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May 2005

REAPPRAISAL

Central Barnegat Bay (BB2)

Bay Shore to Sunrise Beach

January 1999 – December 2002

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REAPPRAISAL REPORT

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New Jersey Department of Environmental Protection
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COMMISSIONER

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EXECUTIVE SUMMARY

This growing area encompasses the waters from Bay Shore to Sunrise Beach, which includes a large section of the Barnegat Bay, Toms River, and Cedar Creek. All 103 sampling stations in the Central Barnegat Bay area (BB2) remain in compliance with their respective classification criteria. The sampling strategy for this area is Systematic Random Sampling. Data were analyzed from January 1999 to December 2002 for total coliform (TC) and fecal coliform (FC). The water quality of the Central Barnegat Bay was consistent with the shellfish growing area classification as specified by the National Shellfish Sanitation Program (NSSP) criteria: at this time no change in classification is recommended for the Central Barnegat Bay. Currently, the headwaters of the Toms River are classified as *Prohibited*, and the remaining waters of Toms River are classified as *Special Restricted*. The portion of the Barnegat Bay adjacent to Toms River is classified as *Seasonal (Nov-Apr)*. The Cedar Creek is classified as *Special Restricted*, and there is a buffer of *Special Restricted* waters on the western portion of the Barnegat Bay. Apart from marina buffers, the rest of the Barnegat Bay in this growing area is classified as *Approved*. All lagoons are classified as *Prohibited*. There are no direct discharges into the waters of the Central Barnegat Bay region, however, the Ocean County Utilities Authority's central outfall pipe runs beneath the waters of this growing area. This pipeline is four miles long and runs from the treatment plant in Bayville, east to the Atlantic Ocean. In February of 2003 there was break in this pipeline that closed a large portion of the Central Barnegat Bay, these waters were re-opened in May of 2003. In October of 2003 the same area was again closed in response to a second sewage line break; this time, waters were re-opened in December of 2003 (See Spill or Other Unpermitted Discharges for more information).

INTRODUCTION

PURPOSE

This report is part of a series of studies having a dual purpose. The first and primary purpose is to comply with the guidelines of the National Shellfish Sanitation Program (NSSP), which are established by the Interstate Shellfish Sanitation Conference (ISSC). Reports generated under this program form the basis for classifying shellfish waters. Based on the classification, it is determined which waters are safe for harvesting shellfish intended for human consumption. As such, they provide a critical link in protecting human health.

The second purpose is to provide input to the Integrated Water Quality Monitoring and Assessment Report, which is prepared pursuant to Sections 305(b) and 303(d) of the Federal Clean Water Act (P.L. 95-217). The information contained in the growing area reports is used for the 305b portion of the Integrated Report, which provides an assessment to Congress every two years of current water quality conditions in the State's major rivers, lakes, estuaries, and ocean waters. The reports provide valuable information for the 305(b) portion of the Integrated Report, which describes the waters that are attaining state designated water uses and national clean water goals; the pollution problems identified in surface waters; and the actual or potential sources of pollution. Similarly, the reports utilize relevant information contained in the 305(b) portion of the Integrated Report, since the latter assessments are based on instream monitoring data (temperature, oxygen, pH, total and fecal coliform bacteria, nutrients, solids, ammonia and metals), land-use profiles, drainage basin characteristics and other pollution source information.

From the perspective of the Shellfish Classification Program, the reciprocal use of water quality information from the reports represent two sides of the same coin: the growing area report focuses on the estuary itself, while the 305(b) report describes the watershed that drains to that estuary.

The Department participates in a cooperative National Environmental Performance Partnership System (NEPPS) with the USEPA, which emphasizes ongoing evaluation of issues associated with environmental regulation, including assessing impacts on water bodies, and measuring improvements in various indicators of environmental health. The shellfish growing area reports are intended to provide a brief assessment of the growing area, with particular emphasis on those factors that affect the quantity and quality of the shellfish resource. The shellfish growing area reports provide valuable information on the overall quality of the saline waters in the most downstream sections of each major watershed. In addition, the reports assess the quality of the biological resources and provide a reliable indicator of potential areas of concern and/or areas where additional information is needed to accurately assess watershed dynamics.

HISTORY OF NSSP

As a brief history, the NSSP developed from public health principles and program controls formulated at the original conference on shellfish sanitation called by the Surgeon General of the United States Public Health Service in 1925. This conference was called to order after oysters were implicated in causing over 1,500 cases of typhoid fever and 150 deaths in 1924. The tripartite cooperative program (federal, state, and shellfish industry) has updated the program procedures and guidelines throughout workshops, held periodically until 1977. Because of concern by many states that the NSSP guidelines were not being enforced uniformly, a delegation of state shellfish officials from 22 states met in 1982 at Annapolis, Maryland, and formed the ISSC (Interstate Shellfish Sanitation Conference). The first annual meeting was held in 1983 and continues to meet annually at various locations throughout the United States.

The NSSP *Guide for the Control of Molluscan Shellfish* sets forth the principles and requirements for the sanitary control of shellfish produced and shipped in interstate commerce in the United States. It provides the basis used by the Federal Food and Drug Administration (FDA) in evaluating state shellfish sanitation programs. The five major points on which the FDA evaluates the state include:

1. The classification of all actual and potential shellfish growing areas as to their suitability for shellfish harvesting.
2. The control of the harvesting of shellfish from areas that are classified as restricted, prohibited, or otherwise closed.
3. The regulation and supervision of shellfish resource recovery programs.
4. The ability to restrict the harvest of shellfish from areas in a public health emergency, and
5. Prevent the sale, shipment or possession of shellfish that cannot be identified as being produced in accordance with the NSSP and have the ability to condemn, seize, or embargo such shellfish.

FUNCTIONAL AUTHORITY

The authority to carry out these functions is divided between the Department of Environmental Protection (DEP), the Department of Health and Senior Services, and the Department of Law and Public Safety. The Bureau of Marine Water Monitoring (BMWM), under the authority of N.J.S.A. 58:24, classifies the shellfish growing waters and administers the special resource recovery programs. Regulations delineating the growing areas are promulgated at N.J.A.C. 7:12 and are revised annually. Special Permit rules are also found at N.J.A.C. 7:12 and are revised as necessary.

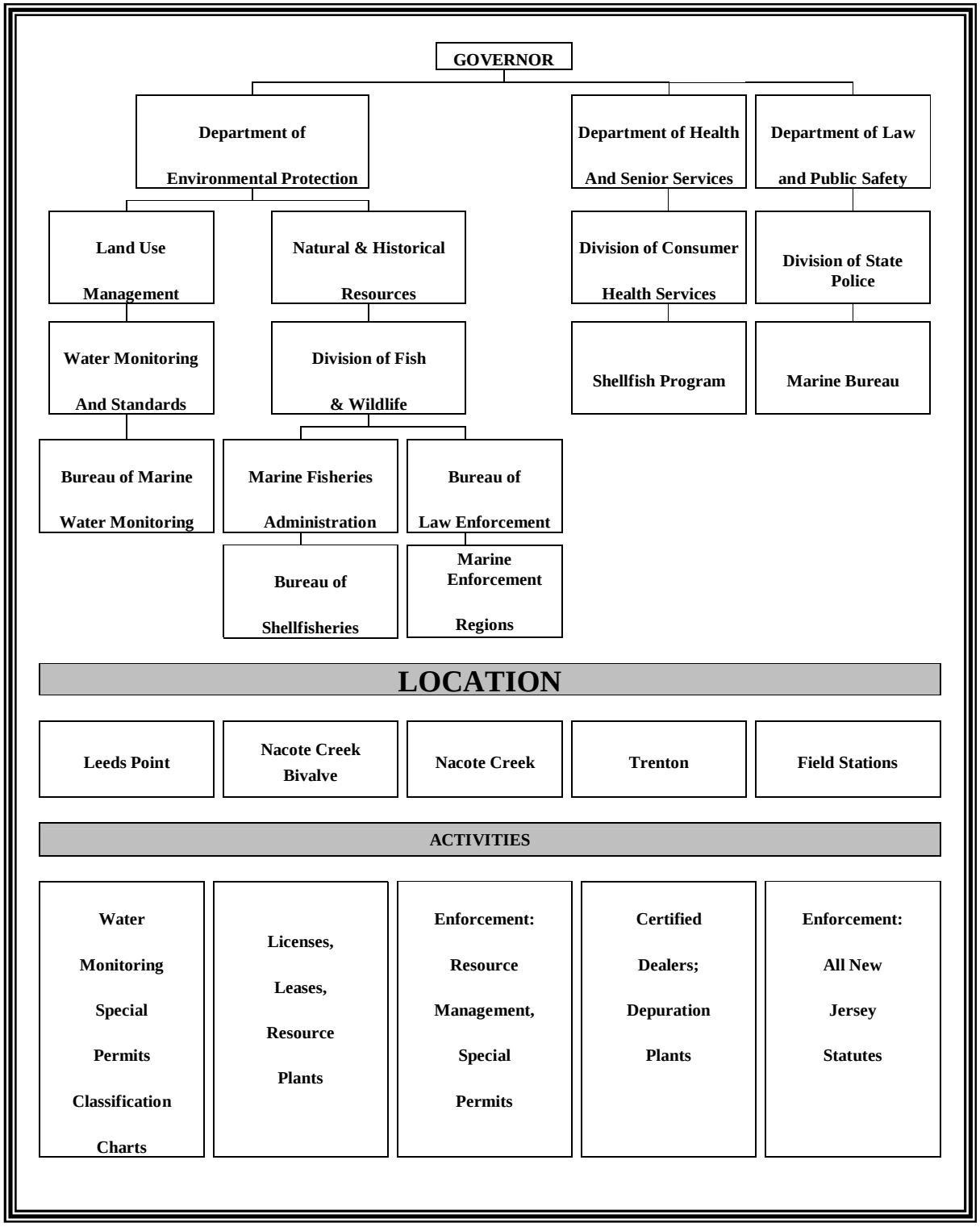
The Bureau of Shellfisheries, in the Division of Fish and Wildlife, issues harvesting licenses and leases for shellfish grounds under the Authority of N.J.S.A. 50:2 and N.J.A.C. 7:25. This bureau, in conjunction with the BMWM, administers the Hard Clam Relay Program.

The Bureau of Law Enforcement, in the DEP Division of Fish and Wildlife, and the Division of State Police, in the Department of Law and Public Safety, enforce the provisions of the statutes and the preceding rules.

The Department of Health and Senior Services is responsible for the certifications of wholesale shellfish establishments and, in conjunction with the BMWM, administers the depuration program.

The division of authority between the three agencies can be seen in Figure 1.

FIGURE 1: STATE OF NEW JERSEY SHELLFISH AGENCIES



IMPORTANCE OF SANITARY CONTROL OF SHELLFISH

New Jersey waters are home to hard clams, soft clams, blue mussels, surf clams, and oysters. Mussels and oysters are found on hard surfaces, like bulkheading, while clams burrow into the sandy bottom. The growth rate of these bivalves depends a lot on water quality, but it usually takes a few years for these species to reach an appropriate size.

Emphasis is placed on the sanitary control of these shellfish because of the direct relationship between the pollution of shellfish growing areas and the transmission of diseases to humans. Shellfish-borne infectious diseases are generally transmitted via a fecal-oral route. The pathway is complex and quite circuitous (see Figure 2). The cycle usually begins with fecal contamination of the shellfish growing waters. Contamination reaches the waterways via runoff and direct discharges. Sources of such contamination are many and varied, and include urban and storm water runoffs, faulty septic systems, boat dumping, agricultural runoff, waterfowl, and animal wastes. Filter feeding molluscan shellfish, known as bivalves (clams, oysters, and mussels), pump large quantities of water through their bodies during the normal feeding process. During this process the shellfish also collect microorganisms, which may include pathogenic microbes, and toxic heavy metals/chemicals. It is imperative that a system is in place to reduce the human health risk of consuming shellfish from areas of contamination.

Accurate classifications of shellfish growing areas are completed through a comprehensive sanitary survey. The principal components of the sanitary survey report include:

1. An evaluation of all actual and potential sources of pollution,
2. An evaluation of the hydrography of the area, and
3. An assessment of water quality.

Complete intensive sanitary surveys are conducted every 12 years with interim narrative evaluations, reappraisals, completed on a three-year basis. Reappraisal reports are less detailed discussions of the principle components included in the sanitary surveys. In addition, the reappraisal report does not require a full shoreline survey. If major changes to the shoreline or bacterial quality occur, then the intensive sanitary survey report is initiated prior to its l2 year schedule. If only a section of a growing area is either upgraded or downgraded from its current shellfish classification, a partial intensive report (Partial Sanitary Survey) is conducted for that shellfish growing area. Annual Reviews are written on a yearly basis for each shellfish growing area.

This report is a reappraisal of the Central Barnegat Bay area (BB2).

After assessment of the growing area, the accurate classification can be

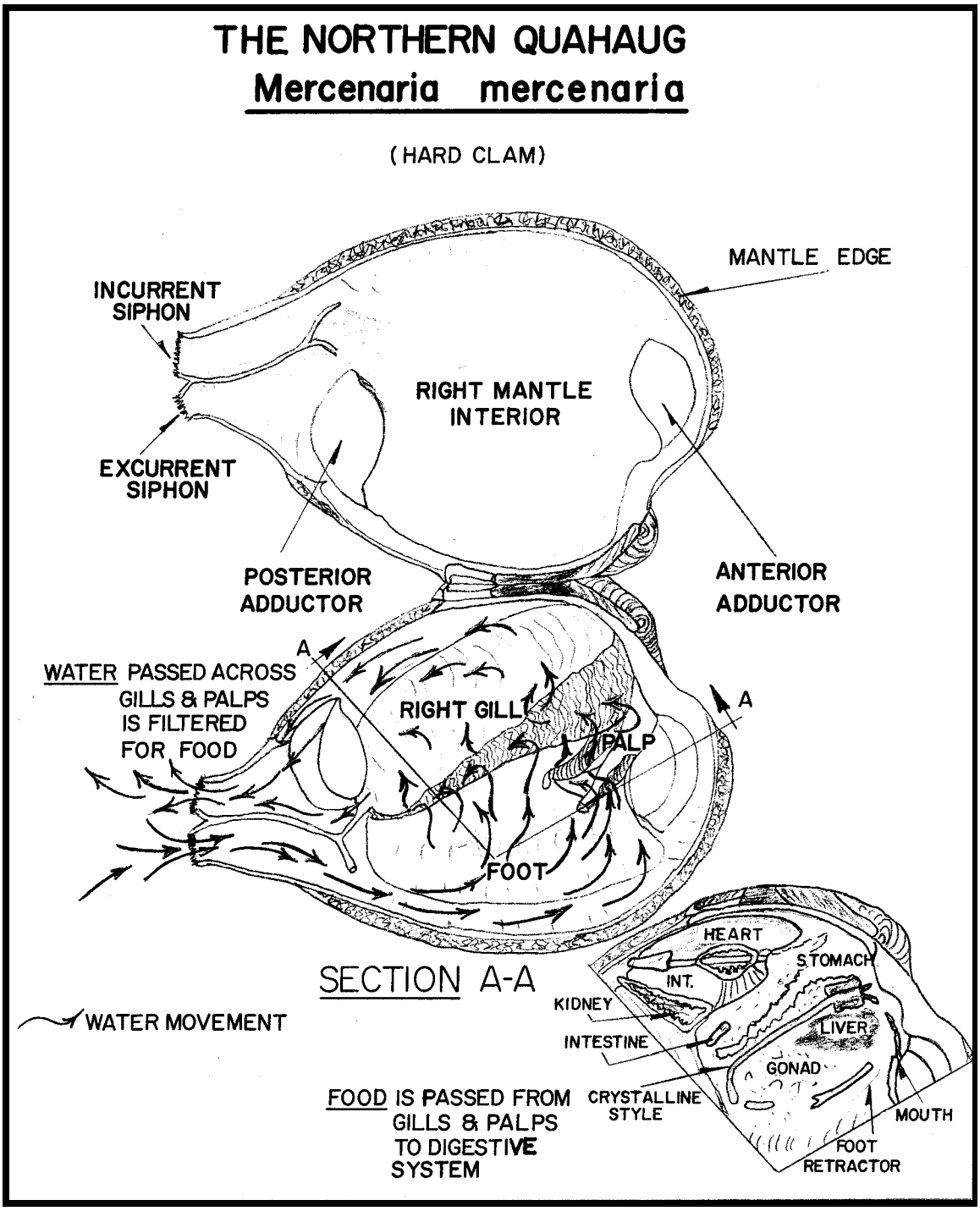
determined. The possible classifications are *Approved, Seasonal, Special Restricted*, and *Prohibited*. *Approved* waters can be harvested for shellfish all year round. *Seasonal* waters can be harvested for all, or part, of the winter; there is a *Seasonal (Nov-Apr)* classification and a *Seasonal (Jan-Apr)* classification. *Special Restricted* waters are approved for harvest, followed by depuration or relay, which help to cleanse bacteria from the shellfish. Depuration is a process that purifies the shellfish by pumping UV treated bacteria-free water through clam holding tanks for a minimum of 48 hours, which will, "render the depurated shellfish alive, and microbiologically acceptable within the meaning of State statutes and regulations" (N.J.A.C. Chapter 12 7:12-1.2, 12-3). Relaying means taking the market size shellfish from *Special Restricted* waters for replanting in *Approved* areas where they purge for a minimum of 30 days. Harvesting clams for either depuration or relay requires issuance of a Special Permit, acquired at the Bureau of Marine Water Monitoring. No harvest is allowed in *Prohibited* waters.

If, over time, the data support improving water quality and are within the requisite criteria, then an upgrade in classification can be made. However, if the data show values exceeding criteria, then the downgrading of that particular area is required.

According to harvesting regulations, there can be no shellfish taken from waters before sunrise or after sunset or on Sundays, except as provided in N.J.S.A. 50:2-1 (NJDEP Shellfish Growing Water Classification Charts). Only those who hold a Commercial Clam License may catch more than 150 clams a day or sell or offer the clams for sale. All hard clams harvested must be at least 1½ inches in length (NJDEP Shellfish Growing Water Classification Charts).

The following narrative of the Central Barnegat Bay growing area constitutes this bureau's assessment of the above - mentioned principal components to comply with the three-year reappraisal. Additionally, a partial shoreline survey was completed.

FIGURE 2: CROSS-SECTION OF MERCENARIA MERCENARIA



PROFILE OF GROWING AREA

LOCATION OF GROWING AREA

This growing area, the Central Barnegat Bay, is located in Ocean County and includes the waters of the Toms River, Cedar Creek, and the central section of the Barnegat Bay. For the designation of shellfish growing areas, the waters of the entire Barnegat Bay are broken up into northern, central, inlet, and southern sections. This growing area is referred to as the Central Barnegat Bay area. The northern boundary is Bay Shore, a small community north of the Mathis Bridge. The southern boundary is Sunrise Beach, located in Forked River, eight miles south of the Mathis Bridge (See Figure 3). The last Sanitary Survey for this area was completed in 2000.

Ten municipalities surround this growing area; Dover Township, Island Heights Borough, South Toms River Borough, Beachwood Borough, Pine Beach Borough, Ocean Gate Borough, Berkley Township, Lacey Township, Seaside Park Borough, and Seaside Heights Borough.

This area is displayed on chart # 4 of the current State of New Jersey Shellfish Growing Water Classification Chart. The population statistics for the adjacent municipalities are shown in Table 1 (Census 2000).

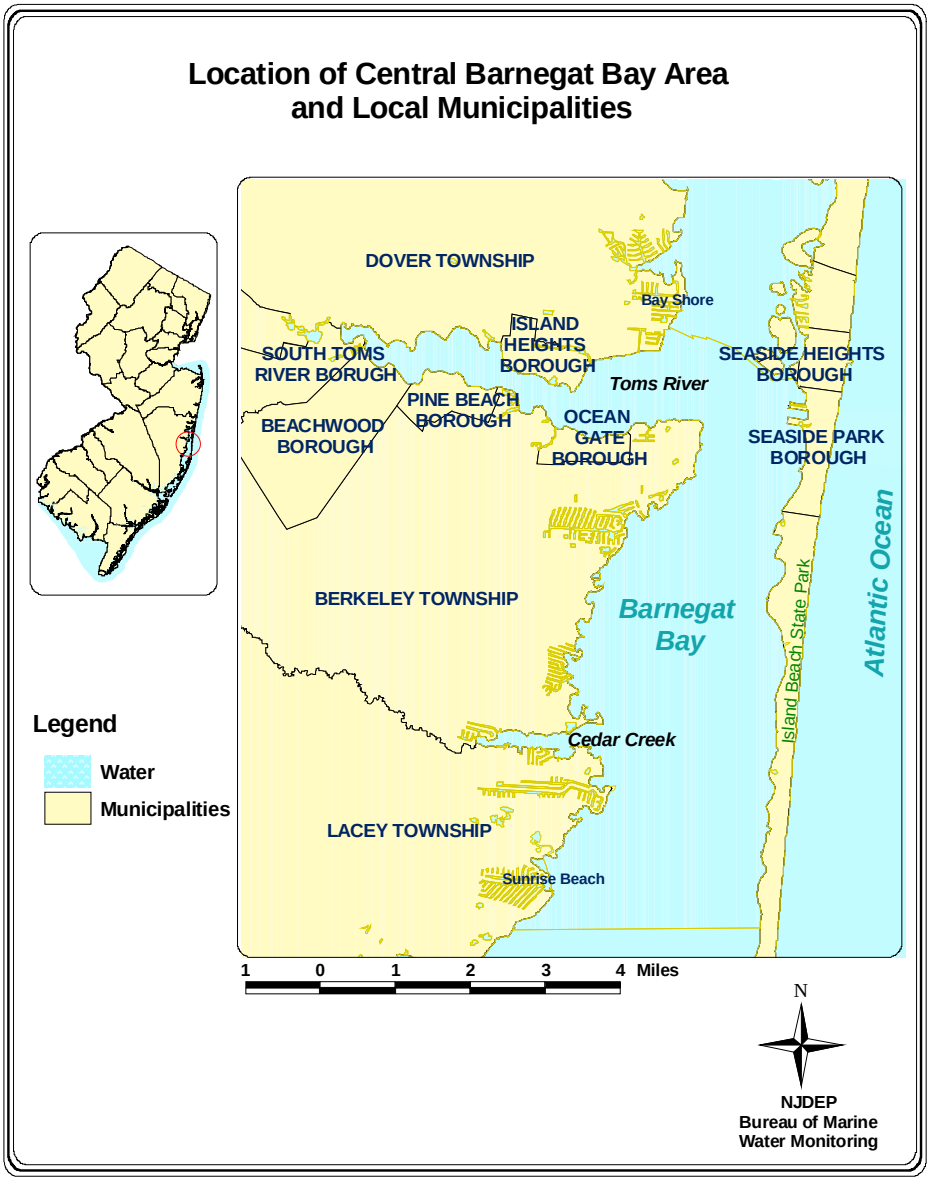
TABLE 1: POPULATION INFORMATION FOR THE CENTRAL BARNEGAT BAY

Community	Area (Square Mile/s)	Population (2000 Census)	Population Density (Population/Sq. Mi.)
Dover Township	44.0	89,706	2,038.8
Island Heights Borough	0.6	1,751	2,918.3
South Toms River Borough	1.2	3,634	3,028.3
Beachwood Borough	2.5	10,375	4,150.0
Pine Beach Borough	0.6	1,950	3,250.0
Ocean Gate Borough	0.5	2,076	4,152.0
Berkley Township	42.9	39,991	932.2
Lacey Township	87.0	25,346	291.3
Seaside Park Borough	0.9	2,263	2,514.4
Seaside Heights Borough	0.3	3,155	10,516.7

In 1990, the populations of these municipalities totaled 158,763. The year round populations of these municipalities increased within the last decade. According to the 2000 Census,

the populations of these same municipalities totaled 180,247, an increase of about 11%. The summertime populations of these municipalities are much higher; on average these municipalities see a 20% population growth during the summer months (Barnegat Bay Estuary Program, 2003).

FIGURE 3: LOCATION AND MUNICIPALITIES



DESCRIPTION OF GROWING AREA

The Central Barnegat Bay region includes the waters of Toms River, Cedar Creek, and a large section of Barnegat Bay. This growing area includes almost 13,500 acres of marine waters. Some 8,850 acres are *Approved* waters, approximately 1,085 acres are *Seasonal (Nov-Apr)*, about 2,040 are *Special Restricted*, and roughly 1, 525 acres are *Prohibited*.

Toms River is a large waterway surrounded by urban areas. The inland waters of Toms River are *Prohibited* for harvesting shellfish. Both the land use and the nominal amount of resources in this region contribute to keeping these waters classified as *Prohibited* (Farnsworth, 2000). The eastern portion of Toms River is *Special Restricted*, which was upgraded in the last Sanitary Survey (2000) due to improving water quality. There are many small tributaries that feed into Toms River, which include Davenport's Branch, Jake's Branch, Union Branch, and Wrangle Brook. These freshwater inputs mix with the salt water of the bay to create an estuary.

The Barnegat Bay Inlet can be found just north of Barnegat Light, approximately seven miles southeast of Cedar Creek. The inlet governs the tides in Barnegat Bay and provides a tidal flush for the bay water.

The majority of the western coastline of the Central Barnegat Bay is wetlands, with a mix of urban and forested areas further inland. The greater part of the eastern coastline is Island Beach State Park, a natural habitat for birds and wildlife. Further north on the eastern coastline are the boroughs of Seaside Heights and Seaside Park, which have high urban land use, especially during the summer. There are numerous minor streams and creeks in this growing area, as well as many lagoon systems.

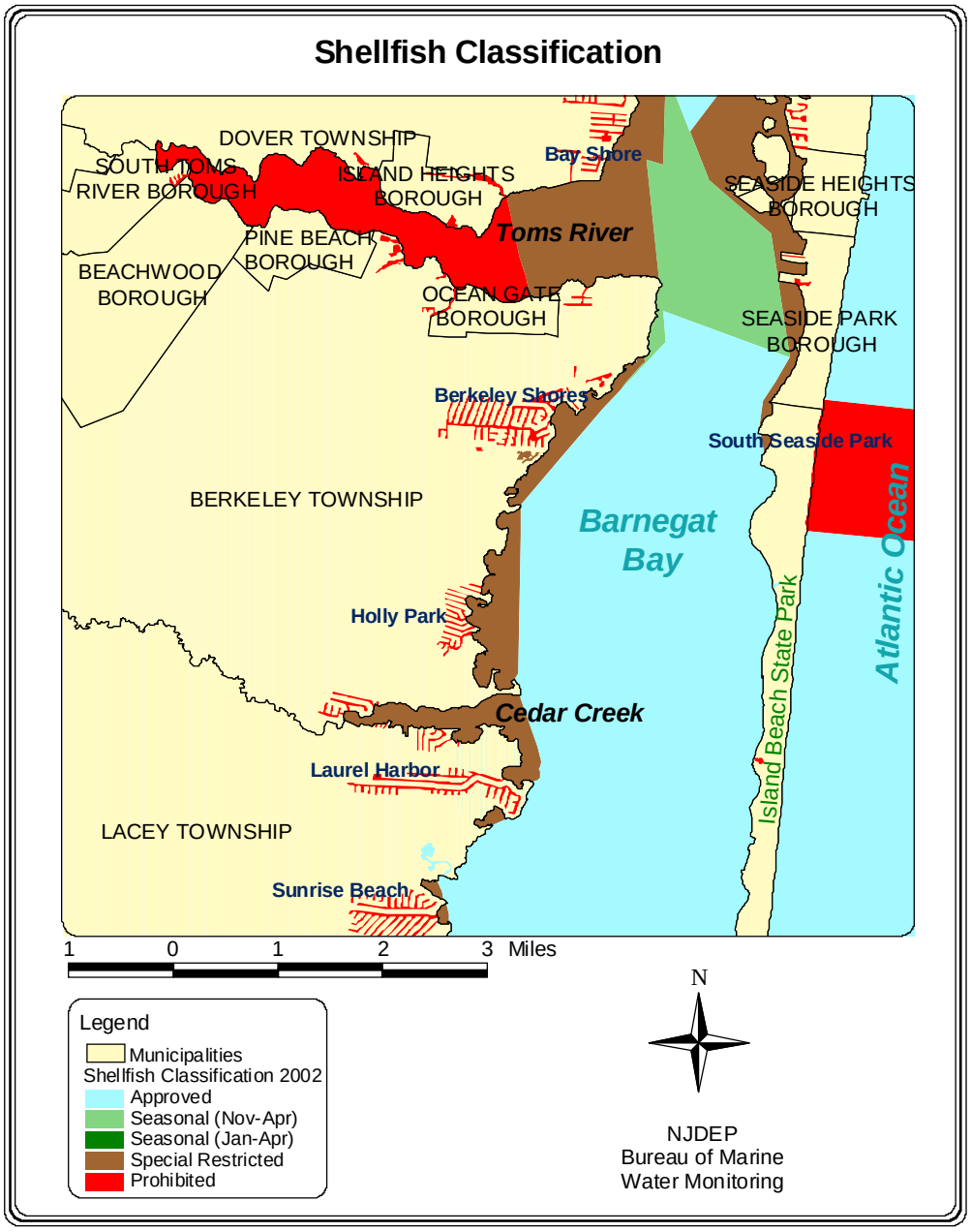
Much of the Central Barnegat Bay area is *Approved* for harvesting shellfish, with buffers of *Seasonal, Special Restricted,* or *Prohibited* around the urbanized areas and marinas (see Figure 4).

There are many marinas in this area, which have significant high use in the summer months due to the influx of tourists. The tourist industry produced 1.67 billion dollars in 1998 for Ocean County alone (Barnegat Bay Estuary Program, 2003). Seaside Park and surrounding areas are well known tourist spots on the Jersey Shore during the summer. Therefore, the waters in the summertime often receive more pollutants due to factors like an increased population and recreational boating.

The Central Barnegat Bay area (north of Cedar Creek), including Toms River, is not currently productive, according to the last clam census in the 1980's done by Fish, Game, & Wildlife (see Figure 10). The Inlet and Southern Barnegat Bay growing areas are relatively productive for clams. In these aforementioned growing areas, there are relay beds where clams from naturally productive *Special Restricted* areas are transplanted to *Approved* waters to purge

themselves of bacteria for 30 days. Although there are minimal amounts of the various species within the Central Barnegat Bay, the most densely populated and economically productive species is *Mercenaria mercenaria* (hard clam).

FIGURE 4: CURRENT CLASSIFICATION OF CENTRAL BARNEGAT BAY



HISTORY OF GROWING AREA

The Central Barnegat Bay area is divided into four assignment runs, one in Toms River and the remaining three in the Barnegat Bay section. Toms River was sampled under the Adverse Pollution Condition of rainfall until 1998. Then the sampling strategy was modified to Systematic Random Sampling (see Sampling Strategy below for further information).

The other three assignment runs are within Barnegat Bay. Barnegat Bay was sampled under the Adverse Pollution Condition of rainfall until 1997, when the sampling strategy was modified to Systematic Random Sampling. Presently, all four assignment runs are sampled under the Systematic Random Sampling Strategy.

Over the last five years there were upgrades to some sections of the Central Barnegat Bay area. In 1998, a change in the shellfish water classification of this area occurred in the vicinity of Seaside Park, where 1,267 acres of *Seasonal (Jan-Apr)* waters were upgraded to a *Seasonal (Nov-Apr)* classification.

In the last Sanitary Survey (2000), the mouth of the Toms River was upgraded from *Prohibited* to *Special Restricted*.

A large middle section of Barnegat Bay was also upgraded in the last Sanitary Survey from *Seasonal (November – April*) to *Approved*. The bay area outside of Cedar Creek, located between Berkley Township and Lanoka Harbor, was also upgraded in classification from *Seasonal (November – April)* to *Approved*.

These reclassifications are all a result of improving bacterial water quality in the area (see Figure 4 for current classifications).

In 2004, a 3-acre buffer was added to Wheelhouse Marina, which is located just north of Island Beach State Park in the Central Barnegat Bay area (NJDEP, 2004; see Appendix F). This classification change was a downgrade from *Approved* to *Seasonal (Nov – Apr)*. This downgrade will also be included in an upcoming New Jersey report on marinas.

METHODS

Water sampling was performed in accordance with the Field Procedures Manual (NJDEP, 1992).

Approximately 3,841 water samples were collected in Central Barnegat Bay for total and fecal coliform bacteria testing between January 1, 1999 and December 31, 2002 and analyzed by the three tube MPN method according to American Public Health Association (1970). Figures 5 & 6 show the Shellfish Growing Water Quality monitoring stations in the Central Barnegat Bay. Nearly 1,640 stations total are monitored each year for coliform levels throughout the state; 103 are located in the Central Barnegat Bay area.

Water quality sampling, shoreline, and watershed surveys were conducted in accordance with the NSSP *Guide for the Control of Molluscan Shellfish,* 1997.

Data management and analysis were accomplished using database applications developed for the Bureau of Marine Water Monitoring. The mapping of data was performed with the Geographic Information System (GIS:Arcview®).

FIGURE 5: NORTHERN STATIONS OF CENTRAL BARNEGAT BAY

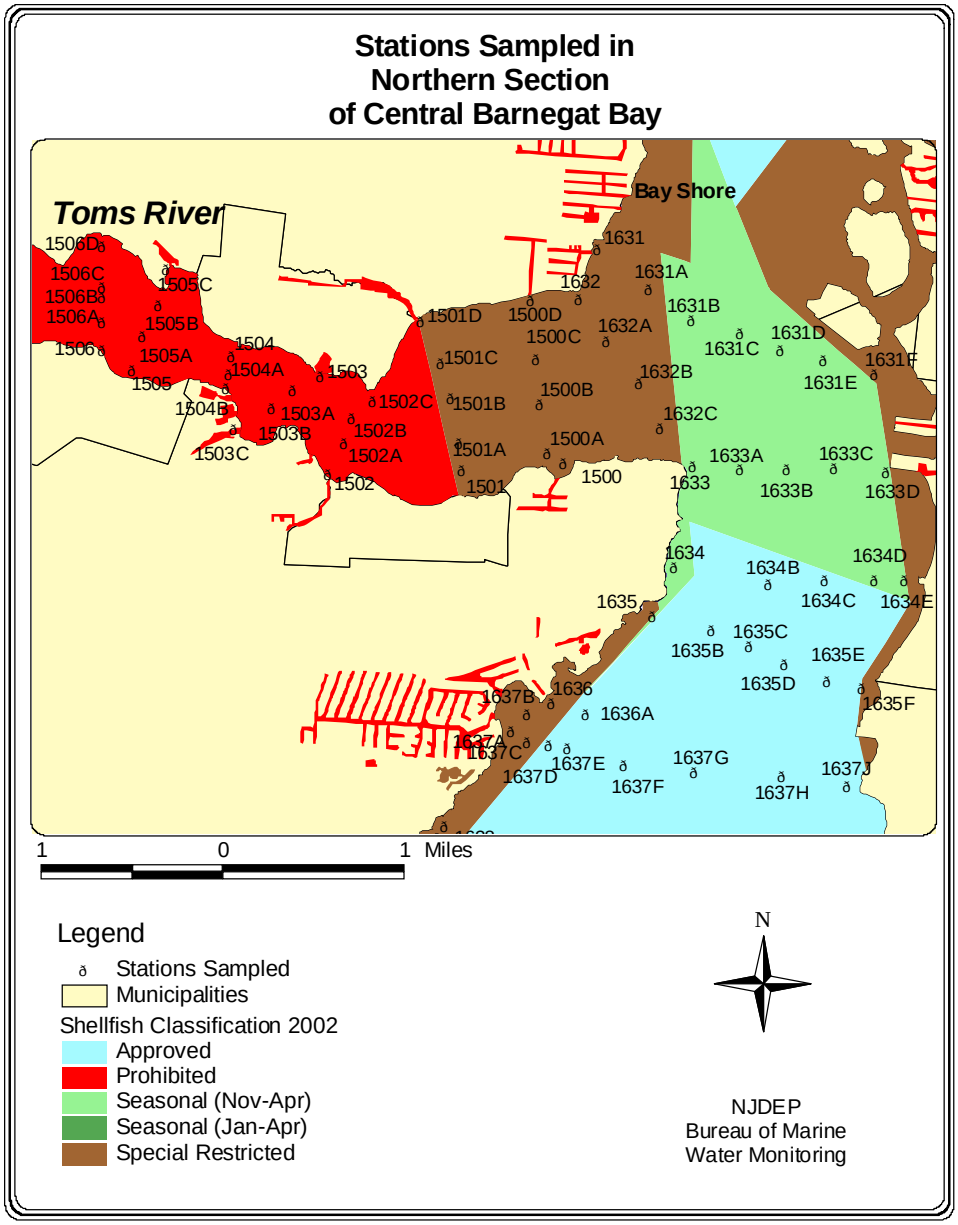
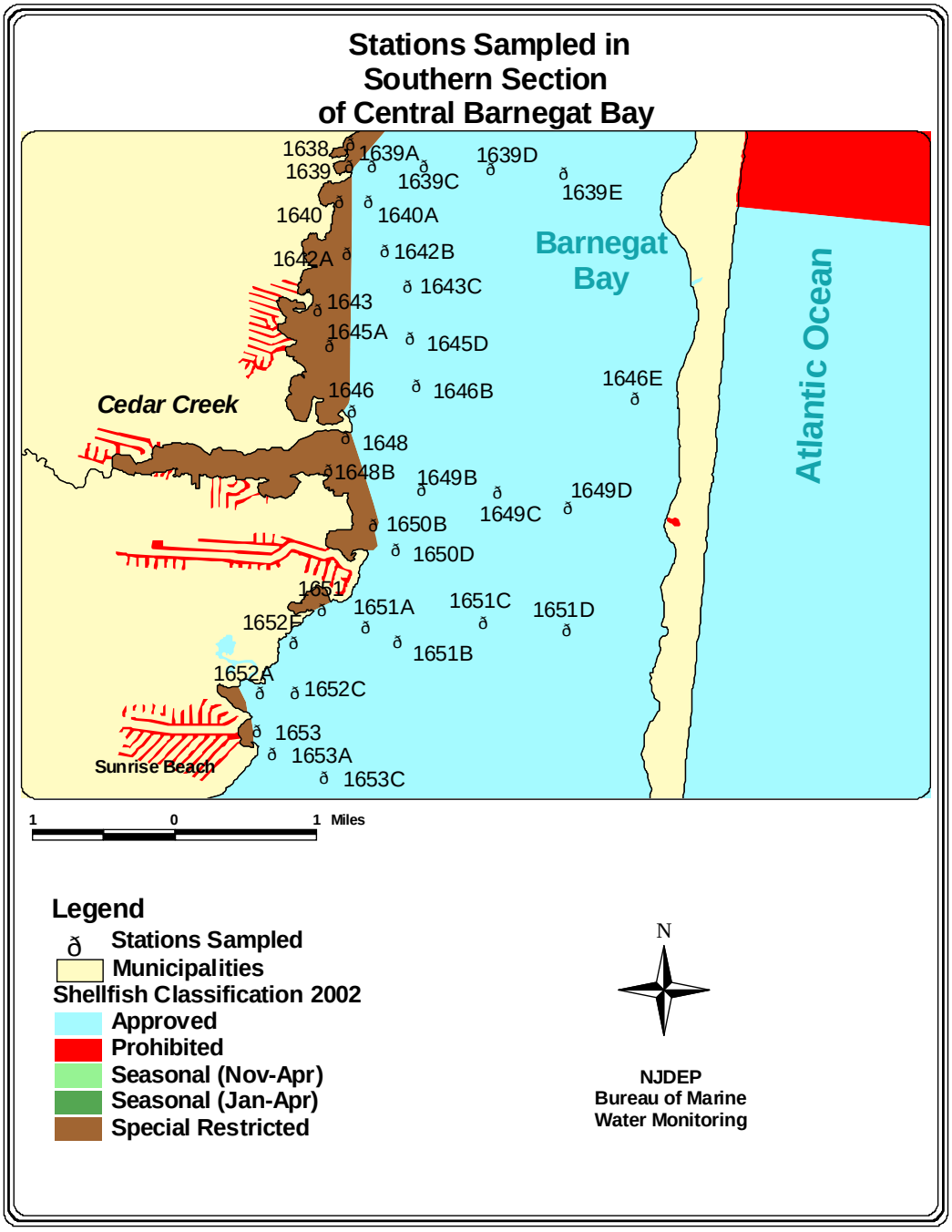


FIGURE 6: SOUTHERN STATIONS OF CENTRAL BARNEGAT BAY



BACTERIOLOGICAL INVESTIGATION AND DATA ANALYSIS

The water quality of each growing area must be evaluated before an area can be classified as *Approved, Seasonal, Special Restricted,* or *Prohibited. Approved* waters can be harvested for shellfish all year round. *Seasonal* waters can be harvested for all, or part, of the winter; there is a *Seasonal (Nov-Apr)* classification and a *Seasonal (Jan-Apr)* classification. *Special Restricted* waters are approved for harvest, followed by depuration or relay, which help to cleanse bacteria from the shellfish. No harvest is allowed in *Prohibited* waters.

Criteria for the bacterial acceptability of shellfish growing waters are provided in the NSSP *Guide for the Control of Molluscan Shellfish,* 1999 Revision.

SAMPLING STRATEGY

The State Shellfish Control Authority has the option of choosing one of the two water monitoring sampling strategies for each growing area.

The Adverse Pollution Condition Strategy requires that a minimum of five samples be collected each year under conditions that have historically resulted in elevated coliforms in that particular growing area. The results must be evaluated by adding the individual station sample results to the preexisting bacteriological sampling results to constitute a data set of at least 15 samples for each station. The adverse pollution conditions usually are related to tide and rainfall, but could be from a point source of pollution or variation could occur during a specific time of the year.

The Systematic Random Sampling strategy requires that a random sampling plan be in place before field sampling begins. This strategy can only be used in areas that are not affected by point sources of contamination. A minimum of six samples per station are to be collected each year and added to the database to obtain a sample size of 30 for statistical analysis.

The Central Barnegat Bay area is sampled under the Systematic Random Sampling strategy described above (see Table 2 for the Total Coliform and Fecal Coliform criteria under this strategy).

NSSP CRITERIA

Each shellfish-producing state is directed to adopt either the total coliform criterion, or the fecal coliform criterion. While New Jersey bases its growing water classifications on the total coliform criterion, it does make corresponding fecal coliform determinations for each sampling station. These data are viewed as adjunct information, and are not directly used for classification.

The total coliform criterion was developed to ensure that shellfish harvested from the designated waters would be free of pathogenic (disease-producing) bacteria. Each classification criterion is composed of a measure of the statistical 'central tendency' (geometric mean) and the relative variability of the data set. For the Systematic Random Sampling Strategy, variability is expressed as the Estimated 90th percentile (see Table 2). For the Adverse Pollution Condition sampling strategy, variability is expressed as the percentage that exceeds the variability criteria (see Table 3).

TABLE 2: CRITERIA FOR SYSTEMATIC RANDOM SAMPLING STRATEGY

	Total Coliform Criteria		Fecal Coliform Criteria	
	Geometric mean (MPN/100 ml)	**Estimated 90th percentile** (MPN/100 ml)	**Geometric mean** (MPN/100 ml)	**Estimated 90th percentile** (MPN/100 ml)
Approved Water Classification	70	330	14	49
Special Restricted Water Classification	700	3300	88	300

TABLE 3: CRITERIA FOR ADVERSE POLLUTION CONDITION SAMPLING STRATEGY

	Total Coliform Criteria		Fecal Coliform Criteria	
	Geometric mean (MPN/100 mL)	**No more than 10% of samples can exceed** (MPN/100 mL)	**Geometric mean** (MPN/100 mL)	**No more than 10% of samples can exceed** (MPN/100 mL)
Approved Water Classification	70	330	14	49
Special Restricted Water Classification	700	3300	88	300

SHORELINE SURVEY

CHANGES SINCE LAST SURVEY

In March of 2003, "the Trust for Public Land purchased and donated 211 acres on Good Luck Point, previously owned by AT&T, to the United States Fish and Wildlife Services for addition to the Edwin B. Forsythe National Wildlife Refuge system" (Maskaly, 2003). This acquisition, which is located within this growing area, will help preserve these wetlands for the native wildlife and their habitats (see Figure 7).

The Shoreline Survey revealed some new residential development in the area of Good Luck Point. Most of the new developments were along lagoons, likely adding more outfalls to the area. There is also a great deal of ditching in this area, some which appear to be relatively new. Mosquito ditches are thin trenches patterned over a portion of wetlands. Mosquito ditches help prevent the spread of the West Nile Virus by allowing fish to come into the wetlands to eat the mosquito larvae. West Nile Virus is transmitted by female mosquitoes and affects various species including birds and humans. It is also debated that mosquito ditches prove harmful to the natural environment, by reducing the salt marsh soil and plant mass. The use of pesticides to control mosquito populations might also negatively influence the water quality, although this will not be assessed in this report. The condition of the wetlands is very important to the health of the shellfish due to their indirect link via the food web.

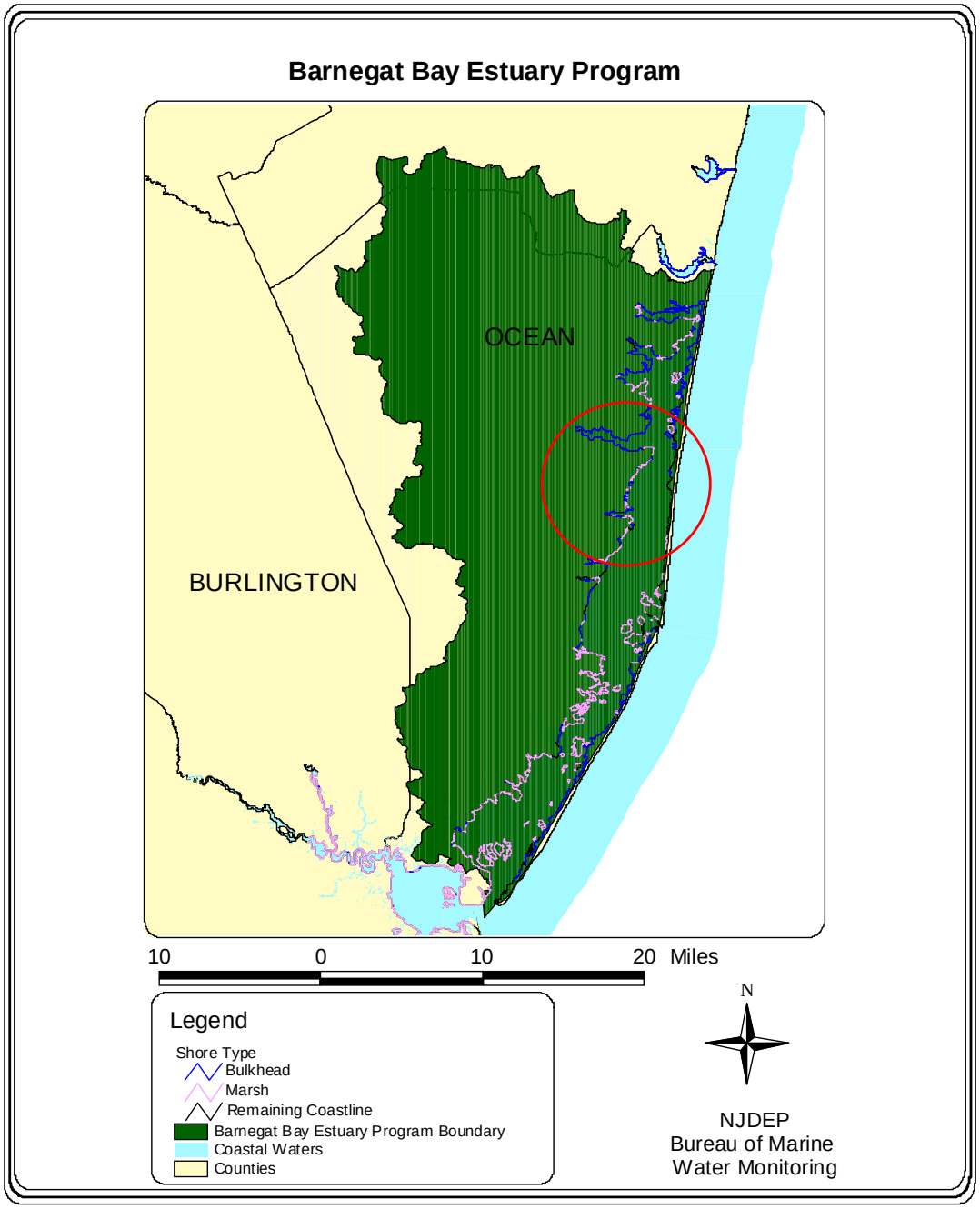
According to Captain Don Owens, who collects samples in these waters for the Bureau of Marine Water Monitoring, new construction and upgrades to bulkheading have recently occurred in the Central Barnegat Bay area. Approximately 45 percent of the Barnegat Bay Estuary shoreline is bulkheaded (Barnegat Bay Estuary Program, 2003; see Figure 8). Beach and shallow water habitats are taken away from birds and other creatures when bulkheads are constructed. Additionally, bulkheading is often made of pressure-treated wood, which harbors many harmful chemicals, like arsenic, cadmium, chromium, and copper.

"The Barnegat Bay watershed is highly susceptible to environmental degradation. Historically, these waters have served as repositories for raw sewage, sewage effluent, toxins, and garbage. Estuarine wetlands and shorelines, and inland areas have been destroyed or modified to accommodate development" (Barnegat Bay Estuary Program, 2003). The Barnegat Bay Estuary Program will play a vital role in keeping the waters healthier for the

public, as well as the shellfish. Some of their proposed goals include: a non-point source pollution project; taking steps to eliminate pathogen contamination; and recovering habitat loss. "The NJDEP, Bureau of Marine Water Monitoring has provided substantial amounts of current and historic bacteriological water quality data to the Barnegat Bay Estuary Program. The data have been useful in characterizing water quality conditions, ecosystem characteristics, and resource status in the Bay region" (Farnsworth, 2000).

FIGURE 7: GOOD LUCK POINT - AREA OBTAINED FROM AT&T AND ADDED TO THE EDWIN B. FORSYTHE NATIONAL WILDLIFE REFUGE - PICTURE TAKEN APRIL 30, 2003

FIGURE 8: BARNEGAT BAY ESTUARY PROGRAM (SHOWING BULKHEADING)



LAND USE

The majority of land use in this area is divided into urban, wetlands, and forested areas (see Figure 9). Island Beach State Park and Good Luck Point are wetland areas. Wetlands serve to purify water and organic and inorganic materials are removed for plant growth. Therefore, the wetlands contribute to maintaining the water quality in this area.

Urban areas are found along Toms River, in occasional pocketed lagoon areas along the western shoreline, and north of Island Beach State Park. These areas experience population fluxes each year, high in summer, lower in winter.

Forested areas are interspersed around the Central Barnegat Bay. Several forested areas are within the National Pinelands Reserve; others are parks and undeveloped sections. If the trend of new urban development persists in this area, the acres of forested areas will continue to dwindle.

Agricultural land use is not particularly high in this area; furthermore, the agricultural areas tend to be situated inland. Therefore, as runoff travels over land and through streams, where pollutants can be removed by vegetation and by adsorption to sediments. As such, sources inland can be expected to have less of an impact to coastal waters than sources located directly adjacent to those same coastal waters.

Populations of birds have been known to congregate in various places within this growing area. Birds that frequent the area for breeding purposes include the, "gull-billed tern, common tern, least tern, great blue heron, herring gull, great egret, snowy egret, little blue heron, tri-colored heron, black-crown night heron, glossy ibis, laughing gull, great black-backed gull, and black skimmer" (Barnegat Bay Estuary Program, 2003). On the shoreline survey there were observations of laughing gulls, snowy egrets, and various geese. Oftentimes, the waterfowl nest within the wetlands, where runoff washes their wastes directly over the land and into streams and bays.

Runoff is a term for the surface water that moves from land to the ocean. During this transition the water picks up both nutrients and pollutants. While some of this runoff provides nutrients for plants and animals, excessive nutrient loads can lead to eutrophic conditions.

Runoff brings various pollutants into streams, bays, oceans, and other water bodies. Aside from bird wastes, the runoff also brings pollutants like agricultural pesticides, animal waste, and remnants from faulty septic systems. In this region, runoff from the urban areas is most likely to have a negative impact on nearby water bodies.

One might consider the impact of animal waste on water contamination insignificant; however, this is a serious issue. Fecal waste carries a lot of bacteria, and runoff can easily bring the bacteria to swimming beaches and other water bodies. Among other things, this can cause sicknesses of humans and animals, and the contamination of shellfish. Faulty septic systems create the same problem, bringing bacteria-

laden runoff back to streams, lakes, bays, and eventually the Atlantic Ocean.

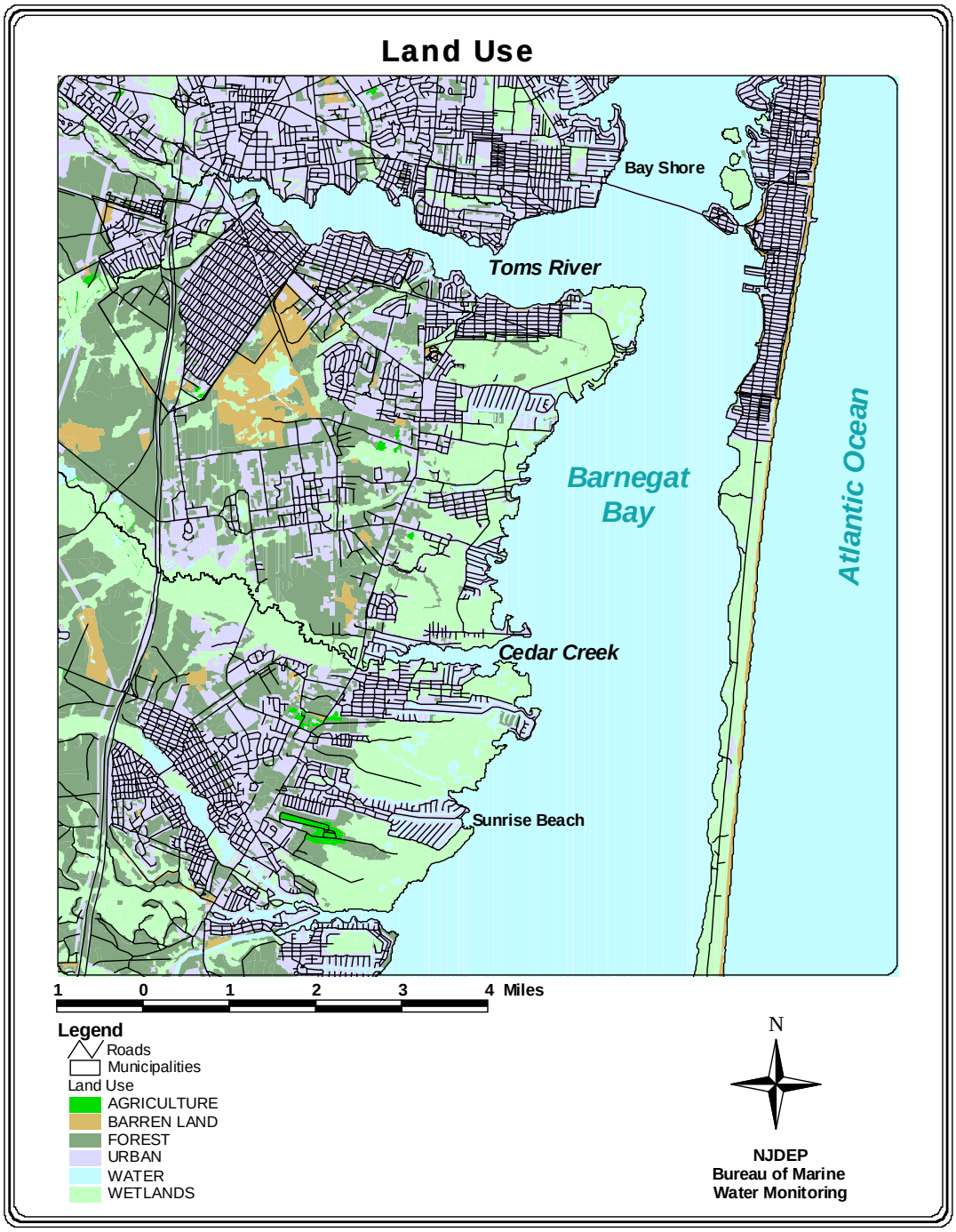
The back-bay waters make the Central Barnegat Bay area a suitable locale for lagoon communities. A lagoon is essentially a manmade canal, surrounded by bulkheaded properties, with access to the bay. Lagoon communities gradually became regulated under the Wetlands Act of 1970. In 1978 construction of lagoon communities was greatly restricted. Work in lagoons became regulated in September 1980 (Ehinger, 2005). Lagoon areas are laden with storm water outfalls that often drain directly into the canal water. Additionally, many homeowners have docks, which are used to store their own boats. Although there are pump out stations at many marinas, some boat owners will discharge sanitary waste directly into the bay water. For these reasons, all lagoons are classified as *Prohibited*. The area directly outside all lagoons are appropriately classified as *Prohibited, Seasonal (Nov - Apr), Seasonal (Jan - Apr),* or *Special Restricted*.

TABLE 4: LAND USE BREAKDOWN OF BARNEGAT BAY WATERSHED (IN ACRES)

Land Use Type	1986	1995	Net Change
Agriculture	7,142	5,738	-1,404
Barren Land	10,471	9,644	-827
Forest	163,395	155,883	-7,512
Water	74,610	74,499	-111
Urban Land	77,278	87,935	10,658
Wetlands	92,141	91,338	-803

From 1986 to 1995 there was a substantial increase in the amount of urban land development, which demonstrates the high growth of this region (see Table 4). Extensive portions of the 1995 urban acreage were previously agriculture and forest acreage. This general trend has continued since 1995 throughout Ocean County, and the whole state. As a result, New Jersey has begun to concentrate on 'Smart Growth'; an effort to preserve the existing natural lands in New Jersey by well managed planning. Most of the Central Barnegat Bay growing area is within Smart Growth Zones (NJDCA, 2005). There is also a statewide Brownfield project, which focuses on improving rundown urban areas to pull in businesses and residents that might otherwise construct new facilities on undisturbed land. Currently, there are no noted Brownfield projects within Ocean County (NJDEP, 2005). Both of these projects are efforts to reduce the amount of natural land lost to urban growth.

FIGURE 9: LAND USE PATTERNS



EVALUATION OF BIOLOGICAL RESOURCES

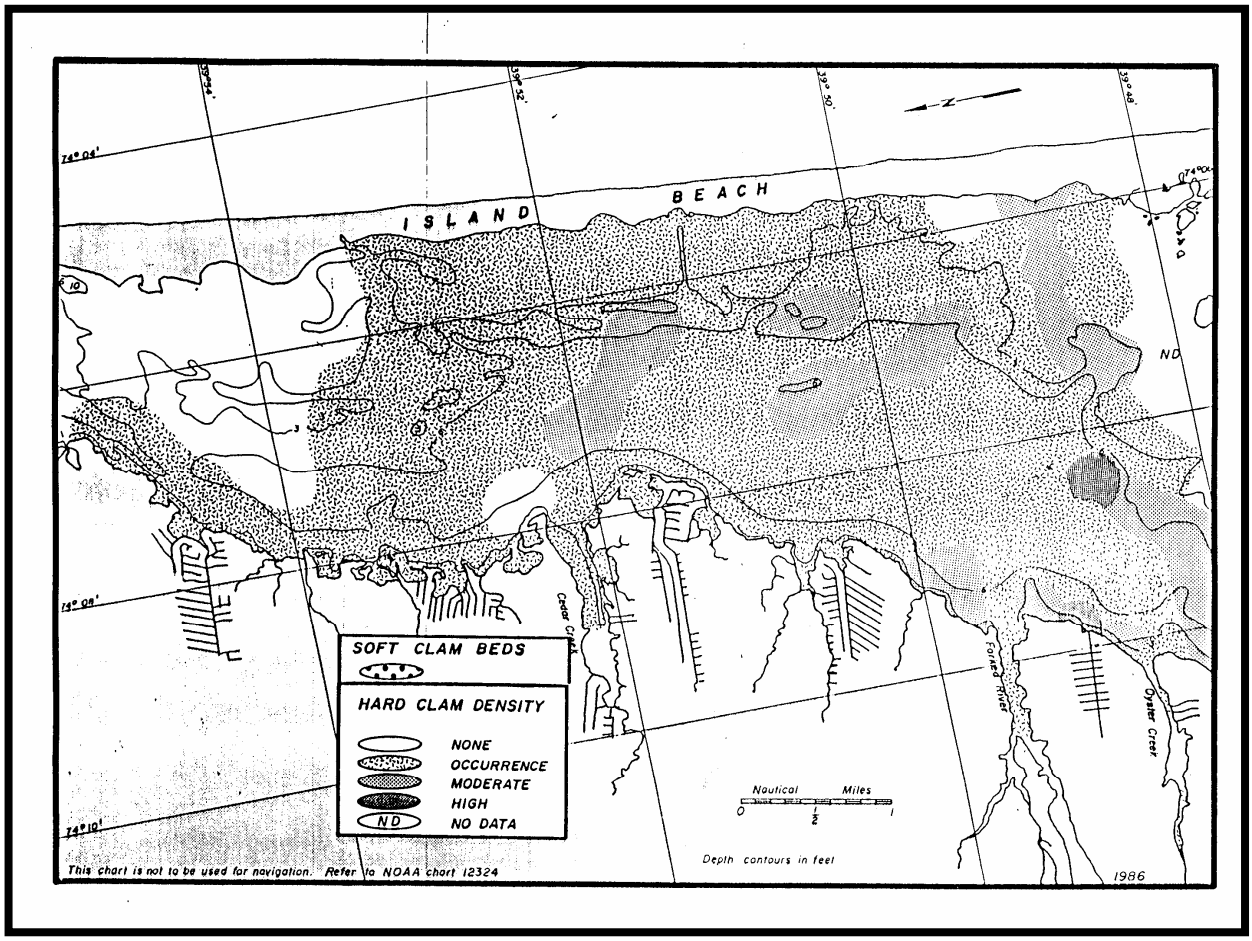
The Central Barnegat Bay area is not productive at this time (see Figure 10). While an occurrence of hard clams was documented in this area in the 1980's, their now appears to be minimal resources (Farnsworth, 2003 & NJDEP Fish, Game, & Wildlife, 1986). However, this does not mean that viable shellfish resources may not be present in the future. Factors that contribute to having a viable resource include: salinity, dissolved oxygen levels, bottom conditions, and predator activity.

Barnegat Bay has been experiencing moderately heavy silting because of low tidal flow, which can cause suffocation in clams (Bates and Moore, 2003).

The Southern Barnegat Bay region is used for the relay program. Clams from *Special Restricted* areas are brought to *Approved* waters to purge themselves for at least 30 days. There is a strict quota set by the New Jersey Shellfish Council. Depuration, where clams filter UV-treated water for 48 hours in a depuration plant, is not convenient to this area because the only depuration plants in New Jersey are located near Sandy Hook. Both depuration and relay require a special permit issued by the Bureau of Marine Water Monitoring.

FIGURE 10: HARD CLAM DENSITY (1986)

- *1986 was the last time a density study was done in this area.*

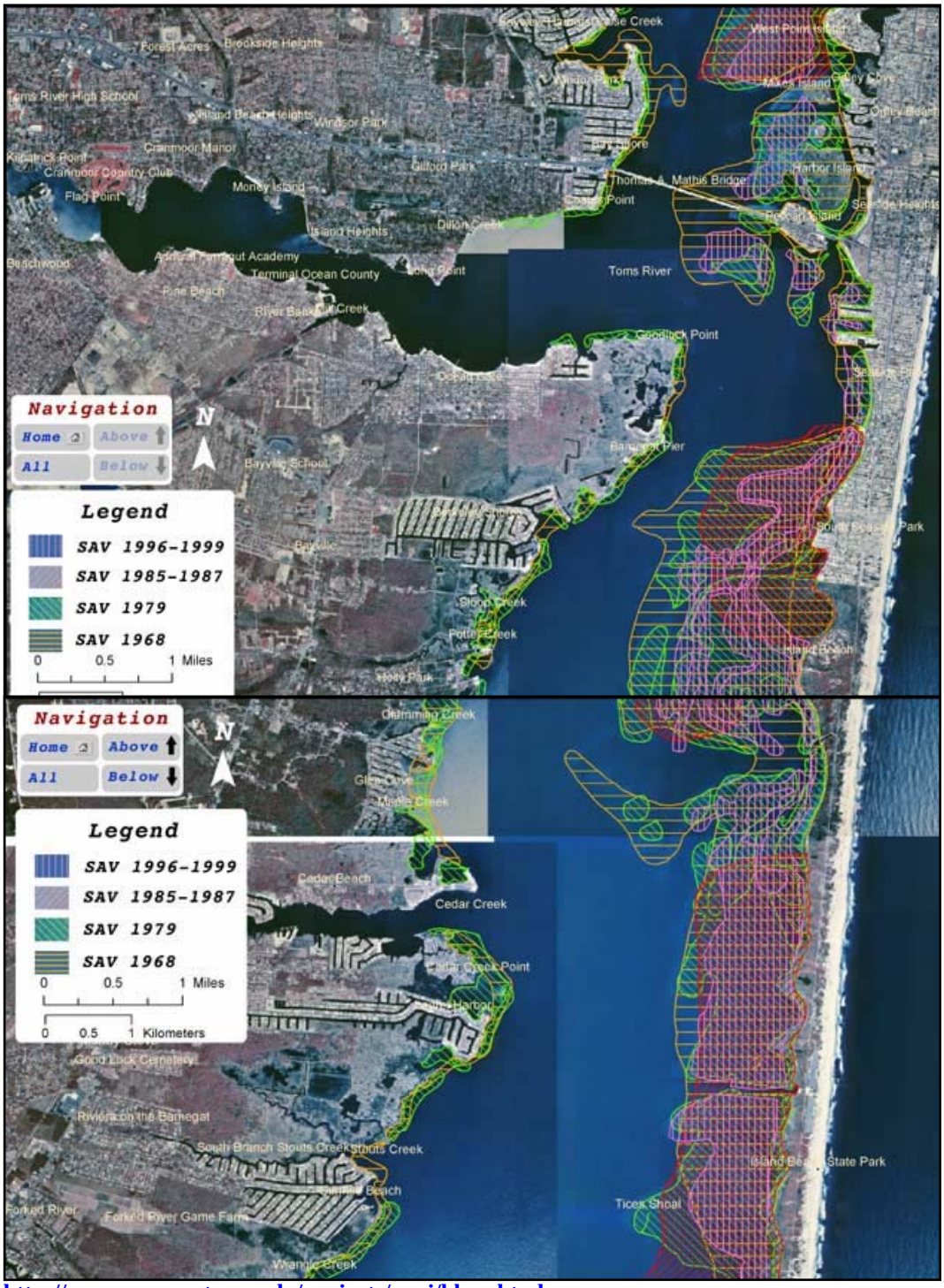


In Barnegat Bay, the submerged aquatic vegetation (SAV) is predominately eelgrass, Zostera marina, and widgeon grass, Ruppia maritima (CRSSA – Rutgers, 2003). The vegetation is an essential part of the bay ecosystem, offering habitats and nursery grounds for numerous species. The SAV of the bay is a good indicator of its overall health. "Barnegat Bay contains over 75% of New Jersey's SAV habitat. Comparison of the 1970's and 1980's with the 1990's surveys show a decrease of nearly 33% in SAV area" (CRSSA – Rutgers, 2003). The main section of SAV in the Central Barnegat Bay area is located on the eastern coastline, along Seaside Park and Island Beach State Park (see Figure 11).

Fortunately for shellfish, many harmful procedures (i.e. dredging, dumping, and filling marshes) have been stopped due to governmental regulations (CRSSA – Rutgers, 2003). However, natural lands continue to disappear due to development. More environmentally significant areas, such as riparian lands, small bird islands, the Pine Barrens, and shoreline buffer areas require increased protection (CRSSA – Rutgers, 2003). All of these environmental changes will help to avert indirect pollutants to the waters, and, consequently, protect the shellfish.

FIGURE 11: LOCATION OF SUBMERGED AQUATIC VEGEATATION IN THE CENTRAL BARNEGAT BAY

*** CRSSA – RUTGERS. BARNEGAT BAY RESOURCES. MARCH 2003.**



http://www.crssa.rutgers.edu/projects/runj/bbay.html

IDENTIFICATION AND EVALUATION OF POLLUTION SOURCES

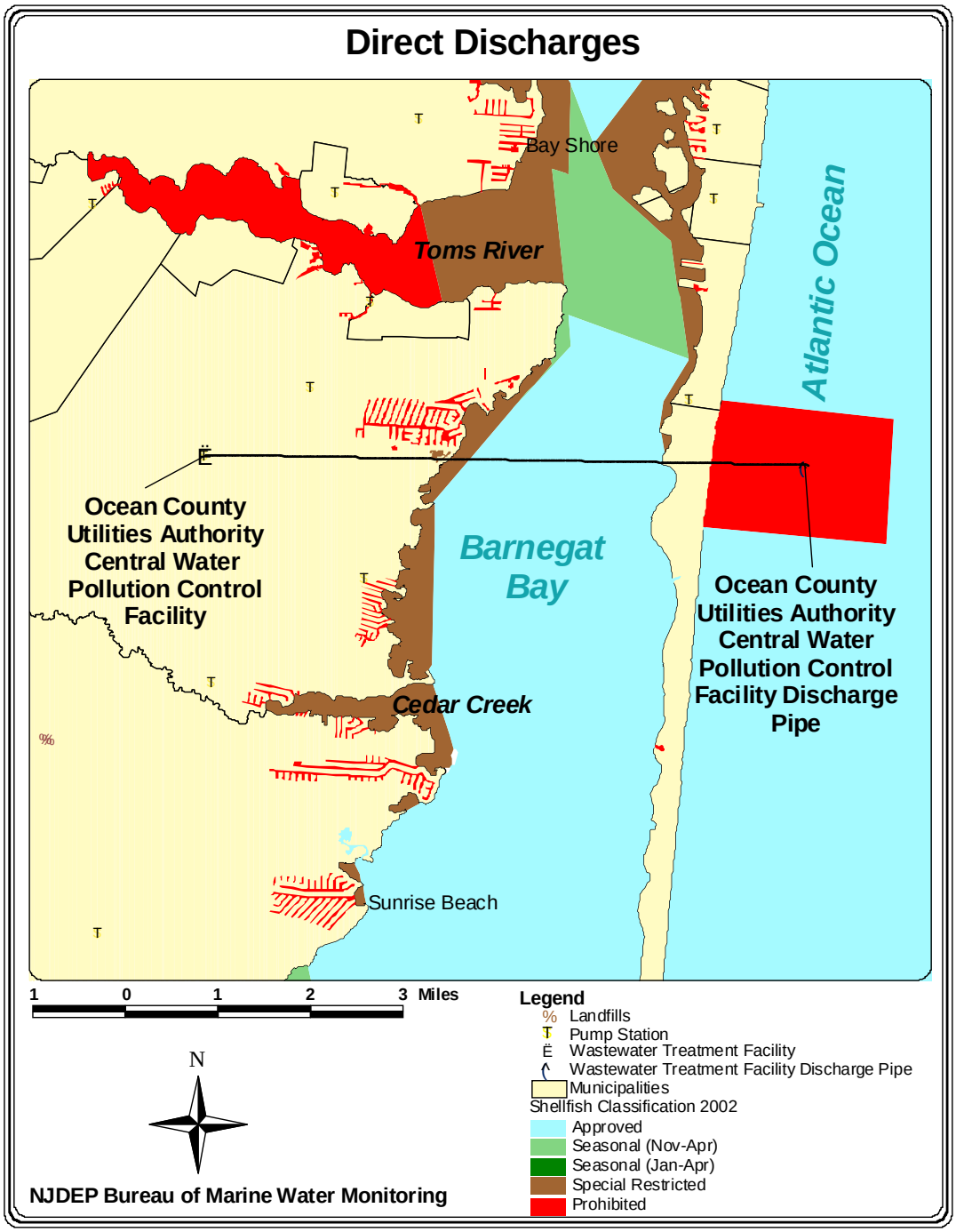
EFFLUENT DISCHARGES

There are no known effluent discharges directly into the Central Barnegat Bay waters. The Ocean County Municipal Utilities Authority (OCMUA) Central Facility treats the domestic wastes and handles the sanitary wastewater. The plant is located three miles south of Toms River and west of Route 9 in Bayville, Berkeley Township. The capacity of the plant is 28-32 million gallons per day (Moore, 2003). The facility sends treated effluent one mile into the Atlantic Ocean at a location east of Seaside Park. As a precautionary measure, the NSSP requires a closed safety zone, so ocean waters adjacent to the outfall line are classified as *Prohibited* for the harvesting of shellfish for a distance of 1.5 miles offshore (see Figure 12). Although the ocean outfall line is not within the confines of the Central Barnegat Bay area; the pipeline runs through this growing area. Therefore, there is the potential for leaks and breaks in the line, which would effect the surrounding waters. Such a leak occurred on February 2, 2003 and, as a result, a large section of the Central Barnegat Bay was temporarily closed for harvest. As of May 2, 2003, the problem was fully remedied and since the coliform levels were within criteria, the closure was lifted. On October 23, 2003 the same area was again closed due to another break in the same sewage line. These waters were re-opened for harvesting on December 11, 2003 (see the **Spills or Other Unpermitted Discharges** section and Figure 19 for more details). Currently, this pipeline is undergoing repairs. There are also 19 pump stations associated with the OCMUA Central Facility. They are all well maintained and equipped with emergency alarms in case of a spill.

OTHER DIRECT DISCHARGES

Several years ago the Ciba-Geigy facility, located in Toms River, ceased all surface water discharges including the company's pipeline discharge to the Atlantic Ocean. Currently, NJDEP is seeking compensation for natural resource damages at the Ciba-Geigy superfund site (DEP Postmaster, 2003).

FIGURE 12: DIRECT DISCHARGES



INDIRECT DISCHARGES

The quality of a sewer system depends heavily on the municipal planning of the sewer lines (see Table 5). New residential developments joining into a sewer system must be adequately planned for in order to handle the increased volume. The ages of the pipes and facilities also factor in when assessing the potential for sewer problems.

Septic systems are harder to regulate since they are not the responsibility of the municipality, but the property owner. As previously mentioned, a faulty septic system can add bacteria into runoff, which can then enter water bodies, causing high bacteria counts.

Known contaminated sites are scattered throughout this area, (see Figure 13). Less than half of the known contaminated sites are in close proximity to the shoreline. Most of the sites occur in urban areas, where there are existing buffer areas of *Prohibited* or *Special Restricted*. These buffers lessen the likelihood of humans consuming contaminated shellfish.

These known sites, including leaking underground storage tanks, are potential sources of chemical contamination. Action of the responsible party is required to eliminate these contaminated sites. Many of these contaminated sites are underground storage tanks that contain petroleum, which when mixed with water, rises to the top, not directly affecting burrowing clams. Also, soils surrounding the underground tanks absorb the leakage, making it less likely to migrate to marine waters. For these reasons, there is a smaller possibility of the petroleum leaks negatively affecting the shellfish.

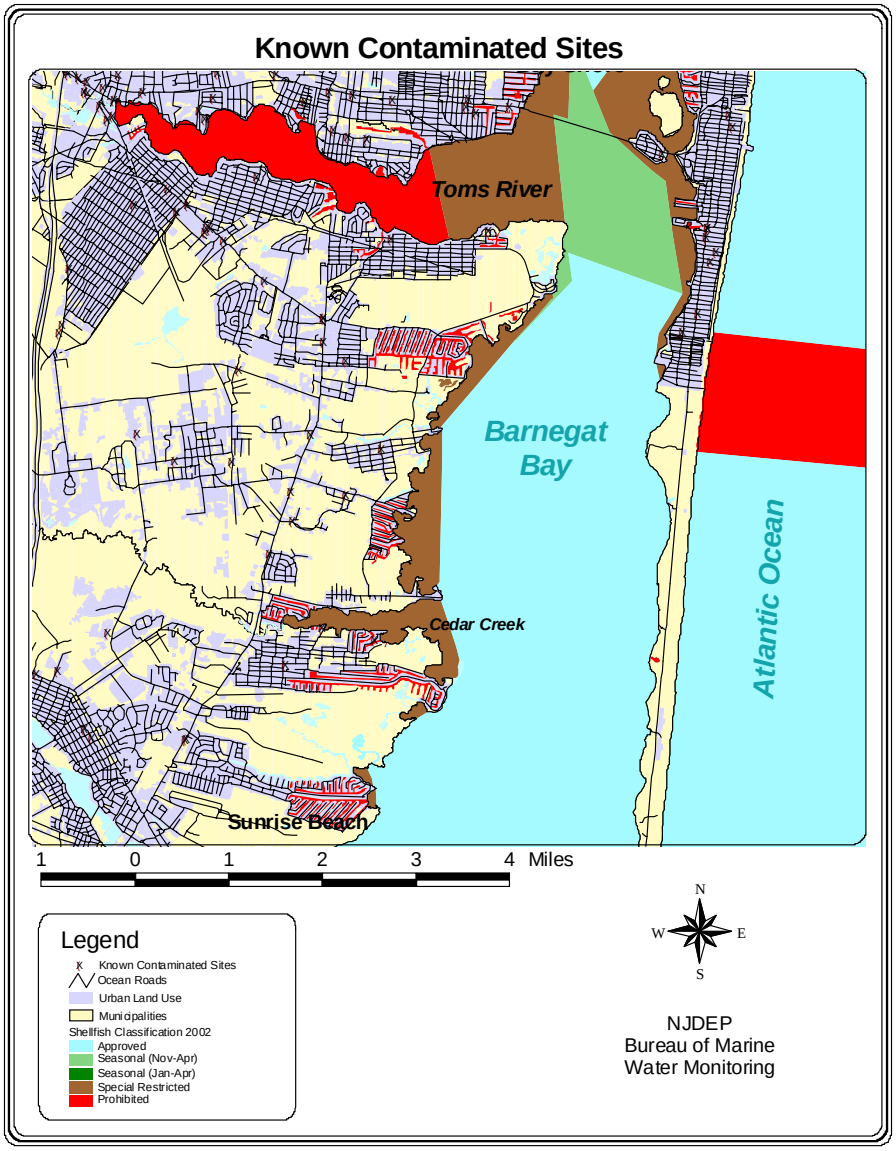
TABLE 5: MUNICIPALITY SEWER PERCENTAGES

Municipality	Public Sewer	Septic Tank or Cesspool	Other Means	Percent w/out Sewer Service
Beachwood Borough	2,934	306	4	9.40%
Berkeley Township	17,631	2,190	52	11.00%
Dover Township	35,297	312	44	0.90%
Island Heights Borough	693	0	2	0.00%
Lacey Township	8,892	596	25	6.30%
Ocean Gate Borough	1,028	24	0	2.30%
Pine Beach Borough	858	14	0	1.60%

Seaside Heights Borough	2,836	7	1	0.20%
Seaside Park Borough	2,449	5	0	0.20%
South Toms River Borough	1,127	6	0	0.50%
TOTAL	**73,745**	**3,460**	**128**	**4.64%**

Source: 1990 Census of Population and Housing, STF-3, Profile 23 (out of 27).

FIGURE 13: INDIRECT DISCHARGES TO THE WATERS OF THE CENTRAL BARNEGAT BAY



STORM WATER INPUTS

There are many storm water outfalls in the Central Barnegat Bay area (see Figure 16). Storm drains along roads collect runoff and transmit it to storm water outfalls. The outfalls deposit the runoff directly into the bay, or indirectly via other water bodies. Therefore, pollutants in the runoff gradually make their way to the bay/ocean waters. The first flush after a rain event often carries the most pollutants.

The storm water outfalls are mostly found in urban areas, and are especially common within lagoon communities. Lagoon storm water discharges are especially harmful because lagoons see little tidal flushing, heavy boat usage, and high quantities of bulkheading (see Figures 14 & 15).

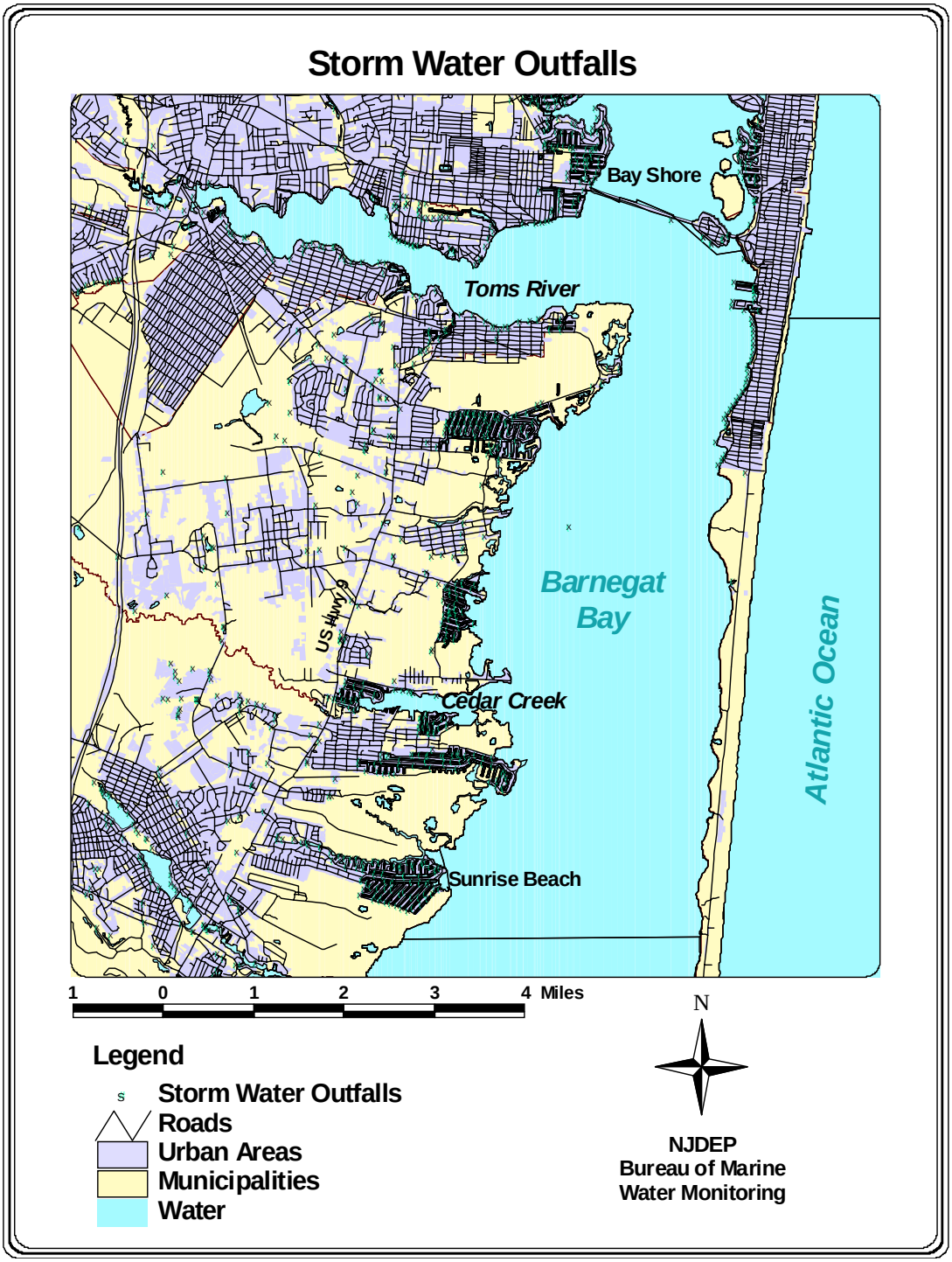
As mentioned previously, contaminated runoff reaching storm water outfalls is a major contributor to the pollution of water bodies. Pesticides, carrion, animal wastes, and petroleum products are among the harmful materials in runoff. Seeing the substantial amount of outfalls in this area, it is crucial their role in coastal pollution.

The Bureau of Marine Water Monitoring conducts storm water projects, where water samples are taken before and during a storm event in order to determine the effect of runoff. Once a possible source of the problem is identified, then the appropriate State and local officials are notified to attempt to remedy the situation. Over the last several years there was a nonpoint source pollution project done by the Bureau of Marine Water Monitoring in the area of Seaside Heights. Seaside Heights is located at the northeastern boundary of the Central Barnegat Bay area; however most the sampling for the project was within the Northern Barnegat Bay area. Initial high levels of coliform lead to a nonpoint source pollution protect where levels of fecal coliforms were taken before, during, and after rain events. Once the data were analyzed, the sources of contamination were identified, and the proper authorities were notified to work on resolving the problem.

FIGURES 14 & 15: STORM WATER OUTFALLS PICTURES TAKEN ARIL 30, 2003

LEFT -ISLAND BEACH STATE PARK OUTFALL **RIGHT – A GOOD LUCK POINT LAGOON OUTFALL**

FIGURE 16: – STORM WATER OUTFALLS IN CENTRAL BARNEGAT BAY



MARINAS

Boating is a very popular summertime activity within Barnegat Bay. There were more than 180 marinas in Ocean County in 1999 (Ocean County Planning Dept, 2003). There are also many lagoon and waterfront communities with additional slips. In the Central Barnegat Bay area there are a total of 46 marinas (see Figures 17 & 18).

Although good for tourism, the marinas, and the accompanying boats, can discharge many harmful pollutants into the water. Gas fumes, oil, and grease from boats and marinas can contribute to the contamination of the waters. There are some irresponsible boat owners who do not use available pumpout stations, instead dumping human wastes directly into the local water bodies. Therefore, marina facilities have the potential to affect the suitability of shellfish growing areas for the harvest of shellfish. The biological and chemical contamination associated with marina facilities may be of public health significance.

New Jersey defines a marina as "any structure (docks, piers, bulkheads, floating docks, etc.) that supports five or more boats, built on or near the water, which is utilized for docking, storing, or otherwise mooring vessels and usually, but not necessarily, provides services to vessels such as repairing, fueling, security or other related activities" and designates the confines of the marina as *Prohibited* for the harvest of shellfish (N.J.A.C. Chapter 12 7:12-1.2, 12-4). Adjacent waters are classified using a dilution analysis formula (see Equation 1).

It is recognized by the NSSP *Guide for the Control of Molluscan Shellfish*, 1997, that there are significant regional differences in all factors that affect marina pollutant loading. The manual, therefore, allows each state the latitude in applying specified occupancy and discharge rates. The NSSP guidelines assume the worst case scenario for each factor.

EQUATION 1: MARINA BUFFER EQUATION. (ADAPTED FROM FDA. 1989):

$$BufferRadius(ft) = \sqrt{\frac{2x10^9(FC/person/day)x2(person/boat)x[(.25slips \geq 24') + (0.065 \times slips < 24')]x2}{140000(FC/M^3)xdepth(ft)x0.3048(M/ft)x\pi x2(tides/day)}}x3.28(ft/M)$$

Explanation of terms in equation:

Fecal coliform per person per day:	2×10^9
Number of people per boat:	2
For slips able to accommodate boats > 24 feet (combination of factors yields multiplier of 0.25):	
Number of slips occupied:	50%
Number of boats occupied:	50%
For boats < 24':	6.5% discharge waste
Angle of shoreline:	180°, which results in factor of 2
Number of tides per day:	2
Depth in meters:	depth in feet x conversion factor
Water quality to be achieved:	140000 FC/meter ^{3}
Convert meters to feet:	3.28

Marina buffer zones can be calculated using the above formula. The State of Virginia and the USFDA also developed an alternative to this formula, which determines buffer zones using a dilution analysis computer program. The formula above considers only dilution and occupancy rates. The computer program is a water quality model that considers tidal exchange and bacterial die-off.

There are 46 marinas in the central Barnegat Bay area, as shown in Figure 19 and Table 6. Although there are marinas all over this growing area, they are particularly numerous in Toms River, Cedar Creek, and around the Seaside Heights/Park area. The waters enclosed by a marina are classified as *Prohibited*. Depending on the size of the marina and its water quality, the water immediately adjacent to each marina may be classified as *Prohibited*, *Special Restricted*, or *Seasonal (Jan-Apr or Nov-Apr)*. A *Seasonal* classification does not allow harvest during summer months when the marina is active. Marina buffer zones were calculated using the Virginia Model or the marina buffer equation. The size of each buffer zone is shown in Table 6.

A 3-acre *Seasonal (Nov-Apr)* buffer was added around Wheelhouse Marina in 2003, this buffer was determined by the Virginia Model.

FIGURE 17:GOOD LUCK POINT MARINA - PICTURE TAKEN DECEMBER 19, 2002

FIGURE 18: MARINA FACILITIES LOCATED IN CENTRAL BARNEGAT BAY

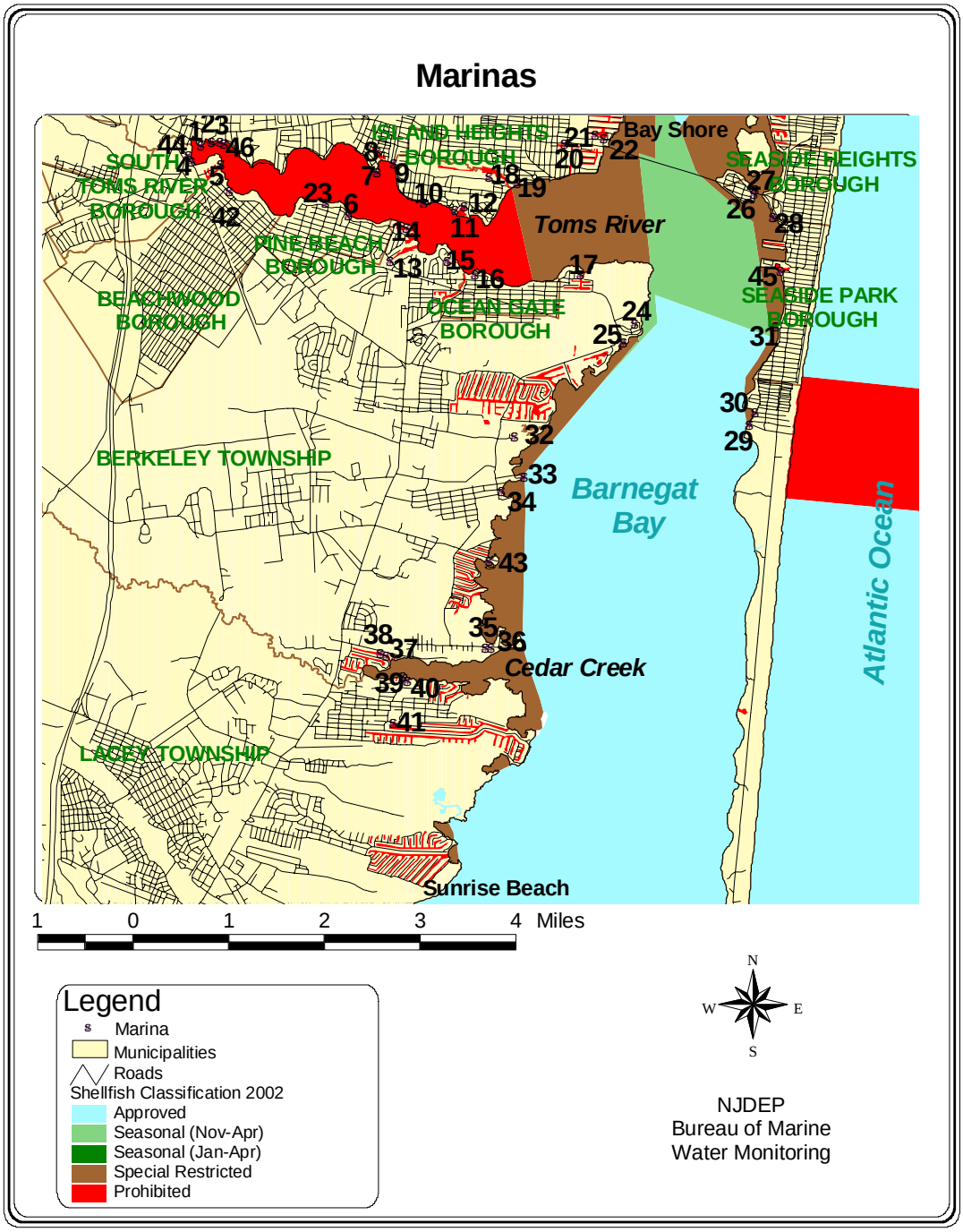


TABLE 6: MARINA FACILITIES LOCATED IN THE CENTRAL BARNEGAT BAY AREA

MAP KEY	MARINA NAME	NUMBER OF SLIPS	BUFFER (RADIUS IN FT.)
1	Toms River Boat Works	15	551
2	Jack Baker's Lobster	10	401
3	Riverfront Landing	50	1002
4	Cedar Cover Marina	60	838
5	Lighthouse Point Marina	240	2068
6	Pine Beach Yacht Club	20	423
7	Toms River Yacht Club*	90	1344
8	Brenton Harbor Marina	37	439
9	Island Beach Civic Association	50	511
10	Island Heights Yacht Club*	37	487
11	Nelson Marine Basin*	100	1021
12	Cozy Cove Marina*	85	878
13	RiverBank Marina*	215	1696
14	Stump Creek Spillway	25	634
15	Santo Marine Corp	85	1168
16	Ocean Gate Yacht Club	25	423
17	Ocean Gate Yacht Basin*	185	708
18	Dillon's Creek Marina*	210	1961
19	Gilford Park Yacht Club	85	1168
20	Barnegat Bay Boat Sales	150	1146
21	Pier One Marina*	40	899
22	Tide's In Marina	45	850
23	Toms River Municipal Boat Marina	15	491
24	Good Luck Point Marina*	113	1512
25	Becker's Boat Basin	28	441
26	Coty's Marina	32	801
27	Pelican Cove Condos	40	801

MAP KEY	MARINA NAME	NUMBER OF SLIPS	BUFFER (RADIUS IN FT.)
28	Seaside Boats	20	289
29	Wheelhouse Marina*	86	(3 acres)
30	Red Top Boats Marina	70	1190
31	Seaside Park Yacht Club	39	633
32	Rinderer's Marina	27	476
33	Dick's Landing	32	1116
34	Whitey's Landing	40	442
35	Downe's Fishing Camp	65	1615
36	Trixie's Landing	75	965
37	Up the Creek Marina	80	1700
38	Cedar Creek Marina*	64	1417
39	Lanoka Harbor Marina	206	2834
40	Ocean Beach Marina South*	60	559
41	Laurel Harbor Marina*	156	156
42	Beachwood Yacht Club	85	1075
43	Windows on the Bay	6	177
44	Bay Villa Yacht Club	100	1267
45	Seaside Park Municipal Ramp	185	1738
46	Seaport Yacht Sales	25	575

*=Pumpout Station Available.

SPILLS OR OTHER UNPERMITTED DISCHARGES

The tourist population in the summertime inundates the utility usage in the Central Barnegat Bay area. However, the cold winter months also prove hard on water and sewer lines. Therefore, breaks and/or leaks can happen at any time and the Bureau of Marine Water Monitoring must be ready to respond to spills and assess the probable effects on the shellfish waters.

In 2000, a sewage break was located on Swan Island (i.e., Harbor Island or Middlesedge Island) west of Seaside Heights. It is not known how long this break was there before it was discovered, since the island is a bird roosting area. Swan Island lies right above the northern cutoff of the Central Barnegat Bay area, but stations 1631 – 1631F are likely to show the flushing effects of the spill. There was never a closure of this area because none of the neighboring stations were over their classification criteria when the spill was found. Since the spill was on the island, most of the contamination stayed upon the landmass. Upon reviewing the data for stations 1631E and 1631F since 1993, it is not clear when the spill might have initially occurred.

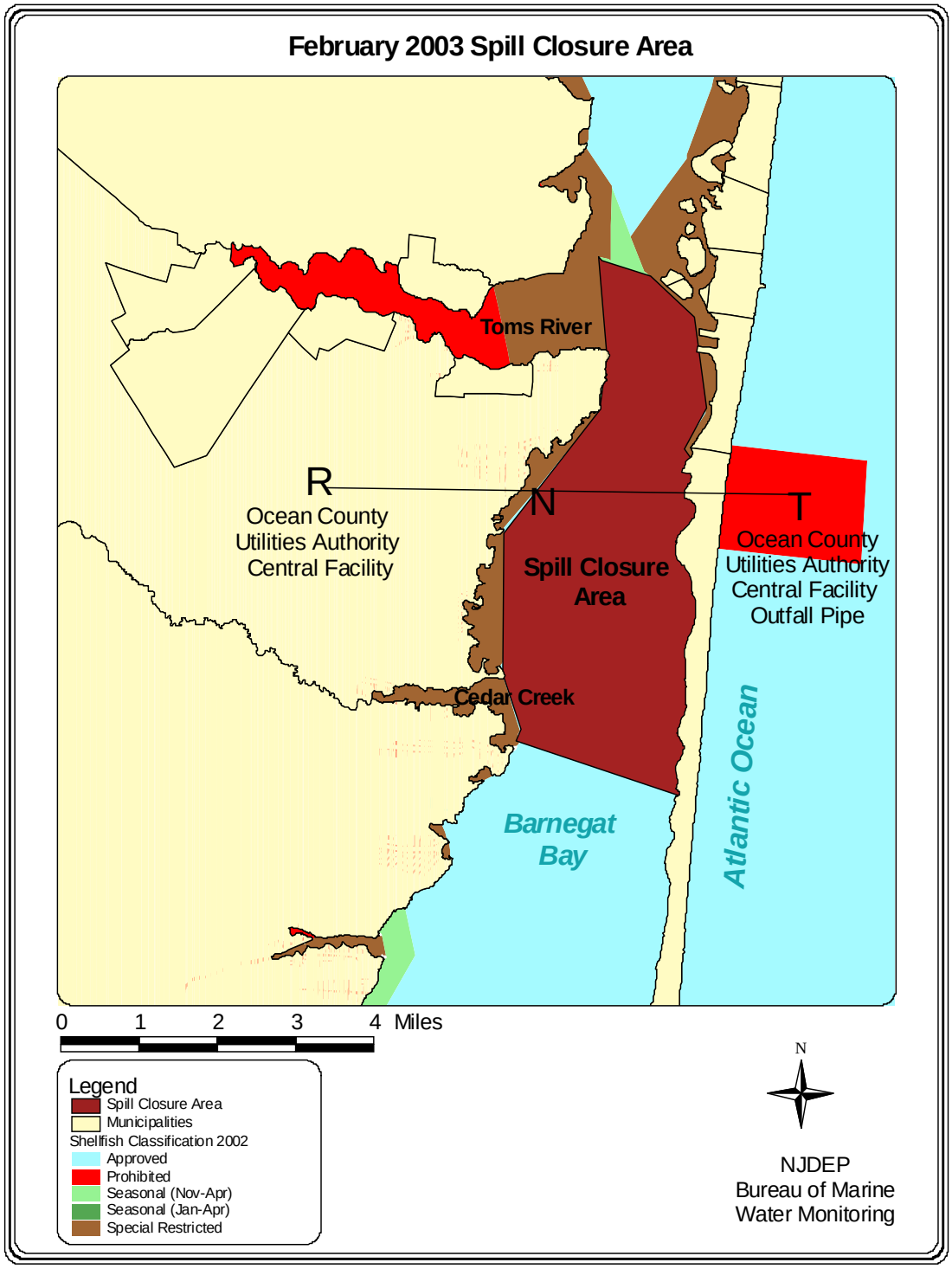
On February 2, 2003 a section of the Barnegat Bay was closed due to a sewage line break (See Figure 19). There was a minor breach (1.5-2.5 inch hole) in the Ocean County Utilities Authority's central outfall pipe. This pipeline is four miles long and runs from the treatment plant in Bayville east to the Atlantic Ocean. Reportedly, there was little effluent flow from the pipe and the waste had already been treated with chlorine (Moore, 2003).

The waters were closed as of February 2, 2003 and the line was not permanently fixed until April 1, 2003. After a thirty-day flushing period for the bay and the shellfish, the area was reopened (May 2, 2003). All shellfish harvesting was condemned and prohibited during the closure period. The closure area included "all waters of the Barnegat Bay south of the Mathis Bridge (Route 37) to a line from the northernmost point of land on the mainland located at the northeastern extent of Laurel Boulevard in Lacey Township bearing 105 degrees T to the cupola on Island Beach State Park." During the flushing period, testing was done to ensure the bacteria levels were acceptable for harvesting shellfish. As of May 2, 2003 the waters were opened to their appropriate 2003 classifications.

On June 6, 2003 Barnegat Bay was declared a "No Discharge Zone". This means no boats can discharge treated or untreated sewage into the bay.

On October 23, 2003 the same area was again closed due to another break in the same sewage line involved in the February 2003 closure. These waters were re-opened for harvesting on December 11, 2003. This pipeline appears to be quite old and in deteriorating condition; action is currently being taken to prevent these closures from repeatedly occurring and potentially harming the shellfish by making repairs to the lines.

FIGURE 19: FEBRUARY 2003 SPILL



HYDROGRAPHY AND METEOROLOGY

The Toms River drainage basin covers an area of approximately 123 square miles. The mean flow of a 73-year accumulation of data is 303 cubic feet/second (cfs). In 2000, the annual mean flow was 174 cfs and the peak value was 453 cfs (USGS, 2003). Some years, the peak flow gets as high as 1,500 cfs (USGS, 2003). Generally speaking, the flow in the winter months is a little higher than the summer months, which could be due to precipitation. The conditions of the river are often directly related to the rainfall. In 2000, there were drought conditions throughout New Jersey, which may explain why the peak flow in 2000 was relatively low.

Cedar Creek has a drainage area of 56 square miles; however, there is no up-to-date information on the creek's discharge values or flow rates. There are also numerous small tidal creeks, like Potter's Creek, that lack discharge and flow rate information. The tidal range for Barnegat Bay, as measured at Bay Shore, is approximately two feet (Farnsworth, 2000).

Tidal influx allows dilution of pollutants in bay water with the ocean water that is typically of higher water quality. Since the inlet is about 7 miles south of Cedar Creek, the Central Barnegat Bay area does not see prime tidal flushing. Even so, coliform levels are low enough for most of the waters to remain classified as *Approved*.

Toms River has the greatest potential to be impacted by storm water runoff, due to the numerous storm water outfalls in urban developed areas. The western section of the Toms River is classified as *Prohibited* and the eastern section is classified as *Special Restricted*. Cedar Creek and populated coastline areas are also impacted by storm water runoff, and are appropriately classified as *Special Restricted*.

PATTERNS OF PRECIPITATION

Precipitation patterns in the coastal areas of New Jersey are typical of the Mid-Atlantic coastal region. Typical summer storms are localized storms associated with thunderstorms. Winter storms are frequently associated with northeasters. Hurricanes can occur during the summer and early fall. Tropical Storm Floyd hit the New Jersey shore in mid-September 1999. In September 2000, another tropical storm, Gordon, also reached the New Jersey shore. Although the rainfall was minimal in each event (0.22 inch and 0.52 inch, respectively), data show slightly higher coliform values in Toms River during September of 1999 and 2000. There were no other major tropical storms or hurricanes in this area between 1999 and 2002.

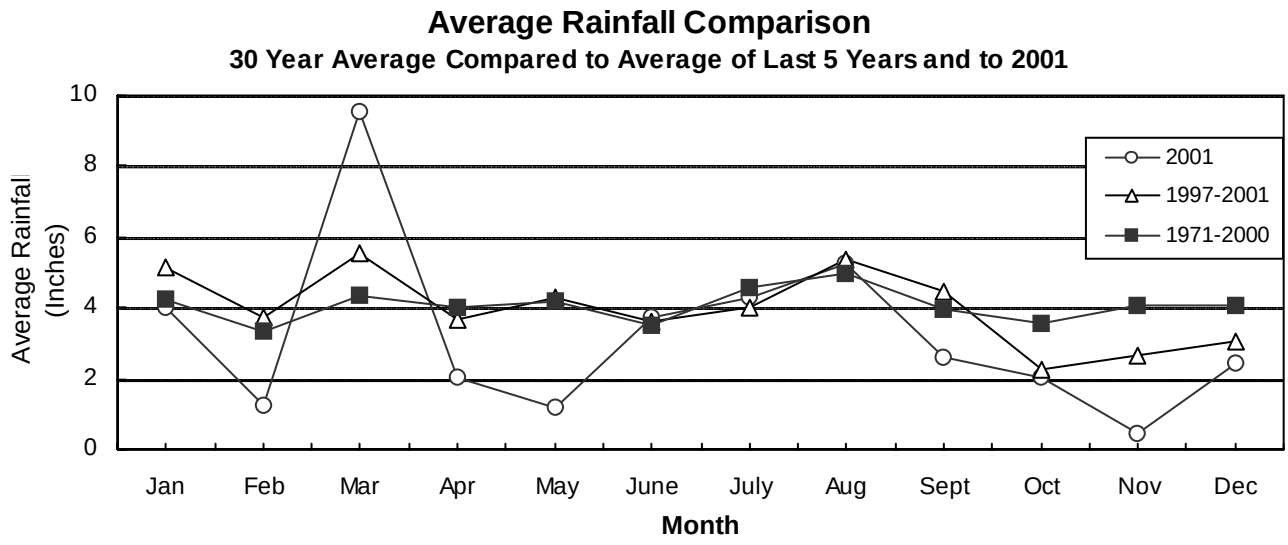
TABLE 7: ACTUAL AND AVERAGE PRECIPITATION (IN INCHES) RECORDED AT TOMS RIVER

MONTH	1997	1998	1999	2000	2001	Average over 5-Year Period 1997-2001	Average over 30-Year Period 1971-2000
January	2.15	6.01	9.65	3.80	4.00	5.12	4.22
February	3.21	7.15	2.50	4.58	1.23	3.73	3.35
March	3.88	7.01	3.85	3.39	9.57	5.54	4.34
April	4.08	5.62	3.72	2.94	2.06	3.68	4.02
May	2.60	11.95	2.04	3.64	1.19	4.28	4.17
June	2.25	5.20	2.04	5.00	3.72	3.64	3.52
July	5.18	1.94	0.83	7.75	4.27	3.99	4.56
August	7.63	1.86	8.48	3.57	5.28	5.36	5.00
September	4.52	1.86	5.62	7.81	2.58	4.48	3.95
October	2.65	2.16	3.85	0.58	2.05	2.26	3.55
November	5.46	1.43	2.10	3.83	0.44	2.65	4.05
December	5.45	1.40	3.74	2.32	2.44	3.07	4.08
TOTAL	**49.06**	**53.59**	**48.42**	**49.21**	**38.83**	**47.82**	**48.81**

Source: Data provided by Department of Geography, New Jersey State Climatologist, Rutgers University, 2002.

Prepared by: Ocean County Department of Planning, May 2002.

FIGURE 20: AVERAGE RAINFALL COMPARISON



Source: Data provided by Department of Geography, New Jersey State Climatologist, Rutgers University, 2002.

Prepared by: Ocean County Department of Planning, May 2002.

Precipitation inputs for the period of 1997 through 2001 are shown in Figure 20 and Table 7. Table 8 shows the climatological data obtained from NOAA for the sampling dates (January 1, 1999 – December 31, 2002). There have been no significant changes in hydrography since the sanitary survey in 2000. The primary weather station for this area is Toms River, NJ (Dover Township). The secondary weather station for this area is Brant Beach, NJ. The secondary station data are used when data from the primary station are incomplete.

TABLE 8 : CLIMATOLOGICAL DATA

Rainfall and Temperature Recorded at NOAA's Toms River Station 8816 (* - Secondary Station - Brant Beach 0990)

Sampling Date	Precipitation in Inches			
	Sample Day	One Day Prior	Two Days Prior	Average Temperature (Fahrenheit)
1/26/1999	0.05	1.01	1.32	36
1/27/1999	0	0.05	1.01	35
2/24/1999	0	0	0	21
2/25/1999	0	0	0	30
3/18/1999	0	0	0	54
3/25/1999	0.005	0.01	0.05	54
3/26/1999	0	0.005	0.01	41
3/29/1999	0	0.58	0.58	39
3/31/1999	0	0	0	50
4/9/1999	0	0	0.005	64
4/12/1999	0.91	0.91	2.11	42
4/14/1999	0	0.005	0.915	52
4/15/1999	0	0	0.005	50
4/28/1999	0	0	0	53
5/10/1999	0	0.25	0.35	69*
5/13/1999	0.1	0.1	0.1	62*
5/14/1999	0	0.1	0.1	59*
6/7/1999	0	0	0	71
6/11/1999	0	0	0	63
7/12/1999	0	0	0	69
7/15/1999	0	0	0.42	66
8/9/1999	0.35	0.35	0.35	71
8/11/1999	0	0	0.35	69
8/18/1999	0	0.005	0.005	77

Sampling Date	Precipitation in Inches			
	Sample Day	One Day Prior	Two Days Prior	Average Temperature (Fahrenheit)
9/7/1999	0.005	0.065	0.065	77
9/15/1999	0.005	0.005	0.005	73
9/23/1999	0	0.15	0.15	72
10/4/1999	0.005	0.005	0.005	69
10/12/1999	0	0.21	0.41	57
10/25/1999	0	0	0.2	41
11/18/1999	0	0	0	33
11/19/1999	0	0	0	40
11/29/1999	0	0	0.4	40
12/1/1999	0	0	0	29
12/7/1999	0.84	0.89	0.99	48
12/17/1999	0	0.005	1.005	43
1/4/2000	0.7	0.73	0.73	55
1/6/2000	0	0	0.7	36
1/10/2000	0.45	0.455	0.46	49
1/12/2000	0	0	0.45	46
2/15/2000	0.03	2.53	2.53	43
2/17/2000	0	0	0.03	45
2/25/2000	0	0	0	57
3/6/2000	0	0	0	43
3/14/2000	0	0.12	1.09	40
3/27/2000	0	0	0	56
3/28/2000	0.61	0.61	0.61	60
4/10/2000	0.1	0.1	0.1	39

Sampling Date	Precipitation in Inches			
	Sample Day	One Day Prior	Two Days Prior	Average Temperature (Fahrenheit)
4/12/2000	0.17	0.17	0.27	47
4/13/2000	0	0.17	0.17	43
4/17/2000	0.27	1.25	1.255	60
4/25/2000	0	0.005	0.005	53
5/1/2000	0	0.05	0.05	52
5/16/2000	0	0	0.5	55
6/5/2000	0	0	0.3	67
6/13/2000	1.02	1.02	1.02	65
6/14/2000	0.35	1.37	1.37	59
7/10/2000	0	0	0	70
7/13/2000	0	0	0.005	71
7/24/2000	0	0	0.65	73
8/7/2000	0.08	0.08	0.85	75
8/8/2000	0.005	0.085	0.085	80
8/16/2000	0	0.45	0.78	73
9/19/2000	0	0	0	68
9/29/2000	0	0	0.52	55
10/2/2000	0	0	0	56
10/10/2000	0	0	0	***
11/13/2000	0	0	0	49
11/16/2000	0.05	0.1	0.38	42
11/17/2000	0	0.05	0.1	44
11/27/2000	0	0.6	0.6	44
12/5/2000	0	0	0	33
12/18/2000	0	0	0.55	46

Sampling Date	Precipitation in Inches			
	Sample Day	One Day Prior	Two Days Prior	Average Temperature (Fahrenheit)
12/19/2000	0	0	0	37
1/26/2001	0.005	0.005	0.005	28
2/2/2001	0	0	0	40
2/13/2001	0	0.2	0.2	27
2/21/2001	0.7	0.7	0.7	45
2/26/2001	0	0	0.18	44
3/13/2001	0.005	0.945	0.945	40
3/19/2001	0	0	0	38
3/21/2001	2.31	2.31	2.31	41
3/26/2001	0	0	0	38
3/27/2001	0	0	0	28
4/6/2001	0	0	0	44
4/9/2001	0	0	0	45
4/16/2001	0.3	0.3	0.3	52
4/19/2001	0.11	0.11	0.11	42
4/24/2001	0	0	0.1	67
4/25/2001	0	0	0	61
5/1/2001	0	0	0	***
5/2/2001	0	0	0	67
5/15/2001	0	0	0	58
5/21/2001	0.6	0.6	0.6	56
6/6/2001	0	0	0	67
6/13/2001	0	0	0	77
7/13/2001	0	0	0	68
7/16/2001	0	0	0	73

Sampling Date	Precipitation in Inches			
	Sample Day	One Day Prior	Two Days Prior	Average Temperature (Fahrenheit)
7/23/2001	0	0	0	73
8/7/2001	0.005	0.005	0.015	80
8/10/2001	1.3	1.3	1.3	86
8/15/2001	0	0	0	71
9/4/2001	0	0	0	69
9/18/2001	0	0	0	62
10/9/2001	0	0	0.15	42
10/18/2001	0	0	0	46
10/24/2001	0	0	0	66
11/9/2001	0	0	0	45
11/14/2001	0	0	0	43
11/15/2001	0	0	0	52
11/27/2001	0.005	0.01	0.31	50
12/3/2001	0	0	0	43
12/10/2001	0.06	0.065	1.265	38
12/12/2001	0.005	0.035	0.095	50
12/13/2001	0.005	0.01	0.04	55
12/18/2001	0.1	0.45	0.45	46
12/19/2001	0	0.1	0.45	43
1/17/2002	0	0	0	38
1/24/2002	0.28	0.38	0.38	46
1/29/2002	0	0	0	53
2/14/2002	0	0	0	28
2/19/2002	0	0	0	38
2/21/2002	.005	.01	.01	51

Sampling Date	Precipitation in Inches			
	Sample Day	One Day Prior	Two Days Prior	Average Temperature (Fahrenheit)
2/26/2002	0	0	0	53
3/11/2002	0	0	0.005	35
3/25/2002	0.22	0.22	0.22	37
3/26/2002	0.9	1.12	1.12	50
4/5/2002	0	0	0	37
4/17/2002	0	0	0	79
4/18/2002	0	0	0	74
4/23/2002	0.005	0.285	0.385	44
4/24/2002	0	0.005	0.285	44
5/13/2002	0.63	1.33	1.33	55
5/20/2002	0	0	1.35	47
6/6/2002	1.55	1.95	1.95	73
6/11/2002	0	0	0	74
7/15/2002	0	0	0	77
7/19/2002	3.2	3.2	3.2	80
8/6/2002	0	0.005	0.005	68
9/10/2002	0	0	0	72
10/10/2002	0.8	0.8	0.8	63
10/15/2002	0.35	0.35	0.37	48
10/17/2002	0.005	1.705	2.055	53
11/18/2002	0	0.58	3.18	39
11/19/2002	0.09	0.09	0.67	40
12/11/2002	ND	ND	ND	38
12/16/2002	ND	ND	ND	33
12/17/2002	ND	ND	ND	26

WATER QUALITY STUDIES

BACTERIOLOGICAL QUALITY

SUMMARY OF CENTRAL BARNEGAT BAY AREA

The data for this report was collected from 103 stations in the Central Barnegat Bay area. A total of 3,841 surface water samples were analyzed from this growing area for total coliform (TC) and fecal coliform (FC) during the January 1999 to December 2002 time period.

Assorted areas in Toms River and Barnegat Bay are classified as *Approved, Special Restricted, Seasonal (November-April)* and *Prohibited* (see Figure 4). Sampling stations located in *Prohibited, Special Restricted* and *Seasonal* waters have the potential for an upgrade in classification based on improved bacteriological water quality.

Four separate assignment runs are required for this large growing area. Three of these assignment runs are in Barnegat Bay (102, 107, 108) and one is in Toms River (97). This report examined the data from the assignment runs done in-between January 1, 1999 and December 31, 2002. These assignment runs provided sufficient samples for evaluation, bearing in mind the sample size must be at least 30 for each station according to the Systematic Random Sampling strategy.

COMPLIANCE WITH NSSP *APPROVED* CRITERIA

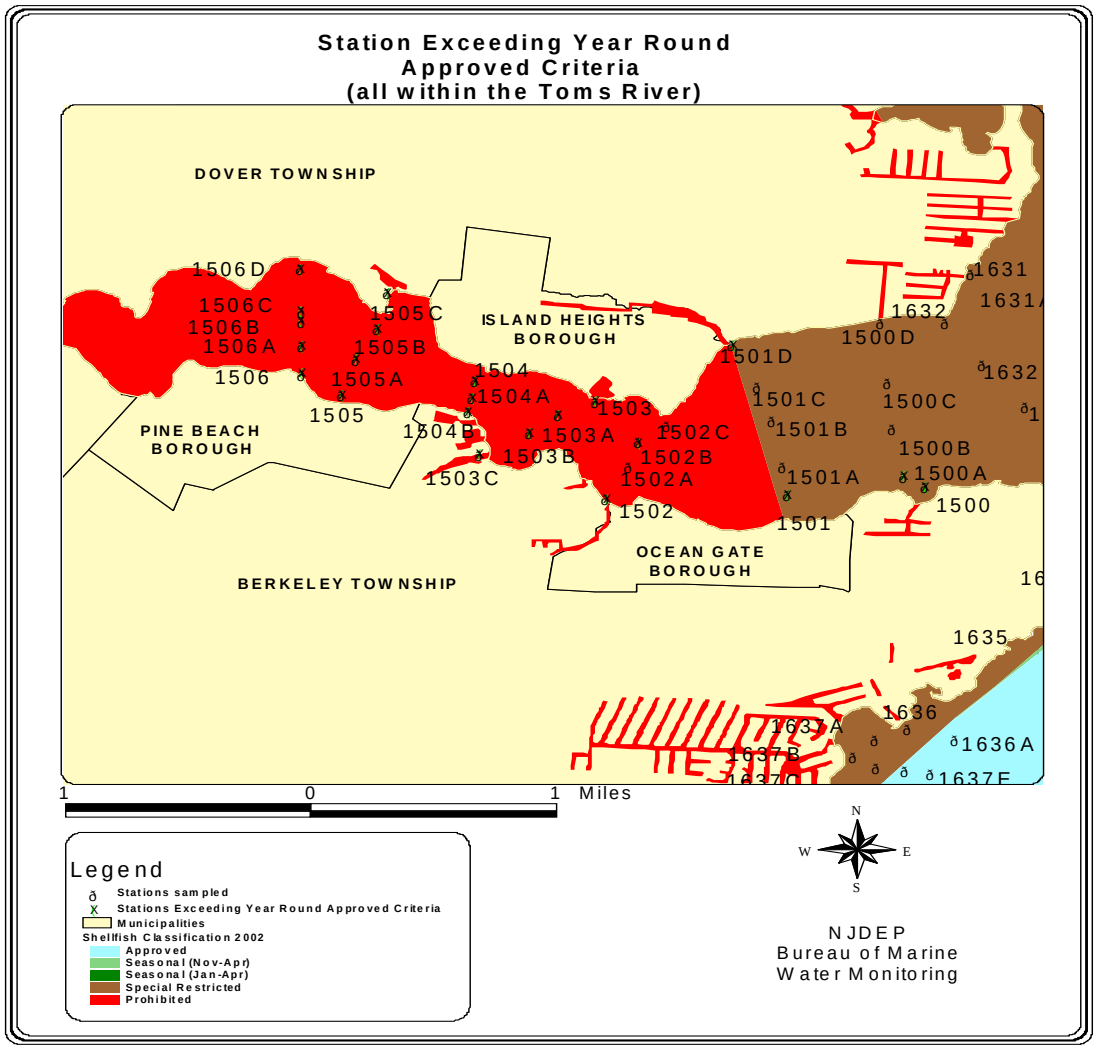
Each sampling station must comply with its respective classification criteria according to the National Shellfish Sanitation Program (NSSP) Model Ordinance (1997 Revision). The classifications are *Approved, Seasonal, Special Restricted,* and *Prohibited.* For the Systematic Random Sampling strategy there is a minimum of 30 data sets for each station. In order for waters to be classified as *Approved,* the total coliform Geometric Mean must be below 70 MPN/100ml and the total coliform Est. 90th Percentile must be below 330 MPN/100ml (see Table 2). All stations that are currently located in *Approved* water meet the total coliform criteria; therefore, no changes in classification are needed based on the stations in *Approved* waters.

Based on current data, all of the stations in Barnegat Bay meet the total coliform criteria for *Approved* waters. Therefore, all sampling stations in Barnegat Bay support their respective classifications for Approved, Seasonal, or *Special*

Restricted waters, based on a minimum of 30 data sets. It is anticipated that this trend will continue, and more areas of the Central Barnegat Bay will be suitable for upgrades in the future.

Since the western part of the Toms River is currently classified as *Prohibited*, regular sampling is not required under the NSSP guidelines. In addition, the biological resources in the river are limited. Therefore, sampling was sporadic for several years. However, regular sampling of Toms River has been in effect since 1997. Even though current data show that the entire river meets the criteria for *Special Restricted* waters, there are numerous stations in the upper (western) part of the Toms River that fail to meet the *Approved* criteria. The only stations that exceeded the *Approved* criteria are presently located in *Prohibited* or *Special Restricted* areas (see Figure 21).

FIGURE 21: SAMPLING STATIONS EXCEEDING APPROVED CRITERIA



COMPLIANCE WITH NSSP *SPECIAL RESTRICTED* CRITERIA

All sampled stations complied with the NSSP total coliform criteria for *Special Restricted* Waters. For waters to be classified as *Special Restricted*, the Geometric Mean must be below 700 MPN/100ml and the Est. 90th Percentile must be below 3300 MPN/100ml. Since no stations in *Special Restricted* had values above the NSSP criteria, no changes in classification are needed.

COMPLIANCE WITH NSSP *APPROVED CRITERIA DURING SEASONS*

All Data (Summer and Winter)

The year round data are divided between the summer and winter sampling seasons. The summer season runs from May through October, and the winter season runs from November through April.

Winter Data (November – April)

All stations in the Barnegat Bay section of this growing area met the total coliform *Approved* criteria during the winter months. Twelve stations in Toms River had high Est. 90th Percentiles in the winter months, but they were all stations that also had high year-round values and are not situated in *Approved* or *Seasonal* waters.

Summer Data (May – October)

All of the stations that did not meet year-round total coliform criteria also did not meet criteria during the summer season. However, seven stations that met the year round criteria for *Approved* waters had high Est. 90th Percentiles during the summer months (1501A, 1502A, 1502C, 1639, 1642A, 1643, 1648B). None of these stations are classified as *Approved* and none exceed *Special Restricted* criteria, so no change in classification is needed.

TIDAL EFFECTS

Ocean water enters the bay through the inlet at Barnegat Light. Tidal exchange is a mechanism that mixes impacted water with higher quality water. Generally, the amount of *Approved* waters in this area shows there is a decent amount of mixing and diluting occurring. This combination also helps to improve the water quality of the sections adjacent to the urban shorelines, which are often contaminated by runoff.

Ten stations have a tidal component since their T-statistic probability is less than or equal to 0.050 (see Table 9 and Figure 22). The geometric means were higher during flood than during ebb for all of the noted stations. Nine of the stations are located near the western shoreline of the Barnegat Bay, six in *Approved* waters and three in *Special Restricted* waters. This western shoreline is scattered with urban development, but is mainly wetlands. These wetlands most likely introduce animal waste during the flood tide, which could help explain the higher coliform values.

The remaining station (1634D) is slightly west of Seaside Park, in *Seasonal (Nov-April)* waters. When extending the time frame to include 30 samples for both ebb and flood, station 1634D is the only one that still has a tidal component. This station will be monitored closely in the future.

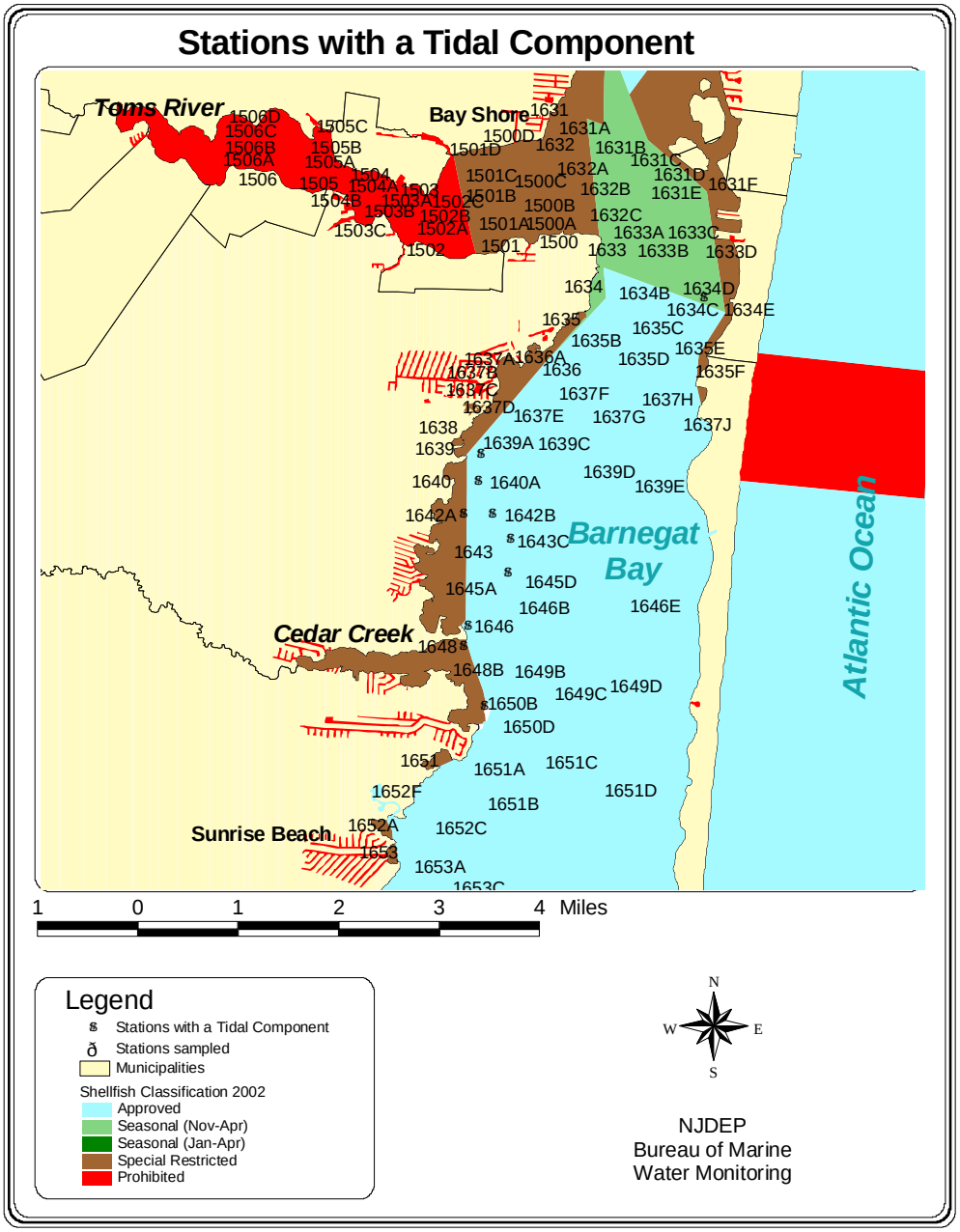
Although several of the stations with a tidal component are within *Approved* waters, the geometric mean and est. 90th percentile still meet criteria. Presently, no changes in classification or in sampling protocol (such as tidal preference) are needed as a result of the tidal components at these stations.

TABLE 9: TIDAL EFFECTS

Station	Status	Tidal t-Statistic Prob.	EBB		FLOOD	
			Total Coliform Geometric Mean MPN	Number of Samples	Total Coliform Geometric Mean MPN	Number of Samples
1634D	S	0.047	6.6	27	17.3	16
1639A	A	0.029	5.8	16	15.6	20
1640A	A	0.018	5.0	16	16.3	20
1642A	SR	0.007	4.9	17	26.2	18
1642B	A	0.029	4.2	16	10.6	20
1643C	A	0.014	4.5	16	11.6	19
1645D	A	0.013	3.7	16	9.0	20

1646	A	0.015	5.3	16	15.9	19
1648	SR	0.010	5.5	16	19.1	20
1650B	SR	0.006	4.7	16	15.9	20

FIGURE 22: SAMPLING STATIONS AFFECTED BY TIDE



SEASONAL EFFECTS

It is important to understand the factors that contribute to high total coliform levels and which season these factors impact. Boat use is a major factor in this area and most recreational boating occurs during the summer. Runoff from urban areas is perhaps the most influential factor on the coliform levels in this growing area. Runoff occurs year round, however, things like pesticides and bug sprays are used more heavily in the summer season.

This area also sees a population surge in the summer, which increases sewage use as well as other utilities. Therefore, it is very probable that the stations with a seasonal component are affected by non-point source pollution from increased summer population and/or increased use of water-related activities (boating, etc.) during the summer.

Seasonal components were observed at seven stations. The T-statistic probability must be less than or equal to 0.05 for a station to have a seasonal component (see Table 10). Four of the locales are scattered in Barnegat Bay between Berkley Shores and South Seaside Park (1634D, 1635C, 1635E, & 1637F). Of these, stations 1635C, 1635E, & 1637F are in *Approved* waters, and station 1634D is in *Seasonal (Nov-April)* waters.

The three remaining stations with a seasonal component are scattered. Station 1653A is in *Approved* waters off the coast of Sunrise Beach, while station 1650D is in *Approved* waters off the coast of Laurel Harbor. Station 1502B is in the *Prohibited* waters of Toms River (see Figure 23).

Stations 1653A, 1650D, and 1502B have higher values in the summer while the remaining stations have higher winter values. Stations with higher winter values are slightly atypical because there are lower temperatures and no tourist influx. Usually the higher temperatures and seasonal recreational uses contribute to high summer coliform values.

None of the noted stations had a Geometric Mean that exceeded the established values for the present classifications. The Est. 90th Percentile values for these stations also fit within criteria. No changes in classification are needed as a result of the seasonal components at these stations.

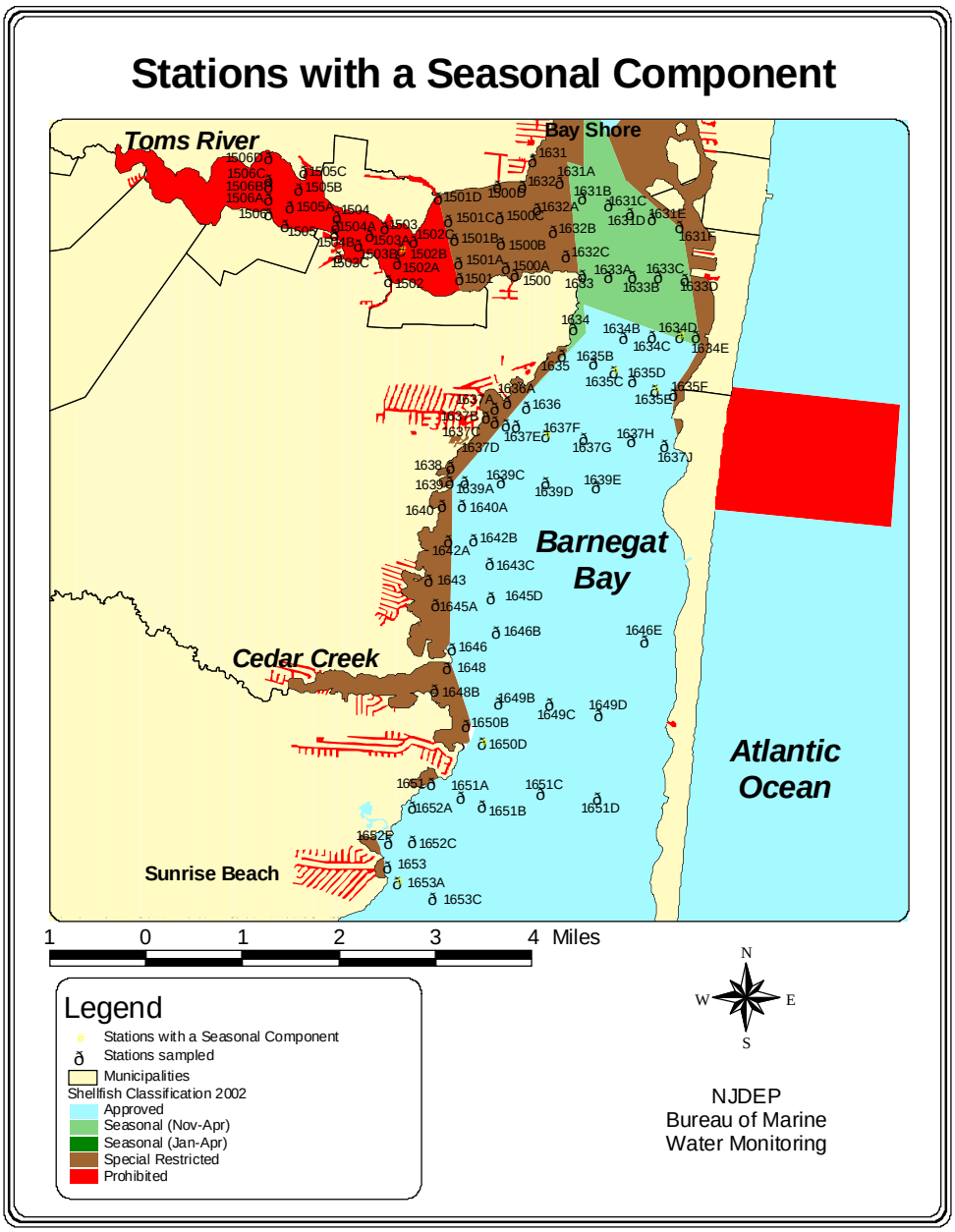
However, continued surveillance is recommended, especially at stations 1650D & 1653A. These stations are located in *Approved* waters and also had a seasonal component when the time frame was extended to get a data set of 30 for both the summer and the winter. These stations may be affected by non-point source pollution from increased summer population and/or increased use of water related activities (boating, etc.).

Although these stations with a seasonal component do not require changes in present classifications, they are areas where potential problem could arise in the future. Presently, all stations that were impacted by season remain in compliance with their respective classification criteria.

TABLE 10: SEASONAL EFFECTS

Station	Status	Seasonal t-Statistic Prob.	SUMMER			WINTER		
			Total Coliform Geo. Mean	Est. 90th	Number of Samples	Total Coliform Geo. Mean	Est. 90th	Number of Samples
1502B	P	0.0350	107.1	1,110.5	14	30.1	137.9	18
1634D	S	0.0092	4.8	10.9	11	11.9	81.2	32
1635C	A	0.0153	4.2	12.0	11	10.3	60.6	32
1635E	A	0.0461	5.0	11.9	11	9.8	63.6	32
1637F	A	0.0088	3.8	6.7	11	7.8	38.1	32
1650D	A	0.0470	12.4	99.1	15	4.8	11.2	21
1653A	A	0.0486	10.5	80.8	15	4.1	11.4	21

FIGURE 23: SAMPLING STATIONS AFFECTED BY SEASON



RAINFALL EFFECTS

Non-point source pressures on shellfish beds in New Jersey originate in materials that enter the water via storm water outfalls. These harmful materials include bacteria and other wastes that negatively impact the surrounding water quality.

The Bureau of Marine Water Monitoring has begun to identify particular storm water outfalls that discharge excessive bacteriological loads during storm events. In some cases, specific discharge points can be identified. When specific outfalls are identified as significant sources, the Department of Environmental Protection works with the county and municipality to further refine the source(s) of the contamination and implement remedial activities.

It should be noted that a particular short-term data set might not indicate significant rainfall effects even if the historical data indicate that a significant effect occurs in a particular area. This is due to one or more of the following factors:

- Data during the short term may consist of primarily rainfall data or dry weather data. In this case, if there are insufficient data points in each category, the test for significance can not be done.
- Data collected after rainfall in the normal sampling regime may miss the effects of the 'first flush'.
- Rainfall data are based on the closest established NOAA station. Since rainfall patterns along the coastline, particularly during the summer months, tend to include locally heavy rainfall, the rainfall amounts recorded at the NOAA station may not accurately reflect the rainfall at the sampling station(s).

At this time, there are no stations with a rainfall correlation greater than or equal to 0.600; therefore, rainfall does not appear to be a significant factor for the stations located in this growing area (see Appendix for data). A relationship between rainfall amounts and total coliform levels is suggested if the rainfall correlation coefficient is greater than 0.600. Over the last couple of years there was a rainfall study done in Seaside Heights, the source of the problem was found, and the municipality is working to remedy the situation. The Bureau of Marine Water Monitoring is also planning more storm water projects for impacted areas.

RELATED STUDIES

Although the Bureau of Marine Water Monitoring assesses classification based on total coliform, there are many other tests run on the retrieved water samples. In addition to testing for total coliform, all samples are also tested for fecal coliform (until June 2003). The laboratory is also capable of testing for levels of biotoxins, nutrients, and metals in the water.

MARINE BIOTOXINS

The Bureau of Marine Water Monitoring collects samples at regular intervals throughout the summer to determine the occurrence of marine biotoxins. The Bureau of Marine Water Monitoring, in accordance with the NSSP requirements, also analyzes the data. The NJDEP and USEPA (United States Environmental Protection Agency) conduct routine helicopter surveillance looking for color abnormalities in New Jersey waters, indicating an algal bloom.

Phytoplankton are photosynthetic algae that play a critical role at the base of aquatic food webs. Normally, New Jersey's coastal waters are populated with non-threatening diatoms during the summer months. However, algal blooms have historically been rather common to the Barnegat Bay area.

The Bureau of Marine Water Monitoring Phytoplankton reports continue to illustrate blooms of *Aureococcus sp*. (brown color) and *Nannochloris sp*. in this area. The phytoplankton studies are used to show what species are present and in what concentration (see Figure 24). The blooms have not included a significant number of particular species that are of human health concern related to shellfish consumption. Although the present quantities of these species are not a concern for human health, they can affect other aspects of the aquatic environment (loss of fauna, etc.). There have been no incidents of algal blooms with acute toxic phytoplankton in New Jersey. Reports are available electronically at: http://www.nj.gov/dep/bmw/reports.htm.

Recently, Barnegat Bay was included in a special study done by the Division of Science, Research, and Technology that monitored the occurrence of 'brown tides,' *Aureococcus anophagefferen*s. These brown tides can be linked to reducing finfish population, lessening natural habitats, and decreasing shellfish growth. The algal species of brown tides are not usually hazardous to human health. This study shows that the brown tide concentrations in the Central Barnegat Bay reached severely high levels during the July of 2002 (NJDEP DSRT, 2002). Such high levels may impact shellfish populations. However, they are not toxic to humans and are, therefore, not factored into recommendations of this report for shellfish growing water classifications.

FIGURE 24: PHTOYPLANKTON STATIONS THROUGHOUT NEW JERSEY

NUTRIENTS

Nutrient and dissolved oxygen samples are collected at seven stations in this growing area four times each year. The parameters are evaluated, analyzed, and provided in a separate report by the Bureau of Marine Water Monitoring, available on the web at: www.nj.gov/dep/bmw/. The last nutrient report was written in 2000 and states that the Barnegat Bay waters are likely stressed due to low dissolved oxygen levels, abundant nitrogen species, and algal blooms (NJDEP, 2000).

MUSSEL WATCH

The National Oceanic and Atmospheric Administration (NOAA) monitors several stations in New Jersey as part of its Mussel Watch Program (Figure 25). Using the mussel tissues, NOAA runs various parameters, including heavy metal concentrations. The closest mussel watch station to the Central Barnegat Bay area is located in the Atlantic Ocean, just outside of the Barnegat Inlet. This station was tested in 1999 and 2002; the tissue results for arsenic, cadmium, chromium, lead, nickel, or mercury did not exceed FDA guidance values.

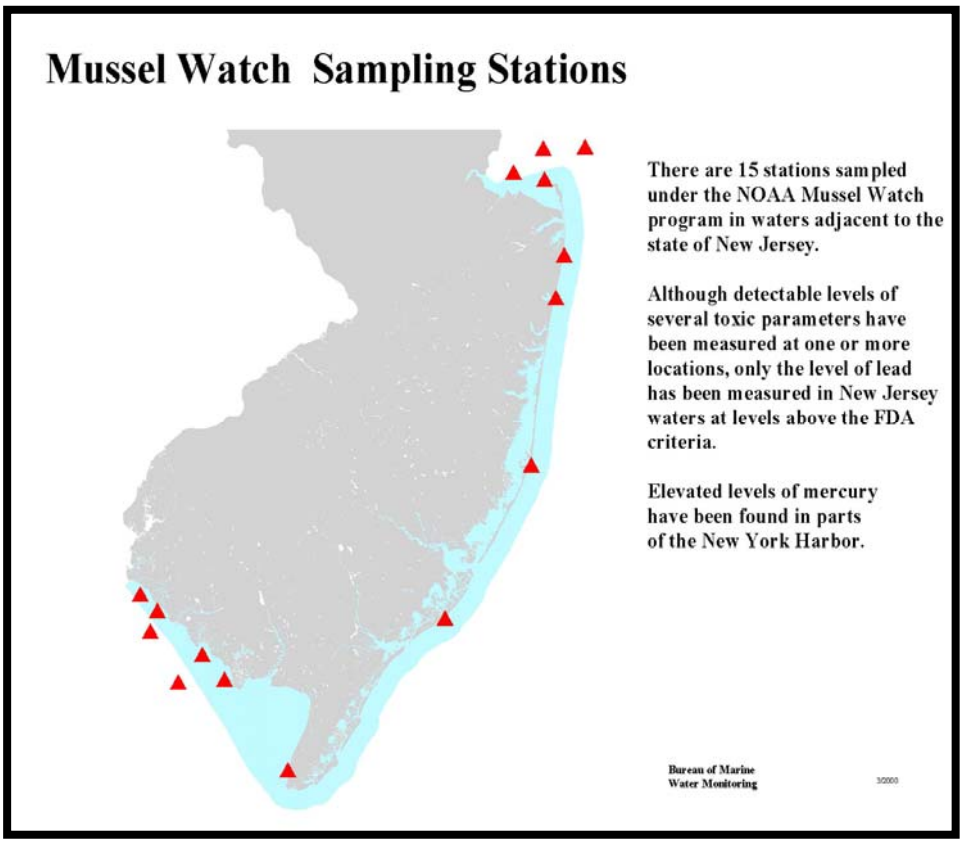


FIGURE 25: SAMPLING SITES WHERE NOAA MUSSEL WATCH DATA HAVE BEEN COLLECTED

INTERPETATION AND DISCUSSION OF DATA

BACTERIOLOGICAL DATA

Total Coliform Evaluation

The water quality data obtained from the sampling period of January 1999 to December 2002 are listed in Appendix 1. Systematic Random Sampling Strategy was used to collect the samples, laboratory tests were run for total coliform, and a thorough analysis of the data was performed for this report.

The bacteriological data for each station support their respective criteria for *Approved*, *Seasonal*, or *Special Restricted* classification under the total coliform standard. The stations that exceed *Special Restricted* criteria are classified as *Prohibited*. Based on all of these data, this growing area is adequately classified.

There were ten stations with a tidal component and seven with a seasonal component, but on analysis it was found that all stations impacted by season and/or tide remain in compliance with their respective classification criteria. There were no stations impacted by rainfall.

Fecal Coliform Evaluation

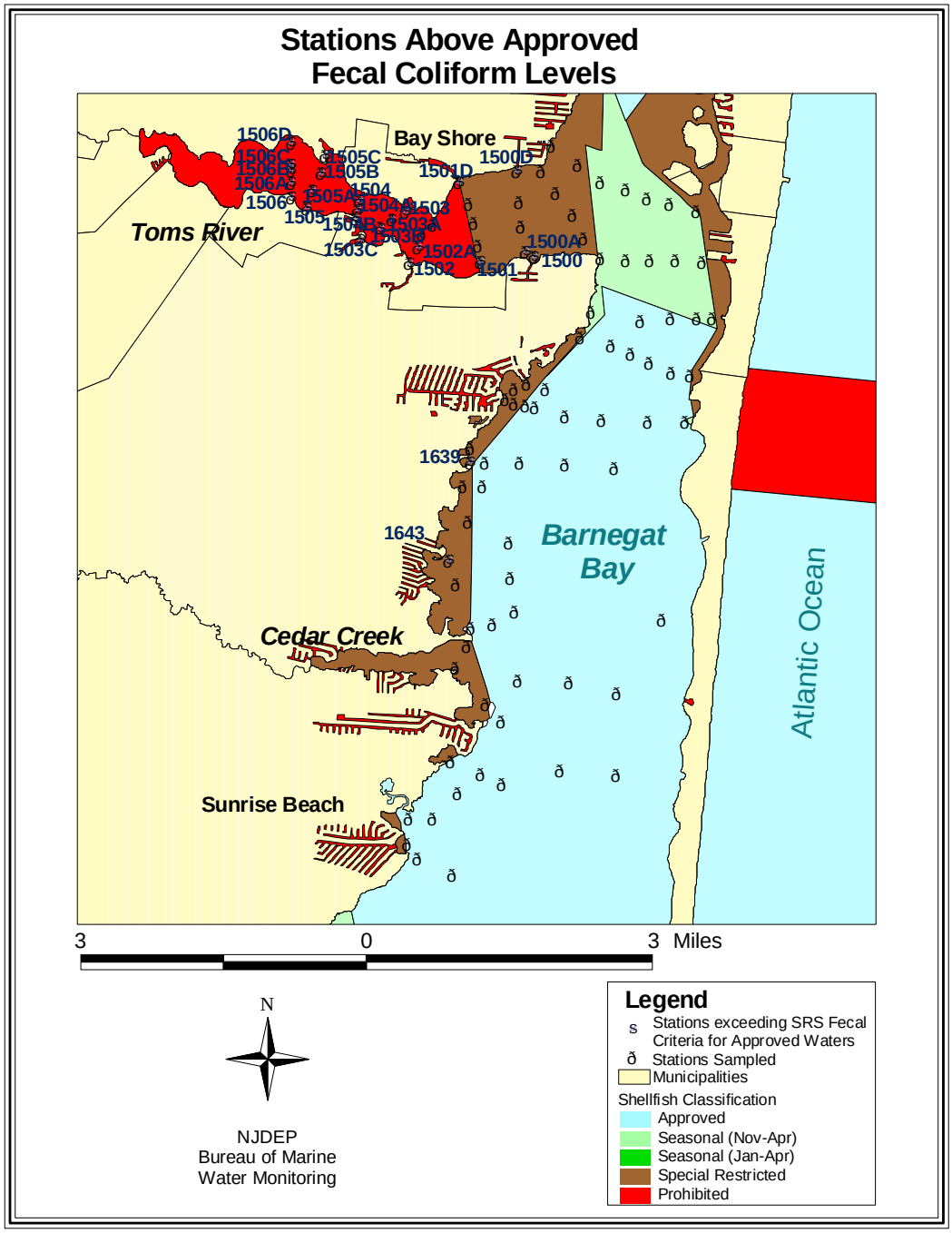
Shellfish classifications are based on the analysis of total coliform levels, but the Bureau of Marine Water Monitoring also conducts fecal coliform testing, which is viewed as adjunct data, and is not directly used for classifying in many areas.

For the waters to have an *Approved* classification the Fecal Geometric Mean must be below 14 MPN/100 ml and Fecal Est. 90th Percentile must be below 49 MPN/100 ml. For the waters to have a *Special Restricted* classification, the Fecal Geometric Mean must be below 88 MPN/100 ml and Fecal Est. 90th Percentile must be below 300 MPN/100 ml (see Table 2). Twenty-five stations did not fit the fecal coliform levels for *Approved* classification; station 1505C also exceeded the Fecal Est. 90th Percentile criterion for *Special Restricted*, which is not a problem since under current classification this station lies within *Prohibited* waters (see Figure 26 and Table 11). All of the other stations that exceeded the *Approved* criteria are presently situated in *Prohibited* or *Special Restricted* waters; therefore, the current shellfish classifications remain properly designated. From the given data, no downgrading of waters would be required in this growing area if data analysis switched from a total coliform criterion to a fecal coliform criterion. However, this statement is based on year-round data, the raw data for the summer and winter seasons would be needed to assess the *Seasonal* classifications before any action was taken.

TABLE 11: STATIONS ABOVE YEAR ROUND FECAL CRITERIA

Station	Status	Fecal Geo. Mean	Fecal Est. 90th	Fecal Sample Size
1500	SR	11.9	50.8	31
1500A	SR	9.9	59.1	32
1500D	SR	11.5	65.0	32
1501	SR	10.4	59.7	32
1501D	SR	17.2	107.1	32
1502	P	16.8	94.6	32
1502A	P	11.6	53.5	32
1503	P	17.0	131.3	32
1503A	P	16.7	136.6	32
1503B	P	23.1	154.6	32
1503C	P	25.0	154.8	32
1504	P	18.1	78.9	32
1504A	P	15.2	69.8	32
1504B	P	21.6	150.2	32
1505	P	22.3	104.3	32
1505A	P	14.1	61.5	32
1505B	P	25.5	109.0	32
1505C	P	48.5	460.6	31
1506	P	23.6	133.9	32
1506A	P	28.2	141.2	32
1506B	P	21.1	98.4	32
1506C	P	21.5	166.4	32
1506D	P	22.3	141.0	32
1639	SR	10.9	70.0	35
1643	SR	9.9	55.1	34

FIGURE 26: STATIONS EXCEEDING FECAL COLIFORM CRITERIA



CONCLUSIONS

BACTERIOLOGICAL SUMMARY

Analysis of the Central Barnegat Bay shellfish growing area samples indicate that total coliform levels meet the standards of the National Shellfish Sanitation Program (NSSP). The western portion of the Toms River should remain *Prohibited* due to the high total coliform levels. The eastern portion of the Toms River fits within the criteria for *Special Restricted*. The Barnegat Bay, at the mouth of the Toms River, is adequately classified as *Seasonal (Jan-Apr)*, since it receives the flush from the northern portion of the Barnegat Bay and Toms River, both which have high summer populations. The urban coastline of Barnegat Bay is classified as *Special Restricted*, including Cedar Creek, and should remain so, due to runoff, outfalls, and marinas. The rest of Barnegat Bay is *Approved*, excluding *the Special Restricted* areas off of Seaside Heights and Seaside Park. There is no reason to downgrade these *Approved* waters, since all stations fit within the total coliform *Approved* criteria. The continuation of improving water quality may allow for future upgrades in this area.

RECOMMENDATIONS

BACTERIOLOGICAL EVALUATION

RECOMMENDED CLASSIFICATION CHANGES

Currently, there are no recommendations for changes in classifications.

RECOMMENDED CHANGES IN MONITORING SCHEDULE

There are no recommended changes for the monitoring schedule.

RECOMMENDATIONS FOR FURTHER STUDY

Stations 1634D, 1650D, & 1653A should be monitored closely. Stations 1653A & 1650D, which are in *Approved* waters, had a seasonal component when the summer and winter sample sizes were expanded to thirty. Station 1634D, in *Seasonal (Nov-Apr)* waters, had a tidal component when the ebb and flood sample sizes were expanded to thirty.

LITERATURE CITED

APHA. 1970. Recommended Procedures for the Examination of Seawater and Shellfish, 4th ed., American Public Health Association, Washington, DC.

APHA. 1995. Standard Methods for the Examination of Water and Wastewater, 19th ed., American Public Health Association, Washington, DC.

Barnegat Bay Resources. CRRSA Rutgers. 24 March 2003. http://www.crssa.rutgers.edu/projects/runj/bbay.html.

Barnegat Bay Estuary Program Comprehensive Conservation and Management Plan. Barnegat Bay Estuary Program. 7 March 2003. http://www.bbep.org/ccmp.htm.

Bates, Todd and Kirk Moore. "Study: Steep decline in clams found in Little Egg Harbor". Asbury Park Press. 21 July 2003.

Census Bureau, US (2000). US Government. 5 March 2003 http://quickfacts.census.gov/qfd/states/34000.html.

Connell, R.C. 1991. Evaluation of Adverse Pollution Conditions in New Jersey's Coastal Waters. New Jersey Department of Environmental Protection, Marine Water Classification and Analysis, Leeds Point, NJ.

CRSSA Rutgers. Barnegat Bay Resources. March 2003. http://www.crssa.rutgers.edu/projects/runj/bbay.html.

Ehinger, Ruth. Personnel Communication via Email. State of New Jersey. DEP. Policy, Planning, and Science. 6 April 2005.

Farnsworth, John. 2000. Sanitary Survey. Shellfish Growing Water Area BB2 Toms River to Forked River. NJDEP, Bureau of Marine Water Monitoring, Leeds Point, NJ.

Maskaly, Michelle. "Land Donation really is 'Good Luck'". Ocean County Observer. 27 March 2003. http://www.injersey.com/news/backstories.pl?id=713414&paper=9

Moore, Kirk. "Divers to patch OCUA outfall line in Barnegat Bay." Asbury Park Press 6 February 2003. Ocean County Observer. Online. 7 February 2003. http://www.injersey.com/observer/.

Moore, Kirk. "Sewer leak in Berkeley prompts ban on clamming." Asbury Park Press 5 February 2003.

N.J.A.C. (New Jersey Administrative Code) Title 7. Department of Environmental Protection. Chapter 12 7:12-1.2, 12-3 &12-4.

NJDCA (New Jersey Department of Community Affairs). Office of Smart Growth. Maps and GIS Data. The 2001 State Plan Policy Map and Other Maps. Smart Growth Areas. 3 May 2005. http://www.nj.gov/dca/osg/resources/maps/index.shtml

NJDEP Brownfields Site Mart. 3 May 2005. http://www.njsitemart.com

NJDEP Division of Science, Research, and Technology. (DSRT) Brown Tide Newletter. *Aureococcus anophagefferens* (Brown Tide) "golden brown algal cell causing the lack of feeding" July 2002. http://www.state.nj.us/dep/dsr/browntide/bt.htm

NJDEP Postmaster. "Press Release: New Jersey Seeks Compensation for Natural Resource Damages at Ciba-Geigy Superfund Site" 2 October 2003. Contact: Fred Mumford.

NJDEP. 1992. Field Sampling Procedures Manual. New Jersey Department of Environmental Protection, Trenton, NJ.

NJDEP Fish, Game, & Wildlife. 1986 Hard Clam Shellfish Survey.

NJDEP. 1999, 2000, 2001, 2002, 2003, & 2004. State of New Jersey Shellfish Growing Water Classification Charts. New Jersey Department of Environmental Protection, Marine Water Monitoring, Leeds Point, NJ.

NJDEP. 2000. Annual Summary of Phytoplankton Blooms and Related Conditions in New Jersey Coastal Waters. (Summer 1997). New Jersey Department of Environmental Protection, Freshwater and Biological Monitoring, Trenton, NJ.

NJDEP. Watershed Management Area 13: The Barnegat Bay Drainage. 12 May 2003. http://www.state.nj.us/dep/dsr/watershed/area_13.pdf.

New Jersey Pinelands Commission. NJ Government. 18 March 2003. http://www.nj.gov/pinelands/.

NOAA. Climatic Records for New Jersey. Accessed monthly. www.ncdc.noaa.gov/onlineprod/drought/xmgr.html

Ocean County Department of Planning. Ocean County. 24 February 2003. http://www.co.ocean.nj.us/planning/planninghome.htm.

Ocean County Utilities Authority. OCUA. 6 February 2003. http://www.ocua.com/.

Peters, John. Reappraisal Report. Shellfish Growing Water Area Little Egg Harbor Bay. NJDEP, Bureau of Marine Water Monitoring, Leeds Point, NJ.

Save the Barnegat Bay. Home Page. 19 March 2003. http://www.savebarnegatbay.org/.

Soloman, Eldra, Linda Berg, Diana Martin. Biology (fifth edition) New York: Saunders College Publishing, 1999.

USGS, Water Resources. USGS 01408500 TOMS RIVER NEAR TOMS RIVER NJ. 7 March 2003. http://waterdata.usgs.gov/nj/nwis/dv/?site_no=01408500&agency_cd=USGS

USPHS. *Guide for the Control of Molluscan Shellfish*, 1997.

USPHS. 1995. National Shellfish Sanitation Program Manual of Operations, Part I: Sanitation of Shellfish Growing Areas. US Public Health Service, Food and Drug Administration, Washington, DC

Zimmer, B. and Groppenbacher, S. 1999. NJ Ambient Monitoring Program Report on Marine and Coastal Water Quality NJDEP Bureau of Marine Water Monitoring, Leeds Point, NJ.

ACKNOWLEDGMENTS

This report was written under the direction of Robert Connell, Jr., Bureau Chief, Alena Baldwin-Brown, Executive Assistant, and Leslie J. McGeorge, Administrator. Mike Kusmiesz assisted in statistical and GIS data analysis. Special acknowledgment is given to Captains Donald Owens, Rich Rand, and supervisor Bob Schuster for their perseverance in collecting shellfish water quality samples in the BB2 area (Central Barnegat Bay). This study would not have been completed without the analytical capabilities of our microbiology laboratory staff, including Eric Feerst, Supervisor, Lisa DiElmo, Elena Heller, Bruce Hovendon, and Bob Seabrook; and our chemistry laboratory staff, including Mike Dileo, supervisor, Dawn Feldman, and Stephanie Tablack. Deborah Watkins, Paul Weisghan, Julie Nguyen, and Mike Curtis gave guidance in the written report.

APPENDICES

A. Statistical Summary

B. Seasonal Evaluation

C. Precipitation

Rainfall Correlation

Cumulative Rainfall

D. Tidal Evaluation

E. Data Listing - 1999 through 2002

F. Figure: Wheelhouse Marina Buffer