NITROGEN FROM THE ATMOSPHERE:

UNDERSTANDING AND REDUCING A MAJOR CAUSE OF DEGRADATION IN OUR COASTAL WATERS

SCIENCE AND POLICY BULLETIN #8

by Robert Howarth, Ph.D. and Diane M. Rielinger

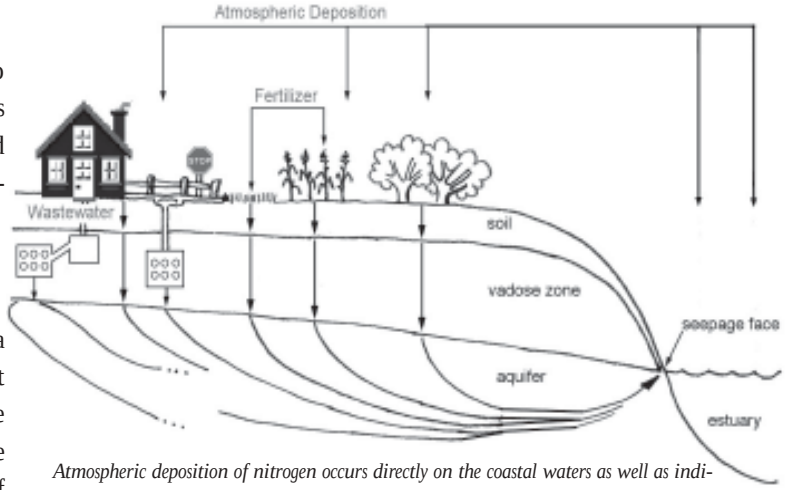
Over the past few decades, nitrogen enrichment has grown to become the largest pollution problem for coastal marine ecosystems of the United States. At present, two-thirds of the coastal rivers and bays in the contiguous United States are moderately to severely degraded from this pollution.

Too Much of a Good Thing

Nitrogen is an essential nutrient for all life, and it comes as a surprise to many people that a nutrient can be a pollutant at all, let alone causes destruction. However, just as over eating can cause obesity and a host of health problems for an individual, excessive nutrient enrichment is damaging to the ecological functioning of aquatic ecosystems. Symptoms of nitrogen pollution include greener and murkier waters; degradation and destruction of seagrass beds; depletion of oxygen with subsequent loss of fish, shellfish, and other marine life; increased incidences and duration of harmful algal blooms; and lowered biotic diversity.

In response to added nitrogen, mats of macroalgae flourish and block sunlight from reaching eelgrass. Photo courtesy of Joe Costa.

Many of the coastal ponds and harbors of Cape Cod, the Islands and elsewhere in southeastern New England, particularly the shallow lagoons that have extensive seagrass beds, are highly susceptible to the effects of nitrogen pollution. These seagrass-dominated systems are particularly sensitive since nitrogen enrichment encourages the growth of algae that shade out the grasses.



Atmospheric deposition of nitrogen occurs directly on the coastal waters as well as indirectly by deposition onto the landscape of the watershed. Atmospheric deposition of nitrogen, along with wastewater and fertilizers, is the leading cause of eutrophication in southeastern New England coastal waters (Adapted from Valiela et. al., 2000).

Nitrogen from the Air

The nitrogen that reaches coastal ecosystems comes from many sources. Nationally, agriculture is the dominant source, while in many of the coastal ponds and bays of Cape Cod most of the nitrogen comes from septic tanks and lawn and garden fertilizers.

However, a major and often overlooked source of nitrogen comes from the atmosphere. Atmospheric deposition includes nitrogen compounds dissolved in precipitation (e.g. acid rain) as well as "dry deposition." Dry deposition includes nitrogen associated with small particles that are in the air and reactive nitrogen gases that interact with vegetation, soils, and water. For the United States as whole, atmospheric deposition of nitrogen probably contributes 40% of the nitrogen that reaches coastal rivers and bays.

Nitrogen from the atmosphere is deposited both directly onto the surface waters of coastal ecosystems and onto the watersheds that feed these systems. As a percentage input, the direct deposition is particularly important in bays where the ratio of watershed area to bay water surface area is relatively small. For many bays where the watershed area to bay surface

area is less than 5:1, more than 20% of the total nitrogen inputs come from direct atmospheric deposition.

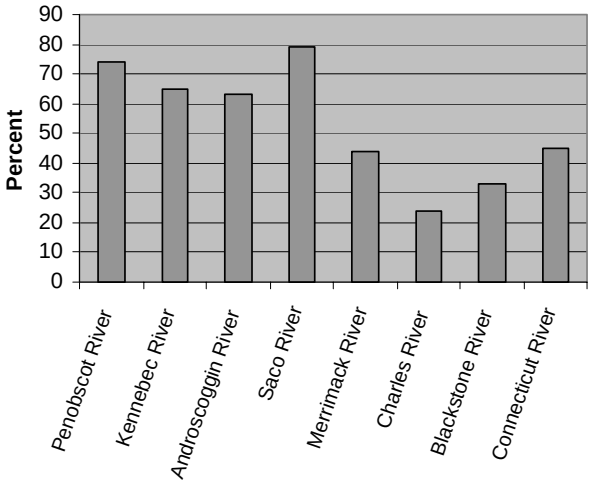
Unlike direct deposition to surface waters, not all of the nitrogen deposited onto the land of the watershed makes it into the coastal marine waters. Some of the nitrogen is retained in the landscape while some is subsequently exported through groundwater and surface tributaries and rivers to coastal waters. In many forested regions, only 10% to 20% of the nitrogen deposition is exported downstream, but on Cape Cod the export is much higher – 50% — because the sandy soils are poor at retaining nutrients. Where the land has been developed into suburban and urban landscapes and the forests removed, nitrogen from atmospheric deposition is more readily exported from the land to coastal waters. Nutrient budgets for several coastal marine ecosystems along the Atlantic coast have suggested that between 6% and 50% of the total nitrogen inputs comes from nitrogen deposition onto the watershed lands, and recent evidence indicates that many of these estimates are probably low.

The rate of atmospheric nitrogen deposition in southeastern New England is among the highest found in North America, at more than 10 kg nitrogen per hectare per year (roughly 10 pounds nitrogen per acre per year). Human activity has probably increased this nitrogen deposition 10-fold since the dawn of the industrial age, and perhaps more. In addition to degrading coastal water quality, nitrogen pollution in the atmosphere is the major cause of ozone pollution and smog in the northeast. It is a major source of acid rain, and contributes to greenhouse warming of the planet and ozone depletion in the stratosphere.

"The rate of atmospheric nitrogen deposition in southeastern New England is among the highest found in North America."

Note: These figures represent national averages. For Cape Cod and other coastal areas in southeastern New England, where agricultural uses are very low, sources of nitrogen are dominated by wastewater and atmospheric deposition. Derived from data in Howarth et. al., 2002

Percentage of Nitrogen In Major New England Rivers That Originates From Fossil Fuel-Derived Atmospheric Nitrogen Deposited onto Landscapes



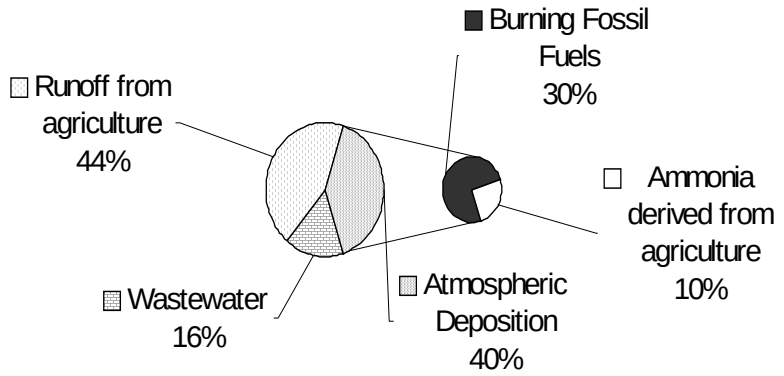
Derived from data in Boyer et. al., 2002

Sources of Nitrogen Pollution

So how are we adding nitrogen pollution to the atmosphere? For the US as a whole, three quarters of the atmospheric nitrogen that is deposited on our coastal waters comes from the burning of fossil fuels (this is about 30% of the total nitrogen that enters coastal waters). The other quarter of the atmospheric pollution (10% of the total nitrogen that enters coastal waters) comes from agricultural sources, and particularly from animal wastes that volatilize ammonia gas to the atmosphere. In New England, the proportion from fossil fuel burning is somewhat greater and the proportion from agricultural wastes is somewhat less than for the country as a whole.

Of the nitrogen pollution from fossil fuel burning, the three largest sources for the United States are, in order: electric power plants and industrial combustion sources (43%), on-road vehicles (cars, trucks, and buses - 31%), and off-road mobile sources (construction vehicles, tractors, boats, lawn mowers, etc. - 21%). The nitrogen from electric power plants can often travel long distances through the atmosphere, since the smokestacks inject the nitrogen into the atmosphere well above the ground. Thus, much although not all of the nitrogen pollution in New England from power plants originates in mid-Atlantic and mid-western states. On the other hand, much of the nitrogen from

Sources of Nitrogen Pollution to Coastal Rivers and Bays in the US on Average



mobile sources is emitted close to the ground and is deposited quite near the source, with relatively little long-distance transfer. Local vehicles are a major source of nitrogen deposition in southeastern New England.

Of the major pollutants regulated under the Clean Air Act, nitrogen oxides are the only pollutant that has not been significantly reduced as a problem over the past decade, due in large part to our insistence on traveling more miles and driving gas-guzzling SUVs whose emissions are poorly regulated.

"Local vehicles are a major souce of nitrogen deposition in southeastern New England."

What Can We Do?

So what can governments and citizens do to reduce the atmospheric deposition of nitrogen and minimize the adverse impacts to our coastal waters? A wide variety of options are available. The biggest thing we can do is to reduce our energy consumption and reliance on the burning of fossil fuels. The less fossil fuel burned, the fewer nitrogen oxides are introduced into the air, and hence the less nitrogen available to be deposited into our coastal waters and their watersheds.

Locally, reductions in mobile sources of air pollution (cars, trucks, lawnmowers, etc.) will have a direct impact since most of this pollution does not travel far. For pollution originating from sources further away than our own backyards, by reducing our use of fossil fuels locally, we can serve as a model for other areas. Other nation-wide environmental programs, such as recycling, originated from local grassroots efforts also serve as a model. Also, we can make our voices heard to encourage actions by regional, state, and national government that support an increase in renewable energy.

Many of the measures outlined below are the same energy-conservation and money-saving tips that people have been hearing about for years. Some are simple, with little or no cost associated with them. Others require capital investments; however, rebate programs, grants, and tax incentives can often greatly reduce these costs and make the payback time very short.

♦ Changes in behavior that conserve energy can go a long way towards limiting emissions from the burning of fossil fuels. Some simple activities, like those listed in the following table, can produce tremendous results. Two school districts on Cape Cod have saved over $250,000 in energy costs and reduced their emissions over the last two years by implementing some of these behavior changes.

♦ When purchasing products, make the consideration of environmental impacts part of your buying decisions.

- Buying a fuel-efficient car (>32 mpg) or an alternative fuel car can cut your nitrogen emissions by more than 50% when compared to a 4-wheel drive SUV.
- Buying Energy-Star® labeled products guarantees energy savings as compared to an unlabeled, less efficient product. Energy-Star® light bulbs use up to 75% less electricity than a conventional incandescent bulb.
- Products made from recycled materials generally require less energy to manufacture, so look for the recycled label when shopping for everything from paper (23-74% less energy) to glass (4-32% less energy) to building materials (47-74% less energy for steel).
- Consider replacing your fossil-fuel energy with non-polluting renewable power. Even if you cannot install a renewable energy generator (such as solar panels or a wind turbine) in your own home, many power companies now offer green power programs from which you can purchase renewable energy.

♦ Besides reducing our reliance on fossil fuels, we can also safeguard and enhance natural landscapes, which can uptake significant amounts of nitrogen pollution.

- The protection of wetlands and forests can help to buffer coastal waters from atmospheric nitrogen that is deposited in the watershed. Forests in the Waquoit Bay watershed, for example, retain 40-62% of atmospherically derived nitrogen.
- The protection of natural open spaces also prevents additional nitrogen inputs from wastewater and fertilizers generated by development.
- Using native plants for landscaping will eliminate the need for added fertilizers.

♦ Plan for the future.

- Development that uses "smart growth" techniques and principles will maximize open space protection, be pedestrian-friendly, and re-use existing structures.
- Buildings that are designed, renovated, or built with attention to energy efficiency will save energy for years to come.

Simple Low-Cost and No-Cost Solutions to Reduce Energy Use

* Walk instead of drive.
* Use public transportation or carpool.
* Activate the power-saving measures on your computer.
* Shut your computer down when you leave.
* Turn off the lights when you leave the room.
* Use natural daylighting where possible.
* Turn down your thermostat, especially when you are not home and at night
* Add more insulation to your buildings

Nitrogen from the atmosphere is a major cause of degradation to coastal waters in southeastern New England. Reducing the sources, principly fossil fuels, will help restore and protect our valuable coastal bays and harbors by limiting the amount of nitrogen pollution from atmospheric deposition.

Further Reading:

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The Waquoit Bay National Estuarine Research Reserve is part of the National Estuarine Research Reserve System, established by section 315 of the Coastal Zone Management Act, as amended. Additional information about the System can be obtained from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 1305 East-West Highway, Silver Spring, MD 20910.
Production and printing of this publication were made possible by grants from the National Oceanic and Atmospheric Administration to the Waquoit Bay National Estuarine Research Reserve.
The Waquoit Bay National Estuarine Research Reserve is co-managed by the Commonwealth of Massachusetts: Jane M. Swift, Governor; Bob Durand, Secretary, Executive Office of Environmental Affairs; Peter C. Webber, Commissioner, Department of Environmental Management; Todd A. Frederick, Director, DEM Division of Forests and Parks.

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