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WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Biologically-Mediated Nitrogen Dynamics in Eutrophying Estuaries: Assessing Denitrif'ication and N2 Fixation Responses to Proposed N Loading Reductions in the Neuse River Estuary

Duration: From I July, 1997 To 30 June, 1998

Federal Funds: $33,67

Non-Federal Funds: $67,347

Principal Investigators: Hans W. Paerl, UNC-CH Institute of Marine Sciences, 3431 Arendell
Street, Morehead City, NC 28557 and, James L. Pinckney same address as above.

Congressional District No.: 6th

Water Problem and Research Need:

Troubling symptoms of nutrient-driven eutrophication are proliferating regionally and nationally. Most larger river systems and estuaries in the southeastern U.S. are showing signs of water quality degradation. The Neuse River-Estuary, NC is an ecosyst em experiencing sudden and rapid reduction in water quality and urgently requires the development of effective, attainable, and ecologically-sound nutrient management strategies. Within the past two decades, the Neuse has undergone a transition from a bal anced and productive system to one experiencing unprecedented biogeochemical change and trophic deterioration. Nuisance dinoflagellate, cryptomonad, and cyanobacterial blooms, accompanied by hypoxia/anoxia, toxicity, fin- and shellfish kills, are growing in frequency, duration, and areal extent (Paerl 1987, Paerl et al. 1995). The research outlined in this proposal examines the role of two biologically-mediated processes (denitrification and phytoplanktonic N2 fixation) that are potentially major regulato rs of N-cycling characteristics and rates in riverinc and estuarine habitats. Phytoplankton primary production in the lower Neuse river and estuary is controlled by N availability (i.e., N4imited) throughout much of the year (Paerl 1987, Paerl et al. 1995 , Boyer et al. 1994). Excessive N-loading and expanding algal blooms have promoted eutrophic conditions in the lower reaches of the Neuse River (Boyer et al. 1993, Paerl et al. 1995). Riverine loading of dissolved inorganic nitrogen (DIN) is dominated by nitrate-nitrite (NO~) which declines non-conservatively down-estuary under most flow conditions (Christian et al. 1991). While much emphasis has been placed on biotic assimilation and recycling of nitrogen in the Neuse (Boyer et at. 1995, Christian et al. 1991), an alternative fate of DIN is microbially-mediated denitrification in estuarine sediments. Denitrification is thought to be a substantial annual sink for nitrogen inputs to estuarine systems (Kemp et al. 1990, Seitzinger 1988, Smith et al. 1985), but no published data exist for the Neuse. Determining the role of microbially-mediated denitrification in N cycling and N budgets of the Neuse River Estuary is critical for a complete understanding of the fate and effects of nutrient inputs to estuarine ecosystems.

Deteriorating water quality and associated negative impacts on fisheries and recreation have prompted calls for an N input "cap" and an overall 30% reduction in N-loading to the Neuse River (NC DEHNR Draft Neuse Basin Management Plan). However, changes in N4oading may result in shifts in the ratio of dissolved nitrogen to phosphorus (N:P) loadings and concentrations in the Neuse River. Alterations in N:P in the river water may have significant impacts on aquatic communities beyond a simple reduction in phytoplankton productivity and biomass (standing stock), including shifts in species composition and possible selection for species adapted to growth in waters with reduced N:P (Tilman et al. 1982, Smith 1983). The phytoplankton community could conceivab ly become dominated by N: fixing (diazotrophic) cyanobacteria that may circumvent N-limitation imposed by the managed N-depletion by "fixing" atmospheric N into biologically-available forms (Fogg 1974, Paerl 1990). Additionally, reduction in N loading may affect the magnitude and distribution of microbially-mediated denitrification.

Competitive Interactions between cyanobacteria and other phytoplankton species may reduce food availability for primary and secondary consumers (zooplankton and fish), altering the trophic structure (food webs) in the Neuse (Fulton & Paerl 1987a, b). An **assessment of** the impact of N-loading reductions on phytoplankton communities is needed to determine if additional controls may be **necessary** to effectively manage nuisance cyanobacterial growth in the Neuse River-Estuary.

Results and Benefits:

Results of this research will provide insights into the effects of N-loading reductions on the phytoplankton community, specifically on the *potential* for the enhancement of nuisance cyanobacterial blooms by lowering N:P ratios. Benefits will include a preliminary assessment of the effects of a proposed 30% N-loading reduction on the present (existing) phytoplankton community, an evaluation of the N2 fixing potential and rates under reduced N-loading, baseline data for monitoring the effectiv eness of N-loading reductions, and identification of other factors (e.g., P, timing of loading, etc.) that may have to be managed to achieve the desired level of phytoplankton productivity and water quality in the Neuse River-Estuary. Additionally, this p roject will provide information on rates of denitrification, an unknown, yet potentially important fate of nitrogen in the Neuse River and other mid-Atlantic shallow, N impacted estuaries. Projections will be made regarding the change in magnitude and dis tribution of microbially-mediated denitrification following proposed reductions in N loading.

Several groups (including the Pl's and multidisciplinary teams at the DSGS-Raleigh Office, NC State Division of Water Quality, NC State University, and UNC-Chapel Hill) are currently developing two-and three-dimensional water quality models for the Neu se River-Estuary. One of the "data gaps" for this effort is the lack of quantitative information on the relationship between hydrodynamic conditions, nutrient loading/concentrations, and phytoplankton community composition and responses. Additionally, the models lack sufficient data on the role of microbially-mediated denitrification in N-cycling in the Neuse River Estuary. The proposed research will provide critical data for linking system hydrodynamics with nutrient dynamics and subsequent impacts on ph ytoplankton responses, algal bloom dynamics, and species alterations. We will be provide data necessary for model parameterization, development, and simulations. These data will also be very useful for testing and validating existing water quality models (e.g., HYDROQUAL, WASP).