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The nitrogen cycle in the ocean, past and present

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Some three decades after the first measurements of nitrogen isotopes (δ15N) were made in the marine environment, 27 nitrogen enthusiasts from nine nations congregated on the verdant flanks of Mount Royal, in Montreal. This meeting represented the first for the PAGES Working Group “Nitrogen cycle in the ocean, past and present” (NICOPP). Over three days, this group discussed recent findings, summarized the state of knowledge, and highlighted outstanding challenges related to the use of sedimentary δ15N as a tracer of the marine nitrogen cycle. From a series of stimulating talks and enthusiastic discussions, three overarching topics emerged.

Seeing the big picture
While some areas of the ocean are dominated by either water column denitrification, nitrate utilization, or N2 fixation (Fig. 1), overlap between these processes can produce complex spatial patterns in nitrogen isotopes, apparent in simulations with coupled ocean-biogeochemistry models. As a result, isolated sediment records can be deceiving, as any one is likely to be a time-varying amalgam of all three processes. However, when assembled, records show coherent changes over time even in complex regions, with clear relationships to their oceanographic contexts, allowing the multiple processes to be disentangled. Accordingly, it was resolved by the NICOPP Working Group to amass a global database of all available bulk sediment N isotope measurements, to help move beyond the ambiguity of isolated wiggly lines.

The devil’s in the details
There has been considerable concern, over the decades, regarding just what N isotopes in marine sediments represent. The hopeful interpretation is that bulk combustible nitrogen, an easily measured quantity, represents the isotopic composition of the integrated marine organic export flux. However, isotopic alteration during sinking and burial, and contributions from terrestrial nitrogen, have been shown to modify the bulk isotope record in some environments. To account for these secondary influences, measurements are being made in a growing number of sedimentary fractions and specific compounds. These include the organic nitrogen trapped within microfossils, corals, chlorophyll and amino acids, as well as inorganic nitrogen. The results, so far, reveal new dimensions of complexity, as these individual components can vary with species assemblages, growth conditions, and trophic structures; yet, they often parallel