BARNEGAT BAY PARTNERSHIP

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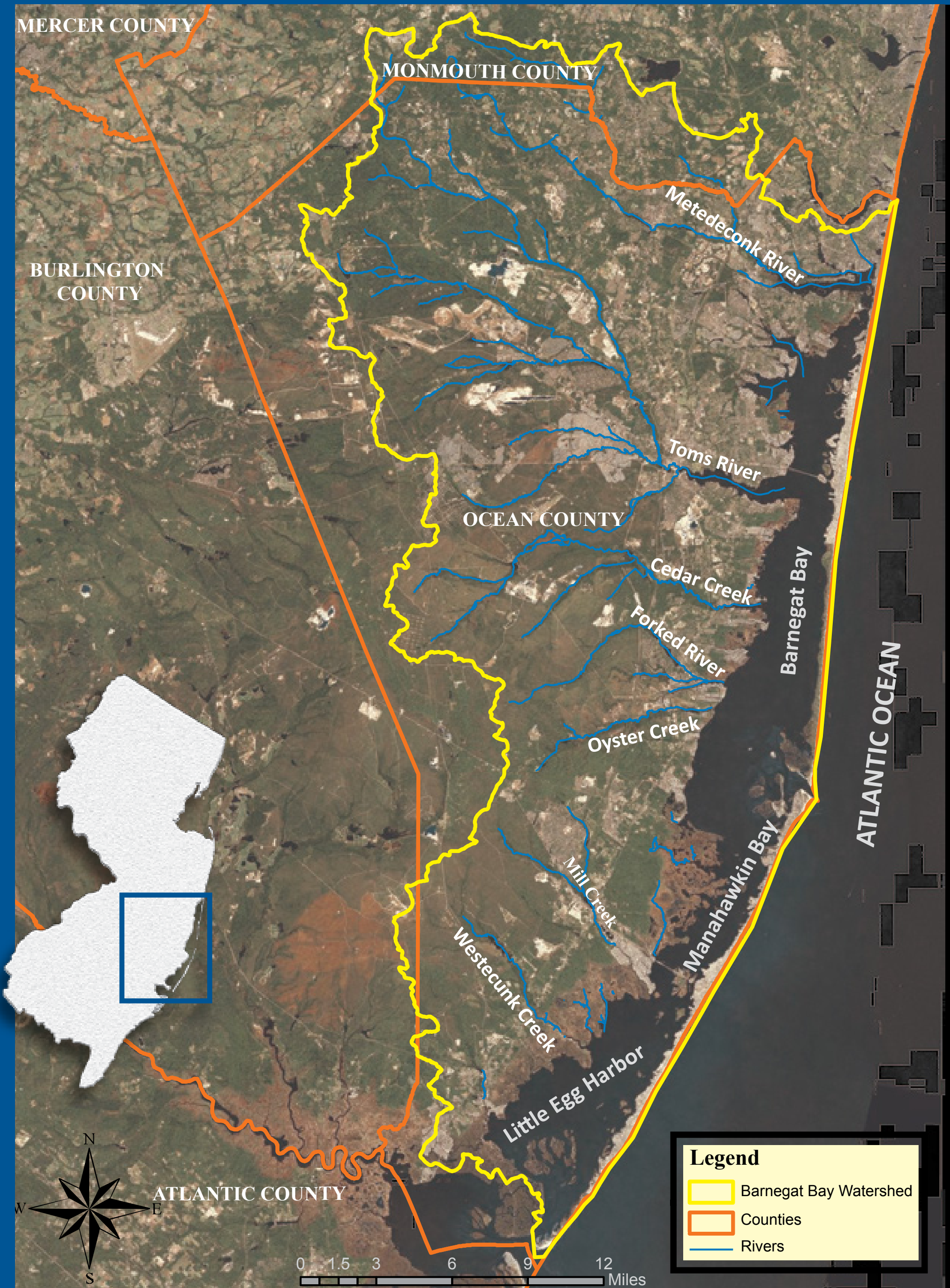
State of the Bay Report | 2011



COVER PHOTOS (l. to r.):
Island Beach view to the bay. Photo by Kathleen Spivey.
Fishing boat. Photo by Glenn P. White.
Black skimmer. Photo by Glenn P. White.
Cattus Island. Photo by Kathleen Spivey.
OPPOSITE: Island Beach. Photo by Kathleen Spivey.
BACK COVER Summer at Tice's Shoal. Photo by Melissa Danko.

BARNEGAT BAY PARTNERSHIP
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State of the Bay Report | 2011

Barnegat Bay Partnership

Director's Comments

L. Stanton Hales, Jr., Ph.D.
Director, Barnegat Bay Partnership

Located amidst two of the largest metropolitan areas in the United States, the Barnegat Bay watershed has become home to roughly 600,000 people, not including the half-million tourists who visit the area every summer. This population growth and tourism have brought many benefits, including educational and recreational opportunities and economic prosperity, and resulted in Ocean County being recognized several years ago as one of the best places in the country to live. Unfortunately, as we document in the following *State of the Bay Report*, the growing human population has altered much of the landscape within the watershed and contributed to diverse problems in the Barnegat Bay.

Of the 19 various indicators used to portray the overall condition of the bay, the overwhelming majority clearly show that the Barnegat Bay is in trouble. First and foremost, high nutrient loadings to the bay from past and present activities have contributed to excessive production of phytoplankton and benthic algae, which have led to high turbidity, low dissolved oxygen, and/or eelgrass decline in parts of the bay. The loss of eelgrass is particularly worrisome because so many recreationally and commercially important fishes and shellfishes in the bay depend on it.

Although the losses of natural landscapes have slowed significantly during the past decade, we continue to destroy forested and wetland habitats and convert them for human uses. These and other disturbances of the landscape are changing how water and other substances (*e.g.*, sediment, nutrients) are carried to the bay. Water does not infiltrate into compacted soils but flows over the ground resulting in more stormwater runoff, which carries fertilizer and other pollutants to the bay more rapidly. Downstream storm flows and increased erosion make people and property more vulnerable to coastal hazards.

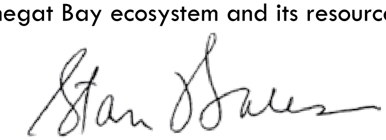
Perhaps even more worrisome than the current condition of the bay are the longer-term trends in the bay's condition—11 of the 19 indicators are not improving or are worsening. For example, groundwater withdrawals are increasing with population growth. Water conservation and appropriate re-use must become more important throughout the region or the bay's decline will continue.

We don't have enough data collected consistently over time to assess trends for one-third of the indicators. We simply do not know if dissolved oxygen concentrations or various problems are getting better or worse. It is important to understand that monitoring and assessing the bay are not only important to recognizing the bay's condition, but are also important to assessing the effectiveness of our corrective actions. Without more comprehensive monitoring, we do not know if we are spending our funds appropriately or wisely.

Not all of the news is bad. The Ocean County Natural Lands Trust, N.J. Department of Environmental Protection, U.S. Fish and Wildlife Service, and several nongovernmental organizations continue to purchase and protect open space at an impressive pace. Closures of bathing beaches and shellfish beds have generally declined. Some threatened species, most notably osprey, are doing well locally. These improving conditions give us hope for the future.

There is a renewed sense of optimism among the many agencies and organizations working to protect and restore the bay due to Governor Chris Christie's recently announced Action Plan. With ten distinct components and a ten-year commitment of funding to address stormwater pollution, the Action Plan represents a historic commitment by the state to the protection of the bay. However, the Action Plan alone will not fix the bay overnight; moreover, the bay is not solely the state's responsibility. All of the bay's stakeholders, from tourists to boaters to the industries which use the bay, must also step up and commit to protecting and improving the bay. Our economy and quality of life depend on it, now more than ever!

With apologies to Gifford Pinchot, "A brighter future for the bay will become reality only if we make ourselves responsible for that future." See the last page of this report to learn some simple actions you can do to help protect the bay. Working together, we can protect and restore the Barnegat Bay ecosystem and its resources.



Barnegat Light. Photo by Kathleen Spivey.

Executive Summary

This report presents the current environmental conditions of the Barnegat Bay and its watershed, and compares current conditions with those reported in the 2005 State of the Bay Report. In this report, 19 indicators are used to assess the physical, chemical, and biotic conditions of Barnegat Bay using recent and ongoing research by academic, government, and private-sector scientists and engineers.

In 1999, the National Oceanic and Atmospheric Administration reported that Barnegat Bay was impacted by excessive macroalgae and nuisance algal blooms, and declared it highly eutrophic. A 2007 follow-up study found that conditions in Barnegat Bay had declined since the 1999 report, largely attributed to increasing watershed development and associated increases in non-point source nitrogen loads.

WATER QUALITY

Water quality within the Barnegat Bay watershed continues to be a source of concern. A recently completed update on nutrient inputs suggests that excess nitrogen continues to enter into our rivers and streams, eventually ending up in Barnegat Bay. Once there, nitrogen and other nutrients contribute to excessive production, also known as eutrophication, a process marked by nuisance algal blooms, low dissolved oxygen, and other adverse effects that stress the biota of the bay. In addition to nutrients, pathogenic bacteria and other pollutants entering the rivers and bay from stormwater runoff and other non-point sources are causing closures of bathing beaches and shellfish harvesting areas, though the frequency of closures has been reduced during the past five years.

WATER SUPPLY

As the population in the watershed continues to grow, the amount of water withdrawn from rivers, streams, and aquifers for human uses increases. This reduction in fresh water supply to the bay changes its temperature, salinity, and flushing rate, all of which impact the biota that call the bay home.

HABITAT AND LIVING RESOURCES

Aquatic and terrestrial habitats within the bay continue to be lost. Sea grasses, a critical nursery habitat for many recreationally and commercially important fish and shellfish species, are at the lowest biomass levels ever documented in the estuary. The area of tidal wetlands along the bayshore has decreased by almost 8%, and the area of developed land within the watershed has increased to 34%.

But not all of the news is bad. Through a variety of public and private partnerships, open space preservation continues throughout the watershed, with over 8,000 acres protected over the past five years. Osprey, a threatened bird in New Jersey, is making a comeback, with the population in Barnegat Bay approaching near historic levels.

HOW TO USE THE STATE OF THE BAY REPORT

A gauge is shown for each environmental indicator, except for a few indicators for which doing so would be inappropriate. The gauge provides a summary of the indicator's status and trend, incorporating quantitative measures where available and the best scientific judgment of the review panel. Determination of an indicator's status is based on data available for 2005-2009, while the trend is based on the longest complete dataset available for that indicator. In some cases it was not practicable to use a five-year indicator for the status determination.

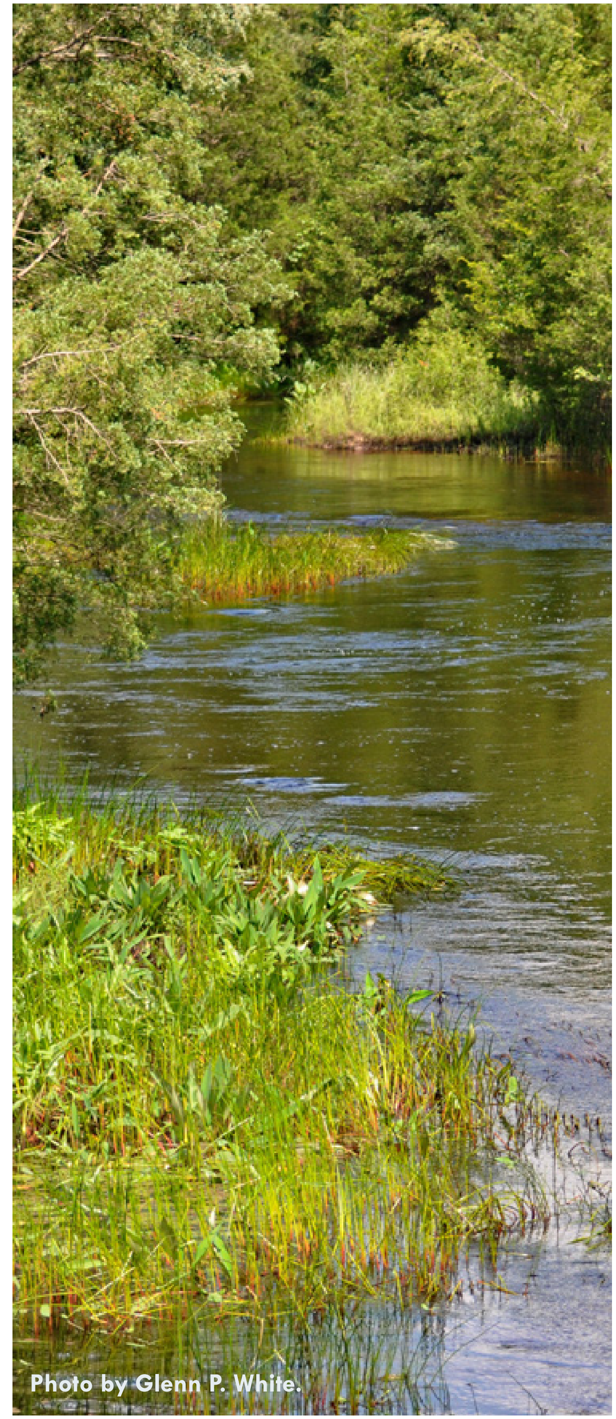
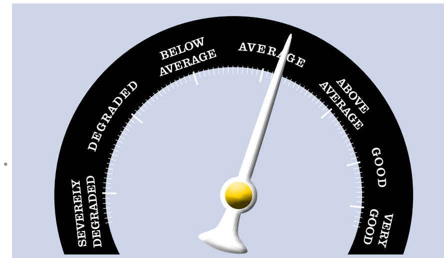


Photo by Glenn P. White.

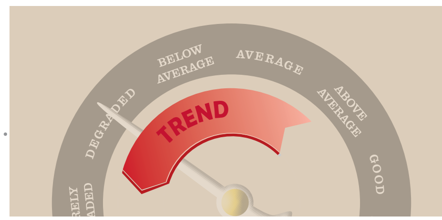
Status Ratings (needle)

- The needle points to the appropriate status for the indicator.

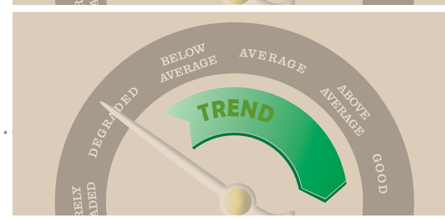


Trend Ratings (internal arrow)

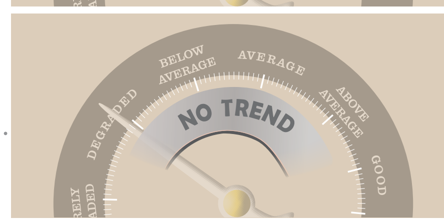
- A trend arrow pointing left indicates a deteriorating condition



- A trend arrow pointing right indicates an improving condition



- A double-sided arrow indicates no discernible trend

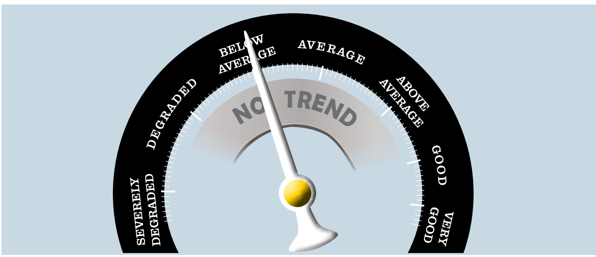


- A question mark (?) indicates that there was not enough data to develop a trend

STATE OF THE BAY'S

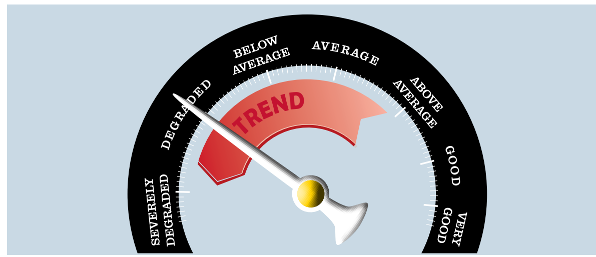
WATER QUALITY: Estuarine Eutrophication Assessment

Nitrogen Loading



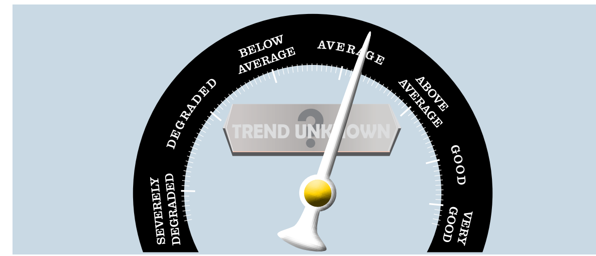
In 2009, it was estimated that the combined total nitrogen load to the Barnegat Bay-Little Egg Harbor estuary was 650,000 kilograms of nitrogen per year (kg N/yr). Because this load is contributing to eutrophication, the condition is considered below average.

Macroalgal Blooms



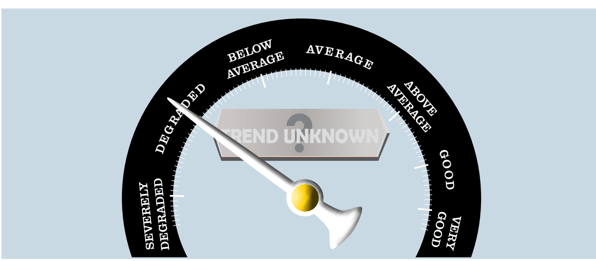
Nuisance algal blooms, especially the green-tide forming taxa, continue to be an issue, smothering seagrass beds and other critical habitat.

Turbidity



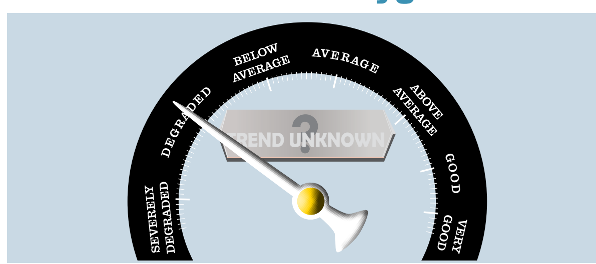
Over the last two seagrass-growing seasons, secchi depths (a measure of turbidity) throughout the bay have been greater than one meter, the secchi depth generally accepted as the minimum needed for seagrass growth. Long-term trends in turbidity are difficult to discern due to other confounding environmental factors.

Harmful Algal Blooms



A harmful brown tide bloom was documented in Little Egg Harbor in August 2010 through opportunistic sampling. Routine monitoring for brown tide has not been conducted since 2004.

Dissolved Oxygen



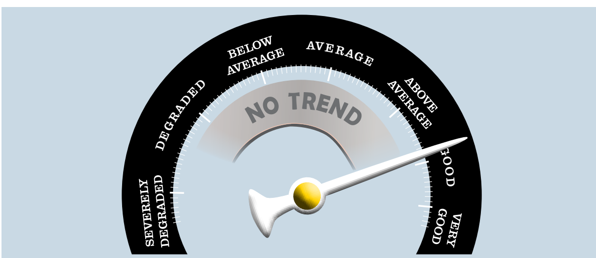
The northern portion of the estuary is listed as impaired for dissolved oxygen on the state's *List of Water Quality Limited Waters*. In 1999 and 2002, a total of three stations located in the upper part of the estuary had values below 4 milligrams per liter (mg/l), the level at which biota may begin to show signs of stress from low oxygen. In 2010 there were three stations in the central part of the estuary that had similar conditions.

STATE OF THE BAY'S
WATER QUALITY: Freshwater Assessment

Temperature and pH

Over the past five years, monitoring for temperature and pH has occurred at seven stations within the watershed with varying frequency. Summer and winter temperatures in each region have been generally consistent over the past four to five years, while spring temperatures have shown a slight decrease. Throughout the time series available, pH in winter and spring were similar across all three regions. In the summer, pH in the central segment was substantially lower than the north and south when averaged across all years.

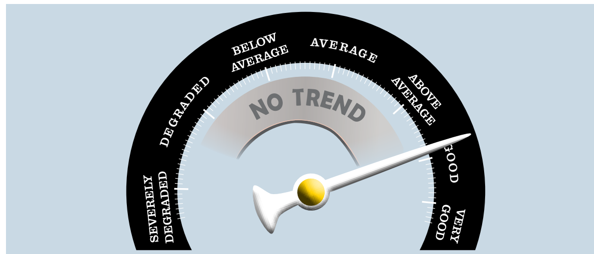
Freshwater Macroinvertebrates



Macroinvertebrates are commonly found throughout the watershed's streams, fulfilling an important role in the aquatic food web. These populations of benthic macroinvertebrates can be used as indicators of water quality. While the percentage of streams classified as having "excellent" water quality has increased over the 10-year period, so has the percentage of streams classified as "poor" and "fair," while the percentage of streams considered "good" has decreased.

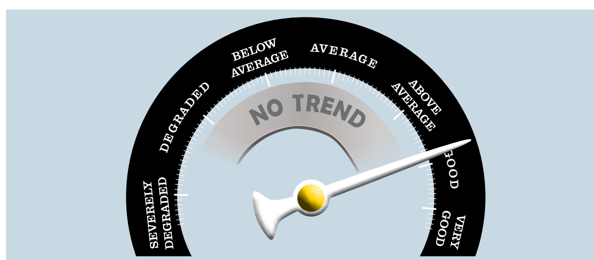
STATE OF THE BAY'S
WATER QUALITY: Human Use Impairments

Bathing Beach Closures



Water samples are analyzed from 36 public bathing beaches in the county on a weekly basis between Memorial Day and Labor Day. The number of closures at the county's public recreational bathing beaches varies from year to year, attributable primarily to the number, duration, and intensity of rainfall events. The total number of closures has generally declined over the past five years.

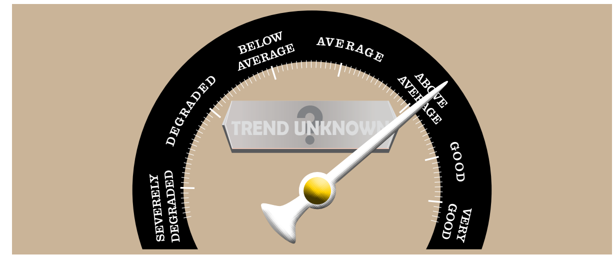
Shellfish Bed Closures



Currently, the waters of the Barnegat Bay consist of approximately 80% "approved," 5% "prohibited," and 15% "seasonal and special restricted" for shellfish harvest. There have been no substantial changes in the percentages of classified waters over the past five years.

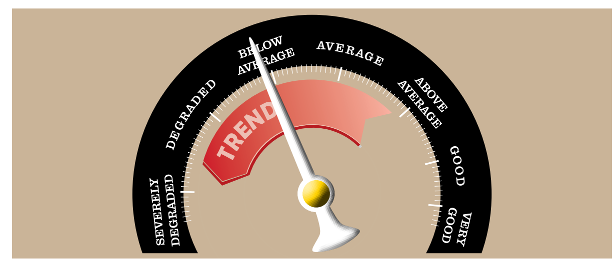
STATE OF THE BAY'S
WATER SUPPLY:

Shallow Groundwater Quality



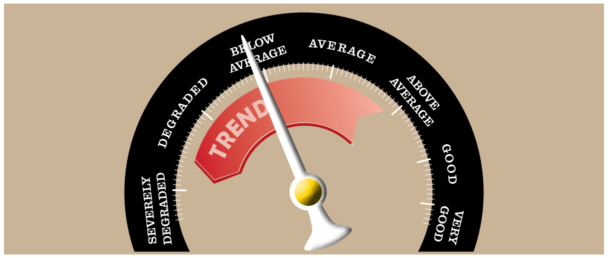
Ground water discharges from the Kirkwood-Cohansey aquifer system is the largest source of fresh water input to Barnegat Bay and is also the source of public water withdrawals. The quality of shallow groundwater in the watershed was assessed and found that federal and state primary drinking-water standards were exceeded in less than 1% of the sampled wells.

Streamflow



The U.S. Geological Survey maintains a network of stream gauging stations that measure the rate of flow in some of the major streams in the watershed on a continuous basis. The largest river in the watershed, the Toms River, has seen average streamflow over the past 20 years decline below the historic 79-year average.

Water Withdrawals

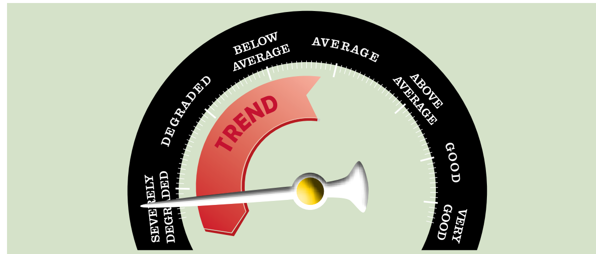


Fresh water is withdrawn from surface waterways and groundwater for a variety of purposes, including public supply, agriculture, landscape irrigation, commercial and industrial uses, mining, and power generation. The most recent estimate for 2005 shows that Ocean County's fresh water withdrawals averaged approximately 77 million gallons per day and have increased over the past several decades, together with population growth.

STATE OF THE BAY'S

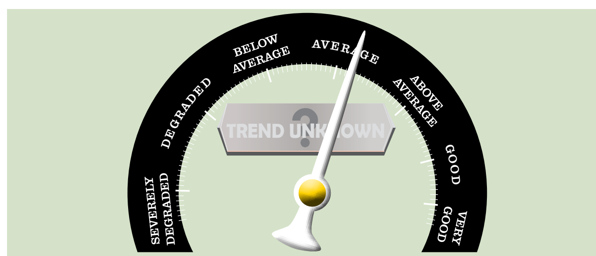
Habitat and Living Resources:

Seagrass



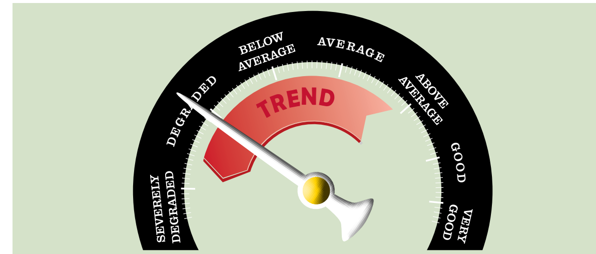
The decline of seagrass in New Jersey's coastal bays is a major concern because it is critically important as a source of nutrition and habitat for many fish and invertebrates. While the area of the bay bottom covered by seagrass has expanded slightly over the past seven years, the amount of seagrass within that area has decreased significantly. The lowest amount of seagrass within a given area ever recorded by Rutgers University was documented in 2009.

Watershed Integrity Measures



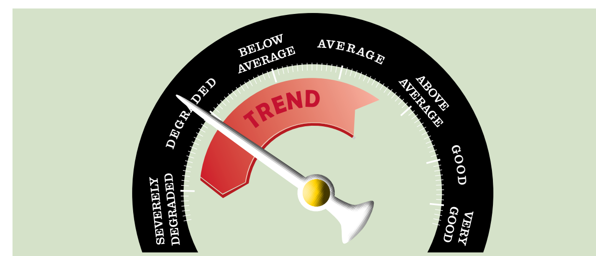
In 2003, studies were conducted on water quality, stream vegetation, fish assemblages, and frog and toad assemblages of the five major subwatersheds of the Barnegat Bay located within the Pinelands National Reserve. The ecological integrity of the five study basins varied, with many of the survey sites displaying some level of biological impairment.

Land Use-Land Cover



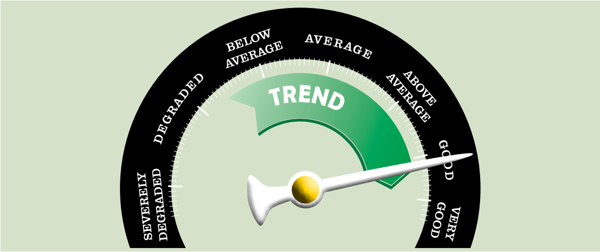
The conversion of forested areas and wetlands into urban settings reduces the amount of habitat available for plant and animal species and leads to sediment contamination, increased nutrient levels in surface waters, and increased incidences of low dissolved oxygen levels in water. Urban land use in the watershed has continued to increase, from approximately 25% of the watershed in 1995, to approximately 30% in 2006.

Wetlands



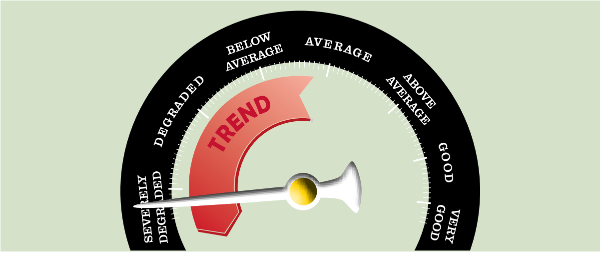
The wetlands within the watershed are an integral part of this sensitive ecosystem, providing habitat and a nursery for various fish, shellfish, and wildlife. There were approximately 21,449 acres of tidal wetlands and 66,732 acres of fresh water wetlands within the Barnegat Bay watershed in 2007. This represents an 8% decrease in tidal wetland area and a 5% decrease in fresh water wetland area since 1995.

Protected Lands



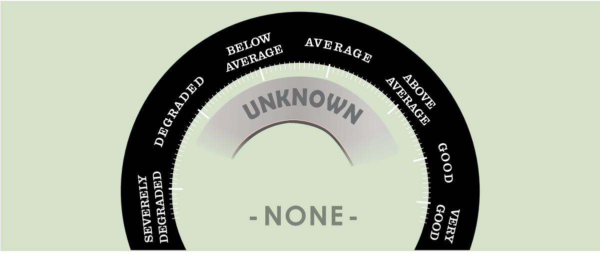
Protected lands serve as important refuges for wildlife and can also serve as corridors for movement between larger parcels. These open spaces also enhance water quality and aquifer recharge by allowing rainwater to filter directly into the ground. Between January 1, 2005 and December 31, 2009, approximately 8,300 acres in the Barnegat Bay watershed were acquired by federal, state, county, local, and non-governmental agencies for conservation purposes.

Shellfish Resources



Shellfish (clams, oysters, scallops) within Barnegat Bay have shown a marked decline from historic levels. There is currently a limited commercial and recreational fishery for hard clams and no fisheries for scallops or oysters.

Rare, Threatened, and Endangered Animal Species



There have been 6 "federally threatened or endangered" animal species, 13 "state endangered" animal species, 12 "state threatened" animal species, and 38 animal "species of special concern" sighted in the Barnegat Bay watershed since 1970.

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Introduction

THE NATIONAL ESTUARY PROGRAM

The National Estuary Program was established by Congress in 1987, via Section 320 of the Clean Water Act (33 U.S.C. 1330; P.L. 100-4, *et seq.*) to protect "estuaries of national significance." The Act directs the U.S. Environmental Protection Agency (USEPA) to develop plans for attaining and maintaining water quality in an estuary. The plan should include protection of public water supplies and the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife, and should allow recreational and other activities and uses in and on the water, and require control of **point** and **nonpoint sources of pollution** to supplement existing regulatory controls of pollution.

POINT SOURCE POLLUTION

a single identifiable localized source of air, water, thermal, noise, or light pollution.

NONPOINT SOURCE POLLUTION

pollution affecting a water body from diffuse sources, such as stormwater runoff or pet waste.

BARNEGAT BAY NATIONAL ESTUARY PROGRAM/ BARNEGAT BAY PARTNERSHIP

The Barnegat Bay National Estuary Program (BBNEP) was established in 1997, following the nomination of former Governor Christine Todd Whitman to provide an inclusive, local stakeholder-based mechanism to protect the Barnegat Bay for its economic, environmental, and cultural resources. Establishment of the BBNEP built upon the foundation that was provided by the state of New Jersey via P.L. 1987, Chapter 397, which created the Barnegat Bay Study Group. The BBNEP's Comprehensive Conservation and Management Plan (CCMP) was completed and approved by the partners in May 2002.

More recently, the BBNEP changed its name to the Barnegat Bay Partnership (BBP) to better represent its mission, and the CCMP was supplemented by a 2008-2011 Strategic Plan to refocus and guide the partners' collective effort.

Today, the BBP is one of 28 National Estuary Programs and comprises federal, state, and local government agencies, academic institutions, nongovernmental organizations, and businesses working together to restore and protect a nationally significant estuary, the Barnegat Bay.

THE BARNEGAT BAY: A COASTAL LAGOON

The Barnegat Bay-Little Egg Harbor (BB-LEH) estuary is a lagoonal estuary, a semi-enclosed feature where fresh water and saltwater mix. A nearly continuous barrier island complex extends along the eastern edge of Barnegat Bay, separating it from the Atlantic Ocean. Seawater enters the Bay at three locations: the Point Pleasant Canal via the Manasquan Inlet in the north, the Barnegat Inlet between Island Beach State Park and Long Beach Island, and Little Egg Inlet in the south. Salinity in the bay is highest (close to seawater) near the mouths of the southern inlets and lowest near the mouths of the large rivers. Freshwater flow into the bay is primarily through surface waters, (*i.e.,* rivers and streams such as the Metedeconk River, Toms River, Cedar Creek, and Westecunk Creek) but also through groundwater input. Tidal range is 3.3 feet near the Little Egg Inlet, 4.5 feet near the Barnegat Inlet, and only 1 foot at the Point Pleasant Canal. Because of the limited amount of water entering the system, the flushing rate, or the amount of time it takes to replace all of the water in the bay, is slow (about 3 months). This means that contaminants (nutrients, sediments, or chemicals) that enter the bay may stay there for an extended period. The **watershed** of the Barnegat Bay is approximately 670 square miles and encompasses nearly all of Ocean County and includes small portions of Monmouth and Burlington Counties.

Nutrient (substances used by living things to promote growth, generally nitrogen and phosphorous in estuaries) inputs into the Barnegat Bay are predominately from nonpoint sources such as stormwater runoff, groundwater, and atmospheric deposition. The types and amounts of nutrients are mostly determined by the surrounding land uses—suburban development, compared to forests or wetlands. In general, the northern portions of the watershed are more highly developed than the

(CONTINUED ON NEXT PAGE)

TMDLs IN THE BARNEGAT BAY WATERSHED

A TMDL (Total Maximum Daily Load) quantifies the amount of a pollutant (known as pollutant loading) a water body can assimilate without violating the state's water quality standards. TMDLs for nonpoint pollution calculate load allocations, which consist of the identification of categories of nonpoint sources that contribute to the pollutant of concern. The load allocation also includes specific load reduction measures for those categories of sources, to be implemented through best management practices (BMPs), including local ordinances for stormwater management and nonpoint source pollution control, headwaters protection practices, or other mechanisms for addressing the priority issues of concern.

A TMDL in New Jersey is considered to be "established" when the NJDEP finalizes the study report and formally submits it to the USEPA. The TMDL is considered "approved" when the NJDEP-established TMDL is approved by the USEPA. The TMDL is considered to be "adopted" when the USEPA-approved TMDL is adopted by the NJDEP as a water quality management plan amendment and the adoption notice is published in the *New Jersey Register*.

TMDLs FOR BARNEGAT BAY	STATUS
TMDLs for Mercury Impairments Based on Concentration in Fish Tissue Caused Mainly by Air Deposition	Established
TMDLs for Pathogens to Address Bamber Lake, Lake Carasaljo, Deer Head Lake, Holiday Lake, Lake Barnegat, Manahawkin Lake, Ocean County Park Lake, Ocean Township Bathing Beach, and Pine Lake	Adopted
TMDLs for Total Coliform to Address Shellfish-Impaired Waters in Barnegat Bay Watershed	Approved
TMDL for Phosphorus to Address a Stream Segment in North Branch Metedeconk River	Approved
TMDL for Phosphorus to Address Eutrophic Lake Pohatcong	Approved
TMDL for Fecal Coliform in Cedar Creek, Metedeconk River, Toms River, Forked River, and Barnegat Bay	Approved

WATERSHED

the geographic region within which water drains into a particular body of water.

Introduction

(CONTINUED FROM PREVIOUS PAGE)

southern portions, and this is reflected in the nutrient loads (amounts) reaching the bay.

ENVIRONMENTAL INDICATORS

"Indicators" are specific, measureable characteristics that can be used to observe changes in environmental conditions over time. Each indicator helps us understand the current condition of a key component of the Barnegat Bay ecosystem, and whether the trend for that element is positive or negative. They also provide a tool for evaluating the effects of management actions. Collectively, the indicators provide a picture of the overall ecological condition of the Barnegat Bay.

HOW WERE THE INDICATORS SELECTED?

The 19 indicators in this *State of the Bay Report* were included for their representativeness of the bay's habitat, resources, and concerns. We reviewed recent and ongoing research and evaluated what data were available and how they could describe the current conditions and the ways in which the bay has changed over the last five years.

The indicators were selected through a collaborative effort among the Barnegat Bay Partnership office, U.S. Geological Survey (USGS), N.J. Department of Environmental Protection (NJDEP), Rutgers University, and Brick Township Municipal Utilities Authority (BTMUA). Subsequent to selection, additional review of the indicators was provided by experts in the field, many of whom serve on the Barnegat Bay Partnership's Science and Technical Advisory Committee (STAC).

This report contains only a portion of the indicators that could have been included, but they provide an accurate representation of the changes to the bay. All of the "primary indicators" identified in the Barnegat Bay National Estuary Program's *2003 Monitoring Plan* have been included in this report. Primary indicators "are environmental or other resource characteristics that will provide the most effective subject areas for communicating Comprehensive Conservation and Management Plan progress to the public." Further, "secondary indicators" were included to provide additional detail about the condition of the bay and its resources. Taken together, they tell a story about the status and trends of both the natural resources and water quality in our watershed. As such, they serve as the basis for measuring the progress of those who are working to implement the *Barnegat Bay Comprehensive Conservation and Management Plan* and the *BBP's 2008-2011 Strategic Plan*.

The data utilized in this report were generated by a number of federal and state agencies and academic institutions. While the Barnegat Bay Partnership has strived to use only the highest quality data available (please see our Quality Assurance Performance Plan available at **http://bbp.ocean.edu/pages/345.asp**), we rely upon the expertise of the contributors to determine their accuracy. Therefore, questions concerning data should be addressed to the appropriate contributing source.

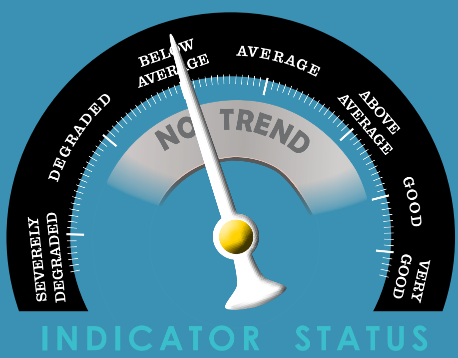
STATE OF THE BAY'S WATER QUALITY: Estuarine Eutrophication Assessment

"Eutrophication," an increase in the rate of supply of organic matter into an ecosystem, is one of the leading issues facing Barnegat Bay today. This process can lead to a cascading chain of negative environmental impacts, fueling algal blooms, creating hypoxic (low dissolved oxygen) or anoxic (no dissolved oxygen) conditions, and ultimately leading to changes in the bay's biotic communities. In the brackish and saline portions of the Barnegat Bay watershed, eutrophication is overwhelmingly driven by increases in nitrogen from nonpoint source pollution, but may also be affected by changes in temperature and other water quality parameters (*e.g.*, phosphorus). In freshwater rivers, creeks, and streams, phosphorous is the major nutrient of concern. The challenge that eutrophication poses begins at the headwaters of the bay in the westernmost reaches of the watershed and requires our collective action.

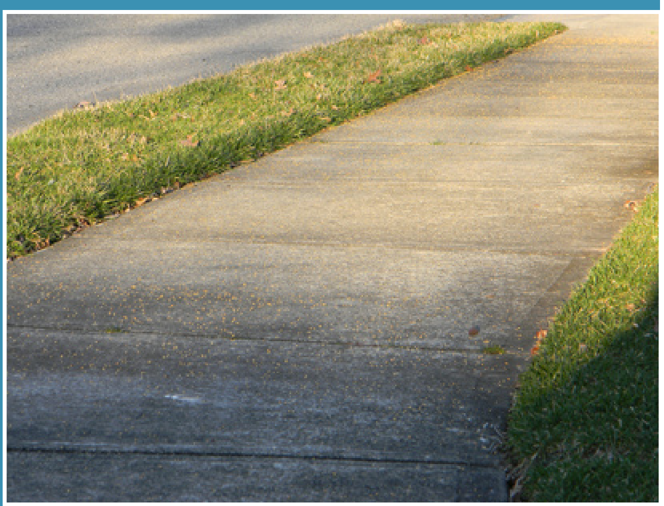
View of a sunset on the bay from Seaside Park.
Photo by Glenn P. White.

INDICATOR

Nitrogen load



Fertilizer incorrectly applied and left on a sidewalk. Photo by Jim Vasslides.



BACKGROUND

Nitrogen is one of the primary nutrients that can adversely impact water quality in estuaries. Estimates of the nitrogen load (amount of nitrogen that is delivered) to the Barnegat Bay-Little Egg Harbor estuary are needed to help assess the importance of nitrogen sources within the watershed and to develop nutrient-management strategies that can be used to help maintain or improve the ecological health of the estuary.

In residential and commercial areas, sources of nitrogen to surface- and groundwater include lawn fertilizers, septic-system wastes, leaky sewer pipes, and industrial discharge; in agricultural areas, sources include crop fertilizers, animal manure, and septic-system wastes. Additionally, nitrogen can enter the atmosphere through automobile emissions, industrial emissions, natural nitrogen-fixation processes, and emissions from agricultural sources, with subsequent deposition on land or water surfaces.

STATUS

A study was completed in 2009 by the U.S. Geological Survey to update the estimates of nitrogen loads to the Barnegat Bay-Little Egg Harbor (BB-LEH) estuary using the most recent and accurate data available through the year 2008. Based on all data evaluated, the combined total nitrogen load to the BB-LEH estuary was estimated to be 650,000 kilograms of nitrogen per year (kg N/yr). Surface water (which includes terrestrial and atmospheric sources in the watershed) contributes 66% (431,000 kg N/yr) of the total nitrogen load; direct groundwater discharge to the estuary contributes 12% (78,000 kg N/yr); and direct atmospheric deposition to the estuary contributes 22% (141,000 kg N/yr); (**FIGURE 1**). The study results offer evidence of the relation between land use and nitrogen levels. In general, total nitrogen yields (kilograms per square kilometer per year) were greater in developed areas (greater than 10% urban land cover) than in undeveloped areas (less than 10% urban land cover); (**FIGURE 2**).

TRENDS

Loading estimates from the 2009 study were compared to a previously published estimate obtained by using similar methodology, but less current data (through 1997). The 2009 total nitrogen load estimate (650,000 kg N/yr) is about 10% lower than the 1997 estimate (720,000 kg N/yr). Differences between the two estimates can be attributed to both the use of different data sources, and actual changes in the magnitude of nitrogen loads from various sources.

In the 2009 study, the N load to the estuary from atmospheric deposition was estimated to be 141,000 kg/yr—roughly 42 percent lower than the 1997 estimate of 242,000 kg/yr. Much of the difference can be attributed to lower deposition rates at the Edwin B. Forsythe Wildlife Refuge station, a newly installed data-collection station that is located along the coast in closer proximity to the estuary than at the Washington Crossing, New Jersey station, which was used in the previous estimate. Another factor contributing to the lower atmospheric-deposition estimate is a regional downward trend over time in the deposition rate of certain atmospheric contaminants, including nitrate.

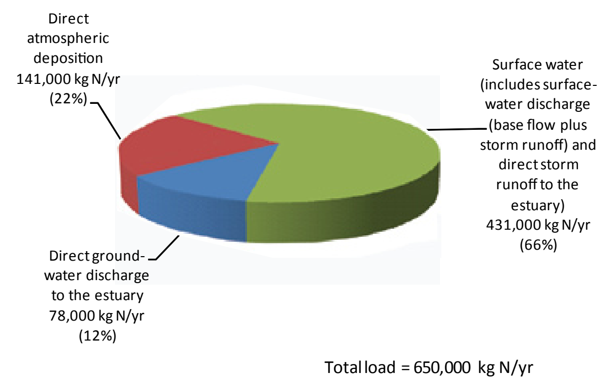


FIGURE 1. ***Relative contributions of nitrogen loads to the Barnegat Bay-Little Egg Harbor estuary from surface water, groundwater, and atmospheric deposition (kg N/yr, kilograms of nitrogen per year).***

The load of 405,000 kg N/yr from surface-water discharge (excluding direct storm runoff) to the estuary is 4% higher than the previous estimate of 390,000 kg/yr. It is particularly important to examine changes in load for the Toms River basin because it is the largest basin in the watershed, it contributes the largest total nitrogen (TN) load to the estuary, and it is the most comprehensively monitored basin in the BB-LEH watershed. Based on the 1997 study, the TN load from the Toms River basin was estimated to be 150,000 kg/yr, whereas the 2009 estimate is 170,000 kg/yr. Increased TN loads in this basin are due to increases in nitrogen concentrations.

Direct storm runoff which represents stormwater flowing directly into the estuary was not calculated previously, but represents about 4% of the total nitrogen load for the 2009 estimate. The 2009 N load of 78,000 kg/yr from direct groundwater discharge to the estuary is 12% lower than the previous estimate of 89,000 kg/yr. However, because the sample size (represented by the number of wells included in the analysis) is so small, a statistically meaningful assessment of trends in direct groundwater discharge is not possible and a lower median concentration does not necessarily reflect a downward trend in concentrations.

DATA GAPS

While this study identified increases in total nitrogen loading in surface-water discharge, the reason(s) behind the increase has not been identified. Reducing or eliminating these sources is key to the overall reduction of nitrogen into the bay. Further, a more complete analysis of the direct groundwater discharge and ocean water components of the bay's hydrology is needed.

For more detailed information regarding nutrient loads to the Barnegat Bay, please see the report entitled "Contributions of Nitrogen to the Barnegat Bay-Little Egg Harbor Estuary: Updated Loading Estimates" prepared by the USGS, available on the web at **http://bbp.ocean.edu/Reports/USGS_NLoadUpdate_Final.pdf**

Data were provided courtesy of the NJDEP, USGS, New Jersey Pinelands Commission, National Atmospheric Deposition Network, and the USEPA's Clean Air Status and Trends Network.

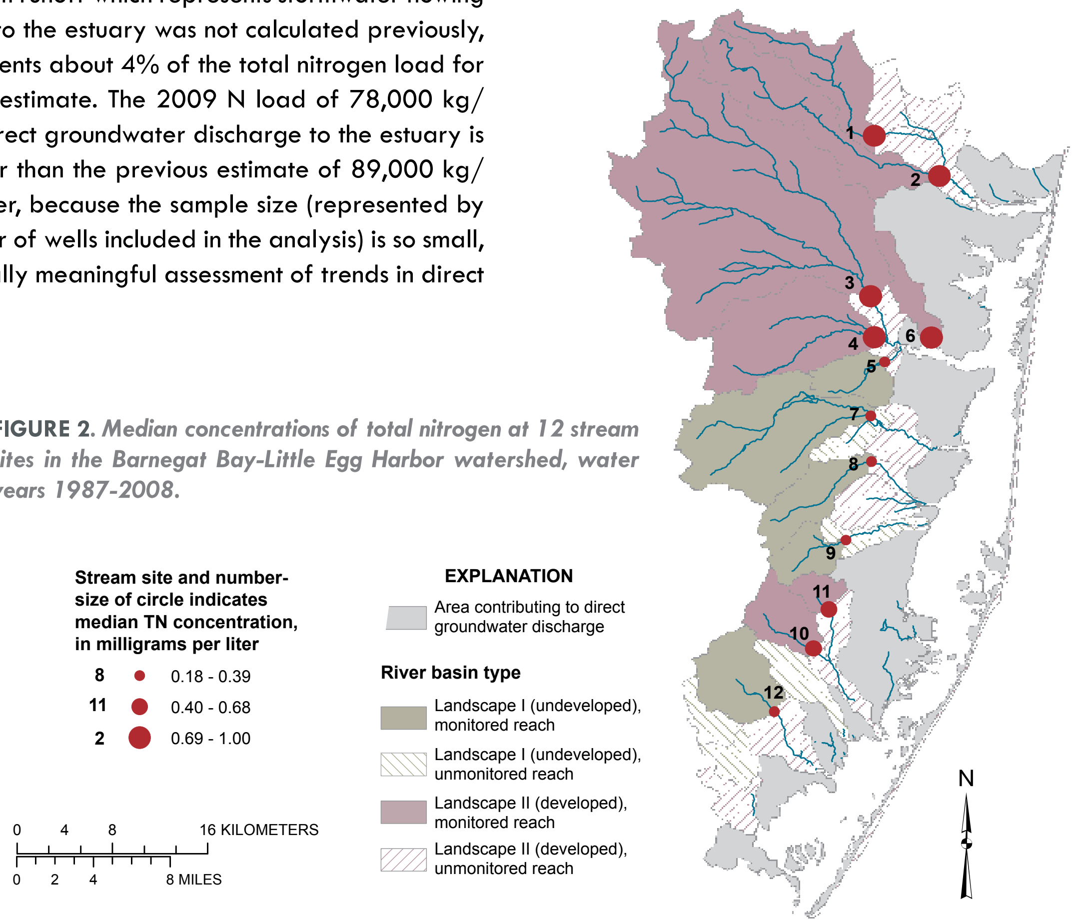


FIGURE 2. *Median concentrations of total nitrogen at 12 stream sites in the Barnegat Bay-Little Egg Harbor watershed, water years 1987-2008.*

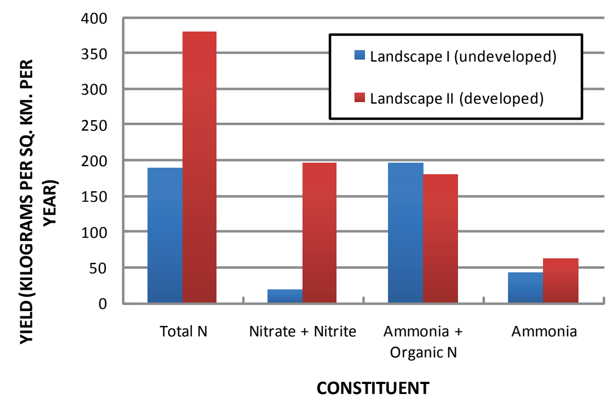
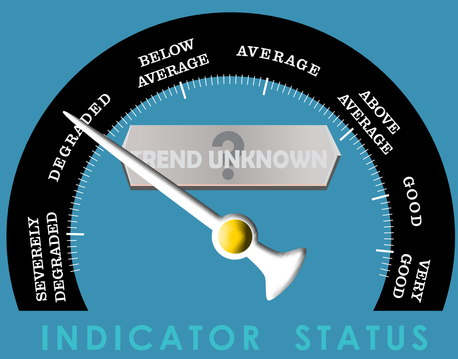


FIGURE 3. *Average yields of nitrogen compounds for undeveloped (less than 10% urban land cover) and developed (greater than 10% urban land cover) subwatersheds of the Barnegat Bay-Little Egg Harbor watershed, water years 1987-2008 (N= nitrogen).*

INDICATOR

Harmful Algal Blooms



Brown Tide Alga (*Aureococcus anophagefferens*). Photo courtesy of Mary Downes Gastrich.

BACKGROUND

Recurring phytoplankton blooms have been documented in Barnegat Bay which are symptomatic of eutrophication problems. These blooms are typically characterized by the explosive growth of a single phytoplankton species, which can create an array of negative impacts. Excessive growth of some phytoplankton species generates harmful algal blooms (HABs), also known as brown, yellow, and red tides. Toxic forms are particularly dangerous to numerous organisms, including macroalgae, shellfish, finfish, and humans. Secondary impacts include shading of benthic habitats, altered grazing patterns, and changes in trophic dynamics that are detrimental to estuarine function. HAB-forming species that have been recorded in the BB-LEH estuary include *Aureococcus anophagefferens, Dinophysis* spp., *Gymnodinium* (*Karlodonium*) spp., *Heterosigma* sp., and *Prorocentrum* spp.

Brown-tide blooms caused by the minute algal pelagophyte, *Aureococcus anophagefferens*, were first reported in New Jersey coastal bays in 1988. These algal blooms can discolor the water brown and may cause negative impacts on shellfish, notably the ecologically and commercially important hard clam and scallop, as well as on seagrasses. Adverse shellfish impacts include a reduction in the growth of juvenile and adult hard clams and mussels, reduced feeding rates of adult hard clams and other shellfish, recruitment failures, and increased mortality of bay scallops. The dense shading of benthic habitats caused by these blooms may also contribute to the loss of seagrass beds, which serve as important habitat for finfish and shellfish.

Chlorophyll *a* is a plant pigment used to determine the amount of algal biomass present in a body of water. While there will be a background amount of chlorophyll *a* in a water sample due to naturally occurring phytoplankton, excessive amounts indicate an algal bloom may be occurring. The NJDEP's Bureau of Marine Water Monitoring (Bureau) collected an average of 72 chlorophyll *a* samples in the estuary during the summer season from 1999-2010 as part of the Coastal Water Quality Network. In 1999, the Bureau, in conjunction with the USEPA, began bi-weekly summer monitoring at six stations in the estuary to identify phytoplankton species. With the help of the NJDEP Forest Fire Service, Rutgers University, and the USEPA, the Bureau has recently added routine aircraft remote sensing for chlorophyll *a* over the estuary for the spring and summer season to monitor for algal blooms.

STATUS

Algal blooms have been recorded occurring throughout the bay at various time and spatial scales during the 2005-2009 time period. While routine monitoring for brown tide was discontinued in 2004, a harmful brown tide bloom event was documented in Manahawkin Bay and Little Egg Harbor in August 2010.

TRENDS

Average summer chlorophyll *a* concentrations have fluctuated both by year and bay segment (**FIGURE 1**) since long-term monitoring began in 1999. Because no routine monitoring for brown tide has been conducted since 2004, it is not possible to determine a trend for brown tide blooms. However, given that a brown tide bloom was documented in 2010 through opportunistic sampling, it is likely that other bloom events occurred and went unrecorded during the five-year time frame.

DATA GAPS

While the recent addition of remote sensing for chlorophyll *a* allows for an estuary-wide assessment of phytoplankton abundance, it does not provide for the identification of the plankton species associated with chlorophyll *a* levels. The current sampling regime would require modification to accurately identify phytoplankton species throughout the estuary at the appropriate temporal and spatial scales. This includes reinstatement of the extensive brown tide monitoring program that took place from 1995 to 2004.

To learn more about the NJDEP phytoplankton monitoring program, log on to **www.state.nj.us/dep/wms/bmw/phytoplankton.htm**. For additional information about brown tide in New Jersey, please visit **www.crssa.rutgers.edu/projects/btide/** and **www.state.nj.us/dep/dsr/browntide/browntide-rps-2006.pdf**

Data provided by the NJDEP and Rutgers University.

Average Summer Chlorophyll *a* Concentrations by Year

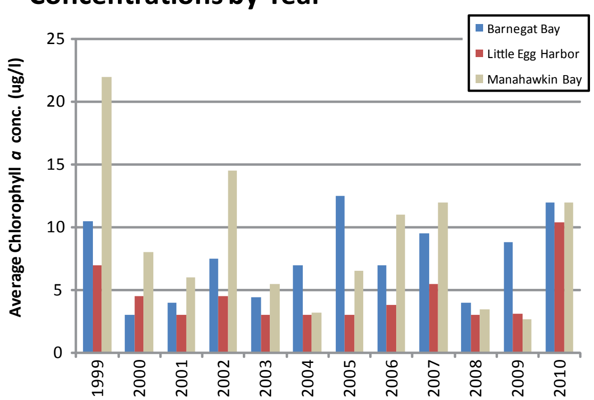
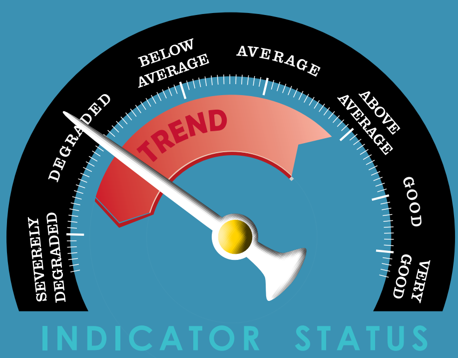


FIGURE 1: *Average summer Chlorophyll a concentrations by year and bay segment from the NJDEP Bureau of Marine Water Monitoring Coastal Water Quality Network.*

A typical intertidal mudflat in the bay. Photo by Glenn P. White.

INDICATOR

Macroalgal Blooms



Excessive Sea Lettuce growth.
Photo by Dr. Michael Kennish.

BACKGROUND

Recently, scientists have placed greater emphasis on macroalgal blooms in shallow eutrophic estuaries. While not toxic, these outbreaks are considered nuisance algal blooms due to their negative ecological effects. Macroalgae in the Barnegat Bay-Little Egg Harbor estuary are part of a drift community. Sheet-like masses of certain species (e.g., *Ulva lactuca* and *Enteromorpha* spp.) are particularly problematic because they grow rapidly when light and nutrient conditions are favorable, outcompeting seagrasses. High biomasses of macroalgae can seriously damage seagrass by forming thick mats that overlie and smother the plants underneath. The accumulation and decomposition of dead plant matter on the estuarine floor then lead to sulfide buildup in bottom sediments in the root zone. This biogeochemical process contributes to additional loss of seagrass habitat. The dense mats of macroalgae can also have similar impacts on the benthic invertebrate communities that live in and near the seagrass beds.

Macroalgal impacts on seagrass beds were assessed in 2004-2006, 2008, and 2009 as part of comprehensive surveys conducted in the central and southern portions of the BB-LEH estuary by Rutgers University.

STATUS

Damaging effects of macroalgae blooms were recorded in seagrass beds of the estuary over the 2004 to 2009 period. The surveys in 2004 and 2005 revealed 39 species of macroalgae in the seagrass beds, with red and green algae being the dominant forms. Although the macroalgal blooms did not cover entire seagrass beds at any time, the cumulative impact of blooms at spatially restricted locations resulted in patches of extensive bare bottom areas within the beds. *Ulva* blooms were especially damaging in this regard (see photo).

TRENDS

The percent cover of macroalgae on the seagrass beds fluctuated by year and sampling period (**FIGURE 1**). Macroalgal blooms were most extensive in the seagrass habitat during the 2004 and 2008 survey years, but also occurred at some locations during other years. The absolute percent cover of macroalgae on the seagrass beds at the 120 sampling stations was highly variable, ranging from 0-100%. The mean percent cover of macroalgae at the sampling stations in turn ranged from 2-21% during all sampling periods.

DATA GAPS

Monitoring and assessment of macroalgal impacts to seagrass should continue on a biannual basis to determine the extent of habitat alteration due to these blooms and the effects of nutrient load reduction on their growth.

Data were provided by Rutgers University.

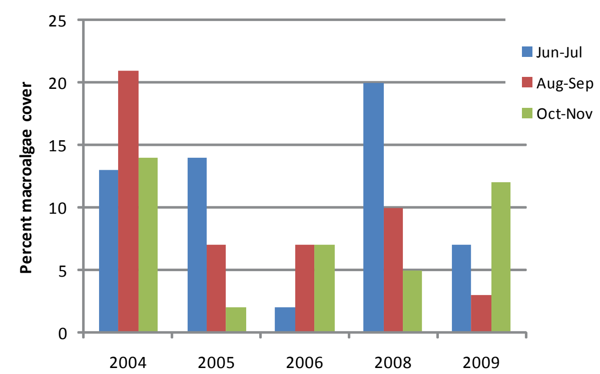
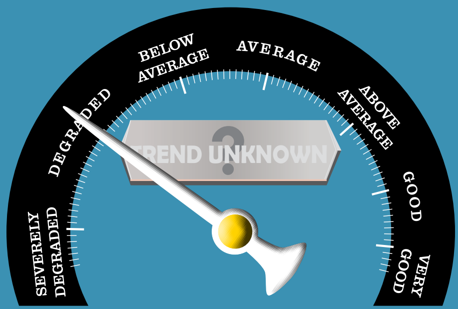


FIGURE 1: *Percentage of seagrass beds covered by macroalgae in 2004-2006, 2008, and 2009 by sampling period. Data were provided by Rutgers University.*

The bayside shoreline at Island Beach State Park.
Photo by Glenn P. White.

INDICATOR

Dissolved Oxygen



Rockweed (Phaeophyta), a common bay algae. Photo by Kathleen Spivey.

BACKGROUND

Dissolved oxygen is a fundamental requirement for the maintenance of balanced populations of fish, shellfish, and other aquatic organisms. The nature and extent of the organism's response to low oxygen concentrations depends on several factors, including the concentration of oxygen in the water, how long the organism is exposed to reduced oxygen, and the age and condition of the organism.

Because dissolved oxygen is so important to marine life, New Jersey has established surface water criteria for oxygen levels in marine waters. The surface water criterion for estuarine water is four milligrams per liter. Dissolved oxygen concentrations below two milligrams per liter are considered lethal to aquatic life, while concentrations above two, but below the four milligrams per liter designation, may support some, though not all aquatic life. Prolonged periods of exposure to below-optimum conditions (between 4 and 5 milligrams per liter) adversely affects many aquatic species.

STATUS

The northern portion of the estuary is listed as impaired for dissolved oxygen on the state's *List of Water Quality Limited Waters*, known as the "303(d) List" (named after a section of the Clean Water Act). This listing was based on dissolved oxygen measurements obtained between 2005 and 2007 from a continuous water quality monitor located in Seaside Park. Continuous water quality monitors can detect daily fluctuations better than the NJDEP routine water monitoring network because low dissolved oxygen conditions are expected to occur in the early morning hours, which are not usually sampled by routine manual fixed station monitoring.

TREND

The NJDEP Bureau of Marine Water Monitoring assesses summer dissolved oxygen conditions through their Coastal Water Quality Network. Over the past 12 years, an average of 44 fixed stations were sampled each year on a quarterly basis throughout the estuary (**FIGURE 1**). In 1999 and 2002, a total of three stations located in the upper part of the estuary had summer minimums below 4 milligrams per liter. Three stations in the central part of the estuary had summer minimums below 4 milligrams per liter in 2010. All other stations sampled during those years, and all the other years, did not drop below the 4 milligrams per liter threshold. Variations from year to year can be caused by a variety of factors, including the weather preceding the sample collection, water temperature, other water quality parameters (*e.g.*, nutrients, chlorophyll *a*), and the time of sample collection. To look for any long-term changes and their causes, more continuous monitoring of dissolved oxygen is needed to understand the daily fluctuations and how they relate to weather conditions and water quality.

DATA GAPS

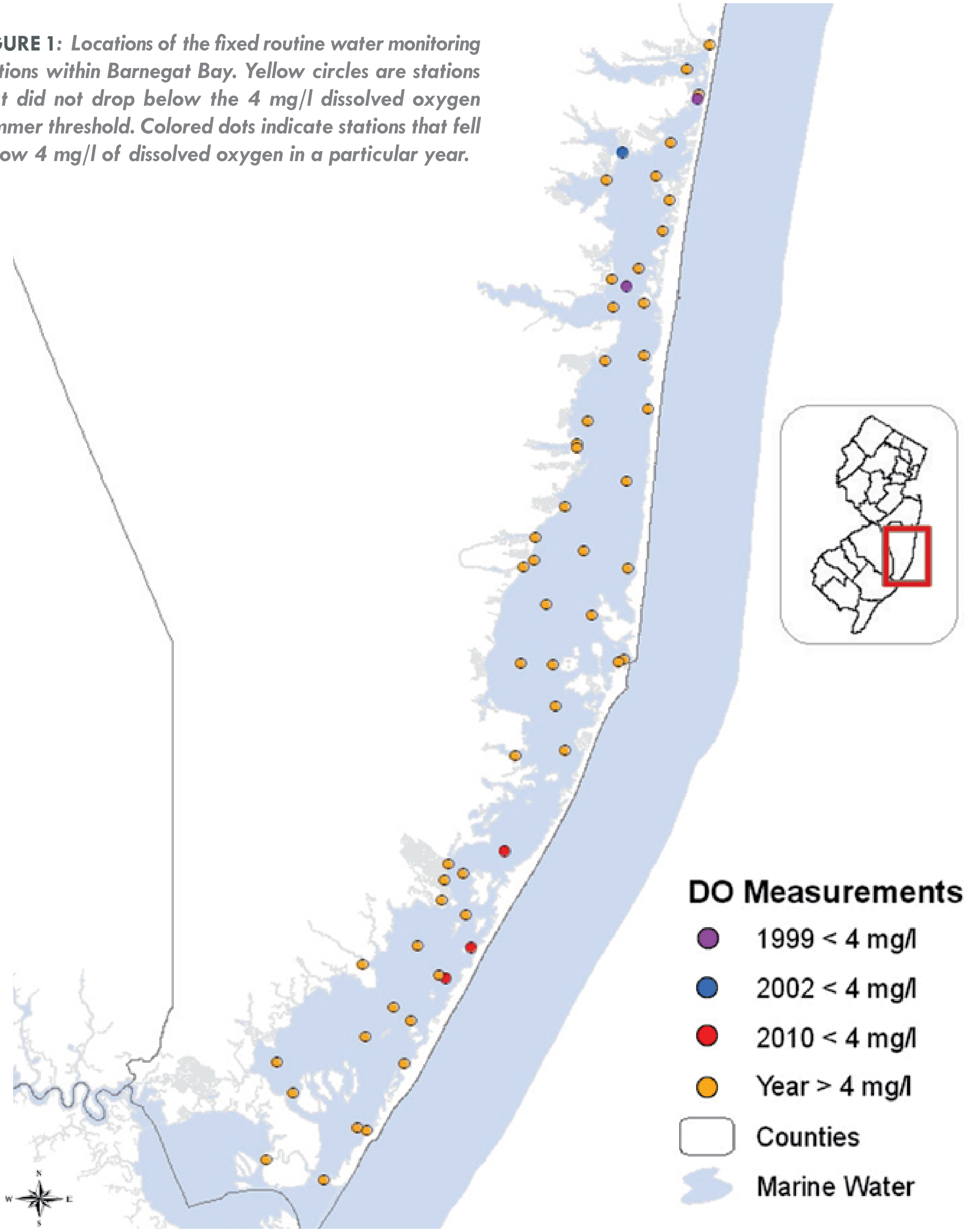
During the 2005-2010 time period there were only three continuous water quality monitors located throughout the entire bay: Mantoloking, Seaside Park, and Manahawkin. To get an accurate representation of dissolved oxygen levels and their fluctuations on both short- and long-term time scales, as well as baywide, additional sensors are needed.

For additional information on the NJDEP Bureau of Marine Water Monitoring's Coastal Water Quality Network, and the latest data analysis, please visit them online at **www.state.nj.us/dep/wms/bmw/waterquality.htm**.

Data were provided courtesy of the NJDEP Bureau of Marine Water Monitoring, NJDEP Bureau of Water Quality Standards and Assessment, and Monmouth University.


Life on the bay. Photo by Kathleen Spivey.

FIGURE 1: *Locations of the fixed routine water monitoring stations within Barnegat Bay. Yellow circles are stations that did not drop below the 4 mg/l dissolved oxygen summer threshold. Colored dots indicate stations that fell below 4 mg/l of dissolved oxygen in a particular year.*



INDICATOR

Turbidity

INDICATOR STATUS

Using a secchi disk to measure turbidity. Photo by Jacalyn Toth.

BACKGROUND

Poor water clarity in shallow estuaries can be attributed to a number of sources, including organic material (especially living or dead algae), dissolved tannins, and suspended sediments due to wind and wave action or human activities such as boating. Turbid waters may supply building material for maintaining estuarine structures and provide food and protection to resident organisms; however, the extensive particle loads of turbid waters are harmful if they bury benthic communities, inhibit filter feeders, or block light needed by seagrasses.

The NJDEP Bureau of Marine Water Monitoring utilizes a secchi disk to measure turbidity (water clarity) as part of the Coastal Water Quality Network. The disk is lowered into the water at 33 sampling locations throughout the estuary on a bi-weekly basis to see how far light can penetrate into the water column. Secchi depths of one meter or greater are considered healthy for seagrasses.

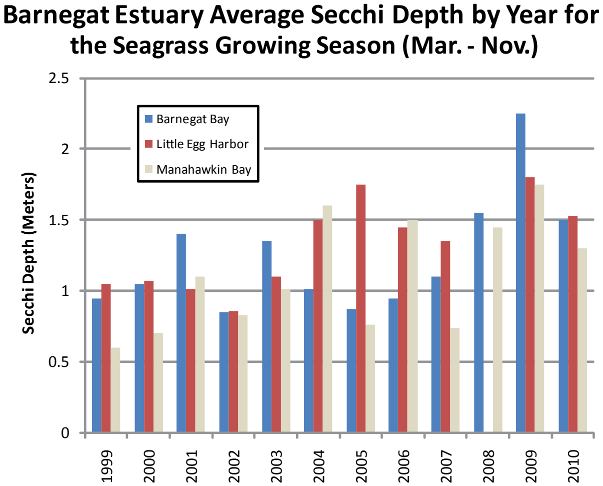


FIGURE 1: *Average secchi depth for the Barnegat Bay during the seagrass growing season (March to November) from 1999 to 2010 as recorded by the NJDEP Coastal Water Quality Network. Please see the map in the Dissolved Oxygen section for sampling locations.*

STATUS

Currently there is no regulatory criterion for turbidity in the bay. However, over the last two seagrass growing seasons secchi depths throughout the bay have been greater than one meter (**FIGURE 1**).

TRENDS

Turbidity varies from year to year based on a number of factors, including the weather preceding the sample collection, freshwater flows, water temperature, other water quality parameters (*e.g.,* Chlorophyll *a*), and the time of sample collection. It is therefore difficult to identify long-term trends in turbidity.

DATA GAPS

None.

Data were provided courtesy of the NJDEP Bureau of Marine Water Monitoring.

STATE OF THE BAY'S WATER QUALITY:

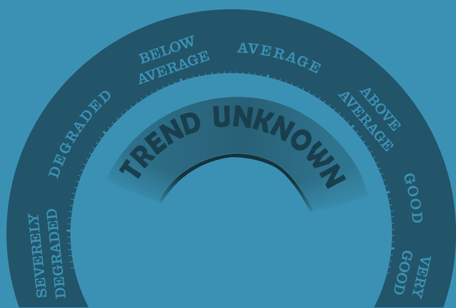
Freshwater Assessment

While seemingly far from the Barnegat Bay itself, municipalities such as Plumsted, Lakehurst, Manchester, Jackson, Wall, Millstone, and Freehold contain the headwaters and tributaries that eventually join together to form the Toms River and Metedeconk River. This fresh water mixes with saltwater to create vital nursery areas for life along the entire Atlantic coast. Along with many other creeks and streams, these waterways flow through our communities, connecting all of us to Barnegat Bay.

A salt marsh in Cattus Island County Park.
Photo by Kathleen Spivey.

INDICATOR

Temperature and pH



INDICATOR STATUS: INSUFFICIENT DATA

An intertidal salt marsh at Island Beach State Park. Photo by Kathleen Spivey.

BACKGROUND

Water quality in Barnegat Bay is strongly influenced by the fresh water that comes from rivers, streams, and creeks. The major rivers and streams carry over 80% of the fresh water that enters the bay, with the remainder coming from precipitation, smaller creeks and streams, and direct groundwater discharge. The characteristics of the incoming fresh water influence water quality in the bay, including temperature, pH, and dissolved oxygen.

Temperature

Temperature is an important indicator, as many fresh water and estuarine aquatic species are adapted to living within an optimal range, and departures from that range can cause stress, leading to reduced feeding, reduced reproduction, higher metabolic costs, and even mortality. Furthermore, warmer water does not hold as much dissolved oxygen, a key component for life in aquatic environments.

STATUS

Over the past five years the NJDEP and USGS have monitored temperature at seven stations within the watershed with varying frequency (**FIGURE 1**).

TRENDS

The relatively short time frame over which comparable temperature data have been collected makes an in-depth trend analysis problematic; however, the collected data are sufficient for illustrative purposes. Summer and winter temperatures in each region have been generally consistent over the past four to five years, while spring temperatures have shown a slight decrease (**FIGURE 2**). Across all years and seasons, temperatures in the southern portion of the bay were generally lower than those of the central and northern portions.

pH

The acidity of a waterway (known as pH) is also an important indicator of freshwater ecosystem health. A pH value < 7 is considered acidic while a pH value > 7 is basic. Transitions from natural landscapes to agricultural and suburban/urban uses are typically reflected in waterways by an increase in pH. This is particularly problematic in the central and southern portions of the watershed, where the headwaters of many of the waterways are in the Pinelands and, therefore, have naturally low pH. The unique aquatic species endemic to the Pinelands have evolved to survive in these acidic waters, and raising the pH may have adverse consequences.

STATUS

Over the past five years the NJDEP and USGS have monitored pH at seven stations within the watershed with varying frequency (**FIGURE 1**).

TRENDS

The relatively short time frame over which comparable data have been collected makes an in-depth trend analysis problematic; however, the collected data are sufficient for illustrative purposes. Throughout the time series available, pH in winter and spring were similar across all three regions (**FIGURE 3**). In the summer, pH in the central segment was substantially lower than the north and south when averaged across all years. Variability between years was also highest in summer compared to winter and spring.

DATA GAPS

While data are collected from the Metedeconk River and its tributaries as part of the NJDEP and USGS sampling protocol, the collection dates are sufficiently far enough apart from those in the Toms River and waterways to the south that it makes comparisons between rivers difficult. In addition, data from the fall season needs to be collected more regularly to make valid comparisons.

Data were provided courtesy of the NJDEP and USGS through the USEPA STORET data warehouse.

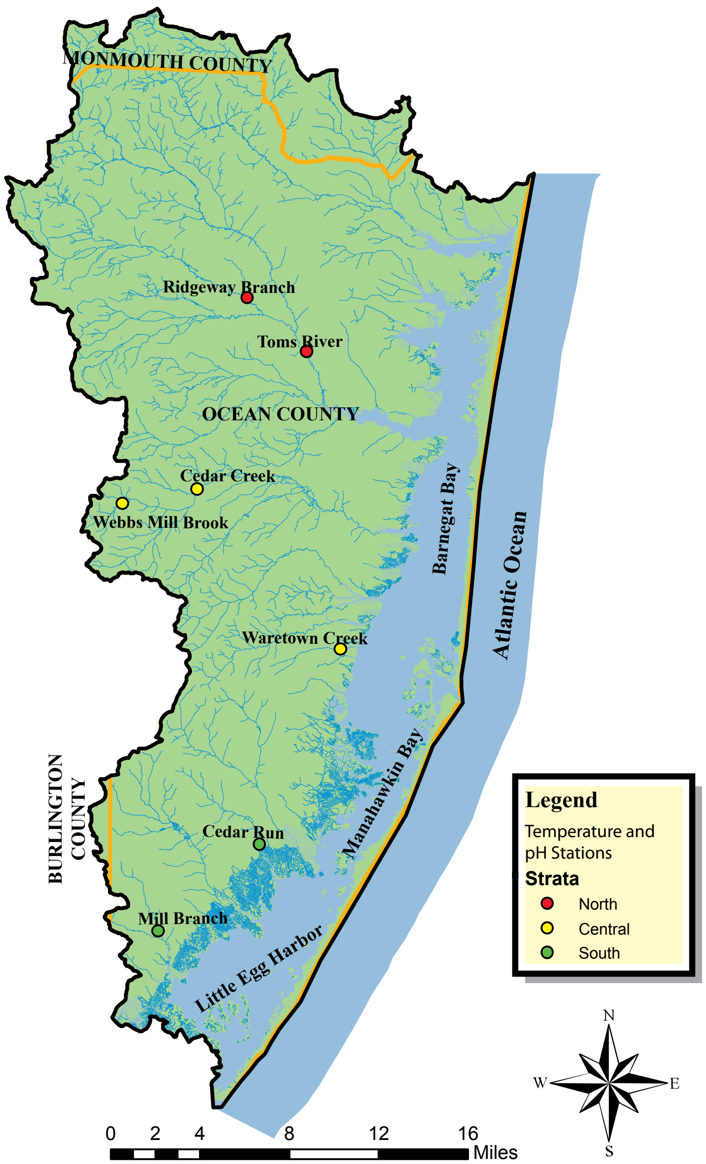


FIGURE 1: *Long-term temperature and pH sampling station locations within the watershed utilized in this report. Data were provided by the NJDEP and USGS.*

FIGURE 2: *Stream and river temperatures throughout Barnegat Bay. Winter samples were collected December-March, spring samples April-May, and summer samples August-September. See map for the locations of the sampling stations. Data were provided by the NJDEP and USGS.*

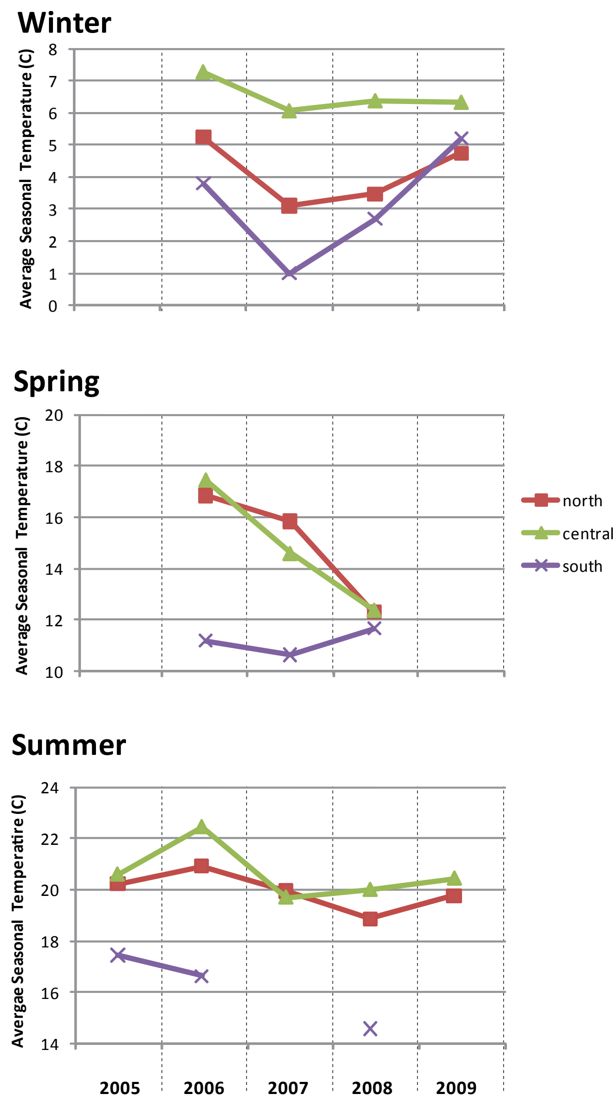
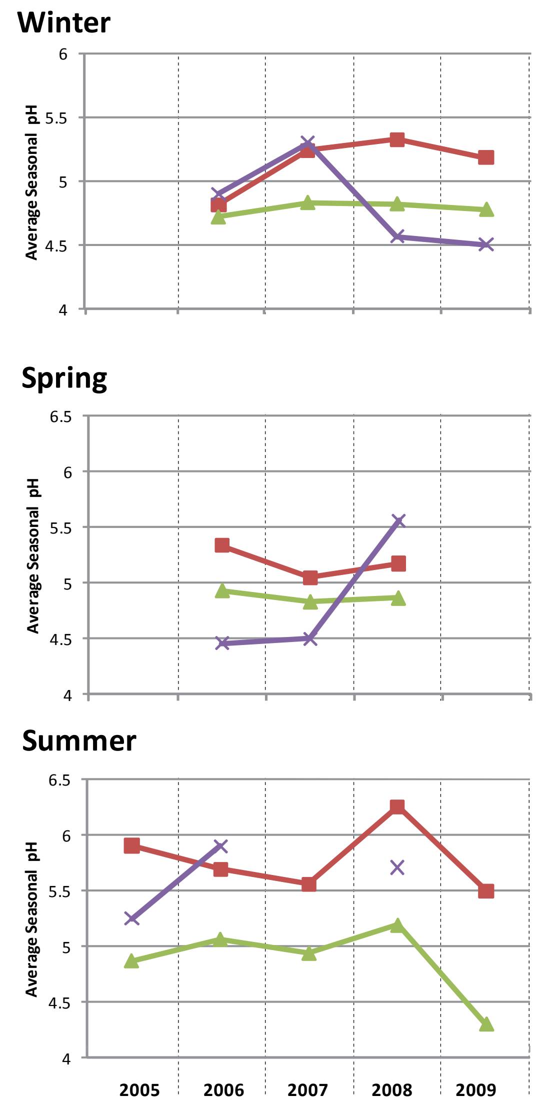
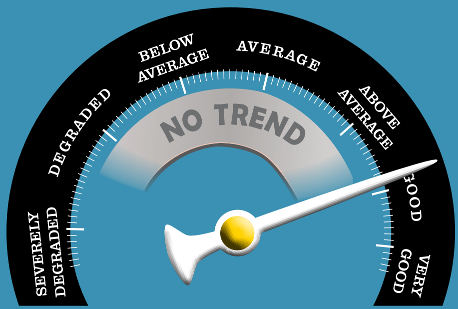


Figure 3: Stream and river pH throughout Barnegat Bay. Winter samples were collected December-March, spring samples April-May, and summer samples August-September. See map for the locations of the sampling stations. Data were provided by the NJDEP and USGS.



INDICATOR

Freshwater Macroinvertebrates



Stonefly larvae. Photo courtesy of the NJDEP Bureau of Freshwater and Biological Monitoring.

BACKGROUND

Freshwater biological monitoring refers to the use of in-stream populations of benthic macroinvertebrates as indicators of water quality. Benthic macroinvertebrates are larger invertebrate animals inhabiting aquatic habitats. In fresh water, common forms are aquatic insects, worms, snails, and crustaceans. Macroinvertebrates are commonly found throughout the watershed's streams, fulfilling important roles in the aquatic food web. Species comprising the instream macroinvertebrate community occupy distinct niches governed by environmental conditions and their tolerance to pollution. Changes in environmental conditions may be reflected by changes in the macroinvertebrate community structure. Assessments of ambient water quality can then be based upon standardized measures of said changes in community structure.

There are a number of advantages to using benthic macroinvertebrates as indicators of freshwater quality: 1) they are good indicators of localized conditions of water quality due to their limited mobility, which makes them well suited for the assessment of site-specific pollution impacts; 2) they are sensitive to environmental impacts from both point and nonpoint sources of pollution; 3) they serve as the primary food source for many species of fish important to both commercial and recreational fishermen; and 4) they can be used to assess non-chemical impacts to the benthic habitat, such as by thermal pollution or excessive sediment loading (siltation).

The NJDEP Bureau of Fresh Water and Biological Monitoring conducts macroinvertebrate sampling through its Ambient Biomonitoring Network (AMNET; **FIGURE 1**). This network is designed to evaluate the health of in-stream benthic macroinvertebrate communities using a monitoring and assessment methodology (Rapid Bioassessment Protocol) that produces an index of water quality with categories of "excellent," "good," "fair," and "poor." Under AMNET, 63 streams within the Barnegat Bay watershed were sampled for benthic macroinvertebrates in 2004-2005 (Round 3) and 1999-2000 (Round 2). In Round 1 sampling (1994-1995), 57 streams were sampled. Sampling protocol was modified slightly between Rounds 2 and 3 in that sampling was restricted from year-round, to April through November, taking macroinvertebrate life histories into account. This affected primarily the central and southern watershed segments, which had been sampled in the winter during Rounds 1 and 2.

STATUS

Based on 2004-2005 sampling, 35% of the streams monitored in the watershed are classified as excellent, 24% are classified as good, 32% are classified as fair, and 9% are classified as poor (**FIGURE 2**).

TRENDS

While the percentage of streams classified as having "excellent" water quality has increased over the 10-year period, so has the percentage of streams classified as "poor" and "fair" (**FIGURE 2**). This overall pattern is

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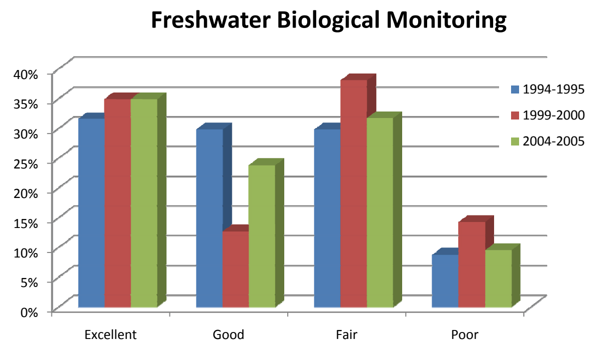


FIGURE 2: *Percentage of sampled streams within the Barnegat Bay watershed that obtained each of the Rapid Biological Protocol index scores for the three sampling periods.*

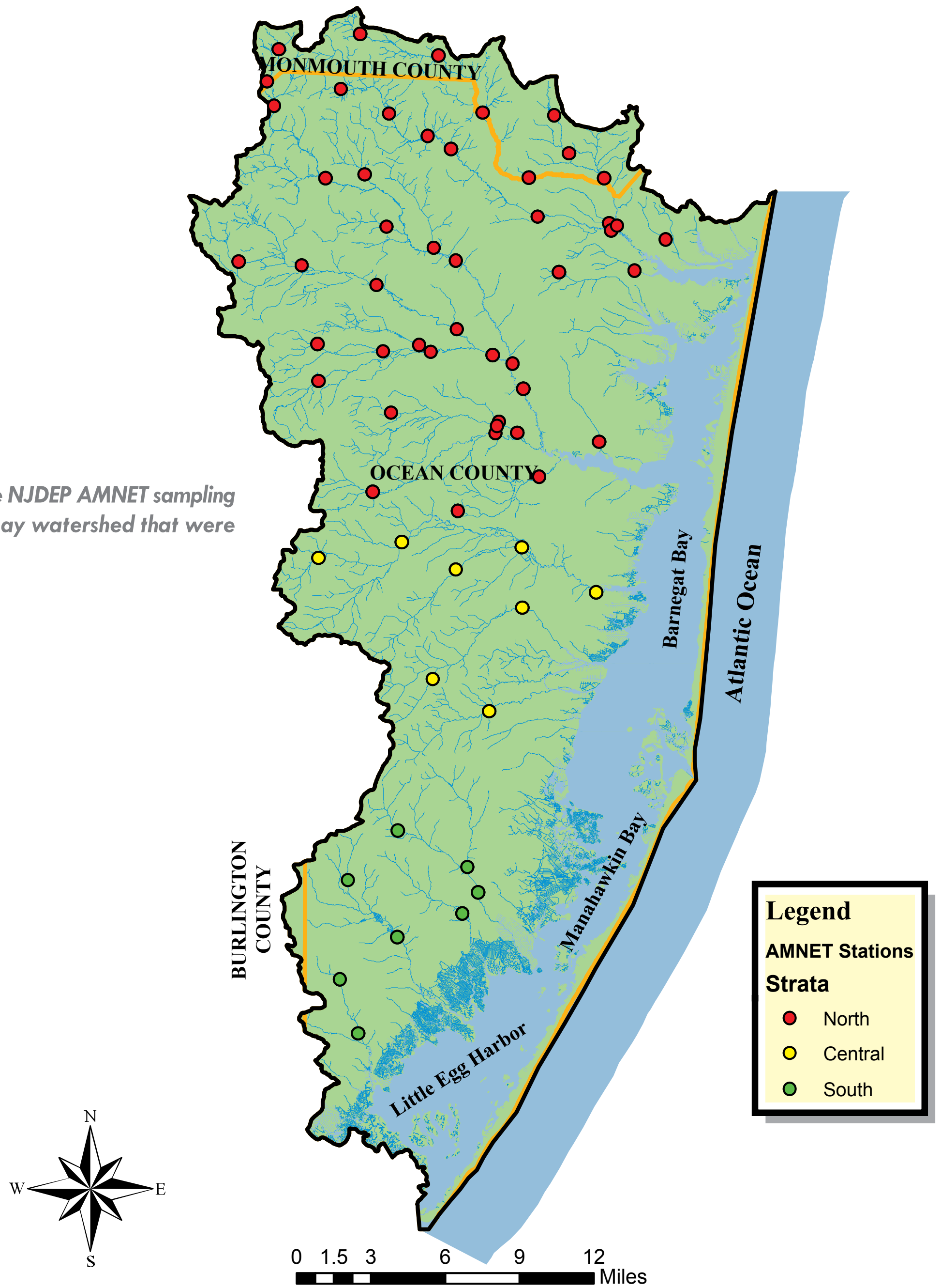


FIGURE 1: *Location of the NJDEP AMNET sampling stations in the Barnegat Bay watershed that were utilized in this study.*

INDICATOR

Freshwater Macroinvertebrates

(CONTINUED FROM PREVIOUS PAGE)

reflected in the northern segment, while water quality in the central segment has generally improved and been variable in the southern segment (**FIGURE 3**). It is worth noting again that results for the central and southern segments should be viewed with caution due to the change in sampling seasons between Rounds 2 and 3.

DATA GAPS

The data from additional sampling conducted in 2009-2010 need to be analyzed to confirm the patterns identified between Rounds 2 and 3, given the changes in protocol.

Data were provided by the NJDEP through the AMNET database.

Caddisfly larvae. Photo courtesy of the NJDEP Bureau of Freshwater and Biological Monitoring.

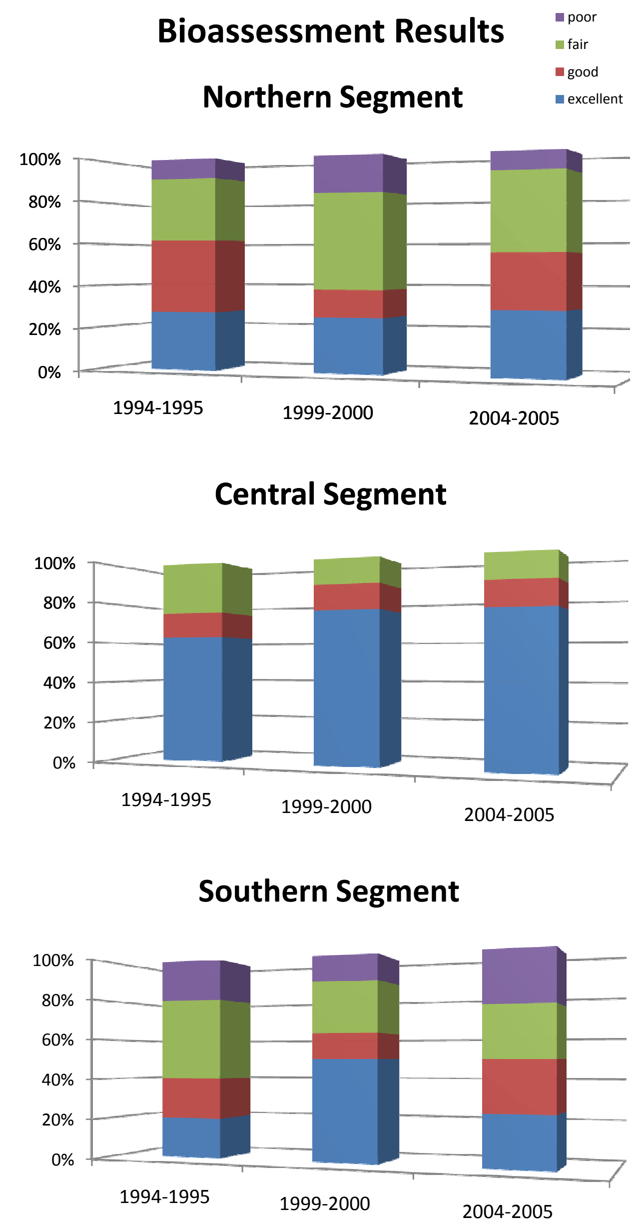


FIGURE 3: *Percentage of sampled streams within the northern, central, and southern portions of the Barnegat Bay watershed that obtained each of the Rapid Biological Protocol index scores for the three sampling periods.*

STATE OF THE BAY'S WATER QUALITY: Human Use Impairments

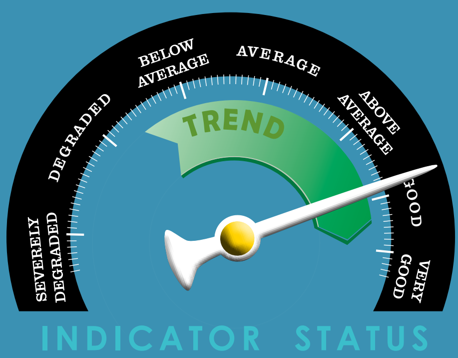
The Barnegat Bay has long been a favorite spot for recreational activities like boating, swimming, fishing, and clamming. Unfortunately, our enjoyment of the bay can be disrupted by the presence of pollutants which may limit our interaction with the water in order to avoid exposure.

The reasons for closing a bathing beach are often similar to those for closing waters to shellfish harvesting—pathogens like viruses, some bacteria, and parasites. These pathogens mainly originate from stormwater runoff and animal wastes.

An intertidal marsh at Edwin B. Forsythe National Wildlife Refuge. Photo by Glenn P. White.

INDICATOR

Bathing Beach Closures



Residents enjoying a beach in the watershed. Photo by Shannon Shinault.

BACKGROUND

For the past 30 years, the Ocean County Health Department (OCHD) has obtained and analyzed water samples from all public bathing beaches in the county on a weekly basis between Memorial Day and Labor Day. Results of bathing beach monitoring provide an indication of the levels of pathogenic bacteria in the waters that are utilized for recreational bathing. These findings are used by the OCHD to determine whether beaches are to remain open for bathing. Closure statistics for beaches on the bay, freshwater lakes, and rivers provide an indication of the amount of bacteria from various sources being flushed from the watershed into the waterways that eventually flow into the bay. The number of brackish water beach closures in a particular year provides an indication of the extent to which the use of the bay for recreational bathing is impaired by these various sources. Closure statistics also provide a general indication of the nonpoint source loadings of contaminants and pathogens other than bacteria. Stormwater typically contains suspended solids, nutrients, organic carbon, petroleum hydrocarbons, heavy metals, and pesticides, in addition to bacteria.

Freshwater samples are analyzed for fecal coliform, which is a group of coliforms present in the digestive tract of warm-blooded animals. In 2004, the NJDEP (at the suggestion of the USEPA) changed the required indicator organisms for brackish and saltwater beaches from fecal coliform to *Enterococcus*, a bacterium found in the digestive tracts of warm-blooded animals.

STATUS

Lakes

The OCHD samples nine public recreational bathing lake sites during the bathing season (**FIGURE 1**). The bathing areas at the lakes represented approximately 70% of all closings during the 2005-2009 bathing seasons. Two factors, stormwater runoff and waterfowl waste, influence the occurrence of elevated bacterial counts in lakes of the BB-LEH watershed.

Without external factors such as waterfowl, the lakes appear to recover to pre-storm coliform levels within approximately 24-36 hours after a rainfall event. With an abundance of waterfowl, the lake may require several days to recover. The severity of the initial influx of bacteria is proportional to the density of development in the area serviced by the storm drain system that empties into a given lake. Lakes which are surrounded by a lower density of housing (such as Harry Wright Lake in Manchester) recover fairly quickly in comparison to Lake Barnegat and Deerhead Lake in Lacey Township, which receive stormwater from a relatively higher population density.

Creeks

The OCHD samples two public recreational bathing creek sites during the bathing season, both on the freshwater portions of Cedar Creek (**FIGURE 1**). Cedar Creek is an example of how bacteria-free a water body can be without the influence of storm drains. The stream is not encumbered with storm drains and, as a result, it seldom has an elevated bacteria count (two total closures from 2004-2009 for both beaches).

Bays and Rivers

The OCHD samples 15 public recreational bathing bay beach sites and 10 public recreational bathing brackish river sites (**FIGURE 1**) throughout the recreational bathing beach season. The river sites are along the Toms, Metedeconk, and Manasquan rivers, while the bay sites are located throughout the eastern and western sides of the bay. Non-point source pollution delivered via stormwater is the primary source of contamination at these beaches.

TRENDS

When the data from county public recreational bathing beaches that have been sampled routinely for 10 years are analyzed, there is a general decrease in the number of bathing beaches closed due to poor water quality (**FIGURE 2**). The fluctuation in the number of closures is attributable primarily to the number, duration, and

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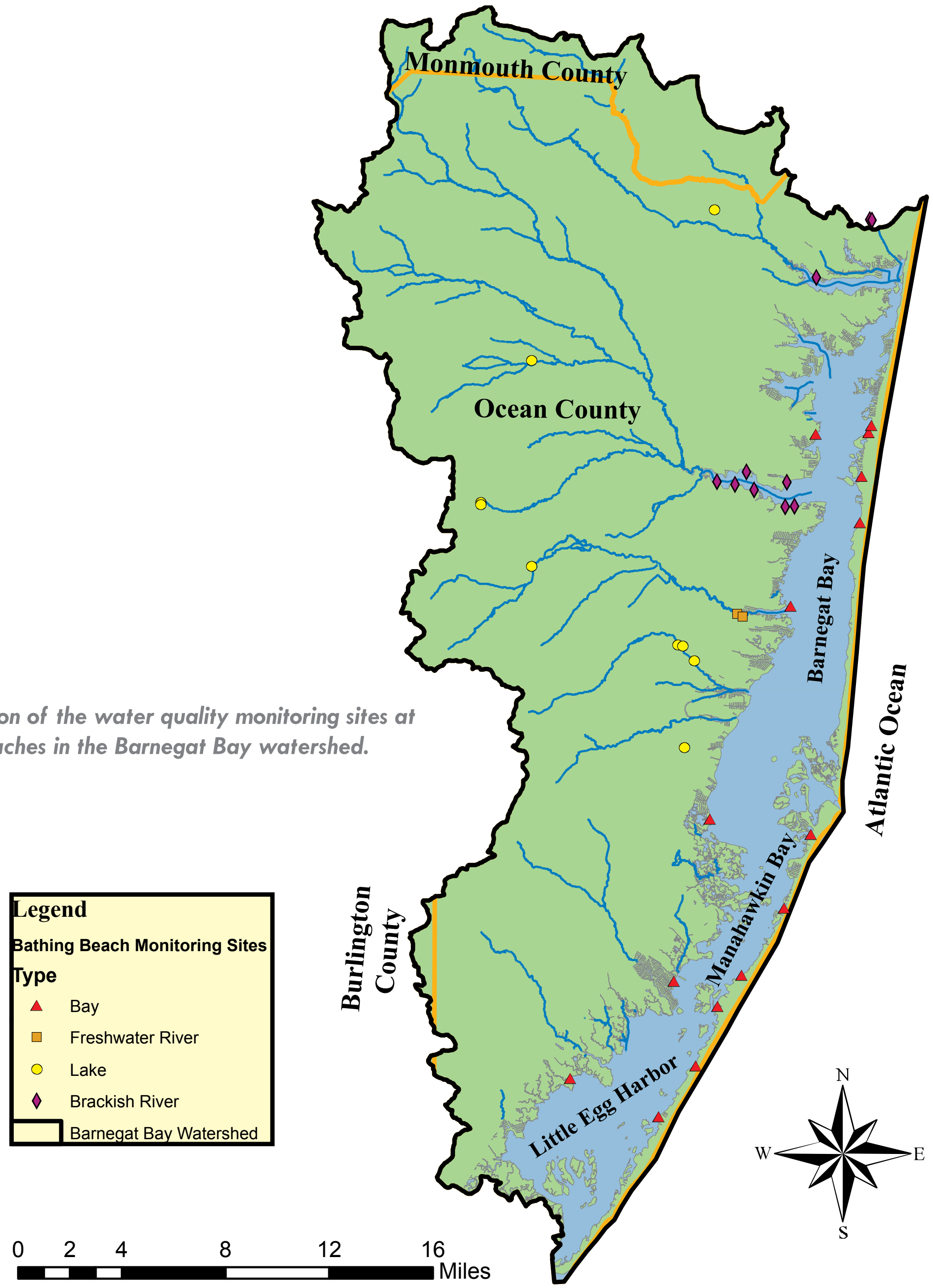

FIGURE 1: *Location of the water quality monitoring sites at river and bay beaches in the Barnegat Bay watershed.*

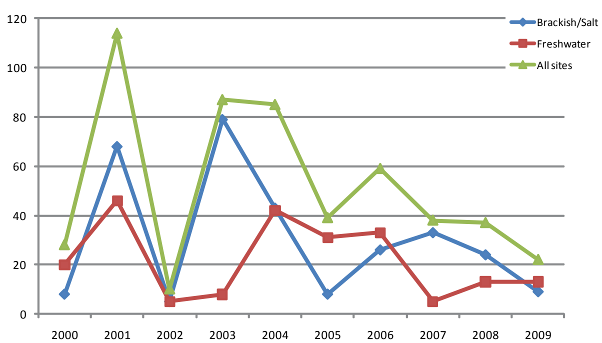

FIGURE 2: *The number of beach closings within the watershed over the past 10 years. This only includes beaches for which data were available for all 10 years, and does not include 2009 "rain-provisional" sampling. Freshwater sites include 8 lakes and 2 creeks, while brackish/saltwater sites include 8 bay beaches and 10 brackish river beaches.*

INDICATOR

Bathing Beach Closures

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intensity of rainfall events occurring immediately before and during the recreational bathing season.

Manchester Township decided to close Pine Lake to its bathers in 2006 due to the high number of closures that occurred during the previous bathing seasons. Likewise, Stafford Township decided to close Ocean Acres Lake to its bathers, and Ocean County Parks and Recreation also closed A. Paul King County Park to bathers in 2007. The closure of these lakes has substantially decreased the total number of closures of public bathing beaches.

The relatively light amount of rain which affected beach closures in 2009 would have produced only three closures at bay and river beaches; however, the county sampling program received additional money to perform "rain-provisional" sampling to help investigate and further confirm that most bacterial beach closures are rain-event driven. The rain provisional sampling occurred irrespective of the day of the week, including weekends. No particular measurement of rainfall was used in determining the occurrence of the sampling event. Rather, a judgment was made to determine if the amount of rain during each rain event was enough to produce significant movement of water from the discharge pipe of a storm drain. This additional sampling produced 22 additional closures of bay and river beaches, which would not have occurred if samples were only taken on a weekly basis.

DATA GAPS

The results of the rain-provisional sampling preliminarily indicate that many of the beach closures are rain-event driven; however, the amount of rain required to instigate a closing was not quantified. This information could be used to further refine the sampling scheme to answer questions regarding bacterial sources and pathways.

For additional information regarding beach closings and water quality updates during the recreational bathing season, please visit the Ocean County Health Department online at **www.ochd.org/waterSamples.aspx**.

Data were provided courtesy of the Ocean County Health Department.

Private walkway to the beach. Photo by Michelle Malven.

Sea Nettles

In the past few years, public concern has been growing about the apparent increase of an unwelcome visitor to the Barnegat Bay – the sea nettle jellyfish (*Chrysaora quinquecirrha*). It has been widely reported in the press that summer blooms of the sea nettle have made several back-bay bathing beaches unswimmable and contributed to declining summer real-estate rentals. While there has been a tendency to blame the bay's eutrophication and declining water quality for the apparent increase in sea nettles, other conditions may also be affecting the apparent increase of sea nettles and other "jellies" in the bay.

Unfortunately, little information is available about jellyfishes in the Barnegat Bay, especially with regard to blooms. To address this data gap, scientists and others from the Barnegat Bay Partnership, the New Jersey Sea Grant Consortium, Monmouth University's Urban Coast Institute, and Rutgers University's Jacques Cousteau National Estuarine Research Reserve, convened a one-day workshop in May 2009, entitled "The Jellyfish Jam," to review available information about jellies and the problems they may cause in the Barnegat Bay. Leading jellyfish research scientists from the Smithsonian Institute, Yale University, Stony Brook University, Millersville University, St. Mary's College, and Rutgers University provided important insights about jellies, including their unique life histories, their roles in marine food webs, and possible causes for their increases throughout the world and in the Barnegat Bay. Ironically, many human activities have the potential to increase jellyfish populations in the bay and elsewhere.

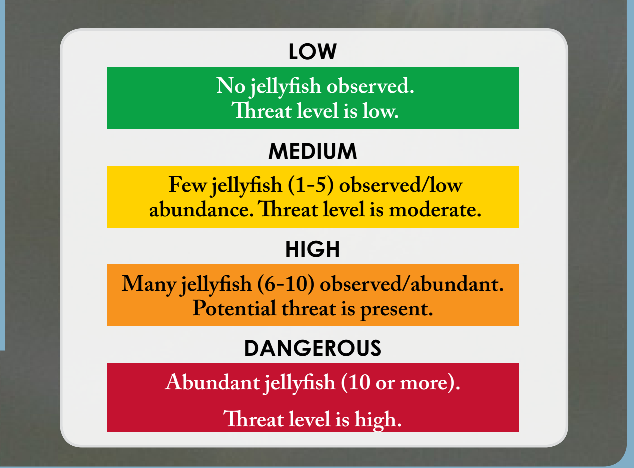
Increased development around the bay, including bulkheads, pilings, and floating docks, may be providing more structure to which an early life-stage of jellyfish can attach and reproduce. Changes in the bay's salinity or hydrology may also have an effect. Sea nettles prefer a narrow salinity zone, so large-scale changes in salinity, such as during dry years, may affect their abundance and distribution in the bay. Warming water temperatures often increase reproduction rates, and may lead to more production of jellyfish. The removal of predators and potential competitors for food through increased fishing pressure may also affect sea nettle abundance. However, we do not know which species, if any, prey on sea nettles in Barnegat Bay. Lastly, poor water quality (*i.e.*, high nutrient concentrations and/or low dissolved oxygen) may contribute to greater food supplies for jellyfishes or to lower abundances of the competitors and predators, such as fishes. Thus, poor water quality may increase the abundance of jellyfishes.

Clearly, many factors are likely affecting the abundance of jellies, especially sea nettle, in the bay. Unfortunately, as Alan Collins, Ph.D. from the Smithsonian Institute acknowledged, we have a "deep and profound ignorance" about jellies in the bay. Because sea nettles and other jellies are likely here to stay in our estuary, learning more about them appears essential to reducing their impact on people. As a result of the discussion at The Jellyfish Jam, two educational institutions are now conducting surveys of jellyfishes in Barnegat Bay. As human effects on coastal environments continue to increase, such proactive efforts may become increasingly important to our enjoying the bay.

Warning System Aims to Spread Awareness and Reduce Stings for Beachgoers

During the summer of 2010, the Ocean County Health Department and the Barnegat Bay Partnership piloted the "Sea Nettle Warning System" to help heighten awareness and understanding of sea nettles in Barnegat Bay and help prevent swimmers from getting stung.

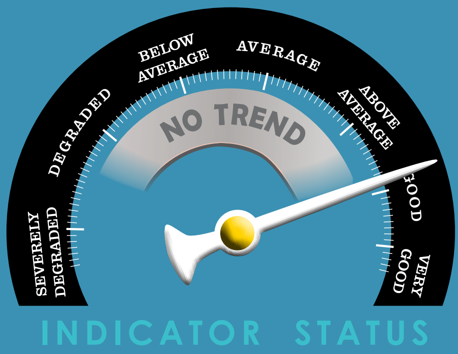
Bay or river beaches in the following nine Ocean County municipalities were selected for the first phase of the project: Seaside Heights, Brick, Point Pleasant Borough, Island Heights, Beachwood, Toms River, Pine Beach, Ocean Gate, and Lavallette. Employees of the Ocean County Health Department worked with lifeguards at these beaches to collect data and monitor the abundance of sea nettles present during the summer season. At each beach, information was posted on a sign hanging from the lifeguard stand. In addition to signage and monitoring at the pilot beaches, the Ocean County Health Department created a new web page on their site with information about what to do if you are stung by a sea nettle or other stinging jellyfish and ways to avoid being stung. Visit **http://bbp.ocean.edu/pages/323.asp** for additional details about the pilot program.



Sea Nettle (*Chrysaora quinquecirrha*). **Photo by Ellie Rogalski.**

INDICATOR

Shellfish Bed Closures



Clammer working in the bay. Photo by Rob Auermuller.

BACKGROUND

The NJDEP's Bureau of Marine Water Monitoring (Bureau) monitors the shellfish-growing waters contained within the Barnegat Bay. To ensure that shellfish within these waters are safe for consumption, the waters are analyzed using coliform bacteria, which is an indicator of human and animal waste. Based on the National Shellfish Sanitation Program requirements, the bay waters are classified as "approved," "seasonal," "special restricted," and "prohibited."

STATUS

Currently, the waters of the Barnegat Bay consist of approximately 80% "approved," 5% "prohibited," and 15% "seasonal and special restricted" for shellfish harvest (**FIGURE 1**). Poor water quality around shellfish beds is generally attributable to contamination from stormwater runoff and other nonpoint sources rather than single, point-source discharges.

TRENDS

There have been no substantial changes in the percentages of classified waters over the past five years. From 1999-2009, an average of 3,655 samples were collected and analyzed for coliform bacteria each year as part of the Bureau's monitoring program. When looked at bay-wide, there is no clear trend in the average overall coliform bacteria levels by year (**FIGURE 2**). Given that bacterial concentrations can be influenced by rainfall and other meteorological conditions, this year-to-year fluctuation is not surprising. Overall, the estuary has low coliform bacteria concentrations, though localized concentrations may be high.

DATA GAPS

None.

For additional information on the NJDEP Bureau of Marine Water Monitoring Shellfish Sanitation Program and the latest classification maps, please visit their webpage at **http://www.state.nj.us/dep/wms/bmw/index.html**.

Data were provided courtesy of the NJDEP Bureau of Marine Water Monitoring.

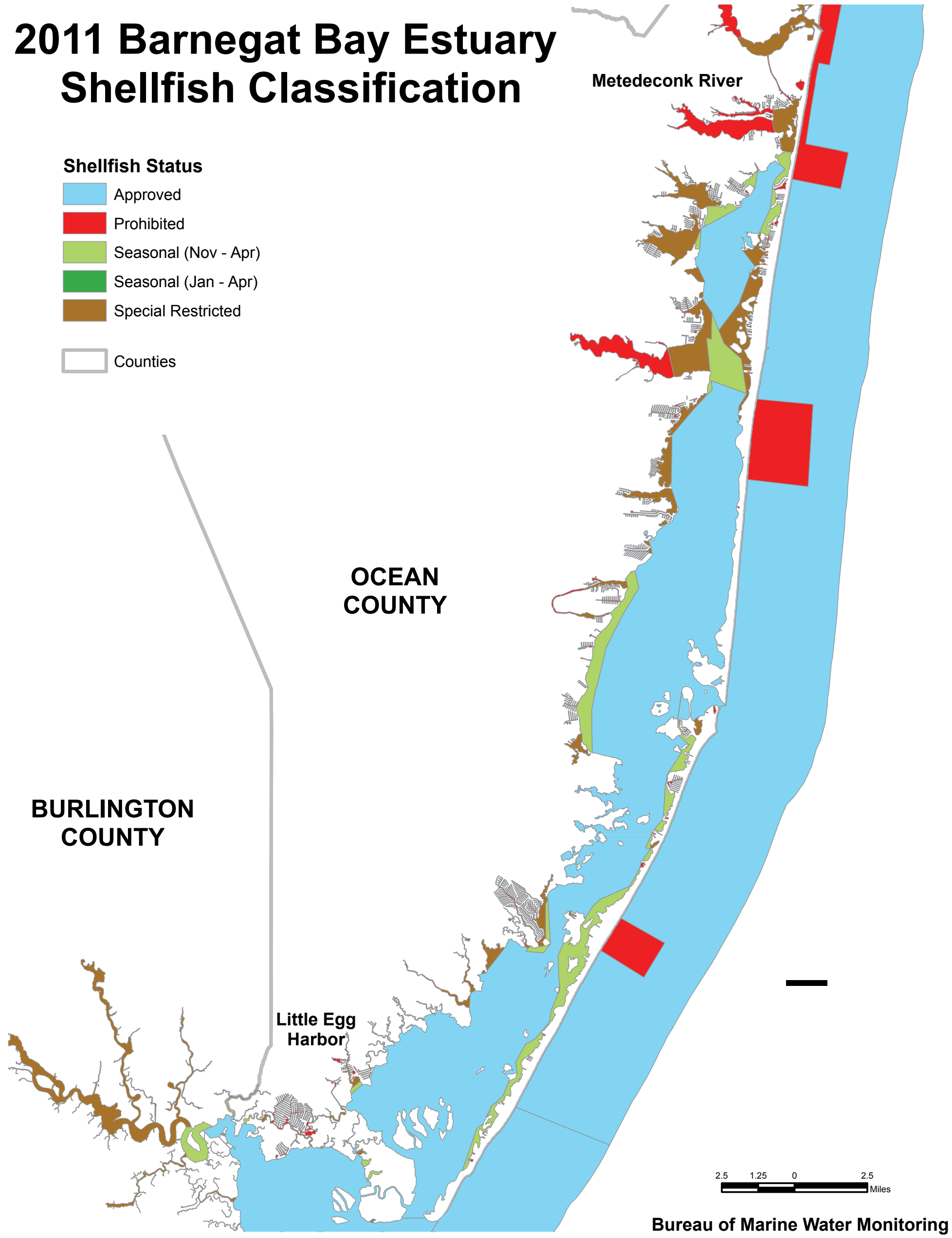


FIGURE 1: *2011 shellfish growing water classifications for the Barnegat Bay.*

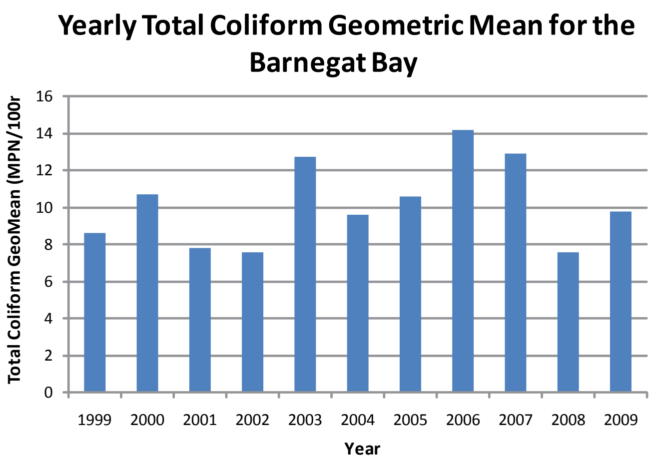


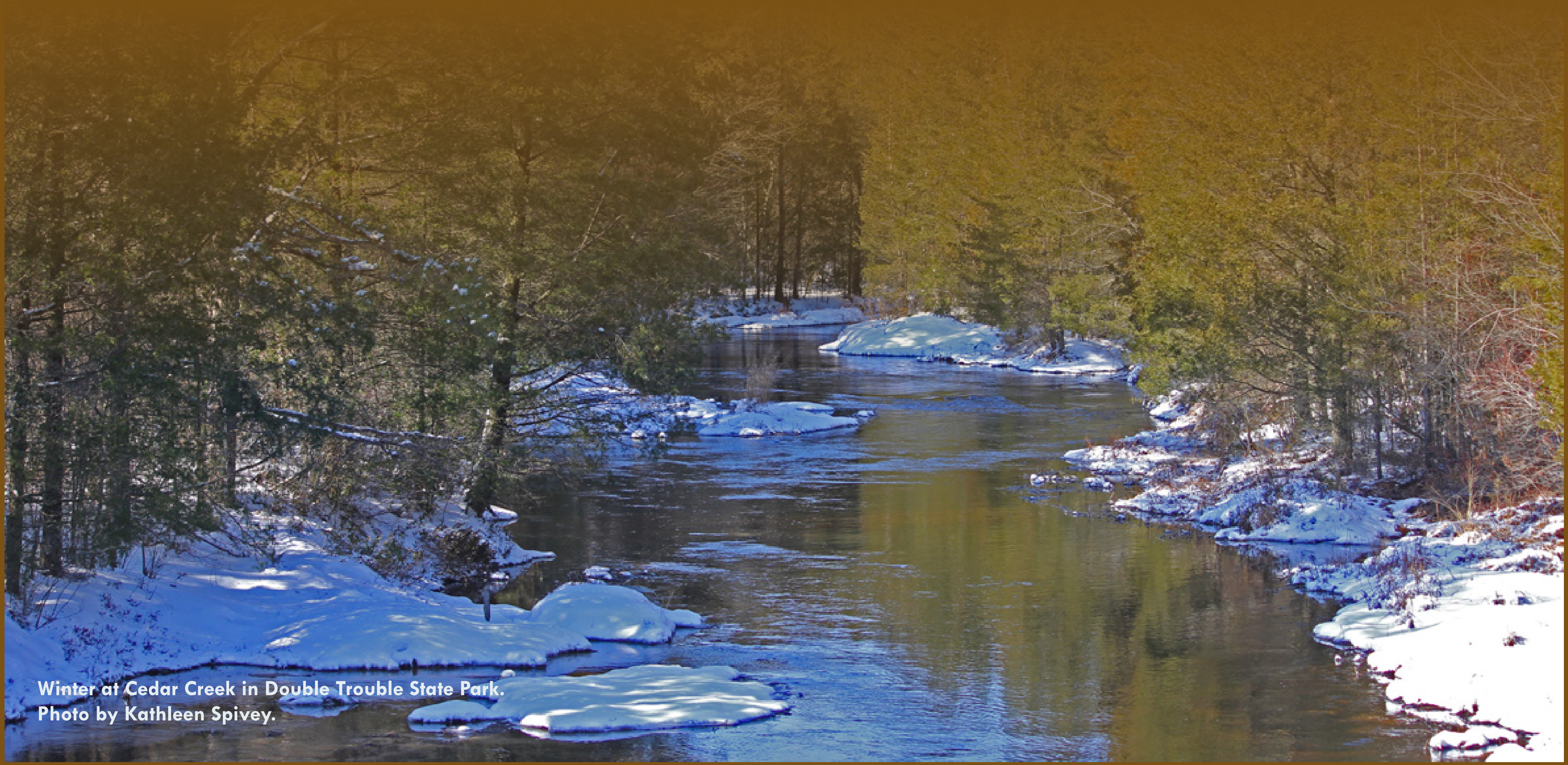
FIGURE 2: *Bay-wide mean total coliform counts by year.*

Fishing boat at Barnegat Light.
Photo by Kathleen Spivey.

Seed hard clams waiting for planting.
Photo by Cara Muscio.

STATE OF THE BAY'S WATER SUPPLY

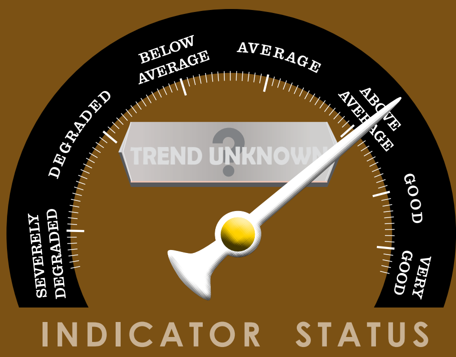
Fresh water plays a crucial role in estuarine health. Not only does the mixing of fresh water with ocean water produce the salinities required by estuary inhabitants, the rate of freshwater flow into the estuary also affects the rate at which the estuary is flushed, which in turn affects many water-quality and ecological processes. Maintaining an adequate rate of freshwater flow while addressing the needs of an ever-increasing human population will be critical in meeting estuarine water-quality and habitat goals.



Winter at Cedar Creek in Double Trouble State Park.
Photo by Kathleen Spivey.

INDICATOR

Shallow Groundwater Quality



A tributary to the Metedeconk River. Photo by Rob Karl.

BACKGROUND

The shallow, unconfined Kirkwood-Cohansey aquifer system underlies most of the Barnegat Bay-Little Egg Harbor watershed and is a major source of water supply for communities within the watershed. Groundwater from the aquifer system discharges to major streams in the watershed (including the Toms and Metedeconk Rivers) and to other smaller streams and tributaries, with eventual release into the estuary. Groundwater discharge—direct plus indirect—from the Kirkwood-Cohansey aquifer system is the largest source of fresh water input to Barnegat Bay.

The U.S. Geological Survey, using data stored in a water-quality database maintained by the Ocean County Health Department, assessed the quality of shallow groundwater in the Barnegat Bay-Little Egg Harbor watershed with respect to established drinking-water standards. The percentage of wells that contain water in which concentrations of a given constituent exceed the federal and state primary drinking-water standard, known as the Maximum Contaminant Level (MCL), provides an indication of the amount of poor-quality groundwater (with respect to the MCL) that may be discharging to the estuary.

STATUS

Contaminants that enter the environment through human inputs were examined, including arsenic, mercury, nitrate, volatile organic compounds, and pesticides. In 2005, the MCL for each of the constituents measured was exceeded in water from less than 1% of the sampled wells. Although the MCL provides one benchmark that can be used to evaluate water quality, in the case of nitrate, much lower concentrations are considered to be environmentally problematic. For this reason and because of the important role that nitrogen plays in eutrophication, concentrations of nitrate also were compared to other recommended criteria and threshold values. Frequencies of exceedance were substantially higher for these nutrient criteria and threshold values than for the nitrate MCL (10 mg/L as nitrogen).

TRENDS

The frequency of MCL exceedance was calculated for each of the constituents for the years 1987-2005; however, an accurate assessment of trends is not possible.

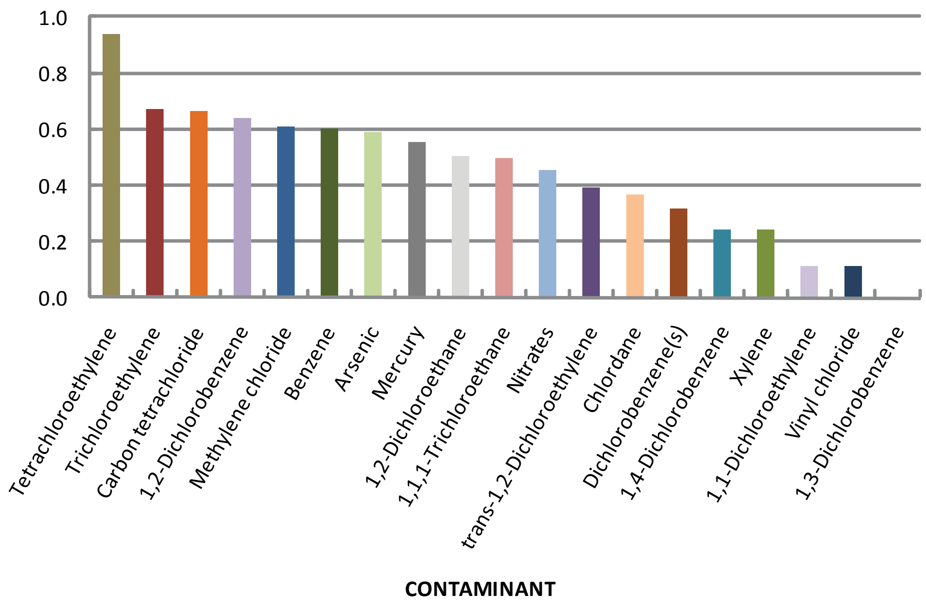
DATA GAPS

Additional information is needed concerning local land-use change, well construction characteristics, and changes in the geographic pattern of wells sampled, as each of these variables may factor into apparent trends.

For more detailed information, please see the full report "Assessment of a Shallow Ground-Water-Quality Indicator" prepared by the U.S. Geological Survey, available on the BBP website at **http://bbp.ocean.edu/Reports/USGS%20 Shallow%20Ground%20Water%20Quality%20 Indicator-2007.pdf**.

Data were provided courtesy of the Ocean County Health Department and U.S. Geological Survey.

FIGURE 1. *Percentage of privately-owned wells in which concentrations of the listed contaminants exceeded federal and state MCLs in 2005. (Source: Ocean County Health Department, New Jersey, water quality database; MCL= Maximum Contaminant Level)*



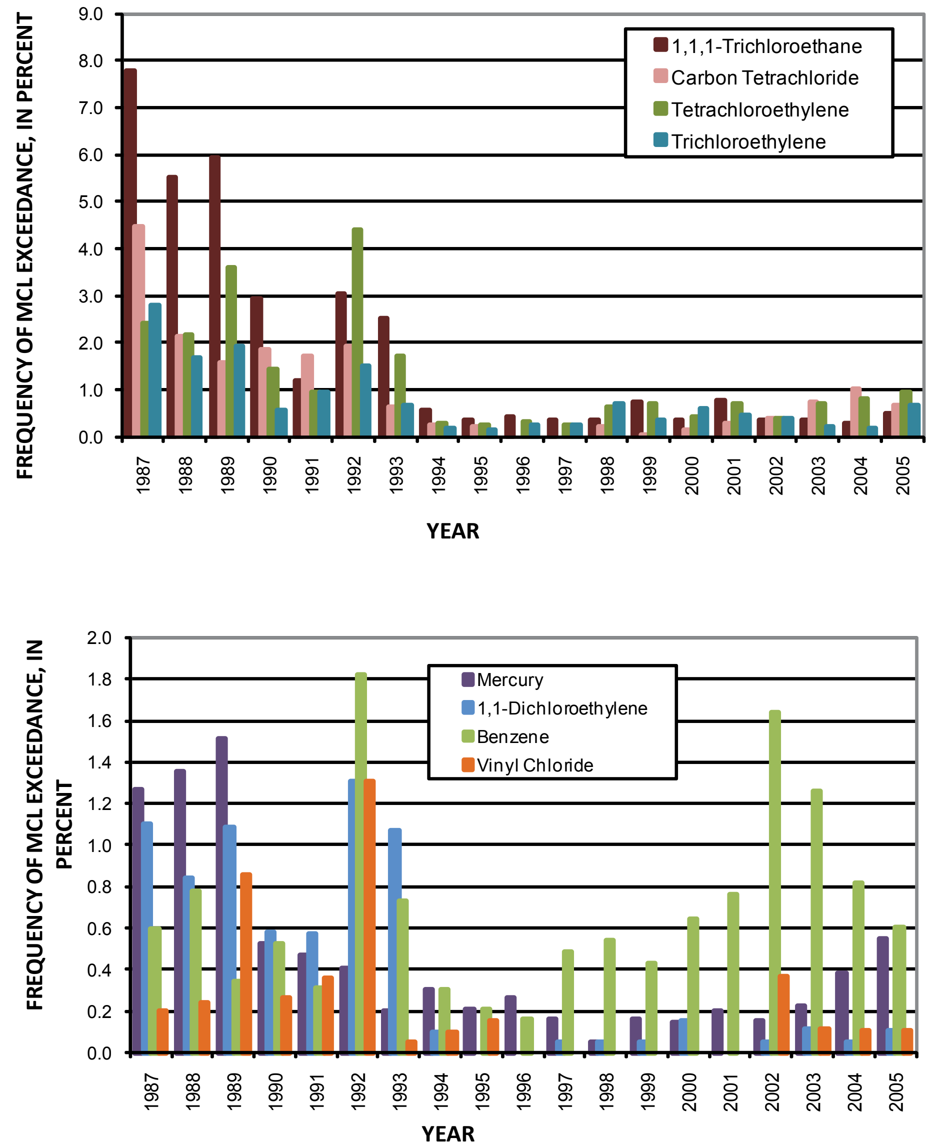
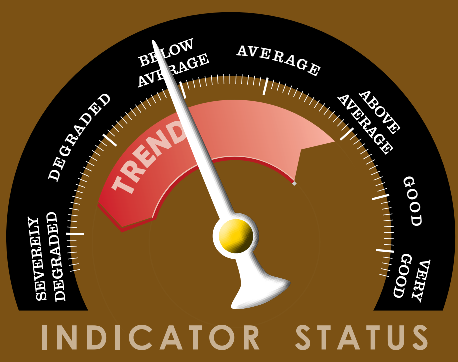


FIGURE 2 A-B. *Frequencies of exceedance for selected constituents in the Ocean County Health Department, New Jersey, water-quality database, 1987-2005: (a) 1,1,1-trichloroethane, carbon tetrachloride, tetrachloroethylene, and trichloroethylene; and (b) mercury, 1,1-dichloroethylene, benzene, and vinyl chloride.*

INDICATOR

Streamflow



Cedar Creek, Double Trouble State Park.
Photo by Glenn P. White.

BACKGROUND

Flow measurements of rivers and streams that contribute to the estuary have been made at 14 stations, and these measured inputs account for approximately 79% of the surface-water discharges from the watershed. The remaining 21% of the surface-water discharge enters the estuary as runoff from unmonitored areas; all told, it adds up to almost 26 cubic meters per second, or about 590 millions gallon per day. These freshwater inputs are critical to maintaining many of the ecological processes that take place in the estuary.

The U.S. Geological Survey maintains a network of stream gauging stations that measure the rate of flow in some of the major streams in the watershed on a continuous basis, including the North Branch of the Metedeconk River, Toms River, Cedar Creek, and Westecunk Creek (**FIGURE 1**). Other stations throughout the watershed have either been retired or are used to make measurements less frequently. While data from other stations are available, the Toms River gauging station has the longest continuous record and is the sub-watershed with the largest contribution to the bay.

STATUS

The Toms River gauging station has been in continuous operation since 1929, and drains 319 square kilometers in upstream area. Stream discharge, or the average flow passing this station, ranged from 4.9 cubic meters per second (112 million gallons per day) in 2008 to 6.6 cubic meters per second (151 million gallons per day) in 2005 (**FIGURE 2**).

TRENDS

Average stream discharge at the Toms River gauge over the 79-year record is approximately 6.0 cubic meters per second (137 million gallons per day), or about 23% of the fresh water flowing into the estuary. Annual average discharge at this station has ranged from a historic low of 3.6 cubic meters per second in 1981 to a high of 9.2 cubic meters per second in 1958. From 2005 to 2008, discharge averaged 6.0 cubic meters per second, while the 10- and 20-year averages are 5.6 and 5.7 cubic meters per second, respectively. These longer term trends toward below average annual discharges reflect climatic variability and the effects of land-use change.

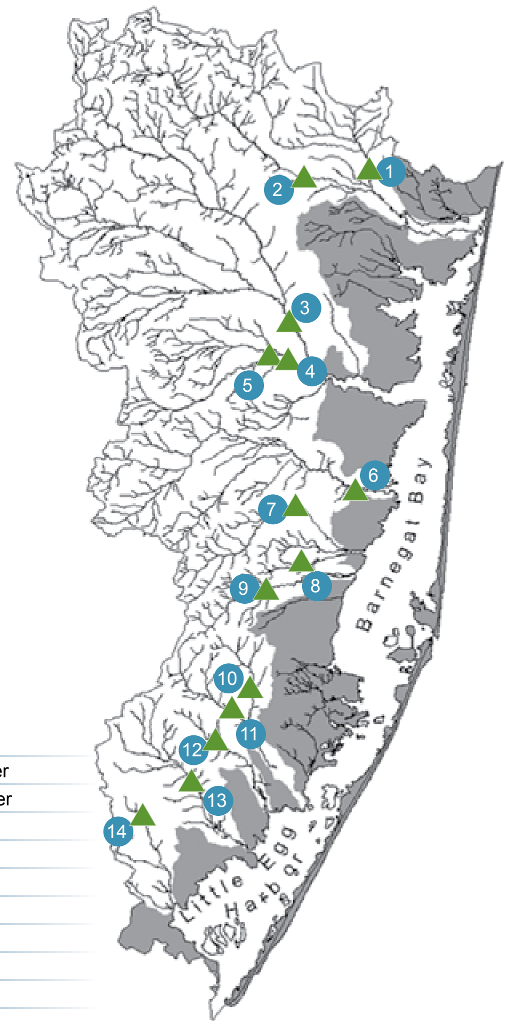
DATA GAPS

None.

For additional streamflow data, including near real time for the continuously operated gauging stations, please visit the USGS New Jersey Water Science Center's website (**http://nj.usgs.gov**).

Data were provided courtesy of the U.S. Geological Survey.

FIGURE 1: *Location of streamflow gauging stations in the Barnegat Bay-Little Egg Harbor estuary and watershed. Stations 1, 3, 6, and 13 are continuously operating stations while the remainder are either discontinued or used to make measurements less frequently.*



#	STREAM NAME
1	North Branch Metedeconk River
2	South Branch Metedeconk River
3	Toms River
4	Wrangel Brook
5	Davenport Branch
6	Cedar Creek
7	North Branch Forked River
8	South Branch Forked River
9	Oyster Creek
10	Mill Creek
11	Fourmile Branch
12	Cedar Run
13	Westecunk Creek
14	Mill Branch (tributary to Tuckerton Creek)

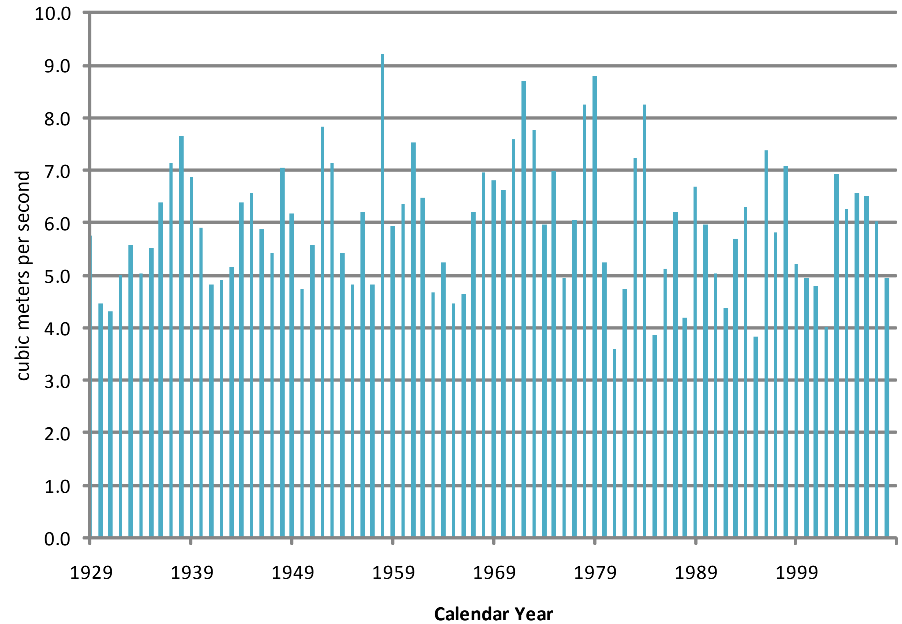
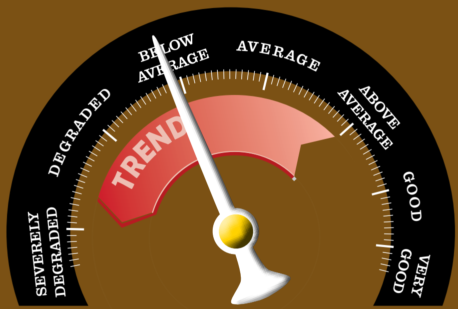


FIGURE 2: *Annual stream discharge of the Toms River. Annual stream discharge is 6.0 cubic meters per second. Data from the U.S. Geological Survey National Water Information System.*

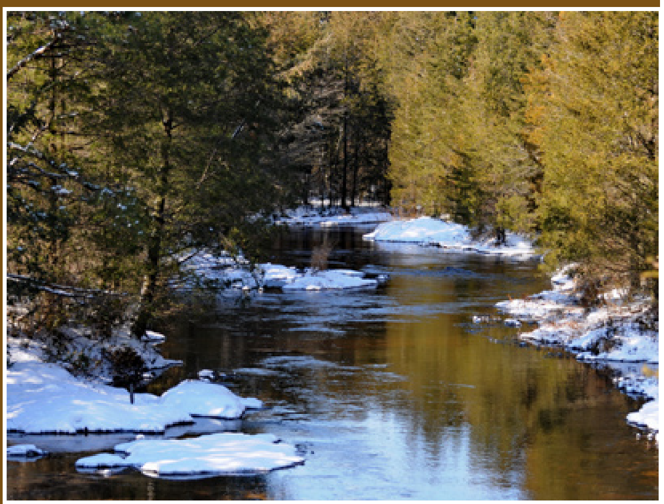
INDICATOR

Water Withdrawals



INDICATOR STATUS

Cedar Creek, Double Trouble State Park. Photo by Glenn P. White.



BACKGROUND

Fresh water is important for a variety of human activities, including public supply, agriculture, landscape irrigation, commercial and industrial uses, mining, and power generation. Sources of fresh water include both surface waterways (such as lakes, rivers, and streams) and groundwater. Shallow, unconfined groundwater sources tend to be hydrologically linked to surface waters, and withdrawals from these surficial aquifers can affect streamflows. Deeper, confined groundwater sources are isolated beneath the Barnegat Bay watershed and withdrawals from these aquifers do not typically affect surface waterways.

In a natural setting, fresh water from streams and rivers and groundwater discharge would make its way to Barnegat Bay unimpeded, but in reality a significant amount of fresh water is captured and removed from the system before it ever makes it to the bay. Landscape irrigation and public supply are two major fresh water usage categories that serve as a net loss of water in the Barnegat Bay watershed.

Landscape irrigation is considered a "consumptive" water use, as nearly all the water is lost through evaporation and transpiration and very little returns to the system. It is difficult to accurately account for much of the irrigation usage in the watershed, since in many cases the withdrawals are made for small-scale landscape irrigation needs and occur at rates that are beneath regulatory thresholds (*i.e.*, <100,000 gallons per day).

Public supplies are provided for domestic, commercial, and industrial water needs in many areas of the watershed, particularly in the northern and coastal regions. Most areas with public water service also have public sewer service, with wastewater being directed to one of three centralized wastewater treatment facilities and, ultimately, the Atlantic Ocean. Where public supplies are drawn from surface water or shallow aquifers, water that would otherwise make its way to the Barnegat Bay is intercepted, utilized, treated and discharged offshore. Essentially, the natural system is short-circuited. Returning high-quality, treated wastewater to its point of origin in the watershed would be ideal, though it is important to recognize that the existing centralized wastewater treatment system was developed to address water quality problems that resulted from many small discharges of questionable-quality wastewater throughout the watershed.

STATUS

The most recent estimate (2005) shows that Ocean County's fresh water withdrawals averaged approximately 77 million gallons per day (**FIGURE 1**). The majority (approximately 71%) of fresh water withdrawals are used for public supply (**FIGURE 2**). Discharge of treated wastewater to the Atlantic Ocean from centralized wastewater treatment facilities in 2009 averaged approximately 52 million gallons per day (**FIGURE 3**).

While irrigation and the water supply/wastewater discharge situation present problems for freshwater inputs to the bay, they also present relatively easy-to-implement opportunities for improvement through water conservation. Landscaping with native, drought-tolerant plantings and implementing highly efficient watering practices (i.e., xeriscaping) can drastically reduce the amount of water used for irrigation. Similarly, by installing efficient water fixtures and repairing leaks, it is estimated that households can reduce water use by as much as 35%. The importance of water conservation in the Barnegat Bay watershed cannot be over-emphasized, especially considering that the New Jersey Statewide Water Supply Plan projects severe water supply deficits for this region in the coming years.

TRENDS

Fresh water withdrawals in the Barnegat Bay watershed and centralized wastewater treatment discharges have increased over the past several decades, and are closely linked to population growth (**FIGURE 4**).

DATA GAPS

Currently it is impossible to determine the amount of water withdrawn from small wells (withdrawals of <100,000 gal/day) as they are not regulated or specifically tracked. These wells would commonly be used for household supply, or more commonly, for landscape irrigation where water is basically lost to evapotranspiration, and therefore not returned to the watershed.

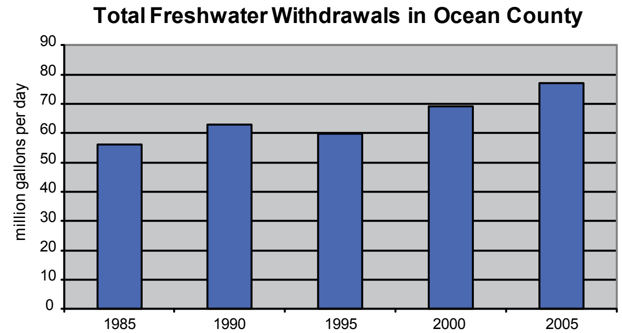


FIGURE 1: *Total fresh water withdrawals in Ocean County from 1985-2005. Amounts are in millions of gallons per day. Data were provided courtesy of the U.S. Geological Survey Aggregated Water Use Data System.*

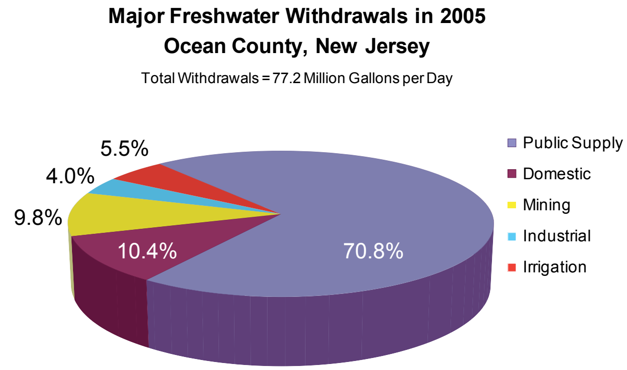


FIGURE 2: *Breakdown of the fresh water withdrawal usage for Ocean County in 2005. Public supply refers to water withdrawn by public and private water suppliers that provide water to at least 25 people. Public-supply water is delivered to users for domestic, commercial, and industrial purposes, and also is used for public services. Data were provided courtesy of the U.S. Geological Survey Aggregated Water Use Data System.*

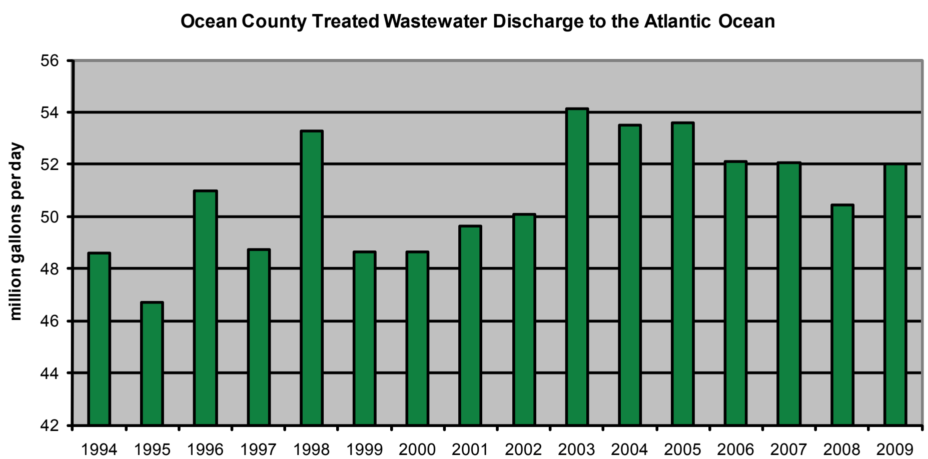


FIGURE 3: *The amount of treated wastewater discharged directly to the Atlantic Ocean from Ocean County during the years 1994 to 2009 in millions of gallons per day. Prior to the regionalization of the county wastewater treatment system, these flows eventually made their way into Barnegat Bay. N.J. Department of Environmental Protection NJPDES Municipal Flow Data.*

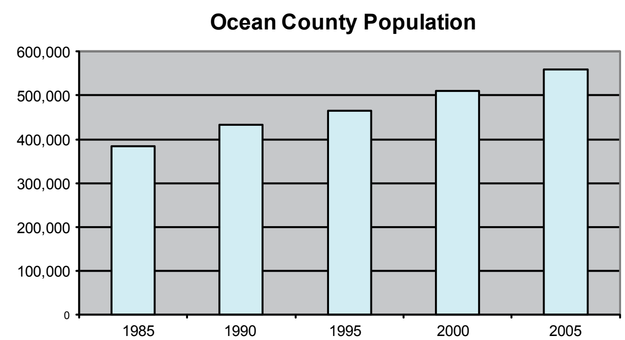


FIGURE 4: *The population of Ocean County from 1985 to 2005. Ocean County is New Jersey's fastest-growing county. Data were provided courtesy of the U.S. Geological Survey Aggregated Water Use Data System.*

Metedeconk River Watershed Protection and Restoration Plan

Metedeconk River in February 2005.
Photo by Michael Lensi.

The Metedeconk River is a critical water resource for northern Ocean and southern Monmouth Counties. It is a major source of fresh water inflow to the Barnegat Bay, and provides countless economic, recreational, and aesthetic benefits to the community. It also serves as the principal water supply source for the Brick Township Municipal Utilities Authority (Brick Utilities), which provides drinking water to more than 100,000 area residents in four towns.

Brick Utilities is presently spearheading a Metedeconk River Watershed Protection and Restoration Plan (MRWPRP) to preserve this resource into the future. The project is being funded through a grant from the NJDEP, with additional in-kind funding contributions from Brick Utilities.

The main goals of the project are to preserve the Metedeconk River as an important water supply source for the region, protect and improve the health of the Barnegat Bay estuary, and address water quality impairments that have been identified by the NJDEP and must be addressed under the Clean Water Act.

The MRWPRP will document specific measures that can be put in place to protect river water quality and flow characteristics as growth occurs in the watershed over the coming decades. It will also identify areas of the river that have become degraded as a result of human activities and outline projects to restore these areas and improve water quality. Examples of such projects include stormwater system improvements/retrofits and streambank and lake restoration. There are very few point source discharges in the Metedeconk watershed, so nonpoint source pollution and stormwater are the main problems affecting the Metedeconk River system.

The Metedeconk River encompasses roughly 90 square miles as it flows from its headwaters in Freehold, Jackson, and Millstone eastward through Howell, Lakewood, Brick, and Point Pleasant Borough towards the Barnegat Bay. Within this large area, there are many individuals who have a stake in the Metedeconk River and any management plan that might be developed to protect it. These stakeholders include local government, state and federal government agencies, businesses, organizations, and individual landowners. Each stakeholder has unique, and sometimes disparate, perspectives and priorities. In order for the MRWPRP to be successful, it must be developed with the input and active participation of the various watershed stakeholders.

The project has brought together the watershed towns, the Barnegat Bay Partnership, Monmouth and Ocean Counties, and other interested stakeholders to form a "Metedeconk Watershed Stakeholder Advisory Committee." The committee provides a forum for the plan's development where key watershed issues and local concerns are explored, problems are identified and prioritized, and agreed-upon Metedeconk River protection strategies are selected.

By following a watershed planning process, the project partners can be confident that the MRWPRP will be built on consensus and has the support of the stakeholders. Ultimately, this will help secure successful plan implementation. The project has been designed to include the immediate implementation of the highest priority protection and restoration measures identified in the plan.

This project will not be a one-time study. Instead, it will be the start of a cooperative, long-term partnership among the watershed stakeholders to protect this important natural resource. It will also serve as the blueprint for other efforts within the Barnegat Bay watershed.

STATE OF THE BAY'S HABITAT AND LIVING RESOURCES

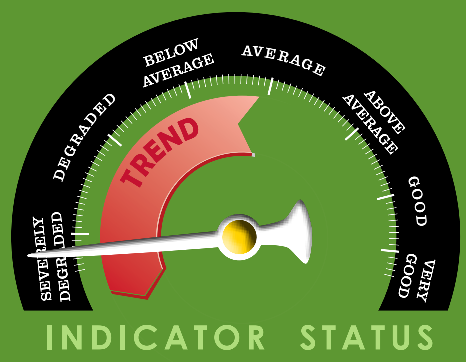
The Barnegat Bay watershed is more than just water. It includes the bay's intertidal and subtidal shallows, seagrass beds, and coastal wetlands, as well as important terrestrial habitats such as the forests of the world-renowned Pinelands National Reserve, freshwater wetlands of all types and sizes, and extensive grasslands. Mention the Barnegat Bay, and many people think of the fish, crabs, clams, and birds that reside in and around the bay. When combined with the other species found within the watershed, these organisms form links in the food web that support the diversity of life that makes the Barnegat Bay a unique place.

But as the human population within the watershed continues to grow, these habitats undergo alteration, conversion, and fragmentation, placing additional stressors on the already fragile ecosystem. There have been substantial losses in eelgrass and shellfish, and the status of many fish populations in the bay is believed to be in decline. A similar situation exists for many terrestrial plants and animals. But there have been successes as well, suggesting that these losses are not irreversible.

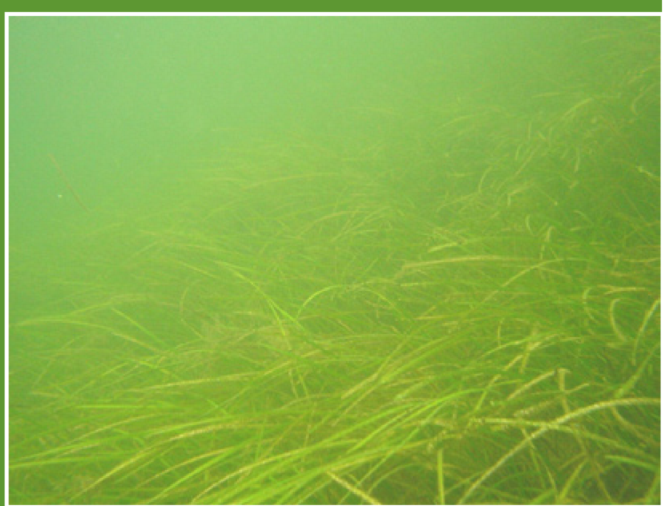
Bay grasses. Photo by Kathleen Spivey.

INDICATOR

Seagrass



Submerged aquatic vegetation.
Photo by Rutgers University.



BACKGROUND

The decline of seagrass in New Jersey's coastal bays is a major concern because seagrass is critically important, both as habitat for many fish and invertebrates, and as a source of nutrition. Various recreationally and commercially important estuarine and marine species (e.g., *Argopecten irradians, Mytilus edulis, Callinectes sapidus,* and *Cynoscion nebulosus*) use the beds extensively during at least a part of their lives. Seagrass beds also play a significant role in biogeochemical cycling and trapping and stabilizing sediments and associated materials. In addition, they are major primary producers and hence are greatly affected by nutrient levels, as well as an array of other environmental, biotic, and anthropogenic factors such as turbidity, light intensity, major storms, high water temperatures, ice scouring, propeller scarring, anchoring, dredging, wasting disease, algal blooms, epiphytic overgrowth, and sea urchin overgrazing. Seagrass subsystems, which in the Barnegat Bay consist of eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*), are excellent indicators of water quality and sediment quality conditions because they integrate water quality and benthic attributes. Finally, they serve as indicators of overall ecosystem health, thereby influencing coastal management decisions. Therefore, by assessing the condition of seagrass beds over time, it is possible to establish accurate trends in estuarine condition.

STATUS

Comprehensive investigations of seagrass in the Barnegat Bay-Little Egg Harbor estuary over the past seven years indicate a general decline of habitat condition in response to increasing eutrophic impacts. Reduction in plant demographics reflects an insidious decline in eelgrass, in particular, due to nutrient enrichment. This is supported by the fact that water clarity, a major determinant in seagrass growth, appears to have increased during the same time frame as recorded by NJDEP turbidity measurements.

TRENDS

Remote sensing surveys indicate that seagrass habitat expanded from 5,184 ha in 2003 to 5,253 ha in 2009. It now covers ~14% of the estuarine bottom. Despite the recent increase in the area covered by seagrass, the amount of eelgrass within a given unit of area has decreased by 50-87.7% between 2004 and 2006. Statistically significant reductions in shoot density, blade length, and areal cover also occurred over this three-year study period, and have continued. The lowest eelgrass biomass values ever recorded by Rutgers were documented in 2009 (**FIGURE 1**).

DATA GAPS

While the eelgrass populations in the central and southern portions of the bay have been studied, there has been little attention paid to the mixed eelgrass/widgeon grass beds in the northern portion of the estuary. Given the highly developed nature of that part of the bay, these beds may be a crucial habitat component. Further, there is a need for constant annual monitoring of seagrass beds estuary-wide to assess remedial measures now being established. Also, the recent trend of increased water clarity during a time of decreasing seagrass densities warrants further investigation.

Data were provided courtesy of Rutgers University.

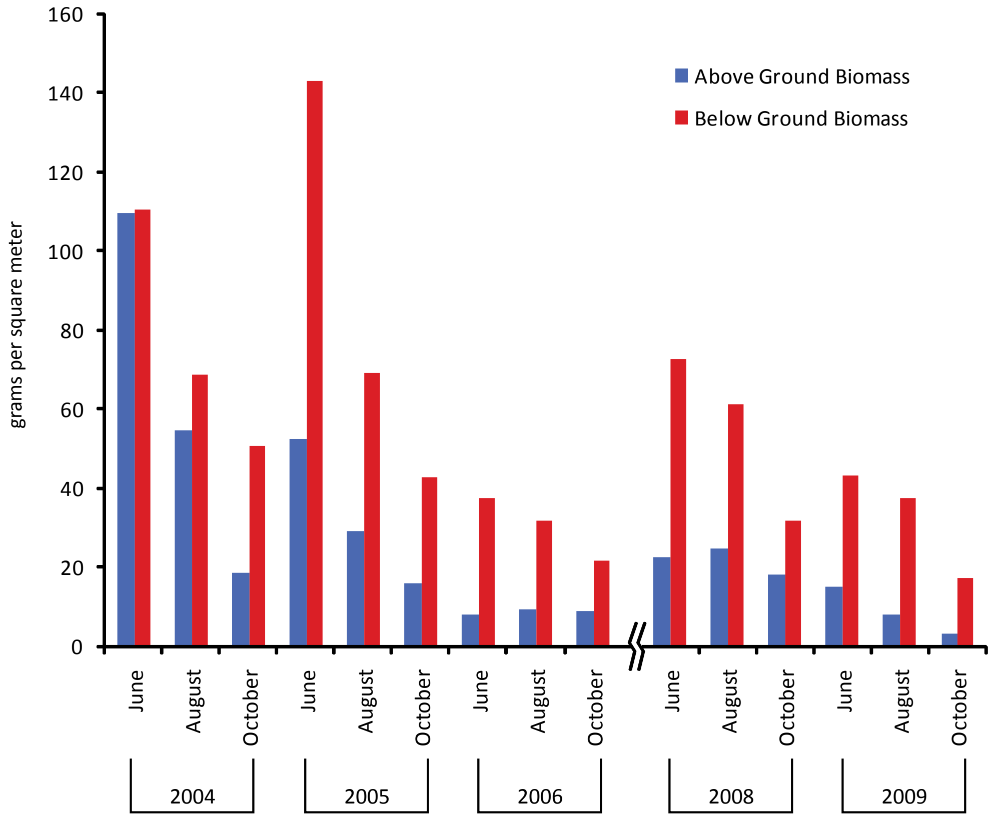


FIGURE 1. *Annual above-ground and below-ground biomass of eelgrass in the Barnegat Bay-Little Egg Harbor estuary between 2004 and 2009.*

An empty beach along the bay. Photo by Glenn P. White.

INDICATOR

Watershed Integrity Measures

Blackbanded sunfish. Photo byJohn F. Bunnell.

BACKGROUND

Streams and impoundments within the Pinelands are characterized by acidic conditions (pH <7), which has led to distinctive plant and animal assemblages, typically consisting of species well adapted to acidic conditions. Because of this unique environment, factors such as specific conductance, pH, stream vegetation, and fish and anuran (frogs and toads) assemblages are each good indicators of land-use-related watershed disturbances. Taken together, these individual biotic (plants, fish, frogs, and toads) and abiotic (pH, specific conductance) factors provide an index of the ecological integrity of a watershed.

In 2003, Pinelands Commission scientists conducted studies on water quality, stream vegetation, fish assemblages, and anuran assemblages of the five major subwatersheds of the Barnegat Bay that are located within the Pinelands National Reserve: Toms River, Wrangel Brook, Cedar Creek, Mill Creek, and Westecunk Creek. They found that in general, Pinelands stream sites with upstream development and upland agriculture have higher pH and specific conductance values, higher percentages of non-Pinelands plant species, more non-Pinelands fish species, and a greater abundance of bullfrogs than stream sites in basins with little altered land.

STATUS

The ecological integrity of the five study basins varied, with the overall highest ecological integrity associated with the Cedar Creek and Westecunk Creek study basins. Many of the survey sites displayed some level of biological impairment. Nonnative bullfrogs were widely distributed in the watershed, with the bullfrog occurring at nearly twice as many sites as the native carpenter frog. Nonnative fish (e.g. pumpkinseed, tessellated darter, and bluegill) were present at a relatively high percentage of impoundments compared to stream sites.

TRENDS

This study was the first of its kind within the watershed, so there are no earlier data to compare to. The Pinelands Commission intends to repeat this study in 2011, at which time changes within the watershed can be assessed.

DATA GAPS

As this was the first study of its kind in the watershed, the 2011 follow-up study will provide an opportunity to assess potential changes in the watershed and identify any areas where additional data are needed.

For additional information on the study and details on individual subwatersheds, please visit the Science section of the Pinelands Commission website at: **www.state.nj.us/pinelands/science/complete/watershed/index.html.**

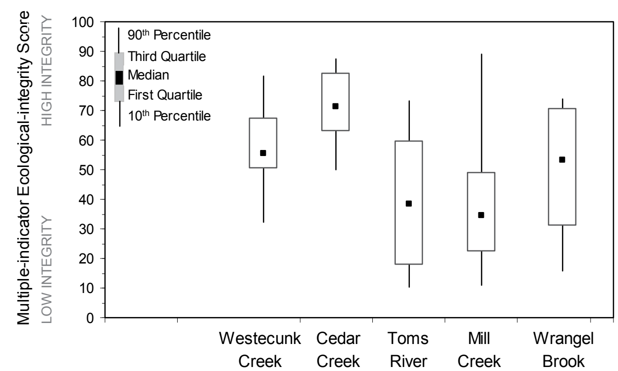
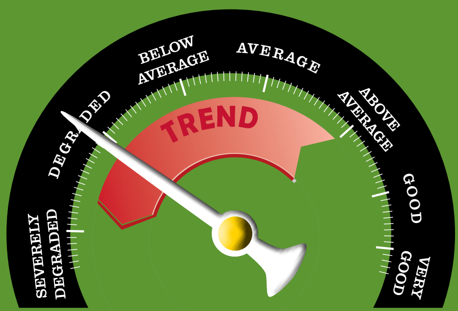


FIGURE 1: *Multiple-indicator Ecological-integrity scores for the five subwatersheds investigated by the Pinelands Commission. The black square represents the middle value for sites ranked within each subwatershed and is somewhat analogous to an average value. The open rectangle represents the range that half of the sites fell between and the vertical lines represent the range that 80% of the sites fell between.*

Sampling on Cedar Creek. Photo courtesy of NJDEP Bureau of Freshwater and Biological Monitoring.

INDICATOR

Land Use - Land Cover



INDICATOR STATUS

Development in South Seaside Park.
Photo by Ocean County Planning Department.

BACKGROUND

Changes in land use can have dramatic and far-reaching impacts on the environment. The conversion of forested areas and wetlands into **urban** settings directly reduces the amount of habitat available for plant and animal species not adapted to living in close proximity to humans. Further, this alteration not only disrupts hydrologic and other natural cycles, but has been linked to the degradation of estuarine habitat quality far removed from the site of disturbance through sediment contamination, increased nutrient levels in surface waters, and increased incidences of hypoxia (low dissolved oxygen levels) in water.

As part of an ongoing monitoring effort, the Grant F. Walton Center for Remote Sensing and Spatial Analysis has mapped and assessed recent land use change in the Barnegat Bay-Little Egg Harbor watershed, utilizing 2006 aerial photography.

STATUS

Updated mapping reveals that urban land use occupied approximately 103,746 acres (30%) of the Barnegat Bay-Little Egg Harbor watershed in 2006, excluding water. Including all altered land uses (*i.e.*, urban plus agricultural and barren lands), the total altered land area is 116,985 acres, or nearly 34%.

TRENDS

Urban land use in the watershed has continued to increase, from approximately 25% of the BB-LEH watershed in 1995, to approximately 30% in 2006. However, the rate of conversion of forest, farm, and wetland to urban land use slowed from approximately 1,590 acres per year between 1995 and 2002 to 1,092 acres per year between 2002 and 2006. Despite this slowing, the watershed is continuing to experience a significant conversion of forested and wetland habitats to urban land cover, thereby exacerbating nutrient loading to the BB-LEH estuary.

DATA GAPS

As newer imagery becomes available, similar analysis will need to be conducted to determine if the rate of land conversion continues to slow or reverses the most recent trend and accelerates.

For a more detailed report on land use changes and its effect on riparian corridors, please visit the Grant F. Walton Center for Remote Sensing and Spatial Analysis at **http://crssa.rutgers.edu/projects/coastal/riparian/report/CRSSA__BB_LULCC_Riparian_study_2007_revised.pdf**

Data were provided courtesy of the Grant F. Walton Center for Remote Sensing and Spatial Analysis at Rutgers University.

URBAN

Defined here to include all land covered with structures, including but not limited to houses, buildings, and parking lots.

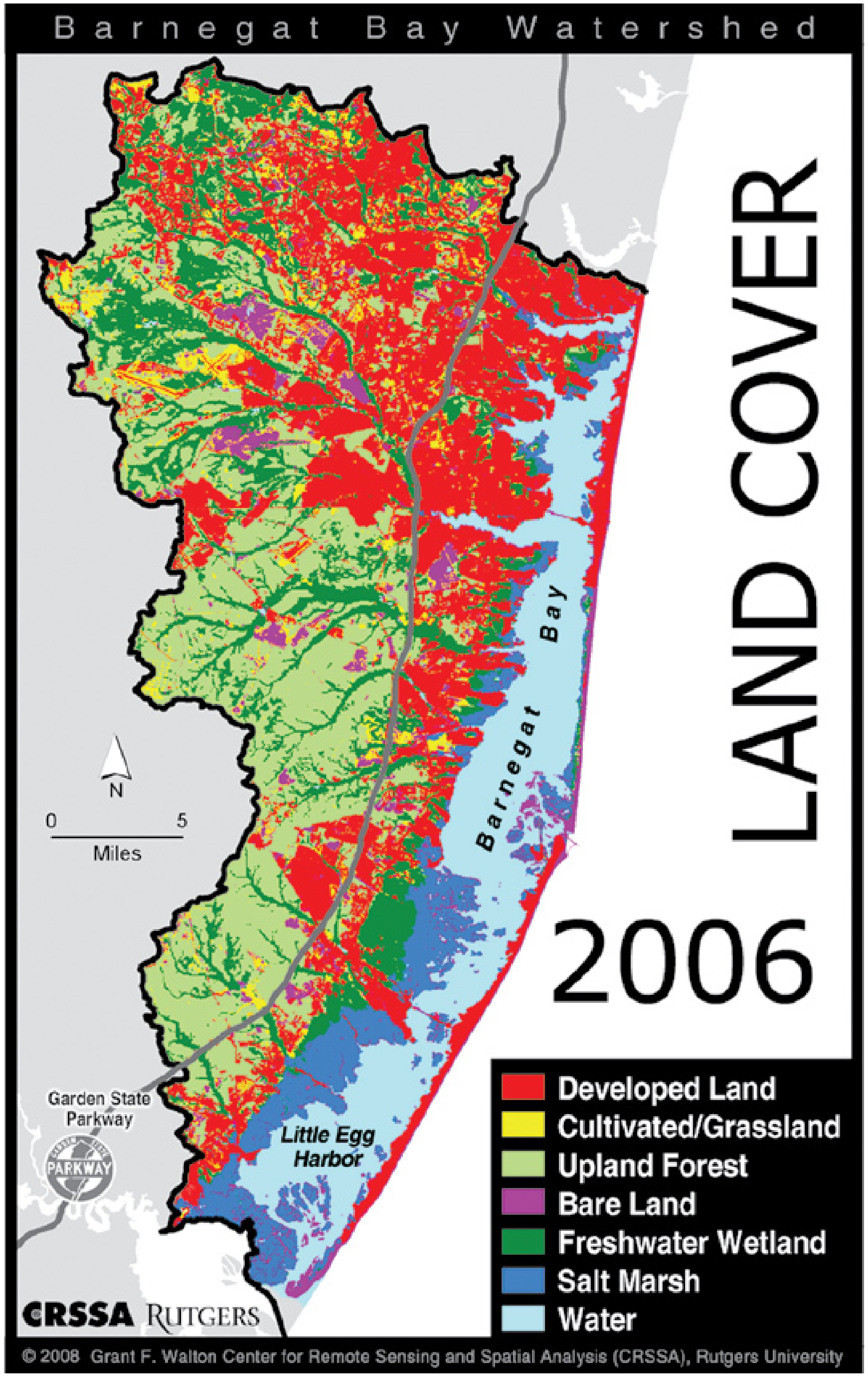
FIGURE 1: *Map of land use-land cover for the Barnegat Bay-Little Egg Harbor watershed as of 2006.*

TABLE 1: *Year 2006 land cover as acres and as % of the Barnegat Bay watershed's land area.*

LAND COVER DESCRIPTION	ACRES	% OF LAND AREA
Urban	103,746	29.8%
Agriculture	4,205	1.2%
Barren	9,034	2.6%
Forest	142,579	40.9%
Wetlands	8,9048	25.5%
LAND AREA TOTAL	348,612	

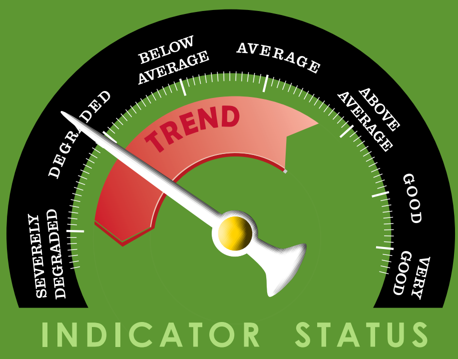
TABLE 2: *Urban and altered (urban + barren + agricultural) land totals and % of the watershed land area by year.*

	1995	2002	2006
Urban Land			
Area (acres)	87,757	99,308	103,746
% of watershed	25%	28%	30%
Altered Land			
Area (acres)	102,258	112,819	116,985
% of watershed	29%	32%	34%



INDICATOR

Wetlands



Low marsh habitat in Edwin B. Forsythe National Wildlife Refuge. Photo by Glenn P. White.

BACKGROUND

The Barnegat Bay estuary is home to many diverse species of plants and wildlife. The wetlands surrounding the area are an integral part of this sensitive ecosystem, providing habitat and a nursery for various fish, shellfish, and wildlife. In the latter half of the 20th century, Ocean County has experienced an exponential growth in population which has adversely impacted water quality and natural resources, including wetlands and wildlife. Increased boat traffic wake has aided in the erosion of salt marshes along the waterfront and development along the mainland and barrier islands has changed the land cover in many places, resulting in wetlands losses.

The Richard Stockton College Coastal Research Center recently performed an analysis in the Barnegat Bay estuary using Geographic Information Systems (GIS) Land Use-Land Cover datasets available from the NJDEP to determine the change in area of tidal and fresh water wetlands for the years 1995, 2002, and 2007.

STATUS

There were approximately 21,449 acres of tidal wetlands and 66,732 acres of fresh water wetlands within the Barnegat Bay watershed in 2007.

TRENDS – TIDAL WETLANDS

Within the Barnegat Bay Watershed Management Area, the amount of tidal marshes has decreased by approximately 8% in 12 years (1995-2007). The majority of areas of tidal wetlands loss are along the bay and tidal waterway shorelines, adjacent to navigational channels and waterways. This suggests these losses are due to erosion as a result of increased boat traffic in the estuary, wind-generated wave energy, and/or sea level rise. Additionally, areas in the back bays near residential areas appear to have been lost due to development, altering the original landscape delineated as wetlands.

TRENDS – FRESHWATER WETLANDS

Freshwater wetlands have decreased by approximately 5% cumulatively in the 12-year time period. The majority of fresh water wetland losses have been associated with development within the watershed. The loss areas calculated between the years of 1995 and 2007 show that the changes occurred due to wetlands areas being altered into residential or forest areas.

It should be noted that there were areas of tidal and freshwater wetland gains, but these gains never equaled the amount of wetlands loss. Interpretation of the datasets show that areas displaying gains in wetlands coverage were located in relatively small, sheltered, tidal waterways, lagoons, and freshwater ponds.

DATA GAPS

Additional research needs to be conducted to determine how much of the ongoing tidal wetland losses can be ascribed to each of the various causes, as the potential solutions vary. The Partnership, in conjunction with a number of other organizations, is currently investigating the effects of sea level rise on our coastal wetlands (see MACWA sidebar).

Data were provided courtesy of the Richard Stockton College Coastal Research Center.

MID-ATLANTIC COASTAL WETLANDS ASSESSMENT

The Mid-Atlantic Coastal Wetlands Assessment (MACWA) was established by the Partnership for the Delaware Estuary (PDE) to include the Delaware Estuary as part of the National Water Quality Monitoring Network. The Barnegat Bay Partnership has joined the MACWA effort and is working together with PDE, the NJDEP, the Academy of Natural Sciences of Philadelphia, USEPA's Region 2 and Headquarters Offices of Wetlands, Oceans and Watersheds, U.S. Fish and Wildlife Service and other partners to develop an integrated coastal wetlands monitoring and assessment network in New Jersey. This will allow us to better understand the health and future conditions of our critical wetlands.

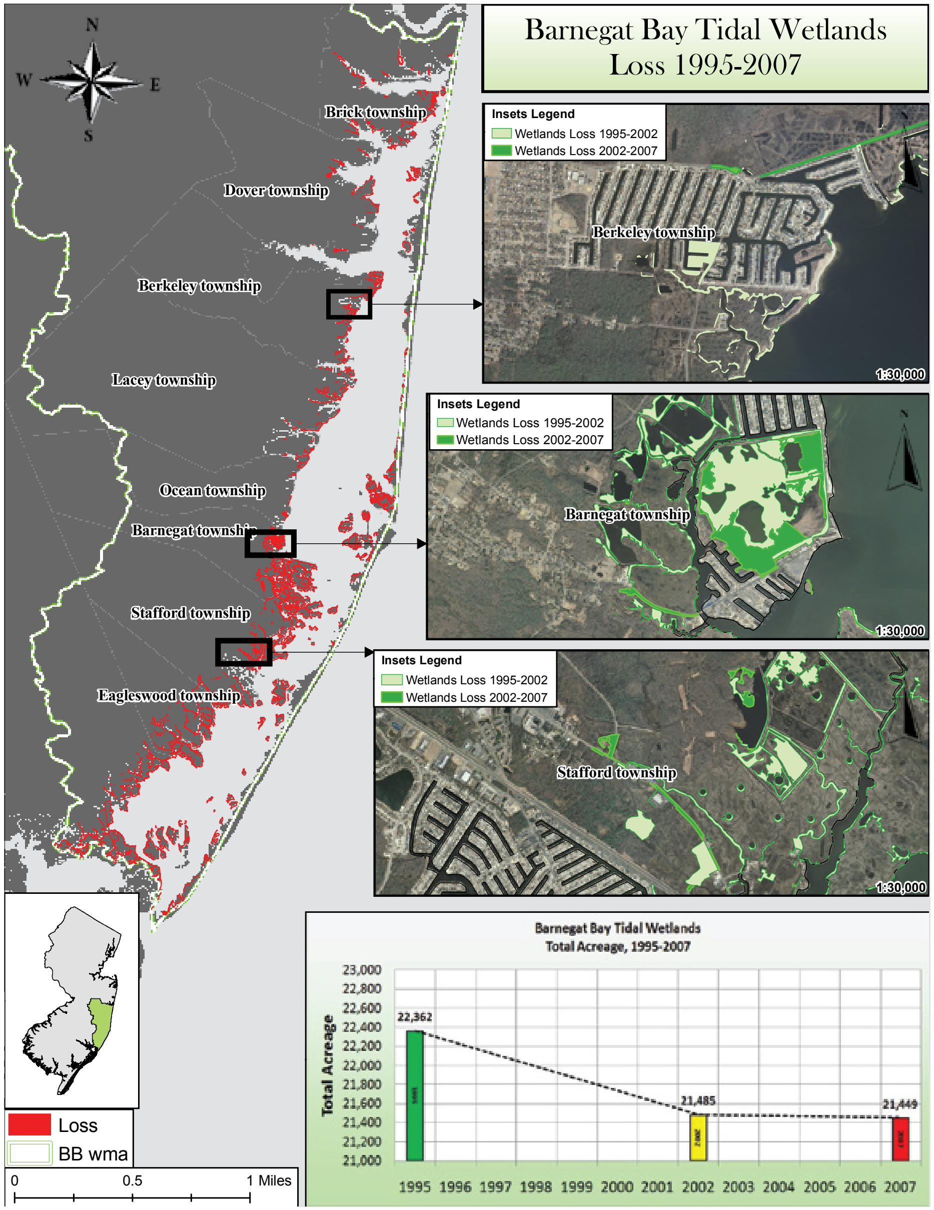


FIGURE 1: *The areas of the main figure in red depict tidal wetlands lost in the watershed between 1995 to 2007, with close-ups of select areas in the insets. The total acres of tidal wetlands in 1995, 2002, and 2007 as calculated from aerial photographs are shown on the column graph.*

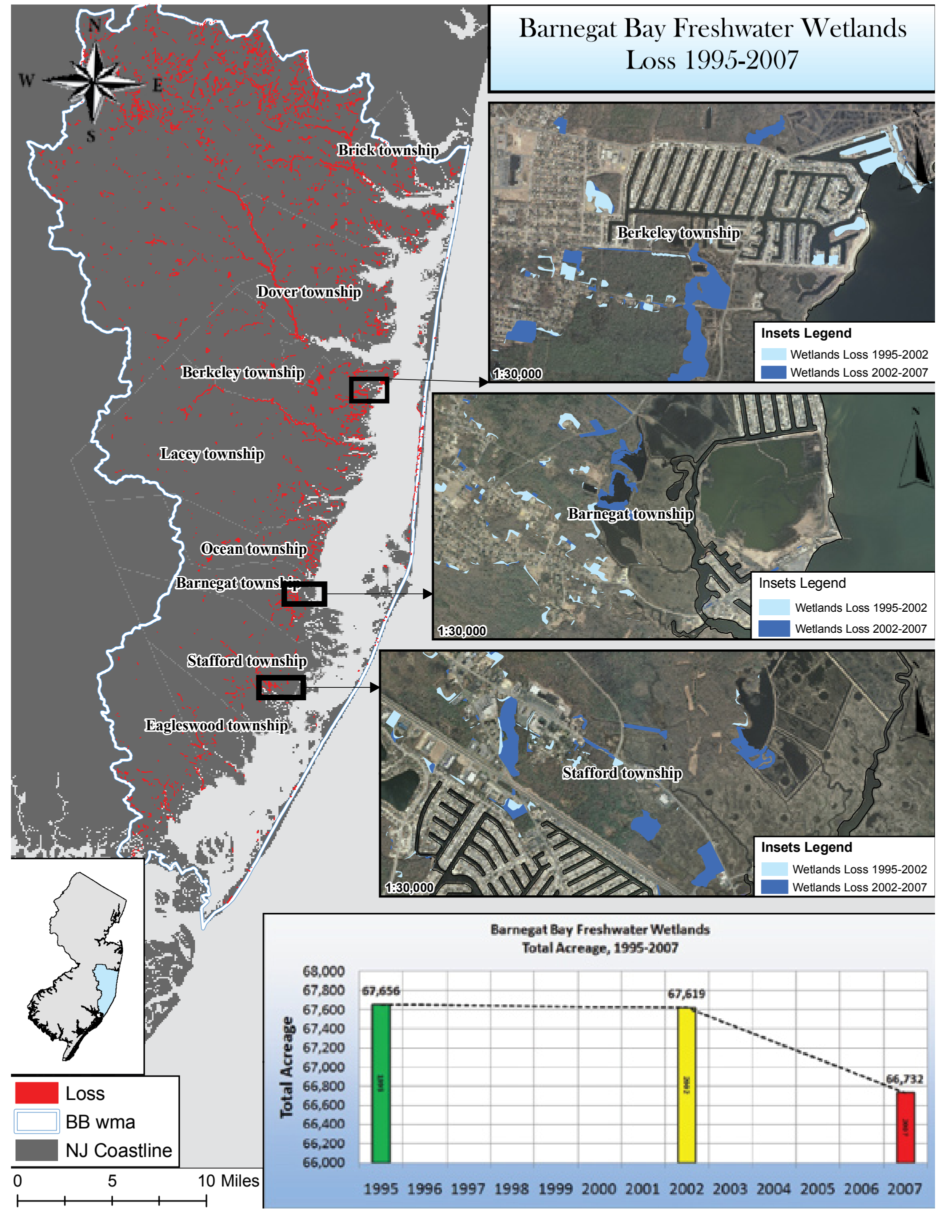
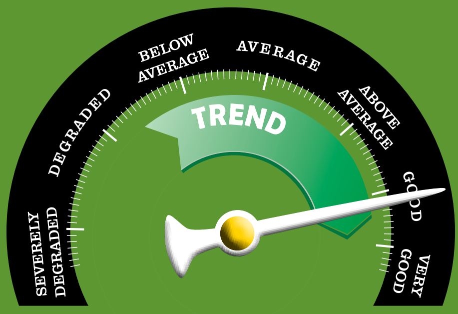


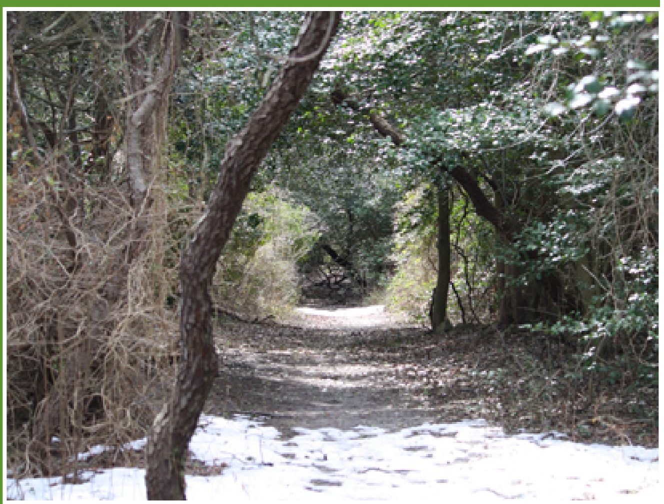
FIGURE 2: *The areas of the main figure in red depict freshwater wetlands lost in the watershed between 1995 to 2007, with close-ups of select areas in the insets. The total acres of freshwater wetlands in 1995, 2002, and 2007 as calculated from aerial photographs are shown on the column graph.*

INDICATOR

Protected Land



A hiking trail in protected land.
Photo by Kathleen Spivey.



BACKGROUND

Protected lands are those areas where development is restricted to passive recreation (such as walking, hiking, horseback riding, cross-country skiing, snowshoeing, bird watching, nature observation, boating, picnicking, fishing, and hunting) or conservation (such as nature preserves, parks, and arboretums).

Protected lands are important for a variety of purposes. Because they generally have minimal human disturbances, they serve as important refuges for wildlife, especially for those animals that tend to avoid human interactions. A substantial amount of protected lands in Ocean County lie along rivers and streams, and can also serve as corridors for movement between larger parcels. With low levels of impervious surfaces and other man-made development, open spaces enhance water quality and aquifer recharge by allowing rainwater to filter directly into the ground. Protected lands along the edge of the bay, usually composed of coastal wetlands and maritime forests, buffer the adjacent lands from storm surge and flooding.

STATUS

Between January 1, 2005 and December 31, 2009, approximately 8,300 acres in the Barnegat Bay watershed were acquired by federal, state, county, local, and non-governmental agencies for conservation purposes (**FIGURES 1** and **2**). These purchases bring the total acreage of publicly-owned land in the watershed to over 130,800 acres. This also includes publicly-owned lands (such as Lakehurst Naval Air Station) which are not set aside for natural resource conservation, but due to size and limited land-use, is preserved in its natural state and protected from development.

TRENDS

It is difficult to determine trends in protected land as the acreage acquired in a given year is subject to the vagaries of the real estate market. However, the newly acquired parcels raise the percentage of publicly-owned land from 34% of the watershed's land area in March 2004 to 37% in December 2009.

DATA GAPS

None.

Data were provided courtesy of Ocean County Natural Lands Trust, U.S. Fish and Wildlife Service Edwin B. Forsythe Wildlife Refuge, and the NJDEP Green Acres Program.

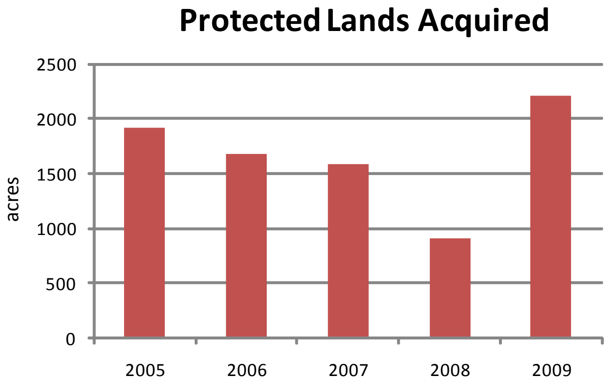


FIGURE 1: *Acreage of protected lands acquired within the watershed from 2005-2009 by Ocean County Natural Lands Trust, U.S. Fish and Wildlife Service, NJDEP Green Acres, and other non-governmental organizations (e.g., Trust for Public Land).*

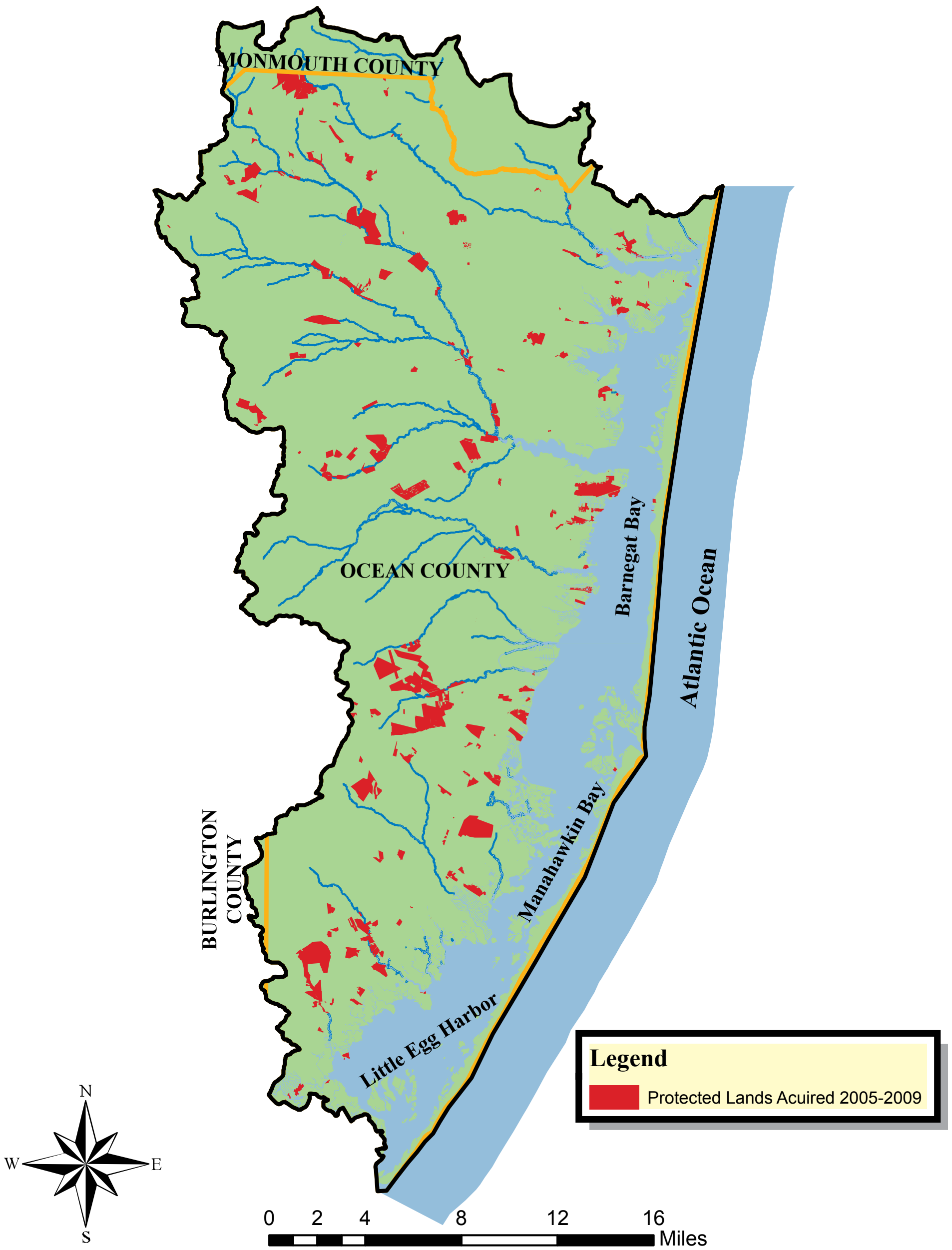
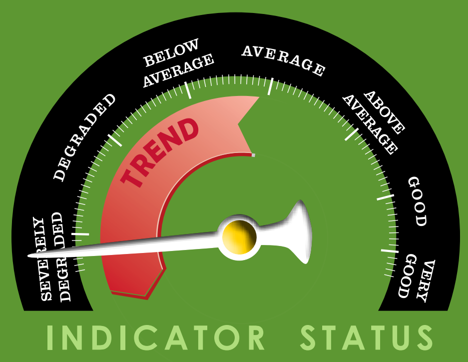


FIGURE 2: *Map of protected areas acquired within the watershed from 2005-2009 by Ocean County Natural Lands Trust, U.S. Fish and Wildlife Service, NJDEP Green Acres, and other land preservation groups.*

INDICATOR

Shellfish Resources



Hard clams. File photo by Barnegat Bay Partnership.

BACKGROUND

Estuarine shellfish have limited mobility, are sensitive to environmental changes, and are a commercially and recreationally important species, making them a key indicator used to assess ecological condition/impairment of estuarine systems nationwide. Historical records note the presence of hard clams (*Mercenaria mercenaria*), Eastern oysters (*Crassostrea virginica*), and bay scallops (*Argopecten irradians*) in Barnegat Bay. For example, Barnegat Bay oyster beds were documented in "A report of the oyster industry of the United States" (Ingersoll, 1881). Native American Indian oyster shell middens found along Barnegat Bay date back to pre-colonial times.

STATUS

There is currently a limited commercial fishery for hard clams within the Barnegat Bay. Hard clams are also harvested on a recreational basis, centered mainly around the southern portion of the estuary. There is limited natural recruitment of oysters into the estuary, and scallops are occasionally found during seagrass and hard clam sampling, such that there is no fishery for either species.

TRENDS

Commercial hard clam landings for Ocean County have fallen from a high of nearly 1.4 million pounds in 1970 to approximately 15,000 pounds in 2005, the last year for which county-specific data are available from the National Marine Fisheries Service voluntary reporting database (**FIGURE 1**). The drop in landings corresponds with a decrease in both commercial (**FIGURE 2**) and resident-recreational (**FIGURE 3**) clamming licenses statewide from 1980 to 2007.

DATA GAPS

There has not been a complete assessment of the hard clam population in Barnegat Bay since 1986, and the reason for the precipitous decline in abundance over the last 40 years has not been determined. There is also a need to assess the contribution of NJDEP clam seeding within the Sedge Island Marine Conservation Zone (MCZ) to the recreational harvest there. Researchers at Rutgers University are currently working on a data summary document as a first step in addressing some of these data gaps.

Data were provided courtesy of Rutgers Cooperative Extension, NJDEP Bureau of Shellfish, and National Marine Fisheries Service.

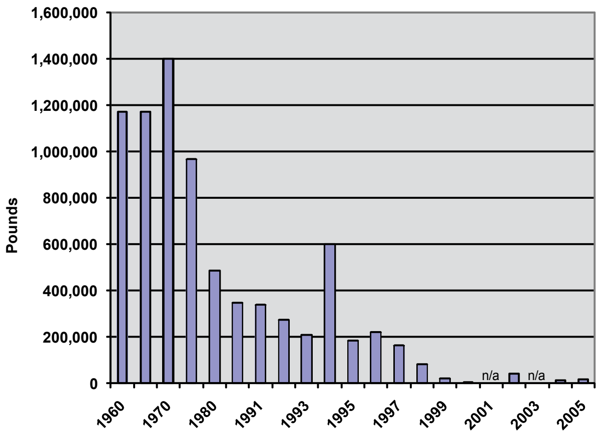


FIGURE 1: *Hard clam landings for Ocean County from 1960-2005. Data was unavailable for 2001 and 2003. Data were provided courtesy of the National Marine Fisheries Service.*

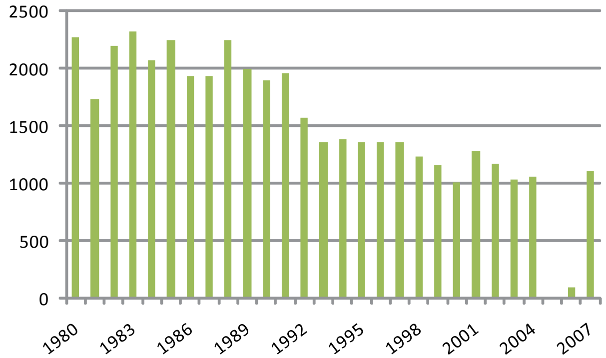


FIGURE 2: *Statewide commercial hard clam license sales. Data was unavailable for 2005. Data were provided courtesy of the NJDEP, Bureau of Shellfisheries.*

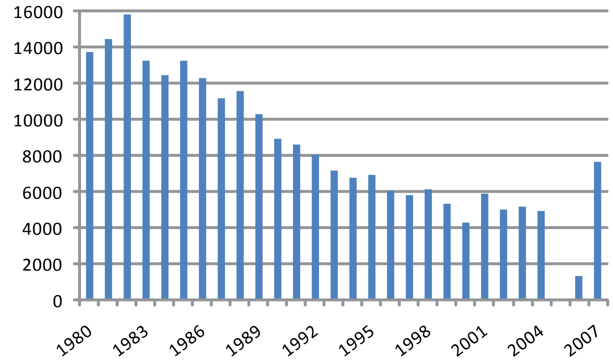
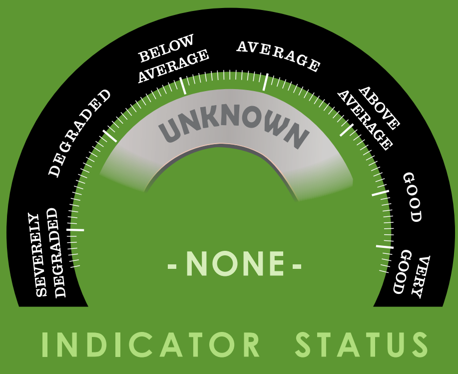


FIGURE 3: *Statewide resident-recreational hard clam license sales. Data was unavailable for 2005. Data were provided courtesy of the NJDEP, Bureau of Shellfisheries.*

Black skimmer. Photo by Glenn P. White.

INDICATOR

Rare, Threatened, and Endangered Animal Species



Bog turtle. Photo by U.S. Fish and Wildlife Service Walkill National Wildlife Refuge.

BACKGROUND

The Barnegat Bay watershed contains a multitude of habitat types, including portions of the world-renowned Pinelands National Reserve. It is located along the Atlantic Flyway for migrating bird species, and sits at the confluence of two temperature regimes. It is also under intense development pressure. This combination of factors explains why this area contains so many rare, threatened, and endangered animal species.

The NJDEP, Division of Fish and Wildlife, Natural Heritage Program (NHP), and Endangered and Nongame Species Program (ENSP) have been collecting data on the occurrence of state and federally listed rare, threatened, and endangered animal species since 1970. In 1994, the ENSP adopted a landscape level approach to imperiled species conservation by developing the "Landscape Project." Through geographic information system (GIS) technology, the Landscape Project uses species location data and land use-land cover, as well as species life history information to produce maps that depict critical wildlife habitat throughout the state. The most recent version of the Landscape Project (v.2.1) was completed in 2008, and uses 2002 aerial image derived land use-land cover along with species occurrence data as of 2008.

STATUS

There have been 6 federally threatened or endangered animal species, 13 state endangered animal species, 12 state threatened animal species, and 38 animal species of special concern sighted in the Barnegat Bay watershed since 1970 (Table 1). The habitat in which these species occur is shown in **FIGURE 1**. The area (acres) within each habitat category is given in Table 2.

While not discussed here, there are three federally threatened plant species known to occur within the watershed; swamp pink (*Helonias bullata*), Knieskern's beaked-rush (*Rhynchospora knieskernii*), and seabeach amaranth (*Amaranthus pumilus*). The state of New Jersey maintains a separate list of endangered plant species as well.

TRENDS

Because of changes in methodology between versions of the Landscape Project, no long-term trend in habitat area is available. There have been no first-time observances of state or federally threatened or endangered species in the watershed since 2004.

DATA GAPS

There is limited information regarding the populations of many of the threatened and endangered species within the watershed. By their very nature, data collection for these species is difficult, and most of the information available comes from studies required as part of a regulatory process and is therefore not widely available. Comprehensive population studies of the most critically imperiled species should be a priority to ensure that adequate protection is being afforded to them before they are lost from the watershed.

For additional information on New Jersey's threatened and endangered species or on the Landscape Project please visit the NJDEP ENSP website at **http://www.njfishandwildlife.com/ensphome.htm**.

FIGURE 1. *Mapped habitat for threatened and endangered animal species and animal species of special concern with the Barnegat Bay watershed. Known habitat for state and federally listed species is displayed in the darkest shade, known habitat for species of special concern is in the intermediate shade, and habitat that meet a threshold criteria and are available to rare, threatened, and endangered species are in the lightest shade.*

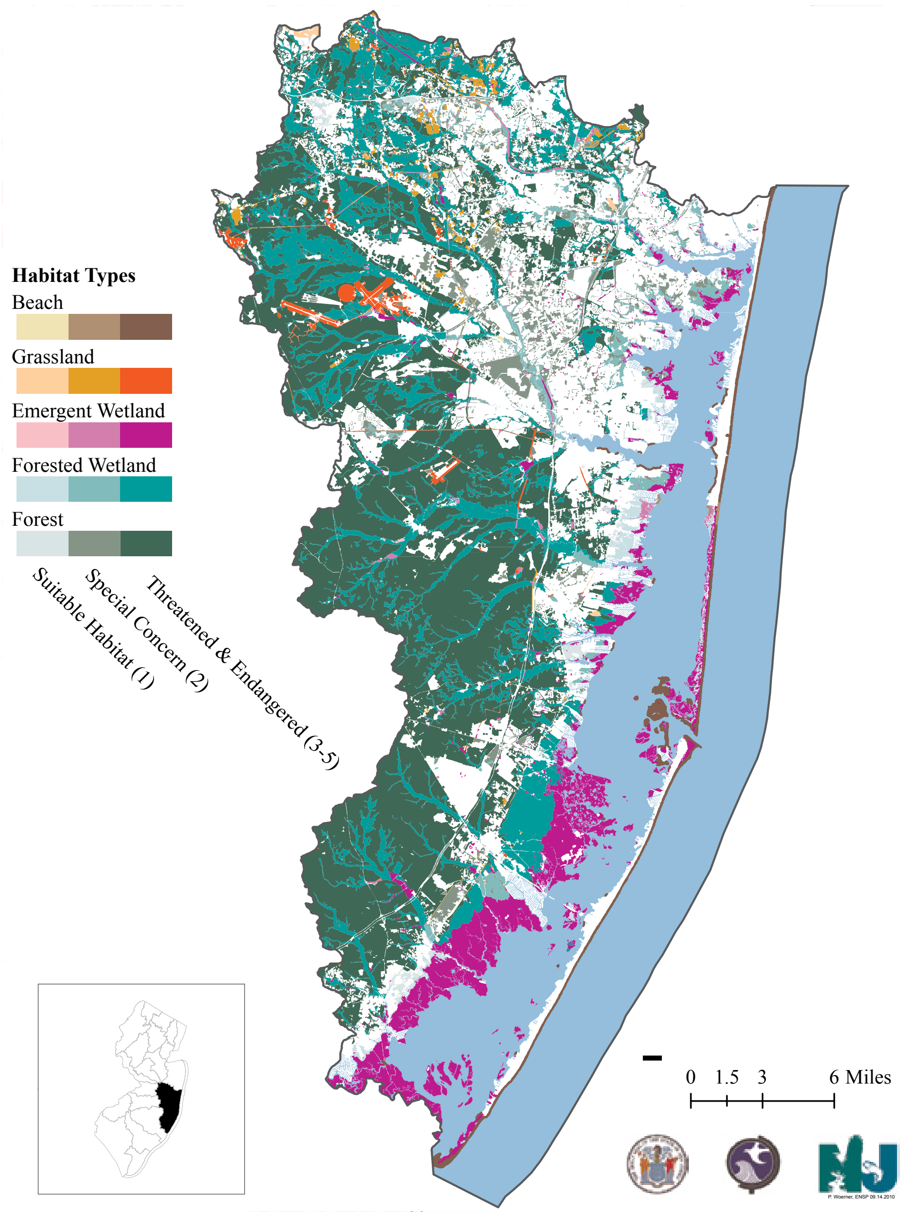


TABLE 1: *Federal and state listed threatened and endangered animal species occurrences mapped in the Barnegat Bay watershed since 1970. Species status is in parentheses.*

BIRDS	
Piping plover (federally threatened)	Roseate tern (federally endangered)
Bald eagle (state endangered)	Black skimmer (state endangered)
Least tern (state endangered)	Northern harrier (state endangered)
Pied-billed grebe (state endangered)	Red-shouldered hawk (state endangered)
Upland sandpiper (state endangered)	Vesper sparrow (state endangered)
Peregrine falcon (state endangered)	Barred owl (state threatened)
Black rail (state threatened)	Cooper's hawk (state threatened)
Black-crowned night heron (state threatened)	Yellow-crowned night-heron (state threatened)
Grasshopper sparrow (state threatened)	Osprey (state threatened)
Red knot (state threatened)	Red-headed woodpecker (state threatened)
Savannah sparrow (state threatened)	
REPTILES AND AMPHIBIANS	
Atlantic green turtle (federally threatened)	Bog turtle (federally threatened)
Kemp's or Atlantic Ridley turtle (federally endangered)	Atlantic loggerhead turtle (federally threatened)
Cope's Gray treefrog (state endangered)	Corn snake (state endangered)
Timber rattlesnake (state endangered)	Northern pine snake (state threatened)
Pine Barrens treefrog (state threatened)	
MAMMALS	
Bobcat (state endangered)	

Table 2: Acres of habitat category for each Landscape Project habitat type in the Barnegat Bay watershed.

HABITAT TYPE	HABITAT CATEGORY		
	Suitable	Special Concern	Threatened and Endangered
Beach	6	35	1,688
Grassland	343	2,453	2,629
Emergent Wetland	198	1,785	24,496
Forested Wetland	2,919	7,200	52,693
Forest	1,424	12,179	129,847

INDICATOR

Rare, Threatened, and Endangered Animal Species






❶ Northern Harrier hunting in Edwin B. Forsythe National Wildlife Refuge. Photo by Kathleen Spivey.
❷ Pine Barrens Tree Frog. Photo by Andrea Gingerich.
❸ Adult Piping Plover. Photo by Gene Nieminen.
❹ Barred Owl at Edwin B. Forsythe National Wildlife Refuge. Photo by Kathleen Spivey.
❺ Juvenile Bald Eagle on Cattus Island. Photo Glenn P. White.
❻ Peregrine falcon at Edwin B. Forsythe National Wildlife Refuge. Photo Kathleen Spivey.

Osprey – A Success Story

The return of ospreys to the Barnegat Bay watershed is a rare and encouraging wildlife management success story. Ospreys (*Pandion haliaetus*) are well-loved birds of our coastal bays and marshes. Formerly known as the fish hawk, ospreys rely almost exclusively on fish for their diet. They (like eagles and falcons) succumbed to the effects of DDT, habitat loss, and persecution and their population dropped to about 60 pairs statewide by the early 1970s. Since inclusion on New Jersey's Endangered Species List in 1973, the osprey population has shown a steady increase, with 485 pairs of ospreys observed nesting throughout New Jersey in 2009, approaching historic numbers of approximately 500 nesting pairs (pre-DDT exposure). In the Barnegat Bay watershed there were 78 active nests in 2009, a 32% increase from 2006. The Barnegat Bay watershed nests averaged 1.68 young per nest in 2009, more than twice the number needed for a stable population.

One potential reason for the osprey's resurgence is that they have been willing to nest on built structures, such as duck blinds and channel markers. Statewide, most ospreys (75%) use the single-post platforms that have been designed and installed for them by volunteers and the Conserve Wildlife Foundation of New Jersey, while others nest on available structures like cell towers (8%), channel markers (4%), duck blinds (3%), dead trees (2%), and other structures (7%).

The recovery of ospreys was made possible by a cleaner environment, including the ban on DDT and other pesticides and toxins which allowed ospreys to successfully reproduce. Ospreys are an inspirational lesson as we consider environmental protection and our ability to assist in nature's resiliency.

For more information on the success of ospreys in Barnegat Bay and throughout New Jersey, visit the NJDEP, Division of Fish and Wildlife, Endangered and Nongame Species Program's website at **http://www.njfishandwildlife.com/ensphome.htm**.

❶ Osprey nest building at Edwin B. Forsythe National Wildlife Refuge. Photo by Glenn P. White.
❷ A curious osprey fledging. Photo by Kathy Clark.
❸ A banded osprey fledging. Photo by Kathy Clark.

TOPIC

Climate Change

Storm surge in December 2007.
File photo by Barnegat Bay Partnership.

BACKGROUND

It is widely recognized that long-term changes in climate will have a significant impact on New Jersey's coast, including the Barnegat Bay estuary. By definition, evaluation of the effects of climate change requires the examination of long-term datasets, often longer than those available for many of the other indicators in this report. While we do not completely understand all of the effects climate change will have on the watershed, we do know that estuaries are particularly vulnerable to many aspects of climate change, including higher air and water temperatures and more precipitation with more frequent and intense storms. Changing sea level, air and water temperatures, and precipitation amounts may have a profound impact on the species that call Barnegat Bay home.

SEA LEVEL RISE

The impacts of climate change have already been observed here in New Jersey, where we are experiencing one of the highest rates of sea-level rise in the continental United States. The tide gauge at Atlantic City shows a sea level rise rate of increase of approximately 4 mm per year (about 16 inches per century) since the early 1900s (**FIGURE 1**).

Though these rates seem small and perhaps of little immediate concern, they are recognized by national and regional experts to be of sufficient magnitude to transform the character of the mid-Atlantic coast, with the potential for increased flooding episodes, large-scale loss of tidal wetlands, and possible disintegration of barrier islands. Of equal concern, future rates of sea-level rise in the region are projected to nearly double.

AIR TEMPERATURES

In their 2007 report on New Jersey, the Union of Concerned Scientists stated that the average temperatures across the Northeast have risen more than 1.5 degrees Fahrenheit (°F) since 1970, with winters warming most rapidly—4°F between 1970 and 2000. If higher emissions of carbon dioxide continue, it is projected that the seasonal average temperatures across most of New Jersey will rise 7°F to 12°F above historic levels in winter, and 6°F to 14°F in summer, by late century. Under the higher emissions scenario, New Jersey's urban areas can expect a dramatic increase in the number of days over 100°F.

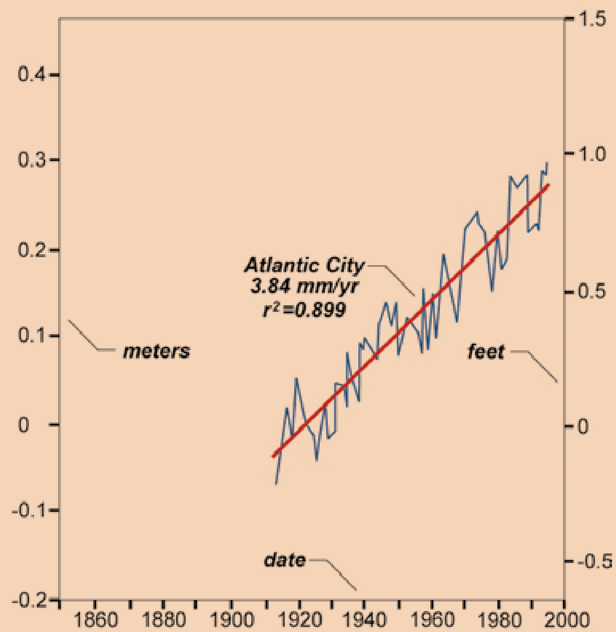


FIGURE 1. *Tide gauge records for Atlantic City; red trend line shows steadily increasing sea level since 1910 (New Jersey Geological Survey, "Sea Level Rise in New Jersey," Information Circular, 1998).*

WATER TEMPERATURES

Since approximately 2000, the average annual sea surface temperature in Barnegat Bay in the spring, summer, and fall has consistently risen at Little Egg Inlet, the southern entrance to the bay (**FIGURE 2**).

The implications of a changing climate could be far reaching in the bay. The bay's water level is rising faster than the coastal wetlands are able to accumulate sediment and raise their elevations, contributing to losses of low-marsh habitat and a restriction of high-marsh habitat. As air temperatures and precipitation patterns change, plants may be subjected to conditions that they have not evolved to cope with, such as heat stress and drought. Vernal pools (temporary wetlands created by winter precipitation that are critical to many amphibian life-cycles) may be reduced in size and duration due to changes in winter precipitation and early drying. Increasing water temperatures have a direct effect on the biota of the bay. There are many northern and southern migratory fishes that are dependent on Barnegat Bay as nursery areas. However, during this same period of increasing water temperatures, fishes that depend on the estuary at some point during their lifetime have responded to this rise in temperature. While the numbers of recently hatched migratory southern species has increased, there has been a concurrent decrease in recently hatched northern fish species (**FIGURE 3**). This may lead to a replacement of some important recreational and commercial species.

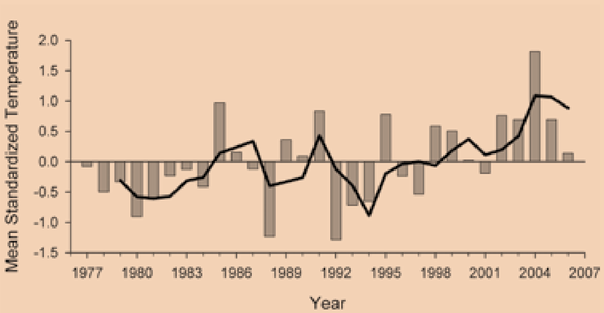


FIGURE 2. *The vertical bars represent the difference in temperature for that year compared to the 30-year average. The dark line is the three-year moving mean. Taken from Able and Fahay, 2010.*

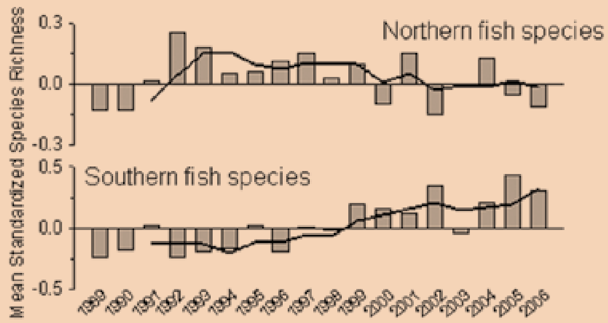


FIGURE 3. *The vertical bars represent the difference in the number of species identified that year compared to the long-term average. The dark line is the three-year moving mean. Taken from Able and Fahay, 2010.*

CLIMATE READY ESTUARIES PROGRAM

The "Climate Ready Estuaries Program" (CRE Program) is a partnership between the USEPA and the National Estuary Programs to help prepare for the diverse projected impacts of climate change and sea level rise in coastal areas. In May 2009, the Barnegat Bay Partnership was selected to participate in the CRE Program. The funding provided has enabled the Barnegat Bay Partnership and its key partners to further our collective climate change vulnerability assessments and adaptation planning activities. These activities will enable the Barnegat Bay Partnership to develop a climate change adaptation strategy which informs local municipalities and the public about regional challenges and their potential solutions.

More information about the EPA's Climate Ready Estuaries Program can be found at **http://www.epa.gov/climatereadyestuaries**. The Barnegat Bay Partnership's CRE Program information is at **http://bbp.ocean.edu/pages/300.asp**.

Sunset over Barnegat Bay. Photo by Kathleen Spivey.

TOPIC

Oyster Creek Nuclear Generating Station

BACKGROUND

The Oyster Creek Nuclear Generating Station (OCNGS or the Station) is an existing nuclear-fueled electric generating station located between the South Branch of the Forked River and Oyster Creek, two tributaries of Barnegat Bay. The Station withdraws up to 662.4 million gallons per day (MGD) of water from an intake canal that leads from the Forked River, uses this water as non-contact cooling water, then discharges these waters into a discharge canal which leads to Oyster Creek. The plant also withdraws approximately 732 MGD of water from the intake canal and discharges it directly into the discharge canal (without added heat) for the purpose of diluting the thermal discharge from the non-contact cooling water.

IMPINGEMENT AND ENTRAINMENT IMPACTS

The majority of environmental impacts associated with intake structures are caused by water withdrawals that ultimately result in aquatic organism losses. In that regard, cooling water intakes can have two types of effects. The first effect, referred to as *impingement*, occurs when organisms are caught on the intake screens or associated trash racks. The second effect, referred to as *entrainment*, occurs when organisms pass through the facility's intake screens and the cooling system itself.

Impingement takes place when organisms are trapped against intake screens by the force of the water passing through the cooling water intake structure. Impingement can result in starvation and exhaustion, asphyxiation, and descaling (fish lose scales when removed from an intake screen by a wash system) as well as other physical harms.

Entrainment occurs when organisms are drawn through the cooling water intake structure into the cooling system. Organisms that become entrained are normally relatively small, including early life stages of fish and shellfish. Many of these small organisms serve as prey for larger organisms that are found higher on the food chain. As entrained organisms pass through a plant's cooling system they are subject to mechanical, thermal, and/or toxic stress.

Over the history of OCNGS operation, impingement and entrainment surveys were conducted between 1975-1980, 1984-1985, 2005-2006, and 2006-2007. A study conducted from September 1975 through August 1977 reported impingement of 13 million fish and invertebrates. A second study conducted from November 1984 through December 1985 reported impingement of 22 million fish and invertebrates. In more recent studies from September 2005 through September 2006, over 51 billion fish and shellfish life stages were entrained through the plant condensers, compared to 84 billion fish and shellfish life stages entrained from October 2006 through September 2007.

Because comprehensive surveys of fish populations have not been conducted in the estuary for more than 30 years, it is difficult to quantify the adverse effects of OCNGS on the bay's fish and invertebrates. However, a comparison of the number of organisms recently

Oyster Creek Nuclear Generating Station. Photo courtesy of the U.S. Nuclear Regulatory Commission.

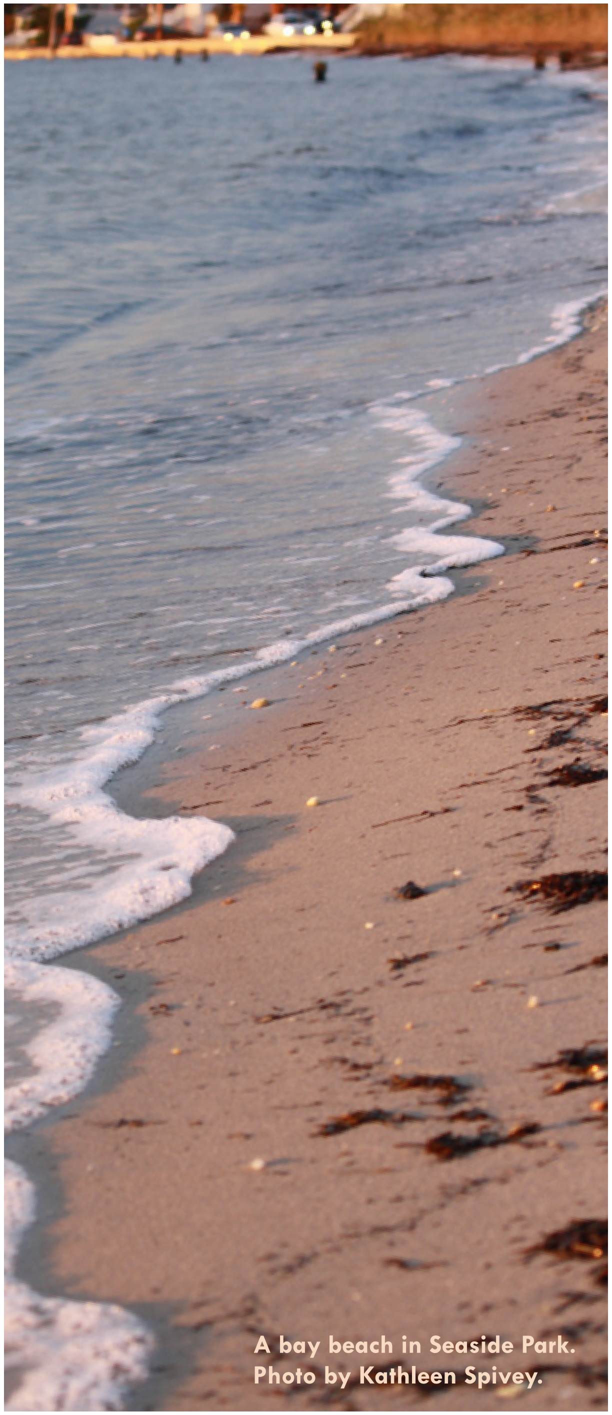
impinged on intake screens at the OCNGS (2005-2007) to historical impingement numbers (1975-1985) indicates a dramatic drop in impingement numbers through time, suggesting a correspondingly large decrease in their overall population within the bay. The species showing the most acute decrease in numbers included sand shrimp (-84%), blueback herring (-86%), bay anchovy (-92%), Atlantic menhaden (-95%), and bluefish (-97%). Impingement numbers of blue crab and winter flounder, two recreationally and commercially important species, dropped by 51% and 78%, respectively.

THERMAL IMPACTS

The cumulative thermal impacts on the bay's biota are not well understood. Water temperature in the discharge canal can reach 110°F, which can affect the behavior, physiology and habitat utilization of aquatic organisms in the area. Behavioral changes include avoidance of Oyster Creek during summer and early fall by certain species, and an attraction to Oyster Creek during the winter by migratory species who should have left the bay due to cold temperatures. During planned or emergency shutdowns these migratory species can suffer large-scale die-offs due to cold shock, such as the death of 2,980 striped bass in January 2000. The high water temperature also decreases the amount of oxygen present in water and increases Biological Oxygen Demand (how much oxygen is consumed by living organisms in the water) resulting in dangerously low dissolved oxygen concentrations in the water.

CHLORINE IMPACTS

Chlorine is injected through each of the circulating pumps daily to prevent and remove fouling organisms, such as bacteria. Chlorine directly kills small marine organisms entrained in the cooling system and can impact organisms residing in the discharge canal and surrounding waters. Furthermore, chlorination of OCNGS condensers generates nitrogenous (nitrogen-based) compounds, notably chloramines and their derivatives, which can impact water quality in Oyster Creek and Barnegat Bay-Little Egg Harbor. These nitrogenous compounds may also contribute to eutrophication of the estuary; however, the potential impacts have not been adequately assessed.



A bay beach in Seaside Park. Photo by Kathleen Spivey.

Conclusion

STATE OF THE BAY'S
WATER QUALITY

STATE OF THE BAY'S
WATER SUPPLY

STATE OF THE BAY'S
HABITAT AND LIVING RESOURCES

As documented in this *State of the Bay Report*, the Barnegat Bay has undergone a number of changes over the past five years, many to the detriment of the bay's ecology. As the human population continues to grow, we strain the watershed's limited resources. We are converting the natural landscape into urban areas at a pace that is not ecologically sustainable and are withdrawing fresh water from the system at a steadily increasing rate. The increased nutrient loads making their way into the bay as a result of past and present urbanization are having dramatic negative effects. Seagrasses, one of the key components of our aquatic system, are at their lowest recorded biomass. Nuisance algal growth is on the rise, as are the abundance of stinging jellyfish.

There are, however, some bright spots. The Ocean County Natural Lands Trust, the NJDEP, the U.S. Fish and Wildlife Service, and various non-governmental organizations continue to purchase lands for open space preservation at an impressive pace. Closures of bathing beaches and shellfish beds within the watershed have generally declined over the past five years due to improved water quality related to pathogens. Osprey, a species that was on the precipice, is making a comeback.

While a large amount of data was analyzed as part of this report, there is still a great deal that we do not know about the bay. There is no current information regarding the status of recreational and commercially important fishes (flounders, weakfish) in the bay. There is little information about threatened and endangered species population sizes within the watershed, or the quality of the sediment that supports seagrass habitat. We do not have an estimate of organic matter production for the bay, a working model of water circulation patterns for the whole bay, or a comprehensive understanding of the benthic community structure. There is no long-term surface- and groundwater quality monitoring plan in place. Lastly, the effects that climate change and sea level rise will have are not well understood.

But make no mistake—there is enough scientific information available to enable us to take significant action. Over the past five years our partners have come together to restore upland and aquatic habitats throughout the watershed, improving riparian buffers, removing debris from streams and the bay, and eradicating invasive plants and replacing them with native marsh grasses. Through countless tours, seminars, classes, pamphlets, and brochures, our partners have educated both residents and visitors about the importance of Barnegat Bay and how their actions can have a positive impact. In the summer and fall of 2010, the New Jersey State Legislature introduced a bill to reduce the impact of nitrogen-based fertilizer on Barnegat Bay and a bill that sought to improve and restore soil health throughout the watershed, both of which were signed into law by Governor Christie in January 2011.

The Barnegat Bay Partnership will use this momentum as a springboard, pressing forward with research critical to filling in the gaps in our knowledge of the bay, and using this understanding to refine our restoration and protection techniques. We hope that you will join us in this endeavor and together we can build upon the successes gained in the past five years.

To find out how you can help, please visit our website at **http://bbp.ocean.edu**.

Cedar Creek in Double Trouble State Park.
Photo by Kathleen Spivey.

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Barnegat Bay at sunset. Photo by Glenn P. White.

SEVEN SIMPLE WAYS YOU CAN HELP THE BARNEGAT BAY

❶ **Be a responsible pet owner.**	Pick up after your pet and dispose of the waste in the trash or toilet. Pet waste contains disease-causing microorganisms called pathogens which can impact water quality. **www.state.nj.us/dep/dwq/pdf/tip_brochure_Petwaste.pdf**
❷ **Make your yard a sponge.**	Set up a rain barrel to capture roof runoff, plant a rain garden, use pervious pavers on your patio, and plant the edges of your property with native shrubs and ground covers to keep rainwater from running off into the street where it can carry pollutants into the nearest waterway. **http://bbp.ocean.edu/pages/248.asp**
❸ **Fertilize properly and sparingly.**	Fertilizer over-application and poor application techniques have the potential to introduce excess nitrogen into the bay. Help reduce this problem by having your soil tested, reading the labels on the fertilizer bags, following the application instructions, and complying with the new fertilizer legislation. **http://ocean.njaes.rutgers.edu/documents/NJFertilizerLaw2011.pdf**
❹ **Reduce use of pesticides.**	Infestation is the sign of an ecosystem out of balance. Many problems can be solved just by increasing the biodiversity in your garden and improving the health of your soils. If that doesn't work, try some "integrated pest management." **www.pestmanagement.rutgers.edu/ipm/index.htm**
❺ **Take your car to the car wash instead of washing it in the street.**	Many soaps used for washing cars contain phosphates, which can be damaging to water quality. Also, commercial car washes use up to 60% less water for the entire wash than the average homeowner uses just for the rinse! **www.epa.gov/owow_keep/NPS/toolbox/other/KSMO_CarWashing.pdf**
❻ **Give 10-feet for the Bay.**	Devoting a 10-foot wide strip along your property line to a native planting of perennials, shrubs, and trees will not only provide much-needed habitat for birds and butterflies, but an all-natural water-filtration facility. Stormwater runoff will be caught by your vegetated buffer and naturally filtered of materials that would otherwise negatively impact water quality. **www.nrcs.usda.gov/feature/buffers**
❼ **Volunteer.**	E-mail Mary Judge at the Barnegat Bay Partnership (**mjudge@ocean.edu**) to join the Barnegat Bay Partnership's list-serve for environmental education and volunteer opportunities to keep informed and to stay involved.

If you want to build a ship, don't drum up people together to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea.

-- Antoine de Saint-Exupery

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Barnegat Bay Partnership