Project Title:
Collaborative Research: GEOTRACES Atlantic Section Nitrate Isotope Measurements

PI's:

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Project Summary:

Intellectual Merit

Nitrogen (N) is one of the two major nutrients required universally by plankton in the ocean, and its availability can affect the ocean's ecology, productivity, and carbon cycle. While the cycling of fixed N in the ocean is in one sense emblematic of other nutrient cycles, it is also unique in that its largest input (N fixation) and output (denitrification) are biologically mediated, which renders the ocean N budget susceptible to complex biological feedbacks. It thus provides a platform for asking one of the core questions of global biogeochemical cycles: How is it that the actions of individual organisms and groups conspire with physicochemical conditions to produce a global Earth surface environment that has been continuously habitable for billions of years?

The dominant terms in the oceanic fixed N input/output budget are poorly characterized, and we focus our attention here on N fixation. Developing robust estimates of the global rate and distribution of N fixation from ''direct'' shipboard measurements of N fixing activity is complicated by the inherent spatial and temporal variability of this biologically mediated flux. Thus, geochemical approaches for estimating N fixation inputs have come to the forefront. Currently, nitrate stable isotope measurements, which could provide an integrative estimate of N fixation on a regional or basin scale, are sparse in the Atlantic, being focused primarily in the Sargasso Sea. The GEOTRACES program provides a platform to put these data into a broader context through the illumination of basin-scale patterns.

We propose to measure the $\delta^{15}N$ of nitrate in seawater and atmospheric samples collected as part of the GEOTRACES North Atlantic Section. Nitrate $\delta^{15}N$ is a GEOTRACES "core parameter" that will complement other measurements and will by itself provide important constraints on the oceanographic processes, including N fixation, lateral nitrate transport, low latitude N cycling, the effect of the North African upwelling regions on nutrient fluxes across the basin, and the exchange of fixed N with the Mediterranean. In addition to yielding such specific process-related insights, this work will provide one of the first cross-basin views of nitrate isotopes in the interior and will thus help to simply characterize the isotope signals of different interior water masses, including the Mode Waters, Antarctic Intermediate Water, Mediterranean Intermediate Water, Lower and Upper North Atlantic Deep Water, and Antarctic Bottom Water. Finally, the isotopic characterization of atmospheric nitrate deposition will inform our understanding of the N isotope budget and isotopic gradients of the North Atlantic. Combined, these measurements

will yield insight into modern biogeochemical processes and will also provide first order background information for both modern physical oceanographic and paleoceanographic applications. As an example of the latter, studies of Atlantic sediments seek to reconstruct past changes in the rate of N fixation, based on the modern finding that N fixation appears to lower the $\delta^{15}N$ of thermocline nitrate in the Sargasso Sea. Progress in this paleoceanographic work relies on a more complete picture of nitrate $\delta^{15}N$ in the modern Atlantic.

Broader impacts

The broader impacts of the proposed study include the mentoring of a postdoctoral investigator and the inclusion of undergraduates in state-of-the-art research. Casciotti and Hastings are early career women scientists, and students at their institutions will be involved in this project. The project will also provide a high-quality nitrate isotope data set for the North Atlantic for use by the broader community. Our data will be submitted to the Biological and Chemical Oceanography Data Management Office, along with full procedural documentation