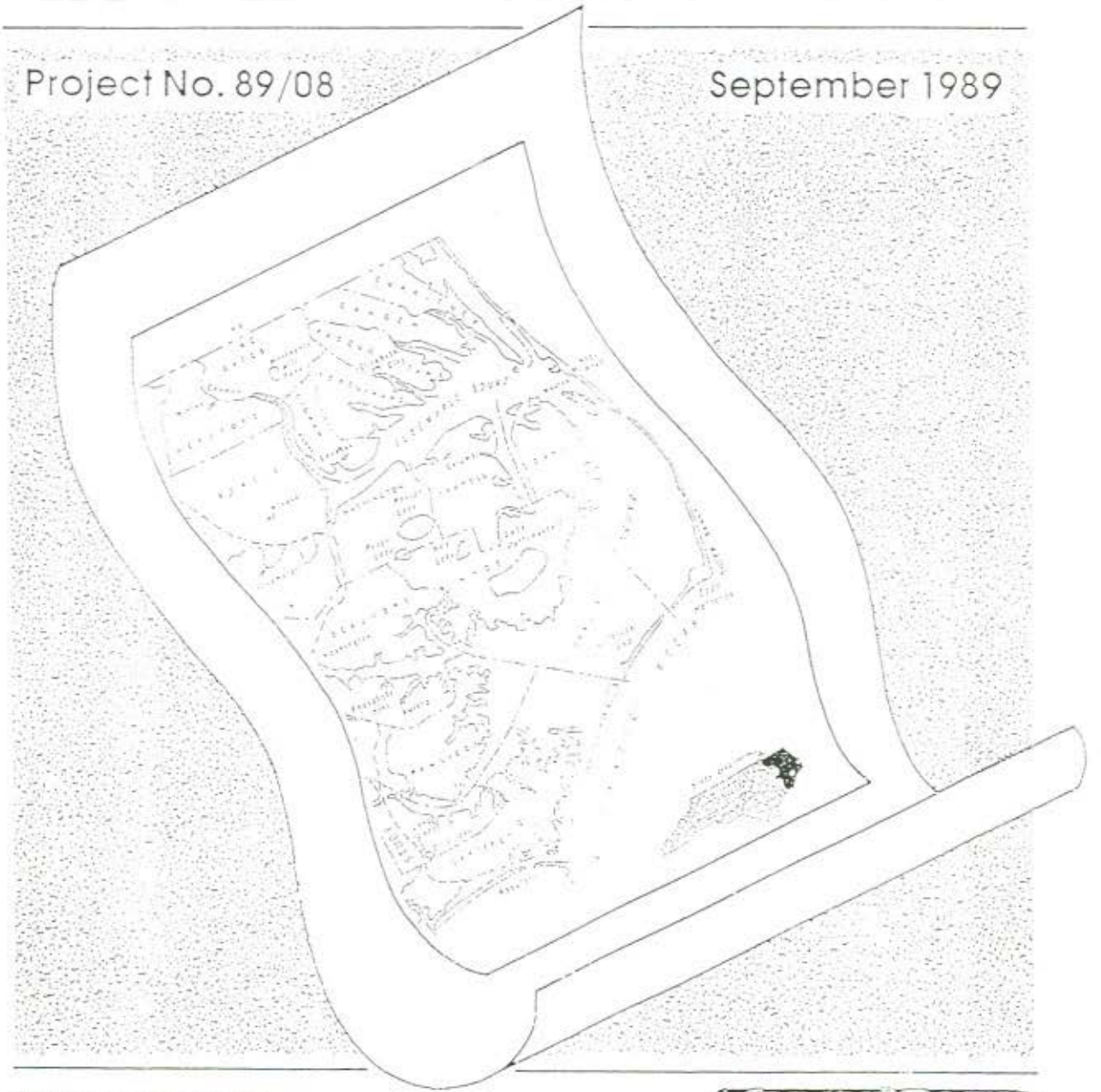
PROJECT ABSTRACTS

FOR THE PERIOD 1989--1990

ALBEMARLE - PAMLICO ESTUARINE STUDY

Project No. 89/08

September 1989



North Carolina Department
of Environment, Health,
and Natural Resources

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National Estuary Program

PROJECT ABSTRACTS

For the Period 1989 -- 1990

Edited By

Robert E. Holman, Ph.D.
A/P Study Program Director

Project No. 89-08

September, 1989

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PROJECT ABSTRACTS FOR THE PERIOD 1989-1990

This is the second year the Albemarle-Pamlico Estuarine Study has compiled project abstracts as a supplement to the Annual Researchers' Review Workshop. The report is a compilation of project abstracts covering the period from 1989 to 1990. The period includes most funded projects during fiscal year 1988-1989 and 1989-1990. Abstracts are organized according to the six major categories of information required to facilitate effective management of the program. These categories include resource critical areas, information management, fisheries, water quality, public participation and human environment.

Resource critical area category includes projects designed to identify specific areas where conflicts between affecting and affected uses are most significant. Projects designed to reduce those conflicts by effective management of these critical areas are also included. Information management efforts will be to provide users with access to data that will aid in addressing the issues associated with each category. The ability to effectively manage the data will be critical to the program's success. Fisheries category consists of projects intended to relate major changes in fisheries health and productivity to human activities. The fisheries processes are isolated from other estuarine relationships because of two specific fishing related phenomena of declining landings and fish diseases which require special attention. Water quality category includes projects designed to examine the causal relationships between human activities, significant instream modifications and the ramifications of changes for estuarine-dependent human activities. This category includes management-oriented investigations of major water quality processes and conflicts. Public participation is being addressed by an active public participation/public awareness program. Participation is intended to facilitate communication between the public and program administration; to marshal support from local governments and regional institutions; and to allow dissemination of information gathered through this study. The success of this first phase of the program (develop a comprehensive conservation management plan) will determine whether the second phase (implementation of the conservation management plan) will become a reality. The final category of human environment involves projects which examine the trends and patterns in the intensity of human uses and the institutional climate where management plans must operate.

These six categories of information gathering and dissemination must be pursued for effective management to take place. There must be an improved understanding of causal connections between human activities and changes in the estuaries for proper management pressure to be exerted on critical relationships, in order to reduce conflicts between competing uses.

Critical Area

HYDE COUNTY SOIL SURVEY

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APES is sharing the local cost of the North Carolina Cooperative Soil Survey Program in Hyde County. The purpose of the survey is to determine the nature and extent of the various soils in Hyde County. This inventory will provide basic land resource data necessary for making proper land use decisions. The data will support local, state and federal level efforts to protect and conserve the natural resources of the county. The potential of land areas will be determined relative to suitability for agriculture, forestry, residential and other uses.

The Hyde County Soil Survey is undertaken through the North Carolina Cooperative Soil Survey Program as a joint effort between the USDA, Soil Conservation Service, the North Carolina Department of Environment, Health, and Natural Resources (EHNR) and Hyde County. Each level of government is responsible for about one-third of the survey's cost. EHNR and the Soil Conservation Service are providing a total of 7 man years of technical expertise. Hyde County is making a cash contribution of $60,000, half of which is funded through APES.

The Cooperative Soil Survey Program requires soil classification according to the national soil taxonomy system and follows standards and criteria established in the USDA National Soils Handbook 1983. Mapping is by trained and experienced DEHNR and SCS soil scientists. Mapping is done in the field and involves inspection by hand augering, observation of landscapes and vegetation, and ph determinations. Laboratory analysis of various physical and chemical properties support the mapping and classification.

Hyde County has a land area of approximately 400,000 acres. Soils mapping was previously done on about 110,000 acres by Weyerhauser, the Soil Conservation Service and First Colony Farms, leaving about 290,000 acres for the Cooperative Soil Survey Program. The previously mapped acres require review and revision before inclusion into the soil survey. The survey began in the fall of 1987 and is scheduled to be completed in the fall of 1990. As of August 1989, 99,170 acres have been regularly mapped and 32,000 acres have revision mapped. Thirty three distinct soil series are being mapped in the county.

The soil survey identifies soil types on 1:24,000 scale aerial photographic base maps. Preliminary sheets are scheduled to become available beginning in late August 1989. A final document will be published by the Soil Conservation Service after completion of the survey.

PROJECT ABSTRACT

Mapping and GIS Implementation of Land Use and Land Cover Categories for the Albemarle-Pamlico Estuarine Study

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The need for land use and land cover data is clearly documented in the A/P Study Work Plan. However, the lack of a land use inventory for the Albemarle-Pamlico Estuary remains a critical gap in the A/P Study resource database. No accurate assessments of nonpoint sources to instream water quality problems can occur without up to date information on land use. These base-line data are also needed for assessing trends, use conflicts, and cumulative impacts of activities that directly impact wildlife habitats, recreational opportunities, and water quality.

The objectives of this project are to develop a current digital land use inventory of the A/P Study drainage area; to integrate these data into the A/P Study database; and to develop mechanisms for maintaining and updating the land use and land cover data. The goal of the project is to provide base-line data on the area's resources in a form usable by scientists and decision makers to facilitate research and management activities.

Landsat Thematic Mapper digital data will be used to map land use and land cover for the entire study area. Data will be classified using U.S. Geological Survey Standard Level II categories. Land use and land cover data will be registered and vertically integrated with the A/P Study database. The data will be available to investigators in a standard data exchange format or for use in combination with other data in the A/P Study's geographic information system. The data will also be available in report form summarized by geopolitical and physiographic boundaries for distribution to the user community.

REGIONAL INVENTORY AND PROTECTION PLAN FOR CRITICAL NATURAL AREAS, WETLAND ECOSYSTEMS, AND ENDANGERED SPECIES HABITATS OF THE ALBEMARLE-PAMLICO ESTUARINE REGION: PHASE 1

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The rapid development of North Carolina's coastal and tidewater regions has caused an urgent need to protect significant natural resources in this part of the state. However, before protection of natural resources and natural areas can be accomplished, it is important to have background information about these resources, such as locations of endangered and rare species and deliniation and description of critical natural areas. The North Carolina Nature Preserves Act delegates responsibilities to the Natural Heritage Program for maintaining the statewide inventory of important natural areas and rare species habitats.

Funding from APES has allowed for a reconnaissance inventory to identify, describe, map, prioritize, and make protection recommendations for special natural areas, exceptional wetland ecosystems, and endangered and rare species habitats in ten counties -- Currituck, Camden, Pasquotank, Perquimans, Chowan, Gates, Hertford, Bertie, Martin, and Washington -- adjacent to Albemarle Sound. Biologists contracted by the Natural Heritage Program have consulted other biologists familiar with these counties, in addition to reviewing soil maps, topographic maps, aerial photos, and other sources to determine sites for survey work that appear to contain significant or critical natural resources.

Approximately 300 sites have been identified from these various sources during the preliminary screening. Some sites will likely not be visited because of time constraints, and others will be visited and found to lack sufficient biological significance to be included in the final report. It is expected that perhaps 100 of these sites will be described in the report.

The final report will be a compilation of critical natural areas, both those already under protection and those lacking protection, in addition to discussions of endangered and rare species, wetland ecosystems and other natural communities, and the geomorphology of the 10-county region. Data from the project will be recorded in the Natural Heritage Program's central inventory management system, which is used by many other agencies for environmental impact assessment, land use planning, resource management decisions, and conservation planning.

Data Management

PROJECT ABSTRACT

Albemarle Pamlico Estuarine Study
Data Management Program

Land Resources Information Service
Department of Natural Resources and Community Development

The Data Management Program, administered by the Land Resources Information Service (LRIS), is an ongoing component of the Albemarle Pamlico Estuarine Study. The goal is to provide management support for the overall objectives of the Study by furnishing natural resource managers and researchers with information to directly aid in addressing the issues of the region.

Major accomplishments of the Program during Fiscal Year 1988-89 include:

- Hiring of a Data Management Coordinator (GIS Coordinator)
- Completion of a formal Data Needs Assessment consisting of a description of the user groups; a list and documentation of the cartographic, tabular, and bibliographic data requirements; and recommendations for implementing the A/P Study Database, including data development priorities
- Completion of a Software Requirements Assessment describing a Data Management and Analysis System, which will provide access by users to the A/P Study Database
- Design and partial implementation of the A/P Study Database and the Data Management and Analysis System
- Preparation of a Data Inventory documenting all known data collections concerning the study area
- Design and partial implementation of an atlas showing cartographic data by layers
- Response to numerous requests for information from users and the A/P Study Office.

Water Quality

FLOWS AND FLOW PATTERNS IN THE PAMLICO AND NEUSE RIVER ESTUARIES

By Jerad Bales, U.S. Geological Survey

Water-quality management relies, to a large degree, on waste-load allocation studies, but estuarine waste-load allocations cannot be effectively accomplished without flow information. Analysis of the effects of management actions on estuarine water quality depends upon the detection of trends in water quality. Water-quality trend analysis is more reliable and scientifically defensible when trends in constituent loading (which require flow information to determine) are used rather than trends in concentrations.

Much of the water-quality, critical habitat, and fisheries research being conducted as a part of the Albemarle-Pamlico (A/P) Study is focused on the Pamlico and Neuse River Estuaries. Immediate concerns related to water quality and the relation between water quality and the living resources must also be addressed. Yet, before this A/P Estuarine Study/U.S. Geological Survey cooperative investigation was initiated, a data-collection network designed to provide continuous flow information for the two estuaries did not exist. Likewise, information on flow patterns in the two estuaries, which is needed to properly implement current management programs, has not been documented for a wide range of natural conditions.

The objectives of this investigation are to (1) collect and interpret long-term, continuous records of data relating to the hydrodynamic nature of the two estuaries and (2) calibrate and validate a numerical model of hydrodynamics and transport in each estuary. In addition to providing improved understanding of the physical characteristics of the estuaries, the study should furnish a tool to aid managers in analyzing constituent loadings, developing waste-load allocations, and investigating the impacts of water-quality changes on living resources.

The investigation consists of (1) long-term continuous data collection, (2) short-term intensive studies, and (3) data analysis and interpretation. Data are being collected and interpreted for the segment of the Pamlico River between Washington and the confluence of the Pamlico and Pungo Rivers. The Neuse River study reach is approximately between New Bern and Oriental.

Long-term continuous data collected as part of this study include (1) tidal elevations, (2) water-quality data, and (3) wind data. Tidal elevations are recorded at 15-minute intervals at five sites on the Pamlico River and six sites on the Neuse River. Water-quality measurements include (1) conductivity at two shore-based sites on both the Pamlico and Neuse and (2) temperature, conductivity, and dissolved oxygen obtained by monitors located on channel markers. Six monitors are located in the Pamlico River and six are in the Neuse River. Each monitor records temperature at one depth, conductivity at two depths, and dissolved oxygen at three depths. Wind speed and direction data are obtained from nearby weather stations. The continuous data are being used to provide boundary conditions for the numerical model, to calibrate the model, and to investigate physical processes, such as seasonal and spatial variations. The data also have been used by other A/P Study researchers and by resource managers.

A short-term set of velocity measurements is planned for the Pamlico River for August 23 to September 18. Point velocities are to be measured continuously by eight *in situ* current meters; salinity and temperature also will be recorded. Vertical profiles of horizontal velocity and salinity are to be measured continuously from anchored boats for approximately 36 hours beginning August 29. A similar set of measurements is planned for the Neuse River in early October. These data will be the basis for calibration of the hydrodynamic model capable of producing records of flows and flow patterns in the estuaries.

OFF-SITE EFFECTS OF WATER-CONTROL STRUCTURES

By Jerad Bales, U.S. Geological Survey

Flashboard risers and tidegates are the two primary types of water-control structures used on the artificially-drained lands of the Albemarle-Pamlico (A/P) region. Water-control structures have on-site benefits to farmers, but the effects of these structures on receiving water quality have not been fully determined. As indicated in the A/P Study Workplan, there is broad recognition that additional research is needed on the off-site effects of water control.

To meet this need, the U.S. Geological Survey in cooperation with the A/P Estuarine Study has undertaken an investigation to (1) evaluate the off-site effects of water-control structures on surface flow and water quality in canals that drain cropland in the A/P region and (2) quantify the effects of drainage from cropland on salinity in a nursery area. This investigation is providing some of the first information on the hydrologic and water-quality changes due to tidegates. The study is providing continuous, high-quality flow data using recording velocity meters in canals that are tide-affected and will presumably have greater receiving-water impact than upland drainage systems. The evaluation of the response of receiving-water salinity to freshwater inputs and conditions is also an important aspect of this work.

Flow and water-quality measurements are being made in three canals located in Hyde County (HC), in three canals in Beaufort County (BC), and in a tidal creek that receives drainage from two of the BC ditches. One of the HC canals has a tidegate located immediately upstream from a data-collection site; tidegates are to be installed in the remaining two HC canals in 1990. This arrangement will provide pre- and post-tidegate data at two sites and will also allow for the simultaneous comparison of drainage from sites with and without control structures. A similar design is utilized at the BC sites, where the control structures are flashboard risers.

Continuous records of flow velocity, water level, discharge, and conductivity are obtained at each of the six canal sites. Bi-weekly and high-flow event determinations of pH, temperature, and dissolved oxygen, nutrient, and sediment concentrations are also made at each of the sites. Continuous records of tidal elevation and conductivity are collected at one location on the tidal creek. Conductivity meters are also located along the longitudinal axis of the creek to provide data for analyses of temporal and spatial variations of salinity in the creek. Water-quality monitors are to be placed in Rose Bay, which receives drainage from the HC sites, to evaluate receiving water quality at those sites.

A preliminary summary of the data follows. Drainage from the BC sites contains sediment concentrations that are, on average, 3 times higher than those at the HC sites. As a consequence, BC drainage water typically contains phosphorous concentrations that are at least twice as great as those at HC. Average dissolved nitrate-nitrite concentrations from the BC sites range from 1.96 to 2.22 milligrams per liter (mg/L) as nitrogen; HC mean values are between 0.30 and 0.47 mg/L. Sediment concentrations at the tidegate site are typically about twice those at the HC sites without tidegates. The mean concentrations of dissolved ammonia, Kjeldahl nitrogen, and nitrate-nitrite at the tidegate site are 0.59, 2.11, and 0.47 mg/L as nitrogen, respectively; comparable mean values at the HC sites without tidegates are 0.14, 1.81, and 0.33 mg/L, respectively. Runoff hydrographs at the tidegate site are significantly more attenuated than those of the collector ditches without tidegates. Also, mean conductivity in the tidegate-controlled canal is 10,100 microsiemens per centimeter (μS/cm), as compared to about 17,200 μS/cm in the adjacent canals. Conductivities of about 80-percent seawater strength have been observed in the uncontrolled HC canals.

WATER-QUALITY TRENDS OF THE ALBEMARLE-PAMLICO ESTUARINE SYSTEM, NORTH CAROLINA

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The U.S Geological Survey (USGS) compiled and analyzed existing hydrologic and water-quality data from over 200 stream and estuary stations of the Albemarle-Pamlico estuarine system (A/P) to identify long-term temporal and spatial trends. The dataset included seven stations of the USGS National Stream Quality Accounting Network, two stations of the National Atmospheric Precipitation Deposition monitoring network, stations of the N.C. Department of Natural Resources and Community Development, and stations from 25 reports by individual investigators. Regression-residuals analysis, the seasonal Kendall's Tau test for trends, and graphical analysis using annual box plots were employed to determine trends.

Profound change has occurred in the water quality of the A/P area over the last 30 years. Analysis of water-quality data upstream from the estuaries indicates increases of discharge-adjusted values of specific conductance, alkalinity, phosphorous, hardness, chloride, and dissolved solids. In the estuaries, pH is increasing except in the Pamlico River, where it is decreasing. There is a generalized decrease in suspended inorganic material in the system. Salinities are decreasing for sections of the Pamlico River, and increasing for parts of Albemarle Sound. Nitrogen concentrations are decreasing except in the Pamlico River, where they are increasing. Phosphorus concentrations are increasing in the Pamlico River and decreasing elsewhere. Annual average data show that nitrogen is the limiting nutrient in the Neuse and Pamlico Rivers. Phosphorus is limiting in the rest of the area. Chlorophyll-a levels are increasing in parts of the Neuse and Pamlico Rivers and decreasing in parts of the Chowan River.

To evaluate the effect of basin characteristics on water quality, linear correlation was used. Agricultural crop variables produced the most correlations with water-quality data. Fertilizer usage had little detectable relation to water quality in the study area. In the section of the Pamlico River near Aurora, relations between employment, road mileages, and water quality indicated effects of development in the area.

REDUCTION OF ESTUARINE NUTRIENT LOADING: N AND P REMOVAL IN COASTAL SWAMPS

By

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ABSTRACT

North Carolina estuaries are naturally rich, but they sometimes show problems of excessive eutrophication: algal blooms, discolored surface water, anoxic bottom water, fish and crab diseases, and fish kills. Control of eutrophication is needed for optimum use of these estuaries. Estuarine water quality depends in large part on the amounts of nutrients coming off the land. We know little, however, about how efficiently nutrients such as sewage nitrogen and phosphorus are removed by forested swamps bordering Coastal Plain streams.

Assessment of nutrient removal from swamp stream waters requires careful selection of study sites and intensive field and laboratory work. In the first year of study we determined the major criteria for good study sites. These criteria were then used to evaluate forty-nine possible Coastal Plain swamp systems which receive municipal wastewater effluents. The final selection consisted of two sites for intensive study and eight additional sites to be sampled less intensively.

During the final two years of the study we shall measure nitrogen and phosphorus concentrations above and below municipal wastewater outfalls every three weeks at the two primary sites downstream of Rich Square and Scotland Neck. From the downstream changes in nutrient concentrations we shall calculate nutrient removal efficiencies. In addition, we shall make similar measurements quarterly at the other sites in order to evaluate differences from one swamp system to another over a range of sizes of towns and streams and over a variety of wetland types and conditions. The results will provide quantitative data on

the percentage removal of wastewater nitrogen and phosphorus so that the value of these wetlands for maintaining water quality in the estuaries may be assessed. This will aid in decision-making regarding both wastewater treatment and wetlands protection.

The Potential for Eutrophication and Nuisance Algal Blooms in the Albemarle-Pamlico Estuary: Principal Investigator Hans W. Paerl, U.N.C. Institute of Marine Sciences, Morehead City, N.C., 28557

Among the suite of issues currently facing private citizens, environmental managers and fisheries interests in the Albemarle Pamlico Estuary (A.P.E.), no concerns are greater than acceptable and manageable water quality. Both the economic (fisheries, tourism, recreational) and aesthetic values of North Carolina's principal aquatic resource ultimately rely on the interaction of nutrients, the physical environment (temperature, tidal and wind mixing, turbidity and resultant transparency) and biological productivity at the base of the food chain in the estuary.

Based on the recent documentation of the accelerated algal production (eutrophication) in key nutrient-enriched A.P.E. tributaries (Chowan, Pamlico, and Neuse Rivers), periodically culminating in nuisance blue-green algal and dinoflagellate blooms, both the public and managers are concerned how water quality and fertility (productivity) may be affected by accelerated nutrient and sediment inputs into the A.P.E. itself. Prior to the initiation of this project, little was known as to either water quality status or eutrophication potentials in the A.P.E.

In order to establish both a "baseline" data set (from which eutrophication trends and rates of change may be determined) and to address key management (in terms of regulating nutrient and sediment inputs) needs and options, the following objectives are being addressed; 1) Determine the relative importance of nitrogen vs. phosphorus as phytoplankton growth-limiting nutrients in A.P.E. 2) Determine the relative importance of sediment-associated vs. soluble nutrients as eutrophicating factors in the A.P.E. 3) Define and understand the environmental conditions required for potential "nuisance" (blue-green algal or dinoflagellate red tide) blooms to become established and proliferate in the A.P.E. 4) Determine if bottom water oxygen depletion is associated with periods of maximum phytoplankton production in the A.P.E. Using a combination of field monitoring, bioassay and experimental manipulations, results thus far show; 1) Over a 20 month period, our bioassay result indicate that nutrient limitation has a high degree of seasonality. Nitrogen has been found to be strongly limiting phytoplankton productivity and biomass during summer and fall months, while during 2 consecutive winter-spring periods, co-limitation by nitrogen and phosphorus has been observed. These findings suggest that future management policies should consider seasonally adjusted N and P input constraints. 2) Microscopic enumeration and identification of phytoplankton species has not indicated a significant role for nuisance blue-green algal or dinoflagellate species. 3) Field measurements of physical parameters have shown, and dye study determined mixing rates have corroborated, a rapidly mixed water column at our study site in the lower Neuse River Estuary. We believe the rapid mixing of the water column is important in that it stimulates desirable phytoplankton production while alleviating problems associated with low oxygen levels in bottom waters.

Albemarle-Pamlico Sound Coupling Study

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Albemarle Sound is a desert relative to Pamlico Sound in terms of fish population. While the cause of this phenomena of a lack of substantial fish colonization in Albemarle is at present not understood, two possibilities present themselves. Either fish larvae present in Albemarle Sound may not survive to maturity or there may be only a small number of estuarine dependent finfish larvae entering the sound. It is the second possibility we are investigating. Under funding from APES we are conducting a field study to examine the hydrodynamic coupling between Albemarle and Pamlico Sounds via Croatan Sound. Oregon Inlet, which is the only possible source of marine fish larvae for Albemarle Sound, suppies ocean waters and fish larvae to northeastern Pamlico Sound.

The funding of the Albemarle-Pamlico Coupling Study began in October, 1988. The field study to examine the hydrodynamic coupling between Albemarle and Pamlico Sounds via Croatan Sound began by identifying potential measurement sites from various coastal maps and aerial photographs. All instruments, including current meters, water level recorders, temperature and conductivity measuring devices and portable meteorological stations were all calibrated and prepped for the first nine month deployment period. Several reconnaissance surveys were conducted by both car and boat to evaluate potential mooring location sites. Given the sizes of Roanoke, Croatan and Albemarle Sounds, this survey took the NCSU team several intensive weeks to conduct. Pamlico Sound is already very well known to the NCSU PI's and required no surveying to identify secure mooring sites. Prior to actual mooring deployment, permission was obtained from the U.S. Coast Guard to install instruments in the inlets and sounds.

By direct measurement we are now determining whether the flow through Croatan Sound is or is not favorable for the transport of larvae from Pamlico into Albemarle Sound. If the flow is unfavorable for transport, improvements in water quality conditions in Albemarle Sound will have little impact on fish population in that sound. The first time series of data are now in hand and will become available for analysis following the editing process.

CITIZEN MONITORING: ALBEMARLE-PAMLICO ESTUARY
Completion Date: October 1989

ABSTRACT: The pilot Citizen Monitoring program on the Tar-Pamlico River was expanded to include the entire Albemarle-Pamlico estuary. Water quality monitoring sites increased from fourteen (14) to sixty-four (64) ranging from Virginia Beach, VA in the north to near Havelock, NC in the south, and from Louisburg, NC in the west to the Kill Devil Hills-Nags Head area in the east.

All volunteer water quality monitors collect data in the following areas: air and water temperature, turbidity (clarity of the water), salinity, dissolved oxygen, pH, and in fresh water areas, nitrate-nitrogen, and phosphate are monitored instead of salinity. In addition the program has begun to explore other methods of sampling, such as bottom sampling for dissolved oxygen, along with sampling for other chemical parameters such as fecal coliform, bacteria associated with human or animal wastes.

The Citizen Monitoring program has approximately 100 persons involved with monitoring various locations in the estuary. Most sites have more than one person collecting data to avoid problems whenever a monitor is unable to sample. We also have a network of four volunteers who take a much more active role in the monitoring program, and also serve on a Steering Committee for the Citizen Monitoring program. These people have helped organize groups of interested persons in the Currituck and Albemarle Sound areas, and the Chowan and Neuse River areas. We continue to have a large number of persons interested in the program and look forward to getting these people involved in the Citizen Monitoring program in the next funding year.

Data that is collected by the volunteers is sent to the coordinator either weekly or bi-weekly. The coordinator checks the data and enters it into a computer program. At regular intervals, the volunteer monitor is contacted and provided copies of the data in graphical and tabular form. Site visits are also done on a regular basis. Coordination between the program and the state monitoring network is also ongoing. The PERT team (Pamlico Environmental Response Team) has been working very closely with the Citizen Monitoring network when examining unusual occurences in the watershed. The Division of Environmental Management, along with the Environmental Protection Agency (EPA) have been active in maintaing the quality of the data collected by the monitors. A continuation of the Citizen Monitoring program has been funded for the 1989-1990 AP Study.

EFFECTS OF WATER MANAGEMENT AND LAND USE PRACTICES ON THE HYDROLOGY AND WATER QUALITY IN THE ALBEMARLE - PAMLICO REGION

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Over two million acres of land have been drained and developed for agriculture and silviculture along the North Carolina coast. As much as one-half of this area drains directly or through tributaries to the Albemarle - Pamlico Estuarine Study (APES) area. Past research has documented the effects of drainage practices and land use on water quality and hydrology of the poorly drained soils of the APES region. This research has demonstrated that drainage practices and land use affect the rate and quality of water draining from agricultural fields; however, the cumulative effects of land use and drainage practices on the quality and volume of water draining from a large agricultural watershed have not been evaluated. Therefore, the objective of this project is to use existing models and results of previous studies to evaluate the effects of land use and water management practices on the hydrology and water quality for a large, poorly drained watershed in the APES region.

A well defined 13400 acre watershed that drains to the Albemarle Sound has been selected for study. Basic soil, land use, and drainage system data have been documented and mapped. The soils, land uses, and drainage practices on this watershed are very representative of the APES region. The hydrology and water quality of the watershed with existing land uses and management practices is being simulated using field scale simulation models, watershed scale channel routing models, and data from previous studies. The same methods are being used to simulate the hydrology and water quality of the watershed with alternate water management and land use scenarios. The alternate water management and land use scenarios include various combinations of controlled drainage practices, drainage system designs, and cropping practices. The existing and alternative water management and land use scenarios are being compared on the basis of total water and pollutant loads to the estuary, and peak outflow rates of water and pollutants.

This project will provide several products important to the overall Albemarle - Pamlico Estuarine Study. The project will produce an evaluation of the potential for using water and land management practices to control the rate, volume, and quality of water leaving the land and entering the estuary. This project will also provide documentation of land uses, soils, and drainage system facilities for a large watershed in the area, as well as a "case study" of the use of models and associated research data to evaluate impacts of agricultural watersheds.

HEAVY METAL POLLUTANTS IN ORGANIC-RICH MUD OF THE PAMLICO AND NEUSE RIVER ESTUARINE SYSTEMS: their concentration, distribution, and effects upon benthic environments and water quality

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Regional grids of 153 and 180 core sites were sampled within the Pamlico and Neuse River estuarine systems, respectively. These 333 core samples represent all possible geographic and geologic conditions, as well as major anthropogenic sources of pollutants throughout the estuarine systems. From these cores, 344 and 360 subsamples respectively, have been processed and analyzed in the laboratory for sediment grain size, sediment composition, and major and trace element composition. The Pamlico River study is now complete and a final report is in press. All field work and sediment analyses have been completed on the Nuese River samples; nowever, the chemical analyses are only about 20% complete at this point in time. Consequently, results of the Neuse River data are in early stages of formulation and synthesis. The remainder of this abstract will present results of the Pamlico River study.

Nine "Areas of Concern" have been identified within the Pamlico River estuarine system and include the following: 1) Kennedy Creek and the area around the Washington waterfront; 2) the middle Pamlico River and 3) South Creek in the area of active phosphate mining; 4) Battalina Creek and 5) lower Pantego Creek in the Belhaven area; 6) inner Pungo River and 7) Pungo Creek agricultural areas; and the marina areas at 8) Broad Creek and 9) Whichards Beach. These areas have surface sediments that are enriched in one or more of the "critical elements" that include the eight EPA priority pollutant metals (As, Cr, Cd, Cu, Ni, Pb, Zn, and Hg) and other important trace elements (Co, Mn, Mo, Ti, V, F, and the nutrient element P). Elemental analysis is based on a partial extraction procedure that approximates "bioavailbility" of the elements and does not represent the total composition of the sediments. Enrichment is determined by comparing the concentration for each critical element to the trimmed mean for surface samples in the estuarine system. Areas containing one or more sample sites with critical elements that are at least 2 times enriched over the trimmed mean are defined as areas of concern.

Kennedy Creek and the Washington waterfront have the greatest number and highest concentration of enriched elements of any area within the Pamlico River. This area is enriched in Hg (14x), P (7x), Zn (6x), Cu (6x), Cr (6x), Ni (5x), Cd (5x), Mn (4x), Co (3x), As (3x), V (3x), Mo (3x), Al (3x), Pb (2x), and Ca (2x). These elements have accumulated as a combined result of various types of major point and nonpoint discharges associated with an urban area and include a municipal sewage treatment plant, industrial facilities, relict waste dumps, historical industrial sites, an EPA "superfund" site, and urban runoff. The most impacted portion of the Pamlico River in terms of aerial extent, is a large segment of the middle Pamlico River and South Creek, both adjacent to active phosphate mining and associated chemical complex. These areas are significantly enriched in Ca (34x), Cd (5x), Mo (5x), P (3x), Na (3x), As (3x), Mn (3x), V (3x), K (2x), Ti (2x), and F. The least polluted portions of the Pamlico River estuarine system are generally the small tributary creeks that are characterized by no point source discharges and have minimum urban and agricultural development. Such areas include Chocowinity Bay and Broad, Durham, Mixon, and Bath Creeks.

Public Participation

INSTITUTIONAL ENHANCEMENT AND PUBLIC INVOLVEMENT PROGRAM FOR SOUTHEASTERN VIRGINIA

Southeastern Virginia Planning District Commission, 723 Woodlake Drive, Chesapeake, Virginia

The Chowan, Northwest, and North Landing Rivers and Back Bay are major tributaries to Currituck and Albemarle Sounds. All are located in or flow through Southeastern Virginia. Land use and other activities in these Basins affect environmental quality in the Sounds. Concurrently, management programs developed through the Albemarle-Pamlico Estuarine Study are likely to affect future development in the Virginia portion of the Basins. To date, relatively little information exchange between North Carolina and Virginia environmental programs has occurred. This program was developed in a cooperative fashion to fill that gap.

The SVPDC is undertaking two major categories of work - Public Participation and Involvement, and Information Exchange and Clearinghouse. The Public Participation component provides for direct involvement of the eight Southeastern Virginia localities in the APES Program. Specific activities to be undertaken include:

Public Participation and Involvement:

- Provision of information about APES through SVPDC's regular publications;
- Conduct of two Workshops/Seminars for local government officials, business and agricultural interests and the general public;
- Establishment and operation of a local government advisory committee; and,
- participation by SVPDC on behalf of its member local governments in APES program meetings.

Information Exchange and Clearinghouse:

- Exchange of information between Southeastern Virginia localities and APES Program staff and researchers; and,
- development of a formalized, ongoing information and data exchange process.

A Project Summary, documenting project activities and experiences and recommending a formal coordination process, will be prepared.

This project will be of direct benefit to the APES Program and Southeastern Virginia localities. It should also assist in fostering increased coordination and cooperation among the Bi- State region's localities.

Elizabeth City State University

ELIZABETH CITY, NORTH CAROLINA 27909

TEACHER ENVIRONMENTAL EDUCATION INSTITUTE - JOHN H. CARSON

The purpose of this institute is to provide participating regular [illegible] and junior high school teachers with techniques to develop the knowledge and the ability, [illegible] to the problem and management of the area's estuarine environment. It is hoped that the knowledge developed through teacher workshops will be channeled through the public school system [illegible] to the problems associated with environmental pollution in the Albemarle Pamlico Estuarine System. A stipend of $25.00 per participant is provided to defray the expense of attending the workshop.

The workshops were held in four different locations to accommodate the maximum number of participants, up to 40 per workshop. The workshop locations were: Elizabeth City, Edenton, Plymouth, and Manteo. Participants were trained to understand the causes of pollution within the estuarine system and how the system is currently managed. The basic format for the workshop was to spend the morning session addressing the problems of environmental management. The afternoon session was devoted to the development of specific class projects that can be utilized in teaching students about coastal environmental concerns.

The second day of the workshop consisted of on-site lectures, testing and experimentation at selected sites near each workshop location.

Each teacher satisfactorily completing the workshop received one renewal credit toward maintaining certification.

Public school teachers are a critical conduit for the dissemination of environmental information. Awareness is fundamental to finding solutions to problems that are raised by the Albemarle-Pamlico Estuarine Study.

INITIAL RADIO PROGRAMMING FOR RAISING PUBLIC AWARENESS AND INVOLVEMENT THROUGH RADIO BROADCASTS

G. Rancer
WRDU Radio, Raleigh, NC

R.V. Fodor
North Carolina State University, Raleigh, NC

The first three of our radio broadcasts intended to bring Albemarle-Pamlico issues to the listening public and to encourage audience participation are scheduled to air in September, 1989. The topic of all broadcasts is fish diseases, and we have verbal commitments from three scientific experts who will address and discuss the problems and their individual research.

Two experts will do live phone-in talks shows. On September 7, Dr. Hans Paerl, UNC Institute of Marine Sciences in Morehead City, will broadcast in Morehead City at station WBTB at 8:00 a.m. On September 19, Dr. Ed Noga, Associate Professor in the NCSU Veterinary School, will be on the air in Wilson at station WVOT at 9:00 a.m., and in Kinston at station WELS at 12:00 noon. We will introduce each of these talk-shows with a 10-minute tape that includes excerpts from a taped interview of our third expert, Dr. Michael Dykstra of the NCSU Veterinary School, and excerpts from a Coastal Awareness Rally held in Raleigh last May. Chapel Hill music composer John Santa has provided music for us to review for incorporating as a "music bed" for the program introductions.

We plan to expand the radio coverage of the topic of fish diseases throughout September and October by using additional experts involved in scientific research and in marine fisheries, and by scheduling them with other radio stations in, for example, Elizabeth City and Jacksonville.

A GUIDE TO ESTUARIES OF THE ALBEMARLE-PAMLICO REGION, NC

Judith A. Gale (author)
and
Whiting Toler (illustrator)

Pamlico-Tar River Foundation
Washington, NC 27889

An estuarine guide for the Albemarle-Pamlico region has been prepared with the goal of educating NC citizens about the characteristics, role, and importance of estuaries; estuarine habitats and their inhabitants; factors affecting water quality and how to recognize water quality problems; and ways that citizens can monitor, protect, and advocate for coastal water quality. The guide will be published this fall (1989).

I. THE INTRODUCTION invites the reader to explore estuarine environs.

II. THE ESTUARINE ENVIRONMENT discusses the characteristics, basic functions, and values of estuaries. The following estuarine habitat types are described: 1) estuarine waters, 2) subtidal benthic environments, 3) intertidal flats, 4) wetlands, and 5) nursery areas.

III. ESTUARINE ORGANISMS describes plants and animals typically found in estuarine habitats. Endangered species are also mentioned. Adaptive strategies and life histories of selected organisms are discussed.

IV. WATER QUALITY identifies water quality problems in NC estuaries, including increased and decreased freshwater flow, nutrient levels, bacteria, and sedimentation. Recognition of water quality problems based on visible biological effects, such as algal blooms, flounder walks, fish kills, and submerged aquatic plants is discussed. Actions citizens can take to protect coastal water quality are identified.

The APPENDICES include a glossary, reading suggestions, a list of keys to estuarine invertebrates, sample estuarine survey sheets, a list of NC agencies concerned with coastal water quality, a list of endangered estuarine plants and animals

LEADERSHIP DEVELOPMENT WORKSHOPS ON WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTION

Thomas J. Hoban
Maurice G. Cook
Simon K. Garber
Frank J. Humenik

North Carolina Agricultural Extension Service
Raleigh, NC 27695

Many water quality problems in the Albemarle-Pamlico Estuarine system result from widely dispersed land use activities. Such activities represent nonpoint sources of nutrients, sediment, pesticides, and freshwater that affect the estuaries. Effective control of such nonpoint source pollution will require cooperation from farmers, local leaders, and other landowners to install best management practices (BMPs). Local leaders need to be further educated and motivated to promote adoption of BMPs. This project will show local political leaders (e.g., county commissioners, municipal officials, and soil conservation district supervisors), resource management professionals (e.g., county Extension agents and SCS conservationists), and concerned citizens how they can improve the success of water quality education programs through a team approach. Obstacles to water quality management will be outlined, along with strategies for an effective water quality management education effort. The importance of teamwork will be stressed. Two-way communication between the citizen advisory committees and local leaders should also improve. The overall goal of this project will be to help increase understanding of and support for the Albemarle-Pamlico Estuarine study. This project will provide local leaders and other interested groups with educational resources and strategies for promoting BMPs and ultimately improving the success of the Albemarle-Pamlico Estuarine study.

The main products from this project will be a series of four leadership development workshops and a popular handbook for controlling the water quality impacts of nonpoint source pollution. Four one-day workshops will be conducted, across the region, during February and March of 1990 to increase local understanding and support for the Albemarle-Pamlico Estuarine study. Local leaders (i.e., county commissioners, municipal officials, and SCD supervisors), resource management professionals (e.g., Extension and SCS), and others from the 33 counties in the study area will be encouraged to attend the workshops. Representatives from other organizations will also be invited (e.g., citizen's groups, N.C. Department of Agriculture, Sea Grant, N.C. Department of Natural Resources and Community Development). Topics covered during these workshops will include: nature of nonpoint source pollution, best management practices, planning for nonpoint source pollution control, educational strategies, economic aspects, and fisheries resources. Emphasis will be on providing relevant information and practical strategies that local leaders and landowners can use to further the goals of the Albemarle-Pamlico Estuarine study. The second major product will be a concise handbook for use by local leaders, resource managers and interested citizens. It will be nontechnical in orientation and present major issues and ideas related to water quality impacts of nonpoint source pollution. Many of the topics covered in the workshops will be included n the workbook. It will serve as a tool for local leaders and others to use in planning and implementing innovative educational programs.

NORTH CAROLINA COASTAL FEDERATION

Hadnot Creek Farm • 3223-4 Highway 58 • Swansboro, North Carolina 28584 • (919) 393-8185

Assisting the Albemarle and Pamlico Citizen Advisory Committees in Conducting a Press Tour, Organizing an Annual Meeting, and Preparing Estuarine Management Recommendations for Protecting Albemarle and Pamlico Sounds

August 1, 1989 to July 31, 1990

$36,500

Jim Kennedy, Environmental Scientist
Principal Investigator

The Coastal Federation will work for the APES Citizen Involvement Committees to organize:

(1) CAC Press Tour: A chartered bus trip similar to the APES press tour conducted by the Federation in 1988 will be planned for the Spring of 1990. This trip will concentrate on issues and study results that are the centerpiece of APES. The majority of the tour stops will be in the Albemarle Sound study area since that region was not included in the first press tour. A scholarship fund will assist local press to cover travel costs to help it participate in the tour.

(2) CAC Annual Meeting: The Coastal Federation will assist the CACs in planning and conducting their annual meeting. The Federation will provide a wide range of services to the CACs to help them plan the meeting's agenda, as well as publicize and conduct the gathering. Emphasis will be placed on designing a meeting that will attract the general public.

(3) CAC Estuarine Management Recommendations: The Federation will assist the CACs prepare a set of recommendations for managing Albemarle and Pamlico Sounds. Three CAC workshops will be held to: (1) evaluate existing estuarine management programs; (2) examine approaches used in other states to manage estuaries; and (3) pull together a final set of recommendations for APES. When approved by the full CACs, these recommendations will propose implementation actions to be included in the APES Comprehensive Conservation and Management Plan.

THE UNIVERSITY OF NORTH CAROLINA
AT
CHAPEL HILL

Institute for Environmental Studies

The University of North Carolina at Chapel Hill
CB# 7410, 311 Pittsboro Street
Chapel Hill, NC 27599-7410
(919) 966-2358

DEVELOPMENT OF EDUCATION MATERIALS FOR THE ALBEMARLE PAMLICO ESTUARINE STUDY

Melva Okun

Environmental Resource Project
Institute for Environmental Studies
University of North Carolina at Chapel Hill
Chapel Hill, North Carolina 27599-7410

To further publicize the issues and concerns of the Albemarle Pamlico Estuarine Study Area the following pieces have been completed: a five part series about the sounds that aired on the National PublicR member station in Chapel Hill that is received by a third of the state. These pieces were also shared with the NPR stations on the coast. Four public service announcements for television broadcast were aired throughout the APES area. Eight radio public service announcements were completed and aired on stations in the APES area.

Completion of an educational booklet describing the state of the estuary will be accomplished in the fall of 1989. This booklet will be distributed free of charge to educators and interested individuals in the APES area.

Beginning in November of 1989, work will begin on planning a two-week workshop on Water Quality and Coastal Ecology for teachers from the APES area. The workshop will take place at East Carolina University in Greenville. Teachers will learn in-depth information about the sounds and water quality issues effecting the area. Several field trips to test the water and to learn from the many local resource people will be scheduled. Teachers will be paid a stipend to participate in the workshop, will receive graduate credits, and will be expected to implement the water quality curriculum in their courses the following year.

A PUBLIC FORUM ON MANAGEMENT NEEDS FOR PROTECTING ESTUARINE RESOURCES IN THE ALBEMARLE-PAMLICO SYSTEM

Richard E. Shaw

Division of Coastal Management, DEHNR
P.O. Box 27687
Raleigh, NC 27611

The Coastal Resources Advisory Council (CRAC), the 47-member advisory board to the Coastal Resources Commission (CRC), will sponsor a public forum entitled "Managing Estuarine Water Quality and Natural Resources in the Albemarle-Pamlico Region." During a series of meetings at two central locations, interested citizens will have the opportunity to express their views and increase their understanding of specific problems related to managing estuarine resources and make recommendations for action by government agencies and other organizations.

A series of three meetings will be held in both Plymouth and New Bern from October 1989 to January 1990. At the first meeting citizens will be allowed to voice their concerns on estuarine resource degradation with regard to (a) sewage disposal and (b) monitoring & enforcement of existing environmental regulations. Citizens will be asked such questions as "Who is responsible for the current state of the A/P resources?" and "How effective are the current programs at protecting the A/P estuary?" In addition to recording oral comments, the project will utilize a professionally-developed survey to solicit citizens' perceptions of the sewage disposal and enforcement problems. The findings will be presented at a second meeting to public officials, resource managers, researchers and environmental groups to give them a feel for the public's perception of the issues. The results of the survey will be presented to the public at the third meeting, after which the resource managers will be given an opportunity to respond to the survey and discuss the problems with the public. Finally, given all that they have heard, citizens will be asked to make recommendations dealing with regulations, enforcement, monitoring, land use planning, public education, and citizen action. The recommendations will be organized in a final report and distributed to the Coastal Resources Commission, Environmental Management Commission (EMC), local governments and interested organizations with the expectation that the report will provide a framework for action on the selected problem areas.

The project will identify citizen attitudes on resource management, evaluate current and potential land use management efforts, and produce recommended alternatives for coordinating government and citizen management activities. In addition, the forum will offer interested citizens the opportunity to express their views on estuarine management problems, learn more about those problems, and to take part in the actual process of policy making for improved estuarine resource protection.

COMMUNITY EDUCATION OUTREACH

Thomas M. Stroud, III

Pamlico-Tar River Foundation
Washington, NC 27889

PTRF sought with this grant to promote the awareness and understanding of estuarine function and issues in the Pitt, Beaufort and Hyde county region. This goal has been achieved to a good degree; outreach contacts have steadily increased as the grant year has progressed, and the groundwork that has been laid this year should result in a more consistent range of outreach opportunities for the continuation of this grant in 1989-90.

Student outreach, though it began slowly, escalated rapidly toward the latter part of the school year and eventually wound up reaching 1,400+ students. Some 55 different classroom sessions were held, ranging literally from grades 1-12 (and including a college class). Perhaps the most successful program, both in terms of content and impact, was a week-long seminar about the Tar-Pamlico held with two biology classes at Washington High School. Similar programs at other schools in the future would be desirable. Further interaction among student-aged groups included meetings with 4-H Clubs, etc., as well as several summer camp meetings (including one camp I organized at Goose Creek State Park).

Outreach to civic clubs (Rotaries, Jaycees, garden clubs, etc.) likewise was slow to start but has picked up this summer. Eighteen such organizations involving c.500 members have been given presentations on the Pamlico and APES. As with the school programs, these were primarily in Pitt and Beaufort counties, with some being held further up the watershed. Efforts to meet with groups in Hyde County elicited little response.

Other outreach efforts have included: (1) three programs this summer at both the Manteo and Pine Knoll Shores aquariums; (2) starting a booth at six different festivals or forums, resulting in contact with 2,000+ people; (3) a series of 22 columns on estuarine issues which ran (or are running) in newspapers in 5 watershed communities (Washington, Greenville, Belhaven, Tarboro and Pamlico County); and (4) appearances on two radio talk shows and one TV morning show to discuss estuarine issues.

The most positive aspect of the outreach effort this year has been the interest of people of all ages in knowing more about the estuary and its problems. Based on this interest, I feel there is a genuine need for a widespread estuarine education effort in the APES region. Many teachers have also expressed support for the idea of helping students understand the unique characteristics of the environment/ecosystem they live in.

The biggest negative probably has been my inability to reach more schools. I attribute this as being partly the fault of my not finding the right channels for communication and partly the fault of red tape within the schools. Also, the greater availability of the results of APES research would facilitate my presentations to civic groups.

Fisheries

ANALYSIS OF PAMLICO SOUND NURSERY AREA DATA

By

Elizabeth B. Noble and Robert J. Monroe

North Carolina Department of
Environment, Health and Natural Resources

Division of Marine Fisheries
P.O. Box 769
Morehead City, NC 28557

A monitoring program of the Pamlico Sound estuarine complex was initiated in 1971 by the North Carolina Division of Marine Fisheries. This long-term database includes environmental variables and juvenile finfish and crustacean relative abundance and diversity. Cluster analysis of over 400 stations by abiotic variables and percent composition of sixteen target species produced distinct station groupings.

Salinity was the key abiotic factor. Low salinity group stations were located in the Pamlico, Pungo, and Neuse rivers, and also the southeastern portion of Albemarle Sound (including Roanoke Island). Dominant species were croaker, brown shrimp, blue crab, and southern flounder. Intermediate salinity stations were found in the bays surrounding Pamlico Sound. In addition to the four species present in the low salinity areas, spotted seatrout, weakfish, and silver perch were most abundant in the Pamlico Sound bays. The next highest salinities were present in those stations behind the Outer Banks. Pinfish, pink shrimp, black sea bass, gag grouper, pigfish, red drum, and gulf flounder were characteristic species of this area. Those stations located behind Core Banks had the highest salinities and species compositions similar to the Outer Banks. Stations in the bays and tidal creeks of mainland Core Sound had the next-to-highest salinities. Summer and southern flounder and brown shrimp were most abundant here. There were also good numbers of pink shrimp, blue crab, pinfish, and croaker.

Results will be utilized by resource managers to better define and protect critical habitats which function as primary nursery areas for economically important finfish and crustaceans in North Carolina.

DETERMINING THE RELATIONSHIP BETWEEN WATER QUALITY AND ULCERATIVE MYCOSIS IN ATLANTIC MENHADEN

Edward J. Noga[1]

and

Donald W. Stanley[2]

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Ulcerative mycosis (UM) is the most common disease affecting the finfish populations of the Tar-Pamlico estuary. This disease has caused numerous epidemics in Atlantic menhaden (Brevoortia tyrannus) since its first observance in 1984. Similar problems have also been observed in many other commercially important estuarine species. Like most diseases in wild fish populations, we presently know very little of how water quality influences UM prevalence. Understanding the possible importance of pollution requires an awareness of how environmental conditions affect the health of the menhaden population. Thus, the purpose of this study is to determine possible linkages between selected water quality parameters and the development of UM.

Atlantic menhaden will be placed into tanks located at various sites along the Pamlico River and water will be pumped directly from the river into the tanks. Temperature, dissolved oxygen, salinity and pH will be measured twice daily (at sunrise and sunset); samples will be collected for nitrite and ammonia thrice weekly. These variables are generally considered to be the factors which most commonly affect fish health in aquatic ecosystems. This research will indicate which of these factors merit closer examination, as well as those which are apparently not important to disease susceptibility.

SHELL DISEASE IN BLUE CRABS FROM THE ALBEMARLE-PAMLICO ESTUARY

Edward J. Noga[1]

and

David P. Engel[2]

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[2]National Marine Fisheries Service, Beaufort Laboratory, Beaufort, NC 28516-9722

Landings of blue crab in the Pamlico River have been steadily declining since 1984. One factor which might be influencing this decline is disease. Shell disease has recently been commonly observed. This disease has been most commonly associated with a bacterial infection of the shell and can ultimately lead to the death of of the crab. While shell disease has been linked to poor water quality, there is no information as to why pollution increases susceptibility. This project is addressing that question by examining the natural bacterial-fighting ability of healthy blue crabs and comparing it with that of individuals with shell disease.

We have isolated bacteria from crabs having shell disease in the Pamlico River and have found that they include a number of bacterial species, including members of the genera Vibrio and Aeromonas. Similar agents have often been associated with shell disease in other crustaceans. Many of these bacteria possess lipase or chitinase enzymes. These enzymes may be used to degrade the outer lipid layer of the shell or the deeper chitinous layer, and thus may be important in invasiveness. However, we have found that the hemolymph (blood) from healthy crabs is capable of inhibiting these organisms. Virtually all the bacteria isolated from crab shells which we have tested are susceptible to hemolymph. We have also found that there are distinct differences in the bacterial-fighting capabilities of individual crabs. The possible implications of these findings to shell disease and the health of the Pamlico blue crab fishery will be discussed.

SCOPING STUDY OF DATA REQUIREMENTS FOR FISHERIES STOCK ASSESSMENT IN NORTH CAROLINA

By

Michael W. Street and Paul S. Phalen

North Carolina Department of
Environment, Health and Natural Resources

Division of Marine Fisheries
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Project 89-02

ABSTRACT

The North Carolina Division of Marine Fisheries' (DMF) mission is to manage the coastal fisheries for the optimum benefit of all of North Carolina's citizens. Management requires the evaluation of the status of stocks under given conditions (stock assessments). Information needed for these assessments includes stock identification, catch (landings, effort, and biological samples), and life history. Available data collected by the DMF come from long term monitoring programs (commercial and recreational statistics, fisheries catch sampling, and surveys) and short term research. Species are prioritized based on commercial and recreational landings, jurisdiction, current problems, and environmental considerations. The highest priority species are hard clams, summer flounder, southern flounder, striped bass, blue crabs and oysters. Gaps in the available data are identified. Recommendations to fill the data gaps are based on data needs, data availability, and priorities. These recommendations include, but are not limited to: continue monitoring programs to collect landings, effort, age and size composition and year class abundance; conduct stock assessments and update them regularly; allocate the time and resources needed to conduct these analyses; implement mandatory commercial fisheries trip ticket reporting; and initiate biological sampling of hard clams and estuarine gill net fisheries.

In order to focus biological sampling, analyses, and reporting into a coherent system, preparation of state fishery management plans is strongly recommended.

ABUNDANCE AND VIABILITY OF STRIPED BASS EGGS SPAWNED IN THE ROANOKE RIVER, NORTH CAROLINA, IN 1988

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Studies on striped bass egg abundance and viability have been conducted in the Roanoke River each year since the mid-1950s by Dr. W.W. Hassler and co-workers from North Carolina State University in Raleigh. The information gathered by these researchers spans nearly 30 years of uninterrupted data collection and is well-known as the best data base on striped bass spawning activity in North America. These records have been extremely important for reconstructing the historical spawning record in relation to exploitation, changes in fishery regulations, and man-induced changes in the flow regime and water quality of the Roanoke River. The APES program ensured the continuation of collecting egg production data after Dr. Hassler retired from actively pursuing these studies in 1987.

The objectives of the study are: 1) to continue the data base established by Dr. Hassler; 2) to develop a means to back-calculate the historical data base in an egg-per-unit-volume format to compensate for radical changes in the flow regime; and 3) to correlate the intensity of striped bass spawning (as measured by egg production) with water releases from the reservoir at Roanoke Rapids, North Carolina.

The study initiated in the spring of 1988 has been completed, and the final report is nearly finished. Sampling for striped bass eggs was initiated at the Pollocks Ferry Hunting Club just downstream of the Caledonia State Prison Farm near Scotland Neck, North Carolina, on 10 April 1988. Sampling was every four hours until the field effort was terminated on 7 June 1988. Eggs were collected with fine-meshed nets suspended in the water column for five minutes. Nearly 90% of the scheduled trips were completed, resulting in 20,144 eggs collected in surface nets for the 60-day period. Overall egg viability was 89%, the best value since 1972. Most of the eggs were collected between the hours of 1000 and 1800 (63%) at temperatures ranging between 18 C and 22 C (79%), pH values of 7.0 to 7.25 (67%), dissolved oxygen levels between 6.0 and 7.9 mg/L (85%), and water velocities between 60 and 100 cm/second (99.5%). Although spawning was observed in mid-April, egg production was low until about 10 May. By 15 May, over 50% of spawning was completed, and no eggs were collected after 2 June 1988. Using the estimation methods of Hassler, approximately 2,082,130,728 striped bass eggs were produced in 1988.

ABUNDANCE AND VIABILITY OF STRIPED BASS EGGS SPAWNED IN THE ROANOKE RIVER, NORTH CAROLINA, IN 1989

Roger A. Rulifson
Institute for Coastal and Marine Resources, and
Department of Biology
East Carolina University
Greenville, NC 27858

This research is a continuation of the 1988 work funded by the Albemarle-Pamlico Estuarine Study.

The objectives of the study are: 1) to continue the data base established by Dr. Hassler; 2) to develop a means to back-calculate the historical data base in an egg-per-unit-volume format to compensate for radical changes in the flow regime; and 3) to correlate the intensity of striped bass spawning (as measured by egg production) with water releases from the reservoir at Roanoke Rapids, North Carolina.

The study initiated in the spring of 1989 has been completed, and the final report is nearly finished. Sampling for striped bass eggs was located at Barnhill's Landing, site of Dr. Hassler's data collection for many years and upstream of Pollocks Ferry Hunting Club, which was the site of egg collection in 1988. Sampling for eggs was initiated on 12 April 1989 in the same manner used in 1988. Field efforts were terminated on 15 June 1988. Only 6% of the 365 scheduled samples were missed due to inclement weather. The number of eggs collected in 1989 was much lower than in 1988, due in part to the extremely wet spring and the resulting discharge of 20,000 cfs from Roanoke Rapids Reservoir over a prolonged period. Only 4,722 striped bass eggs were collected in surface nets during the field efforts, resulting in an overall viability of about 47%. Most of the eggs were collected between the hours of 2200 and 1000 the next morning (82%) at temperatures ranging between 18 C and 22 C (88%), pH values of 7.75 and greater (85%), and dissolved oxygen levels between 7.0 and 8.9 mg/L (99%). The bulk of the eggs were collected during two different water velocity ranges: about 21% of the eggs were spawned at velocities 60-80 cm/second, and about 58% of the eggs were collected at velocities of 100-120 cm/second. These two groups reflect the early spawning observed in April at low flows, followed by an extremely late (and major) spawn during 20,000 cfs discharge the last week in May. Spawning continued until 12 June 1989, when the last eggs were observed in the nets. Using the estimation methods of Hassler, approximately 637,919,162 striped bass eggs were produced in 1989.

ABUNDANCE AND VIABILITY OF STRIPED BASS EGGS SPAWNED IN THE ROANOKE RIVER, NORTH CAROLINA, IN 1990

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Greenville, NC 27858

This research is a continuation of the 1988 and 1989 work funded by the Albemarle-Pamlico Estuarine Study. The intent of the study is to continue a 30-year data base established by Dr. W.W. Hassler of NCSU on spawning success of striped bass in the Roanoke watershed below the Roanoke Rapids Dam near Weldon, North Carolina. In mid-April 1990, waters downstream of the primary spawning habitat will be sampled with fine-meshed nets every four hours for 60 days to determine striped bass egg production and viability. The information will be combined with the previous two years of effort to determine the effects of hydropower discharge on hourly and daily egg production.

FOOD AND FEEDING OF LARVAL FISHES IN THE LOWER ROANOKE RIVER AND WESTERN ALBEMARLE SOUND, NORTH CAROLINA

Roger A. Rulifson and John E. Cooper
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This research is a continuation of the 1988 effort funded by the Albemarle-Pamlico Estuarine Study.

Results from larval striped bass research conducted from 1982 to present indicate that there may be an inadequate food supply in the Roanoke River for finfish larvae, especially striped bass, which limits the successful formation of strong year classes of striped bass in Albemarle Sound. We believe that this inadequacy is the result of: 1) low food abundance (i.e., low zooplankton densities), and 2) food quality (size and mobility of prey relative to size of the fish larvae). Zooplankton is not uniformly distributed throughout the lower Roanoke watershed, but is concentrated only in several specific locations. In past years, striped bass larvae have not fed successfully because their abundance was mismatched in both space and time with the highest zooplankton concentrations. Apparently, prevailing water currents dictate the manner in which striped bass larvae move through the Roanoke River delta on their way to the historical nursery grounds of western Albemarle Sound. This phenomenon does not occur for other finfish species. By examining the larvae of these other species, we will be able to answer the question, " is poor feeding success a result of food concentration, food quality (size and mobility), or timing between the presence of food and initiation of feeding?"

Selected samples from 1982 through 1985 have been examined and the data are presently being computerized for analysis. Zooplankton data from these years have been computerized. During the coming year we will examine larvae from 1986 and 1988, then analyze all years to determine the relative abundance of each species to zooplankton abundance, and the relative feeding success of these fish compared to striped bass.

Human Environment

TITLE: A Comprehensive Environmental Management Plan for the Currituck Sound Drainage Area. Part I: Background Investigations

PRINCIPLE INVESTIGATOR: David A. Adams, Professor, Department of Forestry and Division of University Studies, N. C. State University

Historically, Currituck Sound has been a source of income, recreation, and esthetic enjoyment for citizens of northeastern North Carolina and for visitors from other areas. Periodically, however, undesireable environmental conditions have affected the Sound, precipitating a need for public action. Such issues traditionally have revolved around water quality, salinity, fisheries, and waterfowl.

Between 1958 and 1964, an intensive environmental study of the Sound was conducted. In the 1970s, an invasion of Eurasian Water Milfoil stimulated another burst of research. During the late 1970s, concern again mounted, culminating in public hearings and a salinity-oriented research project. During the last few years, local interests have again become alarmed about the condition of the Sound, this time in relation to environmental changes resulting from the Eurasian Milfoil's demise, present or potential eutrophication, and salinity distribution. The significance of present and proposed connections between Currituck Sound and waters to the north and west has become of particular concern.

This project constitutes the initial stage of a environmental management plan for the Currituck sound drainage area. It will provide 1) an updated bibliography or reference material on Currituck Sound, in computer-accessible form, 2) a synthesis of existing published environmental, economic, cultural, and institutional information on the Sound, 3) a description of perceived current issues, 4) an analysis of requirements for a hydrodynamic model of the area and the status of existing relevant data and information, and 5) an array of alternative courses of action leading to a management plan. These outputs will be valuable to other A/P projects and to the ongoing and prospective activities of state and local agencies.

The project will require close coordination with state and local governmental agencies in North Carolina and with those concerned with the management of Back Bay, Virginia.

NORTH CAROLINA'S ESTUARIES: A PILOT STUDY FOR MANAGING MULTIPLE USE IN THE STATE'S PUBLIC TRUST WATERS

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North Carolina's Coastal Area Management Act states that the management of water areas, especially estuarine waters, is important in achieving the balanced use and preservation of the state's coastal resources. However, CAMA, through its dual program of regulation and planning has focused on land and wetland management. The program has given little attention-through its planning component-to the implementation of a comprehensive management structure for estuarine and public trust waters. Yet, conflicts between public trust users in the state's estuarine waters are increasing. In the face of growing population and development, these existing and potential conflicts should be addressed through a long range planning process.

This project involves the development of an estuarine management structure using the model of state and local cooperation set up under CAMA. The project team is developing a model plan for the estuarine waters of Carteret Country, North Carolina. Our primary objective is to develop a plan that will work to decrease the numbers of conflicts between the various public trust users of the county's waters. By using the CAMA model we hope to demonstrate how the Act's planning process can be extended to cover the state's estuarine waters and to further demonstrate how water use planning can work with land use planning to create an integrated planning process.

There are several important components in the plan's development. The first component involves data collection. This includes organizing and displaying data on county resource and use maps utilizing N.C.'s Land Resources Information Service. We are nearing completion of this component. The data that will be displayed on these maps includes: (1) water quality classifications including ORW classification areas; (2) point source discharges; (3) areas traditionally closed to shellfishing; (4) marinas; (5) county land uses; (6) submerged aquatic vegetation beds; (7) primary and secondary nursery areas; (8) oyster cultch sites; (9) areas of high shellfish valve; (10) maintained channels; (11) navigation obstructions; (12) military restricted areas; and (13) crab pot areas; etc.

The second component in the plan's development involves combining the data, information on existing laws and regulations, and public opinion to develop water use policies and water use classification maps. An eleven member Advisory Board is guiding the project team in the assessment of public opinion. The Advisory Board consists of county residents representing major water users. The land classification maps are being developed in part, by using the LRIS system to identify areas with a combination of characteristics (or lack of characteristics). The final plan will contain an examination of implementation options including water use ordinances.

PUBLIC ATTITUDES TOWARD WATER QUALITY AND MANAGEMENT ALTERNATIVES IN THE ALBEMARLE PAMLICO ESTUARINE SYSTEM.

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Success of the Albemarle-Pamlico Estuarine Study (APES) will require strong public support. Most problems facing the Albemarle-Pamlico Estuarine system arise from human activity. The public, however, may have little understanding of or appreciation for complex water quality problems and coastal management issues. Managers need to understand the attitudes of a broad, representative sample of the public, including those citizens who have not been involved in the Study's public meetings or citizen's advisory committees. This study will analyze public attitudes regarding the importance of the APES resources and the acceptability of particular management alternatives. Information will be collected in a scientific survey of the general public, local political leaders, and interest group representatives.

This project will develop and test a theoretical model relating public attitudes about APES and individual background characteristics that influence these attitudes (e.g. demographic variables, political orientation, knowledge). This will be accomplished in two phases. Phase I will examine basic attitudes and opinions. Phase II (to be proposed next year) will involve followup interviews with the same respondents to assess reaction to different management alternatives. Our strategy will be to combine random sampling from a broad cross section of the population with an intentionally selected group of knowledgeable opinion leaders.

Semi-structured, personal interviews will be conducted with 30 knowledgeable opinion leaders to help identify major issues and concerns to be addressed in the telephone interviews. These will include selected members of various commissions and agencies. Telephone interviews will then be conducted with 600 members of the general public. Individuals for the random sample portion of the study will be selected from three major regions: coastal counties, the inland coastal plain, and urban areas of the Piedmont. The same survey will be used to interview 200 local political leaders and other opinion leaders, representing the various groups of affecting and affected users. We plan to interview by telephone all members of the APES Citizen's Advisory Committees and the Coastal Resources Advisory Council, as well as a random sample of local government officials. So far we are have been conducting an extensive literature review. Letters have been sent to all other Estuarine projects requesting information about similar attitude surveys. We have also sent letters to about 150 social scientists also seeking copies of relevant survey instruments and research reports. We are selecting members for an advisory committee that will provide valuable input to this research project.

EVALUATION OF ENVIRONMENTAL MANAGEMENT AND RESOURCE PROTECTION PROGRAMS IN THE ALBEMARLE-PAMLICO REGION

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Before considering alternative or additional approaches for managing water quality in the Albemarle-Pamlico region, we should examine current efforts to provide protection. Most of these efforts are formally embodied in various government programs (e.g., regulatory, technical assistance, financial assistance, public education programs). This project has focused on several key state government programs; also addressed are the environmental management programs of U.S. Defense Department installations in the region. For the most part, the state programs addressed are based on separate policies, statutes, and regulations; and many are implemented by different agencies within state government.

The individual programs covered in this study are (1) North Carolina's NPDES permit program for point sources; (2) the permit program for onsite wastewater treatment (e.g., septic tanks); (3) the agricultural cost-share program for control of agricultural nonpoint sources; (4) the coastal stormwater runoff regulations; (5) the sedimentation and erosion control program; (6) the permit program for marinas and marine waste disposal; (7) state wetlands protection programs (CAMA AECs and the 401 certification program); (8) critical habitat protection; and (9) environmental management programs at Defense Department installations (Cherry Point and Seymour Johnson). This project is not a complete review and evaluation of these programs; rather it is a screening-level study that should lead to additional detailed evaluations where necessary.

The screening evaluation has followed the framework of implementation analysis, using six evaluation "criteria" that have been associated with effective programs: (1) clarity and substance articulated in program goals; (2) a valid technical theory specifying how objectives may be achieved; (3) a strong program structure including adequate incentive or sanctions and adequate resources for implementation; (4) committed and skillful implementing officials; and (5) continued support of constituents and key political figures.

The final report will evaluate the effectiveness of the nine programs over these criteria, suggest issues of concern in each area, and provide program-specific recommendations.