The Holocene History of Nares Strait: Transition from Glacial Bay to Arctic-Atlantic Throughflow

(The data from HLY03-05GC were generated under the NSF grant awarded to Jennings and Andrews: see funding source below.   Subset of Data is from core: HLY03-05GC)

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DATA SET OVERVIEW:

This subset of data generated under NSF 0713755 are published under the citation below.

ABSTRACT:

Retreat of glacier ice from Nares Strait and other straits in the Canadian Arctic Archipelago after the end of the last Ice Age initiated an important connection between the Arctic and the North Atlantic Oceans, allowing development of modern ocean circulation in Baffin Bay and the Labrador Sea. As low-salinity, nutrient-rich Arctic Water began to enter Baffin Bay, it contributed to the Baffin and Labrador currents flowing southward. This enhanced freshwater inflow must have influenced the sea ice regime and likely is responsible for poor calcium carbonate preservation that characterizes the Baffin Island margin today. Sedimentologic and paleoceanographic data from radiocarbon-dated core HLY03-05GC, Hall Basin, northern Nares Strait, document the timing and paleoenvironments surrounding the retreat of waning ice sheets from Nares Strait and opening of this connection between the Arctic Ocean and Baffin Bay. Hall Basin was deglaciated soon before 10,300 cal BP (calibrated years before present) and records ice-distal sedimentation in a glacial bay facing the Arctic Ocean until about 9,000 cal BP. Atlantic Water was present in Hall Basin during deglaciation, suggesting that it may have promoted ice retreat. A transitional unit with high ice-rafted debris content records the opening of Nares Strait at approximately 9,000 cal BP. High productivity in Hall Basin between 9,000 and 6,000 cal BP reflects reduced sea ice cover and duration as well as throughflow of nutrient-rich Pacific Water. The later Holocene is poorly resolved in the core, but slow sedimentation rates and heavier carbon isotope values support an interpretation of increased sea ice cover and decreased productivity during the Neoglacial period.

-Time period covered by the data:
Holocene record from c. 150 to 10,200 yrs BP

-Physical location of the measurement or platform (latitude/longitude/elevation)
081 37.286’ N; 063 15.467’ W
797 meters water depth

-Data source, if applicable (e.g. for operational data include agency)
Sediment core collected during cruise HLY0301. Gravity core, 371 cm long (i.e. accuracy, precision, frequency, etc.)

DATA COLLECTION and PROCESSING:

The following description of methods is from Jennings et al., 2011. Citation below.

Lithofacies descriptions are based on visual core descriptions and photographs of the newly split cores, x-radiography, and CT scanning. Visual core descriptions were made a year after collection at the Core Repository at OSU where the core is archived. Digital x-radiographs were taken of the working half of the core prior to sampling in 2008 at the Veterinary Hospital on the Oregon State University campus. Computerized tomographic (CT) density measurements were performed on the archive half of the core at the Oregon State University College of Veterinary Medicine in 2010 using a Toshiba Aquilion 64 Slice. Scans were collected at 120 kVp and 200 mAs. For visualization purposes, the resulting images were processed with a "sharp" algorithm to generate sagittal and coronal images every 4mm across the core. Down-core and across core pixel resolution within each slice is 500 µm. The cores were scanned in ~60 cm segments and then joined into a composite image using Adobe Photoshop software.

Thin sections were sampled, using the technique described in Francus and Asikainen (2001), from three intervals: A: 104.5 – 122.5 cm, B: 146.5 – 164.8 cm, and C: 240.5 – 258.9 cm, in order to study the origin of the laminations. Thin-section were prepared using a freeze-drying technique and observed at the petrographic and scanning electron microscopes. Micro-XRF scans were made on each of the thin section blocks in order to retrieve a chemical content with a resolution of 100 µm in the direction perpendicular to the stratigraphy (e.g. Cuven et al., 2010)

Chronology, Radiocarbon dating

Seven radiocarbon dates were obtained; five were on the polar planktonic foraminifer, *Neogloboquadrina pachyderma* sinistral (NPS), but the top date was from an individual mollusk and the basal date was from a combination of NPS and the benthic foraminifer, *Cassidulina neoteretis* (Table 1). We present calibrated ages and ^{14}C ages using a 400 year ocean reservoir correction (i.e. ΔR=0) for all samples and boundaries within the core in order to make the clearest comparison with the published glacial history which is reported in ^{14}C years corrected for an ocean reservoir age of 400 or 410 years (R=400 or 410 yrs). We recognize that a larger ocean reservoir correction likely is needed for some of the ^{14}C dates on marine carbonates from the Canadian Arctic Archipelago. A large ocean reservoir age of 735±85 yrs has been carefully determined (Dyke et al., 2003; Coulthard et al., 2010) so Table 1 also shows the HLY03-05 GC calibrated ages for this larger ΔR in order to show the probable high and low calibrated ages. To complicate this issue further researchers on northern Greenland use an ocean reservoir age, R=550 (i.e. ΔR=150 yrs) to calibrate the N. Greenland glacial records (Moller et al., 2010; Larsen et al., 2010). We calibrated the radiocarbon dates from HLY03-05GC using Calib 6.0 (Stuiver et al., 2010) with the Marine09 calibration curve (Reimer et al., 2009) (Table 1). The HLY03-05GC record extends from 160 to 10,300 cal yrs BP (130-9,010 ^{14}C years BP). The age model for the core is a 0-weight curve fit between the dated levels.

Benthic and Planktic foraminiferal assemblages

Foraminiferal subsamples were 2 cm wide and were taken every 10 cm for the length of the core. Samples were freeze-dried, weighed, soaked in distilled water and sodium metaphosphate, then wet sieved at 1000 µm, 106 µm and 63 µm. The sieve fractions were air dried and weighed, and these sieve fractions provide grain size information.

Benthic and planktic foraminiferal species were identified in the 1000-106 µm fraction using a binocular microscope. Where possible, at least 200 specimens were picked from each sample, to obtain a representative assemblage at each depth. For most samples a microsplitter was used to obtain a representative fraction. However, below 125 cm, there were several samples whose entire count was below 200. All specimens were identified to genus and species level.

The assemblages of foraminiferal species provide key information about the water masses present in Hall Basin (Atlantic Water, Pacific Water, Glacial meltwater), marine productivity (controlled by nutrients in the water, the duration of sea ice cover), sedimentation rates, and the basic physiography of Hall Basin: i.e. is it a deep basin in front of an ice stream facing the Arctic Ocean shelf, or is it a basin within a through flowing strait?).

Stable isotope analyses

Stable isotopes of oxygen and carbon were measured on tests (shells) of benthic, *C. neoteretis* and planktic, *Neogloboquadrina pachyderma* sinistral (NPS) at the Woods Hole Oceanographic Institute Mass Spectrometer Facility. $\delta^{18}O$ values were corrected for sea level changes using Fairbanks (1989) data. Twenty specimens between 150 to 250 μm diameter of each species were submitted for analysis. The $\delta^{18}O$ values of foraminiferal tests varies with both the temperature and isotopic composition of ocean water in which the foraminifers calcify. Lighter/heavier $\delta^{18}O$ values reflect fresher/saltier and warmer/colder water. Very light values can result from influx of isotopically light glacial meltwater. Surface water productivity and export to the seafloor of isotopically light organic matter produced in the surface water are the main controls on $\delta^{13}C$ values in the foraminifers, with large differences in benthic and planktic $\delta^{13}C$ values pointing to higher productivity and efficient export of labile organic matter to the seabed (Maslin and Swann, 2005). An additional factor for the $\delta^{13}C$ values of benthic foraminifers is the "Mackensen effect" in which growth and reproduction of benthic foraminifers, such as *C. neoteretis*, coincides with the episodic production of isotopically light phytodetritus (plant matter formed in the surface ocean that rains onto the seafloor); the affect is isotopically light $\delta^{13}C$ tests which reflect episodic productivity. Episodic seasonal productivity is characteristic of sea-ice dominated environments with short open water seasons, such as Nares Strait.

DATA FORMAT: N/A

DATA REMARKS: N/A

REFERENCES:

Jennings, A.E., C. Sheldon, T.M. Cronin, P. Francus, J. Stoner, and J. Andrews. 2011. The Holocene history of Nares Strait: Transition from glacial bay to Arctic-Atlantic throughflow. Oceanography 24(3):26–41, http://dx.doi.org/10.5670/oceanog.2011.52.