North Carolina Nutrient Summit

Summary and Recommendations

Sponsored by
North Carolina Sea Grant
North Carolina Coastal Federation
N.C. Department of Environment, Health and Natural Resources
Environmental Defense Fund
University of North Carolina Water Resources Research Institute

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Introduction

Coastal waters are one of North Carolina's most important natural resources. Miles of marshes, estuaries and barrier islands provide critical habitat and nurseries for plants and animals. Our rivers, sounds and oceans teem with fish that support our state's economy through recreational and commercial fishing. Pristine beaches draw millions to the coast each year.

But today, reports of algal blooms, fish kills and dead water have become frequent. Enrichment of North Carolina waters with nutrients threatens our coast's sublime beauty and teeming wildlife.

But coastal water quality problems did not happen overnight. Signals of ecosystem stress have been occurring for more than a decade. However, it has been difficult to draw everyone — resource managers, scientists, politicians and the public — together to see the problem from the same perspective.

The "Coastal Futures Committee," established by Gov. James B. Hunt in 1994, recommended that a joint forum should be held to increase communication among scientists, coastal managers and citizens regarding current scientific information and research needs. In response, North Carolina Sea Grant; the North Carolina Coastal Federation; the N.C. Department of Environment, Health and Natural Resources; the Environmental Defense Fund; and the University of North Carolina Water Resources Research Institute sponsored the North Carolina Nutrient Summit in August 1995.

At N.C. State University, scientists, resource managers and the public came together to learn about nutrient enrichment, to understand its impacts and to discuss future management strategies.

"Recent events have shown us all quite clearly that we have a nutrient problem in our coastal waters," says Joan Weld, assistant secretary of the environment for the Department of Environment, Health and Natural Resources. "People are frustrated, and they're angry. We've got to find ways to harness this frustration and work together to solve our problems.

"We still have a great deal to do if we are to protect, preserve and repair our coastal waters," she says.

The North Carolina Nutrient Summit is one step. This report is a summary of the information and recommendations given at this conference.

The Problem

During recent decades, our state's rivers, estuaries and ocean waters have been inundated with nutrients. Nitrogen and phosphorus pour from waste treatment plants and industries; drain from farmlands, forests and city streets; trickle through groundwater from animal waste lagoons and other land-use activities; and rain from clouds seeded by factory, agricultural and fossil fuel emissions.

This deluge of nutrients into ecosystems already rich in their own natural supply causes eutrophication — too many nutrients — which is responsible for a variety of ills now plaguing salt marshes, brackish coastal rivers and nearshore ocean waters.

This overabundance of nutrients is directly or indirectly causing algal blooms, waters with low or no dissolved oxygen, fish kills, a decline in valuable seagrasses and other problems. The two most important nutrients implicated in coastal water quality problems are phosphorus and nitrogen. Nitrogen in its many forms is the main culprit in brackish and marine water; phosphorus is more of a problem in fresh water. The sources of these nutrients are widespread. Both point and nonpoint sources are implicated. Our problem in coastal North Carolina is at least three-fold.

* The linkages and interactions among nutrient sources, fates and impacts are extremely complex and not entirely understood by the scientific community and even less by the general public.

* The population continues to increase along with the generation and release of additional nutrients into natural waters. Therefore reductions in the amount of nutrients released can be overshadowed by the increase of inputs from a growing population.

* Coastal North Carolina is a unique and complex coastal environment that creates a plethora of management problems. Coastal estuaries are large, slow-moving, wind-mixed, shallow bowls. In these estuaries, water sloshes back and forth, driven more by wind than tidal influence. These estuaries flush very slowly to the sea through narrow inlets, making North Carolina coastal waters more vulnerable to impacts from nutrients and other pollutants than coastal areas where rivers flush more readily.

People see the problems, but they don't see the causes. Dissolved nutrients are undetectable to the naked eye. That makes the problem of too many nutrients a hard concept for the public to grasp and embrace. Consequently, many people don't understand that eutrophication is directly related to human activities.

"You remember, Pogo went out to find the enemy, and he came back and said, 'We've found the enemy and it's us,'" says North Carolina Sea Grant Director B.J. Copeland.

The problem with North Carolina's coastal rivers is consumption, Copeland says. "We want a green lawn, a nice car, a big house. We want to live someplace with a view."

Copeland says we have finite natural resources but infinite desires to use them. The many and often conflicting demands are simply increasing pressures on our resources and the people who manage them.

"Nutrient enrichment is a complex issue to manage," says Tom Malone of the Horn Point Environmental Lab in Cambridge, Md. Sources of nutrients vary from direct discharges to groundwater to rain. As scientists and managers shift to the study and prevention of nonpoint nutrient sources, eutrophication has become an even tougher problem to solve.

Other problems complicate the situation, he says. Many agencies cannot afford the costs of data collection and water monitoring. There's also a lack of consensus within the scientific community, a dearth of data on socioeconomic impacts, an uncertainty of what results current management strategies will bring and little information exchanged between scientists, government and polluters.

What's needed, says Malone, is more communication and better information. We must couple studies of land use, fisheries, water quality and nutrient inputs. We need timely incorporation of scientific knowledge into management structures. For this, he says, "Scientists will need to develop ways to agree on what is known and what should be applied and used."

But ultimately, Copeland believes it is the responsibility of government to solve the problems of eutrophication. North Carolina needs more precise resource management regulations, better implementation, stronger enforcement and a more visible and vocal education effort. Until everyone from the resource manager to the developer to the scientist to the Neuse River angler develops a fundamental understanding of the value of our coastal resources, they will continue to be imperiled.

Ecological Impacts of Nutrification

Many people don't understand the complexities of nutrient enrichment or the extent to which it can harm a coastal ecosystem. There may be losses of submerged aquatic vegetation, increases in phytoplankton production, algal or fish population shifts, disruptions of the aquatic food chain, red tides, fish kills, dead waters — even human health problems (Fig.1).

The nutrients of most concern are nitrogen and phosphorous, says JoAnn Burkholder, an aquatic botanist at N.C. State University. Large doses of nitrogen can spur planktonic algal species into rapid growth patterns called blooms. Algal blooms have been reported across the Albemarle-Pamlico estuarine system and in the Neuse and New rivers.

Algal blooms can choke valuable seagrasses that serve as fish habitat, rob waters of life-sustaining oxygen and cause fish kills. Burkholder's studies show that 0.1 milligram per liter of nitrogen is toxic to *zostera*, one of North Carolina's most valuable seagrasses.

Even when we know nutrient levels are high, predicting when algal blooms will appear is difficult, says Jimmie Overton of the N.C. Division of Environmental Management. Although there are winter dinoflagellate concentrations in saline rivers such as the Neuse and Pamlico, algal blooms usually appear in the spring to early fall. "There is a window during which algae can use nutrients to reproduce," says Overton. The low winds, higher temperatures and lower river flow of the warmer months all help determine when and where algal blooms will occur.

Some algal species are advantageous, offering a ready supply of meals for creatures higher up the food chain. Other algae aren't so desirable. Surface blooms of blue-green algae, for instance, are

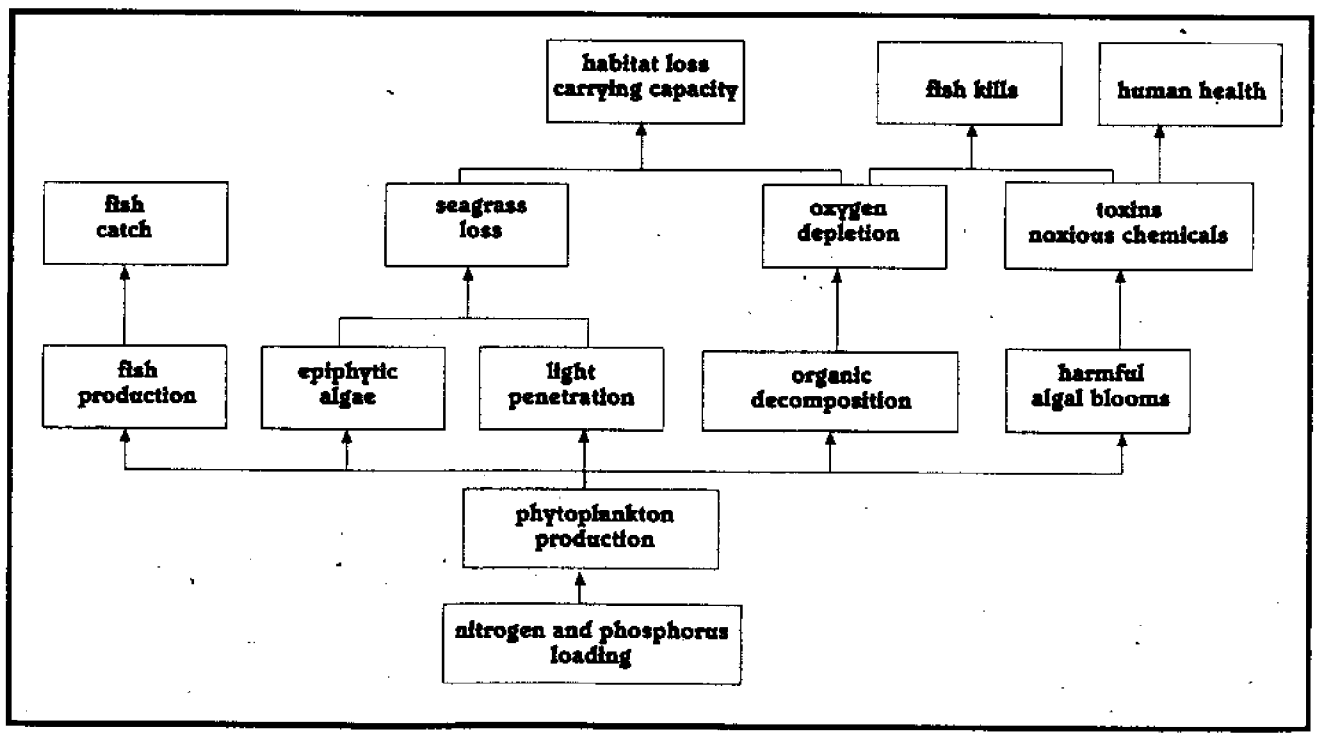


Fig. 1. Effects of nutrient enrichment (contributed by Tom Malone).

inedible for some marine animals because they release toxins and are too big for tiny zooplankton to eat.

Dinoflagellates, a form of algae, can be toxic to fish and shellfish or contaminate them with toxins that make them undesirable meals for others, including humans. Since the 1950s, countries around the world have seen an increase in red tides — massive blooms of toxic dinoflagellates that color waters red, yellow or brown; kill fish and shellfish; and cause respiratory irritations in humans.

Burkholder was one of a team of researchers who recently discovered *Pfiesteria piscicida*, a "killer dinoflagellate." Research shows this organism is stimulated by excessive nutrients, especially phosphorous. *P. piscicida* emits a lethal neurotoxin into the water and air, causing fish to suffocate and die. Burkholder believes *P. piscicida* may be the cause for 50 percent of the fish kills in the Pamlico-Albemarle estuary. And some questions have been raised about its effects on human health (Fig. 2).

"Do we have evidence of water quality degradation?" asks Burkholder. "I'd say we do."

Poor water quality can mean more than fish kills and habitat loss, it can have human health impacts too. Most waterborne diseases, such as cholera, giardia, Norwalk syndrome and other viruses, parasites and bacteria are transferred through human and animal wastes, says Mark Sobsey of the Department of Environmental Sciences and Engineering at the University of North Carolina at Chapel Hill. To detect these organisms, called enteric pathogens, North Carolina measures fecal coliform, an indicator of waste-related bacteria.

There may be problems with this method of testing, says Sobsey. Fecal coliform may not detect all types of bacteria and viruses in the water. Fecal coliform cannot tell you whether the waste source was human or animal. This is particularly important because of the increase of animal production — poultry, hogs and

Ecosystem	Days	No. of fish	Cause
New River	4	4,000	High ammonia, hypoxia (hog spill; fresh water)
New River Estuary	1?	ca. 10,000	Lethal *Pfiesteria* densities preceding kill; second harmful alga, *Phaeocystis*, also known to be stimulated by raw sewage (Hallegraeff 1993); sublethal *Pfiesteria* two days after kill*
Neuse River Estuary	5	100,000s	Hypoxia; sublethal *Pfiesteria* two days after kill*
Pamlico River Estuary	11	100,000s	Lethal *Pfiesteria* during kill; low dissolved oxygen in lower third of water column
Black River	2	10,000s	Anoxia (hog effluent spill?; fresh water)
Roanoke River	2	100,000s	Industrial discharge from faulty management upstream, reservoir water level (hypoxia/anoxia)
Goose Creek (Neuse)	2	110,000	Anoxia, heavy and noxious H_2S fumes; also lethal *Pfiesteria* during kill
Neuse River Estuary	90**	11,000,000	*Pfiesteria* swarming at lethal densities

* In the New River and first Neuse River estuary kills, data were not available for *Pfiesteria* densities as fish were dying. Note: Many other kills were anecdotally reported by fishermen who maintain that few adult menhaden were available to die in the Pamlico because the young had been dying throughout the late spring and summer.

** Fish deaths from July 20 to Oct. 20; most fish died between Sept. 20 and Oct. 20.

Fig. 2. Major fish kills (more than 1,000 fish affected) in North Carolina's rivers and estuaries during the summer of 1995.* Information supplied by J. Burkholder.

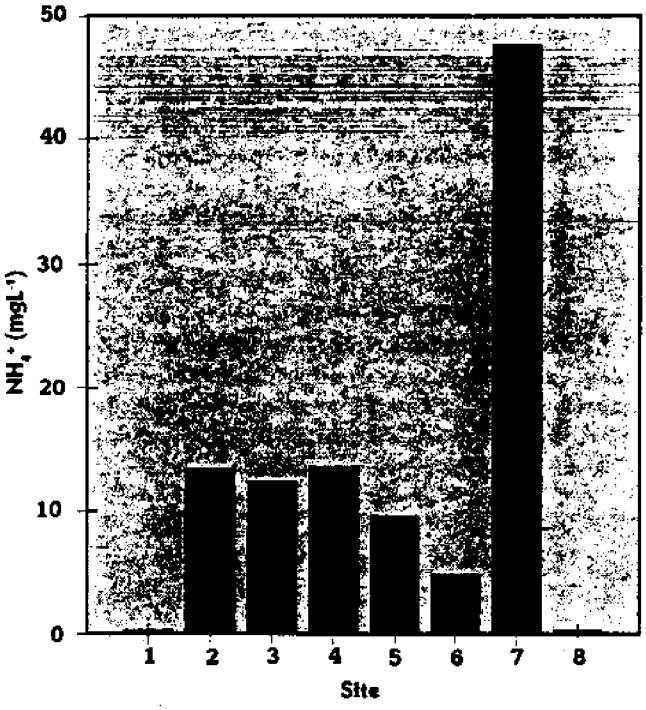


Fig. 3. Ammonium concentrations 48 hours after a major hog waste spill in the New River. Site 1 was above where the wastes entered. Site 7 was at the leading edge of the plume; site 8, downstream. Sites 2-7 were in the affected area. At the leading edge of the plume, concentrations were greater than 45 mg/l — enough to kill most fish species outright. Data from the laboratories of J. Burkholder (NCSU) and M. Mallin (UNC-W).

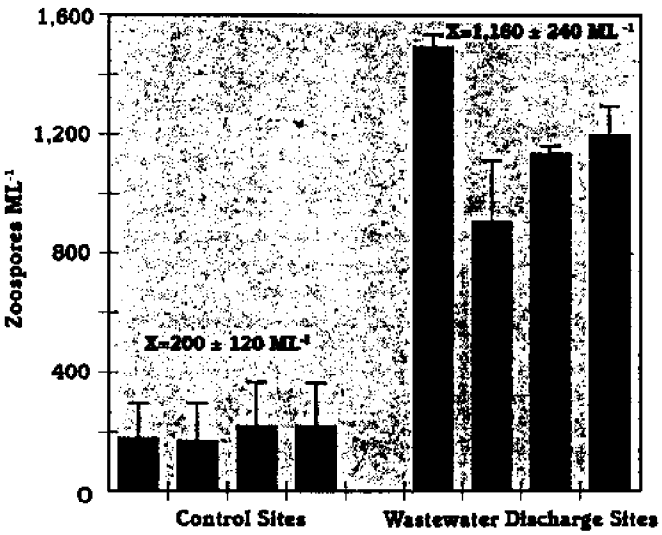


Fig. 4 Abundance of the Pfiesteria zoospore (precursor to lethal, toxic zoospores) from four control sites and four wastewater discharge sites. Samples were taken at the end of the growing season in the New River Estuary. Data from the laboratory of J. Burkholder.

cattle — in North Carolina, says Sobsey. Hogs or cattle produce waste rich in nutrients and capable of carrying diseases (Figs. 3 and 4). Yet animal wastes do not receive the same waste treatment as human waste.

Other methods of water testing, such as enterococci or male-specific coliphages, can address these concerns. North Carolina is one of the few states that does not use these tests.

Nutrient Sources and Trends

A primary cause of nutrient enrichment is our increasing population, says Donald Stanley of the Institute for Coastal and Marine Resources at East Carolina University. As our society continually develops and grows, he says, so do point and nonpoint pollution. More people and more development equals more urban runoff, the need for greater crop yields and larger animal production. It means more waste flow and larger industrial discharges as businesses grow to meet consumer demands.

For each doubling of the human population, says Stanley, wastewater treatment efficiency will have to be improved by 50 percent to maintain current nutrient production rates.

Stanley has been monitoring the water quality of the Pamlico River Estuary for more than two decades. The river has one of the most extensive monitoring histories in the state. Since 1967, water at 20 locations has been sampled biweekly. Stanley has developed a computer simulation of nutrient loading for the last century (Fig. 5.)

Until 1992, phosphorus was increasing. A phosphate mining operation located on the river discharged enormous quantities of phosphorus-rich wastewater into the Pamlico River. Then it

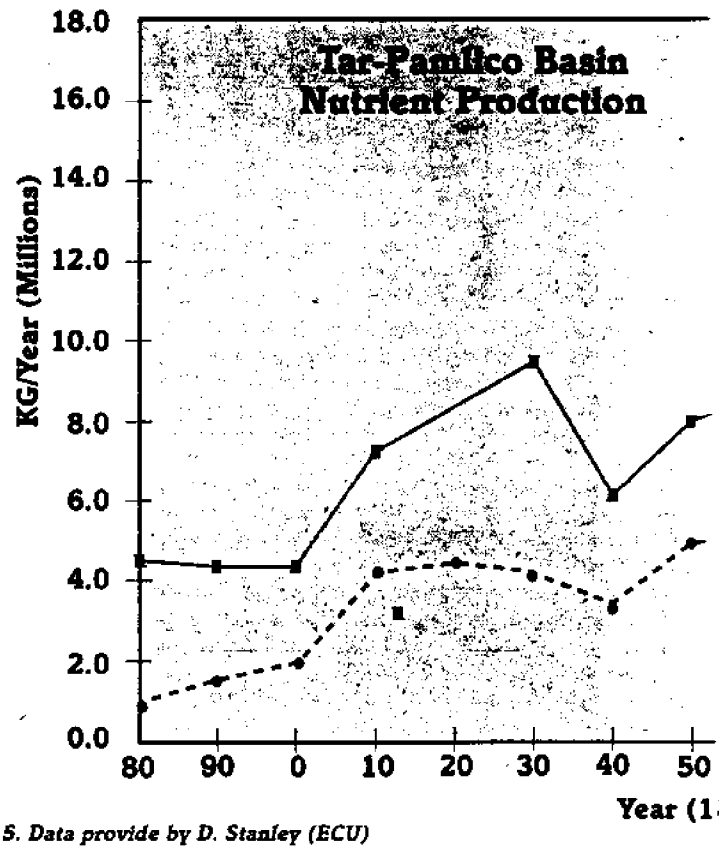


Fig. 5. Data provide by D. Stanley (ECU)

reduced its phosphate discharge into the estuary by almost 90 percent (Fig. 6). But as phosphorus decreased, nitrogen levels continued to increase (Fig. 7 and 8).

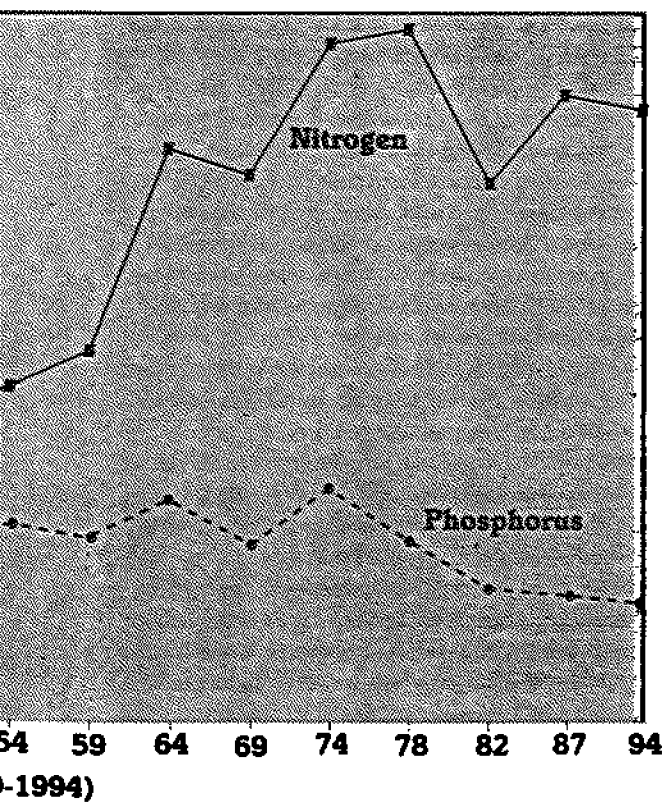
During the past century, there had been little change in land use in the Tar-Pamlico Basin until recently. The area consists of farms, forests, pastures and sparse urban development. But farm fertilizer use increased sevenfold between 1940 to 1978, and animal operations are growing.

In fact, farm animal nutrient production in the Tar-Pamlico Basin has doubled since 1970, says Stanley, making it the fastest growing nutrient source in the Tar-Pamlico Basin (Fig. 8). Atmospheric nitrogen in the region is estimated to have increased fivefold in the past century.

Many people are not aware of how many nutrients can be transferred by atmospheric emissions and groundwater, says James Pinckney of the University of North Carolina at Chapel Hill Institute of Marine Sciences. About 25 percent of new nitrogen inputs are now derived from atmospheric emissions.

There are various nitrogen compounds in rain, says Pinckney, including dissolved organic nitrogen and dissolved inorganic nitrogen such as ammonium and oxides. Although all stimulate algal growth, scientists such as Pinckney are studying whether certain forms of nitrogen have greater ecological impacts than others.

Emissions from fertilizer applications, animal waste lagoons and sewage treatment plants can add ammonium or dissolved inorganic nitrogen to the atmosphere (Fig. 9). Fossil fuel combustion from industry or automobiles add oxides. Nitrogen oxide inputs are expected to increase by 30 percent over the next decade.



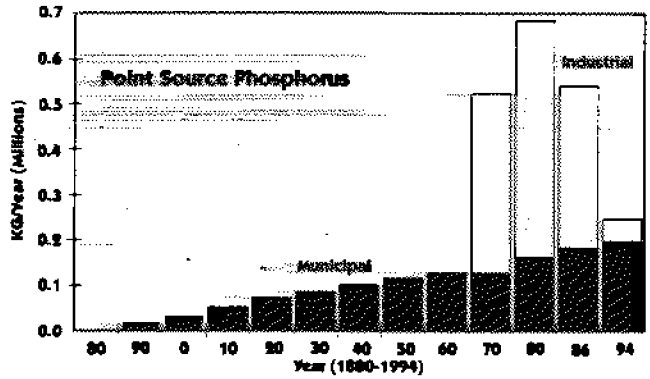


Fig. 6. Data provided by D. Stanley (ECU) for Tar-Pamlico Basin.

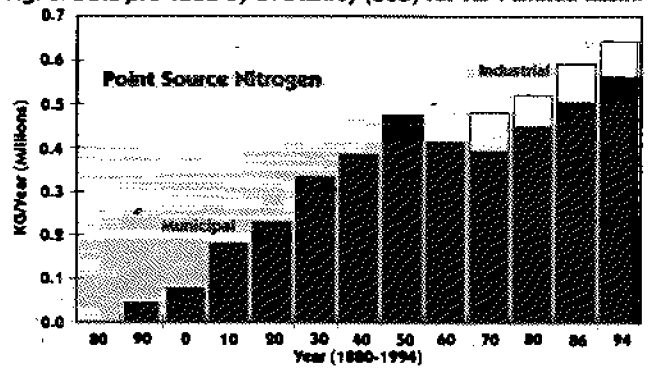


Fig. 7 Data provided by D. Stanley (ECU) for Tar-Pamlico Basin.

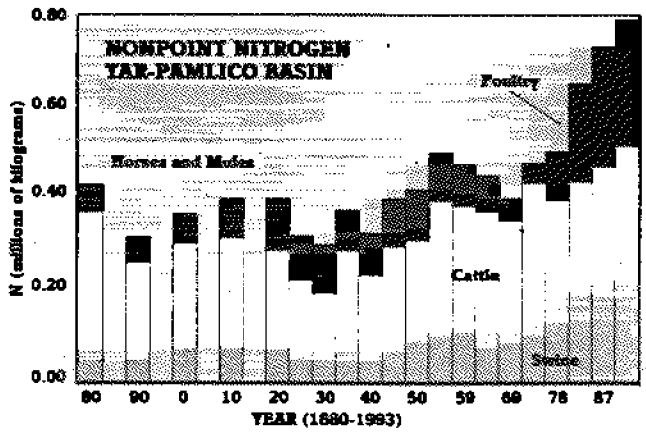


Fig. 8. Farm animal nutrient production has doubled since 1970. Values plotted are 5 percent of sewage nutrient produced by animals. Data from D. Stanley (ECU).

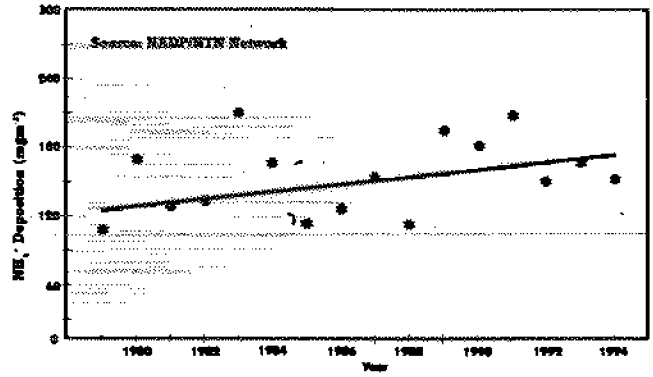


Fig. 9. Ammonium in coastal rain is derived from fertilizer applications, animal waste lagoons, sewage treatment plants and fossil fuel combustion. Data from J. Pinckney (UNC-CH).

Pinckney says that the timing, frequency and duration of nitrogen inputs play a large role in the coastal system's response. More than 50 percent of annual dissolved inorganic nitrogen input occurs during high runoff periods from January to April. From summer to fall, algae use that nitrogen to rapidly reproduce, causing blooms. Some farmers utilize this information, using less fertilizer in periods before heavy rains.

River flow and watershed rainfall amounts are two of the most important factors that regulate algal production, agrees Mike Mallin of the UNC-Wilmington Center for Marine Research. "What happens way up in headwaters has a major effect in upper estuaries," says Mallin. If nutrient sources, such as animal wastes, are washed directly to streams by rainfall, you'll see effects in the estuaries weeks later, he says.

Current Management Strategies and Alternative Approaches

Management strategies for water quality and aquatic resources already exist in North Carolina. The Coastal Resources Commission (CRC), Environmental Management Commission (EMC) and Marine Fisheries Commission each establish regulations regarding water quality. The EMC sets up water quality classifications such as Outstanding Resource Waters and initiated the Nonpoint Source Pollution Control Plan. The Marine Fisheries Commission establishes primary nursery areas for fisheries and regulates activities in these areas. The CRC regulates coastal development and requires coastal communities to write land-use plans. Some problems come in enforcing these agencies' regulations, initiating volunteer plans, distributing water quality information and coordinating between these agencies to develop a single state response.

Although there is little data about nonpoint pollution and few ways to prevent it, the Environmental Protection Agency (EPA) has been developing a watershed protection plan for the past 20 years.

The plan, which aims to reduce point and nonpoint pollution by targeting entire river basins, has three parts, says Mike McGee of the EPA Regional Office in Atlanta, Ga. First, define the problem. Second, get stakeholder involvement. Third, use integrated actions so that government, fisheries, environmentalists, the public and polluters use management plans that work together.

In 1986, EPA helped North Carolina establish a plan for the Albemarle-Pamlico Estuarine System. But the plan lacked support and input from all parties concerned, says McGee. "We need to mobilize stakeholders to form solutions," he says.

The N.C. Division of Soil and Water Conservation has also developed nutrient management strategies based on land-use and watershed protection, says Dewey Botts, the division's director. The division helps support the upgrading of farming techniques, workshops and cost-share programs.

The division's agriculture cost-share program developed best management practices (BMPs) that help farmers grow crops and raise animals in environmentally safe ways. BMPs address erosion, nutrients, animal wastes, sediments, stormwater and chemicals. Unfortunately, BMPs are voluntary. As nutrient problems worsen, farmers need greater incentives to use them.

Among the division's more pressing problems are a lack of staff, funds and time. This is coupled with the new growth of poultry, dairy and hog industries. "We now have half the resources and twice the demands," says Botts. "There are now 7.6 million hogs in the state, and this number doubles every four years." These industries need to be involved in the solutions. "You've got to get them in the room with you," he says.

With so few resources, North Carolina must set priorities and goals, says Steve Levitas of the N.C. Department of Environment, Health and Natural Resources. The government has less and less money to spend on environmental cleanup and protection, and it has been spreading this over too many projects.

Other than research, data collection and increased funding, others recommend new techniques for managing nutrient enrichment. Randy Dodd of the Research Triangle Institute is using a computer model to determine sources, predict nutrient loadings and develop management plans for basins such as the Tar-Pamlico. Animal wastes could be used as fertilizer, even sold to farmers. Shellfish aquaculture might be used to clean up estuaries because clams and oysters feed on phytoplankton.

A key to change is public involvement. "Nutrient pollution must be dealt with in a much more efficient way than in the past," Levitas says. "This won't happen if a large number of people don't recognize that it's important."

Applications of Management (Tar-Pamlico and Neuse Rivers)

Like many, Dave McNaught considers water quality management strategies slow in coming and lacking in strength. "It takes a crisis before we resolve problems," says McNaught, the former director of the Pamlico-Tar River Foundation.

Nutrient enrichment is not a new phenomenon, nor is the public noticing it for the first time, he says. In the 1960s and 1970s, there was evidence of environmental decline in the United States. Federal laws, such the Clean Water Act, were passed.

These laws were not enough, says McNaught. The Clean Water Act, for example, sets classifications for all waters. The act requires that these classifications be maintained. Waters can be declared "nutrient sensitive," meaning nutrient input can be regulated.

"We expected these laws to work alone," says McNaught. "The Tar-Pamlico was getting nutrient enrichment and everybody knew it. But it took two years to declare the Tar-Pamlico system nutrient sensitive." Yet nutrient and pollutant inputs continue to increase as populations and development expands.

Tar-Pamlico area residents still notice declines in underwater seagrasses. They see fish with sores, fish kills and algal blooms. Several communities have surface-water concerns.

The condition of the Neuse River is also evidence that today's management strategies are not enough, says Rick Dove, the Neuse River Keeper and director of the Neuse River Foundation. Recently named one of the 20 most polluted rivers in the United States, the Neuse is threatened by wastewater, chemicals and runoff, Dove says.

This summer, thousands of fish died in kills along the Neuse River. Those who live near the river didn't swim, boat or fish because of the mucky algal blooms. Dove frequently monitors dissolved oxygen levels on the river and finds them very low (hypoxia) or at zero (anoxia).

Dove says that people who live upstream and in the river basin should bear a responsibility just like those who live near the coast. "Division of Environmental Management data predicts that

70 percent of total nitrogen discharged upstream gets to New Bern," says Dove. At Oriental, he says, scientists believe one half of the Neuse River is wastewater.

Many upstream waste dischargers are trying to reduce their impacts on the Tar-Pamlico River. The Tar-Pamlico River Basin Association — a group of waste-treatment facilities — "came together to form a solution to the problem," says Malcolm Green of the Greenville Utilities Commission. The association includes plants from cities that discharge into the basin — Rocky Mount, Greenville, Tarboro, Oxford, Spring Hope and Pinetops.

The association monitors water quality, shares the information, issues discharge quotas and determines a quota trading plan. One plant can "borrow" discharge quota from another. The large plants also provide resources to the smaller ones.

Since forming the association, five members have installed nutrient removal systems. According to Green, nutrient inputs have dropped 20 percent despite an 18 percent increase in total wastewater discharge to the Tar-Pamlico Basin.

"The achievements are real," agrees Doug Rader, a senior scientist with the Environmental Defense Fund, "but our plans aren't progressive enough." A 45 percent total reduction is what we need to relieve nutrient enrichment, he says. And these reductions must be reached in a reasonable amount of time.

Basin and watershed plans can function successfully, says Rader, "We need the best science — science based on linkages. It's time to make basin plans work."

Future Strategies and Returns

One way to increase support for stricter water quality management is to determine how much nutrient enrichment costs North Carolina. It's easy for the hog industry to say it contributes billions to the North Carolina economy, says Kerry Smith, an economist at the School of the Environment at Duke University. Environmentalists can answer that we make billions from coastal tourism, but that does not begin to answer what our resources are worth. "We can buy a barbecue," says Smith, "but we can't buy a river or a pristine coastal scene."

Yet nutrient enrichment generates real economic losses that can be determined. Smith estimates that a 40 percent reduction in nutrients would generate $3 million to $5.2 million from increased use of the Neuse River by recreational anglers. According to Smith's studies, anglers would have paid $147 million to prevent this summer's hog lagoon spills.

Money can also be a factor in gaining compliance to regulations. "People respond to incentives," says Smith. The farmers or animal growers who don't use their land wisely could pay fines. Those in compliance don't pay as much. Eventually, says Smith, the ones that do poorly will do better.

In Green Bay, Wis., polluters have begun to do better. Along the Fox River, the main tributary of the bay, there are 14 pulp and paper mills, dairies, farms and about a half a million people.

In the 1930s, water quality was already a problem in the Green Bay, says Cliff Kraft of the University of Wisconsin Sea Grant Institute. Even then, residents were aware that the problem stemmed from industry and human activities. Although there were many pollution problems, low oxygen levels became the focus for a series of interactions between government, industry and the university. The target was BOD, or biochemical oxygen demand. BOD is a term used to describe organic compounds that take up large amounts of oxygen as they decompose.

As a result of those meetings, several management strategies were implemented in the late 1970s. BODs could only be released at certain times, based on water quality models developed by the University of Wisconsin. As a result, all mills shut down during low-flow summers. There were "cluster discharge" agreements, where one member's discharge could exceed limits if others fell below, and transferable discharge permits.

Although there are other factors in the cleanup (pulp and paper mills switched to municipal discharges, several mills closed, large amounts of a filter-feeding aquatic mollusk, the zebra mussel, invaded the lake and cleaned the water), BOD loadings dropped and dissolved oxygen in the bay increased as a result of the partnership. In 1970, 8,800 pounds of ammonium were discharged each day. In 1995, that number decreased to 95 to 100 pounds.

The bonds between government, university researchers and polluters are what made this management system successful, Kraft says. But it's important that partners in the cleanup develop trust. At first, industries would collect their own data and not share it with scientists. This made the cleanup process slower and more difficult, Kraft says.

Where We Go From Here

Although North Carolina learns more about nutrient enrichment daily, there is much that scientists and resource managers do not know. Research has been fragmented, and there is little historical data to gauge how conditions have changed over time. Regulatory agencies are not sure what current management strategies have achieved, and managers need better information to manage our coastal waters.

Yet management needs to continue today. "We cannot wait

Glossary of Terms

algae — small, floating, nonwoody plants that inhabit fresh and salt water.

algal bloom — rapid algal growth that usually results in a discoloration of the water.

anoxia — no detectable dissolved oxygen.

dinoflagellate— a microscopic algae that is commonly found in coastal waters.

eutrophication — the excessive addition of nutrients that spurs accelerated algal growth, creating more plant biomass than the ecosystem is capable of using.

hypoxia — dissolved oxygen levels between 0 and 5 milligrams per liter.

nitrogen — a biologically important nutrient essential to plant growth, which exists in solid, gaseous and liquid states. Nitrogen supply regulates plant growth in North Carolina's estuarine waters.

phosphorus — a mineral nutrient also required for growth, which exists mainly as phosphate, a dissolved solid.

phytoplankton — microscopic, photosynthetic plants that are suspended in the water column.

until perfect information arrives," says David Moreau of the EMC.

"We've done some good things already," he says. "We've defined nutrient sensitive regions and set effluent limits. We've banned phosphates in detergents. We're funding a program to entice farmers to adopt BMPs. We've developed a nutrient trading scheme in the Tar-Pamlico River.

"All of the steps are in the right direction," he says, "But there is a strong indication that they are not enough."

Bob Lucas, chairman of the N.C. Marine Fisheries Commission, agrees. For Lucas and the fishermen he represents, water quality is important. "If I don't have a say in water quality," he says, "you're sending me out with one hand tied behind my back.

"I have been around the coast my entire life, and I have watched the resource go down before my eyes," says Lucas. Fish stocks are dwindling, and catches are down. Water quality needs to be a part of fisheries management, he says.

Many fishermen, coastal residents and North Carolina citizens who witness fish kills or algal blooms are fed up with studies and analysis. They are ready for action. "How many semester hours does it take to learn that water runs downhill?" asks Tom Mattison, a New River resident.

"We don't need bandaids," Burkholder says. "This is a crisis, a quiet, insidious crisis. It's affecting every single person in the state whether they know it or not."

Recommendations

Below is a list of recommendations compiled from the speakers who presented information at the summit. They recommend to:

- Conduct a comprehensive assessment of current state management strategies that culminates in a plan to reduce nutrients to coastal waters.
- Initiate a more comprehensive monitoring program to follow trends in coastal water quality and assess program progress.
- Achieve more consensus and cooperation among resource management commissions to reduce fragmentation and to promote management of total resources.
- Increase and rearrange funding to accommodate better monitoring, increased enforcement and more focused scientific research.
- Extend land-use planning to include water-use planning as a tool for more effective management of coastal resources.
- Initiate basinwide plans and assessments that strive to reduce nutrients from waste treatment, runoff and groundwater 40 percent.
- Provide better protection of wetlands.
- Provide more incentives for farmers and animal producers to use best management practices and more penalities if they don't.
- Initiate a more comprehensive public education program about coastal water quality issues, the legislation that affects them and the effects of water quality degradation.
- Develop mechanisms to evaluate the socioeconomic values of improving water quality and the societal costs if we don't.
- Develop a priority system for addressing water quality issues based on assessment of effects and impacts.
- Develop a comprehensive coastal water quality model to test the variabilities of runoff rates, input from point and nonpoint sources, nutrients from rainfall, physical/chemical interactions, and biological responses.

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