. Filter sample and sediment boxcore.

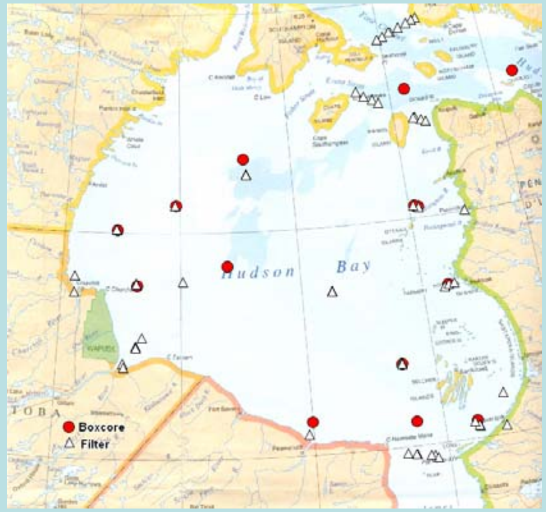

Figure 3. Map of sampling sites in Hudson Bay (sediment boxcores and filters containing suspended particulate).

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Acknowledgements

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