

TO: U.S. Arctic Geotraces Program
FROM: Dr. John P. Christensen, (jchristensen@gescience.com)
DATE: 29 September 2013
RE: Letter of Intent for U.S. Arctic Geotraces Expedition.

The oceans are a source of the greenhouse gas, nitrous oxide (N₂O), to the atmosphere. Nitrous oxide is formed primarily during nitrogen regeneration in the upper waters of the oceans, primarily in waters near the zone of primary productivity. However, production may be accentuated under very low oxygen concentrations associated with denitrifying waters and sediments (Codispoti and Christensen 1985). My past Arctic sampling on cruises of opportunity in the 1990's has shown that the ice-covered Chucki Sea and Canada Basin had very low levels of nitrous oxide relative other oceans and that subsurface maxima were located in and below the surface mixed layer. These vertical distributions would be consistent with the low levels of primary productivity fueling important nitrogen regeneration in the upper waters. However, part of the maxima was also associated with the halocline layers and may be produced in association with the intense denitrification coupled to nitrification that occurs near the sediment surface in the shallow Arctic shelf sediments (Christensen 2008). My sampling in the 1990's was insufficient to allow evaluation of the sediment source for the observed concentrations of nitrous oxide found in the water column. Now, with the significant reduction in sea-ice cover, it would be anticipated that greater nitrogen regeneration would be occurring in both the shelf areas and open basins of the Arctic and that increased shelf productivity may result in increased rates of sedimentary nitrification and denitrification. The Geotraces Arctic expedition would be a perfect opportunity to redetermine the distribution of nitrous oxide in these northern waters and to evaluate the change in outgasing of nitrous oxide from the Arctic Ocean.

To do this sampling well, we would need to measure nitrous oxide concentrations in waters collected by regular Niskin bottles over the full depth of the water column but with emphasis on the upper 500 m. This could be done on 800 ml of seawater (this volume includes duplicate samples from each Niskin bottle and several mandatory bottle rinses). For best results, the samples should be measured on board using gas chromatography. A small coupled gc-quadrupole ms system would be setup on shipboard, and the ms portion of the system would be used to measure the N₂/Ar ratios of the same samples as measured for N₂O (via the gc). Since one source of nitrous oxide may be nitrification / denitrification of shelf sediments, halocline waters would likely also show the imprint of sedimentary denitrification via slightly elevated N₂/Ar ratios. This test would allow us to discriminate between the local productivity associated source from N regeneration (no change in the N₂/Ar ratios) versus the sediment source. Two people would be needed to collect the samples and run the system, and so need to be on-board. We would propose to sample on all legs of the Arctic Geotraces. Samples for nitrous oxide need to be collected in a bubble free manner out of contact with the atmosphere, similarly to dissolved oxygen samples. These bottles would be run on-board by subsampling the bottles in a manner which prevents exposure to lab or outside air. Samples would be run within a day of collection.

References:

Christensen, J. P. 2008. Sedimentary carbon oxidation and denitrification on the shelf and slope of the Alaskan Beaufort and Chukchi Seas. *Open Oceanography Journal*, 2, 6-17.

Codispoti, L. A., Christensen, J. P. 1985. Nitrification, denitrification, and nitrous oxide cycling in the eastern tropical South Pacific Ocean. *Mar. Chem.* 16: 277-300.