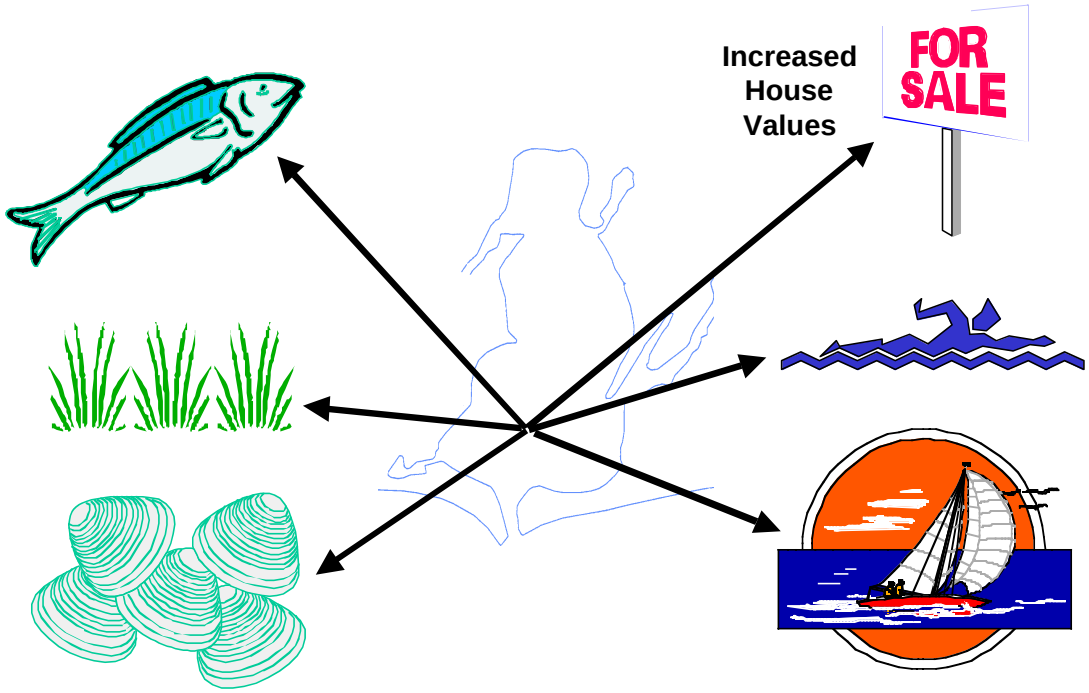
May 2000

CAPE COD—
A Community Connected By Water

This brochure is Part Two in a series on Water Resource Education Information, presented as part of the "Communities Connected by Water" Program

COASTAL EMBAYMENTS

Fishing, shellfishing, swimming, boating: Cape Cod's coastal embayments at their finest. Our coastal resources are why so many of us live here and why so many more come to visit each year. Some of us depend on them to make our living, others depend on them to enjoy our time off. For all of us the continued health, productivity, and beauty of our coastal embayments depend on an increased understanding and protection of these valuable resources.



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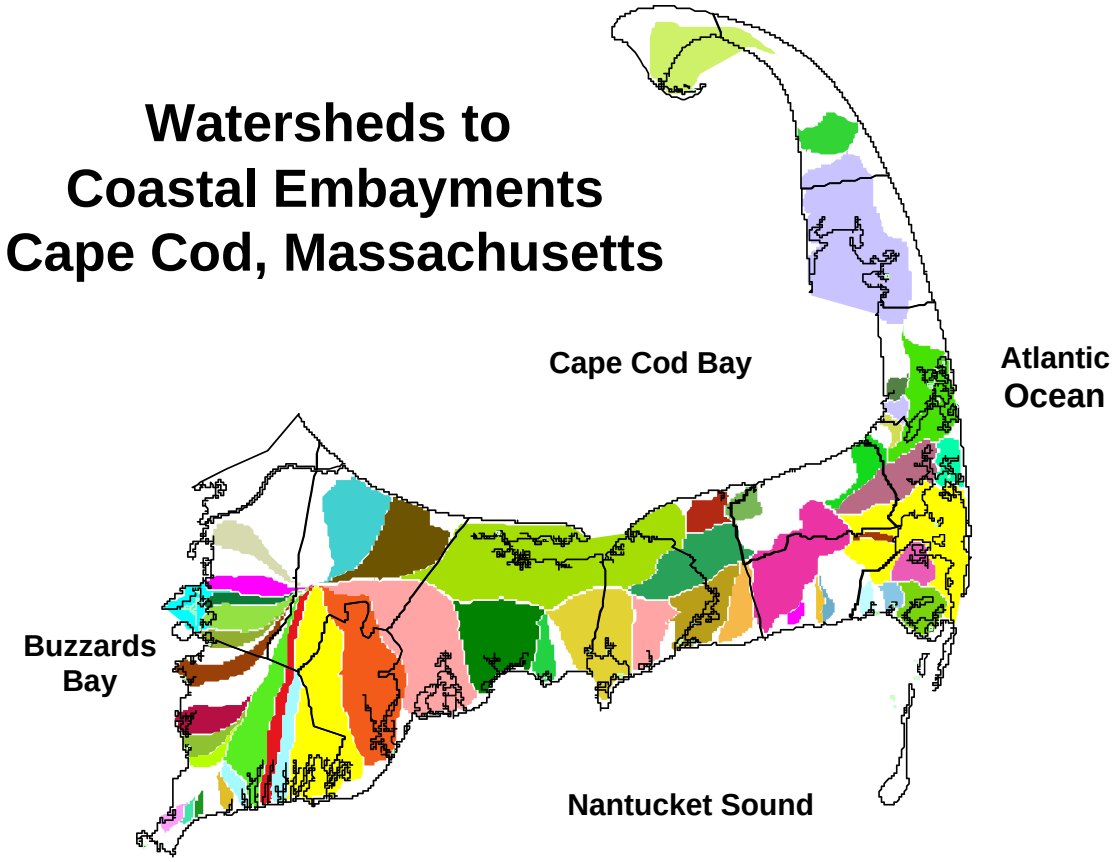
Prepared by the Cape Cod Commission Water Resources Staff
Text and illustrations by Donna McCaffery , Ed Eichner, and Ken Livingston.

What is a Coastal Embayment?

Coastal embayments are enclosed areas of the coastline where the freshwater from groundwater and streams is mixed with salt water from the surrounding oceans. Precipitation that falls on Cape Cod percolates through the soil and recharges our groundwater aquifer, or water saturated soils. On Cape Cod, water moves about one foot per day through our sand and gravel aquifer. It is pushed by gravity toward the shore or a tidal river and ultimately discharges along our coast. In some cases, groundwater is discharged into portions of the coast that have restricted openings to Cape Cod Bay, Vineyard Sound, Nantucket Sound, Buzzards Bay or the Atlantic Ocean. These portions are called embayments and include bays, harbors, coves, and estuaries.

The ever-changing environment of a coastal embayment creates an ecological niche that is important for seagrasses, scallops, soft shelled clams, and as a breeding ground for commercially important offshore fish. These areas are also the primary recreational areas of Cape Cod.

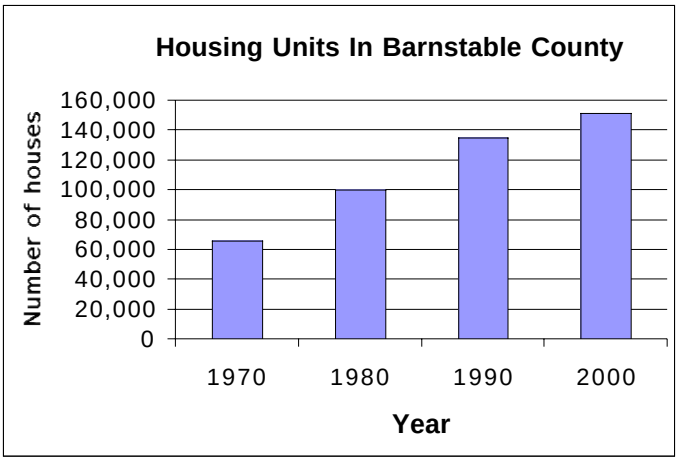
The coast of Cape Cod has over 45 coastal embayments. Some of these have one or more subembayments within them. Each embayment has its own watershed or adjacent land area that supplies freshwater to it. These are also referred to as marine re-charge areas. The map below shows the identified Cape Cod coastal embayments and their watersheds.



Nitrogen: A Major Threat

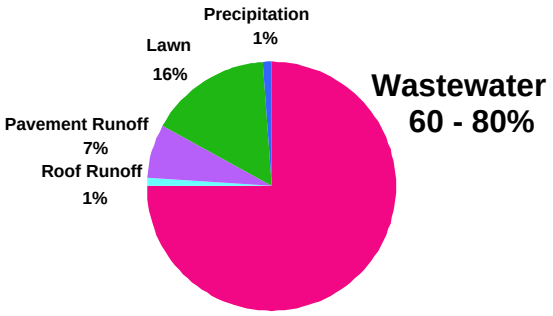
The land areas surrounding coastal embayments are some of the most desirable lands on Cape Cod. These lands are often divided into very small lots each dependent on a septic system for disposal of wastewater. Water that goes through each septic system adds contaminants to the groundwater, which is then discharged into our coastal embayments. Contaminants from septic systems can include metals from our plumbing, phosphate from our detergents, and nitrogen from toilet wastes.

The key contaminant causing the degradation of water quality in Cape Cod's coastal embayments is nitrogen. The amount of nitrogen in the groundwater has been shown to be directly dependent on the housing density. As the population and subsequent land development has increased, the amount of nitrogen entering our groundwater and making its way into our coastal embayments has also increased.

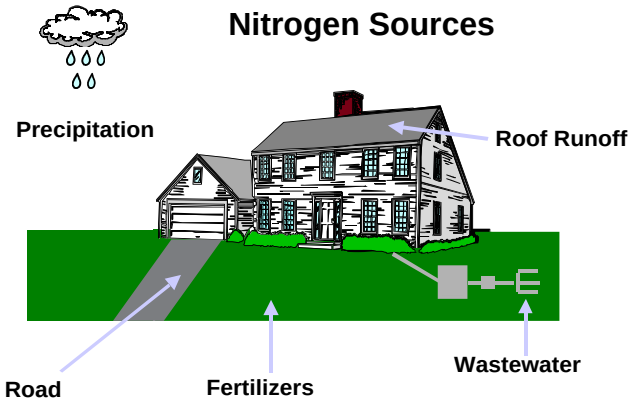


During the 1970's and 80's, Barnstable County experienced an incredible building boom. Between 1970 and 2000, the number of housing units increased 76% for a total of 85,955 new housing units.

Watershed Sources of Nitrogen Load



Roughly 60 to 80% of nitrogen entering embayments is from wastewater. Other sources of nitrogen from watersheds include: fertilizers, stormwater runoff and deposition from the atmosphere.



As population and land development increase in coastal areas, the water quality and the ecosystems within these embayments and subembayments are being threatened. The area of closed shellfish beds is five times greater today than in 1980. Eelgrass has nearly disappeared from many embayments within the past decade. In Waquoit Bay, one of the most impacted and best studied embayments, scallop harvests have decreased from thousands of bushels to just tens of bushels.

Eutrophication

When too much nitrogen reaches an embayment, it acts as a fertilizer causing an over production or "bloom" of algae to grow. This overgrowth of algae makes the water cloudy and reduces the amount of sunlight reaching the bottom.

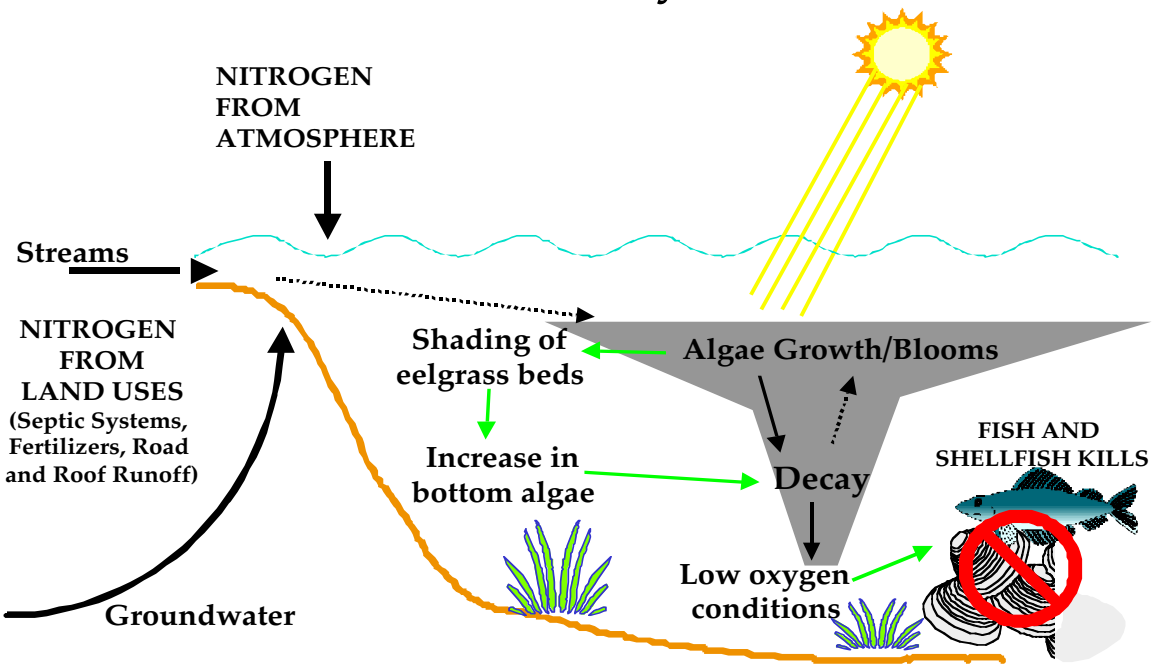
Eelgrass, an important submerged aquatic plant, needs sunlight to grow and begins to die off. Bottom algae grows and replaces the eelgrass beds. Many species of fish and shellfish, including scallops, blue crabs, and winter flounder, rely on eelgrass beds for their nursery, spawning, and feeding grounds. This loss of eelgrass habitat, in turn, reduces their numbers.

Embayments like Waquoit Bay, West Falmouth Harbor, and Popponesset Bay have seen drastic reductions in eelgrass coverages.

Algae have a short life cycle and soon die and decay. The decay process reduces the amount of oxygen dissolved in the water which may cause massive fish and shellfish kills. This process in which excess nitrogen enters a water body and negatively impacts its ecosystems is called eutrophication.

The amount of nitrogen an embayment can use before a eutrophication problem begins is known as its critical load. The critical load is influenced by the flushing rate or amount of time a contaminant, such as nitrogen, stays in an embayment before it is flushed out by the tidal waters. The flushing rate can vary from one embayment to the next depending on its size, shape, and depth.

Generalized Eutrophication in Coastal Embayments



Cape Cod Commission, 1998

Assessing Our Embayments

Figuring out how much nitrogen is too much for a coastal embayment is a difficult task. Basic assessment activities include determining how rapidly tides move in and out of a given embayment, delineating a watershed to the embayment, and adding up all the nitrogen getting to the embayment from the different sources within the watershed. Each of these activities requires a judgement of how much information is sufficient to make a decision about the function of the embayment.

For example, a watershed delineation requires the installation of a number of wells to map the watertable in the area inland of the embayment. Deciding where to install the wells, how many are appropriate, and to what depth to install them requires an understanding of the area's geology and the way groundwater moves around the ponds, streams, and wetlands in the area. Even with this information, there may be disagreements among experienced individuals regarding the best way to complete this assessment.

Assessment of all the factors contributing to excessive nitrogen within a coastal system requires contributions from experts in a number of different fields (for example, hydrology, geology, biology, and chemistry) and vigorous discussion among these experts and the public at large. These discussions have to involve the public because the level of the assessment is also going to be determined by the amount of funds available and these funds are usually publicly generated.

After an assessment has been completed and a target nitrogen load has been identified, management options to attain or remain below the target need to be developed. Because the nitrogen management options generally involve significant investment in higher levels of wastewater treatment than currently offered by standard Title 5 septic systems, development of management options often includes additional assessments.

These assessments can include water quality sampling within the embayment (often accomplished through a citizen monitoring project), characterization of plant and benthic conditions (usually accomplished by a university researcher or consulting firm), or refinement of the original analysis, such as different nitrogen loading assumptions.

Assessments may also include evaluation of boat pumpout facilities and other water quality concerns, such as coliform impacts on shellfish. Properly conducted, these assessments can provide a better understanding of the interactions between the various components of the coastal ecosystem, but the public must provide the answer to the most difficult question: How clean is clean?

Towards Coastal Nitrogen Standards

Current state regulations classify coastal waters into three categories: SA, SB, and SC based on the most sensitive use of the water to be achieved or protected. In addition, the regulations also provide a designation for waters that are so exceptional they should not be allowed to degrade: ORW (Outstanding Resource Water). Unfortunately, these classifications do not currently contain critical nitrogen loads or nitrogen concentration limits. The federal government, in concert with the states, is working on the development of these limits, but it appears that final regulations are at least five years away.

In the early 1990's, the Buzzards Bay Project recommended nitrogen loading limits for coastal embayments and these limits were subsequently adopted for regulatory reviews by the Cape Cod Commission.

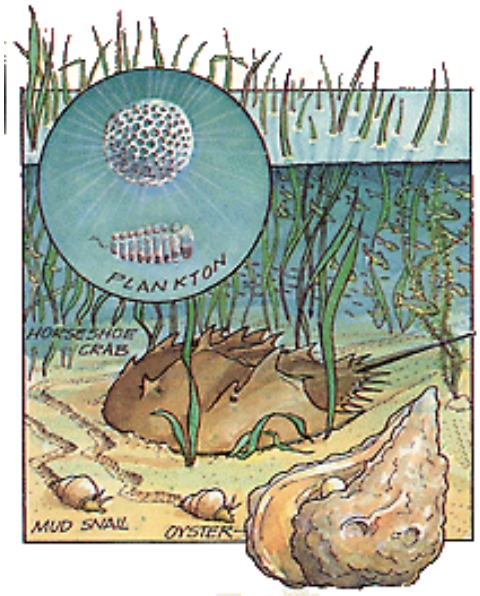
In 1998, the Commission reviewed water quality monitoring data from Cape Cod embayments that suggested that the recommended nitrogen loading limits currently being used allow too much degradation. The Commission suggested limits that allow 25 to 50% less nitrogen at the SA and ORW designations, respectively. Based largely on a review of 8 years of citizen water quality monitoring, the Buzzards Bay Project recently released revised limits that support these reductions.

Background total nitrogen concentrations in healthy marine waters are generally between .01 and .03 parts per million (ppm). The addition of as little as .05 to 0.1 ppm of nitrogen can negatively impact the ecosystems in a coastal embayment. The Commission is working with UMASS-Dartmouth, Center for Marine Science and Technology and in consultation with the Marine Biological Laboratory, Woods Hole Oceanographic Institute, the Buzzards Bay Project and others to comprehensively review available water quality information on Cape Cod and formalize limits to be used in planning and regulatory reviews.

But even with recommended limits, the cost associated with attaining these limits will be a matter for vigorous public debate. Public education regarding the selection of one limit or another will have to clearly convey the different types of ecosystems that a selection will cause. Cape Cod residents who are used to healthy waters full of scallops, eelgrass, and clams will need to understand that maintaining or restoring these types of ecosystems will require public investment in better wastewater treatment and long-term monitoring to ensure targets are met.

Future Decisions

Future Management



Many of Cape Cod's coastal embayments or subembayments are already exhibiting signs of nitrogen overloading. As seasonal and year round population and development continues to increase, developing and implementing management strategies to reduce the amount of nitrogen entering already overloaded embayments or those expected to be impacted by future development will become increasingly important. These strategies can include: increasing lot sizes through zoning requirements, purchasing developable land or development rights, transferring development rights from sensitive areas to more suitable areas, requiring denitrifying septic systems, building community sewer systems for higher density areas, and dredging the embayments to improve tidal flushing.

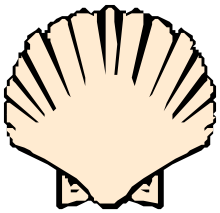
Preserving and restoring our coastal resources for the future will continue to require an informed and educated public. Government agencies, scientists, and advocacy groups like the Association for the Preservation of Cape Cod will have to jointly address these information and educational needs. Completing the assessments and changes necessary to ensure that our embayments and peninsula continue to be desirable destinations will be the next great water challenge for Cape Cod.

For Additional Information:

Association for the Preservation of Cape Cod	(508)255-4142
Barnstable County Department of Health and the Environment	(508)362-2511 X 320
Buzzards Bay Project	(508)291-3625
Cape Cod Commission	(508)362-3828
Cape Cod Cooperative Extension	(508)362-2511
Massachusetts Department of Environmental Protection (Southeast Regional office in Lakeville)	(508)946-2760
Your Local Health Department	_____
EOEA Basin Team Leader	(508) 946-2812

Glossary of Coastal Water Terms

Algal bloom: a rapid overgrowth of algae caused by an excess of nutrients.
Aquifer: underground sediments capable of holding and providing large quantities of water. A sole source aquifer is a region's only supply of water.
Benthic: sediment or near sediment submerged environment
Critical load: the amount of nitrogen an embayment can assimilate before the eutrophication processes occur.
Coastal embayment: a semi-enclosed coastal water body with a restricted opening to a larger water body.
Dissolved oxygen: the concentration of oxygen in water.
Eelgrass: a submerged aquatic vegetation which provides habitat for fish and shellfish.
Eutrophication: the process of increasing plant productivity while also reducing diversity and ecosystem stability.
Flushing time: the amount of time it takes for a pollutant or water to be carried out of an embayment by tides.
Groundwater: water held in the pores of underground soil and sediments
Nitrogen load: the amount of nitrogen entering an embayment from its watershed.
Watershed: the land area contributing freshwater to an embayment.



Communities Connected By Water Series

Winter 1999 - Fall 2000

- Protecting Drinking Water and Coastal Resources Program (Groundwater supply, surface water impacts, wastewater management) presented on the Outer, Upper, Mid and Lower Cape

Upcoming Forums:

- Protecting Open Space and Natural Habitats
- Linking Resource Protection and Growth Management
- Building a Watershed Advocacy Network