Time-series investigations of settling particle flux and composition in the deep Canada Basin, Arctic Ocean

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Background

Motivation

- The central Arctic Ocean is currently experiencing dramatic change in relation to regional and global warming. Marked decreases in sea ice cover are accompanied by changes in freshwater, carbon and nutrient fluxes from surrounding continents.
- In an effort to further our understanding of biogeochemical processes in the cryopelagic Arctic Ocean, as well future pertubations to this system, we are undertaking time-series investigations of particle fluxes to seasonally and permanently ice-covered regions of the deep Canada Basin (**Fig. 1 & 2**).

Approach

- Quasi-continuous observations since 2004 (**Fig. 3**) from a bottom-tethered time-series sediment trap deployed at ~3000 m (800 mab) in the southwest Canada Basin (Station A, 75°N, 150°W, **Fig. 1**) as part of the Beaufort Gyre Observation System (BGOS).
- Time-series traps have also been deployed at different depths at Station A, and in different quadrants of the basin (Station B, C & D; **Figs. 1 & 2**).
- Assessment of biogeochemical fluxes: particulate organic carbon (POC), particulate inorganic carbon (PIC), biogenic Si, and lithogenic particles.
- Assessment of organic matter composition (^{13}C, ^{14}C, C/N)
- Assessment of particle provenance (εNd).

Beaufort Gyre Observation System (BGOS)

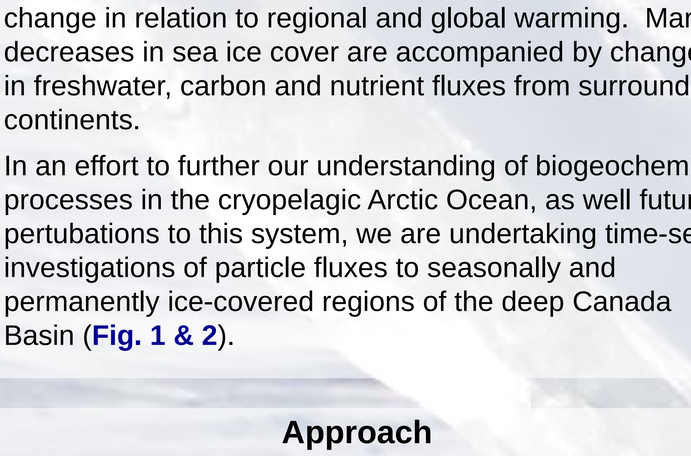

Figure 1. Location of sediment trap moorings in the Canada Basin

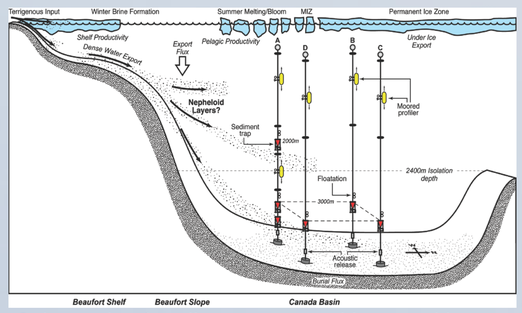

Figure 2. Schematic of sediment trap positions and key processes

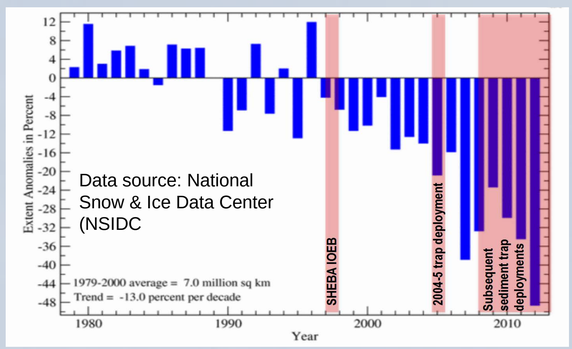

Figure 3. N Hemisphere Sea Ice Extent Sept. Anomalies (1979-2012)

Observations

Spatial Variability in Mass & Component Fluxes

- Particulate matter fluxes to the deep Canada Basin are uniformly low (< 20 mg m^{-2} d^{-1}, **Fig. 4a**).
- Particulate fluxes are dominated (67 - 88%) by lithogenic material (**Fig. 4b**).

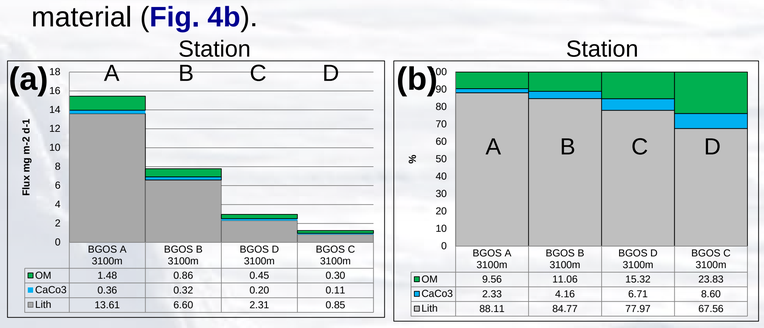

Figure 4. Sediment trap integrated data (3100 m; 2004 - 2010) for Stn A, B, C & D: (a) Component flux; (b) Normalized component concentrations.

Intra- & Inter-annual Flux Variability

- Particle fluxes are generally highest in late winter (maximum ice cover) (**Fig. 5c**).
- Particulate fluxes are consistently low relative to those in other ocean basins. The higher fluxes in 2008 are due to a pulse of lithogenic particles (**Fig. 6a,b**).

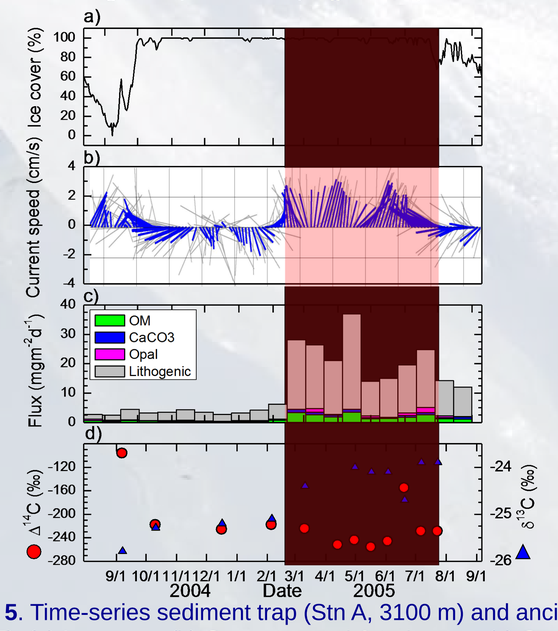

Figure 5. Time-series sediment trap (Stn A, 3100 m) and ancillary data (2004-5): (a) Ice cover; (b) Current speed & trajectory; (c) Component flux; (d) POC stable carbon isotopes ($\delta^{13}C$) and radiocarbon ($\Delta^{14}C$).

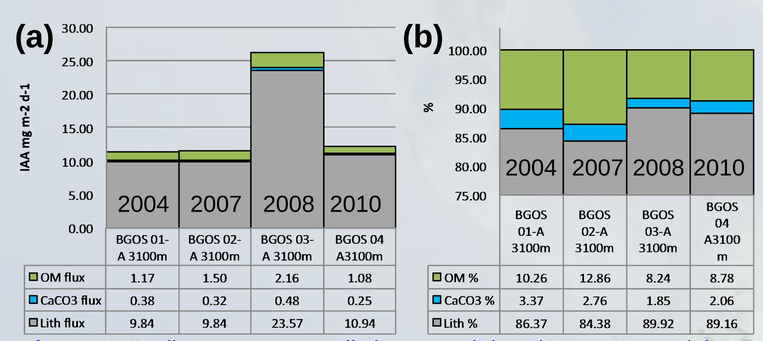

Figure 6. Sediment trap annually integrated data (Stn A, 3100 m) for 2004, 2007, 2008, 2010): (a) Component Flux; (b) Normalized component concentrations.

Depth Variability in Fluxes

- Flux increases with depth (= lateral supply), with consistently higher flux at each depth in 2008 vs 2007.

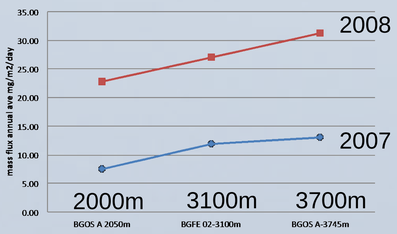

Figure 7. Sediment trap annually integrated mass fluxes at 2000 m, 3100 m & 3700 m (Stn A; 2007 & 2008 deployments).

Observations

Organic Matter Composition & Provenance

- Strong correlation between organic matter ^{14}C age & Al (lithogenic) content (**Fig. 8**). High proportion of pre-aged POC (^{14}C age: 1–4 kyr; **Fig. 5d & 8**).
- Comparison of Nd isotopic composition (detrital fraction) of sediment trap samples and source inputs indicates spatial and temporal variability in provenance of advected particles (**Fig. 9**).

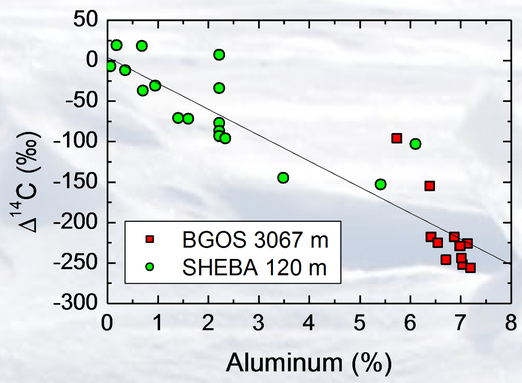

Figure 8. Relationship between Al content and ^{14}C content of POC in Canada Basin sinking particles intercepted at 120 m (SHEBA program, 1997; Fig. 3) and at 3100 m (BGOS Stn A; 2004).

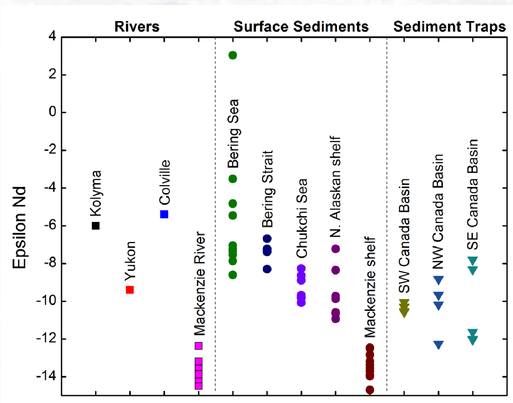

Figure 9. Neodymium isotopic composition (detrital fraction) of Canada Basin sinking particulate matter and proximal fluvial and marine surface sediment sources.

Summary

- Low particulate and organic matter fluxes to the deep Canada Basin indicate a very weak biological pump.
- Predominance of lithogenic material and pre-aged aged (^{14}C age, ~1-4 kyr) organic carbon, with higher fluxes at depth & during maximum ice extent, indicate lateral advection from surrounding margins as the dominant mode of particle supply to the deep basin.
- No evidence of change in the magnitude or nature of C fluxes despite major fluctuations in sea ice cover.
- *Key question: Is the Arctic Ocean system robust or poised for abrupt change?*

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