91-00

PROJECTS FUNDED

by the

ALBEMARLE-PAMLICO ESTUARINE STUDY

updated

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Albemarle-Pamlico Estuarine Study

ABBREVIATIONS USED IN THE TABLE OF CONTENTS

CTAW	Critical Terrestrial Areas and Wetlands
WQ	Water Quality
FI	Fisheries
HE	Human Environment and Population Growth
PP	Public Participation
IM	Information Management
APDP	Action Plan Demonstration Project
APES	Albemarle-Pamlico Estuarine Study
*	indicates a completed project report
+	indicates a completed initial phase report
-	indicates that no report is to be furnished
1**	indicates a first year project
2**	indicates a second year project
3**	indicates a third year project
4**	indicates a fourth year project
5**	indicates a fifth year project

OTHER COMMON ABBREVIATIONS

A/P	Albemarle-Pamlico
BMP	Best Management Practice
CCMP	Comprehensive Conservation Management Plan
CRC	Coastal Resources Commission
CTE	Critical Trace Element
DAg	NC Department of Agriculture
DCM	NC Division of Coastal Management
DEM	NC Division of Environmental Management
DMF	NC Division of Marine Fisheries
DSWC	NC Division of Soil and Water Conservation
EMC	Environmental Management Commission
MFC	Marine Fisheries Commission
NC CGIA	NC Center for Geographic Information and Analysis
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
SAV	Submerged Aquatic Vegetation
SCS	US Soil Conservation Service
US EPA	US Environmental Protection Agency
USGS	US Geological Survey
WRC	NC Wildlife Resources Commission
WRRI	Water Resources Research Institute

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INTRODUCTION

The Albemarle-Pamlico Estuarine Study was the first National Estuary Program to be designated under the 1987 amendments to the Clean Water Act. It represents a cooperative effort between the U.S. Environmental Protection Agency and the State of North Carolina. It was designed as a 5 year program to combine scientific research, the evaluation of potential management alternatives, and public involvement and education to protect the long-term productivity of our estuarine waters. The Albemarle-Pamlico study area encompasses 30,000 square miles of the North Carolina and Virginia watershed for Albemarle and Pamlico Sounds.

The ultimate goal of the Study is the development of a Comprehensive Conservation Management Plan (CCMP), due in February of 1992. The CCMP will make recommendations for coordinating various state, federal, and local programs with responsibility for specific aspects of the estuarine environment and its watershed in an effort to protect these valuable resources.

To develop a more thorough understanding of the dynamics of the natural estuarine system and the impacts of related human activities, the Albemarle-Pamlico Estuarine Study has funded numerous research, out-reach, demonstration, and development projects. This document is a compilation of summaries of all those projects funded through the Study.

CRITICAL TERRESTRIAL AREAS AND WETLANDS

126 **Brinson** 88-14

An Analysis of Fringe Wetlands in Albemarle and Pamlico Sounds

This study was conducted as a preliminary characterization of fringe wetlands. Three reaches of the A/P area's shoreline were examined on National Wetlands Inventory (NWI) maps to determine wetland type, zonation of vegetation, and geomorphic characteristics: southern Albemarle Sound, Croatan Sound, and northern Pamlico Sound. In freshwater areas where fringe wetlands dominate, some sites develop a gradient in species composition, vegetation, structure, and hydrology that distinguishes shoreline forest stands from interior wetland sites. In brackish water areas zonation of vegetation tends to be determined by salinity, with marsh vegetation near the edge grading into shrubs and trees further from the shore. Fringe wetlands are influenced by wind-driven water level changes, consequently, hydroperiod varies with location and climatic conditions. Common approaches for predicting the effects of rising sea level on fringe wetlands are inappropriate for these unique habitats; new methods must be developed.

193/274/335 **Pierce** no report

Hyde County Soil Survey

The soil survey: (1) determined and mapped the nature, distribution, and extent of various kinds of soils in Hyde County; (2) identified on aerial photos the various significant landforms; and (3) recorded on maps the potential land uses for all areas. All maps will eventually be digitized and entered into the NC Center for Geographic Information and Analysis (CGIA) APES database.

203/301/401 **Roe** 90-01, 92-07

Inventory of Natural Areas

This report is a compilation of critical natural areas under protection and unprotected, and a discussion of the rare/endangered species, wetlands, other rare areas, and geomorphology of the region. The N.C. Natural Heritage Program undertook a reconnaissance inventory to identify, describe, map, prioritize, and make protection recommendations for special natural areas, exceptional wetlands, and endangered and rare species habitats. The first phase incorporated 10 counties adjacent to Albemarle Sound. 96 sites were identified as containing biological or physiographical significance at the national, state, or regional level. The second phase incorporated data from 7 counties adjacent to the Pamlico. The third phase will incorporate information from 17 inland counties. Data from the project are recorded in the Natural Heritage Program's central inventory management system, a system used by many other agencies for resource assessment.

An Inventory and Protection Plan for Critical Natural Areas, Exemplary Wetlands, and Endangered Species

Identification and description of the region's significant natural areas is essential for determining critical resource areas and developing protection and management strategies for these areas. The resource data, natural areas boundaries, and protection and management recommendations for each natural area will be incorporated into the state's Natural Heritage Biological and Conservation Data Base and information clearinghouse. Results of the project will provide information necessary for the general region land use inventory evaluation of land use management efforts, wetlands trends analysis, and development of comprehensive environmental management plans and individual natural areas protection and management plans.

WATER QUALITY

1** **Tyler** 89-09

Potential for Long-Term Persistence of the Red Tide Dinoflagellate, (Ptychodiscus brevis), in North Carolina Coastal Waters

In October of 1987, the toxic red tide dinoflagellate Ptychodiscus brevis, which normally resides along the Florida coast, was introduced into North Carolina waters via the intrusion of a Gulf Stream eddy. The transported population resulted in the closure of shellfish beds in North Carolina due to the presence of brevetoxin in the shellfish. A major field effort was undertaken in February 1988 to determine the extent of the organism distribution. Benthic samples and water column samples were collected and incubated in the lab for one month to determine the presence of cysts. Benthic samples yielded no motile population, suggesting that Ptychodiscus may not have formed a resting stage in North Carolina waters. Without further study, however, the possibility of a resting stage having been formed cannot be ruled out. Lack of recurrence of blooms of Ptychodiscus in North Carolina in late 1988 give credence to the view that the original 1987 inoculum did not encyst.

1** **Stewart** 87-03

Workshop: Hydrodynamics and Water Quality Modeling

This document is a compilation of papers presented at a workshop held on Sept 3-4, 1987, for modelers and managers. Models were presented regarding the Chowan, Tar-Pamlico, and Neuse Rivers; the A/P Sounds; Chesapeake Bay; Green Bay; Long Island Sound; and Narragansett Bay. Some of the major conclusions reached were the necessity for: (1) specific management objectives for model development, (2) dispersion models, wind-driven models, and basin-wide models, (3) standardized data and analyses, and (4) linking physical parameters to living resources. Specific recommendations for APES included: (1) focus on kinetic system-wide approaches, (2) link chemical and biological processes, (3) look at eutrophication, (4) coordinate monitors, modelers, and managers and involve other interests such as agriculture and industry, and (5) collect data specifically needed for modeling.

113/277/311/417/514 **McNaught/Perlic/Blinkoff** 87-06

Citizens Water Quality Monitoring Program

In the first year of APES, Pamlico Tar River Foundation (PTRF) designed and implemented a pilot program for water quality monitoring using volunteers in the Tar-Pamlico basin. The Citizen Program for the Chesapeake Bay served as a model and area scientists were consulted. In April 1988 sixteen trained and equipped volunteers began weekly sampling following strict procedures for measuring water and air temperatures, nutrients, pH, dissolved oxygen, salinity, and a limit of visibility. The monitoring efforts of the Citizen's group are closely tied with those of Division of Environmental Management (DEM) and US Geological Survey (USGS). Standardized forms are mailed to the project coordinator for verification and entry into a computer data base which is compatible with the state and federal agencies. Periodic "quality control sessions" are held to

review procedures, conduct quality control exercises, and assess the precision of the data. Citizen's results have been found to fall within the same range of accuracy and confidence as those of DEM. Currently, approximately 66 sites throughout the study area are monitored weekly by more than 80 volunteers.

129/205/305 **Paerl** 90-15

The Potential for Eutrophication and Nuisance Algal Blooms in the Lower Neuse River Estuary

Three stations in the mesotrophic Lower Neuse River Estuary were studied over a three year period to determine the potential for nuisance algae blooms and the associated episodes of bottom water hypoxia and anoxia. Algal biomass varied seasonally (high in the summer, low in the winter), but also responded to changes in the river flows. In general, the estuary was found to be nitrogen limited, especially in the summer, but additions of nitrogen and phosphorus were more effective in stimulating algal growth than additions of nitrogen alone. Algal blooms were observed, but not blooms of nuisance taxa (though the nuisance taxa were often present). Zooplankton maintained low species richness throughout the study, exhibiting blooms only in the late spring. Management recommendations aimed at minimizing the likelihood of nuisance algal blooms include the reduction of: dissolved inorganic nitrogen, atmospheric nitrogen (acid rain), dissolved inorganic phosphorous, and suspended sediments.

130/213/333 **Kuenzler** 90-14

Reduction of Estuarine Nutrient Loading: Nitrogen and Phosphorous Removal in Coastal Swamps

This study was designed to determine the efficiency with which Coastal Plain riparian wetlands strip out nitrogen and phosphorous from municipal wastewater effluents. Seven sites were studied extensively and two sites were studied intensively. Samples were taken from above the outfalls, from the outfalls themselves, and from stations at increasing distances downstream of the outfalls. The concentration of nutrients decreased downstream more rapidly than was expected based on dilution alone. Median net removal efficiencies for ammonium, total nitrogen, phosphate, and total phosphate were generally quite high and sometimes reached 100%. Such potential indicates a need to preserve these systems in their natural state.

143 **Bales and Nelson** 88-06

Bibliography of Hydrologic and Water-Quality Investigations Conducted in or near the Albemarle-Pamlico Sounds Region, North Carolina

A bibliography containing 1,100 citations is presented. Citations refer, primarily, to investigations of the effects of land use and land use change on water quality, artificial drainage, hydrology, and hydrodynamics in the Albemarle-Pamlico Sound region of North Carolina. The bibliography is indexed according to the research topic and geographic location of the investigation. The bibliography is computerized and has been transferred to the APES data management system.

144/206/318 **Bales**

Off-site Effects of Water Control Structures (BMPs)

Flashboard risers and tidegates are the two primary types of water control structures on the artificially drained lands of the A/P region. This study investigates the effects of these structures on surface water quality in canals that drain cropland and quantifies the effects on the salinity of nursery areas. Flow, water level, and water quality measurements have been taken in three canals in Beaufort and Hyde Counties. Initial data indicates that off-site effects may be significant.

145/208/317/468 **Bales**

Flows and Flow Patterns in the Pamlico and Neuse River Estuaries

This study was designed to: (1) collect and interpret long-term, continuous records of the hydrodynamics of the two estuaries, and (2) calibrate and validate a numerical model of hydrodynamics and transport in each estuary. Long-term data, collected at 12 sites, included tidal elevation, water quality, and wind data. Continuous data will be used to determine the boundary conditions for the model, to calibrate the model, and to investigate, e.g. seasonal and spatial variations. Short-term data will be collected for further calibration of the model.

167 **Riggs** 89-06

Heavy Metals in Organic-rich Muds of the Pamlico River Estuary

153 stations near known point source dischargers within the Pamlico River were cored and the sediment samples analyzed for the vertical and lateral distribution and concentration of metals. Ten "areas of concern" were delineated as having concentrations of one or more of the 15 "critical" trace elements sampled for, in concentrations of two or more times that of the trimmed mean. Enrichment was found to be quite site specific; some areas were relatively pristine (Chocowinity Bay), yet other areas showed significant enrichment. In general, in areas of enrichment, concentrations of metals were greater in surface samples (two times greater on average), than in deeper samples, suggesting recent anthropogenic contamination of the sediments -- (Kennedy Creek, Middle Pamlico River, Washington Waterfront, South Creek, Battalina Creek, Inner Pungo River, Broad Creek, Lower Pantego Creek, Wichards Beach, and Pungo Creek). The report also compares the sample results with those presented in the National Status and Trends Program report put out by the National Oceanic and Atmospheric Administration (NOAA).

186 **Wells** 89-05

Scoping Study of Water-Column and Bottom Sediments

This paper provides a synthesis of what is known about sedimentation in the A/P system, based on archived and new, published and unpublished data. Older efforts concentrated on grain size and mineralogy studies. The sedimentary structure of the system is relatively simple. The surficial cover ranges from medium sands in the inlets and on the shoals of the Outer Banks, to fine silts and organic-rich clays in the central basin and embayed river mouths and channels. The

transition zones, usually related to bathymetry, are usually very distinct. Much of the terrigenous sediment is trapped in the lower courses of the rivers by processes of estuarine circulation. Areas of preferential settling of organic-rich muds may also define areas of greatest concentration of associated "particle-reactive tracers" and pollutants. There seems to be a relatively rapid vertical flux of large aggregates, possibly accounting for the unusual fluid-mud deposits. The Outer Banks act to trap much of the sediment that manages to "escape" the estuarine system. The net advection of A/P sediments is most influenced by long-term advective processes such as sea level rise and barrier island migration. Based upon current trends, the A/P system is not expected to reach a sediment-filled state.

2**/455 **Cummings**

Merchants Millpond/Upper Bennett's Creek Watershed, Chowan River Basin, North Carolina: a Continuation of BMP Early Implementation for Nutrient Sensitive Waters

The first year funds were targeted at soils testing and animal waste analyses in order to achieve appropriate nutrient management. The second year funds will be used to expand the efforts of installing BMPs such as solid-set waste management systems, exclusion of livestock from streams, filter strips, environmentally safe application of animal wastes, and stock rotation systems. The second phase of the project will address nutrient management, waste management, sediment control, and erosion control through the support of cost-sharing incentives to construct BMPs. BMP construction and operation regulations, set forth in NCAC Title 15, Chapter 6, Section 6E and Chapter 143, Article 21 of North Carolina General Statutes, will be adhered to.

2**/465/549 **Garrett/Bales** 91-06+, 91-10+

Continuous Monitoring

44 stations make up US Geological Surveys' continuous monitoring component of the APES monitoring network. Data on temperature, salinity, dissolved oxygen, and pH is recorded every 15 minutes. Annual summaries will be compiled evaluating spatial and temporal trends in water quality conditions.

All the data collected from the Neuse and Pamlico in the 1989-1990 and 1990-1991 water years have been compiled in A/P reports #91-06 and 91-10. Daily maxima, minima, and means are presented.

2**/473/509 **Tedder** 92-01+, 90-03

Baseline Water Quality Monitoring

94 stations spread throughout the rivers, streams, and sounds of the A/P region make up the Division of Environmental Management's baseline water quality monitoring component of the APES water quality monitoring network. Data on ambient temperature, salinity, dissolved oxygen, pH, nutrients, coliform, and phytoplankton density are measured.

Data from 1989-1991 are included in report 92-01. In the Tar-Pamlico River basin, the lower Pamlico River and tributaries to the Tar River has the most frequent occurrences of hypoxia. The

productive phytoplankton in the Neuse caused high chlorophyll a concentrations, high pH values, and supersaturated dissolved oxygen concentrations. Some algal blooms were recorded in the Albemarle region.

A synoptic survey was conducted on June 25, 1989. The results are recorded in A/P report #90-03. 128 stations were sampled for 33 water quality parameters within a five hour period. The timing of the sampling coincided with a satellite fly-over so that the data collected could be correlated with and for ground-truthing data collected by the satellite. The survey indicated that contraventions in water quality standards (primarily chlorophyll a) were most closely correlated with areas of concentrated human activity. These areas, the Pamlico and Neuse Rivers and western Albemarle Sound, are all designated Nutrient Sensitive Waters. The study also demonstrated that the monitoring stations maintained by the NC Division of Environmental Management (DEM) are in the most impacted portions of the A/P system.

207 **Harned** 89-11

Water-quality Trends and Basin Activities and Characteristics for the Albemarle-Pamlico Estuarine System, North Carolina and Virginia

The report summarizes land-use/land-cover data, geographic descriptions, flow characteristics, and water quality data. Non-parametric trend analyses were performed on the water quality data using the Seasonal Kendall test. Correlation analyses were performed on many water quality parameters including DO, pH, suspended solids, salinity, ammonia, nitrogen, phosphorous, soluble nutrients, and chlorophyll a, as well as on more than 50 basin characteristics and activities. Several very general, system-wide correlations were determined: (1) dissolved oxygen generally increased; (2) pH generally increased; (3) suspended solids, in general, decreased; and (4) chlorophyll a increased. Trends in concentrations of nutrients were very site-specific.

227 **Riggs** 90-07

Heavy Metal Pollutants in Organic-Rich Muds of the Neuse River Estuary

203 core sites within the Neuse River Estuary were sampled. 413 sub-samples were processed and analyzed for grain size, sediment composition, and the concentrations of several major elements, 15 "critical" trace elements (CTEs), and seven "other" trace elements. Seventeen polluted "areas of concern" were identified on the basis of having two or more CTEs exceed the trimmed mean values for those elements. Polluted areas were all associated with known point source discharges. The highest concentration were found near New Bern and Bridgeton, and in Slocum Creek. Six non-polluted areas were identified as being fairly pristine.

232 **Pietrafesa** 90-13

Albemarle-Pamlico Coupling Study

Albemarle Sound has far fewer fish than Pamlico Sound. This study set out to determine whether few larval estuarine-dependent finfish could enter Albemarle Sound because of the patterns of currents. Water flow, water level, water quality, and wind speed and direction through Croatan Sound were measured and modeled to determine the hydrodynamic coupling of the sounds and the

possibilities for larval recruitment. Surface and bottom flows were found to be wind-driven. Wind can set up a "tilt" in the water's surface, and so can enhance tidal flows, limiting the recruitment of fish into Albemarle Sound.

256 **Chescheir/Skaggs/Gilliam** 90-09

Effects of Water Management and Land Use Practices on Hydrology and Water Quality in the A/P Region

This project studied the hydrology of a large, poorly drained watershed in the A/P region. A hydrologic model (DRAINMOD) of the agricultural areas, generally the areas of greatest runoff and greatest nutrient effluxes, was adapted for the study. Average annual effluxes of nutrients and total outflows of water and nutrients were calculated using the volumes predicted by DRAINMOD and other previous research. The medium-scale watershed model FLDNSTRM was used to determine peak outflows from a small control site. Effects of different management schemes were estimated. Drainage from the watershed could be reduced by 28%, Total Kjeldahl Nitrogen effluxes could be reduced by 23-29%, and NO_3-N efflux could be reduced by 48-58% with control drainage practices. Improved subsurface drainage would increase NO_3-N effluxes by 7-15% and, when used in combination with unimproved surface drainage, would decrease Total Phosphorous efflux by 27-31%. Water control and environmental management practices can be used to reduce the cumulative impacts of agricultural development in the A/P Study area.

278 **Rulifson** 90-12

Water Quality as a Function of Discharge from the Roanoke River Reservoir During Hydropower Generation

The effect of springtime water releases from Roanoke River reservoirs on downstream water quality was examined by whole water grab samples from Pollock's Ferry (22 miles below the dam), Scotland Neck, and four stations in the river delta. Samples were collected one day each week from 14 April to 8 or 10 June 1988. Generally, water quality was good at Pollock's Ferry and in three of the four delta stations, with thorough mixing evident during the moderate flows. Downstream increases in dissolved and particulate parameters were likely due to swamp drainage and waste discharge (such as that from municipalities and pulp mills). Dissolved oxygen dropped downstream. Water temperature and pH were positively correlated with river flow at Pollock's Ferry; conductivity and nitrate/nitrite were negatively correlated. Many other water quality parameters were, for certain periods, positively correlated with rapid rise in river stage. The report concludes that the water quality observed at Pollock's Ferry was largely influenced by water releases from Roanoke Rapids reservoir. Water quality in the Roanoke delta was modified by drainage from bordering swamp, municipal, and industrial discharge.

344 **Riggs** 90-17

Heavy Metal Pollutants in Organic-Rich Muds of the Albemarle Sound

This study, like the two preceding studies performed by Riggs, will determine the concentrations and distributions of heavy metals and phosphorous pollutants associated with organic-rich muds in the Albemarle estuarine system. Samples will be processed and analyzed for grain size, sediment

composition, and the concentrations of several major elements (15 "critical" trace elements, and seven "other" trace elements). Sampling will concentrate on areas around known point-source dischargers and "hotspots" will be identified. The changing impact through time of agriculture, urbanization, and industry will be determined. Interrelationships between sediment/water column interactions and resultant chronic effects of heavy metals on the estuarine system will be addressed.

353/458 **Rideout and Overton** 90-19

A Comprehensive Environmental Management Plan for Currituck Sound Drainage Basin and Model Development

Phase I of this project presents a computer-accessible bibliography on Currituck Sound and Back Bay, identifies perceived management issues in the area, and analyzes an array of responsive and prospective management alternatives. Questionnaires, surveys, and interviews were conducted with local residents, local officials, and researchers. The areas of greatest concern were declining water quality, loss of wildlife habitat, and lack of coordinated management efforts. The three categories of alternatives considered and analyzed were: (1) alternatives which would require no new institutions, (2) alternatives which would require the formation of new non-statutory institutions, and (3) alternatives which would require the formation of new statutory institutions. No specific recommendations were made for the future management of the Currituck Sound drainage basin.

During Phase II of this project, a model was developed to determine under what conditions transport is achieved from Lynnhaven Bay to Currituck Sound (23 miles). In this transport model, salinity was used as a conservative tracer. Preliminary results indicate that north-south transport to Currituck Sound did not occur. US Geological Survey hydrologic flow data will be collected and analyzed.

449 **Stanley**

Pollutant Removal from the Stormwater Detention Basin in Greenville, NC

This study will try to determine the effectiveness of the detention basin that will be built in Greenville, N.C. in the fall of 1991. In this way, the merits of stormwater detention basins relative to other BMPs can be assessed. The study will provide information on the surrounding land uses and the chemical characteristics of the resulting stormwater runoff, as well as on the removal efficiency of the pond. The accumulation of heavy metals in the sediments will also be examined.

451 **Cunningham** 92-04

Toxicant Inventory for the Albemarle-Pamlico Estuarine Study

Through direct contact with agency officials, computer retrievals, and on-line literature searches, all available sources of toxicant data for the A/P region were identified, listed, and reviewed. Ambient data were screened by computer against state and federal criteria (primarily N.C. state water quality regulations) to identify potential toxicant problem areas. Maps of potential problem areas were developed and a summary report was prepared. Potential loadings of toxicant was

found to be highest in the Albemarle, with the majority of the dischargers in the Roanoke River basin. Ambient exceedences of water quality standards were found mostly in headwater reaches of tributary streams. Only six estuarine stations were found to be in violation of state or US EPA water quality standards. 22 sediment sites in the Albemarle, 16 in the Neuse, and 13 in the Pamlico were identified as having the potential to be toxic to some test organisms. Fish tissue data was analyzed. 75 exceedences of health requirements for carnivorous creatures and numerous exceedences of the requirements for human consumption were found.

453 **Dodd** 92-10

Point and Nonpoint Phosphorous and Nitrogen Budgets and Flux Estimates for Major Tributaries to the Albemarle-Pamlico Study Area

This study was designed to estimate the magnitude of nutrient sources to surface waters in the A/P region. All major tributary basins were included in this study. National Pollutant Discharge Elimination System (NPDES) compliance monitoring digital data was obtained and exploratory data analysis was conducted. Political boundaries, hydrography, the location of point source discharges, the location of ambient monitoring stations, and land use/land cover data were obtained from NC Center for Geographic Information and Analysis (CGIA). Export coefficients used in previous nutrient budget development were updated based on the results of the literature review. Loading sensitivity analyses were conducted and nutrient budgets were calculated for each land use. Screening criteria were developed to estimate the fluxes based on a variety of water quality data.

Runoff, primarily agricultural runoff, was determined to be the largest potential loading source category of nutrients. Atmospheric nitrogen was also determined to be quite a large contribution.

461 **Engel** 92-09

Blue Crabs: Hemocyanin Concentrations as a Measure of Environmental Quality in the Albemarle-Pamlico Estuary

This research project explored the basis for the earlier observations of abnormally low concentrations of hemocyanin in the hemolymph (blood) of blue crabs in the A/P estuarine system. This study determined that the blue crab populations in the Pamlico and Neuse Rivers continued to have low hemocyanin concentrations in their hemolymph as they appeared to have had in 1988 and 1989. In selected North Carolina estuaries, hemocyanin concentration in crab hemolymph appears to be correlated with location of collection, and time of year. In the Pamlico and Neuse Rivers, it appears that there is no direct correlation between contaminant accumulation and either depressed hemocyanin or shell disease. Of the "natural stressors" examined, depressed dissolved oxygen and elevated temperature correlated well with lowered concentrations of hemocyanin in the hemolymph of blue crabs. This observation suggests that long-term exposure to reduced dissolved oxygen may indirectly cause reduction in hemocyanin concentration among blue crabs in the Neuse and Pamlico Rivers. Crabs with reduced hemocyanin may be at a physiological disadvantage which would result in susceptibility to parasitic infection, inability molt successfully, and inability to repair shell trauma, which in turn, could serve as a focus for shell disease.

467/539 **Bales**

Flow Patterns in the Lower Roanoke and Albemarle

This project is designed to determine the flow rates in the lower Roanoke River between Williamston and Albemarle Sound, the flow patterns in the Roanoke River distributary, and the flow rates and flow patterns in Albemarle Sound, using continuous monitor field data and one-dimensional flow modeling of water level, inflows, bathymetry, wind speed and direction, water velocity, and water quality (temperature and salinity). The existing network of continuous water quality monitors will be maintained and the temperature, salinity, and dissolved oxygen water quality parameters will be evaluated for spatial and temporal trends.

469 **Bales**

Stream Gaging for the Stormwater Detention Basin in Greenville, N.C.

Gages will be placed to measure the influent and effluent flows of the stormwater detention basin in Greenville, N.C. The resulting data will be critical in the determination of basin function and efficiency.

536 **Liddle**

Identification of Ground-Water Recharge Areas Within the Albemarle-Pamlico Estuarine Study Area

The primary results of the proposed study will be the delineation of significant recharge areas for aquifers that discharge into the A/P study area. Recharge maps will be provided in digital format, along with a summary of the quality of the input data and a commentary on the use-limitations of the recharge maps. The proposed research is particularly beneficial in conjunction with other projects in the A/P study that focus on evaluating external inputs to the estuarine system and impacts of land-use practices on hydrology and water quality. Resource managers will be able to utilize the results of the proposed study in land-use planning activities.

550 **Dodd**

Develop Management Strategies for A/P Study Area Sub-basins with Applications to Key Planning Issues

This research will lead to the development of Geographic Information System (GIS) data integration approaches and management recommendations for major sub-basins of the A/P Estuarine Study Area. Four tasks are proposed; in each case GIS data layers will be used extensively. The tasks are: preparation of watershed management profiles showing pollutants, sources, land use, nutrient budgets, etc. for each sub-basin; development of recommendations for enhanced targeting of agricultural best management practices; development and analysis of future scenarios of changes in land use, population, pollutant loadings, etc.; and assessment of critical areas at risk due to pollution. These results will aid in assessing relative severities of regional pollution concerns or sensitivities within the A/P Study area, and in targeting resources to address pollution issues more effectively.

551 **Dodd**

Technical Services for the A/P Study Office

Research Triangle Institute proposes to coordinate an effort of agency staff and researchers to develop recommendations for target nutrient reductions for major estuaries and sounds in the A/P study area. This effort will focus on reviewing the rationale for existing Division of Environmental Management targets and the success of management efforts in achieving these targets; summarizing the water quality status of these waterbodies in consideration of existing water quality standards; and reviewing approaches developed by the Chesapeake Bay program and other National Estuary Programs. The result will be a concise report addressed to water quality managers and administrators with (1) short term recommendations for enhancements of basinwide nutrient reduction strategies; and (2) long term recommendations for research priorities.

5** **Riggs**

Sediment Quality Survey of Northern Currituck Sound & North Landing

This project will generate a database and sedimentological understanding to determine results of the dumping of dredge spoil in shallow, open estuarine environments. Periodic maintenance channel dredging of the inter-coastal waterway results in periodic dumping and so high potential for resuspension by wind and wave action.

5** **APES** 92-06

Evaluation of Albemarle-Pamlico Sounds Sediment Toxicity

Gulf Breeze Environmental Research Laboratory (GBERL) conducted a ten-day acute toxicity test using two benthic organisms and chemical analysis of each sediment sample for a standard array of priority pollutant metals and organic compounds on 10 samples of sediments taken from estuarine tributaries to the Albemarle and Pamlico Sounds. Of the sediments selected for study, 6 were taken from areas believed to have the highest concentrations of heavy metals, and 4 were taken from areas believed to be relatively pristine. GBERL conducted bioassays and chemical analyses and an initial toxicity screening on the 10 selected samples. The results indicated that 4 of the sites were toxic to 1 of the 3 test organisms -- Kennedy Creek, the east prong of Slocum Creek, Oriental Harbor, and Hancock Creek. It is interesting to note that Hancock Creek was originally selected as one of the relatively "pristine" sites.

5** **Burkholder**

Coastal Eutrophication and Disappearing Submersed Vegetation: Lethal Effects of Nitrate Enrichment on Eelgrass and Other Beneficial Aquatic Plants

Surprisingly low, pulsed doses of nitrate can, it seems, be toxic to eelgrass. This study will: (1) determine the threshold of nitrate loading which promotes destruction of eelgrass, and (2) examine whether nitrate enrichment is toxic to other valuable aquatic plants. Submersed vegetation is a very important component of much of the fisheries and aquatic wildlife habitat in the A/P region.

The results of the study will enable the prediction of the success of replanting efforts.

FISHERIES

1** **Stewart** 87-05

Proceedings: Fish Disease Workshop

This document presents the papers given at the workshop held by Water Resources Research Institute (WRRI) in Raleigh, N.C. on September 22, 1987. The main concerns about fish disease regard the economy associated with the fisheries, human health, and the overall health of the environment. Widespread fish disease (ulcerative mycosis) was first discovered in southern flounder in the Pungo and Pamlico Rivers in 1982 and in menhaden in 1984. Direct relationships between pollution sources, the quality of ambient waters, and fish kills have almost never been established in the A/P area. The pathogen (the fungi Aphanomyces and Saprlegnia) causing ulcerative mycosis in menhaden has been isolated, but little is known about the process of infection; there is indication of localized reduced immunocompetence playing a role in infection. Evidence does exist that environmental factors play a role in the development of fish disease and general biological stress. The disease primarily affects young fish in areas of lower salinity in May and June. Fortunately, no signs of ulcerative mycosis (UM) have occurred in commercial catches of menhaden, but effects of the disease on the population as a whole are still unknown. The workshop produced a series of recommendations regarding needed scientific research and public education.

102/260 **Ortega/Sutherland/Peterson** 90-08

Recruitment and Growth of the Eastern Oyster in North Carolina

Oyster recruitment varies spatially and temporally but seems to have declined in recent years along the western edge of Pamlico Sound. Oyster recruitment was generally greater along the Outer Banks in high salinity sites than it was in low salinity sites along the western side of Pamlico Sound. Recruitment was also less at shallow depths where mats were located immediately adjacent to the shore than recruitment at greater depths, further from shore. Recruitment was greatest on the bottom surfaces of shells. Spat density in the fall reflected patterns in the intensity of recruitment, thus, greater numbers of spat were found at sites where recruitment was the highest, in deeper locations, and on the underside of shells. In many instances, however, fall spat densities were reduced in the presence of other organisms and by the degree of sedimentation.

108/236 **Phalen** 89-02

Scoping Study of Data Requirements for Fisheries Stock Assessment in North Carolina

This report focuses on the Division of Marine Fisheries' (DMF's) management requirements and its fish stock assessment programs. The report identifies: the DMF's stewardship and management goals, the needed fisheries data, the sources of available short- and long-term research results, and the data gaps that exist. The primary gaps identified include commercial and recreational

landings, jurisdictions, and environmental problems and considerations. The report makes recommendations for filling the priority data gaps. It addresses stock assessment programs, the collection of commercial and recreational data, fishery independent data, and life history and stock identification data.

116 **Smith/Palmquist** 88-13

The Value of Recreational Fishing on the Albemarle and Pamlico Estuaries

The investigators: (1) conducted a literature survey to review all economic models currently available to describe the demand for comparable types of marine recreational fishing and the values of improvements in its quality; (2) developed a data base that included a complete description of a sample users' recreational fishing opportunities and decisions, and a measure of the environmental quality; (3) developed a model of recreational decisions, and (4) estimated and evaluated the models (including estimates of average catch rates for specific entry points) based on an enhanced data base. The primary users are residents of coastal and near-by counties. A 25% increase in the catch rate would increase the value of a typical trip for an average fisherman by $10-71 (1981 dollars). Such estimates are, however, very sensitive to the original assumptions employed. Subsequent research has altered the assumptions employed by this study. These preliminary results, however, allow initial determinations to be made of the value of improving certain locations and the changes in patterns of use that could be expected to result.

123/235 **Noble** 89-90

Classification of Pamlico Sound Nursery Areas -- Recommendations for Critical Habitat Criteria

The NC Division of Marine Fisheries initiated a monitoring program for the Pamlico Sound in 1971 to explore environmental variables and the abundance and diversity of juvenile finfish and crustaceans. Classifications of areas by species and abiotic variables produced distinct station groupings. Salinity, the key abiotic factor, was the lowest in the rivers and eastern Albemarle Sound, and was the highest in Core Sound and near the inlets. Based on group classifications, recommendations were made for critical habitat criteria. It was recommended that the Marine Fisheries Commission (MFC) recognize the high salinity areas in Core Sound and behind the Outer Banks as critical habitats and nursery areas. It was also recommended that the MFC expand the number of species it considers in determining nursery areas to include, for example, pink shrimp, pinfish, and pigfish.

154 **Pearce/Street** 88-07

Evaluation of Turtle Excluder Devices in the Pamlico Sound Shrimp Fishery

Four different devices were tested in the Pamlico shrimp trawl fishery during October-November 1987 to determine their ability to reduce finfish bycatch while retaining shrimp. The devices were the Scottish Separator Trawl (SST), the Florida Fish Excluder (FFE), the Georgia TED (GT), and the Parrish TED (PT). Testing was conducted on board a local shrimp vessel using a randomized incomplete block design, including a control net. The SST appeared to separate flounder from non-demersal fish, but lost shrimp. The PT caught less fish and shrimp than the control net. The GT

and FFE both had reduced bycatches of finfish and no significant difference in shrimp catch relative to the control net. Both of these gears deserve further testing in North Carolina. Because of its smaller size and ease of installation, the FFE is recommended over the GT at this time as a device for reducing finfish bycatch in the Pamlico Sound shrimp trawl fishery.

170 **Collier/Odum** 88-12

Obstructions to Anadromous Fish Migration

Present and historical usages of rivers and streams within the A/P region by anadromous fish were determined and physical barriers to their migrations in these tributaries were identified (and mapped). Limited data bases meant that attempts at delineations for certain species proved to be impossible. 27 obstructions were identified: 18 dams, 4 canal storm gates, 2 highway culverts, 2 vegetational blockages, and 1 canal navigation lock. An additional 30 impediments were identified in reaches where anadromous fish usage is suspected but not confirmed. Dams have affected all anadromous species, especially those in the Roanoke River Basin. Highway culverts affect mainly alewife and blueback herring. The trend towards using culverts in the place of small bridges may result in significant adverse cumulative impacts unless fish passage designs are employed. Installation of fish passage culverts on all new dams would reduce habitat loss. Restoration of spawning grounds could be effected by installing fish passageways for existing dams.

172 **Davis/Brinson** 89-10

A Survey of Submerged Aquatic Vegetation of Currituck Sound and Western Albemarle-Pamlico Estuarine System

This report addresses the temporal and areal distribution of Submerged Aquatic Vegetation (SAV) in lower Back Bay, Currituck Sound, and western Albemarle and Pamlico Sounds and Estuaries. The extent and/or success of SAV is a function of fetch, depth, salinity regimes, sediment texture, concentration of suspended sediments, degree of epiphyte encrustation, weather, climate, nutrient availability, and the inherent adaptations of the SAV. Most of these potential "stresses" are natural, but some are exacerbated by human activities. The report discusses the Pamlico River; the Neuse River; Western Pamlico Sound; Back Bay; Currituck Sound; Kitty Hawk Bay; Perquimans, Little, Pasquotank, and North Rivers; and other tributaries, embayments, and creeks of the Pamlico Sound system. For each area it describes the status of, any known trends in, and any known factors regarding SAV distribution. The report emphasizes the "stress factors" most easily observed or deduced that may be responsible for the current patterns of SAV distribution -- turbulence, turbidity, and epiphytic growth -- and makes recommendations for further research and monitoring efforts.

In the Pamlico River there was the virtual disappearance of SAV in 1979 due to unusual weather conditions that caused the turbidity to increase dramatically. Some revegetation with wild celery occurred, but not in the areas of high stress. In the Neuse River, there are small healthy beds of wild celery. Western Pamlico Sound demonstrated a paucity of SAV when compared with the eastern portion of the sound. Back Bay was found to be turbid and essentially barren as was the Pasquotank River. Currituck Sound was also found to be somewhat turbid. The Perquimans and Little Rivers had healthy growths of SAV.

187/416/510 **Ferguson, Rivera, Wood** 88-10

Submerged Aquatic Vegetation in the Albemarle-Pamlico Estuarine System

The most productive Submerged Aquatic Vegetation (SAV) habitats in the southern portion of the A/P region for marine shellfish and fish are in the shallow (< 6ft) saline waters on the eastern periphery of Pamlico Sound and throughout the sounds to the south and west (Core, Back, and Bogue Sounds). Eelgrass, shoalgrass and widgeon grass dominate these environments, but such a mixture of species is unique to North Carolina. Overflights and preliminary analyses suggest an estimated area of marine submerged aquatic vegetation (SAV) of approximately 200,000 acres from Bogue Inlet to Oregon Inlet (roughly the same area as is covered by saltmarsh). 80% of the SAV is in southern and eastern Pamlico Sound. Lesser areas do occur west of Bogue Inlet, in western Pamlico Sound, Croatan Sound, and Roanoke Sound, but these brackish and freshwater areas have not been photographed. A visual aerial survey (Dec. 1987 and April 1988) was conducted, seagrass samples were collected, and ground truthing was performed. A demonstration chart was produced delineating location and abundance of SAV in southern Core Sound.

250/339/527 **Noga** 90-22

Shell Disease in Blue Crabs

Shell disease is now a common problem in certain areas of the A/P region. Shell lesions were found to have great numbers of bacteria associated with them, but no greater than the shells of clinically normal crabs. Crab hemolymph (blood) has a powerful bacteriocidal activity, but is inhibited at high temperatures and high concentrations of sodium chloride. A bioassay was developed to test this activity . Lower antibacterial activity was observed in crabs with shell disease and lower antibacterial activity (as little as one-fifth the activity) was observed in crabs from riverine areas.

270/315 **Rulifson**

Food and Feeding in Larval Fishes

Starvation has been hypothesized as being one of the principle causes of mortality of larval Roanoke River striped bass, especially during unusually high or low flow years. Samples will be taken and all fish larvae will be identified and enumerated. Up to 53 fish from each sample will be studied to determine type and number of ingested prey organisms. Using a computer analysis, relationships between: (1) fish abundance/distribution and zooplankton abundance/distribution, (2) ingested prey and zooplankton species abundance, and (3) the feeding success of each species of fish relative to striped bass will be determined. Samples from 1985, 1986, and 1988 will be analyzed. (Flood conditions in 1987 swept all striped bass larvae through the system before they developed to the feeding stage).

272 **Peterson**

Mitigation for the Losses of North Carolina Bay Scallops in the 1987-88 Red Tide Outbreak

Sampling of adult and new recruit scallops was conducted at 9 sites in 1988 and 1989 in Bogue, Back, Core, and Pamlico Sounds. At the same sites, spat collectors were deployed in the early autumn of 1988 and 1989 to measure settlement. Settlement results suggest that surface area of the substrate is an important determinant of recruitment and that recruitment is a reliable index of relative settlement intensity. Bay scallops appear to be recruitment-limited by meso-scale or sound-wide abundance of spawning adults. In Bogue and Back Sounds, recruitment scallop year classes have been extremely poor since the severe Red Tide mortalities of adults and new recruits in 1987-88. Recruitment limitation may imply a need for management intervention to enhance the spawning stock in these depleted areas.

278/269/314/552 **Rulifson** 90-03, 90-11, 91-03

Abundance and Viability of Striped Bass Eggs Spawned in the Roanoke River in 1988, 1989, 1990, 1991

Pollock's Ferry Hunting Club, on the Roanoke River near Scotland Neck served as the sampling station. Paired tow nets (one six inches below the surface and one towed at an oblique angle from bottom to surface) with flow meters collected samples every four hours for the duration of the spawning period. The mean number of striped bass eggs per net, percentage of viable eggs, and stage of development were determined. In this way, egg density and total numbers of eggs were estimated. River stage, surface water velocity, water temperature, DO, pH, and total dissolved solids were also recorded for each sample, so that water quality correlations could be drawn.

To estimate the production and viability of striped bass eggs spawned in 1988, samples were taken at Pollock's Ferry on the Roanoke River, N.C., from 10 April to 7 June 1988 using paired nets towed along the surface for 5 minutes every 4 hours for 60 days. The steady water discharge from Roanoke Rapids Dam likely caused the steady water quality conditions observed. 20,144 eggs were collected, beginning on 12 April and continuing sporadically until 2 June. Estimated total production in the Roanoke River in 1988 was 2,082,130,728. The major portion of the eggs was collected between 11 and 12 May. Three minor peaks were observed (15-16 May, 20 May, and 24-25 May). With the exception of 1986, production was the highest since 1975. Viability was estimated at 89%, the highest since 1972. Age distributions were calculated for the eggs collected. Water temperature and flow characteristics were also recorded. 79% of the eggs were collected in water of 18-21.9 degrees Celsius; 99.5% of the eggs were collected at water velocities between 60 and 99.9 cm/sec; 85% of the eggs were collected in water with DO between 6.0 and 7.9 mg/l; 92% of the eggs were collected in pH above 7.0.

In 1989, eggs were collected at Pollock's Ferry on the Roanoke River, N.C., from 16 April to 9. A big and prolonged release from the reservoir forestalled the peak spawning until late May and may have been the cause of sporadic egg production. Three peaks of spawning occurred 23-24 May, 26-27 May, and 31 May - 1 June. A total of 4,722 eggs were collected. Estimated total production in the Roanoke River in 1989 was 637,919,162. Viability was estimated at 41.8%, the seventh lowest on record. Age distributions were calculated for the eggs collected. Water temperature and flow characteristics were also recorded. Over 50% of the eggs were collected in water flowing at velocities between 100 and 119.9 cm/sec, 22% were collected at velocities from 60 to 79.9 cm/sec.

341/454 **Noga**

Determining the Relationship between Water Quality and Ulcerative Mycosis in Atlantic Menhaden

This project is designed to determine the relationship between the development of ulcerative mycosis (UM) in fishery populations and selected water quality conditions. The project will try to identify which of several factors (temperature, dissolved oxygen, salinity, pH, nitrate, and ammonia) have the greatest potential effect on fish health and so warrant further study. In the first year of the study tanks were set-up on location on the Pamlico River and UM was observed to develop in low salinity areas. In the second year of the study, more tanks will be placed at sites on the Pamlico River, stocked with "low risk" (high salinity) menhaden prior to the two customary seasons of UM outbreak (late fall and late spring). Fish observations and water quality analyses will be conducted.

434 **McKenna** 92-08

An Evaluation of the Blue Crab Fishery

Weekly sampling by gear type was conducted throughout the fishing seasons. Harvest rates and bycatch in the crab pot and trawl industries in Pamlico Sound were assessed. Types of physical injury; incidence of immediate mortality; and incidence of delayed mortality of healthy, damaged, and severely damaged blue crabs in these industries were determined. Fishery-dependent data were analyzed in an effort to develop management strategies for the crab pot and trawl fisheries. Specific management recommendations will appear in the final report.

505 **Ambrose**

Effects of Trawling on Benthic Community Structure and Fish Production: A Literature Review

This work represents the first attempt in North Carolina to evaluate the impact of trawling on benthic community structure and, to our knowledge, the first attempt anywhere to relate changes in benthic community structure to productivity of bottom feeding fishes. Results of the proposed research will make a significant contribution to the resolution of the conflict over the impact of trawling on nearshore benthic communities. The results will be critical for determining whether the shrimp trawl fisheries need to be managed to minimize disturbance of benthic habitat. These results can also be used to evaluate other anthropogenic disturbances to the estuary's benthic habitat such as channel dredging and pier construction.

534 **Cunningham** 92-05

Fishing Practices Mapping and Literature Review of Environmental Impacts

Research Triangle Institute will prepare a final report summarizing current fishing practices and providing maps of the areas where these practices are used. The completed locational database, along with other A/P study data (e.g., location of toxic "hot spots", land use, location of critical nursery areas), which will reside in the North Carolina Center for Geographic Information and

Analysis (NC CGIA) computer facility will be useful for developing management strategies for fisheries resources.

537 **McKenna**

An Examination of Alternative Fishing Devices for the Estuarine Shrimp and Crab Trawl Fisheries

The destruction of nontarget organisms by the shrimp and crab trawl fisheries is a major concern of managers, fishermen, and the public alike. The ecological consequences of this problem are poorly understood. However, there is general agreement among all concerned parties that methods need to be examined that reduce bycatch through manipulation of existing gears or by developing new gears that are species specific. The reduction of bycatch in the crab trawl fishery through the use of finfish excluder devices would reduce the loss of finfish in crab trawling. The development of species-specific gears for the harvest of shrimp would reduce finfish bycatch and should be more cost-effective.

*** **Brouwer** 90-29

Anemic Blue Crabs

In this research project concentrations of hemocyanin (functionally equivalent to hemoglobin) were measured in blue crabs (Callinectes sapidus) throughout coastal N.C. in an effort to (1) determine whether the low hemocyanin levels observed in Pamlico River crabs in September 1988 were associated with a particular season, (2) delineate the areas in which abnormalities occur, and (3) obtain background information on seasonal variability in "unstressed" populations of blue crabs. Spatial and temporal differences in concentrations of hemocyanin were due, perhaps, to environmental conditions (salinity, hypoxia, and disease organisms or agents such as parasites, bacteria, and viruses). Anthropogenic contaminants, particularly organics, may also be causal factors in lowering levels of hemocyanin. Lower concentrations of hemocyanin were not correlated with age or sex or with salinity or oxygen tension. These preliminary studies suggest that hemocyanin levels may, in fact, be related to water quality.

5** **Burkholder**

The Role of a New Toxic Dinoflagellate in Estuarine Finfish and Shellfish Kills in the Neuse and Pamlico Estuaries

A new highly toxic dinoflagellate with multiple life forms has recently been discovered in the A/P region. This study will provide information on the proportion of kills, among a range of target species, which can be directly linked to this new toxic dinoflagellate. Optimal growth conditions and the effects of eutrophication will be determined. The potential for bio-control will also be explored.

HUMAN ENVIRONMENT

*** **Brower** 86-01

Existing Management Programs

This document classifies federal and state legislation according to the environmental problems they address. Included is legislation enacted to address specific environmental problems and legislation enacted to affect general land use. The document describes briefly the legislation itself and includes a description of various tools and techniques available to local jurisdictions for managing development. While a wide variety of tools, techniques, and authority exists, a lack of coordination and insufficient support causes the current management system to suffer.

1** **Holman** 89-07

State and Federal Interrelated Programs to the A/P Study

This report is a compilation of abstracts of five federal and seven state programs that are relevant to or could influence the A/P study: The federal agencies considered are: US Environmental Protection Agency, US Fish and Wildlife Service, US Geological Service, US Soil Conservation Service, and National Oceanic and Atmospheric Administration. The state agencies considered are North Carolina's Department of Agriculture, Division of Coastal Management, Division of Environmental Management, Division of Marine Fisheries, Division of Soil and Water Conservation, Wildlife Resources Commission, and Virginia's Council on the Environment. The report was prepared in conjunction with a workshop held on September 13, 1989, and is intended to serve as a foundation for discussion and to foster better interagency communication.

136 **Tschetter** 89-03

Characterization of Baseline Demographic Trends in the Permanent and Temporary Populations in the Albemarle-Pamlico Estuarine Study Area

The permanent and temporary populations of 33 counties within the North Carolina portion of the A/P study area were studied. Year-round population figures were derived from available census years and state and federal agency projections. Temporary population figures were derived from the number of hotel and motel rooms, the number of campground sites, the number of marinas and boat slips, and the number of recreational housing units. Carteret and Dare Counties had the greatest recreational activity. Several coastal counties experienced significant growth during the 1980s, most especially in recreational housing, hotels and motels, and marinas. Such growth is expected to continue in the near future, with the greatest growth projected for Carteret and Dare County and, to a lesser extent, Hyde County. The greatest development activity will be on the barrier islands.

242 **Clark** 90-10

A Pilot Study for Managing Multiple Use in the State's Public Trust Waters

This report uses Carteret County as a case study for the development of a model water use plan. It begins with a description of current laws and regulations that affect the resources and uses of Carteret County's public trust waters. A model water use plan is then developed through: (1) an analysis of the county's key growth and water use indicators, (2) an analysis of policies regarding the use of the county's public trust waters, and (3) the development of a classification scheme for water use. Finally, the report describes options for implementation of the model water use plan.

279 **Nichols** 90-02

Evaluation of State Environmental Management and Resource Protection Programs in the Albemarle-Pamlico Region

Seventeen individual programs in nine "program areas" were analyzed from the perspective of implementation. The nine program areas are: (1) NPDES controls; (2) on-site treatment systems; (3) large systems using subsurface disposal or land application; (4) urban stormwater regulations; (5) agricultural controls; (6) erosion and sedimentation controls; (7) marina siting and marine waste disposal; (8) critical aquatic habitat protection; and (9) wetlands protection. Considered in the analysis were measures of: (1) tractability of the problem; (2) clarity of the program objectives; (3) technical integrity of the program; (4) adequacy of staff and resources, (5) adequacy of incentives and sanctions; (6) accessibility to supportive constituencies; (7) adequacy of training and technical assistance; and (8) commitment of the implementing agency. Findings, key issues of concern, and recommendations for each program are supplied. In general, under-staffing and inadequate enforcement exist. The report recommends increasing the use of basin-wide or watershed-wide planning, and the imposition of permit fees and taxes.

350/415 **Hoban** 90-27

Public Attitudes Towards Water Quality and Management Alternatives in the Albemarle-Pamlico Estuarine System: Phase I and Phase II

During Phase I an extensive literature review and a personal interview/survey were conducted to determine the level of understanding of the causes, severity, and consequences of water quality problems in the A/P region. Most respondents were fairly knowledgeable about certain major issues, but were not well-informed about the connection between upland drainage and estuarine health. Most respondents were quite concerned about the health of the A/P region, but less concerned about their immediate surroundings. Most associated water quality problems with point source dischargers. University professors seen as most credible; government agencies were also seen as quite credible. Private interest groups, on the other hand, were viewed with some suspicion. It was widely held that management efforts should be expanded, and directed for the public good, not private interests.

Phase II will make operational a theoretical model of the relationships between background characteristics and public attitudes regarding the A/P estuarine system and will continue the extensive interview/survey process. The focus will shift from a consideration of the natural resources themselves to a consideration of management alternatives. Knowledge about and

attitudes regarding the effectiveness and equity of different environmental policies and programs will be assessed. Public support and potential public support for management alternatives within the A/P system will be determined.

358 **Duffin** 90-20

Federal Consistency Review for the A/P Study

This report discusses several options for the A/P Study to meet the section 320(b)7 requirements of the Clean Water Act for a viable process of federal consistency review. Two options are dismissed as impractical or ineffective. Two options received detailed consideration. The State Clearinghouse review process is analyzed, but it, alone, would not allow the A/P Management Conference to put a stop to inconsistent federal projects. The recommended strategy would integrate A/P federal consistency with the NC Division of Coastal Management's (DCM's) federal consistency review by submitting the APES Comprehensive Conservation Management Plan (CCMP) to DCM for adoption under the NC Coastal Management Program. DCM would then be responsible for determining federal consistency.

430 **Bartholomew** 92-01

Environmental Management Strategies: Comparative Analysis and Selected Case Studies

An overview survey of over 70 environmental programs around the world -- coastal and inland; marine, estuarine, and fresh water; and state, regional, and federal -- was conducted and the results summarized. From the extensive list, 19 programs were selected for a more in-depth review and analysis for potential applicability to the development of the APES management plan and implementation strategies. Information was gathered on the mandate, organizational structure, staffing, budget, and public involvement associated with each program. Strengths and weaknesses were analyzed. Detailed recommendations regarding mandates, organization, and public involvement, necessary for successful implementation are presented in the final report.

452 **Duffin**

Evaluation of Federal Program Impacts in the Albemarle-Pamlico Region

A list of all relevant "resource critical" federal activities and programs within the A/P region will be identified. For each of the activities or programs identified, specific associated water quality-related problems or concerns will be described. This will serve as a foundational data base and will aid in the federal consistency review process. The extent to which each program takes water quality related impacts into consideration will be evaluated. Each relevant agency's participation in the federal consistency review program will also be evaluated for efficacy of action, level of technical review, and availability of staff for the review process.

PUBLIC EDUCATION AND PARTICIPATION

113 **Kennedy** 88-03

A Citizens's Guide to Coastal Water Resource Management

This Guide was designed to help people better understand and better utilize coastal and marine resources. It discusses the regulatory process and the potential for citizens' involvement, water quality standards, the N.C. Coastal Area Management Act, Dredge and Fill Permits under Section 404 of the Clean Water Act, sediment and erosion control, and several other state and federal environmental laws. The Guide also discusses several "non-regulatory" ways for citizens to become involved in protecting water resources.

113 **Okun/Tursi** 89-12

Where the Rivers Meet the Sea & Radio and TV Broadcasts

The 67 page booklet "Where the Rivers Meet the Sea" introduces the reader to the physical and cultural aspects of the A/P region. It discusses the uses made of the system, the hydrology of the system, the stresses the system is exposed to, the degradation caused by some of those stresses, and some of the steps citizens can take to remediate the degradation.

A five-part series about the sounds was aired on National Public Radio, in Chapel Hill and on the coast and eight public service announcements were aired on radio stations within the A/P Study area.

A four television public service announcements were produced and aired in the A/P Study area.

114 **Carson** no report

National Estuary Program Designation Ceremony and Associated Public Meeting

A public meeting was held November 14, 1987, in Elizabeth City to highlight management systems, necessary research, and public concerns regarding the A/P region and the A/P Study. Panel sessions and open discussions among citizens and state and federal agency experts were held. Roughly 300 people attended.

176 **Smith** no report

Video Tape and Slide Show

A 30 minute dual-projector dissolve slide program focused on the watersheds of Albemarle and Pamlico Sounds. The path of water was traced from the mountains, through the streams, to the sounds. A 30 minute video followed a similar format, but also addressed issues of pollution, fisheries, and waterfowl migrations, and included some interviews.

209/412 **Conoley** no report

"Striped Bass" & "Precious Waters"

Two exhibits have been developed for the N.C. Aquarium at Pine Knoll Shores. In one, the life history of the striped bass and the environmental stresses affecting stages of the life history are described through the use of graphics, interactive computers, and a large aquarium. Movements of the spawning adults and the juveniles returning to the sea are followed in the display and the importance of salt marsh nursery areas are emphasized. In the other, aquaria, graphics, an interactive map, and videos will promote awareness and appreciation of the region's fragile coastal environment.

224 **Gale** 00-00

A Guide To Estuaries

In this small handbook, the estuarine environment is described, with specific descriptions of the A/P estuarine system. Estuarine organisms are introduced according to the ecological niche they occupy. Water quality is described and discussed. Appendices offer further reading suggestions; describe actions to be taken to become involved in preserving the estuarine environment; list local rare, threatened, and endangered species; and provide lists of scientific and common names of the organisms cited in the text.

225/310/474/524 **Stroud** no report

Community Education and Outreach

The Pamlico-Tar River Foundation (PTRF) engages in outreach to students, civic clubs, visitors of the N.C. aquaria, and the general public. PTRF has conducted special educational programs in local schools, participated in public education at local festivals, given presentations for civic clubs, participated on radio talk shows, and published informative columns in local newspapers.

226 **Nurnberg** no text

1990 Calendar

A spiral bound 12" x 12" calendar with color photographs of scenes from the Albemarle-Pamlico Estuarine area was developed. Two to three lines of text accompany each photo, informing the audience of estuarine resource management issues. 5,000 copies were distributed to school children and others throughout the area.

240 **Carson** no report

Teacher Environmental Education Program

A slide show was developed for public school teachers. Workshops were held in Elizabeth City, Edenton, Plymouth, and Manteo, N.C. to give teachers an understanding of the aquatic

environment and its management, and to provide the teachers an opportunity to develop creative ways of integrating those concepts into their curricula. Participating teachers were asked to submit lesson plans and completed projects to the workshop instructor.

266/439 **Willard** no report

Television Public Service Announcements: "State of the Estuary" & "Yes, in Your Back Yard"

"State of the Estuary" public television campaign was composed of five 30-second spots, aired over 12 months. The spots covered the following topics: (1) an introduction to the sounds and good stewardship, (2) man induced effects on the waters, (3) symptoms of a stressed ecosystem, (4) the plight of the Tar-Pamlico River, and (5) the importance of public involvement in preserving North Carolina's estuaries.

The series of television spots entitled "Yes, in Your Back Yard" targets individual user or interest groups, offering suggestions of practices that help preserve the natural environment. The spots are directed at farmers, industrial workers and small businessmen, developers, boaters, citizens and homeowners, and youths. The spots will be distributed to every television market in North Carolina.

312/409/503 **Powers/Couture** no report

Public Education in the Albemarle Region

Educational programs (featuring a slide presentation and a hands on demonstration of the citizens' water quality monitoring techniques) were presented to civic clubs and public school groups.

The Albemarle Environmental Association targeted nine counties in the Albemarle region. Presentations were given to local government officials regarding results of recent A/P Study findings and initial Geographic Information System generated maps. Accompanying news notes were periodically sent to participating officials.

322 **Fodor** no report

Radio Broadcasts and Public Awareness

Six radio programs were developed and aired on ten radio stations in North Carolina and Virginia. In general, the concepts of estuarine health and good stewardship were stressed. The first program introduced issues of point and nonpoint source pollution, wetlands, and waste treatment. The second and third programs were live phone-in talk shows with local expert scientists. The fourth, fifth, and sixth programs focused on human impacts and economics, public participation, and fisheries and fish diseases.

325/431/542 **Carlock** '89-'90 annual report

Southeastern Virginia: Institutional Enhancement, Public Involvement, and Information Exchange

This project encourages and facilitates public participation, information exchange, and technical evaluation in southeastern Virginia. The Hampton Roads Planning District Commission (HRPDC) facilitates these endeavors, increasing coordination and cooperation within Virginia and between Virginia and North Carolina. Media used include the HRDPC quarterly publications, workshops for local government officials, a local government advisory committee, and others.

328 **Nurnberg** no text

Posters and Bumper Stickers

Three educational posters depicting the resources of the sounds, and two informative and provocative bumper stickers promoting stewardship of those resources, were produced to increase public interest in the activities of the A/P study. These products are distributed free of charge to schools and the general public.

329 **Armingeon** 90-26

Blueprint for Action, Media Tour, APES Annual Meeting

The "Blueprint for Action" was developed through Citizen Advisory Committee workshops as a foundational management plan to encourage communication and to serve as a springboard for the APES Comprehensive Conservation Management Plan (CCMP). It outlines a proposed framework for the development of the CCMP. It lays out goals (long-term and broad in scope) in the four areas discussed in the APES Status and Trends Report: (1) Water Quality: decrease point and nonpoint sources of pollution to maintain resources; (2) Fisheries: restore and conserve all fisheries resources; (3) Critical Areas: halt all destruction of habitat; and (4) the Human Environment: plan and manage growth. The Blueprint also presents environmental objectives, short-term and more specific than the goals. Recommendations for achieving the goals and objectives were divided into fast track and longer-term management actions.

The media tour quite successfully educated several regional and local reporters about the A/P region and the activities aimed at preserving the region's resources.

The 1990 Annual Meeting, held in Morehead City, N.C., was quite successful.

332 **Okun** 90-25

Development and Implementation of Teacher Training Materials

A two-week and one weekend teacher training workshop was conducted during the summer of 1990 for 15 eastern North Carolina teachers. Information was presented in classroom and laboratory exercises, through guest lectures, and on field trips on: the water cycle, ground water hydrology, stream and floodplain morphology and evolution, topography, map reading, water

quality testing, local geomorphology, nonpoint source pollution, and the role of humans in the natural environment.

351 **Hoban** 90-24

Workshop: Water Quality and Non-point Source Pollution

Four one-day leadership development workshops were conducted across the A/P region to increase local understanding of and support for APES, and to present viable options and strategies for action. Local leaders, resource managers, and others were encouraged attend -- over 300 people participated. Topics of the workshops included: nonpoint source pollution, BMPs, planning strategies, educational strategies, economics, and fishery resources. A non-technical handbook on practices for solving problems associated with nonpoint source pollution was produced.

352 **Shaw**

Public Forum on Management Needs

A series of three meetings were held in Plymouth and New Bern, N.C. from October 1989 to January 1990. At the first meeting citizens voiced their concerns about estuarine degradation from sewage disposal and inadequate monitoring and enforcement. At the second meeting, the results of the first were shared with local officials, resource managers, and interest groups. At the final meeting, citizens were asked to make recommendations regarding regulations, monitoring, enforcement, land use planning, public education, and citizen action. The recommendations will be finalized in a report presented to the Coastal Resources Commission, Environmental Management Commission, local governments, and interested organizations.

407 **Armingeon**

Fact Sheets, Public Education, APES Annual Meeting

10 fact sheets will be researched written and distributed widely. The sheets will each discuss and clearly explain one significant scientific study funded by APES.

The 1991 APES Annual Meeting (roundtable, researchers meeting, and coastal festival) will be organized and conducted in Kill Devil Hills, N.C.

The Citizens Guide will be revised and updated (see project #113 above).

408 **Cleary** no report

Radio Public Service Announcements

The purpose of this project was to achieve public participation in the A/P Study. Eight programs (25 broadcasts) were aired in 1990-91 on the state-wide syndicated radio program, "Weekdays with Barbara King". The series will be composed of taped interviews and suggestions of public actions to help preserve the estuarine system.

411 **Powers**

Fact Sheets on the Albemarle Region

The Albemarle Environmental Association produced a series of five fact sheets on the biology, geology, ecology, culture, and history surrounding the Roanoke, Chowan, Perquimans, and Pasquotank Rivers. The fact sheets have been distributed to schools, libraries, and the general public.

413 **McNaught** 91-07

North Carolina Estuarine Resources Center: A Feasibility Study

Pamlico Tar river Foundation worked with Greenways Inc. to complete a feasibility study for the siting, development, and operation of an Estuarine Resources Center, a center that could serve the tourist community, the local educational community, area researchers, and the general public. Demographic, physical, economic, social, and political concerns were considered in this analysis. A discussion of a possible theme and a brief discussion of the requirements for operation were presented. A sample site selection was conducted for eight candidate sites using six weighted variables.

444/502 **Turnage/Meiggs** 92-07

Estuarine and Environmental Health Curriculum

The Elizabeth City-Pasquotank County School Board developed a model modular guide to 14 activities regarding estuarine and environmental health designed for grades K-6, utilizing non-traditional, no-textbook approach. The program: (1) utilizes common and readily available materials, (2) encourages field trips, (3) encourages hands-on learning activities for the children, and (4) encourages community-level activities to raise environmental awareness. 150 teachers will be trained, and roughly 3,900 students will benefit from this highly innovative program.

543 **Carlock**

Environmental Management Program for the Southeastern Virginia Portion of the APES Watershed

This project will result in the development of an Environmental Management Program for the Virginia portion of the APES Watershed. It will be responsive to the specific needs and situations of Virginia localities while serving as a model for development of a coordinated approach by local governments to management of shared resources. By evaluating the applicability of those evolving Chesapeake Bay management approaches that require local government implementation to the Albemarle Basin, it should expand the range of options available for North Carolina environmental management programs. It will further enhance interstate coordination of management efforts.

5** **Armingeon** internal report

A Summary of the User-Group Workshops: February 1992

In February, seven workshops were held to present to different "user-groups" the management options presented in the drafts of the action plans in order to understand their concerns and to elicit their suggestions for additional or alternative management recommendations. The groups that met were: (1) elected officials (southern portion of A/P region), (2) elected officials (northern portion of A/P region), (3) farmers and foresters, (4) commercial and recreational fishermen, (5) Point source dischargers, (6) developers and marina operators, and (7) environmental activists.

Each group was presented with the management recommendations that would most affect it. Open discussion of each option and of any new suggestions followed. The APES staff compiled and, as appropriate, incorporated suggestions into the drafts of the management plan.

Some options were supported by all groups. In general, land use planning and strengthened enforcement of existing regulations were supported. Other options were opposed by one or two groups that would be particularly affected. Most participants did recognize their role in the problems apparent in the A/P region and showed their support for continuing to work, with members of the other interest groups, towards greater environmental protection and conservation.

INFORMATION MANAGEMENT

1** **Stewart** 87-04

Proceedings: Remote Sensing Workshop

This document presents 21 papers given at a two-day workshop held November 9, 1987. Papers fell into six categories: (1) APES and its use of land use/land cover data, (2) the APES data management system, (3) state-of-the-art and summary of issues, (4) in-house programs, capabilities, and expertise, (5) available data bases and data services, and (6) experiences in remote sensing in estuarine areas and integrating remote sensing data into a Geographic Information System.

1**/343 **Siderelis/NC CGIA** 91-08

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

This project resulted in:

(1) a current digital land use and land cover inventory based on Landsat Thematic Mapper data classified, verified, and fully registered and vertically integrated with the APES Geographic Information System (GIS) database;
(2) digital files in a standard data exchange format available to investigators and resource managers involved in APES research or related activities;
(3) a capability within the APES Data Management Center to maintain, analyze, and update the inventory on an as-needed basis in the future; and
(4) land use/land cover classified and verified maps summarized by geopolitical boundaries available for distribution to the user community through the APES program.

2**/3**/4**/5** **Siderelis/NC CGIA** no report

Data Management

General support services have been provided in the creation of an APES database and applications of the Geographic Information System to provide support as needed to the APES staff .

2** **Siderelis/NC CGIA** 90-21

Data Management and Analysis System -- Functional Description Document

The Functional Description Document provides a conceptual view of the five components of the APES Data Management and Analysis System: hardware, software, data, people, and procedures. Interactions of these components result in functions that must be able to be supported by the Data Management System: management and maintenance, data extraction and management, data creation and editing, data manipulation and summarization, and data analysis and display. The report discusses the mission of each of the four major user groups (resource managers, the research

community, local governments, and private citizens and organizations) and defines the general methods of access for each.

*** **Siderelis/NC CGIA** 90-06

Data Requirements Document

This document defines the data requirements for the APES database. The data needs assessment involved obtaining the characteristics of existing data and determining future data needs. Over 50 interviews were conducted with potential "donor" and "user" agencies. The results were used to compile a list of data layers (cartographic and attribute data) required to support A/P Study participants. Priorities were established based on ease of acquisition and utility and a schedule for database creation was developed. 64 sets of cartographic data were identified and ranked, 60 sets of attribute data were identified, and general types of bibliographic data were identified for inclusion in the APES database. The management plan defines issues, makes data management recommendations, and discusses options for implementation of those recommendations.

*** **Siderelis/NC CGIA** 90-28

Data Inventory

This document summarizes over 120 databases related to the A/P Study area: (1) title, (2) creation date, (3) geographic coverage, (4) type -- cartographic, tabular, or both, (5) format -- digital or non-digital, (6) potential candidacy for the APES database, and (7) contact person(s).

5** **Holman**

The Evaluation of Land Use Changes Within the APES Area Utilizing GIS

By evaluating land use data layers and population census data layers that are currently available to the APES a better understanding of what, where, and when human impacts took and are taking place within the APES watershed will be gained. This information will be invaluable in developing workable management strategies for both the entire APES watershed as well as specific locations within the study area.

ACTION PLAN DEMONSTRATION PROJECTS

2** **Lewis** 90-23

Animal Waste Management

The Virginia portion of the Chowan River basin is "nutrient enriched" due, in part, to the prevalence of the large swine production operations with little or no waste utilization planning. This project was initiated to demonstrate the benefits of waste management to the participants in the six county, 75% cost-share program. Five new waste storage facilities were built and nutrient management plans were developed for all participants. In this way, 48,037 tons of manure were brought under management. An additional 13 test plots, to be used for tours and educational outreach, were established to demonstrate the value of land application practices. Unfortunately, even with 75% cost sharing, high installation costs discouraged many producers from constructing systems. More work is needed in promoting the proper application of the wastes in existing storage facilities.

2**/455 **Cummings**

Merchants Mill Pond

This is the same project as is described under WQ 2**/455. The first year funds were targeted at soils testing and animal waste analyses in order to achieve appropriate nutrient management. The second year funds will be used to expand the efforts of installing BMPs such as solid-set waste management systems, exclusion of livestock from streams, filter strips, environmentally safe application of animal wastes, and stock rotation systems. The second phase of the project will address nutrient management, waste management, sediment control, and erosion control through the support of cost-sharing incentives to construct BMPs. BMP construction and operation regulations, set forth in NCAC Title 15, Chapter 6, Section 6E and Chapter 143, Article 21 of North Carolina General Statutes, will be adhered to.

3** **Belk**

Stormwater Detention Basin: Greenville, N.C.

Urban nonpoint sources are a major contribution to excess nutrient inputs in the Tar-Pamlico River basin (where the project was conducted). A stormwater detention basin was constructed in downtown Greenville, N.C. to demonstrate the implementation of an urban best management practice (BMP) to control urban nonpoint source pollution. The basin is situated to receive and treat stormwater runoff entering the Tar River. The 200 acre watershed that the basin serves is representative of local land uses. Interdepartmental and interagency cooperation resulted in the successful design and construction of this urban BMP. Concurrent projects will study the flow and water quality characteristics associated with the detention basin.

418 **Rogers**

Marsh Grass Protection (from Erosion) Through the Installation of Low-Cost Breakwaters

This project is intended to protect coastal marsh areas from erosion through the installation of low-cost breakwaters. Several such breakwaters will be installed in an effort to determine the most efficient design and construction techniques. If the breakwaters prove to be successful, marsh grass could be planted behind them in an effort to increase primary nursery habitat.

*** **Horton**

Solid-Set Waste Management Installations

Solid-set waste management systems have been installed and are operating well at three sites in Washington, Tyrrell, and Bertie Counties. These systems were designed and installed to combat the excessive nutrient enrichment problems associated with livestock waste disposal.

546 **Cummings**

Composting Farm Animal and Seafood Processing Residues Recycling Waste Management Systems

The tremendous increase over the past decade in confined animal operations and the projected increase over the coming decade has made disposal of dead animals a surface and groundwater concern. Aquaculture also is a rapidly increasing enterprise in eastern NC and there is concern of landfills becoming overloaded with biodegradable products such as residues from seafood processing operations. This project will promote alternative and innovative means of managing farm and aquaculture wastes in an environmentally safe manner. Demonstration projects will be made available that include composting waste products, dead animals, and/or seafood processing residues. The proposed target materials for composting will be chicken and pig carcasses and crab by-products. Demonstration sites were selected on conservation and management skills exhibited by the producer, site location relevant to primary waterways and alternate project sites, and the use of the areas as "teaching" aids for technical personnel and agricultural and aquacultural producers.

ALBEMARLE-PAMLICO ESTUARINE STUDY PROGRAM DOCUMENTS

APES **Rader** 87-01

Source Document and Five Year Plan

This lengthy document establishes: (1) the background and purpose of the A/P Study, (2) the environmental, use-oriented, and management conditions of the study area, (3) research and information needs, (4) data management, (5) public participation, (6) budget, and (7) scheduling.

APES **Rader** 87-02

Five Year Work Plan

The Five Year Work Plan is a shortened version of the Source Document (87-01) and contains: (1) the background and purpose of the A/P Study, (2) the environmental, use-oriented, and management conditions of the study area, (3) research and information needs, (4) data management, (5) public participation, (6) budget, and (7) scheduling.

APES **Rader** 88-01, 88-02

Baseline Water Quality Monitoring Plan

This plan was developed from the existing ambient monitoring programs in North Carolina to provide data on the information gaps that exist in the monitoring efforts and to provide a means to evaluate the long-term effectiveness of the management strategies implemented. The program, which began in October 1988, is the result of the expertise of US Environmental Protection Agency, National Oceanic and Atmospheric Administration, Division of Environmental Management, and Division of Marine Fisheries. The program includes investigations of water quality and sediment and biological resources, spatial and temporal analyses, and consideration of episodic events. The program is a compilation of a citizens' monitoring program, continuous monitoring for selected parameters, expansion of the existing ambient monitoring network, emergency response capabilities, surveys of fish tissues, sediment oxygen demand, and sediment characteristics, and a one-time synoptic basin-wide water quality study.

APES **Holman** 88-04

Status Report

The Status Report includes: (1) introduction, (2) milestones and goals, (3) information acquisition, (4) public involvement, (5) monitoring, (6) priority action plans, (7) administrative staff and boards, (8) budgets for Fiscal Year 89 and Fiscal Year 90, (9) publications, and (10) recommendations.

APES **Rader: Beaufort County Magazine** 88-05

The Albemarle-Pamlico Estuarine Study: What Needs to be Done

This 2 page article introduces the A/P estuarine system, discusses signs of environmental stress, defines some of the likely causes of those problems, and describes APES' goals: gathering information, characterizing the system, integrating diverse information, initiating and fostering public involvement, and creating a comprehensive management plan.

APES **Holman** 88-08

Project Abstracts '87 - '88

This is a compilation of abstracts of projects funded by APES in Fiscal Year 88.

APES **Taylor: Wildlife of North Carolina** 88-11

Can Albemarle and Pamlico Be Saved?

This five page magazine article introduces the A/P Study and describes its goals, some of its early findings, and its plans for the future.

APES **Holman** 89-01

Progress Report for 1989

The Progress Report includes: (1) introduction, (2) milestones and goals, (3) information acquisition, (4) public involvement, (5) monitoring, (6) priority action plans, (7) budgets Fiscal Year 89 and Fiscal Year 90, (8) publications, and (9) schedule of events.

APES **Giordano** 89-04

Public Involvement Plan

This document covers: (1) an introduction to the program, (2) its goals and objectives, (3) staffing and program procedures, (4) tasks (education and information, public participation, and local government liaison), and (5) a timeline.

APES **Holman** 89-08

Project Abstracts for the Period 1989-1990

This is a compilation of abstracts from completed and ongoing projects funded by APES in Fiscal Year 89 and Fiscal Year 90.

APES **Copeland** 89-13

Status and Trends Report (draft)

A series of preliminary drafts compiled over 35 investigators' understanding of the A/P estuarine system. The document is organized into four major sections: Critical Areas/Habitats, Water Quality, Fisheries, and the Human Environment. Within each of these sections, individual topics of concern are addressed. The status and trends regarding probable causes of and viable recommendations for each is discussed.

APES **Copeland** 90-02

Public Document (draft)

This booklet (draft) introduces the reader to the A/P region, describes the primary topics of concern, and summarizes the findings of the Status and Trends Report.

APES **National Geographic** 90-04

Coastal Satellite Scene/Poster

Poster-size infrared satellite photos of northeastern North Carolina are available for $10.

APES **Holman** 90-05

Progress Report for 1990

The Progress Report includes: (1) introduction, (2) milestones and goals, (3) information acquisition, (4) public involvement, (5) monitoring, (6) priority action plans, (7) administrative staff and boards, (8) budgets Fiscal Year 89 and Fiscal Year 90, (9) publications, and (10) schedule of events.

APES **Holman** 90-18

Project Abstracts: Fiscal Year 89 & 90

This is a compilation of abstracts from completed and ongoing projects funded by APES in Fiscal Year 89 and Fiscal Year 90.

APES **Waite** 91-09

Annual Report: 1990-91

The report summarizes the Program's progress over the fiscal year. The Information Acquisition Program, Public Involvement Program, Monitoring Program, Data Management Program, and Action Plan Demonstration Project Program are all described. The program's schedule and budget

are also discussed.

APES Steel 91-01

Status and Trends Report

The final Status and Trends Report is an updated and revised version of the draft report prepared two years earlier (89-13). The report maintains the basic structure of the draft report: Introduction, Critical Terrestrial Areas and Wetlands, Water Quality, Fisheries, Human Environment, and Summary. The status, trends, and probable causes of degradation are discussed in detain in this compilation of all known information on the A/P system as a whole.

APES Steel 91-02

Executive Summary of the Status and Trends Report

The Executive Summary of the complete Status and Trends Report was published separately, for wide-spread distribution. Like the full Status and Trends Report, the Executive Summary contains the following sections: Introduction, Critical Areas, Water Quality, Fisheries, Human Environment, and Summary.

APES Steel/Scully 91-00

Projects funded by the Albemarle-Pamlico Estuarine Study

This summary of all the projects funded by the study serves as an overview of the scientific and educational accomplishments of the A/P Study.