VI SUMMARY

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A. THE STUDY

During the last decade, the U. S. Environmental Protection Agency has organized and co-sponsored "management conferences" on estuaries of national concern. These conferences of federal and state environmental regulatory and management agencies were organized to respond to public concern arising from the perception that some of the nation's prominent estuaries are in serious decline in spite of a plethora of laws and regulations enacted in the 1970's to protect them. The Albemarle-Pamlico Estuarine System of North Carolina was designated as one of the estuaries of national concern in 1987. A series of activities was initiated and was scheduled to culminate in 1992 with a comprehensive management plan to more effectively manage the system to reverse the perceived trend of degradation. This technical report is a preliminary analysis of status and trends that will serve as the precursor for development of the comprehensive management plan.

This report attempts to synthesize the existing information about the Albemarle-Pamlico Estuarine System and to assess the status and trends of probable causes apparent in the system. This technical study has been summarized in a general interest document suitable for public use. Specific objectives of the preliminary status and trends analysis project, therefore, were:

1. To develop an outline for each of four broad areas of concern: Critical Areas (Chapter II), Water Quality (Chapter III), Fisheries Dynamics (Chapter IV), and Human Environment (Chapter V); and to set up a mechanism for analysis and summarization;

2. To direct the attention of an organized group of the state's top experts in each area toward developing a consensus of the status of each;

3. To generate a narrative of the status and trends, including an analysis of probable causes, of the four key areas and to test the conclusions against technical experts, organizations and leaders of public opinion; and

4. To publish the current information in a technical document that can later be used to develop a final "Status and Trends Report" and to create a general interest summary for public use.

This exercise was approached through a series of work sessions in which the experts available provided their ideas about the status and trends of issues facing the estuary. Data files available to and utilized by these experts form the basis for the technical analyses. Technical quality was emphasized more than completeness--i.e., it was concluded that it is far better to relate an accurate picture than to include every shred of data that has ever been collected.

It should be emphasized that the content of this report is a "preliminary technical analysis" of the status and trends. It will serve as the base from which a concentrated and extensive analysis of status and trends will be developed during the fourth year of the study. Subsequently, a comprehensive management plan will be developed from the status and trends analysis.

B. THE SETTING

The Albemarle-Pamlico Estuarine System (A/P System) is one of the largest and most important in the United States. With approximately 2,900 square miles of area, the complex is the second largest estuarine system on the East Coast of the United States, exceeded in area by only the Chesapeake Bay. The estuarine system comprises an extensive complex of creeks, rivers,

swamps, marshes and open water sounds dominating northeastern North Carolina. Tributaries originating in the Piedmont serve as conduits to a major geographic portion of North Carolina and southeastern Virginia. Albemarle Sound is the drowned portion of the Roanoke River and its extensive floodplain. Other major, lateral tributaries of Albemarle Sound include the Chowan, Perquimans, Little, Pasquotank and North Rivers on the north; and the Scuppernong and Alligator Rivers on the south. Pamlico Sound is the drowned portion of the Tar and Neuse Rivers and their extensive floodplain. Several small, lateral tributaries drain off the low, flat, swampy coastal area; with the largest one being the Pungo River on the north.

Neither sound is directly connected to the Atlantic Ocean: both are behind extensive barrier islands referred to as the "Outer Banks". Albemarle Sound has three open-water estuaries at its eastern end that are parallel to the ocean and Outer Banks--the freshwater Currituck Sound to the north and brackish Croatan and Roanoke Sounds to the south. Albemarle Sound is connected to the ocean through Croatan and Roanoke Sounds via Pamlico Sound. As a result, Albemarle Sound is strongly influenced by freshwater and only marginally by the ocean. Pamlico Sound is connected to the ocean through several inlets including Oregon, Hatteras, Ocracoke, Drum, Bardon and Beaufort. These tidal connections exert considerable oceanic influence on Pamlico Sound.

Albemarle Sound and Pamlico Sound, as well as Core, Bogue and Currituck Sounds, are the focus of the Albemarle-Pamlico Estuarine Study and therefore this report. The study area extends upstream in tributary basins to the seaward-most impoundment, or if there is no impoundment, to the upstream boundary of the drainage basin, or if the basin extends into Virginia, to the North Carolina-Virginia state line. The seaward limit of the study area is the Atlantic Ocean shoreline.

C. RESPONSE TO ENVIRONMENTAL CONCERNS

Definite changes have taken place in the Albemarle-Pamlico Estuarine System in recent years--hence, the designation as an estuary of national concern. Early in the study, the Albemarle-Pamlico Estuarine Study Work Plan identified a series of environmental conditions that concern scientists, management agencies and the public. There is a general impression that events of concern have become more frequent, and conditions that cause definitive environmental problems are not well understood. The purpose of this summary is to relate our findings to those concerns previously identified.

C. 1. Declines in Fisheries Production

The fisheries resources of the Albemarle-Pamlico Estuarine area are very important to the state and region. Commercial fishing is one of the oldest industries in North Carolina, having its genesis in colonial times. Recreational fishing is a more recent, but rapidly growing component of the coastal economy. Often, both commercial and recreational fishermen seek (or take as by-catch) the same species, thus giving rise to conflicts between these two groups. The increasing demand for fisheries products and recreational pursuits has resulted in potential declines by over-fishing and/or destruction of habitat by certain harvesting techniques. Changes in land use, increases in pollution loadings, and physical perturbations have impacted habitats--all of which negatively impact fisheries yields. Habitat types in the Albemarle-Pamlico Estuarine System include one of the largest coastal freshwater sounds in the country, major anadromous fish spawning and nursery grounds, large areas of sea grass meadows, vast expanses of adjacent and diverse wetlands, and nursery grounds for most of the economically important species on the East Coast. More than 90% of North

Carolina's seafood catches are dependent on the vast, shallow sounds and the multitude of embayments and tributaries around the sounds.

The longest fisheries data base is are the commercial landings statistics, which extends from 1880 to the present. Commercial landings data are generally used to indicate levels and trends in fisheries primarily because they are the longest consistent record available. Landings data, however, are influenced by many factors, such as market demands, price, fishing effort, weather, availability of alternate species, regulations, stock abundance, and validity of reporting, which may render them questionable as indicators of fish stocks. In any case, they characterize the various fisheries and provide insight into fishing trends relative to the various factors which influence the statistics. Unfortunately, very little long-term data exists for recreational fisheries catch.

A fisheries management issue needing immediate attention concerns the collection, assimilation and analysis of the fisheries data base to determine the true status and trends of the fishery resource. Commercial landings indicate drastic declines in most of the anadromous fish (Albemarle Sound) during the past 30 years, but the yield of migratory fish (Pamlico Sound) have fluctuated. While there have been declines over certain periods (e.g., the 1980's), it is unclear if total fisheries resources have in fact declined.

North Carolina allows a wide variety of fishing activities with relatively little regulation, compared to other states. As a result, the Albemarle-Pamlico Estuarine System is one of the most intensively fished areas on the Atlantic Coast. Large numbers of people fish, both commercially and recreationally, for a wide diversity of species and use a large variety of gear. As expected, this intense utilization results in highly volatile management issues. Arguments over the allocation of species and fish to commercial versus recreational interests has intensified in recent years. In addition to commercial versus recreational conflicts, user conflicts often occur between different commercial harvesting sectors.

Impacts on fishery habitats, including fishing practices as well as pollution and physical alterations have increased. Trawls, clam kicking, and mechanical dredging all disturb the bottom. Nursery areas and critical wetlands habitats have been destroyed and/or altered. The impact of by-catch on subsequent stock levels has been recently questioned. Unfortunately, no quantitative relationships between these "perturbations" and fisheries yields have been developed.

C. 2. Sores and Diseases

Epidemic disease was first reported in the Albemarle-Pamlico Estuarine System in the 1970's, when there were massive kills of largemouth bass and white perch and smaller kills of other species in Albemarle Sound. Dying fish frequently had extensive skin lesions, which were referred to as "red sore". During the summer of 1975, as much as 50% of the commercially harvested fish in Albemarle Sound was affected. Levels of the observed bacterial invader, *Aeromonas hydrophila*, apparently correlate with levels of several water pollution indicators, although no direct correlation to the onset of red sore with any known indicators has been described.

More recently, other types of diseases have been recognized in Currituck Sound and Pamlico Sound (and its tributaries). In the winters of 1981 and 1983, southern flounder from the Pamlico and Pungo Rivers exhibited lesions, which significantly declined when the water warmed in the spring. An epidemic of severe ulceration of largemouth bass was reported for Currituck Sound during the winter and spring of 1986-1987. The most common disease currently affecting fish in the

Albemarle-Pamlico Estuarine System is ulcerative mycosis, a fungal infection especially affecting Atlantic menhaden. First reported in the Pamlico River in 1984, it has since been reported for the Neuse River, New River and Albemarle Sound. The disease has also been reported in several species other than menhaden, and it seem that other species are affected when menhaden epidemics are at their peak.

While lesions on finfish have been most intensively studied in the area, problems with shellfish have also recently been documented. In 1987, a shell disease was reported on blue crabs in the Pamlico River. The shell lesions in the Pamlico River blue crabs were reported to be very aggressive, frequently penetrating the carapace and rendering the crab unsalable. The shell lesions were more prevalent on the south side of the Pamlico River where cadmium and fluoride concentrations in the sediments were relatively high.

Disease problems have also recently (1988) been reported in oysters. Core and Pamlico Sound oysters were infected by MSX and Dermosystidium, both of which are fatal. These pathogens have now spread to oysters in other areas. Toxic dinoflagellate blooms in the fall and winter of 1987 resulted in mortalities of bay scallops.

Definitive causal relationships between diseases and sores and environmental factors have not been established, but declining water quality has been implicated. It is evident that finfish and shellfish are exposed to abnormal stresses in certain areas.

C. 3. Anoxia-Related Fish Kills

There are no systematic data regarding fish and benthos kills in North Carolina estuaries, although most fish kills have been attributed to low concentrations of dissolved oxygen. In most cases, measurements of dissolved oxygen have been made after a kill is reported so that precise determination of circumstances at the time of a kill is difficult. Commissioning of the Pamlico Environmental Response Team (PERT) may help close the time gap between reporting and investigation of fish kills and may thereby generate more pertinent information. Comparisons among 23 estuaries in North Carolina, South Carolina and Georgia, indicate that the Pamlico is not unique nor are there prolonged periods of impact. Lack of long-term data for these systems makes it impossible to determine exactly how much impact cultural eutrophication has had on the dissolved oxygen conditions.

Bottom water dissolved oxygen concentration is controlled primarily by climatic and hydrologic factors in the Pamlico River Estuary, the only area where studies have been conducted. There has been no trend toward lower dissolved oxygen concentrations over the past 17 years of record. Low bottom water dissolved oxygen (anoxia) does not occur in the estuary when water temperatures are lower than about 20°C. Above 20°C, dissolved oxygen values of less than 1 mg/liter were found in about 20% of the samples from the upper estuary, but in only 4% of the samples from the lower estuary. Salinity stratification prevents mixing of the bottom water with surface water, which prevents aeration of the bottom water, leading to anoxia. Anoxia can become established in a short period of time during summer; and, conversely, can be dissipated very quickly if mixing occurs.

There is little or no evidence to support the notion that the Albemarle-Pamlico estuarine sediments are quantitatively much different today than they were in past decades and centuries, nor is there evidence that they are functionally different. Anoxic and other adverse water quality episodes have probably been common in past decades, as they are today. However, long-term data upon which to base arguments regarding changes and trends in sediment characteristics and

subsequent water quality impacts simply are not available. In any case, the precise relationship between pollutant loading and pollutant concentrations in sediments is unknown since the role of recycling has not been quantified.

C. 4. Changes in Distribution Patterns of Benthic Organisms

Beds of submerged aquatic vegetation (SAV) occupy the shallow waters immediately behind the barrier islands (seagrass meadows) and some of the tributaries along the mainland side of the Albemarle-Pamlico Estuarine System. Distribution of the SAV varies greatly in space and through time. Near the inlets, and in higher salinity water, the SAV is composed largely of eelgrass and cuban shoalgrass. In waters of somewhat lower salinity, widgeongrass may predominate; and in slightly brackish to fresh areas, wild celery, Eurasian watermilfoil, or a mixture of pondweeds and related species may occur. Currituck Sound once contained dense growths of native SAV's, which were largely replaced by Eurasian watermilfoil during the 1960's and 1970's. The milfoil decreased dramatically during the latter 1970's and was replaced in turn by widgeongrass (a native plant). Similarly, SAV was common in the Pamlico River until the mid-1970's, decreased to about 1% of its former concentration by 1985, and has since recovered to some degree. Seagrass meadows near the Outer Banks have remained relatively stable in their coverage during the past 20 years, although mechanical shellfish harvesting and land-use changes have caused local perturbations.

Studies have indicated that SAV is a very important habitat and food source for many important estuarine organisms. The bay scallop, for example, is dependent upon seagrass meadows for its propagation and survival. However, quantitative links between SAV and secondary productivity are generally unknown.

Declines in the SAV in the tributary areas (e.g., Pamlico River and western Albemarle Sound) are thought to be caused by increases in turbidity of the water. Causes of increased turbidity are thought to be water quality related (i.e., increased algae growth in response to nutrient additions and increases in suspended solids). Available evidence indicates that the increases in nutrient loading seen during the past have been reversed and that the actual loading rates today are declining. Perhaps this could explain some of the reasons for SAV recovery in recent years.

There is considerable interest in the commercial benthic assemblages (i.e., bay scallops, hard clams and oysters), but they do not constitute a significant feature of Albemarle Sound. Distribution and abundance patterns of bay scallops are virtually unknown, although they seem to be intimately related to seagrass meadows. Hard clams are limited in their distribution by salinity, with populations almost restricted to eastern Pamlico Sound and Core Sound. Hard clam abundance is strongly impacted by harvesting pressures and techniques that harm the bottom habitat, both of which have apparently decreased the abundance. Oysters, which require a hard substrate in mid-salinity waters, have recently moved upstream in response to drought conditions. The incidence of MSX and Dermocystidium has dramatically increased since 1988, probably as a result of the hot, dry 1988 summer. Consequently, there has been a dramatic decline in oyster populations. Some shellfish areas are closed to harvesting due to the occurrence of pathogens (as indicated by coliform tests).

Assemblages of benthic animals serve as food for many important finfish and shellfish. In some areas, especially the Pamlico River Estuary, anoxia results in massive die-offs. The benthic population, however, seems to recover during the fall and winter recruitment time when the water does not experience extensive anoxia.

C. 5. Impairment of Nursery Area Function

Nursery areas are those shallow, protected waters where post-larval and juvenile fish and shellfish development occurs. Primary nursery areas are generally located in the upper portions of tributaries and embayments around the sounds and rivers. They are generally bordered by marshes. Primary nurseries are used mostly by organisms which arrive in late winter and spring from ocean spawning grounds and leave by summer. Transport mechanisms are related to wind-induced tides and currents in combination with larval behavior.

Primary nursery areas were first designated in 1977 by North Carolina Marine Fisheries Commission regulations. Designation is based on the occurrence of certain concentrations of specified species. Immediately downstream from primary nursery areas, the secondary nursery areas are larger, deeper waters containing high numbers of mixed sizes of organisms. Most juvenile organisms leave the primary nursery areas during the summer, occupying the secondary nursery areas until they migrate offshore with declining temperatures in the fall.

Because primary nursery areas are located in the upper reaches of estuaries and are characterized by low salinity, they are very easily impacted by activities on adjacent uplands. Variations in freshwater inflow resulting from land drainage or an increase in the area of impermeable surface can alter the velocity and magnitude of salinity changes. Sediments from land clearing and development activities can reduce light penetration and suffocate benthic organisms. Nutrients and other pollutants originating from septic tanks or industrial and municipal point sources and non-point sources can increase production of frequently unwanted plankton or decrease other organisms through toxic effects.

Although there are regulations which can be used to reduce such impacts, the degree to which any perturbation is limiting primary nursery area functioning at any particular time is difficult to demonstrate due to the complexity of the estuary and synergism among environmental factors. While there are many pieces of evidence that primary nursery areas are sensitive to environmental alterations and impending threats, no definitive analysis of environmental or fish population trends in the nurseries has been completed. Because of the tremendous importance of the primary nursery areas to the continued propagation of fish and shellfish, protection of these sensitive areas must continue.

C. 6. Eutrophication

Among the vast suite of nutrients essential for primary production, nitrogen and phosphorus have been of most concern as "limiting factors" controlling eutrophication. Accelerated eutrophication is of environmental and economic concern. Frequently, serious water quality degradation in the form of uncontrolled nuisance algal blooms accompanies accelerated eutrophication. To varying degrees, symptoms of eutrophication have affected many tributaries of the Albemarle-Pamlico Estuarine system, with fully developed cases being observed in some. In all cases, enhanced sediment and soluble nutrient loadings have been identified, or suspected, as causative agents for some forms of water quality degradation.

Sources of pollution are generally grouped into two categories--point sources and nonpoint sources. Point sources of pollution enter a stream or estuary at a discrete location (or point), usually a discharge pipe. Point sources are composed of municipal and private wastewater treatment facilities. These facilities must obtain a National Pollutant Discharge Elimination System permit from the N. C. Division of Environmental Management which limits the amount of pollution

that may be discharged to a given water body. In contrast to point source pollution, nonpoint source pollution is that which enters waters mainly as a result of precipitation and subsequent runoff from land or percolation through the soils–primarily from what has been disturbed by man's activities. Nonpoint source pollution is addressed through a combination of regulatory, cost incentive and voluntary programs. Point sources contribute about 15% of the North Carolina nutrient inputs to the Chowan, about 505 to the Neuse, and about 18% of the nitrogen and 7% of the phosphorus (TexasGulf, Inc.) to the Tar-Pamlico.

In 1988, the N. C. Division of Environmental Management conducted a water quality assessment of the Albemarle-Pamlico study area as part of the statewide Nonpoint Source Assessment (NSA) Report to determine impacts from nonpoint sources of pollution. Using information from "monitored" (based on ambient data) and "evaluated" (based on information other than site-specific data, such as complaints or professional judgement) segments, overall water quality ratings were assigned to nearly all stream and estuary segments. Nearly half (49%) of all stream segments in the A/P study area were judged to be unimpacted by nonpoint sources of pollution, while nearly 40% were partially or seriously impacted (11% were not evaluated). In the estuarine portion of the study area, about 93 of the segments were unimpacted by nonpoint sources. It should be noted that unimpacted indicates that the segment in question met water quality criteria for the designated use.

Trends in land use and nutrient loading over long periods of time were estimated for two major tributaries of Pamlico Sound. Estimates were made for the Neuse River basin by summing computed estimates of annual point and nonpoint source loadings for each county during the period of 1880 through 1985. Twenty years (1967-1986) of data for the Pamlico River Estuary were synthesized. Both sets of data were subjected to a nonparametric trend testing to analyze for statistical significance and magnitude of trends. No such analysis has been done for the Albemarle Sound system.

Despite the scarcity of open-water nutrient and productivity data, a reasonably diverse and comprehensive data bank has been established for some of the main tributaries; especially the Chowan, Pamlico, and Neuse River estuaries. The main forms of nutrient inputs are nitrates and phosphates (ammonia is more significant as an "internally cycled" nutrient). Nonpoint sources are thought to be the major contributors of both nitrates and phosphates, although point sources become more significant for phosphates than nitrates and during the summer nitrate from point sources becomes relatively more important.

Nitrogen, chiefly as nitrate, loading and cycling is a strong determinant in the regulation and ultimate limitation of primary production as well as bloom development in the freshwater tributaries and diverse estuaries examined to date. Accordingly, nitrogen loading and flux rates, as well as magnitude, timing and location of inputs, are of vital importance in assessing production and eutrophication processes in the estuarine portions of the study area. Phosphorus loading, cycling and utilization by phytoplankton, on the other hand, is quite a different picture. There are, indeed, quite high standing concentrations (comparable to other highly eutrophic, similar systems in the country) of phosphate in North Carolina coastal waters. Whereas inorganic nitrogen is often rapidly depleted during summer phytoplankton growth periods, phosphate concentrations act in a much more conservative fashion, indicating both excess supplies and a general lack of phosphorus limitation. Furthermore, phosphorus is effectively recycled between sediments and the water column, assuring the maintenance of sufficient supplies of phosphate during periods of maximum phytoplankton demand (exceptions may occur in the Chowan River during bloom periods when high algal biomass leads to parallel depletion of nitrogen and phosphorus). Phosphorus appears to have

limiting effects (i.e., additions provide stimulation of productivity in the presence of nitrogen) during the high runoff spring months when rapid dilution can occur.

Accelerated nutrient loading, particularly over the past 2 to 3 decades, has ushered in some ominous and increasingly common symptoms of eutrophication, which apparently were extremely rare prior to World War II. However, data to verify the trophic state of coastal rivers and estuaries prior to the mid-1960's simply do not exist. Trend analysis for the Neuse River estuary indicates that total phosphorus loadings from all sources increased about 60% during the past century, primarily due to point sources, and total annual nitrogen loading was estimated to have increased about 70% from both point and nonpoint sources. By contrast, total phosphorus levels in the middle of the Pamlico Estuary have doubled since 1967, with smaller increases both upstream and downstream sections. Nitrogen concentrations are very similar to that of the Neuse. No trend analyses have been performed on other estuaries in the study area. It is recommended that a long-term trend analysis be completed for the Albemarle Sound area. While significant progress has been made in recent years to reduce the nutrient loading to the Albemarle-Pamlico Estuarine System, continuing development and population increases threaten to bring the loading rates back to previous levels in a few years.

C. 7. Habitat Loss

The Albemarle-Pamlico Estuarine System has vast and diverse acreages of critical habitat that constitutes the foundation of the region's inherent wealth. Some of these are particularly important in sustaining its vitality. Habitats were assessed based on their role (1) in maintaining estuarine productivity, (2) as indicators of the environmental health of the region, or (3) of uniqueness, sensitivity to disturbance, or relationship to regional development.

Drastic losses and shifts have occurred in the brackish water submerged aquatic vegetation community. By contrast, the marine submerged aquatic vegetation community appears relatively stable, at least since the recovery of eelgrass from the "wasting disease" of the 1930's. The number of applications for permits for development activities that could potentially affect the seagrasses is increasing, and mechanical harvesting of clams and bay scallops continue to threaten the stability of the seagrass communities. It has been established that the submerged aquatic vegetation serves as critical habitat for several important animals.

Indirect impacts are more subtle and difficult to assess. These effects center around changes in light availability to the plants by changes in turbidity. Turbidity, which results from upland runoff with suspended solids or nutrients, causes decreases in SAV growth and hardiness. This is the primary cause thought to have affected the decline in SAV in the upper estuarine areas.

Coastal wetlands, consisting of tidal salt marshes, tidal freshwater marshes (or swamps), nontidal brackish marshes, fringe swamp forests and nontidal freshwater marshes, receive attention because of the many biological, geomorphical and hydrological values they provide for society. The Albemarle-Pamlico region has one of the most extensive and diverse assemblages of this type of habitat anywhere. In spite of this preponderance of habitat types, the North Carolina systems have received surprisingly little study. It is not possible to judge whether the rate of loss of these wetlands is increasing because of the lack of accurate information for the past; although, the available observations indicate that North Carolina has lost several thousand acres over the recent years.

Tidal salt marshes, because of the high level of protection afforded them, are not likely to suffer future losses as a result of direct impacts like dredging and filling. In addition, the technology for creating new marsh is very advanced. Rising sea level and inlet stability are the primary threats to tidal salt marshes.

Nontidal brackish marshes seem to be stable now, but we do not know the extent of alteration or how alterations are distributed among geographic areas. Analysis could be very easily done by using aerial photography. In many areas, the marshes have been ditched for mosquito control and impounded for waterfowl management. These wetlands are protected by the same mechanisms used for other wetlands. The influence of rising sea level on these and associated ecosystems should be considered in all projections.

Fringe swamps have been harvested for timber. It is likely that they were the first to be cut during colonial times because water provided access. In many places now, poor stocking may make these forests of more limited timber value, especially where shoreline erosion has exposed gum-maple-bay assemblages of smaller trees. Regulatory mechanisms are in place to protect the fringe swamps, but it is doubtful that they receive the level of surveillance that coastal marshes get.

The lack of consistent, comprehensive studies precludes precise identification of historical acreages of riparian forested wetlands and pocosins in the Albemarle-Pamlico area, but the geographic extent is significant. Forested wetland losses have occurred at a high rate on a national basis in recent years, but this may not be the pattern in the A/P region. Dredge or fill of these important habitats are regulated and mechanisms are in place to use them. However, general permits, jurisdictional disputes and categorical exclusions, particularly for silviculture, have contributed to wetland losses.

Going from navigable waters of the United States upstream and inland, one encounters a continuum from strong federal involvement and generally effective overall regulation to almost exclusive local control and fewer restrictions. Construction on lands beneath navigable waters of the United States, extending inland to the mean high water line in tidal waters or the ordinary high water line in nontidal areas and including contiguous wetlands, is regulated by the U. S. Army Corps of Engineers under provisions of the River and Harbor Act of 1899 (33 USC 401, 403). Dredging in coastal waters also requires a state permit (NCGS 113-22). Upland and inland from this zone, deposition of dredge and fill material in other waters and wetlands without a Corps permit is prohibited by Section 404 of the Clean Water Act (33 USC 1344). Much of the same area is included within Areas of Environmental Concern (AEC's) identified by the Coastal Resources Commission under provisions of North Carolina's Coastal Area Management Act (CAMA) (NCGS 113A-101 et seq.). Development in such areas requires a permit from the N. C. Division of Coastal Management. Discharge of pollutants into these areas is similarly regulated by a combination of federal and state laws, generally implemented through permits issued by the N. C. Division of Environmental Management.

A number of activities, which may have profound effect on critical habitat areas, escape the regulatory matrix. Nutrients, pesticides and other pollutants may enter these areas through diffuse overland flow or other nonpoint sources without regulation, although Section 208 of the Clean Water Act (33 USC 1288) and Section 319 of the Water Quality Act of 1987 (33 USC 319) address this subject. Many interior wetlands are not protected against destruction unless fill is involved, and neither the state or nation has legislation directly addressing the wetland issue.

C. 8. Shellfish Closures

When the potential for pathogenic infections in humans from consuming shellfish increase to a certain level, the N. C. Division of Shellfish Sanitation requires that the waters affected be closed to public harvesting of clams and oysters. This level is based on the estimated concentration of "fecal coliforms", which are used as indicators of real pathogens. There are over 300,000 acres of coastal waters closed to shellfishing on either permanent or temporary basis. Only about 50,000 to 90,000 acres of this total are considered to be productive shellfish bottom. The area closed has remained relatively constant over the past few years, down from a high of about 500,000 acres in the 1960's.

The source of pathogenic contamination is the waste from warm-blooded animals. Pathogens enter coastal waters via treatment plant outfalls, percolation from nearby septic tanks, and runoff from uplands inhabited by humans and certain other animals. Often, after heavy rains, several thousands of acres of shellfish production area may be contaminated (therefore, closed) for a period of time. Regulations exist to help prevent land activities that would contribute to pathogenic contamination during runoff events. Most of the closure areas are outside the A/P Study area, but Core and Bogue Sounds, and several small embayments, are affected.

New techniques to more accurately measure contamination and potential human impact have been developed, but have not yet been implemented at the state and federal levels. Their implementation might enable management to more effectively allocate shellfish resources. Relationships between contamination and land-use characteristics are poorly understood.

C. 9. Toxicant Effects

The first detailed study of the metals and toxins in the Albemarle-Pamlico Estuarine System is underway. The first phase, heavy metal pollutants in the Pamlico River estuary, has been completed. The Neuse River estuary and Albemarle Sound will be completed by the end of 1990. The Albemarle-Pamlico Estuarine System is not thought to be severely contaminated relative to estuarine systems in more populous areas of the country, but several "hot spots" have been identified.

C. 10. Increasing Population and Development

The Albemarle-Pamlico Study area has traditionally been rural in its character and is relatively sparsely populated. The diverse and tremendous natural resources, however, are attracting more and more people to the area. Population growth rate is far exceeding the state average, in both the North Carolina and Virginia segments. Building, services, transportation and sales are also increasing at a very rapid pace. These activities, along with increases in population and activities in the drainage areas, are imposing strains upon the governments, facilities, services and natural resources of the A/P region.

The changes and rates of changes are not evenly distributed in the area. Carteret, Dare and Currituck Counties are among the most rapidly growing counties in the state. Related activities are also rapidly increasing the these counties. Increases in recreational populations, when added to the increasing permanent population, have dramatically affected some areas, especially Dare County. There are instances of water supply limitations, groundwater declines and contamination, problems with waste disposal, and drastic changes in land-use to accommodate additional dwellings.

Indirect uses of the area are increasing faster than direct uses, and seem to have profound impact in some areas. And, as the population continues to increase, these trends are expected to continue.