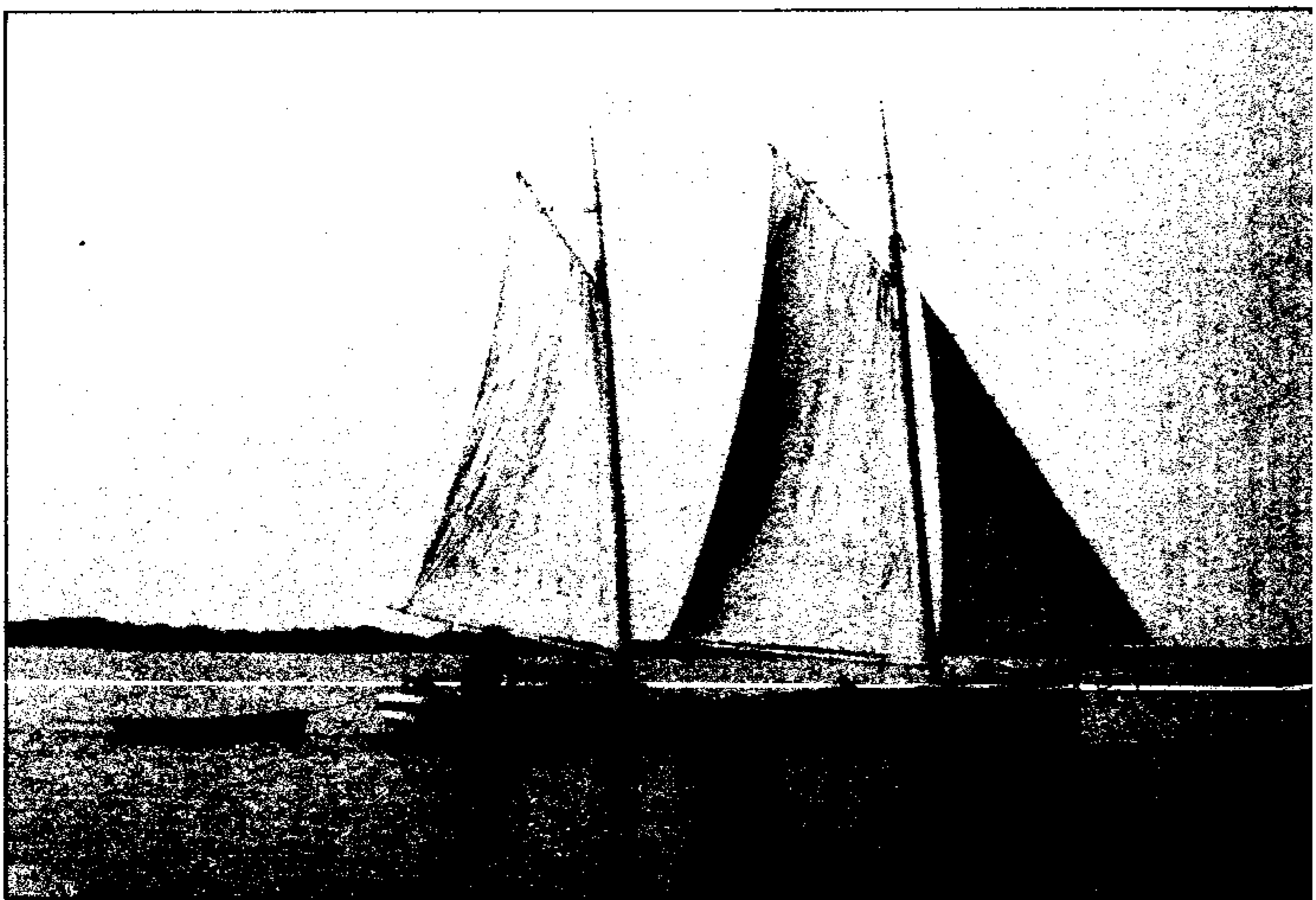
Albemarle Sound Trends and Management

Proceedings of a Conference At The College of the Albemarle March 3, 1982



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ALBEMARLE SOUND -- TRENDS AND MANAGEMENT NEEDS

Proceedings for a Conference

at the

College of the Albemarle
Elizabeth City, North Carolina

March 3, 1982

Sponsored by

University of North Carolina Water Resources Research Institute

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Division of Environmental Management

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Coastal Resources Commission

Albemarle Basin Task Force

N. C. Agricultural Extension Service

FOREWORD

The Conference on Albemarle Sound invited local leaders, government officials and scientists to review what is currently known about the sound and its tributaries and to consider management alternatives for dealing with pollution of these waters.

The Albemarle region has experienced a 74 percent decline in commercial fish catches over the past decade, and nuisance algal blooms on the Chowan River have lowered property values, discouraged tourism and caused fish kills.

In response to these problems, the North Carolina General Assembly appropriated funds for study of the problems and needs of the Chowan River and Albemarle Sound basins. The legislation, House Bill 747, called for the creation of an eight-member commission to conduct the study and report findings to the 1983 General Assembly. The North Carolina Department of Natural Resources and Community Development, currently conducting restoration work in the Chowan River, is expanding these efforts to include Albemarle Sound. The Department is to develop an action plan for the Albemarle by January 1983, outlining any immediate actions necessary as well as what is needed in the way of long-term studies or management plans.

This conference was intended to assist in these efforts by bringing into sharper focus the information available on the Albemarle system and providing a forum for the parties involved to communicate and begin determining what future restoration efforts are necessary.

These proceedings contain the individual presentations and group discussion from the conference.

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OPENING REMARKS

Robert F. Helms
Director, Division of Environmental Management
N. C. Department of Natural Resources and Community Development

I would like to welcome you all here this morning to a special Albemarle Sound Conference. As leaders interested in the future of the Albemarle region, you are being asked to participate in this conference--and I would like to emphasize participation. We hope that the presentations and discussions today will help us all obtain a better understanding of what is known about the sound and begin determining future restoration actions that may be needed to protect and improve its productivity. Before I proceed further, I would like to introduce a few of the key people making this event possible:

Dr. Parker Chesson - Host and Moderator
Dr. James Stewart - Acting Director, UNC Water Resources Research Institute, Co-sponsor
Dr. B. J. Copeland - Director, UNC Sea Grant Program, Co-sponsor

I would also like to introduce a distinguished group of gentlemen who make up what is termed the Chowan-Albemarle Legislative Study Commission. This Commission was established during the 1981 General Assembly with the passage of House Bill 747. They are specifically charged with studying the water pollution problems and water resource needs of the Albemarle Basin, with special emphasis on an evaluation of the on-going Chowan River restoration efforts. I will speak a little more on this during the afternoon session. The members of this Commission are:

<u>Senate</u>

Senator Melvin R. Daniels - Elizabeth City
Senator J. J. (Monk) Harrington - Lewiston

<u>Local Residents</u>

Mr. Stanley Watson Hege (Stanley) - Edenton
Mr. H. W. (Pete) Whitley - Murfreesboro

<u>Representatives</u>

Representative John Gillam, III - Windsor
Representative Vernon G. James - Elizabeth City

<u>Local Residents</u>

Lennie Perry, III - Colerain
David P. Bateman - Tyner

The Division of Environmental Management is furnishing staff support for this Legislative Commission.

The purpose of this conference is to emphasize the importance of Albemarle Sound to the growth and development of the region; to highlight trends in fishery resources, water quality and salinity, and to begin identifying any needed restoration actions. Specifically, the conference is designed to describe:

1. What has occurred in the system

2. What is known about it today

3. What could be done to improve the system

A healthy coastal sound and estuarine system is essential to continued growth of the industrial, fishing, shipping and tourist interests in the northeastern portion of North Carolina. Albemarle Sound is an important part of the large and extensive coastal water system, but developments and changes in the area have put pressures on this resource. There has been a 74 percent decline in commercial fish catches in the Albemarle region over the past ten years. Currently, production in Albemarle Sound is only about one-tenth that of the Pamlico. Areas that supported oysters, clams and crabs can no longer do so. As much as 50 percent of commercial fish catches are affected by red-sore disease. Nuisance blooms of algae plague the Chowan River and Albemarle Sound, lowering property values, discouraging tourism and causing fish kills.

Information and recommendations from this conference will suggest important water management alternatives. Some of these alternatives could, if pursued by state and local governments, natural resource leaders and others, bring about public policy changes needed to improve the productivity of Albemarle Sound.

We are confident that we can turn these signs of deteriorating water quality around, but to do so we must all work together. All facets of state and local government, as well as the residents of this basin, are needed in this effort to ensure the protection and enhancement of the area's valuable water resources. I feel this conference will be an outstanding success if we all begin to understand that the emerging water quality problems of this area are real, but not insurmountable, that decisions need to be made today to affect the type of environment that will exist tomorrow and, perhaps most importantly, that we must establish clear and open lines of communication among all of us participating here today. I hope you enjoy the activities planned for today and that we all leave with a better understanding of the current trends and future potentials for this region.

HISTORICAL PERSPECTIVE OF ALBEMARLE SOUND

David Stick
Historian

Any discussion of Albemarle Sound history should begin with mention of the following: Weapemeoc, the Sea of Rawnocke, Carolina River, the Bay of Albemarle and Albemarle River. For these, in sequence, are the names by which the present-day Albemarle Sound was known to the early explorers, settlers and map-makers.

Weapemeoc was the name applied by native Indians to the area above the sound comprising the present counties of Currituck, Camden, Pasquotank, Perquimans and Chowan when Sir Walter Raleigh's colonists under Ralph Lane, first explored the sound and its tributaries in the spring of 1586. Lane was the one who referred to the sound itself as "the broad sound of Weopomiok," and on a sketch map there is a notation in longhand that this sound of "Weopomiok" contained "freshe water with great store of fishe."

An Early Expedition

There is irony in the fact that Lane and his fellow explorers almost starved as they rode out a violent storm in their open boats at the head of the sound with this "great store of fishe" swimming about beneath them. It happened this way.

The colonists set out from their Roanoke Island base in three small boats to explore the sound and its tributaries, visiting Indian villages along the rivers feeding into the sound from the north and then moving on up the Chowan. There on the west bank they came to the Indian town of Chawanoac, city-sized when compared with others they had visited, for according to Lane it was "able to put 700 fighting men into the fields." Lane took captive the Chawanoac chieftan, a man he described as "impotent in his lims ... but otherwise, for a savage, a very grave and wise man." For two days Lane questioned this wise old Indian about the surrounding territories, and what he learned was enough to set him off immediately in the direction of a fabled land of mountains and gold said to be far up the River Morotico, today's Roanoke River.

It was an ill-fated expedition from start to finish. The spring thaw had begun, and the task of propelling the boats by paddle and oar was laborious and time-consuming. Worse still, the Indians residing along the river, obviously warned of the approach of these foreign invaders, had abandoned their villages and stripped them clean of all edible commodities. But even when Lane's supplies were exhausted, he and his men pressed on yet another day, having resolved that if necessary they could kill two large bull mastiffs, which were used as watch dogs, and prepare a "pottage" of sassafras leaves and fresh dog meat. They reasoned that this would give them sustenance for two additional days, which Lane figured "would bring them downe the current to the mouth of the river, and to the entrie of the sound," where he hoped to be able to take fish from the weirs of the Indians of Weapemeoc.

So the indomitable Elizabethans pressed on against the onrushing current of the flooded Roanoke River until, when their final meager reserve of corn had been eaten, emaciated and weakened in both body and resolve, they were suddenly attacked by Indians. After a brief encounter, the explorers escaped without any serious injuries. It was almost dark by then so they established a sheltered and protected campsite on shore in preparation for a rapid descent of the river at first light the following day. The dogs, companions and guardians, were called on for double service there on the river bank far up the Roanoke: guard duty that night and breakfast the following morning.

The English explorers reached the sound two days later, the stew of dog meat and sassafras long since consumed. By then, however, "the winds blew so strongly, and the billow so great," that, Lane said, "there was no possibilitie of passage without sinking our boats." It was Easter Eve, and Lane, suddenly turned humorist, noted that his men "fasted very trulie." The next morning the wind died down and they entered the broad sound, reaching the Indian village of Chipanum near Little River that afternoon where, as hoped for, they were able to catch some fish and stave off starvation.

If this account of Lane's Albemarle Sound expedition seems more detailed than necessary, you should understand that it has been done deliberately. For in order to put the history of the sound in proper perspective, it is essential to understand that for nearly four centuries since then, year after year, day in and day out, innumerable men and women--black, white and Indian--have had their own encounters with the sound. And its history is nothing more than the aggregate of all those personal experiences since the beginning of recorded time.

General Historical Perspective

The Algonkian Indians, the natives of what is now northeastern North Carolina, lived both by and on the sound and the rivers, creeks, runs and bays that flow into it. Almost invariably their villages were close to the water. There they could keep their canoes, hollowed out of giant trees, in the absence of iron and tools, using fire as their chisel and sharp shells as their adzes. Nearby, they could set their weirs or nets, for the most part consisting of labyrinths of poles and reeds, anchored to the sandy bottom and set out in intricate patterns to entrap the fish as they migrated. These nets were the forerunners of latter-day pound nets and set nets.

The sound was important in other ways. It was a political boundary, separating the Roanoacs on the south from the Weapemeocs and Chawanoacs on the north. Even more important for the Indians was its use for transportation, for the estuarine waters were their highways, and Albemarle Sound was Route A-1-A.

It was more than half a century after Sir Walter Raleigh's last Roanoke Island colony was given up as lost that white settlers began moving south from Virginia. They built their homesteads near the sound, as the Indians had done. And as they began to establish themselves, producing crops and products for export, they were able to sail their small ocean-going craft from sound to sea through two narrow inlets, Currituck and Roanoke. Both were in constant flux, new shoals forming and old ones disappearing with every storm and every fickle change of tide or wind. It was a delicate business, navigating those ever-shifting inlet channels, and numerous vessels and cargoes were lost in the attempt. Both Roanoke and Currituck Inlets have long since closed, but it is a commentary on the perennial problem of finding access from the sound to the ocean that their successor, Oregon Inlet, is no more stable now than they were three hundred years ago.

Raleigh's colonists had taken possession of the area in Queen Elizabeth's name in the 1580s, naming it Virginia in honor of their virgin monarch, but it was not until 1663 that Englishmen formalized the takeover from the native American Indians. That was the year in which eight influential associates and confidants of King Charles II were named "The Lord Proprietors of Carolina" and provided with a grant for all the lands between Virginia and Spanish Florida, extending far westward to the South Seas, or Pacific Ocean. One of the eight Proprietors was George Monck, the Duke of Albemarle; and those of us who pay special attention to words, revelling in the sound of those that roll off our tongues with a melodious rhythm, are thankful that in honoring the Duke his fellow Lord Proprietors chose not to change the designation of the Sea of Raw-nocke to Monck Sound, but named it Albemarle Sound instead.

For a number of years after 1663 there were only two settlements of importance in the Carolina colony, one around Charleston and the other here in the vicinity of the Duke of Albemarle's sound. George Monck, with this magnificent body of water already named for him, was further honored when this area was designated Albemarle County, with Indian names--Currituck, Pasquotank, Perquimans and Chowan--for its four original precincts. Later, as other counties were added south of the sound, it became common practice to refer to the Albemarle region as "the Northern Part of Carolina," a term subsequently shortened to "Northern Carolina " and finally to "North Carolina."

Throughout the proprietary period and for decades thereafter, Albemarle Sound was the hub and the heart of North Carolina. The great bulk of the colony's population was around its perimeter. The leaders of government lived here, and the assembly met here. Edenton, one of the colonial capitals, was the center of trade.

Coasters, small sailing vessels carrying cargo from the other colonies, frequented the area, as did larger sailing craft from the West Indies, many of the latter from Barbados, which became a sort of trans-shipment point for cargo from and to England. The main entrance from the Atlantic Ocean to the sound was Roanoke Inlet, in the vicinity of Nags Head. Though it was referred to as Port Roanoke, the collector for Port Roanoke had his office in Edenton, for almost all of the commerce was bound to Albemarle Sound and much of it to Edenton itself.

Early acts of the colonial assembly took cognizance of the shallow sound and meandering channels running through it, and duties were imposed on vessels and cargo to pay for maintaining beacons and stakes installed as channel markers. In one instance the fee was $2 for each incoming vessel.

The early Albemarle residents relied on the sound not only for export but for transportation from place to place within the colony, for the overland route from Virginia passed through and around a maze of swamps, including one called the Great Dismal. In time, however, trails were hacked through the forests and swamps. In the low boggy areas trees were cut up into logs, which were then laid and sometimes stacked to form the foundation for a roadway, with smaller logs and sand filling the spaces in between. These were the so-called "corduroy" roads, making it possible for people and cargo to be transported overland as well as by boat. There remained, however, the problem of how those travelling by wagon or carriage could get across the broad sound, but the solution came when a man identified as "T. Bell" established a toll ferry across the western reaches of Albemarle Sound. Subsequently, in 1735, Bell sold the operation to Colonel William Mackey, who operated the ferry for years from Edenton to what is now the community of Mackey's in Washington County.

Virgin stands of timber covered the Albemarle Sound area--juniper, cypress, oak and pine--all suited for ship and boat construction. The early residents not only built their own small craft, but in time established shipyards in which larger vessels were constructed. In addition, the native pine produced valuable naval stores (tar, pitch, turpentine and rosin), which became a primary export product of North Carolina. More and more land around the sound was cleared for agriculture, and plantations were established, some with buildings both elegant and palatial. Meanwhile, Albemarle Sound continued to produce valuable harvests of fish, as it had for the Indians.

Thus, a pattern was established that persists today in the Albemarle Sound region. Numerous communities and small towns, on and near the water; large agricultural operations fanning out from the towns; timber, that largest of renewable crops, providing raw material for local use and export as well, and the sound waters giving up that most edible of harvested commodities, fish--shad, rock, herring--especially, in the heyday of the industry, herring. These herring fisheries, dotting the sound shore, employed hundreds of men to set and haul the nets, some of which were more than a mile long, and women as well as men, mostly black, to clean and process the fish, salting them down for shipment. For Albemarle Sound herring and herring roe had won widespread fame as culinary delights.

Numerous tracts have been written on the spread of religion throughout the Albemarle, beginning with the dominance of the Quakers, and on the employment and treatment of slaves on the plantations and their traumatic transition from slaves to free men and women. Other aspects of the history have been detailed as well, covering the gamut of subject matter from architecture, town planning, navigational aids, agricultural advancements and transportation to life on the farms and in the towns.

A History of Perplexing Problems

Throughout its history, however, Albemarle Sound, for all of the advantages and bounties it provided, has been the source of perplexing problems as well, in almost every instance the result of a lack of planning or unwise treatment of its resources by those who used it. An integral part of the transportation system when the northern part of Carolina was populated by Indians and the early settlers, it has proved to be inadequate for use by larger modern vessels. Despite innumerable attempts to provide a stable outlet through the Outer Banks to the sea--beginning with the formation of "The Raleigh Canal Company" in 1787 for the express purpose of improving navigation of the sound and constructing an inlet, to be known as "Raleigh Canal," through the banks at Nags Head, to the current frustrating efforts to stabilize Oregon Inlet--the sound has lacked a deep-water port.

Though the production and processing of soybeans in this country had its beginning near the shore of the sound in Pasquotank, farmers still complain of ever-increasing expenses, deflated real-dollar prices and inadequate access to the markets. And commercial fishermen, at ease and at peace with the world and themselves only when on the water, are in ever-increasing numbers finding it necessary to turn to other pursuits, on dry land.

The people of the Albemarle, traditionally independent, have become adept at begging for government support, with the proviso, of course, that government should send in the aid and then withdraw, leaving the rest to the property owner and the private sector. But as the concentration of population has moved west, first to the interior Coastal Plain and then to the Piedmont, the once-compelling political influence of the Albemarle has diminished to the point where even the loudest voices of our politicians are seldom heard, and even less-frequently heeded, in Raleigh or in Washington.

In the process Albemarle Sound, throughout its approximately 50 miles of length from Kitty Hawk and Point Harbor on the east to the bluffs of Bertie on the west, has been in a continuing state of decline--its water flow affected by dams and withdrawal up the rivers, its water quality damaged by pollution and unwise use, its fisheries in decline, its bridges outmoded, its shore eroding and its people in poverty.

There have been innumerable meetings, seminars and conferences as well as untold numbers of petitions, investigations and reports on what is wrong with Albemarle Sound, all without meaningful results. Will one more such conference, even one focusing on trends and management needs, have any real effect in reversing this decline? Probably not. For those in attendance at such sessions, listening to the evidence of the experts and their dire predictions, have a tendency to do what the Indians and the colonists did and what residents of the Albemarle have continued to do throughout the ensuing centuries. They listen and get worried and ask questions and vow to do something--and then forget about it until some new crisis is cause for yet another study or seminar or conference.

ECONOMIC AND SOCIAL IMPORTANCE OF ALBEMARLE SOUND

Leon E. Danielson
Associate Professor, Department of Economics and Business
North Carolina State University

Introduction

This conference focuses on the water quality in the rivers and sounds of the Albemarle region. While these water resources are valuable to many users, the value in a particular use is dependent upon the quality of the water.

The overall purpose of this paper is to provide a framework for evaluating the social and economic importance of Albemarle Sound to the region. More specifically, a framework will be developed whereby the benefits and costs of water-quality improvement efforts might be estimated. Such a framework requires a recognition that there are many different water-quality problems in the area as well as many different users. An estimation of the benefits and costs to improve water quality must, therefore, include a thorough review of who is impacted by changes in water quality (those bearing the costs as well as those benefiting) and how the impact varies by the alternative solution being considered. Concentration on one alternative solution, or worse, on one beneficiary group, may result in the implementation of an inferior policy because of interdependencies between users. Thus, it is important to realize that there will be gainers and losers for any policy.

The Nature of the Problem

In the United States, navigable waters are owned by the public and are freely available for waste disposal, recreation, irrigation, municipalities and other uses by everyone. Although there may be a fee to treat the water to deliver it to your home, or to gain access to it through private land, there is no charge for the water itself. As a result, there is a tendency to use more of the resource than necessary. Since water bodies like the Chowan River and Albemarle Sound have a limited capacity to assimilate wastes and can become congested, overuse resulting from underpricing the resource can lead to resource degradation. The private market does not work in this case because correct price signals indicating the resource's value are not provided.

Further, once water quality has declined, there is no incentive to clean up the water individually or privately because (1) there are too many users to meet and agree on what should be done and (2) some affected users will not help in solving the problem because they know they will benefit from cleanup even without bearing any of the costs. Thus, in situations such as this, where the workings of the private market fail to maintain water quality, there often is a call for public policies to reduce the extent of water pollution. As leaders in the region, you have a key role in suggesting and analyzing such policies.

But several questions arise when considering alternative governmental policies to improve water quality. What are the benefits and costs of cleanup? How extensive should the cleanup action be? When does the last dollar spent for cleanup not return sufficient benefits to justify the expenditure? Who gains and who loses under alternative policies? These and similar questions need to be answered before public policies are established or public money is used to guide resource use.

Benefit-Cost Analysis

Procedures for estimating the benefits and costs of public projects were first developed in the 1930s to evaluate large-scale water supply, recreation and flood-control projects being proposed throughout the United States. Analyses of benefits and costs were explicitly required by the Flood Control Act of 1936 before federal monies could be allocated. In the years since then, procedures have been refined and modified, but measurement of the quality of the resource, in contrast to quantity, has seldom been adequately incorporated.

In the 1970s, environmental quality became of greater concern to citizens and policy makers, and benefit-cost analysis began to assess the benefits and costs of improvements in the quality of resources. Most of the early research was on the benefits of air-quality improvements. Few studies have addressed the benefits and costs of improving water quality. However, since the late 1970s there have been theoretical developments in the procedures for estimating benefits and costs of water-quality improvement; and while there are still few correctly done empirical studies, the theory for performing the studies is available. Valuation of water quality changes is still not easy, but it can be done.

Put simply, benefit-cost analysis is a framework or set of procedures whereby the benefits and costs of a project can be measured or estimated. Such measurement is designed to improve decision making by providing additional information on the advantages and disadvantages of alternatives. It is not unlike a cost-and-return project evaluation done by private enterprise, but in the case of benefit-cost analysis, the costs and benefits are more difficult to measure because a market for the goods and services often does not exist. Market prices of many inputs and outputs thus cannot be observed but must be estimated. The basis for valuing these nonmarket services and products of a resource project like improved water quality must still be based upon individual consumer and producer preferences because the value of the output of resource projects depends on the user's willingness to use and pay for that output or service. This, in turn, is dependent upon the gains and losses from the policy or project as perceived by affected individuals and firms.

Before turning to the task of identifying user groups that are impacted by changes in water quality, let me briefly mention four related issues and concerns. First is a general skepticism concerning economists' desire to place a value on each benefit and cost item that might result from a project. While quantification of benefits may not be feasible in all cases, an effort to estimate value whenever possible (1) makes it easier to compare alternative policies; (2) reduces the tendency to place an infinite value on services or projects which consumers, if actually given the choice, would perhaps forego, and (3) helps avoid overlooking some user benefits that may result from improved water quality.

Second, analysis of the benefits and costs of a water-quality improvement or other project provides information concerning the economic efficiency of the project but should not include value judgments related to the distribution of gains and losses from a project. Statements about the level and direction of the distribution of gains and losses can be made, but policy makers must ultimately decide between projects that differ in terms of who gains and who loses.

Third, it is necessary to differentiate between benefits that accrue at the local, regional, state and national level. In some cases, benefits at the local level may not be benefits to a larger geographical area because the new project may merely attract customers or users from elsewhere in the region where these benefits would register as a cost.

Fourth, it is essential that terminology be used appropriately. It is confusing if, for example, costs of pollution and costs of pollution control are referred to interchangeably. Further, pollution damages and pollution-control benefits often are used interchangeably. Choice of terms in this case depends on whether one starts from a polluted or pollution-free situation. If the water is currently polluted, movement to an improved-quality situation results in pollution-control benefits. If the water is currently clean, then movement to the new situation results in pollution damages. In this paper, the current situation in Albemarle Sound is taken as given so that improved quality results in costs of control to those helping clean up the water and in pollution control benefits to the users of higher-quality water.

Benefit Categories

Water pollutants directly and indirectly affect people in at least three ways: (1) their health, (2) their activities and (3) the cost and availability of goods and services. Controlling pollution impacts the magnitude of these effects, and benefits arise because of the value individuals place on reduction in the effects of pollution.

To identify the uses and values impacted by changes in water quality requi[illegible] at the outset that the resource be viewed in its totality. This ensures (1) that some cost and benefit categories will not be overlooked and (2) that trade-offs and interdependencies between alternative and perhaps competitive uses wil[illegible] be identified and incorporated in the analysis. In addition, it assists in organizing the analysis of changes in water quality because different valuation procedures must be used depending on whether water is an input in a production process or is used directly by the consumer. That is, the impact of water pollution or changes in water quality differs depending on how the water is used.

The following categories of use are worth considering separately:

In-Stream Uses	Withdrawal Uses
recreation	health
aesthetic and ecological	municipal
commercial fishing	industrial
	household

In-stream use involves use of the water in its natural location—the tributaries and the sound. Benefits are dependent upon the biological productivity of the water or upon use of the land and water in close proximity to its natural location. Water quality required varies for alternative recreational uses (such as swimming versus boating). There is no opportunity for the user to individually treat the water prior to using it. For example, someone swimming will come in direct contact with the water, and his satisfaction level (i.e., the value of the resource) will depend directly upon the quality of that experience. Estimation of the in-stream benefits to pollution abatement involves estimating the value such users place on the increased level of satisfaction gained from using cleaner water or upon the increased biological productivity of the water. In-stream use involves a very large quantity of water and a large number of users. Hence, both costs and benefits of in-stream pollution abatement will be large.

Withdrawal uses for industries, municipalities and households are quite different. First, they involve pumping water out of the natural water body through man-made facilities. Relatively small quantities of water are used, and because the water is confined in tanks, pipes, etc., there is potential for treating it before it is used. Second, water for most withdrawal purposes is used as an input in a production process and, therefore, has its impact on resource value through the quality or cost of the goods and services produced (rather than satisfaction level or biological productivity).

It is also clear that some of these uses preclude or are competitive with other uses, while others are complementary to one another or at least are not competitive. For example, industrial withdrawal (and eventual return) of water may conflict with recreational use if waste discharges are sufficient to degrade the water from the recreationists' viewpoint. More generally, upstream waste discharge can impact on all users downstream if water quality drops sufficiently. Recreational fishermen and the commercial fishermen may not compete with one another, although commercial fishing and sport fishing interests are often at odds. Values for some other uses move together with changes in water quality and do not compete for the waters' services (e.g., recreation, aesthetic and health uses). Thus, although each of these categories of use might benefit from improved water quality through implementation of pollution-abatement measures, stimulation of certain sectors may actually have adverse impacts upon another use because of interdependencies between use categories. Policy makers must often evaluate these trade-offs in their decision making.

Estimating Benefits of Improved Water Quality

How do we estimate the benefits of pollution abatement in the use categories identified? As discussed earlier, pollutants have direct and indirect effects upon people and things--on health, individual activities and satisfaction level, and on cost and availability of goods and services.

But to estimate the change in net benefits that occurs with pollution abatement, it is first necessary to know a great deal about the pollutants and the extent to which pollution abatement will change the rate or location of pollutant discharge into the waters of Albemarle Sound. Second, information must be available concerning the relationship between the changes in the discharge of pollutants into the environment and the change in the level of environmental services (such as the number of fish caught, scenic beauty, pleasantness of boating) or the change in water quality used to produce goods and services. This is often referred to as a dose-damage or dose-response function. Third, the improvement in the level of environmental services must be correlated with the change in willingness of individuals and firms to pay for the improved resource quality. This increase in the consumer's willingness to pay constitutes the proper measure of the benefits of pollution abatement. In a nutshell, estimating of the benefits of pollution abatement requires a great deal of quantitative information about the change in pollutant load, the resulting change in the water resource and, finally, the worth of those changes to consumers and producers.

There are two key points in this procedure that deserve explicit reemphasis. First, pollution abatement is a change in water quality, and hence, the benefits that result from that action are also changes from some base-level value of the resource. Total base value of the resource (such as total travel and tourism expenditures or total dockside value of the fish catch) is determined by many other factors besides the quality of the resource, including the number of similar areas in the region that are competitive with the resource and the social and economic characteristics of the population in the region. It is inappropriate to cite as benefits the total value from these economic sectors because those levels did not result solely from the change in water quality.

Second, it is inappropriate, for example, to use as a measure of benefits the gross change in travel and tourism expenditures in the area from a reduction in water pollution or the gross change in value of the commercial fish catch. An estimate of the change in gross value of the commercial fish catch is an overestimate of benefits to that sector because fishermen must incur expenses to harvest a larger catch and are only willing to pay the change in gross value of the catch less the change in their expenses. That is, their returns have only increased by the net value of their catch. The same is true for travel and tourism expenditures and other use categories.

To summarize up to this point, the benefits of pollution abatement are spread across several use categories and arise from: (1) improved health, (2) the willingness of individual consumers to pay more for water resources that for a variety of reasons yield greater satisfaction to them and (3) the willingness of producers to pay more for water as an input in their production process because the resource has more value to them. Also, to obtain estimates of the benefits of pollution abatement requires information on the current nature and extent of waste discharge and water pollution, on the change in water resource quality when pollution abatement occurs and on the extent to which individuals and firms translate improved water quality into benefits. Finally, the benefits counted must be changes in values occurring due to changes in water quality (i.e., not total base resource value) and must be net benefits above and beyond any increased expenses incurred by water users responding to improved water quality.

Let us now return to the general in-stream versus withdrawal classification scheme and consider individual categories of use under each. This will highlight reasons why resource valuation procedures will not be the same for all alternative-use categories and will allow for more detailed consideration of production and consumption changes that lead to changes in the level of benefits resulting from water quality improvement.

Withdrawal Benefits of Pollution Abatement

Recall that earlier the following benefit categories were identified as withdrawal uses of water: health, municipal, industrial and household.[1]

[1]Benefits to agriculture from water pollution abatement primarily occur where water is used for irrigation. Benefits arise if, before pollution abatement, the water was of too-low quality to allow irrigation or if it caused damage to the irrigation system.

The two characteristics that distinguish these uses from in-stream uses such as recreation are that the water is withdrawn from the water body through pipes and that it can be treated in small quantities before use.

Speaking generally and oversimplifying somewhat, health benefits are gained if pollution abatement reduces sickness and prolongs life. Municipal and household use of water involves withdrawal of raw water, treating it and piping it to the user. Each of these activities is costly, and more so if the raw water is polluted. Benefits from pollution abatement for these uses result from reduced costs of treating the water and from reduced maintenance or repair costs on the water distribution system. Industrial benefits result for similar reasons if the industries withdraw and process their own raw water.

Estimating the benefits of pollution abatement for municipal and household uses that produce water for final consumption is fairly easy and straightforward. Water quality standards dictate what quality must be maintained for these uses, and laboratory experiments can be used to estimate increased maintenance, repair and replacement costs for the treatment and distribution system.

However, estimating benefits to the industrial use category is not as simple as for the other withdrawal uses. It requires an understanding of how the industry responds to the onset of reduced water quality. The industry response would be to spend additional money for treatment, repair and maintenance of its water system. If this were the only change, the benefits of pollution abatement would be the amount by which these costs would be eliminated. However, other industry adjustments occur that make such an estimate incorrect. At the onset of pollution, the industry may do several things, including: (1) search for substitute piping and other materials to use in their water system that will not be affected by the increased pollution, (2) search for less expensive ways to treat the newly polluted water, (3) attempt to change their production process to minimize the impact of pollution or (4) change the product they produce. With these options, and with a goal of profit-maximization, merely using reduced treatment and repair costs would incorrectly estimate the true level of benefits because industry would adopt those measures that reduce the impact of pollution and keep their costs down. Short-run benefits of pollution abatement, then, are equal to the difference between these "adjusted" treatment costs and the treatment costs without water pollution. In the short run and if there are no changes in the level of price at which the output is sold, these benefits accrue to the industry because the profit margin (the difference between revenue received and costs to produce the output) has increased with control of pollution.

In the longer run, it is likely that both consumers and producers benefit. If the reduced costs of production cause the firm to increase the level of output, if a large number of firms are similarly affected or if new firms come into existence because they see the increased potential for profit now that water quality has improved, then the quantity of goods produced rises, the market price of the product or products produced may fall and consumers benefit as well as producers. The benefits of pollution abatement in this case are shared by consumers and producers.

But in the long run, we can carry the analysis one step further. If the increased net returns of the industry rise, providers of inputs may try to raise their prices. If the industry can adjust the quantity of the input used, the supplier of the input may not be able to get his higher asking price. However, if the firm cannot adjust the level at which the input is used, such as in the case of rented land upon which the industrial plant is built, then the owner of the land or other input can extract part of the increased return to pollution abatement from the producer. Hence, owners of such fixed inputs, as well as consumers and producers, may also benefit from pollution abatement.

To summarize, for withdrawal uses where water is used in production of a product sold in the market, pollution abatement benefits can be estimated, but it must be done carefully. Pollution abatement results in benefits that may be shared by consumers, producers and suppliers of inputs. Estimation of benefits requires inclusion of gains to all three groups.

In-Stream Benefits of Pollution Abatement

The in-stream use benefits of pollution abatement listed earlier were recreation, aesthetic and ecological, and commercial fishing. Recreation use includes activities such as swimming, camping, hunting waterfowl and sports fishing. Aesthetic benefits arise from casual passersby and improved physical properties of the water. Commercial fishing benefits arise from increased catches and quality of fish and shellfish that at some time during their life cycle are dependent upon the sounds and estuaries.

Fishery benefits are not easy to estimate because the biological data required to derive the "pollution dose-fishery damage" relationship are difficult to obtain. Recall from the discussion earlier that it is the "change in pollution-change in fishery" biological data that are required. If fish and shellfish populations decline, that portion of the decline due solely to pollution leads to fishery damages. The benefit of pollution abatement is the value of the increased catch occurring when pollution is reduced less the extra expenses incurred to harvest the increased catch. Simply looking at change in catch value is incorrect. If the total fishery is closed because of pollution, the benefits of water quality improvement are more readily available because harvest is zero before cleanup. However, even in this case, the reduced value of dockside catch from the closed area net of expenses overestimates fishery benefits from pollution abatement because with closure of the fishery many of the fishermen will relocate and increase the value of the catch in the new area. Others may shift to different species. Overall, while fishery benefits to pollution abatement may be large, back-of-the-envelope calculations may be incorrect.

The benefits of pollution abatement to recreation, aesthetic and ecological uses arise because individuals receive greater satisfaction and enjoyment from a less-polluted environment and are willing to pay more for use of the resource. At a particular site, benefits are greater because (1) more people may visit the site once it is cleaner and (2) people already visiting the site are likely to be more willing to pay for those visits than before the cleanup.

Recreational benefits from pollution abatement are probably greater than for any other use. Further, more studies have been conducted to value recreation benefits than for any other use. Yet, although recreation-valuation procedures in general have been greatly improved in recent years, valuation remains difficult because (1) a consistent water-quality index that indicates how individuals rate sites has not been developed, and (2) the relation between water quality at a site and an individual's choice to visit the site is not available. Data from most recreation studies have not included measures of water quality and, hence, cannot now be used for water-quality analyses. Also, past studies have often overlooked the importance of other nearby sites that are competitive for the recreationists' time and money. If there are many other similar sites available nearby, the response to pollution abatement at a particular site would be overestimated.

It is clear that the sum of expenditures from travel and tourism in the region would be an overestimate of pollution-abatement benefits because they are not related to the change in benefits occurring due to the change in water pollution. Further, there is need to exclude travel and tourism benefits that occur because of nonwater-related activities. These problems not withstanding, a correct evaluation of recreation benefits to pollution abatement in the Albemarle region could and should be made.

Aesthetic and ecological benefits arise with pollution abatement because an area becomes more pleasant to live in and visit. Also included are benefits from knowing certain habitats and species will exist because of pollution abatement even though the individual would never expect to see them (existence value), and benefits from knowing one has the option of visiting the site if desired (option value). The level of benefits would be indicated by an individual's willingness to pay for those attributes. One method of evaluating the level of aesthetic and ecological benefits is by analyzing property values. Holding other factors constant, land on a polluted water body is expected to be of lower value than land on an unpolluted site. Pollution abatement benefits would, thus, be related to the amount by which land values rise with the decrease in water pollution.

Local Benefits

The benefit-estimation framework and procedures presented earlier are designed to provide estimates of what individuals and firms would be willing to pay for improved water quality. Estimated benefits were based upon increased net returns to firms using the water as an input. They are based upon demand curves for resource quality.

In some cases, impacts across regions were suggested, as in the fishery where a reduction in dockside value of commercial fishery catch in one region might be partially offset by increased catch in another region. From a multiple-region viewpoint, the change in catch value might have little impact. The same could be said, for example, of pollution that pushed recreationists into another region.

However, the individual regions in these two examples would feel the impact of the changes in fishery catch and recreation visits because of the expenditures by recreationists and the dollar value of the catch in their area. In each case one region gains while the other loses. Thus, regions are interested in the possible shifts in resource use between regions that might result from pollution abatement in one or both of the areas.

The magnitude of the impact will also extend beyond the initial dollar expenditures and values identified above. Consider the recreation example.

A recreational visit to Albemarle Sound might entail spending money for gasoline, food and lodging. These are the initial or direct expenditures and are a measure of consumers' willingness-to-pay that is discussed throughout this paper. These expenditures provide income to the owners of those facilities. In turn, they hire people to help run their businesses and purchase food and other supply items as needed. To the extent labor and supplies are purchased locally, a second-round income effect occurs in the form of payments for this labor and goods. Recipients of second-round income also spend a portion of their income and wages. This creates a third-round effect. The process continues for several rounds with a portion of the transaction value lost outside the region in each round because of hiring labor from outside the region, importing food and supplies produced elsewhere, etc.

To estimate the total impact of direct (first-round) plus indirect (second- and later-round) impacts on the region when a sector like recreation expands, analysts use the concept of input-output analysis and the regional employment and income multipliers that are obtained from such a model. Sectors of the economy can be analyzed in as much detail as data will allow. Income and employment multipliers are estimated for each sector to show the extent to which growth in a sector stimulates the region's economy. For example, in a study of Yaquina Bay, Oregon (Stoevener, et al., 1972), it was estimated that a $1 increase in expenditures on marinas and marina supplies resulted in later expenditures of another $1.10 in other sectors of the economy. Although the input-output approach has limitations, especially when too much detail is incorporated either in size of the region or the number of sectors, the approach is useful as part of a more comprehensive analysis.

In addition to income and employment multipliers, regional effects can be analyzed for other changes such as property value, tax base and tax revenue. Analyses of county business patterns are useful to show changes in retail sales and employment by various sectors over the time when water quality was changing.

Costs of Pollution Abatement

This paper has concentrated almost entirely upon benefits of pollution abatement, in particular the categories of use that benefit and how the level of benefits might be measured. However, policy makers must recognize that there are also costs of pollution abatement that are borne by someone or some firm. In the case of Albemarle Sound, the costs of pollution control would be borne by those who must adjust the waste load being dumped into the water. The sectors bearing the costs would primarily be industries, municipalities and agriculture.

In this regard there are two issues: (1) if total benefits of pollution abatement do not exceed the costs, then society would be better off from an economic-efficiency standpoint if the pollution was allowed to continue, and (2) regardless of whether or not total benefits exceed total costs of abatement, the distribution of benefits and costs will likely be uneven, so that some will bear a larger share of the costs while others will acquire a larger share of the gains. The extent of the evenness is dependent on the degree to which the waste discharger has contributed to the water-quality problem.

In the Albemarle region, especially in the Chowan River area, considerable research effort in recent years has provided a great deal of information regarding nutrient loads in the river and the sources of the pollutants. Extensive efforts and expenditures of large sums of money have already been undertaken to reduce nutrient contributions by industries and municipalities.

But just as there is need to provide estimates of the benefits of water-pollution abatement in the Albemarle Sound region, there is also need to assess the magnitude and incidence of the costs of pollution abatement so that informed decisions can be made. Large improvements from a severe water-pollution situation can probably be made at relatively low cost. However, as cleanup proceeds, each incremental improvement will become more and more expensive. At some point incremental costs will exceed incremental benefits.

Regional Economic Development

Let us now look at regional economic development as a possible goal of pollution abatement. To some extent the benefits of cleaner water may lead to industrial development in the region. Recreational activities, which were noted to provide the largest share of pollution-abatement benefits, are dependent to a large degree upon visitation from outside the region. Demand for recreationally oriented industry would likely follow. Other economic activities of a manufacturing and nonmanufacturing nature might also increase.

However, it is essential that regional economic development goals be set realistically, with due regard to the complexities associated with industry-location decisions. Without going into detail, firms locate in areas where they can make a profit. If the characteristics of one region appear to provide the potential for more profit than another, that region will most likely be able to compete more effectively for that new firm. The factors that determine profit-making ability certainly vary by industry type, and firms look for different things. However, in general there will be several characteristics or features that are important, including the cost and availability of industrial sites, the availability of services and facilities (schools, fire protection, police protection, shopping facilities, etc.), energy availability and cost, transportation facilities, nearness to markets and raw materials, labor of sufficient skill and in adequate quantity and the quantity and quality of the water.

If a region is currently hindered by poor water quality, the reduction of pollution will increase its attractiveness in regional economic development efforts. However, the increased success in economic development will depend also on many other factors. If there are severe limitations relative to these factors, then improving water quality will have less economic development impact than if water pollution is the sole limiting factor. Of course, regional economic development may not be a major goal of the water-quality improvement effort in the region. In this case the existence of other industrial location bottlenecks would be immaterial.

Summary

Let me reemphasize some key points:

1. Water of high quality is an important and valuable resource in the Albemarle Sound region. There exist a wide variety of interdependent water-using activities that could yield benefits when water

quality in the sound is improved. Those cited include activities using water in-stream (recreation, aesthetic and ecological, and commercial fishing) and others that withdraw water before use (health, municipal, industrial and household).

2. Benefit-cost analysis, although it has limitations, can provide a framework for organizing data to more systematically evaluate the benefits and costs of a water-pollution abatement program. Recent improvements in procedures for analyzing the impact of water-quality changes reinforce the need for properly done analyses.

3. Analyses of the benefits of water-quality improvement cannot proceed without data showing (a) the nature and extent of pollution, (b) the relation between the change in waste discharge with pollution abatement and the quality of the services and products provided to users of the water and (c) the value of the improved water-quality services to firms and individuals.

4. It is the change in net benefits resulting from a change in water quality in Albemarle Sound that is of interest and not the total value of the industry or sector.

5. Finally, to give you an indication of the general magnitude of benefits estimated to be obtainable from improved water quality in the United States, let me present some national data from Freeman (1979a) on the benefits of meeting the 1985 requirements of the Federal Water Pollution Control Act. Although these are national data, the magnitude of the benefits suggests that the potential high benefits in local areas such as the Albemarle region deserve further analysis and consideration by decision makers.

Table 1. United States Benefits in 1985 from Removal of Conventional Water Pollutants (in billions of 1978 dollars)

Use	Range	Most Likely Point Estimate
Recreation	\$4.1 - \$14.1	\$ 6.7
Aesthetics, ecological property values	1.0 - 5.0	2.0
Health	0.0 - 2.0	1.0
Municipal	0.6 - 1.2	0.9
Industrial	0.4 - 1.2	0.8
Households	0.1 - 0.5	0.3
Commercial fisheries	0.4 - 1.2	0.8
Total United States	\$6.6 - \$24.8	\$12.3

Source: Freeman (1979a, p. xv).

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References

Feenberg, Daniel and Edwin S. Mills. 1980. Measuring the benefits of water pollution abatement, Academic Press, Inc., New York.

Freeman, A. Myrick, III. 1979a. The benefits of air and water pollution control: a review and synthesis of recent estimates. Report for the Council on Environmental Quality.

Freeman, A. Myrick, III. 1979b. The benefits of environmental improvement: theory and practices. Resources for the Future, Inc., Washington, DC.

Stoevener, Herbert H., Joe B. Stevens, Howard F. Horton, Adam Sokoloski, Loys P. Parrish and Emery N. Castle. 1972. Multi-disciplinary study of water quality relationships: a case of Yaquina Bay, Oregon. Sea Grant Special Report No. 348, Corvallis, Oregon.

ALBEMARLE SOUND ECOLOGY AND PHYSICAL CHARACTERISTICS

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Introduction

The Albemarle Sound estuarine system lies within the outer portion of the Atlantic Coastal Plain province, an emergent portion of the ocean's continental shelf. The Coastal Plain is generally a broad, low-relief surface that slopes gently seaward and is moderately dissected by the drainage patterns of the river systems. The incised streams, with their associated floodplains and swamp forests, in combination with the upland interstream divides, produce the major topographic relief; the relief decreases seaward as the Coastal Plain approaches sea level.

Albemarle Sound and its associated tributary estuaries represent a vast complex of fresh- to brackish-water creeks, rivers; and open-water sounds which are the northernmost components and constitute a significant portion of the North Carolina coastal system (Figure 1). The estuarine shoreline of the entire system is in excess of 500 miles in nine counties, including Bertie, Camden, Chowan, Currituck, Dare, Pasquotank, Perquimans, Tyrrell and Washington. Albemarle Sound is oriented approximately E-W and extends from the mouth of the Roanoke River, about five miles northeast of Plymouth, eastward about 55 to 60 miles to Kitty Hawk Bay and Colington Island on the Outer Banks. The main estuary gradually tapers from less than four miles wide at the Albemarle bridge in the western portion, eastward to over 14 miles wide in the area of the Alligator River on the south and the North and Pasquotank Rivers on the north. The Albemarle Sound estuarine system includes seven major embayed lateral estuaries and numerous small embayed laterals. On the north, the major lateral estuaries are, from west to east, the Chowan, Perquimans, Little, Pasquotank and North Rivers, while the Scuppernong and Alligator Rivers are on the south.

Albemarle Sound, the major trunk estuary in the Albemarle estuarine system, is in the Roanoke River drainage system. The main river in this drainage basin is the Roanoke, whose headwaters are in the upper Piedmont of Virginia and North Carolina. The river flows from 1100-foot elevations in the Piedmont highlands, across the generally flat Coastal Plain and becomes the Albemarle Sound estuary just northeast of Plymouth. The river system delivers relatively large volumes of fresh water but today carries a relatively small load of suspended clay sediments to the coastal system because of several major reservoirs on the river system.

Physical Characteristics

Land use in the lowlands surrounding Albemarle Sound is rapidly changing (Heath 1975). Although cultivated land in the state as a whole is decreasing in area, the number of acres under cultivation in the lowlands south of Albemarle Sound is increasing. Most of the mineralized soils have traditionally been farmed, but agricultural activities are now increasing in the shallow organic soils and some of the deep organic soils.

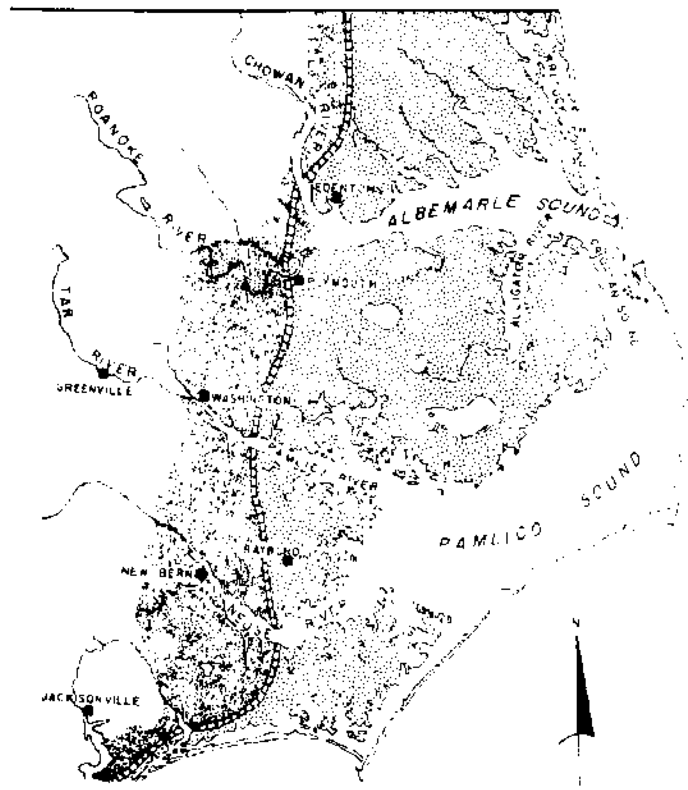

Figure 1. Map of the upper North Carolina coastal zone.

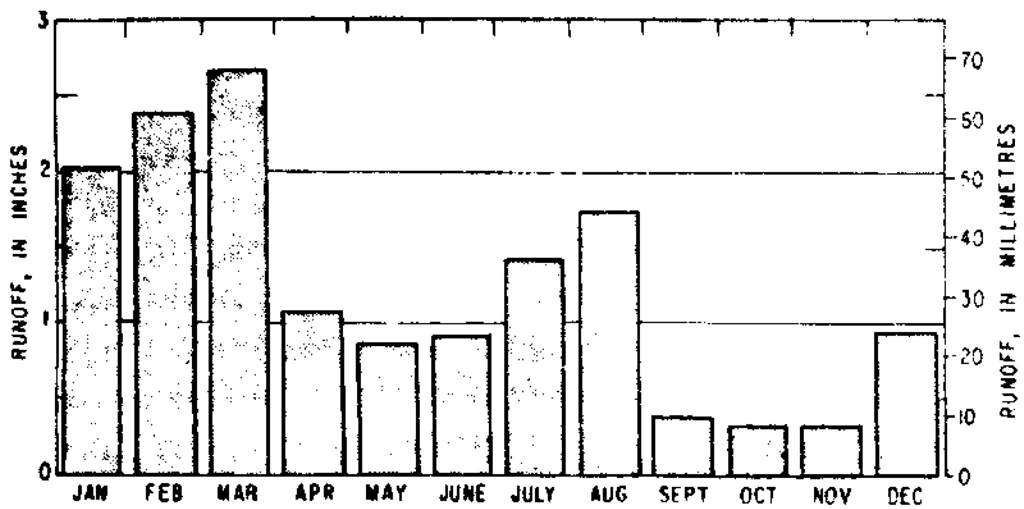

Figure 2. Average monthly runoff for streams draining the Albemarle region (from Wilder et. al. 1978).

In order to effectively cultivate the land of low elevation and high water tables, it must be effectively drained (Skaggs et al. 1980). With the increase in agriculture, there is now a network of canals finding their way to the estuary. Although there are more canals today, this is not a recent activity, since drainage was first initiated in the late 1600s (Lilly 1980). A company owned by President George Washington started the first large-scale drainage project on these soils in the 1790s. The latest period of increased drainage activity began in the early 1970s, when several large corporations became involved in clearing and developing thousands of acres of land in eastern North Carolina.

In general, land use around Albemarle Sound is limited by the fact that it is flat and low-lying and much of it is swampy. The general expense of draining the low-lying land will limit the variety of land uses available to that area.

The two major sources of fresh water into Albemarle Sound are the Chowan River and the Roanoke River. The average annual inflow of fresh water to the sound is approximately 17,000 cubic feet per second (Table 1). Over half that (8,900 cfs) is from the Roanoke River. The net inflow from the rivers entering Albemarle Sound other than the Chowan and Roanoke is about equal to the amount of water entering by precipitation.

Table 1. Gross Water Budget (in cfs) for Albemarle Sound (from Giese et al. 1979).

Month	Precipitation	Evaporation	Chowan Inflow	Roanoke Inflow	All Other Inflow	Net Outflow
January	2,800	1,000	6,500	10,000	4,200	23,000
February	3,400	1,700	9,100	12,000	5,900	28,000
March	2,900	2,200	8,600	10,000	5,600	25,000
April	2,500	3,400	6,600	11,000	4,300	21,000
May	2,800	3,900	3,700	10,000	2,400	16,000
June	3,600	4,200	2,600	8,500	1,700	12,000
July	5,400	4,100	3,000	8,000	1,900	14,000
August	5,000	3,500	3,500	7,500	2,200	15,000
September	4,300	2,800	3,000	6,500	2,000	13,000
October	2,500	1,800	2,200	6,500	1,400	11,000
November	3,000	1,400	2,500	7,500	1,600	13,000
December	2,600	900	4,400	8,300	1,300	16,000
Average Annual	3,400	2,600	4,600	8,900	2,900	17,000

Runoff (and, therefore, freshwater input) is not evenly distributed throughout a year and may be far less than average values for several months at a time (Wilder et al. 1978). The average monthly runoff for streams within the Albemarle Sound area is shown in Figure 2. These values are based on data collected over less than 10 years of continuous record and do not entirely define the flow variations when discharges are averaged over a month. Nevertheless, they indicate the general seasonal variations that might be expected. The amount of runoff is highest during the late winter and early spring months and lowest during the fall.

Before impoundments were constructed on the Roanoke River, the normal flow rate in the river was highest in the winter and lowest in the summer and fall. Comparing the mean discharge prior to impoundment with the water budget calculated for the river after impoundment indicates that the average flow rates in the wintertime are now slightly reduced and those in the summer are now slightly increased.

Winds and tides are the most important short-term factors influencing circulation and water levels in Albemarle Sound, with freshwater inflows from tributaries playing a secondary role (Giese et al. 1979). Easterly winds will tend to produce water levels lower in the eastern end of the sound and higher in the western end, whereas westerly winds usually have the opposite effect. Northerly winds tend to build the water level up along the southern shore and reduce the water level along the northern shore, whereas southerly winds have the opposite effect. Because of the shallowness of the basin, there is little vertical stratification except in the very low reaches of the estuary under certain calm climatic conditions.

The estuary is shallow, averaging only about 12 feet (Giese et al. 1979). The deepest portion is almost 30 feet, but most of the central area of the bay is little more than 18 feet deep. The total volume of Albemarle Sound is about 5,310,000 acre-feet.

The total average outflow from the sound (about 17,000 cfs) is larger relative to its volume (5,310,000 acre-feet) than that of Pamlico Sound (32,000 cfs and 21,000,000 acre-feet). This higher current strength is sufficient to more effectively block saline water from the system. Moreover, the sea water that does reach Albemarle Sound has already been diluted to almost half strength in Pamlico Sound. Thus, the salinity in Albemarle Sound is relatively low.

The aquatic environment of the Albemarle Sound estuary is typically oligohaline (Heath 1975; Bowden and Hobbie 1977). The average surface salinity of the Albemarle Sound estuary does not normally exceed about 5 ppt. It is generally lowest during the spring (Figure 3) and highest during the fall (Figure 4). Salt water seldom penetrates the estuary up to the mouths of the Roanoke and Chowan Rivers (Giese et al. 1979; Bowden and Hobbie 1977). Due to the shallowness of the estuary and its prevailing winds, intense stratification does not normally occur in Albemarle Sound.

Mean monthly temperatures in the Albemarle Sound estuary range between about 5°C during January to about 28°C during July and August. There are fluctuations in these averages so that the extremes in the estuary are as low as 0°C and as high as 30°C (Bowden and Hobbie 1977). Temperature is probably not a limiting factor for most organisms using the estuary.

Apparently there is adequate dissolved oxygen in Albemarle Sound throughout most of the year. Concentrations range from about 4 to 9 ml of O_2 per liter during all seasons of the year (Bowden and Hobbie 1977).

Nutrient Dynamics

Nitrogen and phosphorus are elements frequently considered limiting to phytoplankton productivity in natural waters, and nitrogen is generally considered to be the most limiting in Atlantic Coast estuaries (Kuenzler et al.

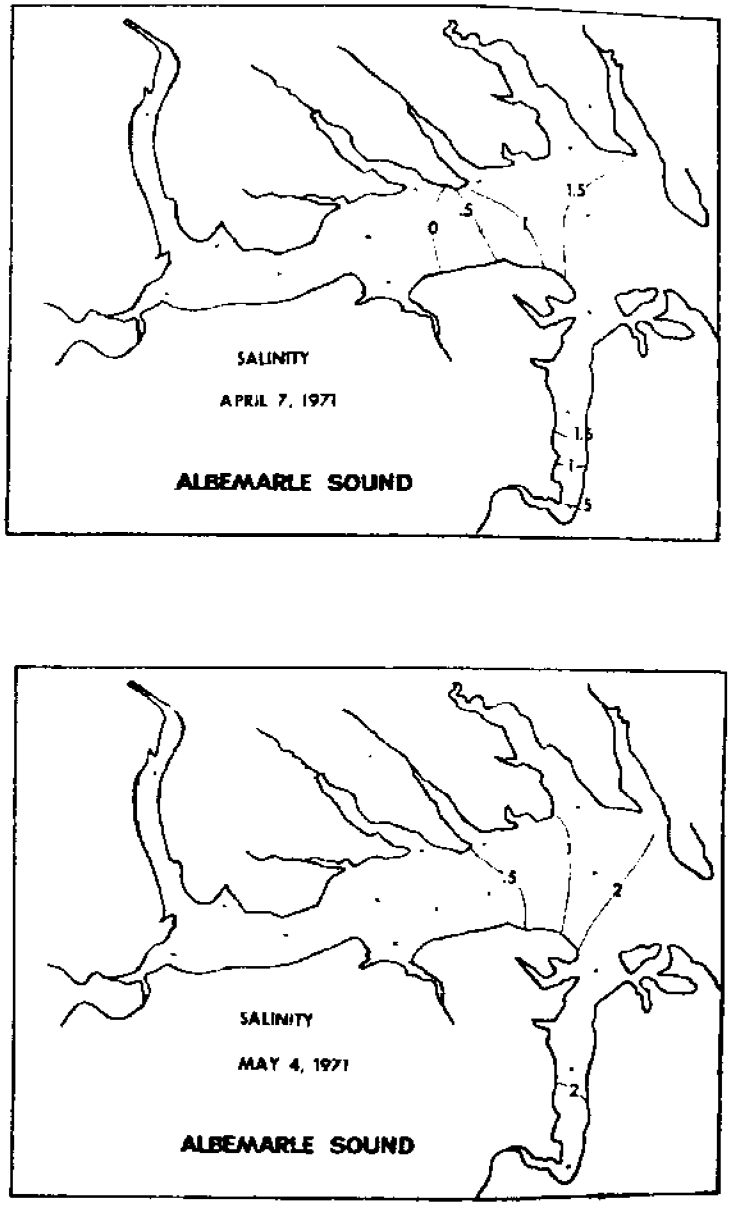

Figure 3. Surface salinities (ppt) in Albemarle Sound during April and May, 1971 (from Bowden and Hobbie 1977).

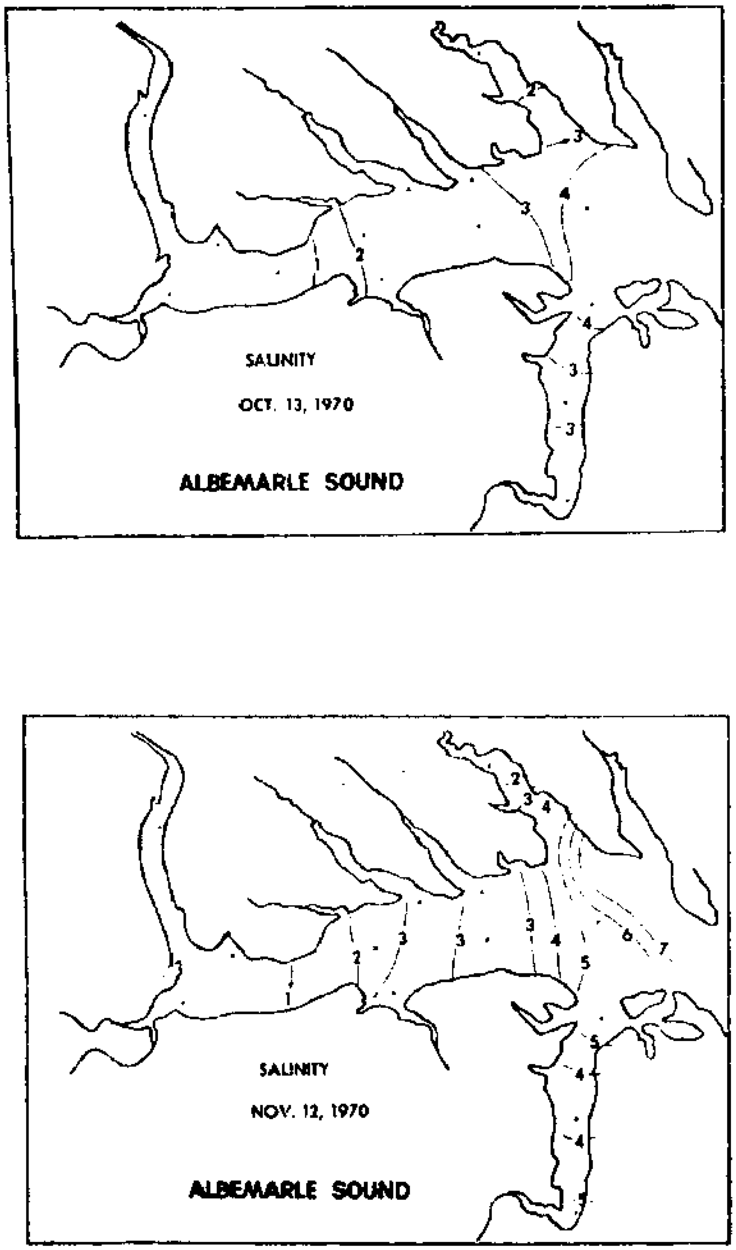

Figure 4. Surface salinities (ppt) in Albemarle Sound during October and November, 1971 (from Bowden and Hobbie 1977).

1979). Albemarle Sound has traditionally been thought to have supplies of both phosphorus and nitrogen for abundant phytoplankton growth (Bowden and Hobbie 1977).

The concentrations of total phosphorus in the Albemarle Sound estuary are variable in both time and space (Bowden and Hobbie 1977). In general, the higher concentrations are in the upstream areas, and the lower concentrations are in the sound itself. The greatest influx of phosphorus into Albemarle Sound occurs during the winter (Figure 5), and the lowest concentrations occur during the summer. Compared to other estuaries in North Carolina, the phosphorus concentrations in Albemarle Sound are relatively low (i.e., seldom more than 5 μg-at/liter), probably due to the low erosion rates in the Albemarle Sound watershed.

A diagram of total phosphorus concentrations in Albemarle Sound indicates that nutrients penetrate far into the sound from its tributaries (Figure 5). For example, the 5 μg-at/liter concentration plume penetrated 60 kilometers into the sound from the Roanoke River end. It should be noted that peaks in phosphorus concentration in the Pamlico and Neuse estuaries occur during the summer, whereas those in Albemarle Sound occur during the winter.

There is no proven criterion for the level of phosphorus that is unhealthy for an estuary. Ketchum (1969), however, suggests that most highly eutrophic estuaries on the East Coast have total phosphorus concentrations in excess of 2.5 μg-at/liter. Although total phosphorus is less abundant in Albemarle Sound than in the other North Carolina estuaries, this threshold is still exceeded on numerous occasions. Thus, one may conclude that phosphorus in the sound is high enough to create eutrophic conditions under the right circumstances.

In general, the concentration of nitrogen compounds in Albemarle Sound is high in the winter and low in the summer (Bowden and Hobbie 1977). Similar to the situation found in the Pamlico River Estuary to the south, most of the nitrogen inputs occur in the winter, while most of the nitrogen uptake occurs in the summer (Kuenzler et al. 1979).

Nitrogen is present in the water in several forms. The most abundant is nitrate, but there are significant concentrations of ammonia and nitrite. Organic nitrogen exists in both the dissolved and particulate forms.

Nitrate, the most abundant inorganic nitrogen form in Albemarle Sound, ranges between a trace and 80 μg-at/liter (i.e., about 5 mg/liter). Although a normal high concentration is about half that, the peak values of nitrate nitrogen indicate that the sound has enough nutrient input to support large-bloom conditions. The high concentrations of nitrate nitrogen present in Albemarle Sound during the winter (Figure 6) can generally be traced to the tributaries around the sound. Normally, the summer concentrations of nitrate nitrogen were relatively low, but in some years there was a strong increase by October (Bowden and Hobbie 1977). The inflow of nitrate nitrogen to the sound penetrated far into the estuary during the winter and early spring months. Quite high concentrations of nitrate nitrogen (i.e., above 0.5 mg/liter) exist in Albemarle Sound during about six months of each year.

This pattern is in substantial agreement with that reported by Stanley and Hobbie (1977), who intensively studied the lower Chowan River just before

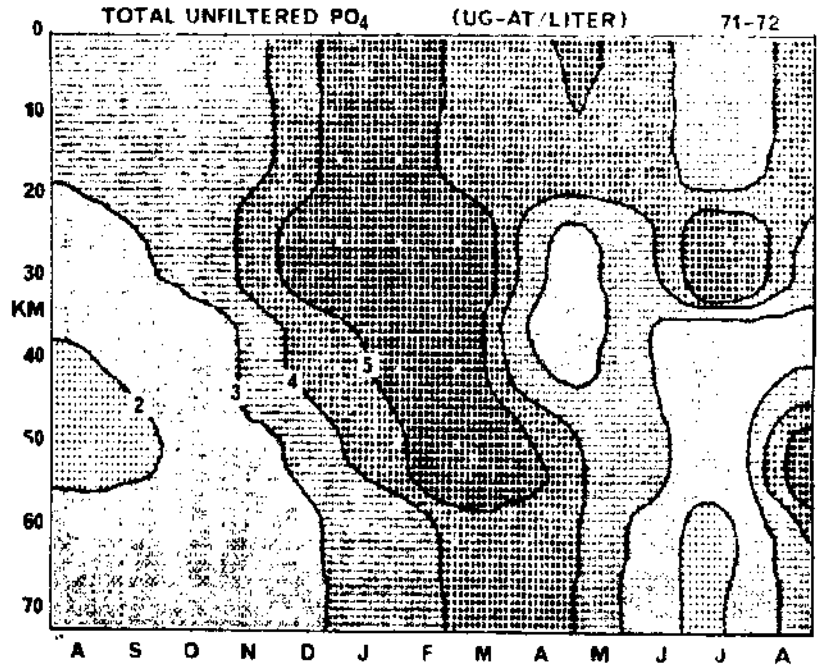

Figure 5. Annual pattern of total phosphorus (ug-at/liter) in Albemarle Sound during 1971-1972 (from Bowden and Hobbie 1977).

it enters Albemarle Sound. They found a distinct nitrate maximum during the winter and a minimum during the summer. They attributed this pattern to high winter runoff and high summer algal nitrate uptake. This pattern also agrees with a similar situation observed in the Pamlico River estuary (Hobbie 1974) and the Neuse River estuary (Hobbie and Smith 1975).

Ammonia nitrogen is also very important to algal productivity. Ammonia concentrations in Albemarle Sound have been found to be erratic both spatially and temporally. Again, the highest concentrations are found, in general, during the winter and the lowest during the summer (Figure 7). However, there are some secondary increases during the early fall and early summer periods corresponding to some temporary periods of high runoff. In general, ammonia nitrogen is more abundant in the mouths of the tributaries than it is in the sound itself, which is some evidence that the source of ammonia is from upstream in the tributaries.

In general, the ammonia nitrogen was somewhat less abundant than nitrate nitrogen, although the peak concentrations range as high as 50 μg-at/liter (i.e., about 1 mg/liter). Like the nitrate pattern, ammonia nitrogen concentrations were similar in the upper reaches of Albemarle Sound and the Chowan River (Stanley and Hobbie 1977). Seasonal and concentration patterns were similar to those of the Neuse River estuary (Hobbie and Smith 1975) and the Pamlico River estuary (Hobbie 1974).

Dissolved organic nitrogen may represent a very large portion of the total nitrogen pool in natural systems (Tusneem and Patrick 1971; Harrison and Hobbie 1974; Kuenzler et al. 1979). Recent evidence indicates that dissolved organic nitrogen may be about 90 percent of the total nitrogen available in estuarine waters. There is no reason to believe that Albemarle Sound does not follow this same pattern (Stanley and Hobbie 1977; Bowden and Hobbie 1977).

Detritus and Organic Carbon

Influx of detritus and organic matter from upstream sources is very important to an oligohaline estuary such as Albemarle Sound (Copeland et al. 1974). The highest concentrations typically occur at the head of the estuary and in the mouths of the many tributaries entering the sound. Concentrations of residue in the incoming water from the tributaries can be relatively high (Table 2). A very large percentage of the total residue settles out of the water once it reaches quiescent conditions. These materials settle to the bottom and become part of the bacterial/animal reworking that takes place in the sediments. The suspended residue is mainly dissolved organic and inorganic materials contributing to a relatively high biochemical oxygen demand (5-day BOD).

There is a large seasonal variability in the amount of organic carbon entering the estuary. The highest concentrations normally occur during late summer and fall, which corresponds to the die-off of plants on the watershed and in the streams and estuary.

With the number of streams entering Albemarle Sound, the total amount of freshwater input indicates that the sound receives very large loadings of detritus and organic carbon each year. It is not possible to separate the amount of materials coming into the system as to their sources. Likewise, data

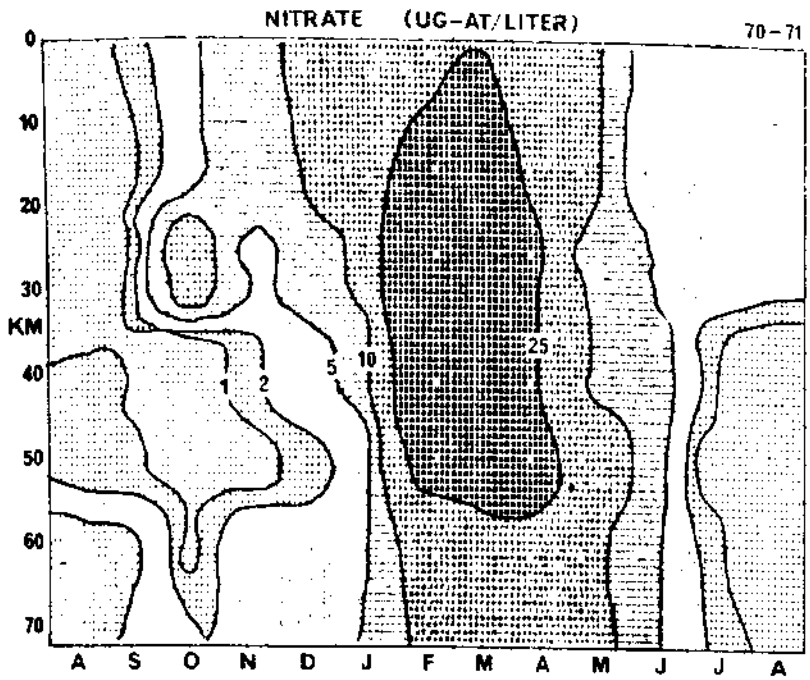

Figure 6. Annual pattern of nitrate nitrogen (ug-at/liter) in Albemarle Sound during 1970-71 (from Bowden and Hobbie 1977).

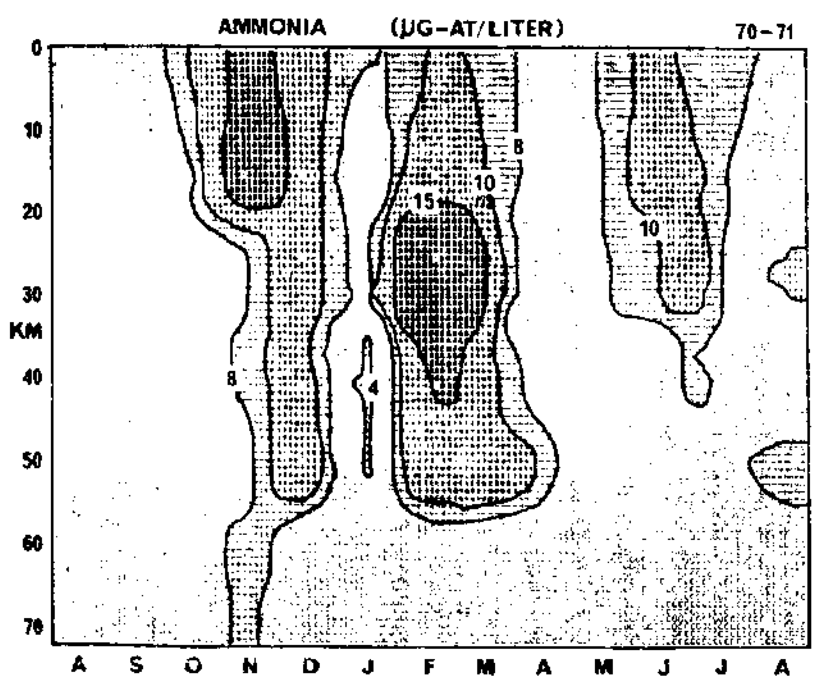

Figure 7. Annual pattern of ammonia nitrogen (ug-at/liter) in Albemarle Sound during 1970-71 (from Bowden and Hobbie 1977).

Table 2. Residue and BOD of Water Entering Albemarle Sound During 1974 in mg/l (from Heath 1975).

Constituent	Alligator River			Scuppernong River	
	June	August	November	August	November
Total Residue	240		1,610		762
Organic	138		320		170
Non-organic	102		1,290		592
Suspended Residue	47	14	26	49	493
Organic	21	10	22	6	87
Non-organic	26	4	4	43	406
5-Day BOD	3.5	1.7	2.3	1.8	1.6

do not exist to estimate the carbon use by sediment respiration and the amount stored in the sediments during the process of sedimentation.

Biological Systems

Phytoplankton

There have been no reports of direct phytoplankton cell counts in Albemarle Sound. Since the sound is typically oligohaline (i.e., below 6 ppt), it is reasonable to assume that the phytoplankton population is dominated by dinoflagellates, blue-green algae and diatoms (Copeland et al. 1974). Indeed, the Chowan River summertime blue-green algal blooms have been well known during the past few years (Stanley and Hobbie 1977).

Typically, the distribution of phytoplankton in Albemarle Sound is patchy and variable (Bowden and Hobbie 1977). The chlorophyll a reported by Bowden and Hobbie (1977) will be used to characterize the phytoplankton seasonality and distribution in the sound. Their reported values are corrected for phaeophytin and, thus, represent a simple estimate of the viable phytoplanktonic biomass. The numbers should be considered as relative because it is well known that the amount of chlorophyll per algal cell will change with changes in nutrient or light conditions.

Chlorophyll concentrations were lowest in the winter and highest in the spring and summer (Figure 8). The highest concentrations tended to appear in the tributary-dominated sections of the estuary, although there were some high concentrations in the lower estuarine section.

Bloom conditions have occurred in Albemarle Sound (personal observation), which may be controlled by flushing activities in the upper reaches. For example, the high-flow conditions after Hurricane Ginger in 1970 apparently washed many of the algae out of the sound, and the typical bloom did not occur in 1971 (Bowden and Hobbie 1977). By the following year, however, when the conditions had stabilized and as the temperature warmed in April, extensive blooms occurred throughout the sound (Bowden and Hobbie 1977). Therefore, the typical oligohaline estuarine conditions prevailed in Albemarle Sound, wherein blooms occur as a result of incoming nutrients and stabilized flow conditions but are occasionally flushed out due to increased freshwater discharges.

Attached Aquatic Plants

Typically, the submerged grasses play an important role in the primary productivity of an oligohaline estuary (Copeland et al. 1974). Generally, the submerged plants cover only a very small percentage of the surface area of the estuary but generally contribute a much larger percentage to the total primary productivity.

In the absence of reports on the submerged aquatics in Albemarle Sound, we can make some assumptions about their role there from the studies done by Zenkevitch (1963) on the Baltic Sea, which is one of the world's best examples of an oligohaline estuarine system. Submerged plants are generally more prevalent in the lower reaches of the estuary and become impoverished as one goes further up the sound to the tributaries.

Microbial Component

A major microbiological problem, commonly referred to as red-sore disease, affects the fisheries of Albemarle Sound (Esch and Hazen 1980). The implicated microbe for red-sore disease is Aeromonas hydrophila, a gram-negative bacterium found in fresh to brackish water (Hazen 1979).

The presence of the bacterium A. hydrophila, the causative agent of red sore disease, seems to be associated with high concentrations of decaying organic residue (Esch and Hazen 1980). The fact that the disease occurs in Albemarle Sound may be associated with the input of high concentrations of organic materials from some of the tributaries.

The threshold level of A. hydrophila is thought to be 40 colony-forming units/ml (Esch and Hazen 1980). This concentration is exceeded during the winter and spring (Figure 9) at several locations in Albemarle Sound.

Zooplankton and Benthos

No systematic studies have been made of the zooplankton and benthos populations of Albemarle Sound. The typical oligohaline estuary has a low diversity of these organisms, and their distribution is patchy (Copeland et al. 1974). We can assume, therefore, that patterns in the sound are similar.

There are some species that tend to thrive in great numbers in a stressful environment such as Albemarle Sound (Copeland et al. 1974). One benthic example is the Rangia clam, which grows in dense beds in the lower sound (N. C. Shellfish Sanitation Division). These animals have been harvested from time to time and marketed for the production of clam chowder (Chestnut and Davis 1975). In recent years, however, these clams have been shown to be heavily contaminated with a bacterial mixture that does not appear to be pathogenic.

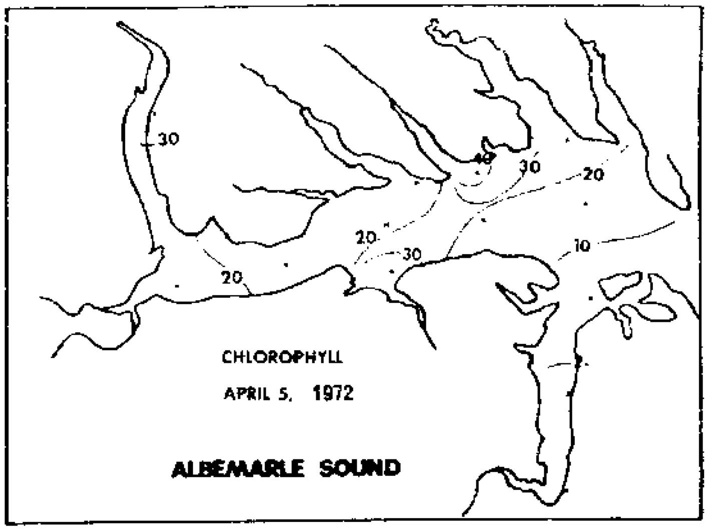

Figure 8. Chlorophyll a (ug/liter) in Albemarle Sound during April 1972 (from Bowden and Hobbie 1977).

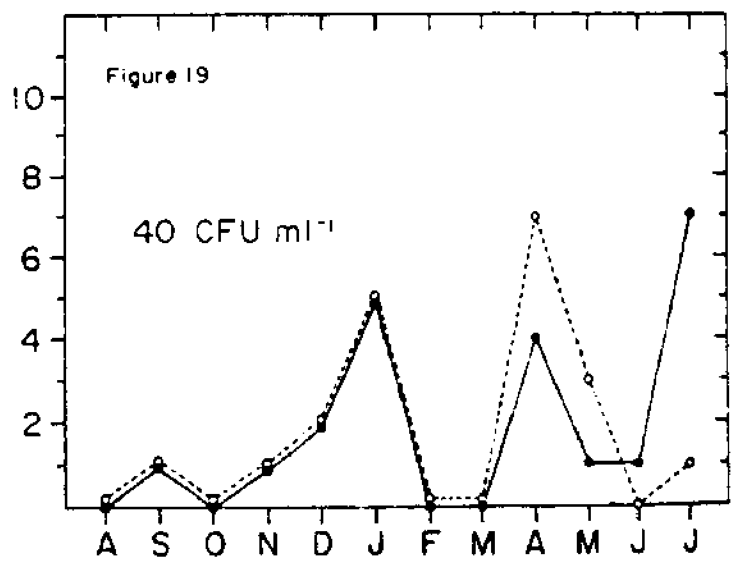

Figure 9. Number of stations (of 20) where the density of A. hydrophila exceeded the 40 cfu/ml threshold level (from Esch and Hazen 1980).

Nekton

The diversity of nekton populations in Albemarle Sound is relatively low (Hester and Copeland 1975; Hassler et al. 1981). The nekton is dominated by the bay anchovy, Atlantic croaker, white perch, blueback herring, hog-choker, white catfish, blue crab and spot (Hester and Copeland 1975). Hassler et al. (1981) found that young-of-the-year striped bass were also prominent in the western Albemarle Sound.

There is considerable variation of the nekton catch in Albemarle Sound over the past 25 years (Hassler, et al., 1981). The researchers reported catch-per-unit effort in the sound indicating orders-of-magnitude differences in the population density from one year to another.

Large seasonal fluctuations are evident for the Albemarle Sound nekton (Figure 10). There are two seasonal peaks in the numbers of nekton in the catch, with the highest occurring during the spring months of April through June and a secondary peak in late summer/early fall. The biomass peaks during the winter and again during the mid-summer season. When subdivided between the western and eastern portions of the sound (Figure 11), there is an obvious dominance by the western portion for the seasonal biomass distribution.

There are three behaviorally different nekton populations that characterize the sound and account for quantitative differences illustrated by the catch data (Hester and Copeland 1975). The indigenous population, occupying the extreme western sound area, is dominated by white perch, catfish and gizzard shad and makes up the large winter peak in biomass. A migratory population inhabits the eastern portion of the sound on a seasonal basis. This group is dominated by spot, Atlantic croaker, bay anchovies and blue crabs and makes up most of the spring population. The third group is the anadromous population, composed primarily of blueback herring and striped bass, which migrate into the freshwater streams to spawn during early spring and move down as juveniles into the estuary during early summer.

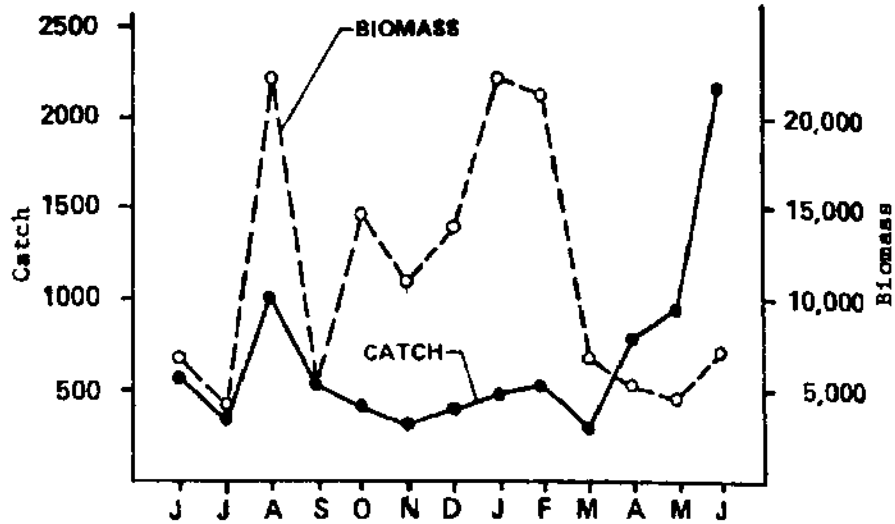

Figure 10. Catch and biomass of total nekton in Albemarle Sound (from Hester and Copeland 1975).

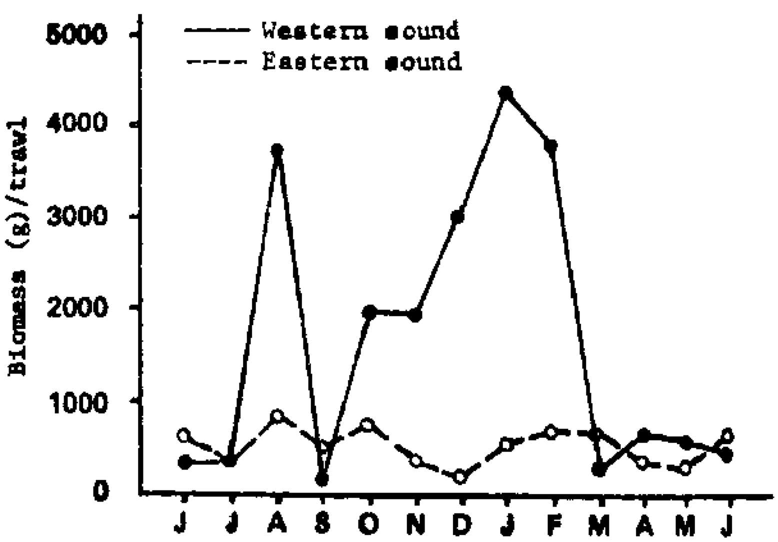

Figure 11. Nekton biomass/unit effort in western and eastern Albemarle Sound (from Hester and Copeland 1975).

References

Bowden, W. B. and J. E. Hobbie. 1977. Nutrients in Albemarle Sound, North Carolina. University of North Carolina Sea Grant College Program, Raleigh, NC 75-25:1-187.

Chestnut, A. F. and H. S. Davis. 1975. Synopsis of marine fisheries. University of North Carolina Sea Grant College Program, Raleigh, NC 75-12:1-425.

Copeland, B. J., K. R. Tenore and D. B. Horton. 1974. Oligohaline regime, p. 315-357. In (Odum, H. T., B. J. Copeland and E. A. McMahan, eds.) Coastal Ecological Systems of the U. S. The Conservation Foundation, Washington, DC.

Esch, G. W. and T. C. Hazen. 1980. The ecology of Aeromonas hydrophila in Albemarle Sound, North Carolina. University of North Carolina Water Resources Research Institute, Raleigh, NC 153:1-116.

Giese, G. L., H. B. Wilder and G. G. Parker, Jr. 1979. Hydrology of major estuaries and sounds of North Carolina. U. S. Geological Survey Water Resources Investigations. 79-46:1-175.

Harrison, W. G. and J. E. Hobbie. 1974. Nitrogen budget of a North Carolina estuary. University of North Carolina Water Resources Research Institute, Raleigh, NC. 74:1-86.

Hassler, W. W., N. L. Hill and J. T. Brown. 1981. The status and abundance of striped bass, Morone saxatilis, in the Roanoke River and Albemarle Sound, North Carolina, 1956-1980. N. C. Division of Marine Fisheries, Morehead City. Special Scientific Report. 38:1-156.

Hazen, T. C. 1979. The ecology of Aeromonas hydrophila in a South Carolina reservoir. Microbial Ecology. 5:179-195.

Heath, R. C. 1975. Hydrology of the Albemarle-Pamlico Region North Carolina: A preliminary report on the impact of agricultural developments. U. S. Geological Survey Water Resources Investigations. 9-75:1-98.

Hester, J. M., Jr., and B. J. Copeland. 1975. Nekton population dynamics in the Albemarle Sound and Neuse River Estuaries. University of North Carolina Sea Grant College Program, Raleigh, NC. 75-02:1-129.

Hobbie. J. E. 1975. Nutrients and eutrophication in the Pamlico River estuary, N. C. University of North Carolina Water Resources Research Institute, Raleigh, NC 74:1-100.

Hobbie, J. E. and N. W. Smith. 1975. Nutrients in the Neuse River estuary. University of North Carolina Sea Grant College Program, Raleigh, NC. 75-21:1-183.

Ketchum, B. H. 1969. Eutrophication of estuaries, p. 197-209. In Eutrophication: Causes, Consequences, Correctives. Report of the National Academy of Sciences, Washington, DC.

Kuenzler, E. J., D. W. Stanley and J. P. Koenings. 1979. Nutrient kinetics of phytoplankton in the Pamlico River, N. C. University of North Carolina Water Resources Research Institute, Raleigh, NC. 139:1-163.

Lilly, J. P. 1980. Blackland soils of North Carolina; their characteristics and management. Technical Publication, N. C. State University, Raleigh, NC. Mimeograph.

Skaggs, R. W., J. W. Gilliam, T. J. Sheets and J. S. Barnes. 1980. Effect of agricultural land development on drainage waters in the North Carolina tidewater region. University of North Carolina Water Resources Research Institute, Raleigh, NC. 159:1-164 + appendix.

Stanley, D. W. and J. E. Hobbie. 1977. Nitrogen recycling in the Chowan River, N. C. University of North Carolina Water Resources Research Institute, Raleigh, NC 121:1-127.

Tusneem, M. E. and W. H. Patrick. 1971. Nitrogen transformations in waterlogged soils. Louisiana State University, Baton Rouge, Agronomy Department Bulletin 657.

Wilder, H. B., T. M. Robison and K. L. Lindskov. 1978. Water resources of northeast North Carolina. U. S. Geological Survey Water Resources Investigations. 77-81:1-113.

CHOWAN-ALBEMARLE STUDY PLAN

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If we look at the Chowan River drainage basin, we see that three-fourths of the drainage comes from Virginia. This illustrates the regional scope of the problem and the need to have several counties, the state and Virginia involved with the restoration efforts. It is also important to note that the sound is much larger than the Chowan River and, hence, a more complicated system to manage.

Algal Blooms

Figures 1 and 2 show the extent of the algal blooms from 1971 to 1979. Two points emerge from this sequence of figures. First, the portion of the river affected by algal blooms has increased with time. While the blooms once were confined to the lower river near Colerain, we now find blue-greens stretching from above Holiday Island to the upper reaches of the sound. This migration of algae into the sound is of concern and is the principle manifestation of declining water quality in the sound. The sequence of figures also helps explain why certain years have been relatively free of blooms and others have experienced significant blooms. Certain climatological conditions apparently need to occur before the blue-green algae can dominate the river throughout a summer and early fall period. These are a wet spring, a hot, calm summer and a significant runoff event sometime during midsummer. The wet spring causes a large nonpoint source input of nutrients because of the high number of rainfall runoff events occurring on already wet soils. The hot, calm summer is needed to give the algae the proper environment and the necessary time to reproduce. A significant runoff event is needed in the summer to give the algae a second dose of nutrients. In the spring of 1980, a very significant bloom began to appear. However, the bloom used up the available nutrients during the dry summer and then decreased rapidly since no additional nutrients were washed in during the dry summer. The drought continued into 1981 and allowed salt water to move up into the Chowan River. The resulting salinity inhibited the growth of the blue-greens throughout the summer.

In response to the massive bloom of 1978, North Carolina officials initiated the Chowan River Restoration Project (CHORE), which included an Action Plan outlining the immediate steps the state could take to improve water quality. A long-term management plan for the Chowan River is in draft form and should be finalized by this summer. With the passage of H.B. 747, an Action Plan will be developed for Albemarle Sound. It will outline the immediate steps the state could take to improve any problems in the Albemarle basin and also recommend whether a long-term management plan needs to be developed.

Importance of Phosphorus

Figure 3 summarizes the algal response to various levels of phosphorus loading to the river. While both nitrogen and phosphorus are responsible for the algal blooms, and while both nutrients need to be reduced, phosphorus is the more important of the two. This is because it is easier and cheaper to reduce and the blue-green algae can fix nitrogen from the atmosphere once

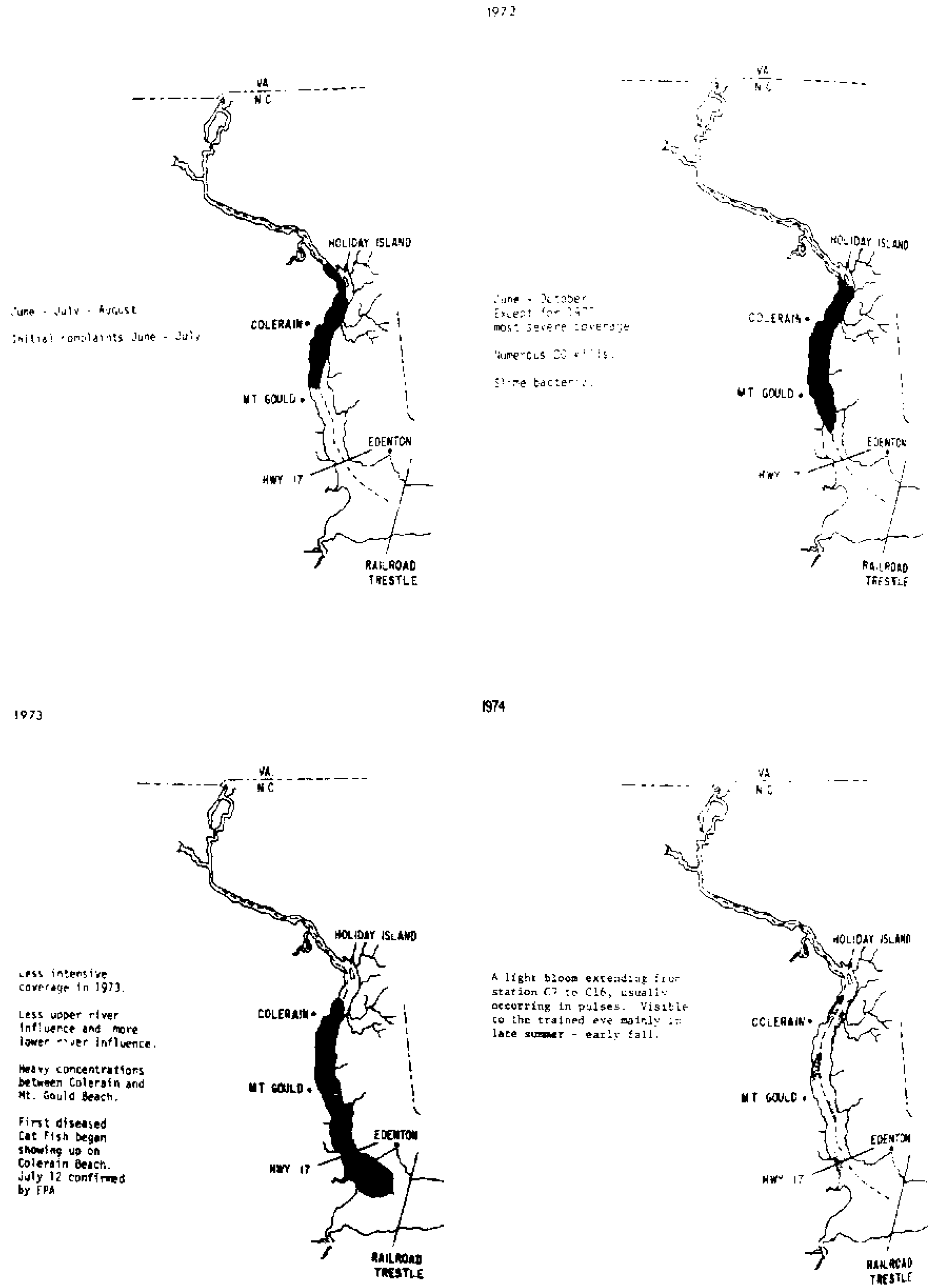

1972
VA
N C
HOLIDAY ISLAND
COLERAIN
MT GOULD
EDENTON
HWY 17
RAILROAD
TRESTLE
June - July - August
Initial complaints June - July
June - October
Except for 1977
most severe coverage
Numerous DO kills.
Slime bacteria.
1973
Less intensive
coverage in 1973.
Less upper river
influence and more
lower river influence.
Heavy concentrations
between Colerain and
Mt. Gould Beach.
First diseased
Cat Fish began
showing up on
Colerain Beach.
July 12 confirmed
by EPA
1974
A light bloom extending from
station C7 to C16, usually
occurring in pulses. Visible
to the trained eye mainly in
late summer - early fall.

Figure 1

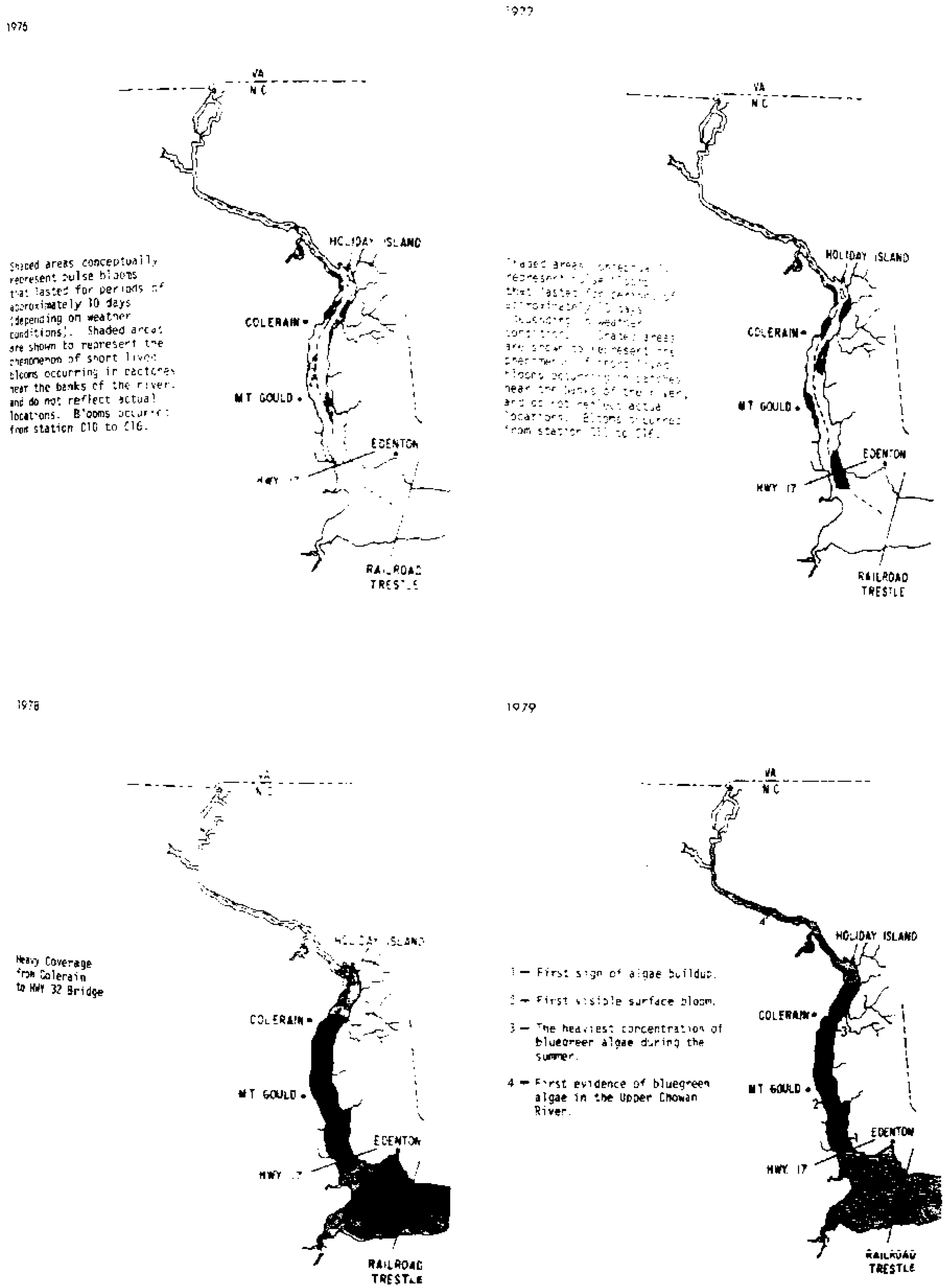

1976
VA
N C
HOLIDAY ISLAND
COLERAIN
MT GOULD
EDENTON
RAILROAD TRESTLE
Shaded areas conceptually represent pulse blooms that lasted for periods of approximately 10 days (depending on weather conditions). Shaded areas are shown to represent the phenomenon of short lived blooms occurring in pockets near the banks of the river, and do not reflect actual locations. Blooms occurred from station C10 to C16.
1977
VA
N C
HOLIDAY ISLAND
COLERAIN
MT GOULD
EDENTON
HWY 17
RAILROAD TRESTLE
1978
Heavy Coverage from Colerain to HWY 32 Bridge
COLERAIN
MT GOULD
EDENTON
RAILROAD TRESTLE
1979
VA
N C
HOLIDAY ISLAND
COLERAIN
MT GOULD
EDENTON
HWY 17
RAILROAD TRESTLE
1 — First sign of algae buildup.
2 — First visible surface bloom.
3 — The heaviest concentration of bluegreen algae during the summer.
4 — First evidence of bluegreen algae in the Upper Chowan River.

Figure 2

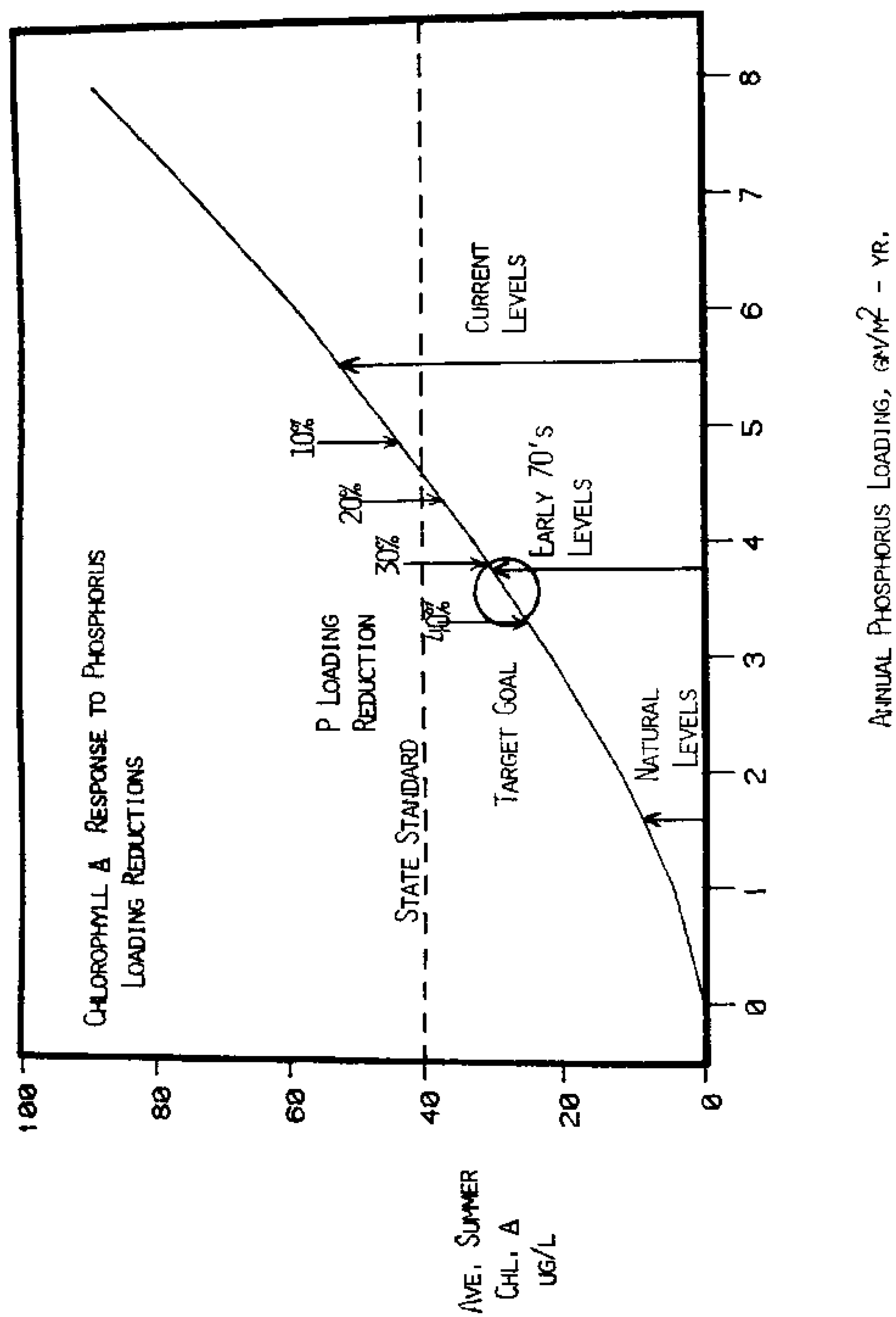

CHLOROPHYLL A RESPONSE TO PHOSPHORUS
LOADING REDUCTIONS
P LOADING
REDUCTION
10%
20%
30%
40%
STATE STANDARD
TARGET GOAL
NATURAL
LEVELS
EARLY 70'S
LEVELS
CURRENT
LEVELS
AVE. SUMMER
CHL. A
UG/L
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
ANNUAL PHOSPHORUS LOADING, GM/M2 - YR.

Figure 3

they are established. The horizontal axis represents the amount of phosphorus delivered to the surface of the Chowan River. The unit of one gram per square meter is about the same as ten pounds per acre. The vertical axis is the average amount of chlorophyll _a_ in the river during the summer. Chlorophyll _a_ is a measure of how much algae is in the river and is easier to measure than identifying and counting algal cells. The water quality standard in North Carolina is 40 µg/l, shown by the dotted horizontal line. Since peaks of chlorophyll _a_ have been found to be about 25 percent greater than the average summer value, a target goal of 25-30 µg/l has been proposed. The curve illustrates how more chlorophyll (or more algae) can be found in the river when more phosphorus enters the river. The first arrow shows what the loading to the river would have been when the entire Chowan drainage basin was forested and also shows the corresponding amount of chlorophyll present (about 10 µg/l). In the early 1970s, the loading was almost four gm/m^2 and the chlorophyll value was about 30 µg/l. Today, the loading is 5.5 gm/m^2 and the chlorophyll value is about 50 µg/l. It can be seen that a 30-40 percent reduction in phosphorus loading is needed to bring the chlorophyll values back to the target goal range.

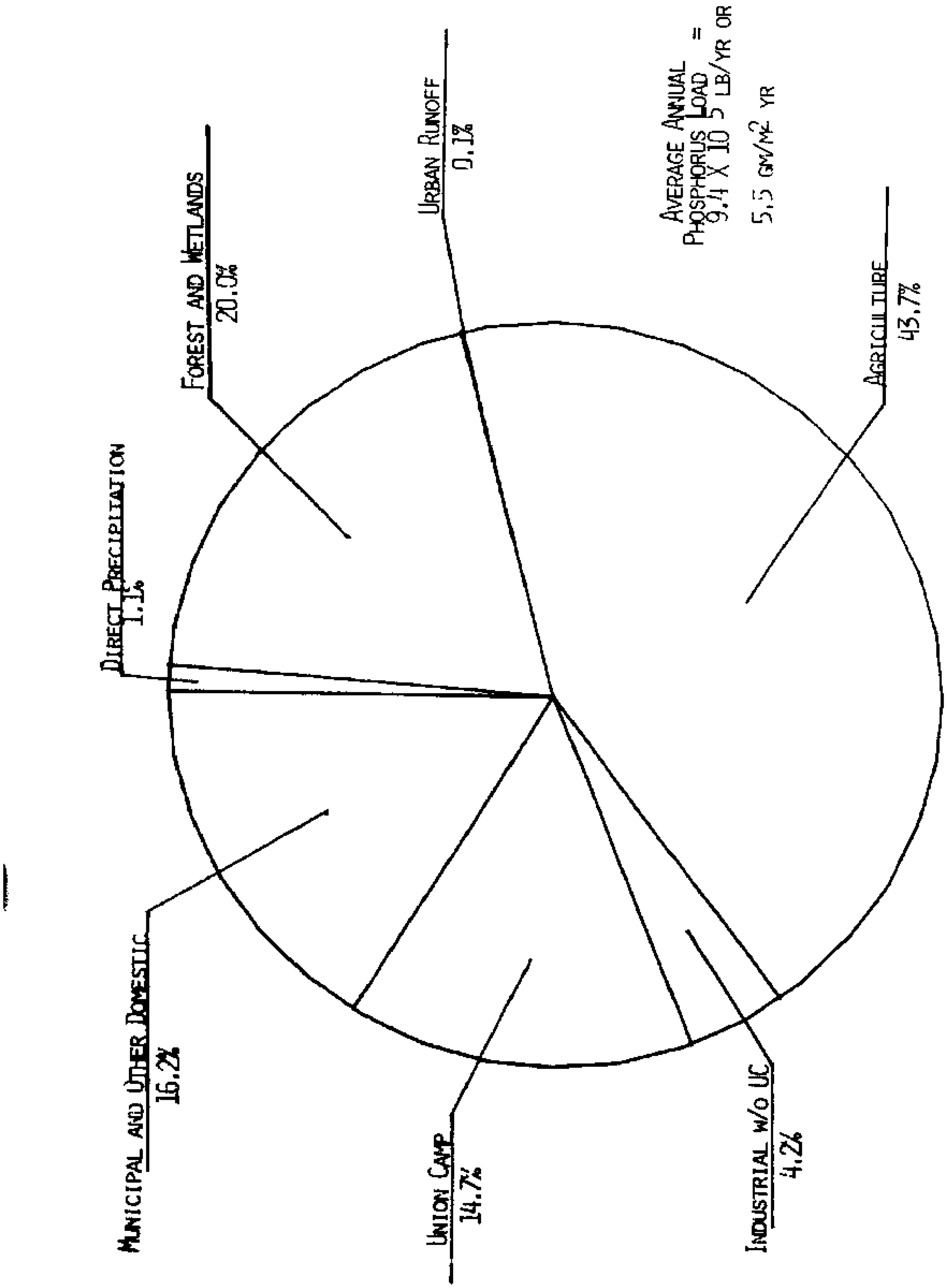
Figure 4 summarizes the annual contributions of phosphorus to the lower Chowan River from the entire watershed. The contributions are: forest and wetlands 20 percent, agriculture 45 percent, industries 20 percent and municipal discharges 15 percent.

Figure 5 summarizes the annual contributions of phosphorus to the lower Chowan River from the North Carolina portion of the basin. The contributions are very similar: forest and wetlands 20 percent, agriculture 45 percent, industry 10 percent and municipal discharges 20 percent.

While there is a relatively good handle on the nutrient input from point sources, better numbers need to be developed to quantify the agricultural input. Special studies were initiated in four predominately agricultural watersheds (1-10 mi^2), illustrated in Figure 6. A fifth, forested control watershed is also shown in the figure, northeast of Murfreesboro.

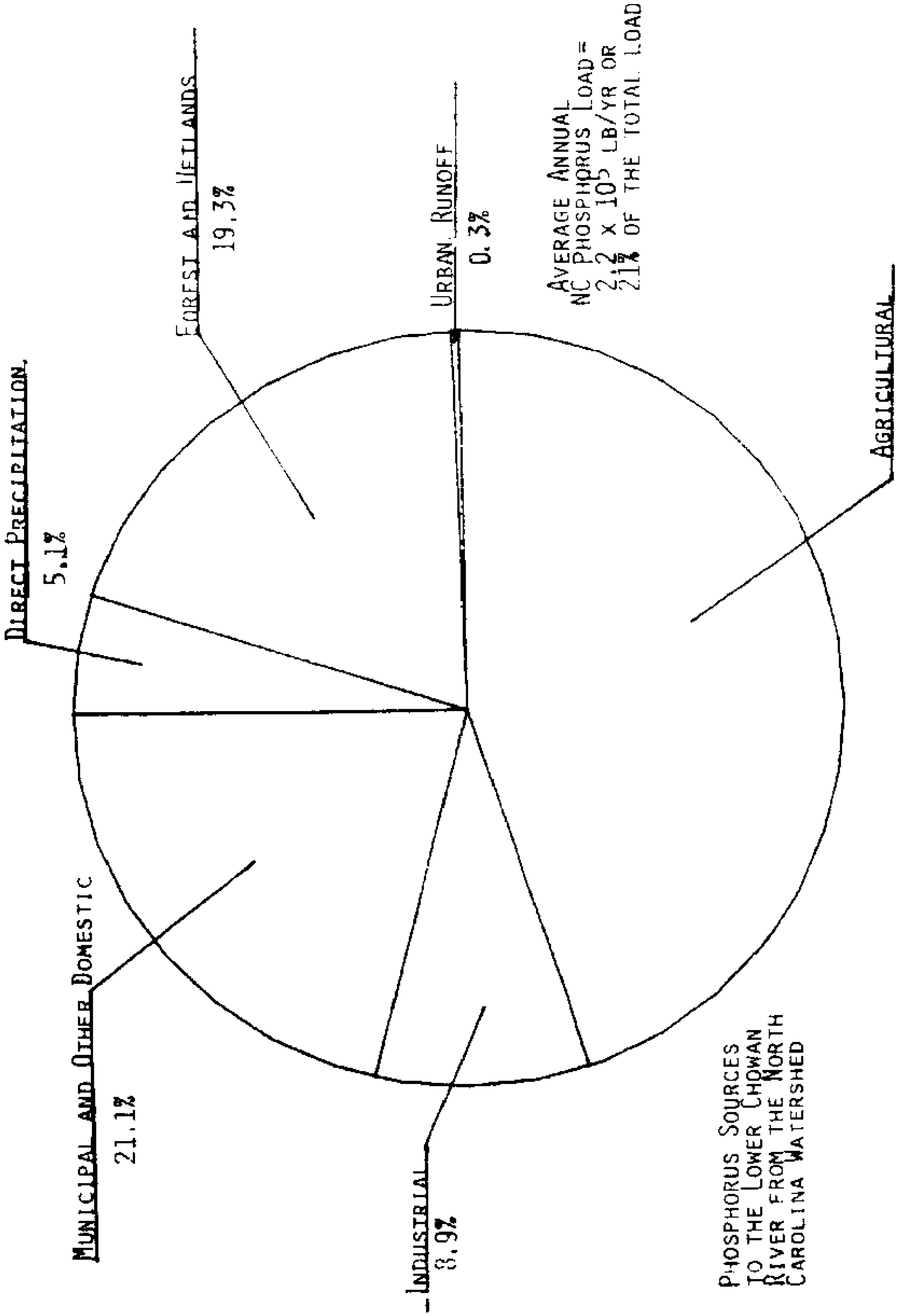
Phosphorus Reductions

Figure 7 again shows the phosphorus budget for the North Carolina portion of the watershed. The shaded portions represent the amount of phosphorus that can be removed with wastewater treatment facilities and good land management practices. It is probably not possible to significantly reduce the phosphorus contribution from forests and wetlands. It is estimated that 30 percent of the agricultural contribution can be removed (or about 15 percent of the total North Carolina input); this is shown by the shaded portion. The dotted line shows 50 percent removal. It is probably very optimistic to think that the agricultural inputs could be cut in half. The relative amount leaving the field is so small that only small improvements can be planned for. For industries and municipalities, it is technically possible to remove all their input. However, it could be quite expensive. In North Carolina, the industrial phosphorus input has already ceased. C. F. Industries no longer makes phosphorus fertilizer, and United Piece Dye Works changed an in-plant process and reduced their phosphorus input from 8 mg/l to 1/2 mg/l. Municipalities are being urged to go to land disposal, which would remove most of their input.



PHOSPHORUS SOURCES TO THE LOWER CHOWAN RIVER FROM THE ENTIRE WATERSHED

Figure 4



Direct Precipitation
5.1%
Forest and Wetlands
19.3%
Urban Runoff
0.3%
Average Annual
NC Phosphorus Load =
2.2×10^5 LB/YR or
21% of the total load
Agricultural
45.2%
Municipal and Other Domestic
21.1%
Industrial
8.9%
Phosphorus Sources
to the Lower Chowan
River from the North
Carolina Watershed

Figure 5

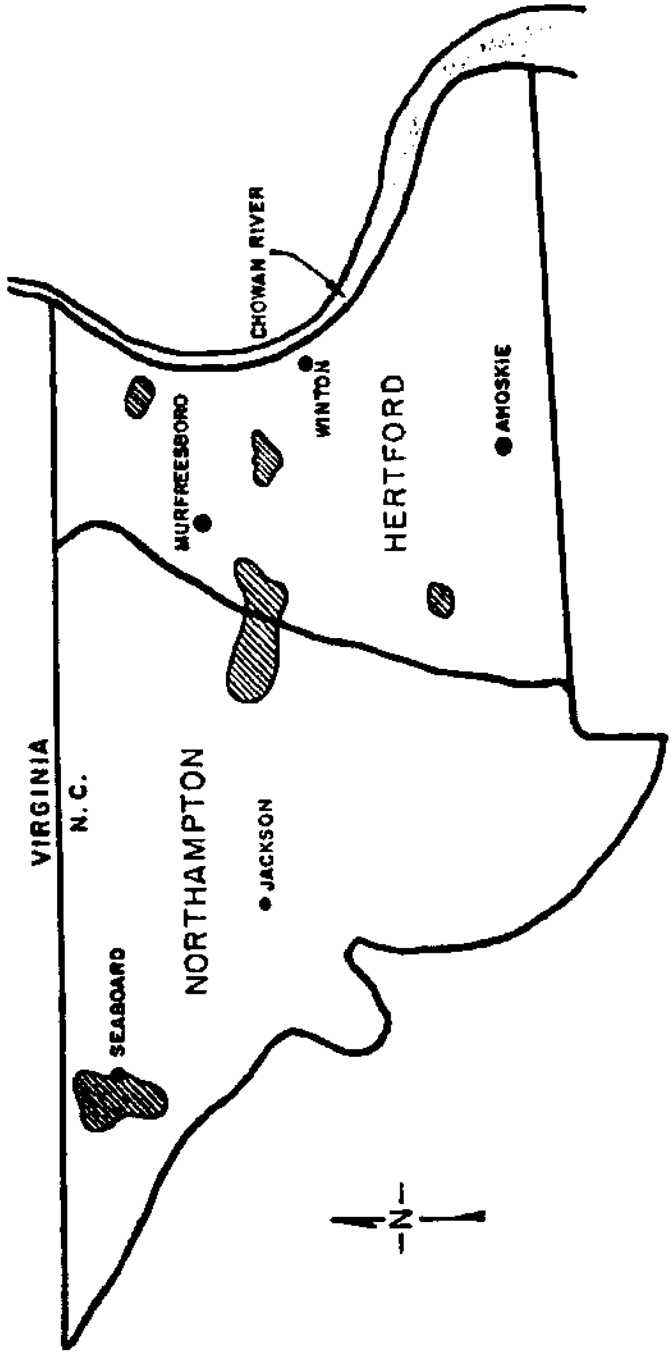

CHOWAN RIVER
WINTON
MURFREESBORO
HERTFORD
AHOSKIE
VIRGINIA
N. C.
NORTHAMPTON
JACKSON
SEABOARD
N

Figure 6

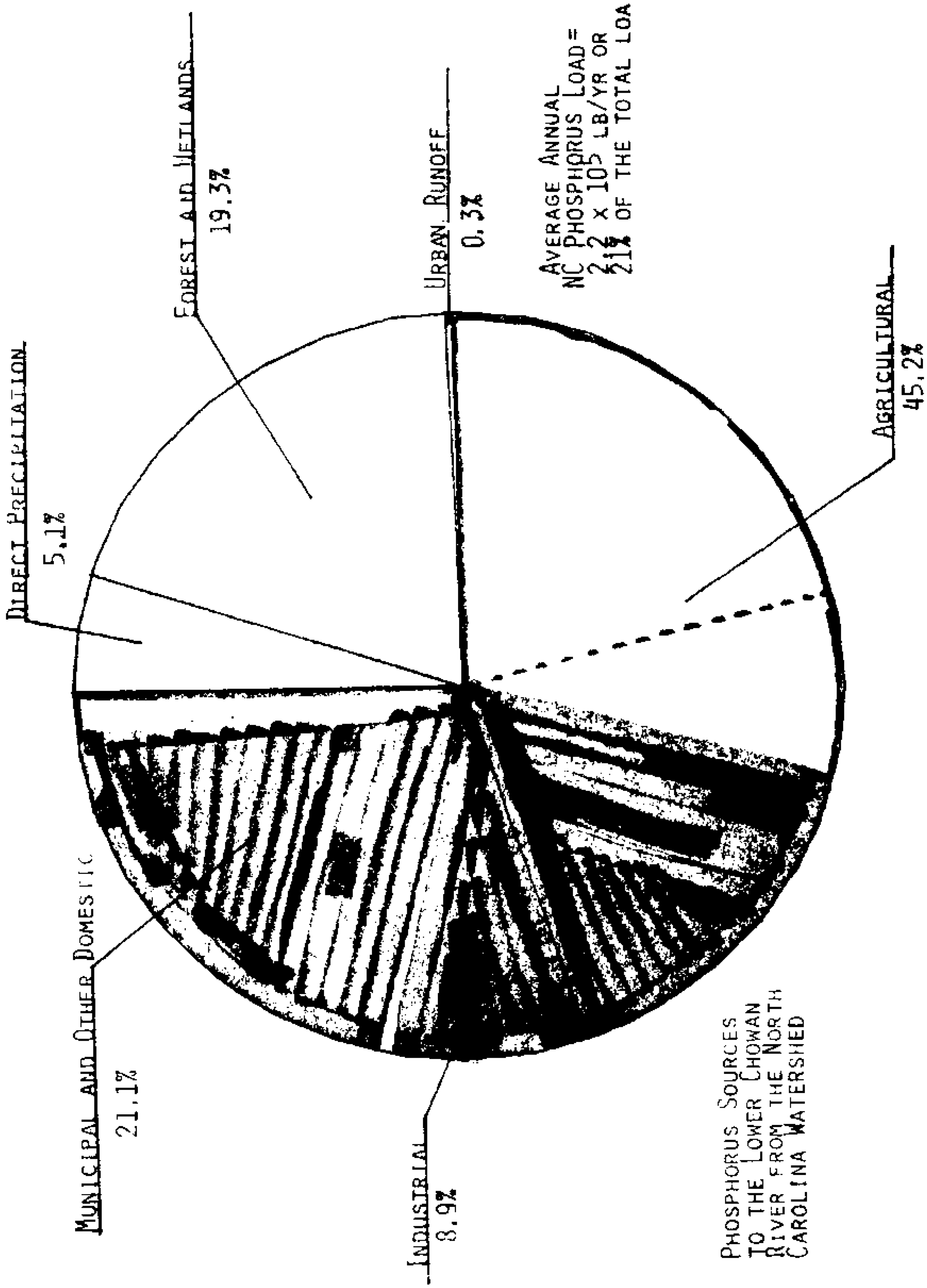

DIRECT PRECIPITATION
5.1%
FOREST AND WETLANDS
19.3%
URBAN RUNOFF
0.3%
AVERAGE ANNUAL
NC PHOSPHORUS LOAD =
2.2 x 10^5 LB/YR OR
21% OF THE TOTAL LOA
AGRICULTURAL
45.2%
MUNICIPAL AND OTHER DOMESTIC
21.1%
INDUSTRIAL
8.9%
PHOSPHORUS SOURCES
TO THE LOWER CHOWAN
RIVER FROM THE NORTH
CAROLINA WATERSHED

Figure 7

Figure 8 takes the 20-percent phosphorus input from municipalities and makes a whole pie chart out of that sum. The dark shade for Woodland and Seaboard indicates that they already have installed land-disposal systems. The lighter shade highlights the towns that have received funds to construct land disposal facilities. Edenton and Ahoskie are scheduled to receive construction funds by the summer of this year.

Figure 9 is a slightly different way of presenting Figure 3. However, time is used instead of phosphorus loading for the horizontal axis. If no cleanup actions were taken, the amount of algae in the river would continue to build, as shown on the no-action curve. A ten-year implementation plan is assumed. It can be seen that a strategy involving both point and nonpoint source inputs is needed.

A more detailed presentation of the proposed work plan for the Chowan-Albemarle Study will be available later this spring.

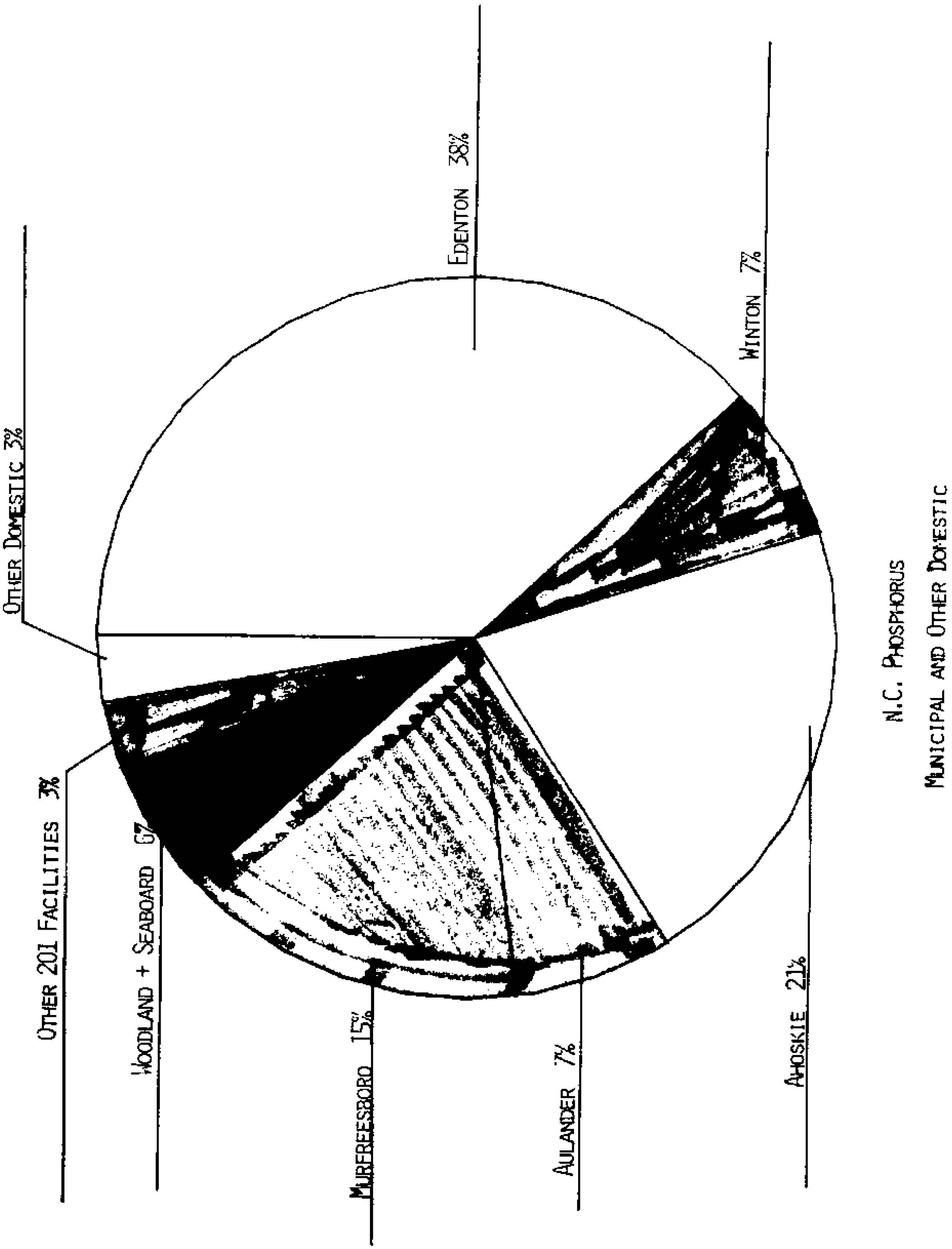

EDENTON 38%
WINTON 7%
OTHER DOMESTIC 3%
OTHER 201 FACILITIES 3%
WOODLAND + SEABOARD 6
MURFREESBORO 15%
AULANDER 7%
AHOSKIE 21%
N.C. PHOSPHORUS
MUNICIPAL AND OTHER DOMESTIC

Figure 8

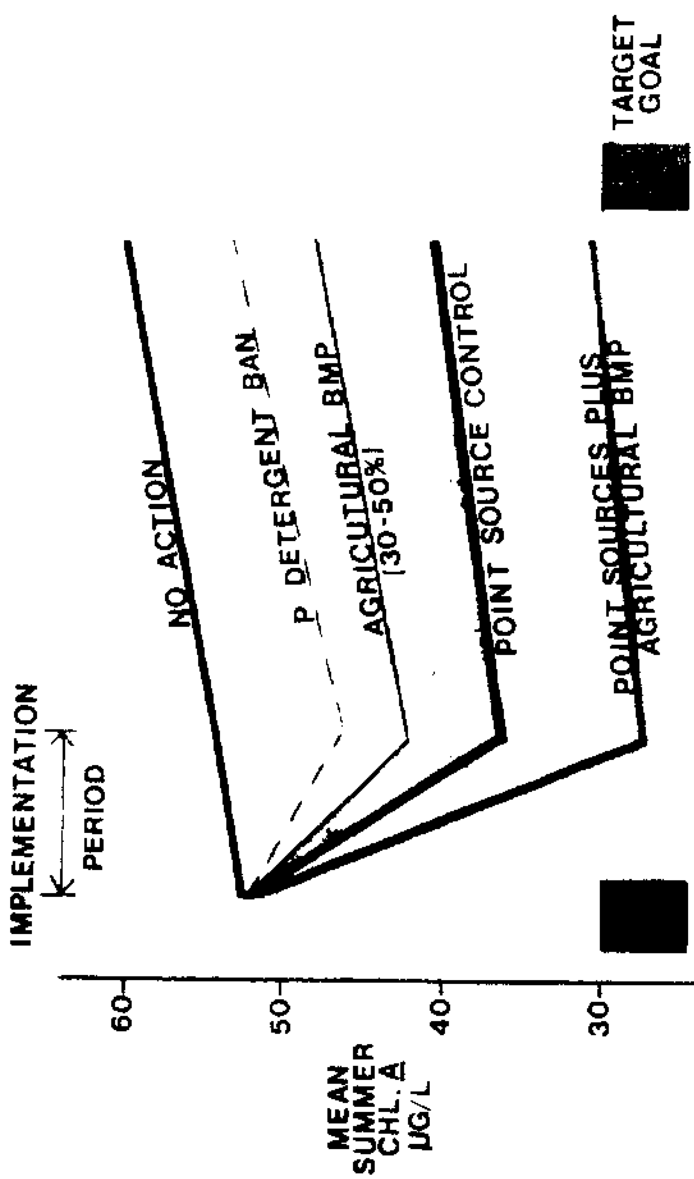

IMPLEMENTATION PERIOD
NO ACTION
P DETERGENT BAN
AGRICULTURAL BMP (30-50%)
POINT SOURCE CONTROL
POINT SOURCES PLUS AGRICULTURAL BMP
TARGET GOAL
MEAN SUMMER CHL. A µG/L
60
50
40
30
20
1980
1990
2000
2010
2020
YEAR

Figure 9

ENVIRONMENTAL FACTORS CAUSING BLUE-GREEN ALGAL BLOOMS IN THE CHOWAN

Hans Paerl
Associate Professor
UNC Marine Sciences Institute

Our study over the past two years has dealt with the causes of blue-green algal blooms in the lower Chowan River and their possible long-term environmental impacts.

This study is one of four on the Chowan sponsored by the UNC Water Resources Research Institute, which is headed by Dr. Jim Stewart. Funds were derived from the Department of the Interior and the state. It is critical that state interests are maintained since the Department of the Interior has indicated a lack of interest in future funding of these studies.

Investigators for the other three Chowan studies are here today. They are Dr. E. J. Kuenzler, who is studying sediment-water column nutrient interactions; Dr. A. M. Witherspoon, who is working on phytoplankton community dynamics in the river, and Dr. Samuel Mozley, who is studying benthic fauna and their distribution in relation to changing trophic status, or water quality, in the lower river. Also, I would like to thank the Division of Environmental Management for help in providing data and samples during these studies.

I will outline the environmental factors causing nuisance blue-green algal blooms in the Chowan, which appear to be diverse, in order to illustrate the complexity of the different inputs causing changes in the river. I will also describe briefly how these blue-green algal blooms have changed the food web or food chain in the river itself. These organisms constitute the base of the food chain that the animal plankton feed on, in turn providing food for fish, which constitute the economic interests in the lower Chowan-Albemarle system.

Lower River Susceptible to Blue-Green Blooms

Our research area was the segment of the lower river between Holiday Island and Colerain. This area is particularly susceptible to blue-green algal blooms. One reason for this is that the Chowan-Albemarle estuarine system is a freshwater system, which makes it susceptible to freshwater nuisance species like the blue-greens.

Another reason is that the physics of the system are very much like that of a large lake. Water moves through the system very slowly so the residence time is long and the system tends to stratify thermally. That is, its temperature gradient resists mixing. Under these conditions, during periods of low flow, the blue-green algae can come to the surface where they dominate, forming nuisance blooms.

In our study the emphasis was on investigating the growth and proliferation of the blooms in the system itself, not on taking samples and incubating them in a laboratory. We wanted to get an idea of what goes on in a single day in the river.

Blue-Green Algae Highly Adaptive

These nuisance blue-green algae we are talking about, *Anabaena*, *Aphanizomenon* and *Microcystis*, are highly adapted to living under nutrient-enriched conditions. They are undesirable items in the food chain for two reasons. First, they form colonies, or clumps, that are too big to be eaten by the small animal plankton that are intermediate between the algae and the eventual fish production. And second, they form toxic materials inside their cells, which they can also excrete into the environment.

One characteristic of the Chowan is that it is highly colored, so light is absorbed in the upper part of the water column. Algae require light for growth, so the amount of potential algal growth in the river is forced up to the surface. The reason the blue-greens are such a problem is that they are able to make themselves buoyant, move up to the well-lit surface and shade out the more desirable algae.

This is probably one reason they have proliferated. They can accumulate in an area where there is plenty of sunlight and form scums (which are not decaying but actively growing algae), causing the light to be absorbed in that scum and shading out the more desirable diatoms and green algae in the underlying part of the water column.

Another detrimental result of the blooms is that since there is very little algal growth at times underlying these scums, a high degree of oxygen is consumed, with no oxygen being produced because there's no other plant growth; so there is increased potential for oxygen loss. These are ideal conditions for setting up the blooms. When the water is very calm during the summer and the surface water heats up, there is very little mixing, and the blue-green algae can then form these scums because they are not forced by the wind to be mixed in.

Another characteristic of the blue-green algae is that when they start to bloom at the surface during the summer, they have a biochemical process called nitrogen fixation, which is the ability to use nitrogen from the atmosphere and convert it to ammonia, which all plant life can use. As a result, they can sustain their own nitrogen needs simply by nitrogen fixation, very much like soybeans do. This is why phosphorus constraints, which were mentioned by Alan Klimek, are so crucial. Since these algae can meet all their nitrogen requirements by using atmospheric nitrogen dissolved in water, the main constraints on their growth are largely through phosphorus. So the amount of phosphorus released during the potential bloom period is a crucial factor in determining to what extent the blooms will proliferate.

Nitrogen inputs are important, too, indirectly. They play a major role in causing the growth of spring algae. Excessive spring nitrogen inputs will lead to a higher amount of phytoplankton biomass. This, in turn, further enriches sediments with organic matter, which leads to greater biological oxygen demands. Excessive biological oxygen demands increase the potential for oxygen deficits, which can lead to accelerated nutrient release from the sediments.

Pulp Mill Effluent

The year 1981 was unusual in that the river hardly flowed at all for about four months, especially from the end of December until about mid-May. Union Camp pulp mill effluent formed a large mass that remained in the segment of the river from Holiday Island to Colerain for about two or three months. This effluent discolors water even more than it is naturally, so the algal growth zone is pushed up even closer to the surface.

In 1981, given the drought, almost all water was effluent, which had a profound effect on the degree of algal growth in the river and the efficiency of that growth.

Efficiency of growth was reduced not only because of the coloration but because of the humic material. These dark-colored constituents of the effluent appear to have a chemical effect on algal growth by interacting with certain chemicals the algae require. To study these effects, we incubated river-water samples (purified to rid them of nutrients) with humic materials equal to amounts in the river last year. Preliminary results, which we hope to elaborate on this year, showed that additions of effluent to Chowan River water with its natural spring (desirable) algae decreased algal growth by about 50 percent, compared to the control sample (river water without added effluent). However, additions of humic materials to populations of blue-green algae showed very little effect. This indicates that the humic material benefits the blue-greens as opposed to the desirable algae. We wondered if the inhibition of growth was a toxic effect. But we found that if we added trace metals back to the humic materials, we could increase the algal growth potential. It looks as if the humics are grabbing onto, or binding, trace metals needed by the algae, thus causing trace-metal deficiencies. The blue-greens, though, are able to counter this effect because they have their own metal-grabbing compounds. They are really very opportunistic and can override many of these environmental effects, whereas the desirable algae cannot. This leads us to the need for further investigation of pulp mill effluent and similar compounds. They may not only be contributing nutrients to the river but by inhibiting growth of the desirable algae, may also be accelerating the rate at which blue-green algae start to dominate the system.

You might ask why we didn't get a blue-green bloom last year. Conditions were right, and the good algae were knocked out by the humic material. Dry conditions during the winter and spring and resulting low flow led to increased levels of salinity, which inhibited growth of the blue-green algae.

In summarizing, I would emphasize three factors to be considered in looking at the occurrence of the nuisance algal blooms:

1. the importance of constraints on nutrient inputs to the river

2. the role of humic materials in inhibiting growth of the desirable spring algae

3. the salinity tolerance of the blue-green algae.

FISHERIES PRODUCTION IN ALBEMARLE SOUND

Harrel Johnson
Coordinator, Fisheries Management
Division of Marine Fisheries
N. C. Department of Natural Resources and Community Development

As I was listening to Alan Klimek and Hans Paerl make their presentations, I suddenly realized that many of the constituents we in the Division of Marine Fisheries serve have been indoctrinated with this program on several occasions. It's no wonder they are so upset when they hear again and again of the impacts of various nutrient inputs and other activities on fisheries production in the Albemarle Sound area.

Simply put, in order to have good fishery resources in Albemarle Sound, it is necessary to provide those resources with the basic requirements for life: food, dissolved oxygen and freedom from disease. As stated earlier, eutrophication, or excess nutrients, can eventually cause changes in food production and the food chain. Overfertilization of our waters can also create an unhealthy situation for fish populations. An example of this is red-sore disease. Dr. Gerald Esch from Wake Forest University conducted research in Albemarle Sound that showed a strong correlation between the incidence of the disease, or the agent that causes it, a bacterium called *Aeromonas hydrophila*, and the amount of orthophosphates in the water, which ties into the phosphorus cycle. The disease itself is also rather complicated in the way it infects fish. A stress-type mechanism is involved. Any time a fish is put in a situation it is not accustomed to--whether it be elevated temperatures, low dissolved oxygen or perhaps exposure to toxins such as those produced by blue-green algae--its defense mechanisms may be lowered, making it susceptible to disease.

Fisheries production in Albemarle Sound was at one time a very significant industry. The sound currently has a very poor standard quality of water, and the bottom line is that water quality is the key to fisheries production. If all the current and planned management activities result in water quality improvements in the near future, I think fisheries production will improve also.

FISHERIES RESOURCES AND TRENDS

Michael Street
Chief of Fisheries Management
Division of Marine Fisheries
N. C. Department of Natural Resources and Community Development

Connell Purvis, Director of the Division of Marine Fisheries, was scheduled to make this presentation, but he was called to give testimony today before a committee of the General Assembly.

I would like to note that one member of our Marine Fisheries Commission, Mr. Earl Smith, is here today. The Commission is extremely interested in the problems in this area and has been for a number of years.

I have a personal involvement in the Albemarle Sound area. I started working here in 1971 and lived in Elizabeth City from 1972 to early 1975 when I was transferred back to Morehead City. My master's thesis was done on river herring down in Georgia. During that time I examined some of the literature and learned a bit about the significance of herring fisheries in this area and their historical aspects.

Fishing has been a very important activity in Albemarle Sound, as Dave Stick mentioned, since colonial times. The early settlements were dependent on the water. Many of the early writings describe the species of fish and fishing methods of the Indians from the Roanoke Island up to the sound. Salt river herring was a very early commodity, which was shipped from the royal port of Edenton to the West Indies. In fact, it was so important that herring was used as currency in this area.

The major fisheries were conducted with seines, many more than 2000 yards long. The work was dangerous since it was conducted during spring when the water was very cold. The seines were used to fish for river herring, shad and striped bass. In many instances these seines were worked by people from the large plantations such as Aroca, Scotch Hall, Eden House and others.

After the Civil War, fishermen were catching large amounts of fish. The fish were either cut and salted in the case of herring or like shad were packed in ice (ice-making machines were developed after the Civil War) before being sent by steamer up the Chowan River to be loaded on rail cars bound for northern markets.

The days of the large catches are presently behind us. Figure 1 shows total landings in Albemarle Sound by major species from 1967 through 1980 in millions of pounds. In volume, river herring is obviously the dominant catch. Catfish is the most steady of the landings, and crabs have become relatively more important in recent years. But from the peak totals of about 23 million pounds in 1969 to the 10 million caught today is a very great reduction.

Striped Bass

As for individual species, striped bass is extremely important in this area, both commercially and recreationally. From fall through spring striped bass are caught with gill nets by fishermen along the Albemarle Sound, Chowan

River, Roanoke River and Currituck Sound (Figure 2). In recent years, the fishery trend has been downward. Major reproduction of striped bass is in the Roanoke River in the Weldon area, with some very minor spawning occurring in the upper Meherrin and upper Nottoway Rivers in Virginia. Sampling done by Dr. William W. Hassler of N. C. State University and by the N. C. Division of Marine Fisheries indicates that there has been essentially no successful striped bass reproduction in the Roanoke River since about 1976. The eggs are spawned but there are problems with their viability. What seems to happen is that the larvae get down in the western Albemarle Sound where something goes wrong. We think it is poor water quality in the nursery area due to such sources as the pulp mill effluent from both the Chowan and the Roanoke Rivers and other industrial, municipal and domestic nonpoint discharges.

Red-sore disease had some significant effects in the late 1970s with 10 to 20 percent of the commercial catch affected during various periods, but fewer were affected last year, principally due to drought conditions and elevated salinities.

We used to sample the Elizabeth City striped-bass tournament every year for information on the age and size of the catch, but I don't think the tournament has been held in the last two or three years because there haven't been enough fish. Data from Hassler indicate that hook-and-line catches in the Roanoke River peaked in 1971 at about 65,000 fish during the spring spawning, down to about 15,000 in 1980 and even fewer in 1981.

In Albemarle Sound, Hassler's data show that in 1970, 96,000 striped bass were taken by sport hook-and-line fishermen. Jointly conducted surveys by the Wildlife Resources Commission and Marine Fisheries during 1977 through 1979 showed about 3,000 fish in 1977, down to 6,000 fish in 1979.

River Herring

Two species of river herring are the blueback, which make up more than 80 percent of the total for most years, and the alewife (goggle eye or forerunner). They are caught by gill nets in the western part of the sound and lower Chowan (Figure 3) during the early part of the season and by pound nets later during the year.

Our sampling of juveniles in the nursery areas of Albemarle Sound and the rivers indicate that similar to striped bass, spawning of herring appears to have been generally unsuccessful since the mid 1970s. We feel that that initial decline was probably caused by foreign overfishing on the high seas before the institution of the Fishery Conservation and Management Act of 1976, which restricted foreign fishing off our shores. Landings by nations such as the Soviet Union, Poland and East Germany were very high during the late 1960s and early 1970s but have been insignificant since about 1975. There have been no signs of recovery in stock. We think this is probably due to water quality.

Blue-green algal blooms, as mentioned earlier today, cause a number of problems. We have some indications that when the blooms occur very early in the year, there may actually be physical interference, a smothering of larvae by filaments during the latter part of the spawning season. Also, there is the matter of shading by the algae and by Union Camp effluent last year, which altered the food chain. Potential problems exist with the food chain, which could possibly lead to starvation. As Hans Paerl stated, there is now some good data from 1981 showing some of the effects of Union Camp effluent, and information recently compiled by the Division of Environmental Management indicates there was also an avoidance reaction to the effluent by river herring in the Chowan in 1981. The effluent made up a high percentage of the total flow of the river during that period because of the drought.

River herring are caught in pound nets in vast quantities during the peak of the season, literally boatloads in a single net. The processing of river herring in the Chowan used to be the largest freshwater fishery in the world, employing hundreds. But now employment is probably down to a mere fraction of what it used to be. Herring are also an important recreational fish on the Roanoke and in all the creeks in this area during April. Work done by Marine Fisheries and by the Wildlife Commission in the late 1960s and early 1970s indicates that during some of the good years an excess of a million fish were taken by recreational fishermen using dip nets.

White Perch

Another important species in the Albemarle is white perch. Landings were the lowest on record in 1980 but recovered somewhat in 1981. They are taken by gill nets throughout most of the sound (Figure 4) during the fall through winter and by pound nets in the Chowan River along with river herring during the spring. A long-lived fish, the perch is able to live up to 8 to 10 years. White perch were severely affected by red-sore disease during the mid and late 1970s, with some year classes essentially wiped out. Virtually every fish taken was affected, and during some years we got very few fish. However, the disease has not been nearly as apparent in the last few years. This species is very important to recreational fishermen. A Wildlife Resources Commission survey indicates that more white perch are taken in Albemarle Sound than any other species by hook and line--an average of 200,000 fish per year for 1977-1979.

Catfish

The other important species group is catfish, principally two species--channel and white catfish as well as a few bullheads. They are fished principally in the western Albemarle Sound, the Chowan River and the Roanoke River by catfish pots and trot lines. Fishermen also catch catfish in pound nets in the Chowan during the spring herring run (Figure 5). Despite seasonal ups and downs, catfish are caught year-round, whereas species like river herring are strictly seasonal. The fishery grew in importance during the 1970s as other fisheries declined, and the trend may continue in the future because of the environmental situation in Albemarle Sound. Catfish can endure, in fact almost thrive on, poor water quality and, thus, may have an advantage over species such as striped bass, white perch or herring. During some research that involved tagging, several hundred white perch and catfish in the Albemarle got very few returns, and most of those were essentially in the same area they were tagged. In fact, one white perch was caught about two or three weeks ago in exactly the same place we tagged it about a year and a half previously.

Blue Crabs

Blue crabs, caught in the central and eastern sound (Figure 6) have increased in importance, particularly in recent years. They are principally a warm-weather fishery, whereas most of the finfish, except catfish, are taken during cold weather. Landings have exceeded a million pounds in some of the more recent years and will probably continue to increase in importance.

In my opinion, the Albemarle Sound fishing industry is depressed. I don't anticipate any recovery in the near future, and the reason is water quality. I think long-term recovery is going to depend on improvements in water quality. As Harrel Johnson said earlier, better water quality should result in more fish, and more fish should result in more landings. The Division of Marine Fisheries has worked for a number of years with the Department of Natural Resources and Community Development, various task forces, industry, agriculture and Virginia officials to develop some mutually agreeable approaches to improving water quality in the sound.

AGRICULTURAL RESOURCES AND TRENDS

D. G. Harwood, Jr.
Assistant Director, N. C. Agricultural Extension Service

The ten counties represented here today have some of the best soils in North Carolina, and this area has been farmed from the very earliest days of the colonization of this state.

Agricultural Trends in the Albemarle Sound Area

The latest data I have, for the year 1978, indicate that there are 3,310 farms in the ten-county area (Table 1), and these farms average about twice as large as the average for the entire state (Table 2). There is a trend toward fewer and larger farms--a trend which is also statewide. Table 3 shows that the value of land and buildings per farm now stands at $271,764 average per farm (about twice state average)--an increase of 136 percent in four years. It is small wonder that debt service is beginning to be a big problem.

As is true for the rest of the state, the number of part-owners is increasing (Table 4), a trend attributable to both the increasing scale of operations allowed by mechanization and the rapidly escalating price of farmland. There are 119 farm corporations in the area, but all except 18 of these are family-held corporations, formed for estate and income tax purposes.

The average age of farm operators is lower for these counties than for the state as a whole, and this average age dropped considerably over the last census period (Table 5). Our experience is that younger farmers are more receptive to adoption of new technology. It is also encouraging that younger men are determining that farming is an attractive occupation.

There were only 28 farms with irrigation reported in this area in 1978, but our observations tell us that many more irrigation systems have been installed since then.

Inventories of hogs and pigs increased by 52 percent between 1974 and 1978, and broiler inventory increased 701 percent, but inventory of cattle and calves dropped 30 percent. Of course, corn and soybeans are big crops in the area, with about 19 million bushels of corn and 5 million bushels of soybeans produced in these counties in 1978. The market value of all agricultural products sold increased from $137 million in 1974 to $180 million in 1978 (Table 6).

Farmers in these counties as well as in the rest of the state have greatly increased efficiency over the past couple of decades, as measured by output per man hour. They have done this by substituting machinery for labor and chemicals for both labor and land. In the ten-county area, farmers used almost $20 million worth of commercial fertilizer in 1978, and almost $10 million of other agricultural chemicals including lime (Table 7).

Agricultural Extension Programs

We in the Agricultural Extension Service recognize and share the desire of the various interests in this area in maintaining an acceptable level of water quality in the rivers and sound. There have been a number of contributors to the water-quality problem, including population pressure, industrial wastes and agricultural nonpoint source pollution. Extension programs in the Biological and Agricultural Engineering and Soil Science Departments are addressing each of these concerns (Table 8). Dr. Frank Humenik, Extension Biological and Agricultural Engineering, and other members of his staff are here today and will be happy to discuss with you the activities they are coordinating. Let me just mention some of these.

1. Demonstration on-site wastewater treatment systems have been designed and installed for use in slowly permeable soils or high water table soils at Camden Middle School, at J. P. Law Elementary School and in cooperation with the Pasquotank, Perquimans, Camden and Chowan Regional Health Department.

2. There has been involvement with state and federal agencies in examining potential sites for land treatment of domestic wastes in the Chowan River Basin.

3. There has been involvement with local industries in evaluating sites for land treatment of industrial wastes, specifically at the three Purdue Poultry sites and at Georgia Pacific.

Turning to production agriculture, I want to mention the work Dr. Jim Barker has done in managing animal waste with emphasis on land application. A package of publications describing implementation of recommended practices is available at each County Extension Office.

Beverly Young and Buddy Atkins here have been leading for the past two and one-half years a research and demonstration project in the Chowan River drainage basin to determine levels of agricultural nonpoint source pollution and ways of reducing those levels. Funding for this work is partially provided by the Water Resources Research Institute. Water quality in four agricultural watersheds and one forested watershed has been monitored. County Extension Offices and SCS and ASCS personnel in Northampton and Hertford Counties have been involved. Producers have been encouraged to use best management practices to control runoff, erosion and loss of fertilizers. Some of the practices being implemented include conservation tillage systems, contour farming, diversions, field borders, grassed waterways, terraces and woodland site preparation and harvesting. ASCS has provided $38,000 in cost-sharing funds for these practices. In-service training at these sites included 50 agency personnel; a field tour had 75 agency attendees, and a related meeting attracted 120 farm owners and others. So far, it has been determined that pollution concentrations are 2 to 20 times higher from agricultural watersheds than from the forested area. An on-campus committee has been working toward integrating best management practices into the ongoing agricultural program. During 1982 water quality will be measured after the best management practices have been completed. This data will be used by agencies in developing workable strategies for managing agricultural nonpoint source inputs to the Chowan River.

The Chowan River research and demonstration project is just one of the projects being implemented across the state under Section 208 of the 1972 Federal Water Pollution Control Act. An Agricultural Task Force, under the guidance and coordination of the North Carolina Soil and Water Conservation Commission, is composed of representatives of ASCS, N. C. State University, SCS, NCDA, N. C. Farm Bureau and N. C. State Grange. The N. C. Division of

Environmental Management and Division of Forest Resources also participated. The Task Force prepared a 208 agricultural plan which identified potential pollution contributors and offered solutions for reduction and control of the pollutants. An implementation group is putting the 208 agricultural plan into action. The program is voluntary--no regulatory program exists to control agricultural nonpoint source pollution. Other projects across the state are in Wayne, Union, Wake, Henderson and Buncombe Counties. These studies and demonstrations should lead to a reduced impact on surface waters from the state's 49 million tons of eroded sediment, 22 million pounds of pesticides, 50 million tons of plant nutrients and 20 million tons of animal manure, part of which could potentially reach streams in a single year. By implementing best management practices, farmers could benefit from reduced erosion, higher yeild potentials, reduced operating costs and increased profits.

We have just employed an Area Extension Integrated Pest Management (IPM) Agent who will serve Currituck, Pasquotank, Perquimans and Chowan Counties. For several years, an IPM program has been underway in this area in which scouts monitor weekly the pest population on the various crops. Cooperating farmers have information about pest populations so that pesticides can be applied when actually needed for a particular field. The cooperating farmers pay about three-fourths of the cost of this program. We have found that the IPM program leads to fewer sprays, thereby reducing risks of impact on water quality.

Our tobacco specialists have for the past two years been encouraging growers to test soil and use only the recommended rates of nitrogen on tobacco. Excess nitrogen is costly, fosters increased sucker growth and contributes to runoff. There has been a dramatic reduction in nitrogen application and a significant improvement in leaf quality.

Agriculture is a very vital part of the economy of northeastern North Carolina, and we are learning a lot about its impact on water quality. The practices now being demonstrated in this area will go a long way toward reducing the impact of agricultural pollutants on water quality. We hope all of you will help us get the recommended practices adopted by farmers in these counties. The N. C. Agricultural Extension Service is open to your suggestions for improving our educational program.

Table 1. Number of Farms

	1974	1978
Bertie	1,055	950
Chowan	377	312
Currituck	175	147
Dare	5	5
Gates	431	386
Hertford	544	437
Hyde	224	213
Pasquotank	304	290
Perquimans	400	397
Tyrrell	173	173
TOTAL	3,688	3,310
NC TOTAL	91,280	89,367

Source: Census of Agriculture, 1978

Table 2. Average Size of Farm (Acres)

	1974	1978
Bertie	167	194
Chowan	153	184
Currituck	308	398
Dare	20	--
Gates	192	191
Hertford	190	226
Hyde	409	436
Pasquotank	207	232
Perquimans	196	211
Tyrrell	220	327
AVERAGE	206	266
NC AVERAGE	123	127

Source: Census of Agriculture, 1978.

Table 3. Value Land and Buildings/Farm

	1974 ($)	1978 ($)
Bertie	80,626	181,985
Chowan	88,180	167,265
Currituck	196,743	394,043
Dare	45,800	353,307
Gates	98,179	184,746
Hertford	98,301	207,564
Hyde	177,853	426,889
Pasquotank	153,207	278,094
Perquimans	117,440	221,611
Tyrrell	106,717	302,138
AVERAGE	116,305	271,764
NC AVERAGE	72,672	135,072

Source: Census of Agriculture, 1978.

Table 4

	Part Owners		Farm Corporations
	1974	1978	1978
Bertie	312	328	43
Chowan	133	143	13
Currituck	71	61	15
Dare	--	--	1
Gates	165	167	6
Hertford	156	167	10
Hyde	102	104	11
Pasquotank	129	130	10
Perquimans	162	184	5
Tyrrell	55	72	5
TOTAL	1,285	1,356	119
NC	22,972	27,748	1,559

Source: Census of Agriculture, 1978.

Table 5. Average Age - Farm Operator

	1974	1978
Bertie	53.5	51.6
Chowan	50.4	51.4
Currituck	51.5	50.7
Dare	--	--
Gates	53.0	50.3
Hertford	54.5	53.1
Hyde	50.6	46.7
Pasquotank	52.5	51.0
Perquimans	49.5	48.8
Tyrrell	55.4	49.4
AVERAGE	52.3	50.3
NC AVERAGE	52.9	51.1

Source: Census of Agriculture, 1978.

Table 6. Market Value -- Agricultural Products Sold

	1974 (000)	1978 (000)
Bertie	$ 29,860	$ 47,135
Chowan	12,907	16,306
Currituck	12,516	13,116
Dare	--	--
Gates	13,610	18,269
Hertford	17,014	22,891
Hyde	12,769	13,722
Pasquotank	16,260	16,677
Perquimans	15,660	20,530
Tyrrell	6,206	11,538
TOTAL	136,829	180,184
NC TOTAL	$2,121,226	$3,033,165

Source: Census of Agriculture, 1978.

Table 7

	Expenses in 1978 for:	
	Commercial Fertilizer (000)	Other agri. chemicals (including lime) (000)
Bertie	$ 4,041	$ 2,209
Chowan	1,808	830
Currituck	1,605	713
Dare	--	--
Gates	2,102	1,221
Hertford	2,220	1,472
Hyde	1,932	860
Pasquotank	2,332	1,014
Perquimans	2,470	871
Tyrrell	1,347	557
TOTAL	$19,857	$ 9,747

Source: Census of Agriculture, 1978.

Table 8. Extension Involvement in Water Quality Programs

1. Demonstration of on-site wastewater treatment systems

2. Potential sites for land treatment of domestic wastes

3. Potential sites for land treatment of industrial wastes

4. 208 Water Quality

    a. Chowan River Basin
    b. Wayne-Lenoir Priority Area
    c. Union Priority Area
    d. Wake County Demonstration Farms
    e. Land of Sky Project

5. Integrated Pest Management Program

6. Reduction of excess nitrogen on tobacco

ROLE OF LOCAL LEADERS

Alfred M. Howard
Chairman, Chowan Regional Task Force

My part in today's workshop is to address the role of local leaders in the task of restoring and preserving the quality of the waters in the Albemarle Sound Basin in order to have:

1. A productive commercial fishing industry
2. A productive sportsfishing industry
3. An active water recreational industry, and to
4. Ensure that all of the citizens of North Carolina may have equal use and enjoyment of our great natural resource, the waters of the Albemarle Sound basin and its tributaries.

To accomplish these desires, based on the information that has been provided here today, the task of restoring the quality of the water will be a formidable one.

Before discussing with you the role seen for each of you invited to today's workshop, permit me to provide you some background information as to how this workshop came into being.

In 1960 a Department of Water Resources survey report concluded that:

1. Commercial fishing and shellfishing activities are important contributors to the economy of the basin.

2. Recreation adds greatly to the economy of the basin.

3. In order that the beneficial uses of water or their potential uses may be adequately protected, both industries and municipalities should provide adequate treatment facilities for their wastes whenever required. In addition, others who create local nuisance conditions or health hazards should take appropriate action.

Another study conducted in 1972 by the Office of Water and Air Resources concluded that:

1. The lower Chowan River is in the beginning stages of eutrophication and that all contributors of nutrients must share proportionately in the blame for this condition and must accept their responsibility for taking remedial action.

2. Acceleration of the eutrophication process must be eliminated or minimized whether the source be agricultural, industrial or municipal.

3. While the Chowan River is the first in North Carolina to show the beginning of a state of eutrophication, it probably will not be the last. All coastal sounds and the lower portions of all major rivers lying north and east of the Cape Fear are subject to the same factors affecting the Chowan.

4. Development and rigid enforcement of a comprehensive water-management plan is vitally needed if the coastal waters of North Carolina are to remain an asset rather than become a liability to the people of the state.

It is now 1982. You will recall the slides showing the algae bloom on the Chowan River in 1971 in the vicinity of Holiday Island. Then recall the later slides showing the bloom extending east of the Highway 32 Bridge across the sound and further east to the vicinity of Laural Point--a spread distance of some 30 miles since 1971.

Importance of Citizen Involvement

In January 1978, a number of concerned citizens in Chowan County formed a Water Resources Committee for the purpose of working together in order to restore the declining water quality of the Chowan River. With the decline in water quality there was a decline in the commercial fishing industry and in sports fishing and water recreational activities. In fact, the economy of the area was suffering as a result of the loss of activity on the river.

Through the efforts of Water Resources Committee members and other concerned citizens, in September 1979, the Chowan River Restoration Project was adopted. Do not be misled. For without active participation by the citizens of the area, the Chowan River Restoration Project would not have been developed, implemented and carried out. What has been accomplished? Several accomplishments can be listed, but one of the most important has been the establishment of the Nutrient Sensitive Waters Classification. Remember the 1972 study conclusion: development and rigid enforcement of a comprehensive water-management plan. No action had been taken by the state agencies to develop such a plan, and no action would have been taken without citizen pressure. Without local citizen involvement, there would be no Chowan Restoration Project. Also, without citizen involvement, there would not have been House Bill 747, which provides for the beginning of the Albemarle Basin Restoration Project, which is really Phase Two of the Chowan Restoration Project.

Citizens' Role in Albemarle Restoration

That brings us to why you are here today. Once Representative James' Bill 747 was enacted last October, planning for this workshop was begun. Dr. Stewart, Acting Director of the Water Resources Research Institute, has chaired the planning efforts. Today, we have two groups here in our effort to begin the task of developing the Albemarle Sound Basin Restoration Project. Before addressing each of the groups, let me provide a short summary of the provisions of Representative James' Bill. The Bill was ratified on October 10, 1981. The major provisions of the Bill are:

1. To create a legislative commission to study the water pollution problems and water resources needs of the Chowan River and Albemarle Sound basins. The commission shall consist of eight members.

2. The lieutenant governor and the speaker of the House of Representatives shall appoint four members each.

3. The commission is to conduct an extensive study of the water pollution problems and water resource needs in the Chowan River and Albemarle basins and shall report its findings to the 1983 General Assembly. The commission report may include proposed legislation, programs and agreements necessary to effectuate its findings.

4. The Department of Natural Resources and Community Development is responsible for conducting the Chowan River Restoration efforts and for initiating studies leading to an Albemarle Sound Restoration Project.

5. The Bill also appropriated monies to fund the fiscal 1982 year's efforts.

The members of the Legislative Commission have an enormous task facing them. Therefore, each of us here today should pledge to provide these eight men all the help and support we can. The successful completion of their assigned task has an important bearing on our futures.

As a starting point for their work, let us provide a recommendation whose successful completion will aid us all in our efforts to restore the quality of our waters. The recommendation is for the commission members to ask all the government agencies to compile a list of all studies, papers and reports that have been conducted concerning the waters of our basin. For instance, I have a list of studies conducted on the Chowan River. The list was compiled in December 1980 and provides the titles of some 48 reports. Several reports have been completed since then. The compilation should contain the title, purpose of the study, a list of conclusions and recommendations. It is recommended the listings be given to the staff of the Water Resources Research Institute for storing in a computer program, thereby making readily available all conclusions and recommendations that have been developed concerning actions necessary to restore the quality of our basin's waters. Also, by employing such a compilation of information, it can readily be seen where additional information is required. Duplication of efforts will be eliminated.

Not only will the information be of great value to the members of the commission, it will be of great value in developing the requirements for the Albemarle Sound Basin Restoration Project.

<u>Establishment of Albemarle Basin Task Force</u>

Now what role is seen for each of you here today as appointed representatives for your respective counties? How did you happen to be appointed?

In order to have representatives from each county within the Albemarle Sound basin, each county board of commissioners was requested to nominate three individuals to attend this workshop who could be depended upon to lead the local effort in getting the Albemarle Sound Basin Restoration Project drawn, approved, funded, implemented and seen to a successful completion. This task will not be a simple one, an easy one or a short-term commitment. It has taken man a long time to pollute our waters. It shall take a long-term, dedicated effort to overcome our mistakes.

After today's workshop, it is our sincere hope that each of you will return to your communities and begin the work of establishing county task forces to work for the restoration of the quality of our waters.

Who should be members of the task forces? First, select members of your community who are willing to work. We have learned that "joiners" are not much help. In fact, they are a burden. Seek individuals with a concern for restoring the quality of our water, individuals concerned with the economic impact the water resources have upon the area. Individuals with these concerns and qualifications should be sought in all segments of the community, such as:

1. Local political leaders
2. Leaders in the agriculture business and the Agricultural Extension Service
3. Commercial fishermen
4. Water recreational business
5. Business men and women
6. Concerned citizens
7. Representatives of the Soil and Water Conservation Service

A task force of about 25-30 members can work effectively and encourage others to participate.

The task force members should include in their activities such tasks as:

1. Assisting in the effort to catalog all point sources of pollution.
2. Monitoring the sampling of discharges to ensure progress is being made to reduce wastewater pollution.
3. Undertaking an educational program to inform citizens of the problems and efforts to correct the sources of pollution and seeking citizen support and participation in the overall effort. Public involvement is a must, for without it this most important effort will fail.

Each county task force will be requested to nominate two of its members to the Secretary of the Department of Natural Resources and Community Development for appointment to the Albemarle Sound basin regional task force. The purpose of the regional task force will be to serve as coordinator for all activities of the county task forces and to provide them with information from the various state agencies on what is being accomplished and what assistance they need to provide in order to further the progress of the overall project.

It is anticipated that a single point of contact will be designated within the Division of Environmental Management for the regional task force. Such an arrangement has worked well for the Chowan regional task force.

Ladies and gentlemen, to implement and ensure accomplishment of a program of such magnitude as the Albemarle Sound Basin Restoration Project will require active participation and/or support by all the citizens of our area. Without active participation, the project is doomed to failure; and if we fail, one must then ask the question: At what time in the near future will we stand on the Oregon Inlet Bridge, look to the east and see the blue Atlantic and look to the west and see our dead green sounds?

ROLE OF THE STATE

Robert F. Helms
Director, Division of Environmental Management
N. C. Department of Natural Resources and Community Development

I hope this last presentation today on the role of the state in its involvement with the water resources of the Albemarle basin will be only the beginning of a continuing, dynamic interaction between all of us. Local leaders, local government officials, the scientific community, state government and the N. C. General Assembly are all vital participants in the implementation of an Albemarle Restoration Project. For while this conference has given me an even greater appreciation for the beauty and value of the water resources of this area, it has at the same time provided me with the sure knowledge that the protection of such a complex, sensitive system can only be accomplished if we all work together. Ensuring that this occurs, that we are all knowledgeable of the problems and potentials of the region and that decisions made at the state level are in harmony with the desires of the residents of the basin, is probably the single most important role of the state. You represent a broad range of interests, all of them important, and all of them should be able to coexist in northeastern North Carolina.

In the next few minutes, I would like to highlight the major reason state involvement is important in an Albemarle Restoration Project, outline the most important roles and responsibilities of the state and conclude by once more emphasizing that the state is only one component of the project. This last point cannot be overemphasized.

Reasons for State Involvement

I can think of at least three reasons the state should be involved. First, the protection of this area's water resources is unquestionably of regional dimension. Numerous counties and hundreds of square miles are involved. We have invited the leaders of 11 counties to participate with us today, but this does not include the significant upstream portions of North Carolina and Virginia that also must be included in any management strategies that are developed. The entire drainage area of the basin can contribute to problems that may be manifested only in the slower-moving coastal waters of the watershed. The solutions to any problems involve several counties; hence, state involvement is appropriate and necessary.

Second, the knowledge and skills that are developed in this basin will be invaluable in addressing problems throughout coastal North Carolina. Over the last 30 years the state has done, I feel, a commendable job of controlling what we term the conventional pollutants, the wastes that originate from cities and the major industries generally associated with North Carolina--textiles, furniture manufacturing and pulp and paper products. But society has become ever more complicated, and we are now being forced to deal with the effects on water quality from chemicals whose names we can hardly pronounce. And in our coastal waters, we are beginning to realize that the increasing pressure of man's activities can slowly accumulate for many years before problems become visible.

The Chowan River is an early indicator of problems also emerging in other portions of our coastal waters, including Albemarle Sound. It is not that the pollutant inputs are that much different in other areas, but that the Chowan system is just a bit more sensitive. So as we devote a considerable part of the state's resources to this area, we are also developing an expertise to be used in other areas of the state--management skills that have not been perfected to date. It is much more straightforward to deal with five miles of the Neuse River below the Raleigh wastewater treatment plant than with the 5,000 square miles of diffuse, nonpoint source inputs in the Chowan River watershed.

Finally, there is no question that this area represents a tremendous natural and economic asset to the state. It fully deserves the attention and protection of state government.

The state should and will be involved because:

1. The system is regional in scope.
2. The techniques we learn will be applicable throughout coastal North Carolina, and probably statewide.
3. The Albemarle region is a valuable asset to the state.

Roles and Responsibilities of the State

Before I discuss the specific roles of the state, I think it might be interesting to note the three major natural resource themes for the Department of Natural Resources and Community Development under this administration because they are closely intertwined with our efforts here today. The first area determined for priority attention was water. This includes an adequate water supply, coastal water management and water quality. This, of course, is precisely what we've been talking about today.

There are two other major natural resources priorities. The second is productive resources. We are using this term to cover the best management, protection and utilization of our fisheries, forests, soils and minerals--the basis for our economy and prosperity. The third theme is outdoors North Carolina. This theme refers to our aesthetic and recreational enjoyment of the environment in North Carolina. We are richly blessed with a diverse and beautiful state. Our citizens greatly value our forests, parks, beaches, lakes and rivers for recreation that is truly satisfying and renewing. So you can see, while water is the primary concern here today, all three of these priorities are related to the proper development of this region.

Why was water selected as a primary theme for the term of this administration? First, good water management is absolutely critical for our economic health. A survey of industrial development professionals in North Carolina identified adequate water and sewer service as the number one necessity in locating high-quality industry in North Carolina. Our state suffers from a low industrial wage level and from excessive unemployment and under-employment in many areas. These economic problems cause real human suffering and waste of human potential. We must make sure that we have the water and wastewater capacity needed to attract high-wage jobs for our citizens.

Second, good water management is essential for the quality of life we value in North Carolina. Water quality is always at the top of the list of problems that citizens are concerned about. Many surveys have shown that our citizens want good water quality and are willing to support what it takes to achieve this goal.

Third, state government's responsibility for water management is great. All citizens have a right to use and benefit from our abundant water resources. By law, state government has a major responsibility in assuring that water resources are managed for the greatest good. With the significant decline in federal resources devoted to water management, the burden on the state becomes even more critical.

Finally, we are now at a critical point in our state's history. We have some serious water management challenges in several areas. There are some warning signs of more problems that are beginning to emerge, and we have been talking today about one of the primary examples of this. But we have not yet reached a crisis level where problems threaten to overwhelm us and where drastic and divisive remedies are needed. In North Carolina, we have time to plan, to act and to shape the kind of future that we want.

And so what should be the role of the state in shaping the future of the Albemarle basin? I would like to summarize four today. The state should be:

1. The coordinator for gathering information
2. The facilitator for obtaining needed research
3. The agent for bringing together local interests, local users, the researchers, the regulators and decision makers
4. The implementor of the management plans that develop from studies of the basin

These first three points are fairly self-explanatory. The state is the logical agent both to gather and house water-quality information and to facilitate the research needed to supplement and complement this information. The large amount of data being gathered and the research that has been accomplished and is underway have already been summarized today. We have a close working relationship with the Water Resources Research Institute, and I feel they have been extremely responsive to our needs. As the entity to bring together all the interests in the basin, what better example could be cited than this conference. In the final role as the implementor of the management plans to protect and enhance the water resources of the basin, several specific activities could be cited.

There are the obvious regulatory responsibilities of establishing water quality standards and stream classifications and of enforcing permit jurisdiction over point-source dischargers. The establishment of the nutrient-sensitive waters classification for the Chowan is an example of the first point. Examples of wastewater-discharge limitations through permits include the elimination of the C. F. Industries discharge in the early 1970s (there is still a nonpoint source concern associated with the industry) and the restriction on the amount of nutrients allowed from North Carolina municipalities in the Chowan basin.

There are also educational responsibilities. These range from contacts with the residents of the basin to work with a voluntary nonpoint source control program for agriculture and forestry operations. Three scientists are housed in Edenton to provide citizen contact as well as study the river. A Chowan regional task force composed of local leaders in the Chowan River basin has been formed and is providing guidance and advice to us. It is also an educational contact for residents in the area. Education and technical assistance constitute the main thrust of our nonpoint source control strategy. The Soil and Water Conservation program in the Department of Natural Resources and Community Development has been asked to take the lead in this effort.

And there is the need for interaction with Virginia and the Environmental Protection Agency (EPA). This is being accomplished in CHORE by the Chowan Bi-State Technical Panel, composed of seven representatives each from North Carolina and Virginia and two representatives from EPA.

In the Chowan River Restoration Project, we developed an Action Plan by the summer of 1979 in response to the massive algal blooms of 1978. This document highlighted the immediate steps the state could take to respond to this situation. We also began developing a long-term management plan to address the overall needs of the basin. This document is in draft form and is being reviewed in-house.

We are now expanding our efforts into Albemarle Sound. In 1981, the General Assembly appropriated $100,000 to study the water pollution problems and water resource needs of this system. By January 1983, we will develop an action plan to highlight immediate actions that should be taken to respond to any identified problems. The action plan will also identify any needed studies or the necessity for a long-term management plan.

Joint Effort Needed

In summary, I would again like to emphasize the need for a joint effort in solving the problems emerging in this basin.

The roles of local and state government overlap with those of each citizen of the basin in one crucial area--in deciding how we wish to utilize the valuable resources of this area and what we want for the future of this region. Our job becomes harder when we realize that in a sensitive and complicated area like this, our standards may not be sensitive or sophisticated enough to measure subtle pollutants that could be affecting, for example, the health of the fishery resource. We must also keep in mind that the everyday, normal activities of agriculture and forestry operations are an important component of the health of the region, yet may also be a significant part of some of the problems. We then begin to realize we are talking about coexistence and balance for all activities, and it is the role of each of you, not state government, to determine where this balance should be struck. For the remainder of this conference and in the immediate future, let's see if we can jointly begin to determine this balance point.

DISCUSSION

James M. Stewart, Moderator

Captain Fred T. Merritt, U. S. Coast Guard, Retired: I've been in this area since 1924, except for periods of temporary duty outside the area with the Coast Guard; and about 50 percent of that time I've been in the Pasquotank River and the Albemarle Sound, and I mean literally. I swam as a child, and I partook of the polluted water, and it didn't kill me.

Listening to what has been said here today, I find that we could probably go on studying this problem for years if we don't begin to take action somewhere along the line. The problem that has caused such an uproar and all the studies now is the algae in the Chowan River. Before that, it was the milfoil situation in Currituck Sound. Milfoil will kill the aquatic plants that are beneficial to the wildlife, and we have had a decided reduction in the area in wildlife, particularly the more desirable species of ducks and geese. Before that, it was the crabs, once a tremendous industry in Albemarle Sound.

I've heard that farming is a detriment to the area's water. We've had farming since the Indian days, and we've had raw sewage dumped into the river and the sounds. But surprisingly, there were plenty of fish, ducks and shellfish. This past summer, 1981, when we had saltwater infiltration was the first time I've seen a soft-shelled crab inside the city limits of Elizabeth City.

I think what the Albemarle Sound area needs is a periodic flushing with saltwater. Last summer, if no other time, proved that saltwater coming into the area would improve the fishing and everything else. Until the study is completed and you find some action to take, don't close inlets. Don't build dunes; don't build structures level on the sand, Put them on pilings and pray for a few hurricanes and dry seasons like last summer.

Manley Fuller, National Wildlife Service: I've heard mentioned something about an interbasin transfer that would be beneficial to both Virginia and North Carolina. How would North Carolina benefit?

John Morris, Office of Water Resources, NRCD: We've got a very complicated situation with our neighbor state. We have one groundwater aquifer that underlies both states, and both states are drawing water from it. Because of the very heavy water use in southeastern Virginia by industry and the cities, the groundwater pressure levels in North Carolina have been substantially reduced all the way down to Albemarle Sound. That's one problem.

The other is pollution in the Chowan River; and as we've heard today, about three-fourths of the nutrients in the river come from the Virginia portion of the basin.

A third main problem is the proposal to use surface water from rivers that flow into North Carolina to help supply southeastern Virginia's water needs, which would be an interbasin transfer. The City of Norfolk is now withdrawing water from the upper Chowan basin and transferring it to Tidewater, and there are several proposals on the drawing board which would either take water from the Roanoke basin or more water from the Chowan basin for the Tidewater area in Virginia.

APPENDIX

All these things are related. In other words, if Tidewater Virginia can get a reliable surface water source, that would reduce their demands on groundwater. Of course, management of the flow of water in the Chowan River and the Roanoke has an effect on water quality in Albemarle Sound.

There are literally dozens of elements and actors in this complicated situation. North Carolina is making a good-faith effort to work with our sister state to determine if they can understand our problems and our needs. We should make the same effort to understand theirs. We think it's worth an effort by process of negotiation to examine all three of these problems and look at various alternatives. And after adequate review by the public in both states we will determine whether we can come up with some solutions to meet these needs of water for Virginia, better management of groundwater and better water quality in the Chowan and Albemarle area.

What this agreement could be, we're not really prepared to say; but obviously, from the North Carolina point of view, we will be looking for better controls on nutrients and other pollutants flowing from Virginia into North Carolina. We will also be looking for better management of groundwater in Virginia. In other words, by spacing wells properly and limiting the amount of water pumped out of the wells, the lowering of the water-pressure level in North Carolina can be reduced. As far as surface water goes, we would want to add some agreements and limits on the amount taken out of rivers flowing into North Carolina so that the impact would be acceptable to interests in North Carolina.

We're just at the first step of trying to work with the state of Virginia in an open way to determine if there is a solution that both states can agree on. If we can't reach a negotiated solution, the only other option would probably be a suit in the federal courts, which would have a very uncertain outcome. So we believe that the best approach is to take some very cautious but careful and good-faith communication and negotiation with Virginia, and we'll just have to see how that works.

Dr. James M. Stewart, UNC Water Resources Research Institute: In a complicated situation like that we need to go in prepared. Regardless of what we say about studies, if we look back to 1970 and at our knowledge and the expertise today, we're in a lot better position now to make restoration efforts.

Question: How will we get the data we need to present to the legislature by January of 1983?

Stewart: It is obvious that in that period of time a great deal of information must be gleaned and consolidated from what has already been done. Also, additional monitoring is planned by the Division of Environmental Management this summer throughout Albemarle Sound.

C. A. Phillips, Chowan County: The Chowan River has been in a state of eutrophication now for some ten or twelve years, and the initial studies have been expanded just in the last session of the legislature to include other bodies of water in the Albemarle basin. It seems to me the information we've gathered should be adequate to start some type of enforcement proceedings.

How are the results of these studies being implemented, and what enforcement actions is the state pursuing? Are we doing all we can in North Carolina to solve our problems below the line so we can lay our program on the line with Virginia and say, "This is what we're doing; we need your help"?

Stewart: I think we've had an evolving process. Some actions have been taken such as the creating of a nutrient-sensitive river classification, which brought about a tremendous amount of enforcement effort on point-source discharges. There's no way that could have been undertaken without the benefit of the kinds of information we've seen presented here by these researchers and the state agencies. Bob Helms, would you like to comment on what the state is doing?

Bob Helms, Division of Environmental Management, NRCD: I stated early this morning that we had spent a million dollars since 1971; and we have reviewed today a lot of the information and data that have been collected from your investment. Some of the best minds in the country have looked at the problem and tried to provide some answers, including an EPA blue-ribbon panel of scientists from all over the United States. There are no simple answers.

We have gathered a lot of information, and we will parade it before your representatives, the Legislative Study Commission. If they are guided by you, they can take that information and try to help you make decisions, because I'm afraid the decisions that must be made are political. I don't mean party politics; I mean choices that you living in the basins have to make.

I have heard several people comment that we're pointing the finger at agriculture. That's not true. We are identifying what the statistics of this moment indicate for agriculture and for point-source dischargers. Since 1971, the Division of Environmental Management, through the Environmental Management Commission, has made some changes in the control of point-source discharges, created the nutrient-sensitive waters classification, initiated other actions and is indeed pushing as hard as they know how. I believe your study commission, when it goes to the General Assembly, will be recommending more things that are not technical solutions but choices you must make as a community. What trade-offs are you going to make? For example, do we change and regulate the amount of water that's impounded on the Roanoke River to allow a change in the mix of water to hold down the blooms? Those are management problems, not technical questions.

Stewart: I will say they are management problems, but even if we could control the flow in the Roanoke, would we know when to do it or how much and what the effect would be? It's easy to say that's a problem, but it's a long way from implementing a program that people will accept and support.

Frank Haskill, Currituck County: You've got problems in the Albemarle and Chowan River, but we've got problems in Currituck Sound, too. Twenty-five years ago we realized that we had a problem in the Currituck, and nobody would do anything about it. In 1962 we had a study done on the Currituck that recommended we have a salinity of 10 percent. Still, nobody does anything about it. Everybody who speaks here today says that as the salinity increases in the Albemarle, so does the quality of the water and the fishing. We need saltwater in Currituck Sound.

Stewart: You're saying we need increased salinity in the Currituck. B. J. Copeland, how complex is that in terms of the amount of water, energy and structures needed?

Dr. B. J. Copeland, UNC Sea Grant Program: I believe the flow of those rivers is the key to the health of the estuaries, including the Currituck, Albemarle and Chowan. Historically, the Currituck did have saltwater in it. Mother Nature had things working pretty well. Then, we decided to develop a wildlife refuge in the lower part of Virginia and transfer some water around, so we now have increased fresh water coming down the Currituck that we didn't have before. Virginia wants to borrow some water, so maybe one trade-off is to encourage Virginia to take some water out of the top side of Back Bay and leave us some of that water in the Chowan.

Second, some folks have suggested that we put an inlet through the Barrier Islands. Calculations indicate that if you do that, you're not going to have any more saltwater in Albemarle and Currituck Sounds than you have today. Water does not run uphill. You will have to decrease the head of fresh water in order to have salt water creep up the tributaries. Albemarle Sound has a fresh water flow of about 17,000 cfs and a volume of 5 million acre-feet, a ratio of about 3 1/2, whereas Pamlico Sound has an average flow of 32,000 cfs and a volume of 21 million acre-feet, a ratio of about 1 1/2, so there's a lot of difference in the Pamlico and the Albemarle. You aren't going to solve the problem by cutting an inlet. You have to change things on the inside. If we can get the Roanoke flowing the way Mother Nature had it, maybe we can get some things going up there.

Haskill: In the very beginning we had an inlet in Currituck Sound. Now in three or four hundred years, the flow of water hasn't really changed. It came in there in the beginning, and the earth hasn't changed that much. They put the locks in operation in Great Bridge and closed it up.

If you'll knock down these sand dunes on the northeast end, we'll get saltwater in Currituck Sound. On extremely high tides that we get out of the southwest, we're going to get rid of some of that fresh water into the ocean; and if they open the locks in Great Bridge like they were in the early, say, 1900s, it's got to flow. Ten percent of seawater, which is what we need in the Currituck, isn't a whole lot. Knock down the sand dunes; let the wind wash it over like it did 50 years ago and open up a lock. We don't need a whole lot to cover the sand dunes.

Copeland: You are right. The washovers that occurred down in the Barrier Islands were a source of some saltwater that occurred every time you got a Northeaster. But Bob Helms hit the nail on the head. Those are choices you've got to make; and if you want to eliminate some of those houses, that's your choice. And it is a political choice, not one a technologist makes.

David Bateman, Chowan County: It seems to me that the saltwater that killed out some of the bad algae, the blue-green algae, last year would have the same effect on the good algae that the small fish need to feed on.

Copeland: No, quite the contrary. As a matter of fact, you would increase the good algae. It's a seasonal phenomenon. The balance of fresh water to saltwater on a seasonal basis is the important aspect, not how much saltwater you have.

Gilliam Wood, Chowan County: If you go back in history a bit, generations of commercial fishermen, including my own father, grandfather and great grandfather, have blamed the decline in fisheries on the closing of the inlets.

I'm a little disturbed that I don't hear more about an infusion of saltwater; and maybe people are here who can say why that's not possible or what it would do, but I believe history is telling us something. We had the best water quality last year in Albemarle Sound we've had in 25 years or more, and that was because of the drought. The overlay of saltwater killed the bad algae and increased the good. We had bait fish in the sound; we had bluefish at the railroad bridge. I think it's telling us something, and that may be a lot simpler to deal with than dealing with Virginia.

Dr. Hans Paerl, UNC Marine Science Institute: The gentleman is correct that it killed off the bad algae. But it didn't necessarily increase the good algae in the river because of the complications due to pulp mill effluent, which tends to have a negative effect on the spring bloom of good algae. We have some evidence, and we're working further also on the Neuse estuary, to indicate what it takes to eliminate these blue-green algal blooms in terms of salinity. But I don't think we're prepared to say that this necessarily benefits the good algae. You've got some other complicating problems in there as well.

Dr. A. M. Witherspoon, N. C. State University: We have studied the salinity factor this summer extensively, and what has happened is this. Blue-green algae are not found in the winter in the water column. They form spores and overwinter in the sediment. When the spring comes with temperatures of 12°C and better, they germinate out of the sediment and form air pockets that will move them up to the light. There, they shade out everything else, creating competition between other algae that may also be in the sediment.

This spring there was an influx of a layer of saltwater that inhibited the germination of these spores. At one percent saltwater, germination was inhibited down to .02 mg/l dry weight. At five percent they germinated less than .01 mg/l. And at 10 percent they failed to germinate. When the blue-greens failed to germinate, the other algae were able to grow more affluently because of the lack of competition. We also found in a past study that milfoil seeds in Currituck Sound would not germinate above 50 percent concentrations of saltwater. So saltwater has played a very definite role in the inhibition of growth in both the blue-green algae and the milfoil in these two areas. It's not that it promotes the other algae to grow, but it inhibits competition.

Dr. Samuel Mozley, N. C. State University: The idea of increasing the salinity of the sounds may solve some of the problems, but let's not forget there are algae in the brackish waters that also bloom. They will cause problems if you don't use an overall, coordinated approach in dealing with the situation. There's still nitrogen and phosphorus coming down the river that will stimulate algal growth in fresh or brackish waters. If these detailed, politically complex management options are not pursued, there is going to be a problem down the road even if salinity is up. We're going to have red tide and other problems that come with saltwater. Don't think a simple opening of a gap is going to solve those problems.

Stewart: Captain Howard, is our tone of discussion going in such a way that we are going to assist the Legislative Commission and the Albemarle Restoration efforts?

Alfred M. Howard, Chowan Regional Task Force: I would just like to go back to when the Chowan Restoration Project was implemented. Two decisions were made. One was to pursue the elimination of pollutants from point sources. That can be controlled through the discharge-permit system. That's a long-term effort because these discharge permits run for a number of years. The establishment of a nutrient-sensitive water classification is a procedure whereby we will be self-cleaning our waters. Because we make the discharges upstream meet the classification requirements, then their discharge will contain less pollutants; and as less pollutants come downstream, the other dischargers will have to come into compliance. So we will be eliminating it all the way down.

The other decision made was to work voluntarily through our agricultural agents to initiate best management practices to help reduce nutrients from these sources. One was a regulatory measure, one voluntary participation. In North Carolina, our Albemarle Basin Restoration Project should be an outgrowth of the Chowan work and what we have learned. If we do this and we set up our rigid management practices, then we can show our sister state to the north that we do really intend to do something about our problem in North Carolina, and then we can say, "Look, we are doing something; we need your help now."

We have been hollering about Union Camp for the last eight years. When we institute the Albemarle Basin Restoration Project, the Roanoke comes into play as one of the tributaries. Now what do we have on the Roanoke? A pulp-paper mill. No one's addressed that yet. Some preliminary sampling has been done, and that pulp-paper mill may be putting more into our system than our friends in the north. That's one of the political decisions that's going to have to be made; and if you look at every river on the eastern shores of North Carolina that is beginning to have eutrophication problems, you will find a pulp-paper mill.

Comment: The possibility of a phosphate detergent ban was mentioned. Haven't some of the states passed laws to remove phosphates from detergents?

Stewart: In the Great Lakes area, phosphate detergent bans did occur; and as a result, they were able to show substantial phosphate reductions. Phosphorus loadings to the Great Lakes from municipal treatment plants in Michigan have been decreased by 20 percent. I would question, however, how much of the phosphate input to the Chowan basin or Albemarle Sound could possibly come from detergents. That has to be a small percentage of the total.

Comment: I simply want to point out that history bears out what the gentleman from Currituck said about saltwater.

Stewart: It would seem to me that as you, the leaders from these 10 counties, get together and talk about these things you will begin to prioritize and put some emphasis on what you want done. Capt. Howard has outlined a few things that you've already specifically said you wanted. Salinity should also be an ongoing consideration.

I would hope over the next few months that you would have a chance to have more input to this Legislative Study Commission; I'm sure that Representative James would like to hear what you think should be done. I think you will all agree that today we only touched the tip of the iceberg in terms of the kinds of information that is now known about the Chowan and the Albemarle. We should try to become aware of the information that is available so we can then make recommendations and state what we think should now be emphasized.

Rep. Charles Evans: I represent the First District along with Vernon James. This is a subject that both of us have been very much interested in for quite some time. I want to congratulate the people who put this conference together. It's been very beneficial in giving us some idea of what needs to be done.

One of the issues that we have been dealing with over the last few months and years is the stabilization of the Oregon Inlet, which has gradually filled in. Part of that issue is the dredging of the inlet to increase the volume of water that passes through it. I'd like to know if anything significant could be contributed by its stabilization. We have had a great deal of unity and comment recently by the commercial fishing industry in Dare County about that subject.

One further point I'd like to make is that I would hope that out of this meeting today will come a louder voice to us in the General Assembly to do something about the problems that we've discussed today. There are a lot of political considerations, and the people of this area need to speak up, not only to us but to their county commissioners, the Marine Fisheries Commission members and all the other state boards and agencies. Let them know something has got to be done before it's too late.

Stewart: Thank you very much, and I'd like to endorse that last comment because funding for many water-related programs such as the 208 program, EPA's water research program and others are being reduced substantially. A greater voice to your legislature is going to be needed if you expect to maintain even the efforts that were outlined today by Alan Klimek. A great percentage of the resources of the Division of Environmental Management has been concentrated right here, and we have other rivers that have problems. Does the Corps of Engineers or Bob Helms want to respond to the question about Oregon Inlet?

Helms: I have not heard any information at all in the Division of Environmental Management that seriously looked at the question of introducing saltwater into the sound.

Stewart: There have been some studies conducted on introduction of saltwater into the sounds in the past, but they have not been discussed today. I would like for someone from the Corps of Engineers to comment on this question.

Edwin G. Long, Jr., Corps of Engineers: We have studied Oregon Inlet from many different directions for a number of years, but salinity is not generally one of our concerns. The indications are that the inlets do not contribute greatly to the salinity gradient in the sound. It dies out very rapidly. It takes wind tide, different pulls in the river and other things to change the salinity gradient significantly.

As far as the flow diminishing through Oregon Inlet, the configuration of the inlet may change, but the hydraulic efficiency generally remains about the same. The exchange of fresh water and saltwater by tidal fluctuation doesn't vary that much. The model studies we have made in connection with stabilization and improvement of Oregon Inlet indicate that any change in the configuration of inlets would improve the flow. But I don't know that it would have any significant impact on salinity gradients in the sound.

Stewart: Representative James, would you like to make a few comments? We'd like to wind this up and have a few questions left for the next conference.

Rep. Vernon G. James: First, I want to thank Murray Nixon for providing the good fish dinner we all enjoyed. I also want to try to enlighten you a bit on the study commission. A legislative study commission is to gather facts to present legislation to correct whatever is wrong. Now this group is supposed to tell us what your plan of action is. You've done the study. Let's get on with the work.

They say 45 percent of the pollution is coming from farm runoff. I asked the questions yesterday in our study commission meeting, "How did it get there? What would happen if we did not farm? How can you control it?" We had a bill in the legislature that does not allow the Department of Natural Resources to check water if it's a nonpoint source. I'm willing to change that legislation if you'll tell me how it's going to affect farming. Are we going to put all the farmers out of business and save the river or are we going to save the farms? Both of them are very important. I think we can have both.

You mentioned farm practices. Nobody has told me what you mean by farm practices. Good conservation practices? I don't know what they are. Are you going to stop the trees from shedding leaves in a swamp? That's a source of nitrogen, I believe. I understand that most North Carolina soils, if you go down deep enough, are rich in phosphate. How much nutrients are going in the river and sound from natural sources? Snow, the "poor man's fertilizer," is full of nitrogen. How are you going to keep snow or rainwater out of the river or the sound?

I appreciate the group getting together. I hope that as a member of the General Assembly, Charles Evans being my partner in this district down here, that we will be able to introduce and pass whatever legislation will help the problem. I want us to get on with the work. I appreciate your time.

Stewart: Representative James, you know, if you take away your Agricultural Research Service and its continued input of technology in agriculture, you're hurting. Suppose we just say we're going to get on with it, with no more research. You have thrown out at least a half-dozen questions that we don't have all the answers to.

Rep. James: There's one thing I didn't say. This bill allocated $100,000. It may be tougher and tougher to have allocations of funds from state tax money in the future, and I hope that we can really make the very best use of it.

Comment: We have information on the total nutrient input from the various sources. I would like to see this information drawn down into the effective input that each area is contributing, that portion we have some control over, and then come up with a net figure that we can influence and see how we are standing in the various areas as we approach the solution to this problem.

Stewart: That's a very good point. I think that message has come home several times. We need to decide on how much of the agricultural nutrient input we can effectively control and get on with that portion. D. G. Harwood outlined a half-dozen best management practices being tested to see what effect they have on controlling nitrogen and phosphorus. It has yet to be completely determined just what effect "X" dollars invested in these practices will have on reducing nutrients.

Comment: I noticed in one presentation that all the slides showed the latest date as 1978.

Copeland: Those are the latest census figures, and they are about the best available for the kinds of data shown.

Beverly Young, N. C. State University: How will the $100,000 appropriated by the legislature be spent?

Helms: The Albemarle Legislative Study Commission, Representative James' commission, will decide how it is spent.

Question: Will periodic saltwater intrusions into the freshwater system solve the algal bloom problem?

Paerl: It will if the salinity is brought up to the level that Dr. Witherspoon talked about and the kind of levels we observed last year. If those occur, I think we can safely say they will keep down the blue-green algae problem. But this is only one of the remedial steps that need to be taken or considered.

I don't want to argue against the historical record, which is very good and very believable. But in terms of other things that are coming into the Chowan catchment, both from Virginia and North Carolina, things are radically different from the way they were 50 or 100 years ago. We've got pesticides, many different organic chemicals, pulp-mill effluent, increased agricultural practices, industrial use--all these things have gone along with the periodic flushings of salinity that occur in these regions as well.

Even though we can show that salinity intrusions do keep down these blue-green algal blooms, we should not simply take that as being the quick fix that is needed. It has the potential for being a beneficial step, but these other factors may, in fact, be equally important in terms of not allowing the good algae to reappear in the Chowan and stay there. I would like to stress that there are a lot of other things going on right now that weren't there a hundred years ago when the fishing was very good.

Stewart: I'd like to thank the committee that worked with us in planning this conference, the participating agencies and especially the planning committee of Alan Klimek, B. J. Copeland, Connell Purvis and Parker Chesson. They played an important role in helping plan today's session. I appreciate very much your questions, and I know the frustrations you must have at having conflicting opinions expressed. At this point I'd like to ask Captain Al Howard to close with a last word.

Howard: We have hoped in setting up the program for today that you will take what you have learned, go back to your respective communities and begin at the community level to gain support for restoration efforts. Our legislative committee needs our support, our input. Without that information, their report next January will not be very effective.

So let's all go back and get our agricultural and industrial people and our other leaders together. Let's use this as the day in which we all step out as a group of citizens to get the job done, because there is no turning back. If we don't clean it up, and that includes all nutrient sources, then we're not going to have the sound for those beyond our time. Thank you.

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