$DO^{14}C$ in the Canada Basin: Placing Limits on Carbon Transfer Processes in the Arctic

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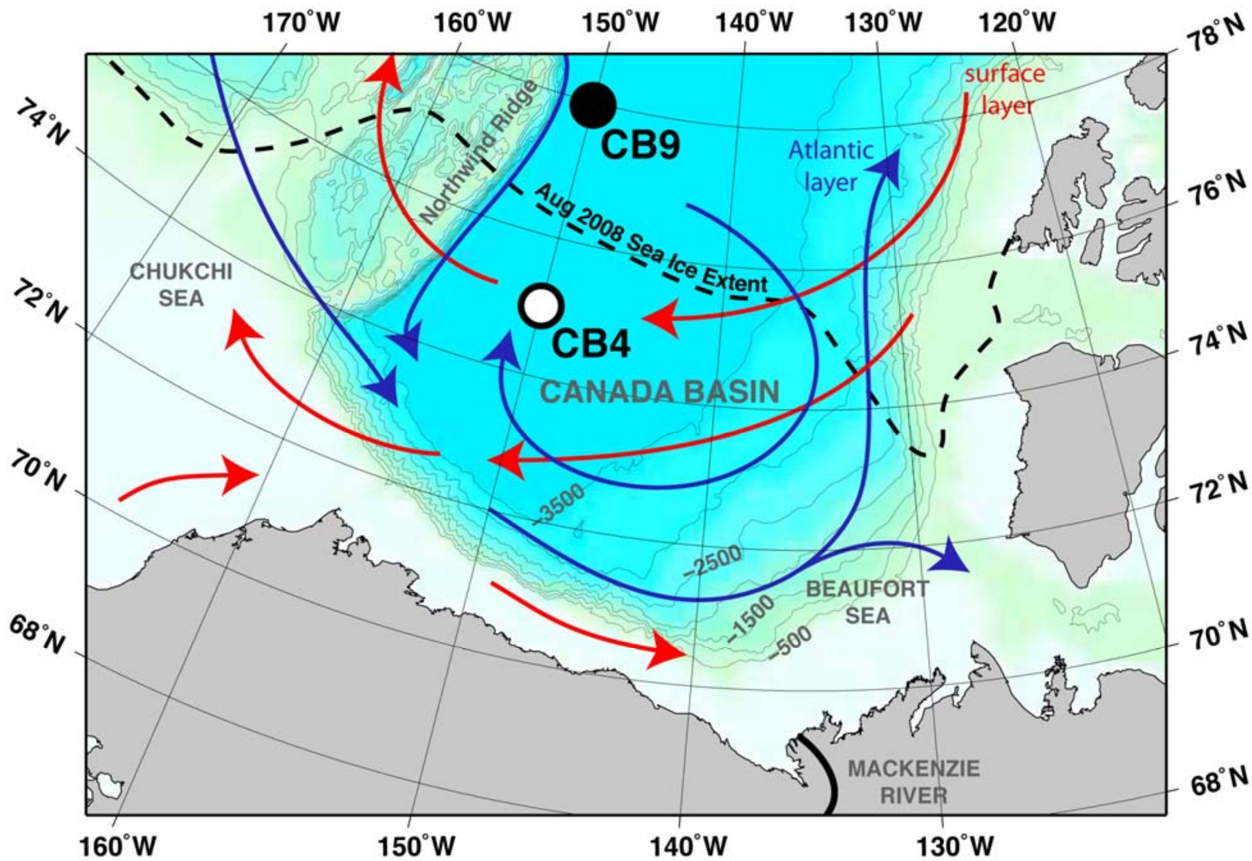
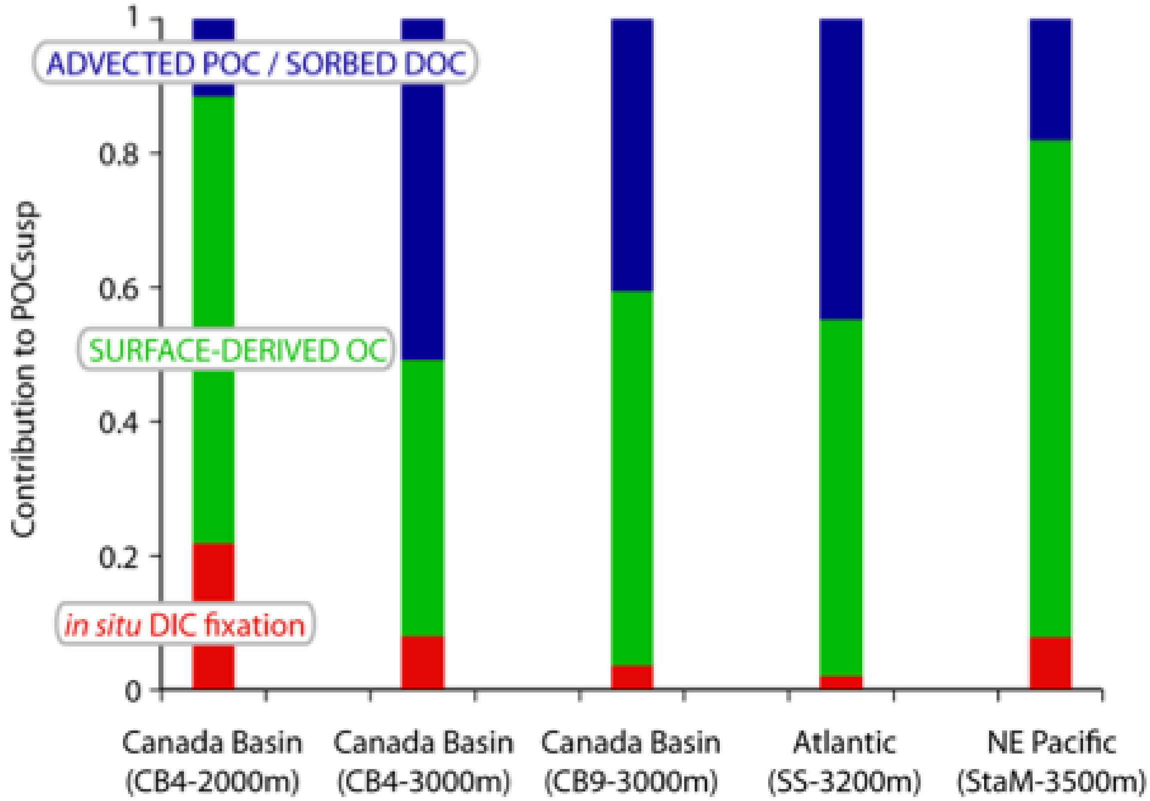
Carbon storage in the oceans is linked to CO_2 levels and climate regulation on long timescales so it is important to understand the effects of modern climate change on carbon storage and cycling in the Arctic where changes have been rapid and dynamic over the past two decades. Carbon isotope measurements provide a powerful tool for investigating carbon cycling in the marine environment. Carbon has three major isotopes—^{12}C, the most abundant; ^{13}C, a stable isotope present at approximately 1% that of ^{12}C; and ^{14}C, an extremely rare, unstable (i.e. radioactive) isotope. Information on the provenance and dynamics of carbon delivered to the ocean can be obtained through the stable carbon and radiocarbon compositions of bulk material such as dissolved inorganic carbon (DIC), dissolved organic carbon (DOC) and particulate organic carbon either suspended (POC_{susp}) or sinking (POC_{sink}). Radiocarbon (^{14}C) decays with a half-life of 5730 yr; the ^{14}C content of biological organic matter reflects that of the CO_2 in the air or water used to synthesize it or that of its food source. Thus, while alive, terrestrial matter has ^{14}C values that reflect that of atmospheric CO_2 and marine organic matter has values that reflect that of surface water DIC. Upon death, the radiocarbon clock starts ticking and ^{14}C decays away at a known rate. In the marine environment, rather than being a true clock, ^{14}C acts as a tracer of ocean circulation processes as well as organic matter transport and cycling. In the Arctic environment, where the potential for input of material from a variety of sources, both terrestrial and marine, is so great, detailed information can be critical to understanding the carbon cycle.

Through funds supplied by the James M. and Ruth P. Clark Arctic Research Initiative, we recently completed a radiocarbon study of three bulk carbon pools—$DO^{14}C$, $DI^{14}C$, and $PO^{14}C_{susp,}$ on samples collected in the summers of 2008 and 2011 at two locations, CB4 and CB9, in the Canada Basin of the Arctic Ocean. Historically, CB4 is covered with ice seasonally while CB9 is permanently ice-covered. In 2011, there was evidence that CB9 will soon be only seasonally ice-covered. Our goal was to understand the cycling and transfer of carbon from the surface water to the sediments as well as provide the first isotopic profile for DOC ever measured in this region. The recent development of the capability to analyze marine DOC samples at NOSAMS was critical to this study. Our results demonstrated the expected basic biogeochemical processes, but also raised some intriguing questions. $DI^{14}C$ results are generally consistent with expectations based on the stratification and sources of water in this basin as well as on isotopic results from previous studies in 1994 and 2004. However, below approximately 600 m, there is a consistent and surprising offset between $DI^{14}C$ values; CB-4 is enriched relative to CB-9. Isotopic results from the organic carbon pools studied provide more puzzles. $DO^{14}C$ values at CB-9 are enriched relative to CB-4 throughout the water column, the reverse of the pattern observed in DIC. Together, the ^{13}C and ^{14}C suggest that at CB-9 there is either a greater influence of modern terrestrial material or chemoautotrophy, the *in situ* biosynthesis of organic matter at depth using $DI^{14}C$ at CB-9 into biomass and subsequent release into DOC.

Results from POC_{susp} are more challenging to interpret. The extremely low concentrations of POC in the deep water column made it difficult to obtain samples large enough for precise radiocarbon measurements. $PO^{13}C$ and $PO^{14}C$ results suggest the particulate material at the surface is dominated by terrestrial material while the deeper material appears to reflect the input of pelagic plankton. Additionally, $PO^{14}C$ results suggest significant chemoautotrophy at depth. We can use isotopic mass balances to calculate the relative importance of chemoautotrophy at the Canada Basin sites and compare it to that observed at sites in the Atlantic and Pacific Oceans.

Analyzing the isotopic content of DIC, DOC and POC in the Canada Basin has provided important new insights into the carbon cycle and will provide a baseline for expected changes in the future. We greatly appreciate the funds we obtained that allowed us to conduct this study.





ADVECTED POC / SORBED DOC
SURFACE-DERIVED OC
in situ DIC fixation
Contribution to POCsusp
1
0.8
0.6
0.4
0.2
0
Canada Basin (CB4-2000m)
Canada Basin (CB4-3000m)
Canada Basin (CB9-3000m)
Atlantic (SS-3200m)
NE Pacific (StaM-3500m)