SUMMARY

The Neuse River Basin has experienced unprecedented growth in the past 50 years. Changing and diversifying land use practices that include forestry, agriculture, industry, wetlands and large urban areas have placed increasing pressure on aquatic and estuarine habitats to accommodate human induced inputs. The result has been a very evident, long term degradation of water quality in the Neuse River Estuary.

The State of North Carolina has recognized this problem and has designated water quality improvement as an issue of highest priority (e.g., the Neuse River Nutrient Sensitive Waters Management Plan, EMC, June 1997). As a first step toward reversing the downward water quality spiral in the Neuse, the North Carolina General Assembly has enacted legislation requiring a 30 percent reduction in nitrogen loading to the estuary. While the scientific/technical community generally believes this will yield noticeable water quality improvements, we currently cannot predict either the extent of its effectiveness or optimal ways in which it should be implemented. Even more disturbing is the likelihood that we will not be able to determine the effectiveness of these measures after the fact due to the significant year to year variations in water quality that routinely occur in the Neuse.

Success in predicting or even identifying the effects of significant management actions in a complex system like the Neuse River Estuary will require an understanding of the linkages between basin-wide loading and ecosystem response. The Neuse River Estuary MODEling and MONitoring (MODMON) project consists of a multi-institutional team of investigators that are collaborating to understand the critical processes governing these linkages and to develop models for use by state officials to assist future management decisions.

Primary funding for the MODMON project has come from a one-time allocation in 1996 by the North Carolina General Assembly to the Department of Environment and Natural Resources. This funding has been sufficient for startup modeling efforts and one year of field work (June 1997 - May 1998). However, understanding a system with the large year to year variations seen by the Neuse River Estuary will be impossible without continued funding for at least the next 5 years. This time will allow modeling and monitoring that resolves some of the natural variations in the system and that spans pre- and post-management periods. The results should include a much clearer understanding of the Neuse system, a rigorous assessment of current model predictions of the effects of nutrient load reduction in the system and the availability of more accurate model predictions to design future management actions.

Students at West Carteret High School participate in oxygen uptake experiments using sediment cores collected from the Neuse River as a part of the MODMON project.
**THE PROBLEM**

The slow flowing waters of the Neuse River Estuary, in combination with the increased nutrient (primarily nitrogen) loading of recent years, provide optimal conditions for enhanced phytoplankton (algae) growth. When phytoplankton grow faster than consumption by animal grazers, massive blooms can occur that color the water green, yellow or red, are malodorous, cause fouling and even release toxins. Environmental constraints eventually cause these blooms to die. However, in slowly flowing waters the dying blooms sink to the bottom and are either decomposed immediately or stored in the bottom sediments and decomposed later. When decomposition takes place, it removes large amounts of oxygen from the water column and may overwhelm the rate at which oxygen is mixed downward from the water surface. This is especially true during times when the water column is stratified (fresh runoff water overlying salty sound water) and/or under calm conditions when little mixing energy is available from the wind. Under these conditions the lower part of the water column can exhibit dangerously low oxygen levels which, if maintained for long enough, create stress for fish and shellfish. Massive fish and shellfish kills have been linked to oxygen stress either directly or indirectly due to increased susceptibility to disease or algal toxins.

**CRITICAL NEEDS**

The 30 percent reduction in nitrogen loading to the Neuse River Estuary legislated by the North Carolina General Assembly should yield noticeable long term water quality improvements. Yet, we currently cannot predict *before hand* either the extent of its effectiveness or optimal ways in which it should be implemented. Even more disturbing is the likelihood that we will not be able to determine the effectiveness of these measures *after the fact* due to the significant year to year variations in water quality that routinely occur in the Neuse.

The Neuse River Estuary MODeling and MONitoring (MODMON) project has assembled an internationally recognized group of scientists from academia, state and federal government and private industry with expertise in modeling, marine physics, nutrient cycling, geochemistry, geology, plankton dynamics and fisheries ecology. The collaborative efforts of this unique group have been focused on water quality problems in the Neuse River Estuary and will lead to better understanding of critical processes that link basin-wide nutrient loading to ecosystem response and to improved models that can be used by state officials to make management decisions. However, success in understanding and ultimately managing a system that experiences considerable year to year variability like the Neuse (e.g., the 1995 fish kills and the 1996 hurricanes), will require a program such as MODMON for at least the next 5 years as well as continued monitoring programs after that. This need is critical if we hope to understand the effects of current management actions and to predict future system responses to proposed management strategies.

With the present funding for the MODMON project, all monitoring efforts are scheduled to end in May of 1998. The modeling and data analysis will end soon after. When completed, we will have a comprehensive data set and water quality models calibrated for a relatively normal hydrologic year prior to the implementation of any management actions. However, what we particularly need is the ability to manage the Neuse for extreme years and to definitively understand the effects of the upcoming management actions. Thus it is critical to continue MODMON for the next several years to provide data and modeling that encompasses the natural variability in the system and that spans pre- and post-management periods. The scientific group and most of the necessary infrastructure are in place to continue these efforts, but we require continued funding to allow this to happen.
**MODMON PROGRESS, MAY - OCTOBER 1997**

The MODMON team includes scientists from UNC - Chapel Hill, NCSU, Duke, ECU, UNC - Charlotte, the US Geological Survey, the state Division of Water Quality and the Weyerhaeuser Corp. While this group has been in place for only a few months, significant progress has occurred toward MODMON project goals. Specifically, we have:

- convened a coordinating workshop at the UNC Institute of Marine Sciences, attended by over 30 North Carolina scientists, to acquaint researchers with overall research goals in the Neuse River Estuary and to establish a framework of active communication and collaboration that has characterized MODMON to date,
- established a MODMON home page at: http://www.marine.unc.edu/ neuse/modmon containing details of this project and presenting latest and archived results in graphical form from both the modeling and monitoring phases,
- collected sediment samples from 185 locations between New Bern and the mouth of the Neuse to determine physical characteristics and chemical properties of the bottom,
- collected 648 cores between New Bern and the mouth of the Neuse to determine the bottom-dwelling animal resources and community composition. Initial sampling in June revealed a dense cover of juvenile bivalves over virtually the entire bottom. Sampling in August showed living bivalves persisting only in well-oxygenated shallow water areas.
- conducted bi-weekly oxygen surveys and fish trawls in a 10 km stretch of the Neuse River Estuary near Cherry Point. Significant fish catches occurred only in water having dissolved oxygen concentrations above 5 mg/l. The benthic animal surveys and the fish trawls together indicate that a substantial amount of bottom area (as much as 60 - 80 %) is routinely unavailable to fish and shellfish due to low dissolved oxygen concentrations in summer and is subsequently degraded as fish habitat because of the loss of invertebrate prey on the bottom;
- conducted oxygen uptake experiments on intact sediment cores to determine rates of sediment oxygen demand;
- obtained 2 months of surface and near bottom water level, salinity, temperature and current velocity data near Minnesott Beach.
- conducted weekly surveys at 17 mid-river locations stretching from the Streets Ferry bridge to the mouth of Neuse River Estuary consisting of dissolved oxygen, salinity, temperature and various additional water quality and nutrient parameters. These data are typically made available in graphical form at the MODMON web site within 24 hours of being collected,
- conducted weekly surveys across the river at up to six locations between New Bern and the mouth of the Neuse River Estuary consisting of dissolved oxygen, salinity, temperature and chlorophyll $a$. These data are also available graphically at the MODMON web site. Together with the mid-river data, we are able to construct weekly maps of the extent of low oxygen conditions throughout much of the Neuse,
- initiated calibration and error propagation studies with the two-dimensional, laterally-averaged circulation/water quality model CEQUAL-W2. Model results and animated simulations can be reached from the MODMON web site,
- constructed and analyzed 16 seasonal models of nitrogen cycling in the Neuse River Estuary to assess variability in the fate of nitrogen loading and the relative importance of loading and recycling,
- held the first of three planned workshops to evaluate alternative strategies for water quality modeling in the Neuse River Estuary,
- initiated an outreach program involving students at West Carteret High School. Students conducted oxygen uptake experiments using sediment cores from the Neuse River Estuary and are analyzing the data in the context of simple calculus equations. Final results will be displayed on the MODMON web site. We believe this outreach effort is an important opportunity to educate the public on critical water quality issues in North Carolina.