N*, A PARAMETER THAT MAY BE USEFUL TO SBI INVESTIGATORS

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The parameter N* ((N* = N - 16P + 2.9) x 0.87) micromoles kg^{-1} (where N=nitrate and P=phosphate) is a potentially useful indicator of the extent to which nitrogen fixation (positive values of N*) or denitrification (negative values of N*) has occurred within a water parcel (Gruber and Sarmiento, 1997). We have previously used a slight modification of this property (in which N = nitrate+nitrite+ ammonium) to make rough estimates of denitrification rates in a portion of the Arctic Ocean and the Ross Sea (Codispoti et al., 2000). On average, we found much more negative values of N* in the Arctic which suggests a much higher denitrification rate than in the Antarctic, presumably as a consequence of denitrification in the extensive shallow sediments of the Arctic Ocean and its adjacent and marginal seas. We were able to make a rough and ready marine denitrification rate estimate (~40 Tg N yr^{-1}) for the Arctic based on some available inorganic nitrogen (nitrate+nitrite+ammonium) and reactive phosphorus data (phosphate), in the inflows and outflows to the Arctic (Table 1). This estimate agreed well with an estimate for denitrification based on a few direct measurements (Devol et al., 1997) but must be regarded as provisional because of the quantity and quality of existing data.

Table 1.
Guesstimates of the Average N* (in micromoles kg^{-1}) in Inflows and Outflows to the Arctic Ocean in the Upper ~200-300m

Inflows:

Atlantic ~ +2 (~0.8 of total inflow)
Pacific ~ -8 (~0.2 of total inflow)
Average ~ 0

Outflows: ~ - 8 (average of Canadian Archipelago and Fram St. outflows)

The SBI program represents an important opportunity to obtain improved N* data from the Pacific inflow region to the Arctic Ocean, but great care must be taken with nutrient determinations, particularly reactive phosphorus, to achieve this happy result. For example, even though the values of N* in the Arctic can to range from approximately +3 to -30, the data in Table 1 suggest that differences of ~2 micromoles kg^{-1} in the average inflow and outlow values for N* can significantly impact the estimated denitrification rate since the range in average values is only ~ 8 micromoles kg^{-1}. Since P is multiplied by 16 in the N* equation, this means that errors of ~0.1 micromoles kg^{-1} in reactive phosphorus can significantly impact calculations of N* in arctic waters. Given maximum reactive phosphorus concentrations in the SBI region of ~ 3 micromoles kg^{-1}, this translates into an error of ~3%. It is possible to achieve accuracies of ~ ± 1% with routine reactive phosphorus determinations, but great care has to be taken to ensure high precision, and standards have to be carefully made and inter-compared to achieve the required accuracy. It would be a major error for the SBI Phase II program to go into the field without the ability to achieve the precision and accuracy required for useful N* computations!

In the absence of nitrogen fixation and denitrification, N* would, in theory, be a conservative property. We know from a comparison of early spring (pre-bloom) and warm season data in the Ross Sea (Codispoti et al., 2000), however, that N* in the upper layers can be influenced by processes associated with phytoplankton blooms. Thus, it is best to concentrate on late winter and early spring data when attempting to calculate N*.

The differences in N* in the Pacific and Atlantic inflows are large (Table 1), but denitrification can decrease the N* values in both Atlantic and Pacific waters. Thus, at least one other water mass tracer may sometimes be required in order to employ N* to gain useful insight into water mass movements and mixing. Nevertheless, N* does seem to be a parameter that can be relatively easily interpreted. For example, we know that the entering Pacific waters have initial N* concentrations that are quite negative and that the Pacific inflow is high in nutrients that fuel productivity which, in turn, can fuel denitrification. Thus, the most negative N* values in the Arctic (~-30) are almost certainly Pacific waters that have been influenced by shelf processes. Similarly the most positive values (~+3) can be found in the Atlantic inflow. Overall, we feel that in shallow arctic waters, N* may have some advantages over formulations that combine dissolved oxygen and inorganic nitrogen or dissolved oxygen and reactive phosphorus (phosphate) to produce quasi-conservative parameters termed "NO" and "PO". Like N*, shallow "NO" and "PO" values can also be influenced by biological processes, but there is the further complication introduced by oxygen exchange with the atmosphere (e.g. Cooper et al., 1999). In addition, these parameters depend crucially on the constancy of oxygen/nutrient Redfield ratios which are more in dispute than the N/P ratio of 16/1 employed in the N* formula (Anderson and Sarmiento, 1994).

References

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