Freshwater Flow Through Hudson Strait

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The Hudson Bay System, which includes the Hudson, James and Ungava Bays, Foxe Basin and Hudson Strait, is a large and very fresh arctic basin due to the input of freshwater from large rivers and to the inflow of Arctic Ocean waters. Freshwater cycles through the Hudson Bay System and, eventually, is exported to the North Atlantic, along the southern side of the Hudson Strait (Figure 1), where it is thought to play a significant role in modulating the Labrador Sea's deep convection and, thus, the climate of the North Atlantic. Indeed, the contribution from Hudson Strait is thought to be the third largest source of freshwater for the North Atlantic – even though the net freshwater flow through Hudson Strait had never been observed.

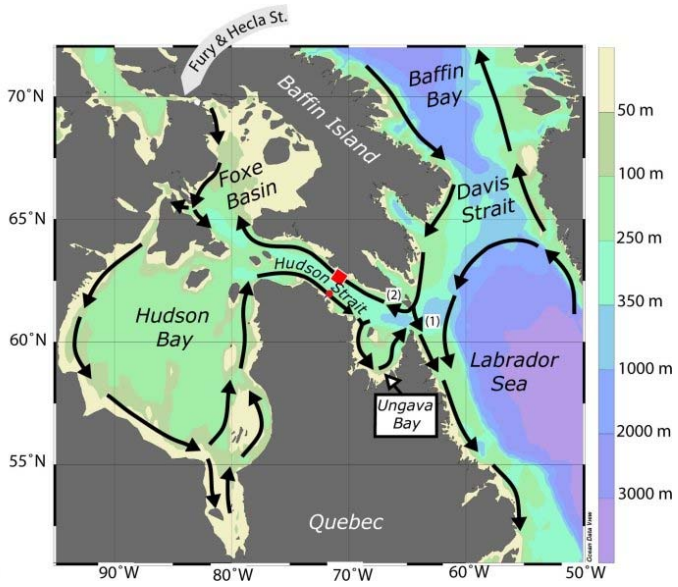

Figure 1: Freshwater pathways in the northwest Atlantic, Hudson Strait and Hudson Bay. The moorings were deployed across the section indicated by the red square (3 moorings across the inflow) and red circle (one mooring across the inflow).

In 2004, I set out to fill this gap by measuring how much fresh water is exported out of Hudson Strait along its southern side. Year-long mooring records revealed a much larger freshwater export than was expected. This excess freshwater could be a result of only two processes: 1) a larger than expected amount of Arctic Ocean fresh water enters the Hudson Bay System, or, 2) the Hudson Bay System has the ability to accumulate and release freshwater due to internal processes. Understanding the sources of this excess freshwater and, in general, the pathways of freshwater in this region is key to our understanding of what governs freshwater input into the North Atlantic and its variability – a crucial aspect of our climate system.

The objective of this project was, for the first time, to measure how much fresh water enters the Hudson Bay System from the Arctic Ocean (along the northern side of Hudson Strait) and how much freshwater exits into the Labrador Sea (along the southern side). To achieve this goal, my Canadian colleague, Professor Yves Gratton, from the University of Quebec, and I deployed four moorings across Hudson Strait. The moorings were deployed in August of 2008 and recovered in October of 2009. We retrieved close to 90% of the data – an astounding success – given the harshness of the environment, which includes large tides, icebergs and sea-ice cover over much of the year.

Due to the large amount of data collected from the moorings, the analysis of the 2008-2009 data is ongoing. However, several important results can already be seen from the

preliminary data shown in Figure 2. The top panel compares the fresh water inflow and outflow on the two sides of the Strait (by simply comparing the salinity from instruments in the upper part of the water column). This simple plot shows that the inflowing waters (red) have a limited seasonal variability and a salinity of about 33, compared to the very fresh outflowing waters with a strong seasonal variability (blue). In the lower panel, furthermore, we compare the fresh water outflow using data from four years of mooring data. These reveal some large interannual variability and, in particular, indicate that 2008-2009 was a year of anomalously large fresh water export (with the freshest waters emerging from the Strait). This is in agreement with ongoing work which suggests that Hudson Bay had been accumulating fresh water during the last few years – becoming progressively fresher – and that this fresh water is now being released downstream into the Labrador Sea. This is the first time we have observed such large interannual variability and it has important implications on the variability of the ocean circulation downstream.

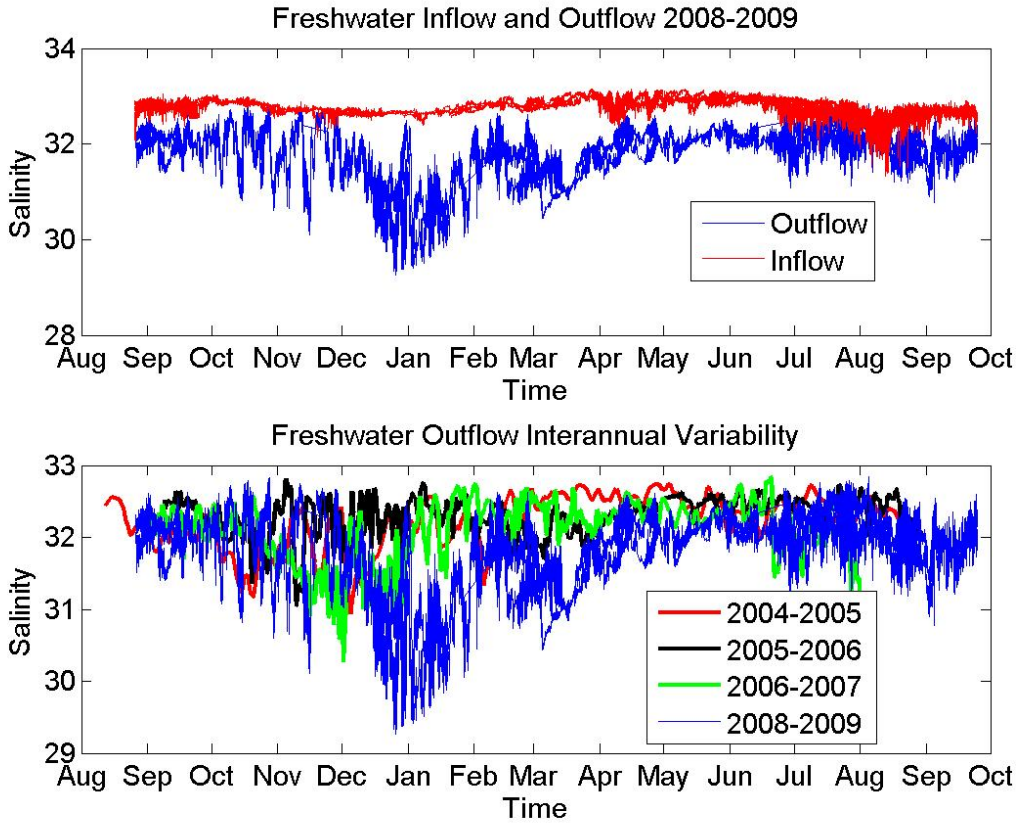

Figure 2: Freshwater through Hudson Strait. Top: Instruments located in the upper part of the water column clearly show the seasonal pulse of freshwater flowing out of Hudson Strait in late fall/early winter (blue) and the much smaller amount of freshwater entering with the inflow (red) throughout the year. Bottom: A comparison of the data from 2004 to 2009 shows the large interannual variability in the outflow and, in particular, the anomalously large export captured in 2008-2009.

The collection of these data, furthermore, has greatly contributed to the development of two important ongoing projects:

1) Synthesis of the Hudson Strait outflow. Thanks to the support from the Comer Science and Education Foundation in collecting these data, I have been able to obtain funding from the National Science Foundation to analyze the variability of the fresh water outflow from Hudson Bay and, also identify the driving mechanisms. This NSF project is supporting a student, post-doctoral fellow, and I and the grant continues through 2012.

2) Continued monitoring of Hudson Strait. Funding for this project has helped raise awareness for Hudson Strait and has established that monitoring of this important gateway is feasible. Presently, we are working together with our Canadian colleagues to establish a continuous monitoring program (funded by Canadian government sources) that will continue the work in the Strait. This is a major achievement and an important one for climate studies – and is an example of how a privately funded project can jump-start a much larger program.