



Nitrogen Cycling in Estuarine and Coastal Ecosystems

Deborah A. Bronk

College of William and Mary – School of Marine Science
Virginia Institute of Marine Science

Summaries and reviews:

- Fenchel, T., and Blackburn, T. (1978). The nitrogen cycle. In: *Bacteria and Mineral Cycling*, Academic Press, pp. 101-126.
- Boynton, W. R., Kemp, W. M., and Keefe, C. W. (1982). A comparative analysis of nutrients and other factors influencing estuarine phytoplankton production. In: V. S. Kennedy (ed.) *Estuarine Comparisons*. Academic Press, New York, p. 69-90.
- Nixon, S. W., and Pilson, M. E. Q. (1983). Nitrogen in estuarine and coastal marine ecosystems. In: Carpenter, E. J. and D. G. Capone (eds.) *Nitrogen in the Marine Environment*. Plenum Press, New York, p. 565-648.
- Valiela, I. (1983). Nitrogen in salt marsh ecosystems. In: Carpenter, E. J. and D. G. Capone (eds.) *Nitrogen in the Marine Environment*. Plenum Press, New York, p. 649-678.
- Postma, H., Kemp, W. M., Colebrook, J. M., Horwood, J., Joint, I. R., Lampitt, R., Nixon, S. W., Pilson, M. E. Q., and Wulff, F. (1984). Nutrient cycling in estuarine and coastal marine ecosystems. In: *Flows of energy and material in marine ecosystems*. Fasham, M. J. R. (ed.) Plenum Press, New York, p. 651-662.
- Ward, B. B. (1992). Nitrogen cycle in the sea. In: *Encyclopedia of earth system science* Academic Press, 295-305.
- Meybeck, M. (1993). C, N, P and S in rivers: From sources to global inputs. In: *Interactions of C, N, P and S Biogeochemical Cycles and Global Change*. Wollast, R., Mackenzie, and F. T. Chou, L. (eds.). Springer-Verlag, Berlin. 163-193.
- Legendre, L. (1995). Plankton and nutrient dynamics in marine waters. *Ophelia* 41: 153-172.
- Valiela, I. (1995). *Marine Ecological Processes*. 2nd ed. Springer, New York, 686. Chapter 14 - Nutrient cycles and ecosystem stoichiometry.
- Boynton, W. R., Garber, J. H., Summers, R., and Kemp, W. M. (1995). Inputs, transformations, and transport of nitrogen and phosphorus in Chesapeake Bay and selected tributaries. *Estuaries* 18: 285-314.
- Capone, D. G. (2000) The marine nitrogen cycle. In: *Microbial Ecology of the Oceans*. D.L. Kirchman (ed.). Wiley, New York, p 455-494.

The classics:

Redfield, A. C. (1958). The biological control of chemical factors in the environment. *American Scientist* 46: 205-221.

Dugdale, R. C., and Goering, J. J. (1967). Uptake of new and regenerated forms of nitrogen in primary productivity. *Limnol. Oceanogr.* 12: 196-206.

Ryther, J. H., and Dunstan, W. M. (1971). Nitrogen, phosphorus and eutrophication in the coastal marine environment. *Science* 171: 1008-1013.

Haines, E., Chalmers, A., Hanson, R., and Sherr, B. (1977). Nitrogen pools and fluxes in a Georgia salt marsh. Academic Press, New York, 241-254.

Eppley, R. W., and Peterson, B. J. (1979). Particulate organic matter flux and planktonic new production in the deep ocean. *Nature* 282: 677-680.

McCarthy, J. J., and Goldman, J. C. (1979). Nitrogenous nutrition of marine phytoplankton in nutrient depleted waters. *Science* 203: 670-672.

Goldman, J. C., McCarthy, J. J., and Peavey, D. G. (1979). Growth rate influence on the chemical composition of phytoplankton in oceanic water. *Nature* 279: 210-215.

Hecky, R., and Kilham, P. (1988). Nutrient limitation of phytoplankton in freshwater and marine environments: a preview of recent evidence on the effects of enrichment. *Limnol. Oceanogr.* 33: 796-822.

Selected topics in nitrogen research

Atmospheric deposition:

Asman, W. A. H., and Larsen, S. E. (1996). Atmospheric processes. In: *Eutrophication in Coastal Marine Ecosystems*. Jørgensen, B. B. Richardson, K. (eds.). American Geophysical Union, Washington, D. C. 21-50.

Seitzinger, S. and Sanders, R. (1999). Atmospheric inputs of dissolved organic nitrogen stimulate estuarine bacteria and phytoplankton. *Limnol. Oceanogr.* 44, 721-730.

Valigura, R. A., Alexander, R. B., Castro, M. S., Meyers, T. P., Paerl, H. W., Stacey, P. E. and Turner, R. E. (2001). Nitrogen loading in coastal water bodies. An atmospheric perspective. In "Coastal and Estuarine Studies" pp. 254. American Geophysical Union, Washington, D. C.

Dissolved organic nitrogen:

- Antia, N. J., Harrison, P. J., and Oliveira, L. (1991). Phycological Reviews. The role of dissolved organic nitrogen in phytoplankton nutrition, cell biology, and ecology. *Phycologia* 30: 1-89.
- Bronk, D. A., Glibert, P. M., and Ward, B. B. (1994). Nitrogen uptake, dissolved organic nitrogen release, and new production. *Science* 265: 1843-1846.
- Seitzinger, S. and Sanders, R. (1997). Contribution of dissolved organic nitrogen from rivers to estuarine eutrophication. *Mar. Ecol. Prog. Ser.* 159, 1-12.
- Bronk, D. A., Glibert, P. M., Malone, T. C., Banahan, S. and Sahlsten, E. (1998). Inorganic and organic nitrogen cycling in Chesapeake Bay: autotrophic versus heterotrophic processes and relationships to carbon flux. *Aquat. Microb. Ecol.* 15, 177-189.

Eutrophication:

- Matthews, E. (1994). Nitrogenous fertilizers: global distribution of consumption and associated emissions of nitrous oxide and ammonia. *Global Biogeochem. Cycles* 8: 411-439.
- Turner, R. E., and Rabalais, N. N. (1994). Coastal eutrophication near the Mississippi river delta. *Nature* 368: 619-621.
- Richardson, K., and Jørgensen, B. B. (1996). Eutrophication: definition, history and effects. In: *Eutrophication in Coastal Marine Ecosystems*. Jørgensen, B. B. and Richardson, K. (eds.). American Geophysical Union, Washington, D. C. 1-20.

Measuring nitrogen concentrations and rates:

- Glibert, P. M., and Capone, D. G. (1993). Mineralization and assimilation in aquatic, sediment, and wetland systems. In: *Nitrogen isotope techniques in plant, soil, and aquatic systems*. Knowles, R. and T. H. Blackburn (eds.). Academic Press, New York, p. 243-272.
- Grasshoff, K., Kremling, K., and Ehrhardt, M. (1999). *Methods of Seawater Analysis*. pp. 599.
- Bronk, D. A., Lomas, M., Glibert, P. M., Schukert, K. J., and Sanderson, M. P. (2000). Total dissolved nitrogen analysis: comparisons between the persulfate, UV and high temperature oxidation method. *Mar. Chem.* 69: 163-178.

Nitrogen Uptake and Limitation:

- Goldman, J. C., and Glibert, P. M. (1983). Kinetics of inorganic nitrogen uptake by phytoplankton. In: *Nitrogen in the Marine Environment*. Carpenter, E. J. and D. G. Capone (eds.). Plenum Press, New York, p. 233-274.

- Syrett, P. J. (1988). Uptake and utilization of nitrogen compounds. In: *Biochemistry of the Algae and Cyanobacteria*. Rogers, L. J. and Gallon, J. R. (eds). Oxford University Press, New York. 23-39.
- Howarth, R. W. (1988). Nutrient limitation of net primary production in marine ecosystems. *Ann. Rev. Ecol.* 19: 89-110.
- Dortch, Q. (1990). Review: The interaction between ammonium and nitrate uptake in phytoplankton. *Mar. Ecol. Prog. Ser.* 61: 183-201.
- Flynn, K. J. (1990). Review: the determination of nitrogen status in microalgae. *Mar. Ecol. Prog. Ser.* 61: 297-307.
- Glibert, P. M., Garside, C., Fuhrman, J. A., and Roman, M. R. (1991). Time-dependent coupling of inorganic and organic nitrogen uptake and regeneration in the plume of the Chesapeake Bay estuary and its regulation by large heterotrophs. *Limnol. Oceanogr.* 36: 895-909.
- Glibert, P. M., and Garside, C. (1992). Diel variability in nitrogenous nutrient uptake by phytoplankton in the Chesapeake Bay. *J. Plankton Res.* 14: 271-288.
- de Baar, H. J. W. (1994). von Liebig's law of the minimum and plankton ecology (1899-1991). *Prog. Oceanog.* 33: 347-386.
- Pantoja, S., Lee, C. and Marecek, J. F. (1997). Hydrolysis of peptides in seawater and sediment. *Mar. Chem.* 57, 25-40.
- Mulholland, M. R., Glibert, P. M., Berg, G. M., Van Heukelem, L., Pantoja, S., and Lee, C. (1998). Extracellular amino acid oxidation by microplankton: a cross-system comparison. *Aquat. Microb. Ecol.* 15: 141-152.
- Kirchman, D. L. (2000). Uptake and regeneration of inorganic nutrients by marine heterotrophic bacteria. In: *Microbial Ecology of the Oceans*. Kirchman, D. L. (ed.). Wiley, New York. pp. 261-288.

Nitrogen fixation, Nitrification, and Denitrification:

- Mosier, A.R., and Schimel, D. S. (1993) Nitrification and denitrification. In: *Nitrogen Isotope Techniques* Academic Press, Inc., pp. 181-209.
- Joye, S., and Hollibaugh, J. (1995). Influence of sulfide inhibition of nitrification on nitrogen regeneration in sediments. *Science* 270: 623-625.
- Ward, B. B. (1996). Nitrification and denitrification: probing the Nitrogen Cycle in aquatic environments. *Microb. Ecol.* 32: 247-261.

Ward, B. B. (2000). Nitrification and the marine nitrogen cycle. In: *Microbial Ecology of the Oceans*. Kirchman, D. L. (eds). Wiley, New York. 427-454.

Paerl, H. W., and Zehr, J. P. (2000). Marine nitrogen fixation. In: *Microbial Ecology of the Oceans*. Kirchman, D. L. (ed.). Wiley, New York. 387-426.

Nutrients and Harmful Algal Blooms:

Paerl, H. W. (1997). Coastal eutrophication and harmful algal blooms: importance of atmospheric deposition and groundwater as "new" nitrogen and other nutrient sources. *Limnol. Oceanogr.* 42: 1154-1165.

Glibert, P. M., and Terlizzi, D. E. (1999). Cooccurrence of elevated urea levels and dinoflagellate blooms in temperate estuarine aquaculture ponds. *Appl. Environ. Microbiol.* 65: 5594-5596.

Photochemical processes:

Bushaw, K. L., Zepp, R. G., Tarr, M. A., Schulz-Jander, D., Bourbonniere, R. A., Hodson, R., Miller, W. L., Bronk, D. A., and Moran, M. A. (1996). Photochemical release of biologically labile nitrogen from dissolved organic matter. *Nature* 381: 404-407.

Kieber, D. J. (2000). Photochemical production of biological substrates. In: *The effects of UV radiation in the marine environment*. de Mora, S., Demers, S. and Vernet, M. (eds.). Cambridge University Press, Cambridge. 131-148.

Trophic interactions and nutrient cycling:

Glibert, P. M. (1998). Interactions of top-down and bottom-up control in planktonic nitrogen cycling. *Hydrobiologia* 363: 1-12.

Coats, D. W., and Revelante, N. (1999). Distributions and trophic implications of microzooplankton. In: *Ecosystems at the Land-Sea Margin*. Malone, T. C., Malej, A., Harding, J., L. W., Smolaka, N. and Turner, R., E. (eds.). American Geophysical Union, Washington, D. C. 207-240.

Wommack, K. E., and Colwell, R. R. (2000). Virioplankton: Viruses in aquatic ecosystems. *Microbiol. Mol. Biol. Rev.* 64: 69-114.

Sediments:

Billen, G., and Lancelot, C. (1988). Modelling benthic nitrogen cycling in temperate coastal ecosystems. In: *Nitrogen cycling in coastal marine environments*. Blackburn, T. H. and Sørensen, J. (eds.). John Wiley Publ., New York. 341-378.

Kemp, W. M., Faganeli, J., Pskaric, S., Smith, E. M., and Boynton, W. R. (1999). Pelagic-benthic coupling and nutrient cycling. In: *Ecosystems at the Land-Sea Margin*. Malone, T. C., Malej, A., Harding, J., L. W., Smolaka, N. and Turner, R., E. (eds.). American Geophysical Union, Washington, D. C. 295-340.