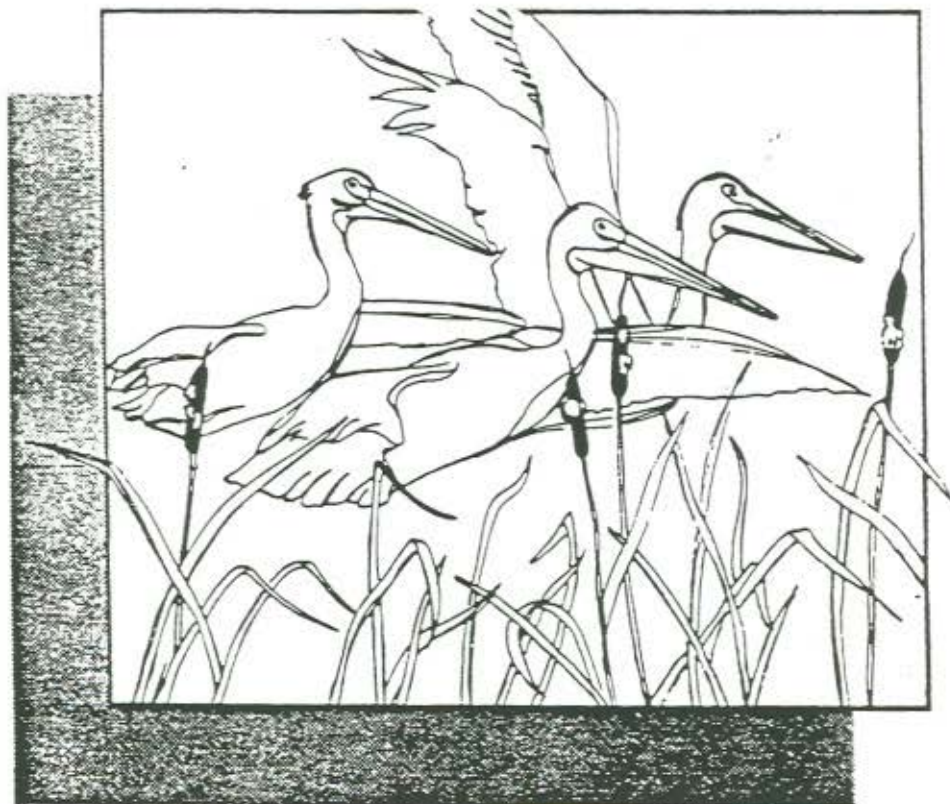


Draft

# ALBEMARLE - PAMLICO ESTUARINE STUDY WORK PLAN

---



---

State of North Carolina Department of  
Natural Resources and Community Development

512 North Salisbury St. Raleigh, North Carolina 27611

## CONTENTS

CHAPTER I:	BACKGROUND AND PURPOSE.....	1
CHAPTER II:	THE ALBEMARLE-PAMLICO REGION.....	4
	NATURAL SYSTEMS, HUMAN USES AND MANAGEMENT TOOLS	
	NATURAL SYSTEMS AND ENVIRONMENTAL CONCERNS.....	4
	HUMAN USES OF THE ALBEMARLE-PAMLICO.....	10
	MANAGEMENT PROGRAMS.....	27
CHAPTER III:	INTERACTIONS AMONG SOCIETAL USES.....	29
CHAPTER IV:	RESEARCH AND INFORMATION NEEDS.....	35
CHAPTER V:	DATA MANAGEMENT.....	58
CHAPTER VI:	PUBLIC PARTICIPATION IN THE ALBEMARLE-PAMLICO ESTUARINE STUDY.....	63
CHAPTER VII:	BUDGET AND SCHEDULING.....	68
APPENDIX 1:	MANAGEMENT TOOLS.....	72

## CHAPTER I

### BACKGROUND AND PURPOSE

The Albemarle-Pamlico is one of the most imposing estuarine systems in the United States. Physically, it dominates the North Carolina coast, with its more than 2900 square miles of protected inshore waters (80% of the State total) and extensive areas of such bordering habitats as beaches, marshes, and swamp forests. Human use of this system is extensive. Population of counties in the watershed has grown steadily since 1970 at a rate of 18,360 new inhabitants per year. This growth has been paralleled by increasing expenditures for recreation and tourism which have grown at an inflation adjusted annual rate of 15.7% since 1975. This increasing human use has contributed to large increases in the number of wastewater treatment plants and industrial discharges. Traditional human uses have waxed and waned since 1970. The area of harvested agricultural land increased about 50% in the 1970's, but has decreased about 10% since 1980 (to 2.3 million acres in 1984). Agriculture remains a significant economic component; however, accounting for over \$1.5 billion in annual gross receipts from field crops and livestock. Forestry produces an annual harvest worth 72-78 million dollars, but total forest area is being reduced by 20,000 acres annually. Commercial fishing produces a processed product value of about \$60 million dollars annually, but landings of major finfish and blue crabs reached historic peaks in the early 1980's and have declined since, while anadromous fish harvests have declined steadily since the early 1970's.

The relationships between changing human use patterns and productivity of the Albemarle-Pamlico region are not understood, but there is growing concern that the natural integrity and productivity of estuaries are affected by the activities of man. As economic development in the coastal area, and in watersheds draining to the coastal area, grows more intense, questions about man's impact gain urgency. Finding realistic, workable means to mediate conflicts between human uses clearly depends upon understanding interactions between human uses and natural systems.

It is equally clear that fundamental choices are now being made, whether wisely or unwisely, by conscious choice or by inadvertence; that will determine the long-term productivity of the Albemarle-Pamlico system. These choices are the cumulative result of thousands of private business and individual decisions and an overlay of three levels of government with varying authority and hundreds of management programs.

There exists no monolithic bureaucracy to "manage the estuarine system for society's benefit", with powers to impose a common purpose upon all who affect the system. The hope for systematic and rational

resource management lies in unification of knowledge and understanding, and voluntary cooperation among institutions. The presumption of this study is that relevant scientific knowledge, acquired in a timely fashion, translated into practical terms, and widely shared among the elements of an otherwise fragmented management structure, will drive these elements toward coherent and effective policy.

On August 15, 1986, the Policy Committee for the Albemarle-Pamlico Estuarine Study resolved that:

The goal of the Albemarle-Pamlico Project will be to provide the scientific knowledge and public awareness needed to make rational management decisions so that the Albemarle-Pamlico estuarine system can continue to supply citizens with natural resources, recreational opportunities, and aesthetic enjoyment.

The objectives of the project will include, but are not limited to, generating understanding of what is needed to maintain, and where necessary restore, the chemical, physical and biological integrity of the estuary, the wildlife habitat of the estuary, the production levels of recreational and commercial fisheries of the estuary.

The specific goals of the National Estuarine Program are stated in the 1987 Clean Water Bill, as amended. They are:

- (1) assess trends in water quality, natural resources, and uses of the estuary;
- (2) collect, characterize, and assess data on toxics, nutrients, and natural resources within the estuarine zone to identify the causes of environmental problems;
- (3) develop the relationship between the in-place loads and point and nonpoint loadings of pollutants to the estuarine zone and the potential uses of the zone, water quality, and natural resources;
- (4) develop a comprehensive conservation and management plan that recommends priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the estuary, including restoration and maintenance of water quality, a balanced indigenous population of shellfish, fish and wildlife, and recreational activities in the estuary, and assure that the designated uses of the estuary are protected.
- (5) develop plans for the coordinated implementation of the plan by the States as well as Federal and local agencies participating in the conference;

- (6) monitor the effectiveness of actions taken pursuant to the plan; and
- (7) review all Federal financial assistance program and Federal development project in accordance with the requirements of Executive Order 12372, as in effect on September 17, 1983, to determine whether such assistance program or project would be consistent with and further the purposes and objectives of the plan prepared under this section.

Therefore, the major thrust of the Albemarle-Pamlico Estuarine Study is to enable resource managers to better preserve the productivity of the estuarine area by expanding relevant knowledge about the impact of human uses upon its physical, biological, and social systems.

## CHAPTER II

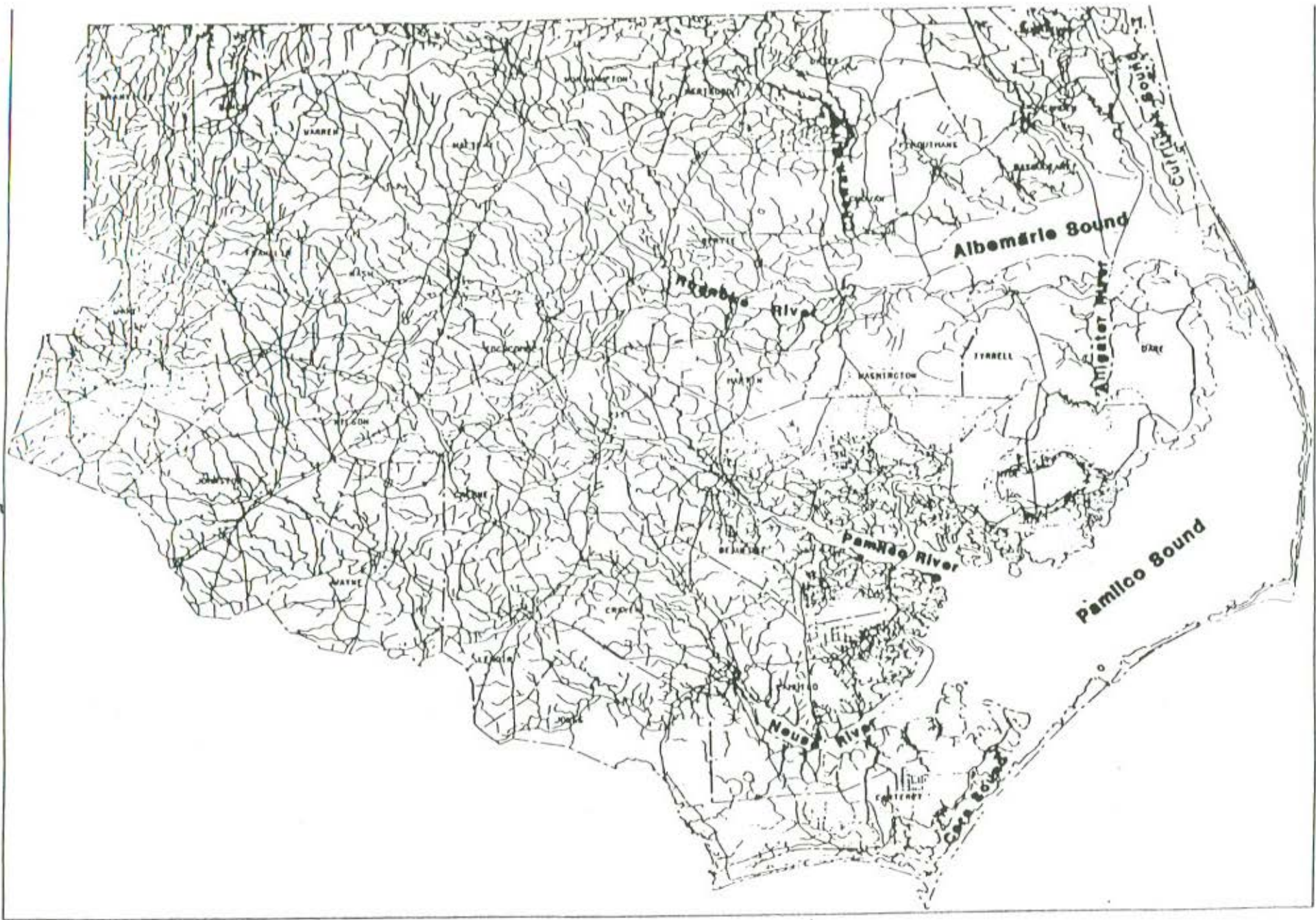
### THE ALBEMARLE-PAMLICO REGION NATURAL SYSTEMS, HUMAN USES, MANAGEMENT TOOLS

#### NATURAL SYSTEMS AND ENVIRONMENTAL CONCERNS

The Albemarle-Pamlico estuarine system itself contains the second largest estuarine surface water area in the United States (ca. 2,900 mi<sup>2</sup>) (Figure 1). This system consists of two large coastal lagoons (Albemarle and Pamlico Sounds) with their associated fringing habitats (beaches, marshes, bluffs, and swamp forests) and rivers (Neuse, Pamlico, Pungo, Alligator, Roanoke, Chowan and others). These waterbodies represent ancient river valleys flooded by the rising sea level during the last several thousand years. The underlying geologic setting is similar throughout the system. Stratigraphy of sediments underlying both land and water areas is relatively consistent, although beds vary in thickness from place to place. Rainfall averages about 50 inches a year, with higher values in summer and winter than in the fall and spring. The mean-monthly daily-high air temperatures for the region range from about 7°C (45°F) in January to over 32°C (90°F) in July. Thunderstorms cause high winds and rainfalls in summer months. The entire region is exposed to hurricanes.

Other environmental features of the Albemarle-Pamlico system vary regionally to create local habitats of quite different character. Some of the differences between the two major sounds are summarized in Table 1.

Salinities vary greatly in both space and time within the Albemarle-Pamlico system. Albemarle Sound has much lower salinities than Pamlico Sound, but both sounds exhibit significant temporal and spatial salinity variations. Evidence suggests that significant declines in salinity have occurred since the 1940's. Historical data are sparse, and changes in analytical techniques and spatial and temporal distributions of samples cause their reliability to be suspect. Analyses do, however, seem to indicate an almost 50% decline in "mean annual salinity" in the region. This decrease occurred during a period (1960-1980) of extensive agricultural clearing and drainage operations. Such operations have two major hydrological effects: 1) to speed movement of rainfall from the land to nearby estuaries and 2) to lower ground-water levels from one to four feet below the land surface. These changes alter water quality in the estuaries and have great significance for the shallow estuarine embayments which serve both as receiving waters for drainage and as nursery areas for many estuarine species. Understanding the historical timecourse and ecological significance of drainage network installation associated with land use conversion and evaluating the potential for mitigation of impairment of nursery areas will be a primary focus of this study.



**Figure 1. Study area for the Albemarle-Pamlico Estuarine Study, including drainage basins upstream to first impoundments, drainage basin boundaries, or North Carolina/Virginia state line.**

TABLE 1  
CHARACTERISTICS OF ALBEMARLE AND PAMLICO SOUNDS

	<u>Albemarle</u>	<u>Pamlico</u>
Surface Water Area (mi <sup>2</sup> )	900	2,000
Watershed Area (mi <sup>2</sup> )	18,360	12,520
Percent area of state inshore total	26	56
Net Freshwater Inflow (ft <sup>3</sup> /sec)	17,000	32,000*
Volume of Sound (billion ft <sup>3</sup> ) (million acre ft.)	231 5.3	915 21
Average time for inflow to equal volume	6	14 weeks
Salinity	low	moderate to high
Fisheries	anadromous and fresh	marine
Percent catch of state total	14.0	78.0
Percent value of state total	5.0	73.0

\*Pamlico includes Albemarle Inflow

NOTE: The Albemarle Sound area includes Currituck and Croatan Sounds and the Pamlico Sound area includes Core and Roanoke sounds. Tributaries are also included. Landings are based on 1968-1985 data.



The dissolved oxygen concentrations in the Albemarle-Pamlico estuarine system are generally high and capable of sustaining fish and other aquatic animals. Concentrations generally range from 4-9 ml O<sub>2</sub>/L with highs occurring during cold months and lows in warm months. A combination of conditions (some natural and some anthropogenic), however, can lead to oxygen depletion events in segments of the estuaries. Oxygen depletion occurs most commonly in the lower reaches of tributary rivers such as the Chowan, Alligator, Pamlico and Neuse, but low-oxygen fish kills can occur throughout the Albemarle-Pamlico system. There is a general impression among scientists and laymen alike that these events are becoming more frequent, but trend analysis is difficult. There also is a general lack of understanding of which sets of conditions cause algal blooms and resulting anoxia, i.e., nutrient concentrations interact with hydrologic conditions in an as yet poorly defined way.

Definite changes have taken place in the Albemarle-Pamlico in recent years. These changes are the basis for major environmental concerns summarized below:

#### Declines in Fisheries Productivity

Major declines in commercial fisheries have occurred in the Albemarle-Pamlico region since the late 1970's. Striped bass, shad and river herring landings from the Albemarle Sound are greatly depressed from historic levels. In addition, commercial landings of croaker, catfish and flounder have trended downward since 1980. Blue crab landings show a similar decrease. The reasons for these declines remain equivocal, but undoubtedly include declining water quality, critical habitat loss and fisheries-related effects. Declines are expected to continue unless causes can be ascertained and corrective steps taken. Research intended to establish causal relationships between various environmental effects and fisheries declines, and to evaluate effects of fisheries practices on fisheries stock is crucial to improved management of the valuable fisheries resources.

#### Ulcerative Sore Diseases

Recent outbreaks of ulcerative mycosis in commercially important species in the Pamlico River present a major challenge. Up to 85%-90% of menhaden sampled were affected in 1985. Many other commercially important species are affected, including flounder and weakfish. Recent investigations suggest that stress related to water quality degradation is an important factor leading to disease outbreaks, but epidemiological relationships are poorly understood. Furthermore, red sore disease in commercially important species in the Albemarle Sound reached epidemic proportions during the 1970's, but the causes for the outbreak and the potential for future outbreaks remain ambiguous. Research on causes of disease outbreaks is sorely needed.

### Anoxia-Related Fish Kills

Recent years have shown a significant increase in fish kills reported in the Pamlico River. Eighty-seven percent of kills reported since 1966 occurred in the last half of this interval. High variability in conditions between years and in reliability of reporting makes trend analysis difficult, yet the information available suggest that fish kills are becoming more common. Most of these fish kills are related to oxygen depletion, related to eutrophication, water-column and benthic respiration and salinity stratification, but the causal mechanics are poorly known. Changes in the vertical distribution of oxygen-depleted zones have been recognized as significant anthropic effects on Chesapeake Bay, but we lack the vertical samples required to document similar trends in the Albemarle-Pamlico region. Fisherfolk, however, complain vociferously about the ravages of "dead water," and are convinced that intensity and extent of affected regions have increased.

### Changes in Distribution Patterns of Aquatic Sessile Organisms

Historic changes in distribution patterns of important organisms have been dramatic in the Albemarle-Pamlico region. Preliminary studies suggest that viable oyster beds have been displaced downstream roughly 10-15 miles in the Pungo, Pamlico, and Neuse Rivers since the late 1940's. The causes for this effect are uncertain, but probably include changes in salinity and sedimentation patterns induced by drainage from agricultural and silvicultural areas as well as cultural harvesting techniques (e.g. removal of shells).

Extensive beds of brackish water macrophytes which existed in 1976 had almost disappeared by 1985. This decline parallels similar declines in the Chesapeake Bay and elsewhere, and represents an environmentally important change in fisheries habitat and waterfowl food. Preliminary research suggests that environmental perturbations were involved, but definite answers await experimental elucidation.

### Impairment of Nursery Area Function

The marshes fringing the lower Pamlico-Neuse Rivers and Pamlico Sound provide essential nursery functions supporting the sound and oceanic fisheries of much of the central Atlantic coast. Most of these areas are bordered by low-lying wetland areas, which must be drained before they can be used for agriculture, silviculture or other dry land uses. The freshwater, sediment, and trace contaminants delivered through these drainage systems have negatively affected the function of those nursery areas. Although the exact extent of existing impairment may prove difficult to estimate where historical data is lacking, identification of impaired areas and assessment of restoration/mitigation potential may be easily accomplished.

### Eutrophication

Blooms of phytoplankton in response to cultural enrichment of estuarine waters with nutrients are well documented in the Albemarle-Pamlico system. Spectacular blooms of noxious blue-greens in the Chowan River occurred in 1972, 1978, and 1983. The Neuse River continues to exhibit high-intensity blooms of blue-green algae whenever nutrient loadings are high in spring, and flow rates are low in summer. Many other tributaries display periodic blooms, depending on flow regimen, nutrient loading, salinity, and meteorologic conditions. Even the Pamlico River, where salinities are normally high enough to prevent blue-green domination of algal assemblages, displays seasonal blooms of dinoflagellates, which probably contribute to oxygen-depletion phenomena in the river. Modification of algal populations in response to nutrient enrichment also has important ramifications for striped bass in the Roanoke River. Research on causal relationships of the eutrophication process is important to allow management of its effects.

### Habitat Loss

Human activities in the Albemarle-Pamlico region have greatly affected ecosystem functions of estuarine habitats and tightly-linked wetland habitats. Dredging and filling of productive bottoms, marshes, and pocosins has modified reproductive, migratory, and feeding patterns for a wide variety of aquatic and terrestrial organisms. The relative habitat value of these areas is poorly known, and restoration or mitigation potential for impacted areas has yet to be evaluated.

### Shellfish Closures

Closure of shellfish waters in North Carolina because of bacterial contamination has excluded from harvest 50,000 acres since 1970. Relatively few of the total shellfish beds in the state occur within the study area, although Pamlico Sound supports large oyster grounds, Core Sound contains important hard clam areas, and Bogue Sound provides a variety of shellfish resources. Most of the less saline areas (Neuse River, Pamlico River, Albemarle Sound and tributaries) contain species such as Rangia cuneata and Macoma spp. which are not exploited extensively. The majority of shellfish closures in the study area have resulted from agricultural operations or from residential or commercial developments.

### Toxicant Effects

Relatively little is known about the effects of toxicants on estuarine organisms in the Albemarle-Pamlico region. Specific locations (e.g. Slocum Creek) have been identified where toxicant problems exist, but large-scale problems have not been documented.

Concern remains over potential toxicity of specific constituents of permitted and proposed discharges (e.g. titanium, fluoride, antimony) and the whole effluent toxicity of others (pulp mill effluent), yet the region is relatively toxicant-free. A systematic baseline evaluation of potentially toxic contaminants has not been conducted.

#### HUMAN USES OF THE ALBEMARLE-PAMLICO

Human activities in the Albemarle-Pamlico include agriculture, forestry, residential and commercial development, mining, national defense, fishing (commercial and sport), tourism/recreation, and wildlife hunting/preservation. These activities all generate wastes that are disposed of within the system. There have been major changes in human use of the Albemarle-Pamlico region over the same timeframe in which the major environmental concerns described above developed. The current level of human activity and recent changes in the intensity of these activities are summarized below.

##### Agriculture

Agriculture is the largest industry in the 28 counties of the central and northern Coastal Plain. These counties contain 45% of the State's cropland and produce about 50% of its hogs as well as 25% of its chickens. Predominant field crops are corn, soybeans, tobacco, potatoes, wheat and peanuts. The region generates over \$1.5 billion annually from agricultural development of its highly productive soils and flat landscape.

Agriculture has evolved across the study region in different ways due to the varying topographic features of the Coastal Plain. The Coastal Plain is divided into two main geographic sections by the Suffolk Scarp. The region west of the Scarp is older, has a higher elevation and the soils generally have a sandier texture. For these reasons, natural soil drainage is generally better west of the Scarp. The high value crops of tobacco and peanuts are grown mostly west of the Scarp and on the ridges and better drained soils east of the Scarp. These crops are very sensitive to even short periods of excessive soil moisture and require very low levels of soil organic matter.

East of the Scarp, row crop agriculture is characterized by larger operations with the main crops being corn, wheat and soybeans. Production of such crops is highly mechanized and relative net income per acre is low.

Artificial drainage is necessary throughout the Coastal Plain except for the upper portions of the local topography. East of the Scarp, requirements for artificial drainage are universal. Elevations are less than 22 feet above sea level, topography is flat and the soils are generally medium- to fine-textured. With an average annual

rainfall of approximately 50 inches and very high peak storm intensities, extensive artificial drainage systems are necessary to prevent damage from excessive soil moisture in the root zone and periodic field flooding. Crops require a water removal system capable of handling about 2 inches of surface runoff within a 24-hour period. This water removal is usually accomplished through gravity flow, although some pumping is done on the peninsula between Albemarle and Pamlico Sounds.

Despite the success of agricultural drainage, the amount of cropland in the region appears to have reached its peak. Landclearing activities begun between 1950 and the late 1970's are mostly complete. In 1975, the Corps of Engineers 404 dredge and fill permit became a major constraint to clearing land. The jurisdiction for the permit was drastically broadened from navigable waters to include wetlands. The inability of First Colony Farms to obtain a 404 permit decision for land clearing after an extensive Environmental Impact Statement process has set a precedent against future land development under the new law. Regardless of acreage, all land development comes under the purview of this permit.

Major concerns about agricultural nonpoint source pollution of the sounds are: (1) nutrient loading of freshwater, particularly with nitrogen and phosphorus; (2) increased freshwater peak flows into saline primary nursery areas; (3) general degradation of water bodies by sedimentation; and (4) coliform bacteria contamination of shellfish areas. The degree of agriculture's impact on these problems remains uncertain and depends upon many factors, including the weather, specific crops grown and the application of Best Management Practices (BMP's). BMP's for the Coastal Plain address soil erosion and sediment delivery, animal waste disposal and water management. Research has shown that BMP's are very successful in reducing pollution from agriculture.

For the future, agriculture in the region is anticipated to remain fairly steady. Cropland acreages are not expected to increase because of economic and legal restrictions on clearing land. The acreage of planted cropland will, however, vary from year to year. Hog and chicken production should continue to grow with a large increase possible if a major processing plant locates within or near the region. The potential for agricultural nonpoint source pollution in the study region will remain fairly constant. Pollution increases, if any, will be attributable to growth in livestock production.

Conservation work is progressing. The N.C. Agriculture Cost Share Program is greatly accelerating BMP implementation in the 18 counties participating in the program. Water management is proving to be very attractive to farmers and its use should increase dramatically.

### Commercial Forestry

The forestland of the study area is a base for production of raw material for a diverse forest products industry. The present stumpage

value of the annual harvest is 72 to 78 million dollars. These forests also function as wildlife habitats, recreational areas, and as a filter and surge control mechanism for fresh waters entering the sounds.

Analysis of recent U.S. Forest Service woodland inventories and information from the N.C. Division of Forest Resources, reveal the following trends in forest use:

1. There appears to have been an average annual reduction in total forest area of 20,000 acres.
2. The extent of the pond pine, the oak-gum-cypress (both typical of poorly drained sites), and the natural pine types decreased between 1964 and 1984. Other hardwood types and pine plantations have increased over the same period.
3. There has been a shift in the land ownership pattern. Acres owned by private individuals has decreased while acres owned by corporations not associated with the manufacture of forest products has increased.
4. Silviculture is changing as follows:
  - a. The degree of disturbance centered upon pine plantation establishment has decreased.
  - b. The annual rate of pine plantation establishment has also decreased.
  - c. The use of herbicides and prescribed fire has increased.
  - d. The rate at which drainage systems for woodlands are being installed has declined. It is estimated that between 75 and 80 percent of the land owned by forest industry for which drainage is a feasible option has already been drained.
  - e. Fertilizer is currently used on pine plantations with phosphorus applied during the establishment of plantations on many poorly drained sites, but with nitrogen much less widely applied. It is estimated that about 10,000 acres per year will receive phosphorus.

From these trends it appears that, at least for the short-term, the forest condition will remain relatively stable. Drainage activity will probably not change. Fertilization activity will likely increase (until energy costs climb). Conversion of forest land to other uses will continue at its present rate until, and if, agriculture becomes much more profitable. The rate of harvest will change little unless climbing energy costs create markets for "energy wood".

### Residential and Commercial Development

Residential and commercial uses on the Albemarle-Pamlico system, are extremely varied. Residential uses include trailer parks, neighborhood housing developments, and condominiums. Commercial uses range from marinas to central business districts.

While the initial rush to develop the coast was on the oceanfront, the diminishing availability of oceanfront land and soaring oceanfront prices has placed new development pressure on the sounds and rivers. These developments are often outside the areas classified in land use plans (LUP's) as developed or transitional (to development), and require amendment to the LUP. When this occurs, the effected county must apply to the State Coastal Resources Commission to amend its LUP. Data on such amendments provide information on shoreline development.

The above information portrays a real trend of increased development with population growth, focused in four coastal counties--Dare, Carteret, Craven, and Beaufort. Land classifications of coastal counties show where growing populations, and the structures needed to house and serve them, will be located. The growing communities are focusing their expansion along the waterways, where the property is more attractive and serves as a more valuable tax base. In general, those counties exhibiting growth are targeting that growth for the shoreline. It is expected that those shoreline areas selected for transition to intense development will surely, and quickly, be used for that purpose.

### Mining and Industrial Development

In general, the Albemarle-Pamlico area is not highly industrialized. However, there are several large manufacturing operations located in proximity to the water having a significant or potentially significant impact on water quality, salinity, and temperature. Individual facilities within the Albemarle-Pamlico region that have been identified by the N.C. Division of Environmental Management, Washington Regional Office, as having a direct discharge to tributaries of the estuary include: a phosphate mining and processing facility on the Pamlico River; pulp and paper mills on the Neuse and Roanoke Rivers; a metal plating operation on the Neuse River; and textile and synthetic fiber manufacturers on the Pamlico, Roanoke, Chowan, and Neuse Rivers.

Many smaller industrial operations may have a localized or cumulative impact on estuarine resources. Examples include hog and poultry processing operations, printing, chemical manufacturing, and boat building and repair. Industrial operations upstream of the immediate study area also affect the estuary, as discussed in the section on waste disposal.

Mining in the Albemarle-Pamlico region may be grouped into three categories: 1) construction materials (consisting of sand and

limestone), 2) phosphate, and 3) peat. Mining for construction materials is highly dependent on local markets in residential, commercial, industrial, and highway construction, and its trends are closely related to trends in population growth. North Carolina's extensive phosphate reserves are a relatively rare resource for international agricultural (fertilizer) markets. Florida's phosphate reserves (the only other significant deposits in the Eastern U.S.) are being rapidly depleted and this practically guarantees long-term growth of North Carolina's phosphate mining industry. Peat reserves in the Albemarle-Pamlico Peninsula are well documented to cover tens of thousands of acres and may be developed for firing steam-electric plants. The economic viability of peat mining is still unproven and the environmental restrictions to be placed on peat mining have not been completely established. Minerals resources underlie the sounds themselves. The exploitation of these resources may become economically viable within coming decades.

Mining for construction materials consists mostly of sand pits scattered throughout the area. These are typically shallow excavations (10 to 20 feet deep) covering a few thousand square feet to a few acres each. Drainage is typically internal, and, with few exceptions, impacts on surface or ground water quality and/or quantity are insignificant.

About 30 million cubic yards of submerged oyster shell deposits have been documented to be in eastern Albemarle Sound. These deposits are a possible mining resource for aggregate, chemical grade lime, Portland cement manufacture, poultry grit, or oyster clutch material. Extensive dredging of clam shells in Lake Ponchartrain, Louisiana, is an example of this type of mining.

Phosphate mining in Beaufort County is by far the largest single mining industry in the state. Nearly half of the product is shipped overseas. The primary use is for enriched phosphate (superphosphates and phosphoric acid) to be used in agricultural fertilizers.

Phosphate mining and beneficiation produces large quantities of colloidal clay and gypsum, which are currently considered waste products. These wastes may become resources in coming decades. About 2000 acres are diked for disposal of these clay wastes from phosphate mining, and approximately 800 acres are devoted to gypsum wastes.

The phosphate industry is characterized by very large withdrawals of fresh ground water -- presently about 60 million gallons per day. Most of this water is cycled through processing operations and then discharged to the Pamlico River.

Texasgulf Chemicals, Inc., the only current phosphate producer in the region, owns or controls some 80,000 to 90,000 acres of phosphate reserves in the Beaufort County area. Some of these holdings include leases of State-owned submerged lands beneath the Pamlico River. Existing available reserves are sufficient for several decades of production at current rates.



Exploration of offshore phosphate deposits is currently underway. Information presently available indicates the existence of large reserves of phosphate rock in submerged lands. These deposits should draw increasing interest as world supplies of this essential plant food diminish.

Large scale peat mining in the Albemarle-Pamlico region is still in speculative stages. Although several tens of thousands of acres and tens of millions of tons of peat reserves are proven and roughly 26,000 acres have been (tentatively) permitted for mining, the economic viability of peat mining has not been established. It now appears that the most likely use of peat will be to fire boilers for electric generation plants.

#### National Defense

The U.S. Department of Defense operates 19 facilities occupying more than 97,000 total acres in the Albemarle-Pamlico region. These facilities can be grouped into several categories:

- A. Atlantic Intracoastal Waterway - The environmental impact from this facility are use-related (petroleum by-products and wastes from the ships head and galley). Maintenance dredging also generates significant, intermittent impacts.
- B. Cherry Point Marine Air Station - The Air Station is a potential source of known and unknown hazardous waste pollutants to both surface and ground water from historical and ongoing activities. Thirty-two hazardous waste facilities/sites have been identified at the Air Station.
- C. Bombing Ranges And Target Areas - Site-specific physical effects occur in these areas. Broader and more significant impacts may prove to be the use-conflicts (exclusion and noise) with commercial fishing, recreation, wildlife, and the Intracoastal Waterway.
- D. Other Facilities - Present impacts from these facilities are minor, although the potential exists for significant future impacts.

The major facilities in the region all face critical environmental issues in the near future.

#### Atlantic Intracoastal Waterway

The AIWW maintenance dredging program will require the identification of new spoil disposal areas in the future. Options may include ocean dumping, the use of pipelines to beach nourishment sites, pipeline to upland disposal sites, creating new spoil islands, and side casting. Choices among these alternatives must be based upon the best possible resource and use data to avoid unnecessary conflicts.

Recreational craft are the dominant users of the Atlantic Intracoastal Waterway. If this trend continues and is reinforced by more year around use from resident and tourist populations in coastal counties, then increased pressure should be expected for marina and second home development along the waterway.

#### Cherry Point Marine Air Station

The CPMAS may be one of the largest polluters in the study area. Improved environmental laws over the past decade and a half have begun to focus on the operating procedures that have caused past environmental problems at this facility. By incorporating CPMAS staff in the Albemarle-Pamlico Study and directing study resources to this area, the ongoing CPMAS studies could be broadened and more comprehensive results sought.

#### Bombing Ranges And Target Areas

The apparent trend for bombing ranges and target areas in the study area is toward expansion and more sophisticated weapons testing. Associated controlled airspace expansions will cause significant conflicts with commercial and private air traffic, recreational and commercial use of the surface waters including the Atlantic Intracoastal Waterway, and the development and use potential of underlying lands, including the National Seashores. A further result of these conflicts will be the curtailment of aircraft use within the study area for resource management overflights for research and enforcement.

#### Waste Disposal

A major use of the Albemarle-Pamlico estuarine system and its tributaries is the disposal of waste generated by domestic, industrial, and defense facilities or by other human activities on the surrounding land.

For purposes of this evaluation, "waste" is any material which enters waters of the State of North Carolina through human action (cf. G.S. 143-213(18)); therefore, not only must the more traditional point source pollutants from industrial and domestic point discharges be considered, but loadings of substances derived from nonpoint sources (e.g. agriculture, forestry, other land conversion activities, stormwater runoff and septic system leaching) must also be evaluated. These nonpoint contributions to total pollutant loads are significant in the Albemarle-Pamlico region, especially for nutrients and sediment, which are two constituents clearly implicated in existing water quality problems.

#### Point Source Contributions

The discharge of waste by domestic and industrial facilities is regulated in North Carolina by the Division of Environmental Management (DEM) of the North Carolina Department of Natural Resources and Community Development (NRCD) under the NPDES permit program. The number of NPDES permits which are currently valid in the study area is shown in Table 2.

TABLE 2

PERMITTED POINT-SOURCE DISCHARGERS IN MAJOR DRAINAGE BASINS IN THE ALBEMARLE-PAMLIC REGION BY TYPE OF DISCHARGE

<u>Basin</u>	Municipal Wastewater Treatment		<u>Other Domestics</u>	<u>Total Domestics</u>	<u>Industries</u>	<u>Total Permits</u>
	<u>Plants</u>	<u>Schools</u>				
Chowan	7	13	8	28	16	44
Pasquotank	9	9	16	34	26	60
Roanoke	9	9	12	30	9	39
Tar-Pamlico	25	35	21	81	52	133
Neuse	38	49	87	174	87	261
White Oak	0	2	3	5	11	16
Total	88	117	147	352	201	553

### Nonpoint Source Contributions

Nonpoint sources contribute significant amounts of sediment, nutrients and other runoff-associated pollutants into the estuarine receiving waters. Evaluations of the relative contributions of nutrients from point and nonpoint sources have been conducted for several major tributaries to the Albemarle-Pamlico system. The major tributaries differ in the relative importance of point and nonpoint sources. The Chowan River waste load is dominated by nonpoint source contributions for both phosphorus (76%) and nitrogen (79%). The Roanoke River Basin downstream from the Roanoke Rapids impoundment shows the same domination by nonpoint sources for nitrogen (63%), but phosphorus inputs originate from mainly point source (64%). The Tar-Pamlico and Neuse Rivers receive similar nutrient inputs from nonpoint sources: 81% and 84%, respectively, for nitrogen, and 37% and 50%, respectively, for phosphorus. The relatively large point source contribution in the Tar-Pamlico comes mostly from Texasgulf Chemicals' phosphate mine in Beaufort County (up to 60% of the basinwide phosphorus loading). The Neuse Basin phosphorus load comes mainly from wastewater treatment plants (up to 45%). Although nutrient budgets for the Albemarle Sound have been compiled by DEM, no comprehensive budget for the Albemarle-Pamlico Sound complex exists.

### Impacts

Impacts of disposal of waste are evident in the Albemarle-Pamlico estuarine system, although the exact causal mechanisms and the magnitudes of the effects are not well documented. The most obvious result of anthropic augmentation of nutrient fluxes into the estuaries has been eutrophication. Noxious growths of microplanktonic and filamentous algae have occurred periodically in the Chowan, Neuse and Pamlico Rivers during the past 15 years. The Neuse River continues to experience high levels of algal density, with concomitant violations of the water quality standard for chlorophylla. Periodic outbreaks of noxious blue-greens still occur in tributaries to the Albemarle Sound, despite extensive nutrient control plans enacted in the region. Major shifts in algal populations due to nutrient inputs have greatly modified food chains in the region and probably have contributed to marked declines in certain fisheries. The Pamlico River commonly experiences early spring and late summer blooms of dinoflagellates, which undoubtedly contribute significantly to severe summer anoxia problems and associated fish and macroinvertebrate kills. Without careful management, increased nutrient loadings will result in even more severe degradation of water quality, which has ramifications for water-dependent uses such as fisheries. The relationship between waste loading and ulcerative sore disease of fishes is not well understood, but the causal connection is plausible. Furthermore, major shifts in distribution and abundance patterns of estuarine organisms (macrophytes, sessile invertebrates and fishes) have resulted at least in part from increasing waste loadings.

## Commercial Fisheries

The environmental diversity and subtropical locations of the Albemarle-Pamlico region results in a complex system of habitats supporting a diverse assemblage of exploitable fishery species. Commercial fishing gears are adapted to specific habitat and life history stage of target species. Some gears are very specific in what they catch. Channel nets take little other than migrating shrimp moving on ebb tides. Clam and oyster tongs and rakes are used to harvest sessile shellfish. Crab pots catch very few finfish. On the other hand, gears such as trawls, pound nets and long haul seines capture a wide variety of seafood. Fishermen can, however, target desirable species with these gears by utilizing certain mesh sizes in selected areas during limited time periods.

In North Carolina, commercial fishing boats and vessels are licensed, not fishermen or gear. The numbers of licensed boats and vessels in the counties comprising the Albemarle-Pamlico area has gone from 6,600 in 1972 to 9,500 in 1985, an increase of 44%.

An important factor to consider is that few, if any, commercial fishermen in rely on only one fishery for their living. Virtually all of the fishermen have an annual round of seasonal fisheries including several different species and gears, and sometimes a non-fishing job during part of the year, as well. This situation is due to the wide variety of fisheries resources which vary in availability during the year, as well as among years. For example, pink shrimp are available during spring and fall, brown shrimp in the summer and fall, and white shrimp only in the fall. American shad and river herring enter the estuaries during February and are gone by mid-June. Blue crabs enter pots during April through November or December in western Pamlico Sound, but can be taken during winter warm spells by pots in the Ocracoke Island area. Thus, North Carolina's commercial fishermen must be versatile in order to be successful.

Sport fishermen take large quantities of finfish, crustaceans and shellfish in coastal North Carolina, using principally rod-and-reel. Many, however, use gill nets, trawls, crab pots and rakes recreationally. The rod-and-reel catches are estimated annually for the entire State as a whole by the federal government (National Marine Fisheries Service), but data are not calculated for smaller units (water bodies or counties) as they are for the commercial fisheries. No data are collected on recreational catches of crustaceans or shellfish. Recreational catches of some species may equal or exceed commercial landings, but without recreational fishing data, evaluation of the status of these species is very difficult.

Table 3 summarizes catch data for commercial species in the Albemarle-Pamlico region from 1972-1985.

Table 3. Landings of principal commercial species from the Albemarle Sound, Pamlico Sound, and Core Sound areas of North Carolina combined, 1972-1985 (in thousands of pounds).

	SPECIES													
	River Herring	Blue-fish	Catfish	Croaker	Flounder	Weakfish	American Shad	Spot	Striped Bass	White Perch	Shrimp	Blue Crab	Hard Clam	Oysters
1972	11,237	77	2,375	755	779	341	402	1,978	429	201	3,125	13,112	77	275
1973	7,926	477	1,888	2,608	898	767	289	3,723	642	145	2,827	11,659	134	380
1974	6,210	1,195	1,739	3,804	1,868	833	349	4,152	511	309	6,234	12,861	40	383
1975	5,949	936	1,654	6,775	1,696	1,639	218	6,767	716	289	2,988	10,783	13	302
1976	6,401	809	1,500	6,677	1,672	1,835	158	8,769	704	184	4,666	11,411	8	214
1977	8,523	813	2,068	8,207	672	4,781	106	2,790	480	268	4,494	11,903	533	266
1978	6,606	482	1,734	7,974	1,327	3,098	364	3,090	532	499	1,744	22,044	471	164
1979	5,031	739	1,512	11,006	1,822	3,261	201	5,570	366	361	2,596	25,154	688	433
1980	6,217	1,101	1,447	12,637	3,077	5,340	150	5,372	433	105	6,632	32,987	777	489
1981	4,611	765	1,716	8,080	2,102	3,290	192	2,729	358	395	1,646	36,202	652	315
1982	9,428	1,008	1,167	7,815	1,803	2,662	270	4,368	244	665	4,196	35,866	873	352
1983	5,868	622	1,050	5,587	2,377	2,178	377	2,373	306	498	3,754	33,042	723	497
1984	6,505	773	1,330	4,506	2,178	2,464	502	2,492	497	440	2,201	31,484	859	563
1985	11,548	977	1,279	4,166	1,841	1,922	309	2,775	280	701	9,601	28,562	886	393

Analysis of the data in Table 3 and elsewhere shows evidence of the following trends for commercial fisheries:

1. Landings of the major finfishes, all of which have fairly similar life histories and are taken by the same fishing gears, reached historic peaks in the late 1970's-early 1980's and have since declined. Reasons for the decline have not been defined.
2. Landings of anadromous fishes (fish which spawn in freshwater but spend most of their life in saltwater--striped bass, American shad, river herring) have declined since at least the early 1970's. The American shad decline may be due to habitat degradation. River herring initially declined because of excessive catches by foreign vessels in the ocean, but recovery has probably been impacted by poor water quality in the Albemarle Sound spawning and nursery areas. Reproduction of striped bass in Roanoke River has apparently been unsuccessful since 1976. This problem may also be due to reduced water quality.
3. Landings of blue crabs, North Carolina's most important commercial fisheries species, reached peak levels in the early 1980's and have declined since for unknown reasons.
4. The hard clam fisheries of Core Sound are probably producing near their maximum potential, given the existing regulatory controls and mix of harvest methods used.
5. Oyster landings are highly dependent on state management efforts, and landings appear to respond gradually to such efforts.

#### Sport Fishing and Recreational Boating

Boating in the Albemarle-Pamlico system is primarily for the purpose of recreational sport fishing. However, boating for the purposes of commercial fishing, sailing, skiing, and other recreation is also common in the study area.

Over 49,000 boats are registered in the 25 counties that border the study area. This is approximately 23% of the 218,000 total boats registered in North Carolina. Sixty-four publicly owned boating access areas (launching ramps) are located within the study area. These are supplemented by at least 117 privately owned or commercial access areas that are available for public use in the study area.

Specific estimates of sport fishing effort and harvest of the Albemarle-Pamlico system are not available. However, the National Marine Fisheries Service (NMFS) has estimated that over 1.8 million

recreational fishing trips were made in North Carolina's inland areas in 1985; to catch over 8 million fish of which 5.5 million were harvested. Spot, pigfish, flounders, and croakers were the major species in the harvest.

Boating pressure on eastern North Carolina waters, particularly the Albemarle-Pamlico estuarine system, is increasing at a rapid rate. The increase in number of marinas that support boating activity (gas docks, sewage pumpout stations, etc.) is evidenced by high numbers of Coastal Area Management Act permit review requests for these businesses. A number of new, publicly-owned boating access areas are constructed each year and existing areas are renovated and upgraded to meet the demands for adequate boat launching facilities. The N.C. Wildlife Resources Commission is also in the process of implementing a Development Program to be funded with newly authorized federal aid monies which will improve boating access to small streams.

An increasing amount of the boating pressure that is being exerted on Albemarle-Pamlico system is not related to sport or commercial fishing. Sailboating, regattas, speed boat races, and other water oriented events are becoming common on Albemarle and Pamlico Sounds and their major tributaries. Conflicts between these users and sport and commercial fishermen are inevitable.

Sport fisheries throughout the Albemarle-Pamlico estuarine system are likely to diminish as a result of increasing human development of the area. In addition to the increase in fishing pressure, development also leads to increase in pollution and contaminant inputs, and an overall degradation of the habitat.

Total annual sport fishing effort on Albemarle Sound declined between 1977 and 1980. The annual harvest of most major species also declined during that period.

The harvest of striped bass from Albemarle Sound has declined in recent years to record low levels. This decline is due to the failure of the population to produce a strong year class since 1970. Extensive research is being conducted to determine the cause(s) of reproductive failures of this population, but the factors leading to the decline have not yet been identified. Stocking of hatchery reared advanced fingerling striped bass is being conducted to bolster the natural populations. The Edenton National Fish Hatchery, operated by the U.S. Fish and Wildlife Service, is located in Chowan County near Albemarle Sound. The hatchery was instrumental in development of striped bass culture. The mission of the Edenton Hatchery is production of stock to support striped bass restoration efforts in North Carolina and in the Chesapeake Bay. The stocked fish and remnants of the naturally produced population are now supporting sport and commercial fisheries in the Albemarle Sound region. Stocking, however, cannot continue indefinitely. If the causes of natural reproductive failures cannot be identified and corrected soon, the fisheries for this species in this area may soon disappear.



### Tourism and Recreation

Tourism and recreation are significant and growing uses of the Albemarle-Pamlico study area. Vacationing on the barrier island beaches is increasingly popular, and recent years have brought accelerated building on the remaining undeveloped, privately owned portions of the Outer Banks and Carteret County beaches. Other recreational activities associated with vacationing at the beaches or along the sounds of the mainland include recreational boating, fishing and hunting, camping or day-trips at federal and state parks and nature preserves, and attendance at other features in the area such as historic sites, outdoor dramas, aquariums, and museums.

Table 4 shows travel expenditures for 1975-1985 for the 20 counties bordering the Albemarle and Pamlico Sounds and their tributaries. Because this information is published each year in current dollars, expenditures have been adjusted to constant (1972) dollars in order to estimate the percentage increase in travel expenditures from year to year not accounted for by inflation alone.

The average annual increase in travel expenditures over the period is 15.7%. In 1983, the base used for estimating travel expenditures in the T&T study was broadened because rentals of homes, cottages and condominiums to transient users became subject to the state sales and use tax. This had a dramatic impact on the figures for some counties having a large number of such units, such as Dare and Carteret. Even when the percentage increase from 1983 to 1984 is excluded, however, the average annual increase in travel expenditures over the period is 13.8%.

Although county level data is not shown in Table 4, two counties, Dare and Carteret, account for 75% of 1985 travel expenditures for the 20-county group, up from 60% in 1979.

Data show an increasing trend in travel expenditures in twenty counties of the Albemarle-Pamlico Study area. This trend is especially strong in the counties containing oceanfront beaches, suggesting an increasing demand for coastal water-related recreational activities.

The general consensus of most recent studies supports the conclusion that demand for recreational activities in coastal areas will rise in the coming years. As recreation related travel into the counties of the Albemarle-Pamlico study region increases, human impacts in terms of waste disposal, destruction of wildlife habitat, stormwater runoff pollution from developed areas, and pollution associated with pleasure boats and marinas will become increasingly significant sources of stress on the estuarine resource.

TABLE 4  
1975-1985 North Carolina Travel Expenditures<sup>1</sup>

Year	Travel Expenditures <sup>2,3</sup> (Current \$)	Travel Expenditures <sup>4</sup> (Constant \$)	% Increase From Previous Year (Constant \$)
1975	\$ 80,405	\$ 64,170	--
1976	92,444	70,193	9.4
1977	118,047	84,743	20.7
1978	131,534	88,219	4.1
1979	219,821	135,275	53.3
1980	242,908	135,702	0.3
1981	328,830	169,064	24.6
1982	353,357	171,532	1.5
1983	379,958	177,883	3.7
1984	519,870	235,876	32.6 <sup>5</sup>
1985	573,742	252,194	6.9

Average annual increase = 15.7%

Average annual increase excluding 1983-84 = 13.8%

<sup>1</sup>For the following counties: Beaufort, Bertie, Camden, Carteret, Chowan, Craven, Currituck, Dare, Gates, Hertford, Hyde, Jones, Lenoir, Martin, Pamlico, Pasquotank, Perquimans, Pitt, Tyrrell, and Washington.

<sup>2</sup>Source: N.C. Travel Study - Technical Report Annual report by the Division of Travel and Tourism, N.C. Department of Commerce.

<sup>3</sup>Current dollars: Nominal value as reported in Travel Study

<sup>4</sup>Constant (1972) dollars: Nominal value deflated using personal consumption expenditure deflator (1972=100), 1975-1984 (1985 estimated) Source: U.S. Statistical Abstract, 1986.

<sup>5</sup>This figure is artificially large due to the effects of tax law changes in 1983 causing seasonal rental of cottages and condominiums to be included in the accommodations sector.

## Wildlife Resources

The Albemarle-Pamlico system is recognized as the most important component of wintering waterfowl habitat in eastern North Carolina. Mid-winter waterfowl surveys have consistently shown that the majority of wintering Canada geese, snow geese, tundra swans, brant, diving ducks, and sea ducks utilize this estuary system for feeding, loafing and roosting. In addition, it is estimated that approximately 40 percent of all wintering puddle ducks utilize the area.

Mid-winter aerial surveys in recent years have revealed the following numbers of wintering waterfowl in the Albemarle-Pamlico estuarine area: Puddle ducks 50,000-100,000 (approximately 30,000 black ducks and mallards), divers 100,000, Canada geese 25,000, snow geese 20,000, tundra swans 75,000, brant 2,000, and 20,000 sea ducks. The resident black duck population is estimated at 2,000. Webless migratory game birds wintering include rails, gallinules and coots. Surveys have shown coot populations to average 15,000-20,000.

The estuary system supports an abundant furbearer resource including river otter, raccoon, mink, muskrat, opossum and nutria. Also, the area represents the northern most range of the American alligator which was recently reclassified from "endangered" to "threatened by similarity of appearance."

In recognition of the rich and diverse wildlife resources in the Albemarle-Pamlico region, the U.S. Fish and Wildlife Service owns and manages nine National Wildlife Refuges encompassing approximately 254,226 acres. These include Matamuskeet, Swanquater, Pungo and Cedar Island NWR's (managed as the Mattamuskeet NWR Complex), Alligator River, Pea Island and Currituck NWR's (managed as the Alligator River NWR Complex), Mackay Island NWR and a portion of Dismal Swamp NWR. The major management objectives of the various refuges include providing optimal habitat for waterfowl and other migratory bird species as well as for threatened and endangered species. Other management objectives include preserving prime examples of habitats, such as the palustine forested wetland ecosystem, and providing opportunities for wildlife-oriented education, interpretation and recreation.

The project boundaries encompass the known distribution of a number of Federally-listed endangered and threatened species (Table 5). In addition to the listed endangered and threatened species, there are species which, although not now listed or Federally proposed for listing as endangered or threatened, are under status review (SR) by the Service. These species also are included in Table 5.

A recent project of special interest is the U.S. Fish and Wildlife Service's effort to reintroduce the red wolf to the wild. Currently, the Service plans to release three pairs of wolves in the Alligator NWR in the late spring of 1987. This marks the first time in North America that an animal extirpated from the wild will be reintroduced from a captive breeding program.

Table 5

Endangered and threatened species historically or currently documented from the Albemarle-Pamlico area. E = Endangered, T = Threatened, SR = Status under Review.

<u>Species</u>	<u>Status</u>
<u>Animals</u>	
West Indian (Florida) Manatee	E
Eastern Cougar	E (Believed Extirpated)
Dismal Swamp Swamp Southeastern Shrew	T
Bald Eagle	E
Red-cockaded Woodpecker	E
Piping Plover	T
Swallow-tailed Kite	SR
Roseate Tern	Proposed T
Bachman's Sparrow	SR
American Alligator	E
Leatherback Turtle	E
Kemp's Ridley Turtle	E
Green Turtle	T
Loggerhead Turtle	T
Carolina Gopher Frog	SR
Shortnose Sturgeon	E
Waccamaw Killifish	SR
<u>Plants</u>	
Rough-leaved Loosestrife	Proposed E
Sensitive Joint-vetch	SR
Riverbank Sand Grass	SR
Chapman's Sedge	SR
Wagner's Spleenwort	SR
Godfrey's Sandwort	SR
Loose Watermilfoil	SR
Spring-flowering Goldenrod	SR
Carolina Lilaeopsis	SR
Seabeach Pigweed	SR

Hunting for waterfowl is very popular and is available on public lands, leased private lands and private hunting clubs. Current estimates of statewide duck and goose hunter numbers are 35,000 and 10,000 respectively. In the estuary area, approximately 1,500 acres of managed waterfowl impoundments are made available for public hunting by the North Carolina Wildlife Resources Commission.

Surveys of hunter use and success have indicated an average of 1,000 man-days of recreation provided, with harvest rates of 2.0 birds per hunter per man-day on managed impoundments. In addition, approximately 10 miles of marsh shoreline is available to public hunting on Commission-owned lands.

Individual private impoundments are generally smaller, but in total acres approach 2,000. Hunting pressure is less intensive and subsequently, hunter success is usually greater. Leases on private lands for hunting rights can run as high as \$100.00 per acre, and memberships to clubs can cost thousands of dollars per year depending on location.

The future will certainly bring greater demands for outdoor recreational opportunities. Wildlife can persist only in numbers that the environment can support. Life cycles of migrating birds require adequate wintering areas which must provide required foods to sustain and prepare migrating birds for spring return flights and successful breeding. Demands on the resource and costs for already limited opportunities will greatly increase.

Management of any population of wild animals is indeed extremely difficult, and it becomes even more complicated when management must be accomplished coincidentally with that of other resources of the land. The Albemarle-Pamlico estuarine system is threatened by the concentrated development of human society along our coast. Its future existence depends heavily on widespread understanding of the value to man of this natural ecosystem, and on a broader appreciation of the strong ties between its neighbors, the uplands and the ocean.

#### MANAGEMENT PROGRAMS

This section examines existing federal, state, and local statutory framework within which environmental problems are managed. Many of the statutes considered were designed to cope with or remediate environmental problems. Others have been included because of their general impact on land use. Despite the quantity of statutes that currently exist, it is apparent that these pieces of legislation have not succeeded in resolving the problems of human use conflicts that presently exist in the Albemarle and Pamlico Sounds. This chapter classifies federal and state legislation according to the environmental problems they address and also includes a description of various tools and techniques available to local jurisdictions for managing development.

### Management Tools

There are two types of federal and state legislation that have an effect on environmental problems. The first involves statutes specifically enacted to address particular environmental problems. Examples of this type of legislation are the federal Endangered Species Act of 1973 and the North Carolina Pollution and Hazardous Substances Control Act. The second type involves those that have an affect on general land use. An example of this type of statute is the Coastal Area Management Act. Taken together, both types of legislation comprise management tools that regulate land use around the Albemarle and Pamlico Sound.

Appendix 1 provides an alphabetical listing of public programs that define the tools available to manage the environment and development of the Albemarle-Pamlico region.

## CHAPTER III

### INTERACTIONS AMONG SOCIETAL USES

All human activities described in the previous chapter interact directly with the Albemarle-Pamlico estuarine system. Interactions in six of those activities (agriculture, commercial forestry, waste disposal, residential and commercial development, mining and industrial development, and national defense directly affect water quality or aquatic resources in the estuaries. The remaining four activities (commercial fishing, sports fishing, recreation and tourism, and wildlife resources), depend upon those resources and thus are affected by modifications of estuarine water quality. Figure 2 shows a conceptualization of the relationship between these predominately affecting and affected societal uses.

Some interactions among societal uses are negative, often resulting in social conflict or competition. Reducing these social interactions through management will require clear and widespread understanding of the environmental processes through which they are manifested. Gaining such understanding is the goal of the Albemarle-Pamlico Estuarine Study.

The first step in building causal webs from human activities through environmental consequences to secondary affects on other human uses is to identify those interactions where conflicts occur. Managers of natural resource agencies in North Carolina compiled a preliminary evaluation of the relative magnitudes of these interactions and a summary of their classification is presented below.

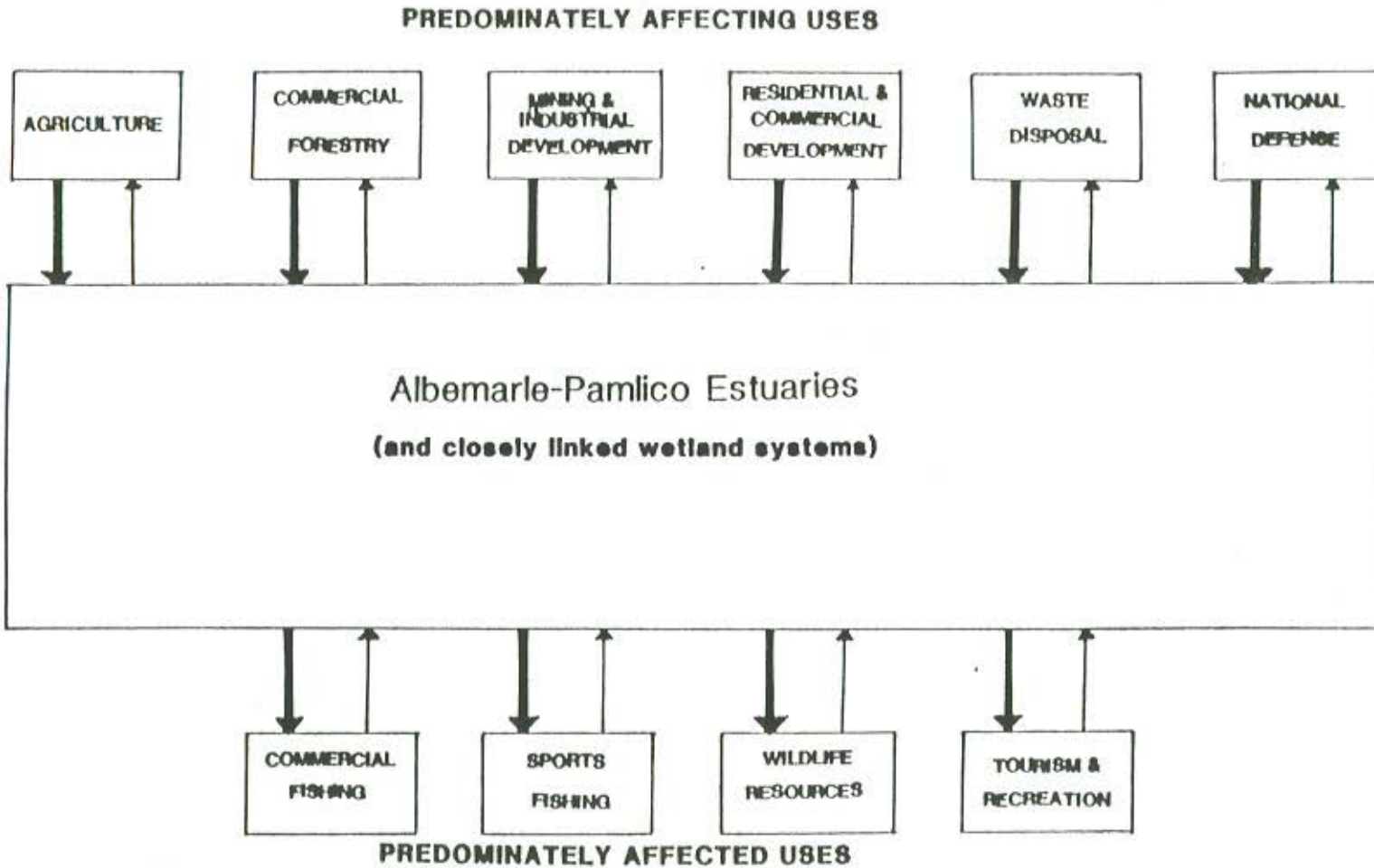
#### Predominantly Negative Interactions

##### Effect of Agriculture on Commercial Fishing (and Sport) Fishing

Widespread conversion of low-lying forested wetland areas to agriculture occurred from about 1940-1981 on the Albemarle-Pamlico Peninsula with peak intensity between 1963 and 1981. In order for this activity to occur, dense drainage networks had to be installed especially in regions with shallow or deep organic soils. These drainage networks have greatly modified the hydrology of the peninsula, especially the rate and location of freshwater delivery into shallow enlargements which serve as primary nursery areas for estuarine species. This increase in nonpoint source runoff has carried with it large loads of sediment, nutrients and toxic contaminants traceable to agricultural activities.

Furthermore, agricultural trends in the entire tributary basins have important implications for water-quality mediated effects on fisheries. Although recent economic troubles have negatively affected agriculture in general, total harvested acres are up markedly in the region since 1970. Also, livestock in the basins is up markedly. Even though programs aimed at improvements in nonpoint source pollution due to agriculture have been very successful in some regions, they are just beginning to be implemented in others.

# INTERACTIONS AMONG SOCIETAL USES



**NOTES:**

1. all significant environmental problems are manifested as effects on some human use
2. only interactions mediated through estuarine/wetland effects are included

Figure 2. Conflicts among human uses of the Albemarle-Pamlico estuarine system.



Impairment of nursery function and changes in the distribution and abundance patterns of sessile estuarine organisms like oysters have been related to land-conversion activities. Dissolved-oxygen-related fish kills in the Pamlico River are becoming more frequent, and are linked to loadings of nutrients and organic substances and changes in local hydrologic regimes. Ulcerative sore disease (ulcerative mycosis) and red sore disease (Aeromonas hydrophila) have both been linked to stress related to a variety of point and nonpoint-derived environmental changes. In addition, agricultural-derived fecal coliform bacteria continue to cause or maintain shellfish closures in the region.

Although, the specific cause-effect relationships between agricultural loadings due to nonpoint source pollution and these environmental effects have yet to be completely understood, but the causal significance of poorly-planned landuse-conversion activities for estuarine problems is clear.

#### The Effect of Waste Disposal on Commercial (and Sport) Fishing

Waste from point sources in the Albemarle-Pamlico region is rich in nutrients and oxygen-demanding substances, both of which contribute to eutrophication-related dissolved-oxygen problems. Human populations in the region continue to increase at a constant rate, with concomitant sewage loading changes. Industrial point sources discharge large volumes in all principal tributaries, up to 85%-90% of total flow in some tributaries at low flow. Fisheries effects of this point-source loading of nutrients, coupled to that from nonpoint sources, include anoxia-related fish kills, eutrophication-driven food chain disruption and likely contribution to the ulcerative sore disease problems. Toxicants may be contributing to declines in striped bass larval survivorship in similar estuaries, and may be involved in the Albemarle-Pamlico declines. Finally, fecal coliform discharges and buffer zones around sewage treatment plants are responsible for large closures of shellfish beds.

#### Effect of Residential and Commercial Development on Commercial (and Sports) Fishing

Nonpoint-source runoff from urbanized areas in close proximity to productive nursery grounds has important environmental ramifications in the Albemarle-Pamlico region. Such runoff carries increased loads of sediment, fecal coliform bacteria and trace contaminants (oil, grease, lead, chromium, cadmium, etc.). Septic systems and marinas are particularly notable sources of coliform organisms. Fisheries effects include nursery ground impairment and contamination of shellfish beds. In addition, dredging for boat basins, channels and marinas and filling of marshes and productive bottoms results in the loss of fisheries habitat.

#### Effect of Mining and Industrial Development on Commercial (and Sports) Fishing

Existing phosphate mining operations and potential mining and processing for of ilmenite and peat may cause significant increases in

total loading of phosphorus, sediment, oxygen-demand substances, freshwater and trace contaminants, with potentially serious implications for estuarine organisms. In particular, an existing phosphate operation, a proposed titanium processing plant and 23,000 acres of permitted peat mines all drain into the central part of the Pamlico River. Major pulp mill discharges exist in the Chowan, Roanoke and Neuse Rivers. Discharge constituents from these various sources undoubtedly contribute to dissolved-oxygen-related fish kills, eutrophication-driven food chain disruption and impairment of nursery function, with obvious consequences for fisheries.

#### Effects of Land-Use Conversions on Wildlife Resources

The wetlands and forests of the northeast coastal plain support a wide variety of wildlife. Conversion of that land to agriculture, commercial forestry, residential or commercial development or mining or industrial development can have serious consequences for native organisms. These effects are mediated through direct destruction of the organisms involved and through habitat destruction. On the other hand, land conversion may actually improve habitat for disturbance-compatible species such as doves and deer. Several rare and endangered species are threatened by habitat losses, including black bear, red-cockaded woodpeckers and American alligators. In addition, land-use conversion often results in instream modifications which may significantly affect nongame species (e.g. the Tar River spiny mussel, Canthya steinstansana).

#### Impact of Commercial Forestry on Commercial (and Sports) Fishing

The same nonpoint processes that mediate the agricultural effect on fisheries occur as a result of commercial forestry operations, but to a much lesser extent. Forestry requires reduced applications of fertilizer and a much reduced disturbance regimen. Nonetheless, the drainage systems put into place to facilitate logging and silvicultural operations result in modified hydrologic regimes in critical estuarine nursery areas, and larger loads of sediment and oxygen-demanding substances into estuarine waters. The effects on fisheries are the same as those due to agriculture, but the overall magnitude is less. Disturbance in forested wetlands often results in increased coliform bacteria concentrations, causing shellfish waters to be closed.

#### Impacts of Waste Disposal on Wildlife Resources

Waste disposal can have significant implications for aquatic species sensitive to water quality changes, or dependent on sensitive species. Also non-aquatic species such as migratory waterfowl are affected when loadings of nutrients or other contaminants from waste disposal affect their primary food source (i.e. aquatic macrophytes).

#### Impacts of Waste Disposal, Mining and Industrial Development, and Residential and Commercial Development on Tourism and Recreation

Waste disposal and related activities have important implications for contact recreation (swimming and boating), recreational

shellfishing and tourism in general. Because the tourist industry depends strongly on aesthetics, unsightly conditions which can result from waste disposal strongly influences its success. Furthermore, seasonal increases in population in resort areas place additional stress on sewage treatment facilities, with potential feedback effects on growth rates.

Environmentally important consequences of this interaction include closures of shellfish waters, closures of areas to contact recreation, degradation of waste quality during peak season treatment plant failures and impairment of aesthetics by waste disposal or related activities.

#### Conflicts between Mining and Industrial Development and Waste Disposal

Because assimilative and dilutive capabilities of streams are limited, disposal of waste from industrial sources and from domestic sources represent competing uses. The volume of waste permitted for a proposed facility and the concentrations of contaminants allowed depend on the loading from existing facilities. Streams with low assimilative capabilities or with relatively high existing waste loads can cause severe restriction in new discharge permits and substantial expense in waste treatment, depending on the degree of conservatism required during the wasteload allocation process. In addition, any activity which modifies flow in a stream will directly affect the discharges which can be permitted.

#### Conflicts between Waste Disposal and Residential and Commercial Development

As above, the limited assimilative capacities of streams result in direct competition between waste loading from businesses, industries, and residential sources. In this case, however, aesthetics and health constraints play major roles in siting of residential and commercial facilities, such that waste disposal can have a direct negative impact on certain potential developments.

#### Impacts of Commercial Fishing on Sports Fishing and Commercial Fishing

Potentially significant effects of commercial fishing practices on fish stocks or nursery functions have occurred in the past and are likely in the Albemarle-Pamlico region. The magnitude of those effects has not been ascertained.

#### Impacts of National Defense on Commercial (and Sports) Fishing

National defense-related activities can have locally significant effects on fisheries, particularly near facilities where toxic substances are handled or where repeated dredging is required. Examples of estuarine areas receiving relatively high impacts from defense facilities include tributaries of the middle Neuse (e.g. Slocum Creek), the upper Neuse River (near Goldsboro) and the Pasquotank River (near Elizabeth City). In addition, the port facilities at Morehead City significantly affect local waterquality.

## Impacts of National Defense on Wildlife Resources

National defense also has negative impacts on wildlife resources. noise from aircraft can have significant effects on migratory waterfowl and large mammals. Also, water quality degradation can significantly affect nongame populations on a local basis. Many of these negative effects are mitigated by the habitat preservation which has occurred as a by-product of restrictions on access (e.g. the Dare County Bombing Range).

## CHAPTER IV

### RESEARCH AND INFORMATION NEEDS

The characterization of conflicts between societal uses of the estuarine system and the examination of existing management systems (Chapter II) provided the focus/catalyst for the definition of research and information needs for this project. State and federal resource managers identified the specific management-related information which would allow maximum resolution of existing and potential conflicts and enable effective management of the valuable estuarine resources to occur through the long term. A prioritized, edited listing of these management-actionable topics was presented to ten groups of expert researchers for evaluation of status and technical and fiscal feasibility, and translation into researchable, actionable statements. The evaluations and translations received, framed within the context of management of conflicts between societal uses and limited to direct actionability, form the basis for this chapter.

Information required to facilitate effective resource management was separated into four general categories: resource critical areas, estuarine relationships, fisheries dynamics and the human environment. The resource critical area category includes projects designed to identify specific areas (both geographic and contextual) where conflicts between affecting and affected uses are most significant, and projects designed to reduce those conflicts by effective management of these critical areas. The estuarine relationships category includes projects designed to explicate causal relationships between human activities, significant instream modifications and the ramifications of those changes for estuarine-dependent human activities. This category includes management-oriented investigations of the major processes mediating the conflicts examined in Chapter III. The fisheries dynamics area consists of projects intended to relate major changes in fisheries health and productivity to human activities. Fisheries processes are isolated from other estuarine relationships because all major conflicts identified in Chapter III listed fishing as the affected use and because two specific major fishing-related phenomena (declining landings and ulcerative mycosis) require particular attention. The final major category, the human environment, consists of projects which examine the trends and patterns in the intensity of human uses and the institutional climate in which management plans must operate. All of these categories of investigation must be pursued for effective management to occur. An improving understanding of causal connections between human activities and changes in the estuaries (both water quality and fisheries), must occur for management pressure to be exerted on critical relationships, in order to reduce conflicts between societal uses. This effort can only be effective, however, when the institutional context of management decisions is understood. Finally, better management of critical areas represents the most effective immediate mechanism for reducing use conflicts.

Each section incorporates three main activities: characterization, evaluation and implementation. Characterization includes scoping studies, information gathering processes, and examination of trends to identify areas of fruitful concentration. Evaluation includes scientific research and other assessments required to understand processes mediating environmental interactions adequately to allow effective management. Implementation includes informational studies and feasibility evaluations of potential management alternatives for specific problems, processes and interactions, as well as attitudinal studies of the affected or regulated populations. In all cases, the direct management utility for each area is given. Projects identified as high priority are marked as follows: highest priority (\*\*), high priority (\*). Parenthetical notations identify probable sources of outside funding for particular projects.

Projects are assumed to result in digitization of information developed in the geographic information system designated for the program whenever that information has direct management relevance. These projects do not represent an exhaustive list of projects which should be funded by the program, but are instead examples of technically feasible research projects with direct management relevance suggested both by resource managers and researchers.

## I. RESOURCE CRITICAL AREAS: IDENTIFICATION AND MANAGEMENT

### General Justification

The Albemarle-Pamlico system is unique in the degree of dependence of its fisheries resources on specific estuarine habitats, many of which are impaired or threatened by human activities. Productivity of those fisheries resources is therefore strongly dependent on accurate characterization and efficient management of those habitats. Mitigation of losses caused by nursery ground deterioration presents an effective potential mechanism to lessen the conflict between land-use conversion activities and fishing activities.

Aquatic vegetative habitats (both submerged and emergent) perform a wide variety of important ecosystem functions, including fisheries nursery capacity, current baffling and sediment consolidation, primary production and refuge predators for prey species. The relative value of each type of vegetation is poorly known. In addition, some of these organisms are very sensitive to environmental perturbations, and have shown dramatic changes in the study area in the last ten years.

A major effect of land-use conversion and associated nonpoint impacts on streams in the Albemarle-Pamlico region is the loss of wetland habitats crucial to the survival of both aquatic and terrestrial organisms. Information on the extent of these losses is sparse, yet can be obtained at relatively low costs. The identification component of such a process can be linked to other proposed projects to yield enormous amounts of critical information at a relatively low cost. Afterwards, rational management strategies can be derived for these important areas preserving their close linkages to the aquatic systems in the Sounds.

### Characterization

- \*\* C.1 Compile and analyze all existing data on Primary Nursery Areas, Secondary Nursery Areas, Inland Nursery Areas, and Anadromous Spawning and Nursery Areas to determine adequacy of designations, to establish baselines and to identify impaired or impacted areas.

Management Utility: Consolidation of information on this important issue will allow more efficient management both across-the-board and on a case-by-case basis. Documentation of nursery importance will strengthen the case for protection. Identification of impaired areas will allow pilot mitigation or restoration projects. Correlative secondary studies based on this information will help identify or evaluate causal relationships to human activities.

- \*\* C.2 Accelerate the National Wetlands Inventory in the Project Area.

Management Utility: Many regulations, both federal and state, apply to the development of wetland areas. Wetlands in the Albemarle-Pamlico region are usually tightly connected to adjacent estuarine waters through hydrologic relationships and nutrient cycling. Knowledge of existing wetland areas can help avoid conflicts between land-conversion and fisheries interests, and be beneficial in site-selection activities, evaluation of proposed projects, evaluation of pre-project conditions in violations cases and even estimation of timber volumes. All watershed planning activities would be greatly facilitated by the availability of accurate wetlands mapping. Many of the other projects proposed here could be completed in conjunction with the National Wetlands Inventory process.

- \*\* C.3 Complete the identification and characterization of natural areas of high significance in the region.

Management Utility: Land-use conversion in the past has occurred largely in ignorance of what was being altered or

of consequences for the estuaries. General scoping studies were conducted under the CEIP program for some areas, but many critical areas are largely unknown. The high correlation between remaining natural areas and wetland areas suggests that natural areas and wetland areas could be mapped at the same time, with relatively low additional costs.

- \* C.4 Document present and historic patterns in location, abundance and composition of submerged aquatic vegetation (SAV) beds.

Management Utility: Precise knowledge of locations of sensitive vegetative habitats would be invaluable in existing regulatory programs in the evaluation of proposed development projects and mitigation efforts. Furthermore, this effort would provide a baseline for trend analysis intended to identify threatened habitat types and to enable management program design. Characterization of trends allows the identification of high-priority areas and species for management efforts, so that evaluative studies and management assessments are applied most efficiently. Restoration pilot studies should be conducted in historic beds, once technical and economic feasibility are established.

- \* C.5 Identify endangered species habitats within the study area (FWS).

Management Utility: Specific federal regulations pertain to endangered species and critical habitats for endangered species. In the Albemarle-Pamlico region, most of these occur in the same wetland areas described above. Preliminary habitat scoping could be done in direct conjunction with the National Wetlands Inventory.

- C.6 Evaluate the potential for restoration or mitigation of altered wetlands in the Albemarle-Pamlico region, especially those in close proximity to estuarine nursery areas.

Management Utility: The potential is great for restoration of some impacted wetland areas to decrease negative effects on nursery areas. An evaluation of alternative strategies, likely success and probable costs should precede any restoration efforts. The potential for water management plans, or even rerouting of drainage away from nursery areas, may be even greater.

### Evaluation

- \*\* E.1 Use existing information on striped bass reproductive patterns to design and conduct experimental evaluations of the loss in reproductive success in the Roanoke River.



Management Utility: Although extensive work has been conducted and proposed on this serious situation, diverse hypotheses still exist on the causes for the decline (toxicity, thermal changes, food chain disruption, etc.). Consolidation of existing information should allow framing of testable hypotheses. The design of mitigation efforts is premature until causal relationships are understood.

- \*\* E.2 Conduct studies to relate information on nursery functions to environmental factors, adult stocks and to human-use-related factors (e.g. land-use conversions, drainage).

Management Utility: Comprehensive scoping work on existing data should be used to frame hypotheses about causal connections between nursery productivity and anthropic change. Knowledge of these processes is essential to effective management and successful mitigation.

- E.3 Assess the available data on fringe wooded swamps, evaluate their functional role and interpret the extent and ramifications of impacts to these systems.

Management Utility: Programs exist to regulate development in wooded swamps, but the functional role of those areas, their significance as aquatic nursery habitats and the impacts of piecemeal development are poorly known. Rational management decisions relevant to wooded swamps can only be made based on an understanding of functional relationships.

- E.4 Examine the current suitability of the Pamlico River for SAV growth, and evaluate the potential for reestablishment of historic SAV beds in that region.

Management Utility: The dramatic recent declines in SAV in the Pamlico River have probably had serious implications for fish and waterfowl populations in that area. Preliminary work suggests that restoration should be possible, but experimental work is required before full-scale restoration should proceed.

- E.5 Determine the relative contributions of major habitat types (including submerged vegetation, nursery habitats and other river and sound habitats) to overall juvenile populations for major species.

Management Utility: Management and mitigation efforts can be concentrated on those species or habitats most receptive to change or most deserving of attention.

- E.6 Characterize the ecosystem function of irregularly flooded wetlands.

Management Utility: Irregularly flooded marshes cover extensive areas in portions of the study area, but the significance of those habitats and the consequences of their modification are uncertain. Permit decisions should be based on reasonable prediction of such consequences.

### Implementation

- \*\* I.1 Evaluate regulatory and other management options, in light of information gathered above, to protect critical nursery habitats. Both technical and economic feasibility should be considered.

Management Utility: Previous efforts at regulation for Primary Nursery Areas have broken down in the absence of adequate technical information. Once the suggested studies are completed, adequate information should be available to allow the design of an efficient, effective management program.

- \*\* I.2 Evaluate alternative strategies for wetland protection in the Albemarle-Pamlico region.

Management Utility: Although many regulations exist which affect conversion of wetland areas, no comprehensive state management strategy has been adopted. If water-related resources are to be managed effectively, a comprehensive, rational wetlands management package must be formulated.

- \*\* I.3 Develop a protocol for monitoring critical areas (Pamlico River, Currituck Sound, Core Sound) for SAV on a 5-10 year return period.

Management Utility: The disappearance in the Pamlico River was evaluated after the fact. Early detection of similar problems would greatly increase the likelihood that causal relationships could be established and that effective management strategies could be developed.

- \* I.4 Document all obstructions to anadromous fish migration and evaluate the potential for mitigation.

Management Utility: Obstructions to migration probably have a very serious impact on anadromous fish such as herring and shad which have shown marked declines in the past decade, especially in tributaries to Albemarle Sound. Identification and evaluation of such obstacles must precede an active mitigation program, if runs of those fish are to be returned to former status.

- I.5 Evaluate the potential for mitigation or restoration of impaired Primary Nursery Areas, including design of a pilot project for such an area. The design should include features intended to document the importance of previously identified factors (conduct after C.1).

Management Utility: Various structural strategies have been proposed to mitigate human impacts on critical nursery habitats. Once adequate information is available, the costs and likely effectiveness of such efforts needs to be ascertained.

- I.6 Design a pilot reintroduction program for SAV in the Pamlico River based on information developed above (conduct after E.4)

Management Utility: Once causal relationships have been evaluated, the expected benefits of such a program can be predicted, and its design optimized.

## II. WATER QUALITY AND ESTUARINE RELATIONSHIPS

### General Justification

Management of natural resources in the Albemarle-Pamlico region depends very strongly on the clear understanding of both nonpoint and point source processes, as well as instream relationships.

Much of the Albemarle-Pamlico region is rural, and land-use conversion represents the source of most contaminants of estuarine waters (sediment, nutrients, trace contaminants). In addition, the low profile of most of the lands east of the Suffolk Scarp requires that extensive drainage networks be installed before effective farming or silviculture can be accomplished. These activities represent a constantly changing mosaic of interactions between land and water which strongly influence instream productivity. Relatively little is known of these processes in some areas, and much of what is known is out of date.

Nutrients and other contaminants derived from point and nonpoint sources have significant effects on water quality in the Albemarle-Pamlico region. Serious algal bloom conditions have occurred and continue to occur when conditions are right in several main tributaries of Albemarle and Pamlico Sounds. These blooms not only are unsightly and have negative impacts on the aesthetics of the region, but also have serious ramifications for estuarine organisms. Clear understanding of the processes at work and the development of a predictive tool are necessary for effective management to be possible.

Although the absolute levels of contamination of estuarine waters in the Albemarle-Pamlico region with toxicants are not nearly as high as many more industrialized estuaries, significant toxicants issues remain. As new and increased industrial discharges are permitted, new standards are necessary in saline reaches of streams not required before. Identification of particular potential trouble spots before they become critical will allow more careful management.

Many of the processes addressed here are related to the dispersal or distribution of anthropogenic contaminants. Local or small-scale phenomena are difficult to understand, and even more difficult to predict without a general knowledge of how basic physical processes affect flow patterns in this complex, estuarine system. All of the models suggested here depend on linkage to more general models to be fully effective.

### Characterization

- \*\* C.1 Construct a detailed, up-to-date land-use map for all counties immediately adjacent to estuarine areas, including critical areas, all drainage networks and water-control structures, and indicating concentrations of high-pollutant-yield land uses (COE?).

Management Utility: No accurate assessments of the contribution of nonpoint sources to instream problems can occur without up-to-date information on land-use. Similarly, planning for water management, land-use modification or impact mitigation depends on accurate drainage network assessment.

- \*\* C.2 Construct a detailed, up-to-date map of all point sources in all counties in basins tributary to Albemarle or Pamlico Sounds, including type of discharge, chemical characteristics, average flow and permitted flows. Establish a mechanism for this map to be regularly updated.

Management Utility: Basinwide management requires current information on point sources discharging throughout the system. This information is available in fragmented form, and can be readily integrated into a useful tool.

- \*\* C.3 Complete soil surveys in the region (specifically Hyde County) (CZM).

Management Utility: Estimation of pollutant yields for a given use depends strongly on soil characteristics. Digitization of soil surveys makes a wide variety of management evaluations possible, from siting studies for septic systems, to evaluation of sites for specific development purposes, to identification of areas where existing population densities exceed the assimilative capacity of the soils. Furthermore, soil surveys provide a wealth of practical information which could be provided to the public through a cooperative federal/state/local venture.

- \*\* C.4 Assemble comprehensive N/P budgets for the Albemarle-Pamlico Sound Complex.

Management Utility: Effective management of cultural eutrophication depends on accurate assessment of the relative contributions of source activities. Estimation of expected efficacy of a particular management strategy requires not only cost estimates but also realistic benefit projections.

- \* C.5 Assemble pertinent water quality data and explore them statistically to identify important relationships and historical trends.

Management Utility: Existing data is sparse and fragmented, and has never been examined in a comprehensive fashion to document instream effects of anthropic activities. Scoping studies are required to frame hypotheses about causal relationships, to identify problem areas and information gaps, and to provide first approximation information to resource managers for ongoing regulatory programs.

C.6 Establish historical trends in land use and drainage.

Management Utility: Assessment of the time course of land-conversion activities should allow examination of long-term and short-term effects in receiving streams, and probably enable correlative studies to be done on nursery area effects.

Evaluation

- \*\* E.1 Investigate and demonstrate the management relevance of estuarine hydrodynamic and water-quality models. Elicit from managers the utility and management applicability of these tools.

Management Utility: The breadth of possible management utilization of models is great, but would be greatly reduced if clear management goals were not targeted before model development. Therefore, a general scoping study of model applicability and availability should be conducted at the outset.

- \*\* E.2 Evaluate water flow characteristics in the Albemarle-Pamlico region by documenting inputs to, major influences on, circulation within, and outflow from the system. Use this evaluation to define approaches to, and management relevance of, hydrodynamic and water quality models.

Management Utility: Many current environmental concerns involve phenomena in which known amounts of materials (phosphorus, nitrogen, oxygen consuming substances, bacteria, etc.) are added to Albemarle-Pamlico water courses but the environmental impact of these additions cannot be accurately predicted because of inadequate knowledge of dilution and reconcentration processes within the receiving waters. A combination of measurement and modeling techniques offer real hope of establishing the range of these processes.

- \*\* E.3 Consolidate all available information on the effects of land-use conversion on estuarine water quality and ecology, to identify information gaps and frame hypotheses about causal relationships between human activities and instream effects.

Management Utility: All management decisions related to land use are predicated upon the understanding of the effects of those activities on the estuaries. Although much work has been done, large amounts of it are not generally available, and no synthesis has been attempted. This initial scoping work must precede any specific management evaluations, and should include correlative studies to relate existing land use and drainage to estuarine nursery function.

- \*\* E.4 Evaluate the significance of sediment/water column interactions in wooded swamps for nutrient-related water quality concerns.

Management Utility: Assimilation of nutrients serves to reduce instream concentration, but under certain conditions recycling from the sediments can dominate nutrient dynamics, a process poorly understood. Wooded swamps not only fringe much of the study area, but are also being proposed as treatment systems for effluents rich in nutrients. Rational decisions on the suitability of such areas depend on knowledge of recycling interactions which is currently sparse.

- \* E.5 Develop a user-oriented model capable of evaluating the effectiveness of nutrient control strategies, and validate for one watershed. The model must allow evaluation of:
- upstream versus coastal inputs,
  - relative importance of N and P as limiting nutrients,
  - physical limitations to primary productivity, including flow and salinity, and
  - differential bioavailability of nutrients from different sources (follows E-1).

Management Utility: Existing models are grossly inadequate for non-conservative substances like nutrients. Wasteload allocations are based on such models. The uncertainty involved in permitting is especially severe in saline portions of estuarine tributaries. Development of a model tailored to the needs of permit-decision-makers would allow much more rational decisions.

- \* E.6 Characterize the distribution and movement of sedimentary particles, into, within, and out of the Albemarle-Pamlico System.

Management Utility: Sediment distribution have both direct and indirect effects on environmental concerns in the Albemarle-Pamlico. Sediments suspended in the water absorb light making it impossible for submerged aquatic vegetation to grow. Sediments on the bottom create shoals that hinder navigation and water flows. Sediments have indirect effects on the environment through their role as surfaces to which toxic and oxygen consuming substances absorb for transport, concentration and accumulation. Sediments on the bottom can liberate absorbed substances through chemical and physical resuspension so that environmental problems crop up at considerable distance from pollution sources. Our current understanding of

sediment dynamics in the Albemarle-Pamlico is woefully inadequate for service in present or future management procedures. A focused activity can fill this need.

- \* E.7 Develop cumulative impacts methodology in assessing land-conversion effects and drainage effects (follows E-2).

Management Utility: The major impediment to limiting nonpoint effects in sensitive drainages has been the inability of regulatory agencies to relate piecemeal changes to instream effects. Modeling probably could do this if a waste-load-allocation style approach were used, assuming maximum tolerable loads of constituents could be determined.

- \* E.8 Delineate conditions under which algal blooms and anoxia are expected to occur in mesohaline portions of the Neuse and Pamlico Rivers.

Management Utility: Prediction of algal blooms from readily available information would allow variable discharge permitting, so that restrictions are tightest when they need to be. If the process of bloom formation were understood, a wide variety of possible mitigational measures could be evaluated (e.g. flow regulation, discharge restrictions, land-use zoning, BMPs). Active management of point-source discharges is limited by the ability of the regulatory agencies to relate anoxia to causal processes. Until that relationship is demonstrated, little effective management of dissolved-oxygen-related fish kills can be expected.

- \* E.9 Conduct sampling of biota to establish baselines for toxic contaminants (FWS).

Management Utility: Little is known about the distribution of toxic constituents in organisms or sediments in the study area. Complex cycling of many elements may result in unrecognized problems without scoping studies such as these.

- \* E.10 Conduct bioassays for pulp mill effluent (EPA).

Management Utility: The need for bioassays is severe for this important category of discharge.

- E.11 Evaluate the risk of development on different mineral and organic soils in terms of pollutant loadings.

Management Utility: Preliminary studies suggest that fluxes of contaminants from different kinds of soils in different hydrologic contexts (e.g. pocosin peats versus floodplain peats versus marsh mucks) are very different.



Soil maps and land-use maps could be used to identify areas with greatest development risk and least development cost.

- E.12 Conduct a scoping study of the relationships between human activities and contamination of organisms by toxicants.

Management Utility: Although reasonable efforts have been directed at bacterial contamination, relatively little work exists on toxicant contamination of shellfish in the Albemarle-Pamlico region. Researchers have suggested that bacteria may not be the only reason for limiting shellfish harvest in closed areas.

- E.13 Evaluate the effects of channelization on water flow rates, constituent concentrations and fisheries utilization of streams in the coastal zone.

Management Utility: Channelization has occurred in large numbers of coastal streams, with unknown effects on physical, chemical and biological characteristics of those waters. Any management plan for the region should include a basic understanding of the effects of channelization.

- E.14 Construct a large-watershed-level model for hydrology and water quality in tidewater areas, to include evaluation of land-use changes and drainage system changes on salinity patterns, sediment loading and nutrient loading.

Management Utility: All predictions of land-use conversion must depend on reasonable understanding of processes mediating the effects. Models seem the most expeditious vehicle for this endeavor, and would be essential in the following tasks.

- E.15 Evaluate the chronic effects of suspended sediment in estuarine areas.

Management Utility: Changes in sediment load due to human activities have been dramatic in many tributary basins, yet the effects are poorly understood for estuarine systems. Many proposed projects result in increased sediment concentrations, yet no sensible control or mitigation efforts can be defended without reasonable knowledge of expected effects.

### Implementation

- \*\* I.1 Evaluate the efficacy of management alternatives to current fecal contamination procedures (e.g. indicator organisms, sampling procedures).

Management Utility: A crucial concern is how well fecal coliform bacteria indicate the presence of disease-causing organisms in estuarine areas. Alternative viral and

bacterial indicators have been proposed, but the managerial improvements that might result are not well known. The presence of high levels of coliform organisms in drainage from disturbed natural areas is especially problematic --does a real risk exist from this source? A formal risk assessment of viruses and pathogens in shellfish and in primary recreation areas would be very useful in interpreting the significance of the human activities for shellfish and contact recreation.

- \*\* I.2 Evaluate the performance and cost effectiveness of various Best Management Practices (BMPs) in coastal situations, using a mixture of field and modeling techniques.

Management Utility: Application of BMPs is currently well-intended, but probably results in excessive expenditures in some areas and inadequate expenditures in others.

- \* I.3 Once nutrient dynamics are better known, evaluate the cost and relative effectiveness of various point and nonpoint source control strategies.

Management Utility: Accurate prediction of the effectiveness of various strategies depends on knowledge of instream processes.

- \* I.4 Design optimal water management strategies for various coastal situations, and evaluate the potential for mitigation of existing water management problems.

Management Utility: Water management is increasingly recognized as a vital component of the coexistence of agriculture and silviculture and fisheries interests. Optimization would serve all these interests.

- \* I.5 Recommend BMP packages for different coastal soils, hydrologic situations and land-uses, based on the above studies.

Management Utility: Optimal application of practical management techniques for a given situation benefits everyone involved. Specific practices should be tailored to the unique situations found in the study area.

### III. FISHERIES DYNAMICS: STOCK ASSESSMENT AND DISEASE

#### General Justification

Crucial concerns in the Albemarle-Pamlico project include the status of fish and shellfish stocks, and the causes of apparent declines in landings for many species.

These fisheries resources are especially important to the region because of their recreational value. They also may be a convenient indicator of the general environmental health of the estuaries. One of the most obvious environmental problems in the Pamlico region is the recent outbreak of ulcerative sore disease on a variety of commercially important fish species. To date, only preliminary epidemiological and pathological work has been completed.

#### Characterization

- \*\* C.1 Conduct a scoping study to identify and evaluate data elements both necessary and sufficient to assess status of important fisheries stocks.

Management Utility: Existing information on fisheries is linked to landings, which are dependent on many interrelated variables. Assessment of actual population levels (and effects of particular human activities) requires much more intensive information. Scoping work on information requirements is, therefore, essential to evaluate the success of management activities.

- \*\* C.2 Consolidate existing information on incidences of ulcerative mycosis and other fish diseases in Albemarle-Pamlico populations.

Management Utility: Extensive management programs should be dependent upon a demonstration that the outbreaks described are anthropogenic and not simply cyclical. Scoping work to define the extent and nature of the problem should be used to generate initial hypotheses for experimental work.

- \* C.3 Identify and characterize existing shellfish beds (NRCD).

Management Utility: Currently, use attainability studies must be done "from scratch" whenever classification changes are requested. Knowledge of existing shellfish beds is fragmentary.

#### Evaluation

- \*\* E.1 Evaluate the effects of fishing practices on water quality and habitat (after C.1).

Management Utility: As intensity of fishing effort increases and stocks decrease, the effects of fishing on water quality are likely to become more and more significant. Very little information on this subject exists from the study area. Identification of specific effects would allow effective management action.

- \*\* E.2 Evaluate the effects of fishing harvest on fish stocks (after C.1).

Management Utility: As above, little information exists, yet strong fishing pressure may be depleting certain stocks. Management changes could reverse any such effects.

- \*\* E.3 Evaluate the relationship between environmental factors and infectability for a target species (menhaden) (WRRJ).

Management Utility: Any program designed to reduce incidence of outbreaks must address the processes involved. If causal relationships cannot be demonstrated, effective management cannot occur.

- \* E.4 Evaluate the conditions required for establishment of viable shellfish beds and evaluate the potential for reestablishment in historic areas.

Management Utility: Large areas of historic beds are now barren. Reestablishment programs should await demonstration of probable bed survival under existing conditions.

- \* E.5 Relate fungal presence to pathogenicity in effected species (WRRJ).

Management Utility: Clear definition of the target problem is essential to effective management.

- \* E.6 Evaluate the management performance of current water classification procedures, in terms of relevance to resource protection and resource use protection.

Management Utility: Extensive controversy has accompanied this important natural resource issue over the past few years. As development pressure accelerates, effective and sensible procedures for resource management must be effected.

- \* E.7 Evaluate environmental effects of marinas and assess possible alternatives to current marina regulatory programs.

Management Utility: As recreational pressures intensify, solid bases for regulation are required to protect the potentially impacted resources yet allow reasonable balanced use of the waters of the State.

## Implementation

- I.1 Evaluate the costs and benefits of requiring excluder devices to reduce bycatch on Sound shrimp boats.

Management Utility: Technology exists to reduce bycatch of scrap fish, but the reduction in catch efficiency of targeted species has not been evaluated fully. These devices may be required in some portions of the study area (e.g. where sea turtles are present). Regulations should be designed with the effects on the fishermen in mind.

#### IV. THE HUMAN ENVIRONMENT

##### General Justification

Essential to effective management of the Albemarle-Pamlico region is a general framework of understanding of social, economic, and institutional systems. Resource managers are faced with a range of options for managing the area to achieve a desired outcome. The analytic tools of the social sciences are required to suggest and evaluate potential management strategies before implementation so that the most promising strategy is chosen.

Of equal importance is monitoring and re-evaluation of a management strategy once it has been implemented. Conditions in existence when the management strategy was chosen may change, or the policy may have unforeseen effects, with the result that the policy fails to achieve its stated objective.

A fairly comprehensive base of certain types of data, such as permanent resident population information, is available but may need to be made accessible in a more useful manner. Other data, such as seasonal population information, is not currently available and needs to be collected.

Economic analysis is frequently overlooked as an aid to management of a resource such as the Albemarle-Pamlico estuarine system. Economics can provide vital information not obtained through other types of analysis, including estimates of the market and non-market values provided by the estuarine system.

The tools of economic analysis can also be used to study the incentives facing users of the estuary and adjacent lands for engaging in various alternative activities. Incentives are provided by markets for goods and services, and by government policies such as subsidies, taxes, or regulations.

In order to effectively manage the Albemarle-Pamlico system, it will be necessary to understand all of the important systems (natural, social, economic, political, etc.) and how they function in the larger system of which they are a part. For example, one cannot hope to manage the natural resources of the region without understanding the politics of the area.

##### Characterization

- \*\* C.1 Evaluate the role of science and professional judgement in policy determinations (including at the local level), and evaluate institutional mechanisms to encourage effective integration.

Management Utility: Studies such as the APES usually result in highly technical determinations of relatively low utility to managers, because basic issues and

assumptions differ between these groups. A mechanism to facilitate communication and coordination between such disparate disciplines is essential in this effort.

- \*\* C.2 Compile baseline data on demographic trends, including population size, composition, geographic distribution and the relative contribution of permanent and seasonal components.

Management Utility: Planning for the future depends strongly on expectations for population parameters and clear knowledge of existing patterns. The shift from less dense resident populations towards denser seasonal populations is significant environmentally and socially.

- \*\* C.3 Characterize existing policy and management systems in terms of efficiency in attaining stated goals, including geographic framework, policy substance, enforcement capabilities, flexibility to societal change, and interrelationships among these systems. Studies should include federal, state and local levels, and clearly examine the role of the Department of Defense in this region.

Management Utility: Identification of areas where stated management goals are not being met will allow targeting of funds to provide information or technical support for those programs.

- \*\* C.4 Evaluate the peoples' knowledge and attitudes about natural resources and regulation designed to protect those resources.

Management Utility: Popular receptivity is vital to the long-term success of this project. All proposed regulation changes must be framed in the context of the regulated population to be effective.

### Evaluation

- \*\* E.1 Estimate economic incentives to landowners adjacent to the estuaries, including those resulting from specific government policies (e.g., swampbuster), for competing land-use alternatives.

- a. agriculture, forestry and peat mining,
- b. resort development and preservation.

Management Utility: Understanding economic incentives will enable management strategies to shift land-use conversion patterns toward desired ends. Comparison of stated goals with actual economic incentives will give much needed information on the true effects of regulation and document the level of effectiveness of a regulation in meeting its stated goal.

\*\* E.2 Interdisciplinary case studies of Neuse River and Currituck Sound.

Management Utility: The most rapid human population increases in the Albemarle-Pamlico region are occurring in the four counties that border the lower Neuse River (Carteret and Craven) and Currituck Sound (Currituck and Dare). The Neuse River and Currituck Sound also represent extremes of the spectrum of major environments that occur within the region. Currituck Sound is a shallow, largely fresh water elongated tidal lagoon whereas the Neuse is a drowned river valley estuary with the full range of low to medium salinities. It is reasonable to assume that expanding populations near these environments will create management problems earlier than they occur in less densely settled areas of the system. As knowledge accumulates from activities of the Albemarle-Pamlico Estuarine Study, it would be most useful if it were consolidated and applied in a case study approach to the lower Neuse River and Currituck Sound areas. This interdisciplinary study (biological, economic, social, and institutional) should be conducted to determine its value in terms of its various uses and products. Procedures should include collection and analysis of information concerning trends in: (1) demography, (2) land use, (3) water quality, (4) infrastructure, (5) institutional structure, (6) regulatory regime and implementation status, (7) fish and wildlife production, and (8) economic activity. Results should be used to analyze the value of the selected estuary relative to types and degrees of potential development.

A pilot project should be begun early in the Albemarle-Pamlico Estuarine Study activities to develop the conceptual framework for the comprehensive studies. The pilot project would also determine the feasibility of studying specific sites within the Neuse and Currituck watersheds.

E.3 Estimate the value of a "non-market" good or service (such as hunting, recreational fishing, or aesthetic values) for a specified geographic area (NCSU).

Management Utility: Studies of this kind are rarely undertaken, but are vital to understand economics of land-use patterns, and should allow more precise evaluation of costs and benefits for particular kinds of regulation.

E.4 Evaluate the potential environmental, social and economic effects of specific target energy and material conservation efforts in the region (e.g., a 20% decrease in freshwater use, a 20% decrease in energy use).



Management Utility: Conservation is often overlooked as a practical tool to reduce human impacts in estuarine areas. A site-specific study of the environmental and social implications and feasibility of specific levels of conservation of particular resources would allow evaluation of the real potential of such a tool.

#### SUMMARY

The projects proposed above each contribute important information intended to facilitate effective management of the natural resources of the Albemarle-Pamlico region. Table 6 shows the pertinence of these projects to the major conflicts targeted in Chapter IV. The proper execution of these (or equivalent) projects should allow the integration of physical, chemical, biological, economic, social, and institutional information to culminate in a management plan to direct the implementation phase of this project.

TABLE 6 - APPLICABILITY OF PROPOSED PROJECTS TO PROCESS  
MEDIATING MAJOR CONFLICTS AMONG HUMAN USES

<u>CONFLICT</u>	<u>PROCESS</u>	<u>CHARACTERIZATION PROJECTS</u>	<u>EVALUATION PROJECTS</u>	<u>IMPLEMENTATION PROJECTS</u>
Agriculture & Commercial Fishing	Drainage effects on nursery areas	IC1, IC2, IC6	IE2, IE5, IIE1, IIE2, IIE6, IIE10, IIE12, IIE13	III1, III2, III5, III11, III4
	Nonpoint runoff effects on Water Quality (eutrophication & anoxia)	IIC1, IIC4, IIC3, IIC5	IIE1, IIE2, IIE4, IIE6, IIE7, IIE13	III1, III3
	Nonpoint runoff effects on sessile organisms distributions	IC4, IC6 IIC5, IIC6, IIIC3	IE4, IIE5, IIE6, IIE10, IIE13, IIE14, IIIE4	III2, III3 III6, III12, III4
	Nonpoint runoff effects on shellfish closure	IIC1, IIC6, IIIC3, IIIC4	IIE2	III1, III5
	Nonpoint runoff effects on Water Quality (relationship to ulcerative mycosis)	IIC1, IIC4, IIC3, IIC5, IIIC2	IIE1, IIE2, IIE5, IIE6, IIE8, IIE10, IIE13, IIIE3	III2, III3, III5
Waste disposal & Commercial Fishing (also Mining & Industrial Development and Com- mercial Fishing)	Discharge of nutrients & oxygen demanding substances (eutrophication & anoxia)	IIC2, IIC4, IIC5	IIE1, IIE4, IIE7	
	Discharge of bacteria causing shellfish closures	IIC2, IIC5 IIIC3	IIIE4	III1
	Discharge of toxicants & nutrients (relationship to ulcerative mycosis)	IIC2, IIC4, IIC5, IIIC2	IIE1, IIE4, IIE7, IIE8, IIE11, IIIE3	
	Discharge of toxicants, etc. (relationship to anadromous fish declines)	IIC2, IIC5	IE1, IIE1, IIE8, IIE9, IIE11	

Residential & Commercial Development & Commercial Fishing	Nonpoint runoff effects on shellfish closures	IIC1, IIC5, IIIC3, IIIC4	IIIE1, IIIE6	IIII1, IIII5
	Nonpoint runoff effects on nursery areas	IC1, IIC1, IIC5, IIIC4	IE2, IE4, IE5, IIIE1, IIIE6	II1, II5, IIIS
	Physical modification effects on habitat loss	IC4	IE6, IIIE2, IIIE6	II2, II3, II4, II6
	Recreational facility effects on Water Quality (especially shellfish closures)	IIIC5	IIIE1, IIIE6, IIIE8, IIIE11	IIII1, IIII5
Land Use Conversion & Wildlife Resources	Wetland habitat loss	IC2, IC3, IC5, IC6, IIC3, IIC6	IE3, IE6, IIIE3	II1, II2
	Instream habitat loss	IC4	IE4, IE5	II3, II6
	Drainage effects on Water Quality	IIC1, IIC3, IIC5, IIC6	IE2, IE5, IIIE1, IIIE2, IIIE4, IIIE5, IIIE6, IIIE7, IIIE10, IIIE11, IIIE12, IIIE13, IIIE14, IIIIE4	II5, IIII2, IIII3, IIII4, IIII5
Waste Disposal (etc.) & Tourism & Recreation	Water quality effects on aesthetics	IIIC2, IIIC4	IIIE7, IIIE11	IIII1
	Water quality effects on recreation	IIIC3, IIIC4, IIIC5	IE1, IIIE11, IIIIE4	IIII1
Mining & Industrial Development & Waste Disposal	Wasteload allocations limitations		IIIE1, IIIE4, IIIE6, IIIE7	
Commercial Fishing & Fishing	Harvesting effect on Water Quality		IIIE1	
	Harvesting effect on stocks	IIIC1	IIIE2	IIII1

## CHAPTER V

### DATA MANAGEMENT

In striving to fulfill the purpose of the Albemarle Pamlico Estuarine Study, the importance of adequate data and of having data in a form that can be readily utilized by managers cannot be overemphasized. To achieve the goal of developing a viable, long term management strategy for the region, managers and researchers have identified research and information needs.

A considerable amount of information about the area already exists. The information is in the form of literature, tabular data, and geographic or mapped data. Additional information will need to be compiled to enable researchers to accomplish the research goals set forth in Chapter IV and to meet the needs of managers. The project will need to bring together the disparate data about the region, including both existing and new data.

The overall objective of the data management efforts of Albemarle Pamlico Estuarine Study will be to provide users with access to data that will aid in addressing the issues outlined in Chapter IV. The ability to effectively manage the data will be critical to the success of the project. This chapter describes the data to be managed and the computer system to be used for managing the data for the Albemarle Pamlico Estuarine Study.

#### DESCRIPTION OF DATA

The following section describes the data collection objectives of the Albemarle Pamlico Estuarine Study. In developing these objectives, three important issues were identified. First, a database for the study, while it may be very large, must be limited to data that is relevant to the research topics that have been identified by the resource managers and researchers and that will be useful in practical estuarine management applications. A careful evaluation of existing databases and of data that need to be compiled must be completed for the Albemarle Pamlico Estuarine Study.

Second, the data must be of good quality. Existing databases will be evaluated according to an established set of procedures, and future data collection efforts must meet these standards. Finally, the data must be put in a form that will be useable by managers and scientists.

#### Data Identification

The process of data identification has already begun. In Chapter IV, a wide variety of research and information needs has been identified. State and federal managers identified management related information that will facilitate effective management of

estuarine resources. In a separate effort, ten groups of researchers have identified the specific information requirements necessary to address the research topics set forth in Chapter IV.

It is difficult at the onset of the Albemarle Pamlico Estuarine Study to anticipate all of the project's long-term research and information needs. As research projects are completed, new information needs will be identified. Data identification will be an on-going task.

#### Data Standards

Working groups established by the Data Sub-Group of the Albemarle Pamlico Estuarine Study Technical Committee are developing data assessment procedures and criteria. These data standards will form the basis for quality control of data.

### COMPUTER SYSTEM

Given the research concerns and data management objectives outlined above and in Chapter IV, a computer system for managing data has been designed to serve the needs of the Albemarle Pamlico Estuarine Study.

#### System Design Objectives

In designing a system for the study, a number of system design objectives were identified.

1. The system must limit the duplication of both systems and data. Duplicating systems will add enormous costs to the project. Duplicating major, dynamic databases is not only redundant, but can pose potential data integrity and inconsistency problems if updates to the databases are not strongly coordinated.
2. The system should permit and accommodate use by managers, technicians, and scientists.
3. The system must provide remote access to a variety of users. Managers and researchers from many different government agencies and universities, both within and outside the project area, must be able to use the data management system.
4. The active utility of the system must be capable of extending beyond the lifetime of the Albemarle Pamlico Estuarine Study. Because a major goal of the study is to develop long-term management strategies for the region, system design must ensure continued database maintenance and access so that the system can be self-supporting beyond the scope of this study.

5. The capability for compiling, storing and analyzing geographic data must be an integral part of the system. Geographic data will be a critical component of the research efforts to develop management strategies and to employ management activities that are adopted.
6. Flexibility is an important design objective. It is difficult at the onset of the Albemarle Pamlico Estuarine Study to anticipate every question or research direction. The system must be flexible enough to manage both new and existing data, to permit ad hoc queries, and to facilitate system design adaptations to handle technological developments or new management strategies.
7. The system must incorporate an effective interface with existing systems. Without this feature, many of the design criteria described above, including system and data duplication, long-term maintenance of the system, and the flexibility to adapt to changing situations and goals, will be impossible to accomplish.

#### System Description

The system will consist of a primary computer system with central control which will be connected through a communications network both to existing systems and to remote users (see Figure 3, Albemarle Pamlico Estuarine Study Computer Systems Diagram). The system will be used for data management, geographic data analysis, statistical analysis, and literature searches.

The system will provide access to data of good quality, data that is relevant to the key issues and in a form that managers can use. The system will permit geographic data analysis, through access to a geographic information system (GIS). Computer systems that store, retrieve, and analyze data according to either their geographic location or their attribute values are called geographic information systems. A GIS provides the capability to convert maps of geographic information to a digital format. The primary purpose of a GIS is to generate information, in the form of either maps or measurements, for use in research or management applications.

The GIS can be used to display the data on graphic terminals, plot the data at various scales, generate areal or linear measurements, aggregate the data to produce interpretive maps, and to overlay separate layers of geographic data where the relationship of those layers is important.

The system will not duplicate the ability to do sophisticated statistical analysis. Rather, the system will enable users to access data for statistical analysis on existing systems such as the Triangle Universities Computer Center. The system will enable users to integrate the results of statistical analysis in practical applications and in conjunction with other data.

Albemarle-Pamlico Estuarine Study  
Computer Systems Diagram

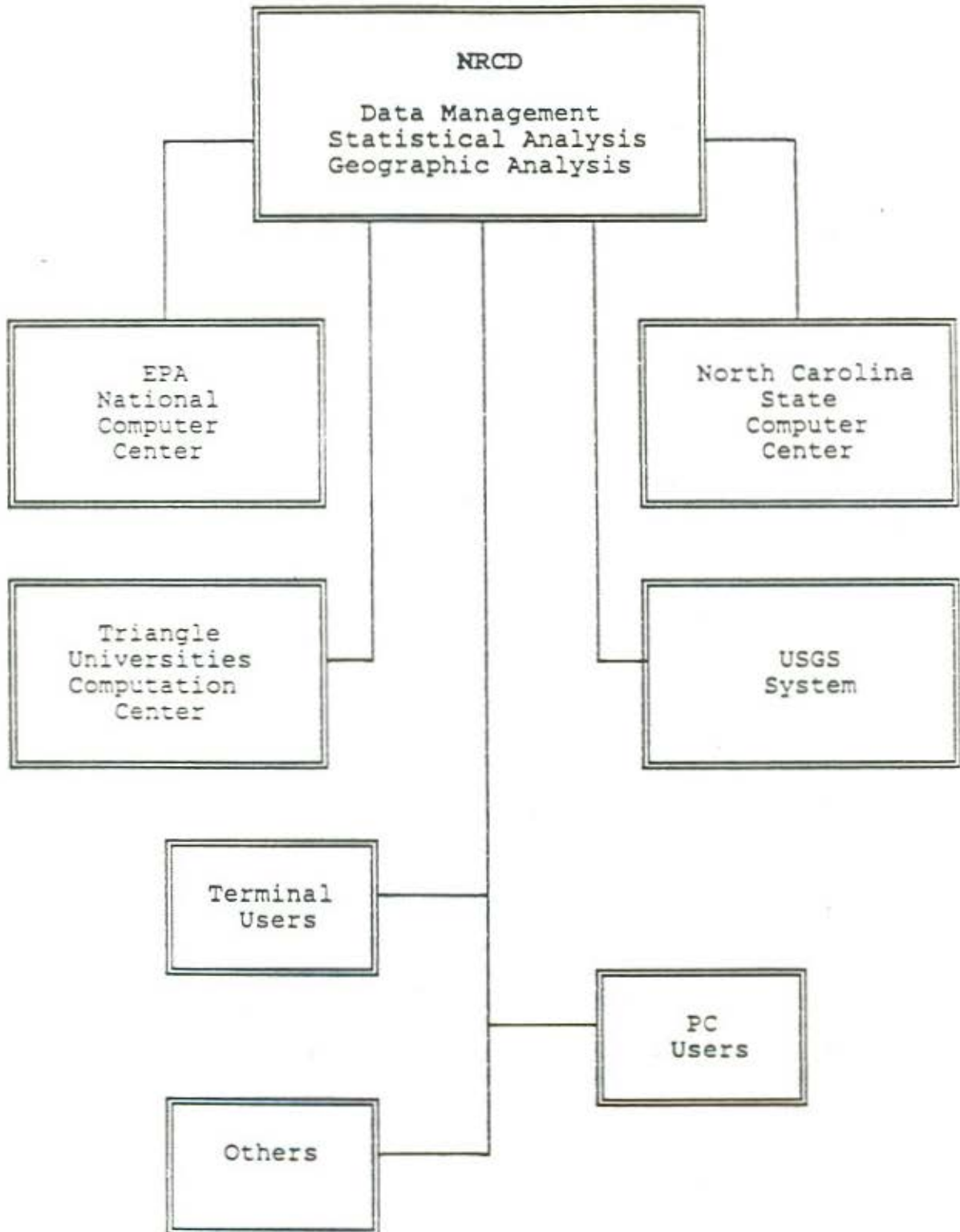


Figure 3

## Land Resources Information Service

The computer system at Land Resources Information System (LRIS), an agency of the Department of Natural Resources and Community Development, will be used as the primary computer system.

The Albemarle Pamlico Estuarine Study will realize several benefits from this arrangement, and a number of system design objectives will be met by establishing LRIS as the primary system. LRIS has an established computer system management "infrastructure" i.e. staff, facilities, procedures, etc. By utilizing an existing computer system as the primary system, the Albemarle Pamlico Estuarine Study will avoid the enormous costs of establishing a new system.

The basic computer hardware to run the system is already on line at LRIS. LRIS also has most of the communications hardware and software for connecting to standard, existing data communications networks, including the State Data Communications Network. The availability of an experienced staff using established procedures will eliminate the expense, the time, and the inefficiency inherent in developing an entirely new system.

LRIS is a service agency and, as such, has no program commitment that would supersede the Albemarle Pamlico program requirements. That would not be the case with most existing computer systems.

LRIS already has a large database of geographic data for the Albemarle Pamlico study area.

Several of these factors relate directly to the system design objectives, including minimal duplication of equipment and data, long-term maintenance of both the system and the data, and the interface with existing systems.

Another system design objective is the capability for dealing with geographic data. LRIS has operated a GIS for ten years and has considerable experience in this technology and its application to natural and cultural resource management. The GIS will be an invaluable tool to researchers and resource managers for gathering information, identifying trends, and evaluating management alternatives.



## CHAPTER VI

### PUBLIC PARTICIPATION IN THE ALBEMARLE-PAMLICO ESTUARINE STUDY

The complex yet fragmented structure of the existing management system for natural resources in the Albemarle-Pamlico region requires cooperation among institutions and individuals for the management goals of this project to be attained. The tight connection between land-use patterns and water-quality-mediated biological problems in this system underlines the need for strong positive relationships with diverse segments of the user population. This need will be addressed by an active public participation/public awareness program, intended to facilitate communication between the public and program administrators, to marshal support from local governments and regional institutions, and to allow dissemination of information gathered through this study.

#### Public Participation Programs

The mechanisms for public participation in the Albemarle-Pamlico Estuarine Study are both formal and informal. The pathways for citizen input include Citizens Advisory Committees (CACs), announced public meetings and conferences, the public review of all public documents, and the placement of a public liaison person in the region (proposed). Additional mechanisms include legislative/governmental liaison, informational presentations to technical groups, and general availability of administrative staff and receptivity to informational and philosophical queries.

#### Citizens Advisory Committees (CACs)

The Policy Committee for the Albemarle-Pamlico Estuarine Study requested that regional Citizens Advisory Committees be established, representing a broad cross-section of interests and occupations. In response, the Technical Committee established a Subcommittee on Public Participation, chaired by Dr. Mike Orbach (East Carolina University). After much discussion and revision, the Technical Committee approved a recommendation from that Subcommittee that two regional CACs be convened, representing the Albemarle region and the Pamlico region. The recommended makeup of those committees is shown in Table 7. Procedures were established for nomination by Technical Committee members or by citizens. Specific Technical Committee members were asked to provide nominations in specific categories such that every category had some nominations.

Table 7: Citizens Advisory Committees for the Albemarle-Pamlico Estuarine Study

There shall be one committee representing the Albemarle Sound region and one committee representing the Pamlico Sound region. Each committee shall be composed of representatives as follows:

- |  |                                  |
|--|----------------------------------|
| 1. Public Officials (2)                      | 7. Agriculture                   |
| 2. Educator                                  | 8. Industry                      |
| 3. Tourism                                   | 9. Environmental Group           |
| 4. Developer                                 | 10. Coastal<br>Engineer/Surveyor |
| 5. Sport Fishing or Wildlife<br>Organization | 11. Private Citizen (4 - 19)     |
| 6. Commercial Fishing Interest               |                                  |

Following an appropriate interval, nominations and supporting materials were considered by the Technical Committee. A consensus was reached, and slates of recommended CAC members were approved by the Technical Committee. These slates were transmitted to the Policy Committee. The structures of the committees and individual members are being considered for approval by the Policy Committee.

The goals and purposes of these CACs were laid out in a Policy Committee directive, originally issued in August 15, 1986, and approved in modified form on February 13, 1987. The charge to these committees will be discussed at their organizational meetings.

Generally, the charge to the Citizens Advisory Committees shall be:

1. to provide a mechanism for structured citizens' input into the Albemarle-Pamlico Estuarine Study from their respective regions; and
2. to assist in the dissemination of information relevant to or developed by the Albemarle-Pamlico Estuarine Study in their respective regions.

The Citizens Advisory Committees will, among other things,:

1. Elect a Chairperson for their respective committee. The two Chairpersons will be members of the Technical Committee.
2. Report at each meeting of the Technical Committee (TC), through their respective Chairperson.
3. Review all documents and materials produced by the Albemarle-Pamlico Estuarine Study. They will include the results of such review in the Chair's reports to the Technical Committee.

4. Take such initiatives as are necessary and appropriate, in conjunction with the other activities of the Albemarle-Pamlico Estuarine Study, to ensure adequate citizen input from affected and interested constituencies in their regions.
5. Meet at their own discretion, but at least twice yearly, in locations convenient to the citizenry of their regions.

An important feature of this process was the election of chairpersons of those CACs, who also serve as voting members of the Technical Committee for the study.

#### Announced Public Meetings and Conferences

The second formal public involvement mechanism is announced public meetings of all kinds. A current list of all such meetings held appears as Table 8. Of these, the most important was the conference held at Beaufort County Community College on February 14, 1987.

Table 8. Public Meetings Held to Date

<u>Group</u>	<u>Date</u>	<u>Place</u>
Tar-Pamlico River Foundation	Sept. 23, 1986	Washington, NC
Neuse River Foundation	Nov. 10, 1986	New Bern, NC
Back Bay Restoration Foundation	November 1986	Knotts Island, NC
Regional Conservation District & SCS	Feb. 10, 1987	Williamston, NC
Public Conference	Feb. 14, 1987	Washington, NC
Currituck Foundation	Feb. 26, 1987	Currituck, NC

The goals of the conference included presentation of the workplan to the general public and exploration of additional public involvement vehicles by comparison to other National Estuaries Program projects. Speakers included Rep. Walter B. Jones, Secretary S. Thomas Rhodes (NRCD), Jack Ravan (US EPA), John Costlow (Duke University Marine Laboratory), Douglas N. Rader (Program Coordinator) and a number of representatives of other programs. Afternoon workshops examined information goals of the project, the role of science in public policy and the role of citizens in estuarine programs.

Additional regional meetings are planned to present information on the workplan for the study to the public and to receive public input on the goals and direction of the study.

#### Public Liaison Staff (Proposed)

The importance of the public involvement effort to this project, the spatial displacement of key administrative personnel from the effected region, and the diversity of duties necessary under the program suggest that a satellite office in the region

would greatly expand the effectiveness of this effort. The office should be located at the Washington Regional Office or the Morehead City Marine Fisheries center, and should involve regular travel between northern, central, and southern locations. Proposed duties of the staff member would include response to public inquiries, dissemination of information and public education, promotion of public awareness of issues of major concern and preparation of a project newsletter. Close communication between central program staff and regional staff will be maintained at all times.

#### Legislative/Governmental Liaison

Maintenance of effective communications between the Albemarle-Pamlico Estuarine Study and governmental units on all levels is vital to the success of the project, both in terms of financial support and effective implementation of recommendations developed during the course of the project. NC Representative Walter B. Jones was instrumental in the procurement of federal moneys for this study and has been vitally involved in its formation. Contacts are being made in the offices of all legislators, state and federal, with interests in the region. The Program Coordinator has made a formal presentation of program information to the Interstate Chowan River Water Quality Task Force, comprising state senators, representatives, and delegates from Virginia and North Carolina. General information about the purpose and goals of the study is being prepared for the entire Legislature.

Local government offices are being contacted with the help of the Washington Regional Office Manager, Ms. Lorraine Shinn, and with regional councils of governments. A series of meetings will be held with those governmental bodies to provide information and garner support for the project. Local governments will be vital to the successful implementation of project results.

#### Relations with the Press

The Office of the Program Coordinator and regional staff are constantly available for informational requests from the press. The Coordinator has provided information on the project to several newspapers. A NRCD radio interview was taped with Mr. Lowell Shumaker on program goals and functions. An article on the project is in the planning stages for Wildlife in North Carolina, for spring or summer release.

#### Informational Presentations to Technical Meetings

Information about the program and results derived from the projects funded under the program is actively disseminated through technical meetings and publications. A list of such meetings appears on Table g.

Table 9. Technical Information Presentation

<u>Group</u>	<u>Date</u>	<u>Place</u>
District Meeting, USGS	December 10, 1986	Winston-Salem, NC
American Fisheries Society	January 30, 1987	Gloucester Point, VA
Coastal Zone '87	May 26-29, 1987	Seattle, WA

Summary

Positive relationships with all segments of the effected population are vital to the success of this endeavor. Now that initial project planning is nearing completion, liaison with the private citizens, local interest groups, local governmental units, and state and federal agencies and legislators will be a major focus of project administration.

## CHAPTER VII

### BUDGET AND SCHEDULING

#### Funds Available

Projected funds available to support program functions are shown in Figure 4. The uncertainty depends on the need and degree of state matching funds, which will not be assured until about July 1, 1987.

#### Allocations to Major Programs

The cooperative agreement identifies four major program components: administration, information management, information acquisition and public involvement. Approximate relative costs of these programs are shown in Table 10, as percentages of total funds and in actual dollar amounts. The program administration component includes program office support and salaries for program staff (including positions to be dedicated to public liaison or data management). The information management numbers are derived from the budget proposed in Chapter VI, and are in line with other national estuarine programs (e.g. \$100K/yr. for Narragansett Bay). The public participation component was suggested by EPA staff, and is similar to other programs (e.g. \$75K/yr. for Narragansett Bay).

#### Allocations Within Major Programs

The areas identified in Chapter IV as major topics for research have been prioritized by a combination of program staff, management personnel and administrative board members. A consensus was reached on highest priority projects within those proposed in Chapter IV. Specific projects suggested for funding during the first year are marked (\*\* or \*) in Chapter IV.

The actual funding of projects must depend on the strength of proposals received in response to RFPs. Nonetheless, balance among the important topics listed in Chapter IV is desirable. Therefore, proportional allocations among topic areas is proposed in Table 11 estimated from likely costs of component projects and relative importance of those areas to management programs.

RFPs should be issued for specific projects when those projects are considered vital, but for more general topic areas otherwise. Each general RFP will list high priority areas, but will also identify other biddable topic areas.

Figure 4

APES FUNDING TIMETABLE

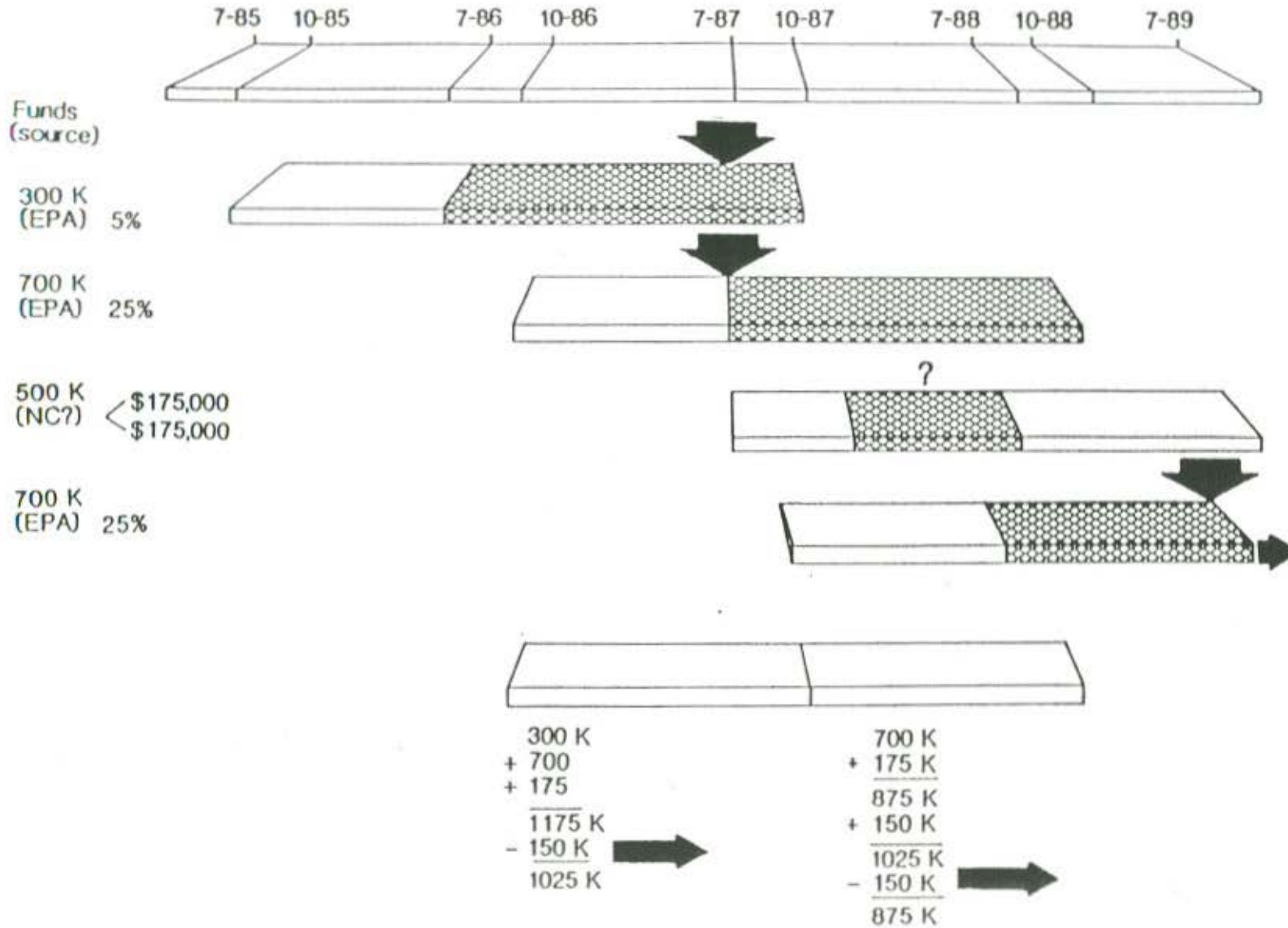


TABLE 10  
PROPOSED FUNDING BREAKDOWN

a. Percentages

	Oct. 1986-87	Oct. 1987-88	Oct. 1988-89	Oct. 1989-90	Oct. 1990-91
Program Admin.	15%	15%	15%	15%	15%
Information Management	15%	15%	10%	10%	10%
Public Participation	10%	10%	10%	10%	10%
Information Acquisition	60%	60%	65%	65%	65%
Total	100%	100%	100%	100%	100%

b. Dollars

Funds

Program Admin.	\$150,000	\$131,000	\$131,000	\$131,000	\$131,000
Information Management	\$150,000	\$131,000	\$100,000	\$100,000	\$100,000
Public Participation	\$100,000	\$ 88,000	\$ 88,000	\$ 88,000	\$ 88,000
Information Acquisition	\$600,000	\$569,000	\$569,000	\$569,000	\$569,000
Total	\$1,000,000	\$875,000	\$875,000	\$875,000	\$875,000



TABLE 11

PROPOSED FUNDING OF INFORMATION ACQUISITION

- I. Resource Critical Areas  
25% of IA
  
- II. Water Quality and Estuarine Relationships  
40% of IA
  
- III. Fisheries Dynamics  
20% of IA
  
- IV. Human Environment  
15% of IA

APPENDIX 1

PROGRAMS THAT AFFECT DEVELOPMENT  
AROUND THE ALBEMARLE AND PAMLICO SOUND  
December 14, 1986

Federal Legislation with a Major Impact  
(in alphabetical order)

Anadromous Fish Conservation Act  
Clean Air Act Amendment of 1967  
Clean Air Act Amendments of 1970  
Clean Air Act Amendments of 1977  
Clean Water Act of 1977  
Coastal Barrier Resources Act (1982)  
Coastal Zone Management Act of 1972  
Comprehensive Environmental Response, Compensation and  
Liability Act of 1980  
Consolidated Farm and Rural Development Act of 1965  
Department of Transportation Act of 1966 (bridges)  
Disaster Relief Act of 1974  
Endangered Species Act of 1973  
Federal Insecticide, Fungicide, and Rodenticide Act  
Federal Environmental Pesticide Control Act of 1972  
Federal Land Policy and Management Act of 1976  
Federal Water Pollution Control Act Amendments of 1972 (see CWA)  
Fish and Wildlife Act of 1956  
Fish and Wildlife Conservation Act of 1980  
Fish and Wildlife Coordination Act of 1934  
~~Fishery~~ Fishery Conservation and Management Act of 1976  
Forest and Rangeland Renewable Resource Planning Act  
Highway Beautification Act of 1965  
Historic Preservation Act of 1966  
Housing and Community Development Act  
Land and Water Conservation Fund Act  
Marine Mammal Protection Act of 1972  
Marine Protection, Research, and Sanctuaries Act of 1972  
Migratory Bird Conservation Act  
Migratory Bird Treaty Act (1918)  
Mineral Leasing Act of 1920  
National Environmental Policy Act (1969)  
National Flood Insurance Act of 1968  
National Forest Service Organic Act (1897)  
Ports and Waterways Safety Act of 1972  
Resource Conservation and Recovery Act of 1976  
Rivers and Harbors Act of 1899  
Rivers and Harbors Act of 1917  
Rivers and Harbors Act of 1968  
Rural Development Act of 1972  
Safe Drinking Water Act of 1974  
Small Business Act  
Soil Conservation Act (1935)  
Solid Waste Disposal Act  
Surface Mining Control and Reclamation Act  
Toxic Substances Control Act of 1976

Water Quality Improvement Act of 1970  
Water Resources Planning Act of 1965  
Watershed Protection and Flood Prevention Act (WPFPA)

Federal Legislation with a Minor Impact  
(in alphabetical order)

Airport and Airway Development Act (1970)  
Airport and Airway Improvement Act of 1982  
Atomic Energy Act of 1954  
Commercial Fisheries Research and Development Act of 1964  
Energy Reorganization Act of 1974  
Energy Supply and Environmental Coordination Act of 1974  
Fish Restoration and Management Projects Act of 1950  
Wild and Scenic Rivers System

Federal Legislation with Marginal or Extremely Minor Impacts  
(in alphabetical order)

Agriculture and Consumer Protection Act  
Deep Seabed Hard Mineral Resource Act of 1980  
Deepwater Port Act of 1974 (as amended)  
Federal Water Power Act of 1920  
Federal Power Act (1935)  
Food and Agriculture Act of 1962 (RC&D)  
Hazardous Materials Transportation Act  
Interstate Land Sales Full Disclosure Act of 1969  
National Ocean Pollution Research and Development and Planning  
Monitoring Act of 1978  
National Wilderness Act of 1964  
Natural Gas Act of 1938  
Natural Gas Pipeline Safety Act of 1968  
Natural Gas Policy Act of 1978  
Noise Control Act of 1972  
Occupational Safety and Health Act of 1970  
Ocean Thermal Energy Conversion Act of 1980  
Ocean Thermal Energy Research, Development, and Demonstration Act  
Oil Pollution Act of 1961  
Outer Continental Shelf Lands Act (1953)  
Port and Tanker Act of 1978  
Public Health Services Act  
Shipping Act of 1916  
Submerged Lands Act (1953)  
Urban Mass Transportation Act (1964)  
Water Bank Act of 1970

PROGRAMS THAT AFFECT DEVELOPMENT  
AROUND THE ALBEMARLE AND PAMLICO SOUND  
December 14, 1986

Legislation in North Carolina with a Major Impact  
(in alphabetical order)

Agricultural Development Act  
Air and Water Resources Act  
Boating Safety Act  
Coastal Area Management Act of 1974  
Conservation and Historic Preservation Agreements Act  
County Service Districts Act  
Dredge and Fill Act  
Drinking Water Act  
Emergency Management Act  
Environmental Compact Act  
Environmental Policy Act of 1971  
Fisherman's Economic Development Program  
Forest Development Act  
Industrial and Pollution Control Facilities Federal Program  
Financing Act  
Industrial and Pollution Control Facilities Financing Act  
Metropolitan Sewerage District Act  
Metropolitan Water Districts Act  
Mining Act of 1971  
~~Mosquito Control Districts~~  
Municipal Service Districts Act  
Municipal Subdivision Control Act  
Municipal Zoning Act  
Natural and Scenic River System Act  
Nature and Historic Preserve Dedication Act  
Oil Pollution and Hazardous Substances Control Act  
Pesticide Law of 1971  
Recreation Enabling Act  
Regional Sewage Disposal Planning Act of 1971  
Regional Water Supply Planning Act of 1971  
Sedimentation Pollution Control Act of 1973  
Small Watershed Projects Act  
Soil Additives Act  
Soil and Water Conservation Districts Act  
Solid Waste Management Act of 1978  
Special Assessments Act  
Stream Sanitation Act  
Structural Pest Control Act  
Toxic Substances Act of 1979  
Water Use Act of 1967  
Watershed Improvement Districts Act  
Watershed Improvement Programs Act  
Well Construction Act (1967)  
Wildlife Resources Law

North Carolina Legislation with a Minor Impact  
(in alphabetical order)

Condominium Act  
Outdoor Advertising Control Act  
Park Commission Act  
Tax Increment Financing Act  
Trails System Act  
Water Safety Act

North Carolina Legislation with Marginal or Extremely Minor Impacts  
(in alphabetical order)

Advertising Control Act  
Air and Water Quality Reporting Act  
Airport Development Act  
Alien Property Act  
Annexation Act  
Archives and History Act  
Atlantic States Marine Fisheries Compact Act  
Balanced Growth Policy Act  
Bicycle and Bikeway Act of 1974  
Building Contract Act  
Carrier Act  
Cemetery Act  
City-County Consolidation Act  
Condemnation Act  
~~Connor Act (registration of conveyances)~~  
Corporations Act  
Dam Safety Law of 1967  
Energy Policy Act  
Engineering and Land Surveying Law  
Fiscal Information Act for Local Government  
Fraudulent Conveyance Act  
Gas Conservation Act  
Highway Safety Act  
Horizontal Property Act  
Housing Authorities Law  
Housing Corporation Act  
Housing Finance Agency Act  
Inheritance Tax Act  
Land Contracts Registration Act  
Land Policy Act  
Land Title Registration Act  
Local Government Bond Act  
Local Government Budget and Fiscal Control Act  
Local Government Fiscal Information Act  
Local Improvement Act  
Mine Safety and Health Act  
Mining Compact  
Municipal Corporations Act  
Municipal Finance Act  
Municipal Fiscal Control Act

Occupational Safety and Health Act of North Carolina  
Oil and Gas Conservation Act  
Public Building Contracts Act  
Public Transportation Authorities Act  
Public Utilities Act  
Public Utilities Commission Act  
Public Works Act  
Quarries and Mines Act  
Real Estate License Law  
Real Property Acquisitions Policies Act  
Right of Way Act  
Rural Electrification Act  
Sales and Use Tax Act  
Sinking Fund Act  
Southeastern Interstate Forest Fire Protection Compact  
Southeastern Interstate Low-level Radioactive Waste Management  
Compact  
Southern Growth Policies Agreement Act  
Southern State Energy Compact  
Supplemental Local Government Sales and Use Tax Act  
Transportation Authorities Act  
Unmarked Human Burial and Human Skeletal Remains Protection Act  
Use Tax Act

LOCAL TOOLS AND TECHNIQUES AVAILABLE  
FOR MANAGING DEVELOPMENT AROUND THE ALBEMARLE AND PAMLICO SOUND

Land Acquisition

Acquisition of Easements  
Advance Site Acquisition  
Transfer of Development Rights  
Compensable Regulation  
Inverse Condemnation

Public Spending

Capital Improvement Program  
Annexation  
Development Timing

Taxation

Special Assessment  
Preferential Assessment

Development Regulations

Legal Challenges to the Validity of Development Regulations  
Constitutional Challenges  
Ultra Vires Challenges  
Procedural Challenges

Regulatory Growth Management Tools

Interim or Temporary Development Regulations  
Conventional Zoning  
Minimum Lot Size Zoning  
Exclusive Agricultural or Nonresidential zoning  
Height Restrictions  
Aesthetics and Land Use Regulation  
Conditional and Contract Zoning  
Special Exception  
Bonus and Incentive Zoning  
Floating Zones  
Performance Zoning  
Planned Unit Development and Cluster or Average Density Zoning  
Subdivision Regulations  
Subdivision Regulations Relating to Off-Site Facilities  
Population Caps  
Official Mapping  
Maximum Lot Size  
Building Inspection  
Annual Permit Limits  
Regulation of Mobile Homes  
Local Environmental Impact Ordinances

\*\* For more information on these local tools and techniques, see the attached appendix, "Development of Growth Management Systems for North Carolina".

