Final Report Summary

Natural Isotopic Tracers for Anthropogenic Nitrogen in Long Island Sound

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Public Summary

Anthropogenic nitrogen loading is the common cause of eutrophication in many aquatic systems, particularly in coastal estuaries and embayments. Excess nitrogen over-stimulates biological production leading to reductions in both water column clarity and subsurface oxygenation. Study of natural variations in stable isotopic ratio has repeatedly proven to be a powerful approach for studying biogeochemical cycles especially those for nitrogen and carbon. While past emphasis has been on global scale processes, utility for understanding regional to local anthropogenic impacts is becoming more widely recognized. Almost as a general observation, natural $^{15}N/^{14}N$ ratio ($d^{15}N$) has been found to increase with degree of eutrophication over a wide range in aquatic systems. Whether a single mechanism or set of mechanisms is responsible is not known and likely varies with the system considered. Such knowledge, though, is critical to making quantitative use of $d^{15}N$ data to diagnose and monitor N-stimulated eutrophication.

In Long Island Sound (LIS), eutrophication has been manifest as seasonal development of hypoxia, particularly at its poorly-flushed western end, during summertime vertical stratification. We have found relatively elevated $d^{15}N$ for the entire LIS, correspondingly increasing from east to west by several ‰. Dated sediment cores indicate that the onset of eutrophication and increasing $d^{15}N$ began with the urbanization of the LIS watershed in the mid-1800's. This ^{15}N enrichment could have been caused by 1) higher $d^{15}N$ in the anthropogenic N source particularly sewage, 2) biological removal of nitrate in the rivers flowing into LIS, and/or 3) denitrification removal of nitrate in LIS proper under hypoxic conditions. We have conducted a study of the isotopic composition of N sources to LIS as well as a seasonal study of the LIS water column to distinguish between these possible mechanisms.

Denitrification as a generator of high $d^{15}N$ values is clearly not as important as originally thought since summertime subsurface O_2 does not appear to become low enough and nitrate concentration not high enough to fuel significant denitrification. Our major conclusions instead include:

1) The high $d^{15}N$ values associate with the historical onset of LIS eutrophication are associated with high $d^{15}N$ values for sewage N.

2) The dominant anthropogenic source is from WWTP input along the East River.

3) Wintertime accumulation of NO_3^- in LIS is an important phenomenon which preconditions the intensity of the late winter/early spring phytoplankton bloom and likely summertime hypoxia. Winter time NO_3^- increase occurs at a rate almost twice that of WWTP and riverine inputs, most likely from regeneration from the sediments. Significant anthropogenic N has thus been stored in LIS sediments which may continue to be released back into the water column for some time to come.