New Jersey Department of Environmental Protection
Land Use Management
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# REAPPRAISAL OF SHELLFISH GROWING AREA NE-4, THE SHARK RIVER 1994-2000

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# REAPPRAISAL OF SHELLFISH GROWING AREA NE-4, THE SHARK RIVER

1994-2001

New Jersey Department of Environmental Protection
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# *EXECUTIVE SUMMARY*

The water quality data presented in this Reappraisal of Shellfish Growing Area NE-4, The Shark River, was collected between November 1994 and June 2000. The waters in this shellfish growing area are classified as *Special Restricted*. It is prohibited to harvest shellfish from this area for direct market without a special permit issued in compliance with the State of New Jersey's Relay or Depuration Programs. The water quality of this shellfish growing area was consistent with the shellfish growing area classification as specified by the National Shellfish Sanitation Program (NSSP) criteria (USPHS, 1997 Revision).

# *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) that are established by the Interstate Shellfish Sanitation Conference (ISSC). Reports generated under this program form the basis for classifying shellfish waters for the purpose of harvesting shellfish for human consumption. As such, they provide a critical link in protecting human health.

The second purpose is to provide input to the water quality inventory portion of the State's *Integrated Water Quality Monitoring and Assessment Report*. This report 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 that provides an assessment to Congress every two years of current water quality conditions in the State's major rivers, lakes, estuaries, and ocean waters. These growing area reports provide valuable information that 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, these 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.

The Department participates in the cooperative National Environmental Performance Partnership System (NEPPS) with the USEPA which emphasizes ongoing evaluation of issues associated with environmental regulation, including assessing impacts on waterbodies 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. In conjunction with the NEPPS Agreement, the shellfish growing area reports also 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 resource and provide a reliable indicator of potential areas of concern and/or areas where additional information is needed to accurately assess watershed dynamics.

## HISTORY

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 after oysters were implicated in causing over 1500 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 through 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 in Annapolis, Maryland, and formed the ISSC. 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 (USPHS, 1997 Revision). 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. Prevention of 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 rules mentioned above.

The Department of Health and Senior Services is responsible for the certification 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.

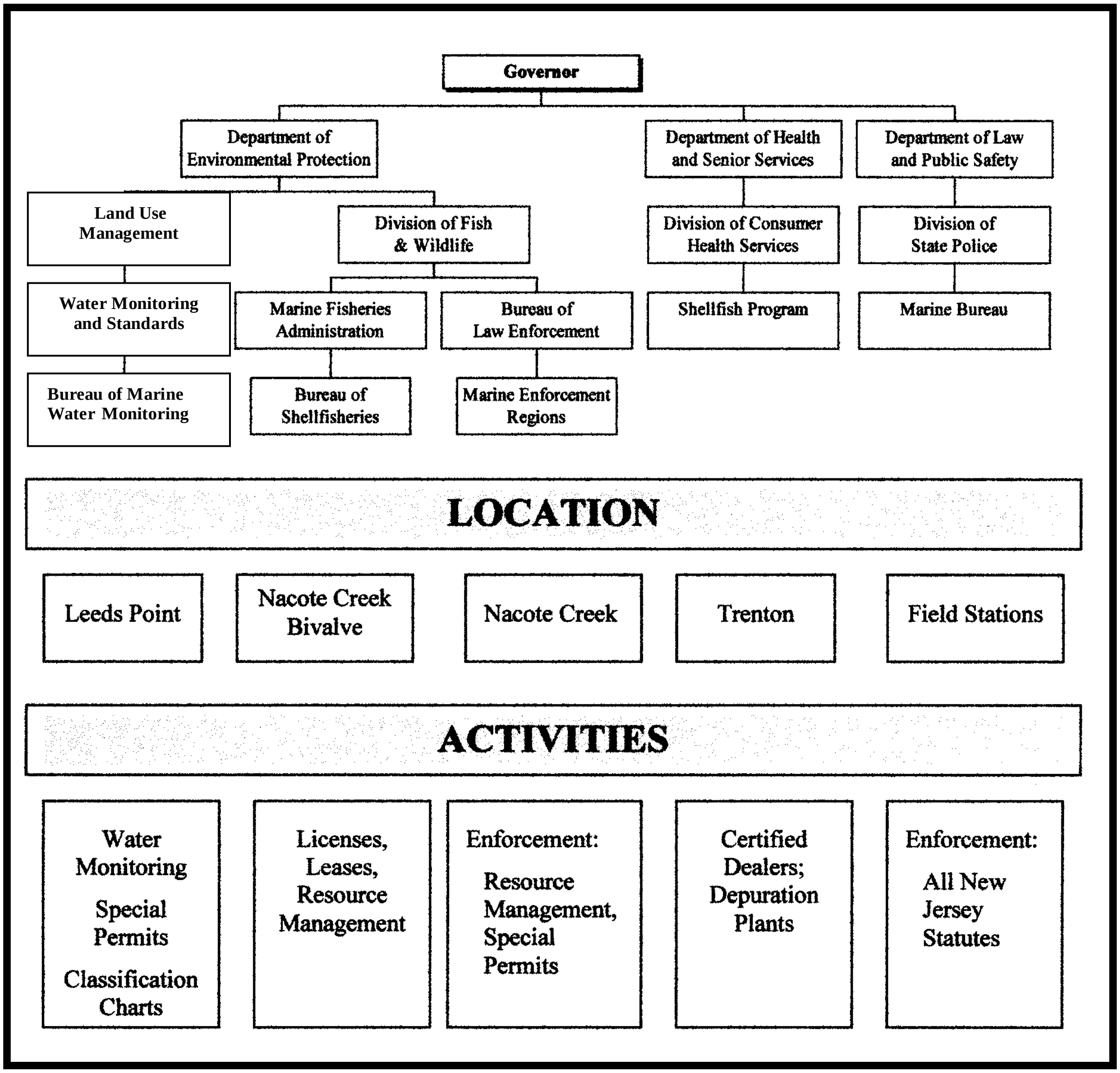


**FIGURE 1: STATE OF NEW JERSEY SHELLFISH AGENCIES.**

## IMPORTANCE OF SANITARY CONTROL OF SHELLFISH

Emphasis is placed on the sanitary control of shellfish because of the direct relationship between 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. The cycle usually begins with fecal contamination of the shellfish growing waters. Sources of such contamination are many and varied. Contamination reaches the waterways via stormwater runoff from urban and agricultural areas and from direct discharges such as wastewater treatment facilities.

Clams, oysters and mussels pump large quantities of water through their bodies during the normal feeding process. During this process the shellfish also concentrate 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. If major changes to the shoreline or bacterial quality occur, then the intensive report (Sanitary Survey) is initiated prior to its l2 year schedule. Also, 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.

The following narrative constitutes this bureau's assessment of the above mentioned components and determines the current classification of the shellfish growing waters of Shellfish Growing Area NE-4, the Shark River.

## *GROWING AREA PROFILE*

### LOCATION

Shellfish Growing Area NE-4; The Shark River is located in the east central part of New Jersey, northwest of the city of Belmar and south of Neptune City, in Monmouth County (USDI-GS, 1989). This river is bordered on the east by Avon-by-the-Sea, to the north by Neptune City, to the west by Neptune Township and Wall Township, and to the south by Wall Township and Belmar Borough.

The locations of the adjacent municipalities are shown in Figure 2, and the population statistics for the adjacent municipalities are shown in Table 1.


**FIGURE 2: LOCATION AND MUNICIPALITIES OF SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

**TABLE 1: POPULATION INFORMATION FOR THE COMMUNITIES NEAR THE SHARK RIVER AREA** (NJ DEPARTMENT OF LABOR, 2001)**.**

| Community | Area (sq. mi.) | Population (2000 Census) | Population Density (persons/sq. mi.) |
|---|---|---|---|
| Wall Township | 30.98 sq.mi. | 25,261 | 815 |
| Neptune Township | 8.81 sq.mi. | 27,690 | 3,143 |
| Neptune City Borough | 0.88 sq.mi. | 5,218 | 5,929 |
| Bradley Beach Borough | 0.60 sq.mi. | 4,793 | 7,988 |
| Avon-by-the-Sea Borough | 0.46 sq.mi. | 2,244 | 4,878 |
| Belmar Borough | 1.39 sq.mi. | 6,045 | 4,349 |
| South Belmar Borough | 0.25 sq.mi. | 1,806 | 7,224 |

## DESCRIPTION

The area of the Shark River and the waters that drain into the Shark River Inlet are located in Monmouth County, New Jersey. The Shark River Shellfish Growing Area is approximately 791.8 acres in area, and can be found on Chart 3 of the "2002 State of New Jersey-Shellfish Growing Water Classification Charts" (NJDEP, 2001). The principal bodies of water in this area are the Shark River, Musquash Cove, and the Shark River Inlet. The Shark River also includes the North Channel, west of the Shark River Island, and the South Arm, the inlet area south of the Shark River Island. Tidal flushing of this area occurs through the Shark River Inlet.

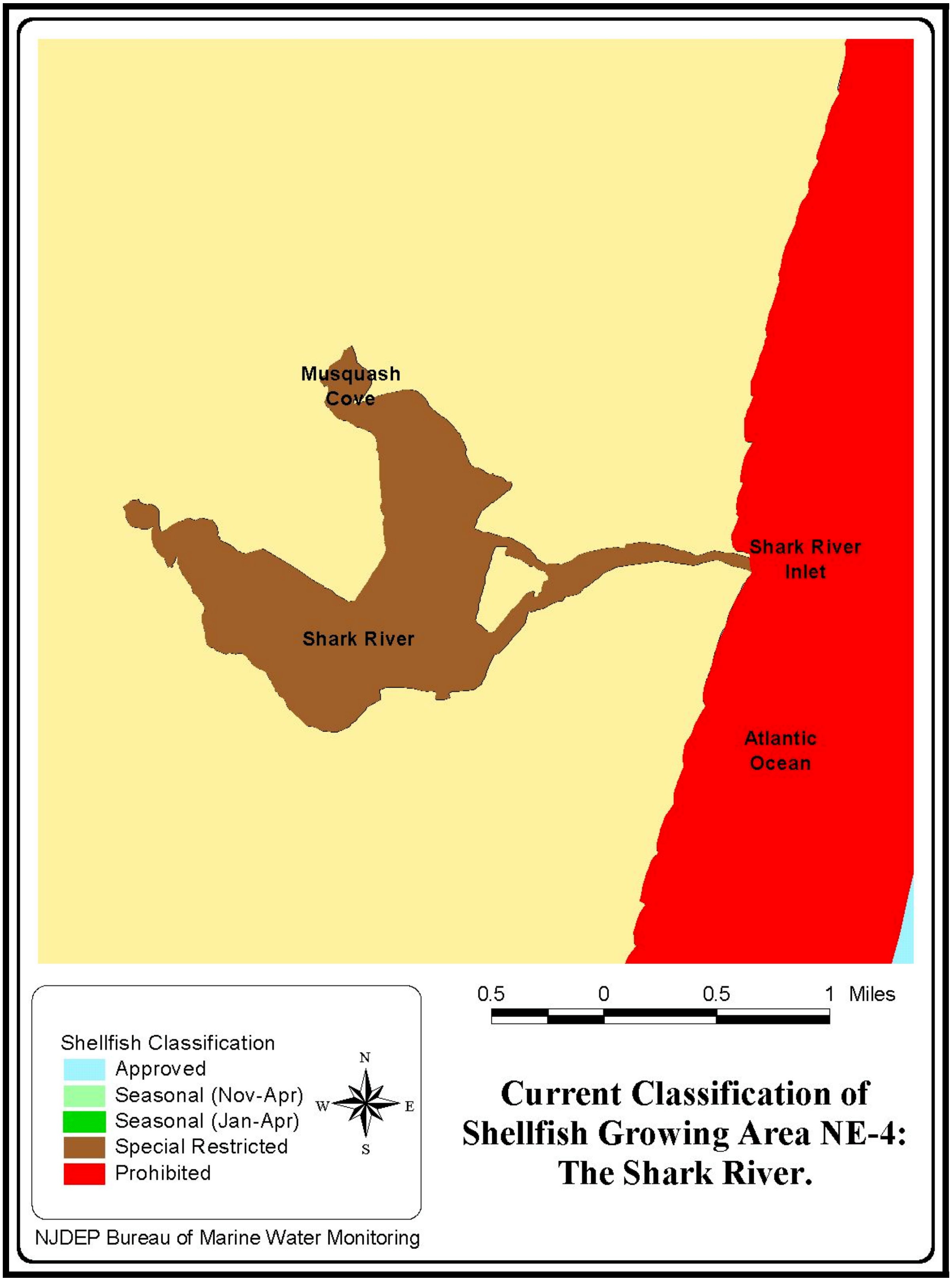


**FIGURE 3: CURRENT CLASSIFICATION OF SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

## HISTORY OF GROWING AREA CLASSIFICATION

The Shark River area has historically been an area with a large abundance of hard clams. The shellfish waters of this area are primarily classified as *Special Restricted* in the Shark River, the Shark River Inlet, and Musquash Cove (NJDEP, 2001) (see Figure 3). The *Special Restricted* classification signifies that it is prohibited to harvest shellfish from these waters for direct market, unless a special permit is issued which is in compliance with the State of New Jersey's Relay or Depuration Programs.

Relay is the transfer of shellfish from a growing area classified as *Special Restricted* to a growing area classified as *Approved* for the purpose of reducing bacterial contamination by using the ambient environment as a treatment process. This allows the shellfish to purge themselves of the bacterial contamination before humans consume them.

Depuration is the process in which bacterial contamination is reduced by purging or siphoning clean water through the shellfish in a controlled laboratory environment operated under the State guidelines. According to the Reappraisal of the Shark River written in 1999, a special two-week long controlled harvest of shellfish in this area was allowed in February 1994 by the State of New Jersey's Depuration Program (Farnsworth, 1999).

Before 1987, this entire shellfish growing area was classified as *Prohibited* waters. It wasn't until 1987 that this area was upgraded to the *Special Restricted* classification, based on an administrative adjustment made in compliance with the definitions in the NSSP 1986 Manual of

Operations. This allowed the State of New Jersey to continue its relay program of the Shark River.

In 1996, the sampling of the Shark River was changed to reflect a decrease in staff, and this area was placed lower on the sampling schedule, along with other areas with no legal harvest permitted and low potential for upgrade. The minimum number of water samples (five samples) was not collected. The 1998 Annual Review of the Shark River, which included data from March 1994 through October 1997, showed that 31 out of the 45 sampling stations exceeded the *Special Restricted* criteria for fecal coliform, while sampled using Adverse Pollution Condition (APC) sampling strategy. It was recommended that no harvesting of shellfish be allowed until additional samples could be collected and analyzed for total coliform bacteria.

Prior to 1998, this shellfish growing area was sampled using the Adverse Pollution Condition (APC) sampling strategy (the condition was rainfall). In 1998, the sampling strategy was changed to Systematic Random Sampling (SRS) strategy, which requires 30 sets of data at each sampling station. In the Reappraisal of the Shark River for 1999, data were evaluated from October 1992 to September 1998 to get enough sets of data for the water quality evaluation (Farnsworth, 1999). Five out of the 53 sampling stations met the *Approved* criteria for water quality, and all of the sampling stations met the *Special Restricted* criteria for water quality. It was proposed not to change the classification of the Shark River from *Special Restricted* to *Prohibited*.

The Shark River was officially designated a No Discharge Zone for marine sanitary devices in May 1998. This was done to improve the water quality of the Shark River during the boating season. However, the Neptune Sewerage Authority did experience some minor sewage spills in 1998, but these spills were of low volume and there was no evidence that they impacted the water quality of this shellfish growing area.

In the 2001 Annual Review of the Shark River, all of the sampling stations met the *Special Restricted* criteria for total coliform bacteria (NJDEP, 2001). There was no significant seasonal, tidal, or rainfall component. No classification changes were proposed for this area at that time. The last Sanitary Survey for this area was written in 1994.

## *METHODS*

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

Approximately 1477 water samples were collected for total and fecal coliform bacteria between 1994 and 2000 and analyzed by the three tube MPN method according to APHA (APHA, 1970). Figure 21 shows the Shellfish Growing Water Quality monitoring stations in the Shark River. Approximately 45 stations are monitored during each year in Marine Water Sampling Assignment Area 57. Water quality sampling, shoreline and watershed surveys were conducted in accordance with the NSSP *Guide for the Control of Molluscan Shellfish* (USPHS, 1997 Revision).

Data management and analysis was accomplished using database applications developed for the Bureau. Mapping of pollution data was performed with the Geographic Information System (GIS: ARCVIEW®).

## **BACTERIOLOGICAL INVESTIGATION AND DATA ANALYSIS**

The water quality of each growing area must be evaluated before an area can be classified as *Approved, Seasonally Approved (November to April), Seasonally Approved (January to April), Special Restricted*, or *Prohibited*. Criteria for bacterial acceptability of shellfish growing waters are provided in NSSP *Guide for the Control of Molluscan Shellfish* (USPHS, 1997 Revision).

### SAMPLING STRATEGY

The State Shellfish Control Authority has the option of choosing one of 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 the 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 (Connell, 1991).

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 Shark River is sampled under the Systematic Random Sampling strategy year-round, with an ebb tide preference for all sampling stations in the Shark River (Assignment Area 57).

## 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 criteria were 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 Adverse Pollution Condition sampling strategy, variability is expressed as the percentage that exceeds the variability criteria (see Table 2). For the Systematic Random Sampling Strategy, variability is expressed as the $90^{th}$ percentile (see Table 3).

Areas to be Approved under the Seasonal classification must be sampled and meet the criterion during the time of the year that it is approved for the harvest of shellfish.

**TABLE 2: CRITERIA FOR ADVERSE POLLUTION CONDITION SAMPLING STRATEGY**

| | Total Coliform Criteria | | Fecal Coliform Criteria | |
|---|---|---|---|---|
| | Geometric mean (MPN/100 mL) | Not more than 10% can exceed (MPN/100 mL) | Geometric mean (MPN/100 mL) | Not more than 10% can exceed (MPN/100 mL) |
| **Approved Water Classification** | 70 | 330 | 14 | 49 |
| **Special Restricted Water Classification** | 700 | 3300 | 88 | 300 |

**TABLE 3: CRITERIA FOR SYSTEMATIC RANDOM SAMPLING STRATEGY**

| | Total Coliform Criteria | | Fecal Coliform Criteria | |
|---|---|---|---|---|
| | Geometric mean (MPN/100 mL) | Estimated 90$^{th}$ percentile (MPN/100 mL) | Geometric mean (MPN/100 mL) | Estimated 90$^{th}$ percentile (MPN/100 mL) |
| **Approved Water Classification** | 70 | 330 | 14 | 49 |
| **Special Restricted Water Classification** | 700 | 3300 | 88 | 300 |

## MARINE BIOTOXINS

The Department collects samples at regular intervals throughout the summer to determine the occurrence of marine biotoxins (NJDEP, 1998). These data are evaluated weekly by the Bureau of Marine Water Monitoring in accordance with the NSSP requirements. An annual report is compiled and is available electronically at: www.state.nj.us/dep/wmm/bmw.

# *SHORELINE SURVEY*

## CHANGES SINCE LAST SURVEY

There have been no significant changes to this shellfish growing area since the last shoreline survey in 1999. The urban area that borders the Shark River, the Shark River Inlet, and Musquash Cove is connected to the public sanitary sewage system. There are 12 sewage pumping stations surrounding this area and they appear to be periodically maintained. About 70% of the shoreline around the Shark River and the Shark River Inlet are bordered with bulkheads. Only Musquash Cove, the southwest (upstream) side of the Shark River, the west side of the Shark River Island, and a part of the shore south of Neptune City are not bordered with bulkheads. Instead, they have an erodable shoreline (see Figures 5, 8, and 11).

A Shoreline Survey was conducted for the Shark River area on October 3, 2001. Photographs of the surrounding marinas, storm water outfalls, bulkheads, shore type, shore structures, and sampling station locations were taken at a variety of locations. Some of these photographs are included in this report. This shoreline survey was consistent with the shoreline survey of the Shark River included in the January 1999 Reappraisal of the Shark River Estuary (Farnsworth, 1999).

**FIGURE 4: BULKHEAD LOCATED AT MACLEARIE PARK ON ROUTE 35 ON THE SOUTH SIDE OF THE SHARK RIVER. PHOTOGRAPH TAKEN ON OCTOBER 3, 2001 AT 9:43A.M.**

## LAND USE

The land use patterns of this area are mainly urban, with significant human activities impacting the shellfish growing area. There are currently 19 marinas in this area, with significant boating and water activities in the summer. The water quality of this shellfish growing area is typically impacted by the non-point pollution sources associated with these activities, along with the many storm water outfalls located in this shellfish growing area. Forests and wetlands border the southwest (upstream) side of the Shark River. There is little or no livestock farming in this area. Figure 6 shows the land use patterns, Figures 14, 15, and 16 show the storm water outfalls, and Figures 17, 18, and 19 shows the marinas for the Shark River.

**FIGURE 5: LOCATION OF ERODABLE SHORELINE SOUTHWEST (UPSTREAM) OF SHARK RIVER. PHOTOGRAPH WAS TAKEN FROM END OF NORTH MARCONI ROAD IN THE FORT MONMOUTH- EVANS AREA ON OCTOBER 3, 2001 AT 10:12 A.M.**

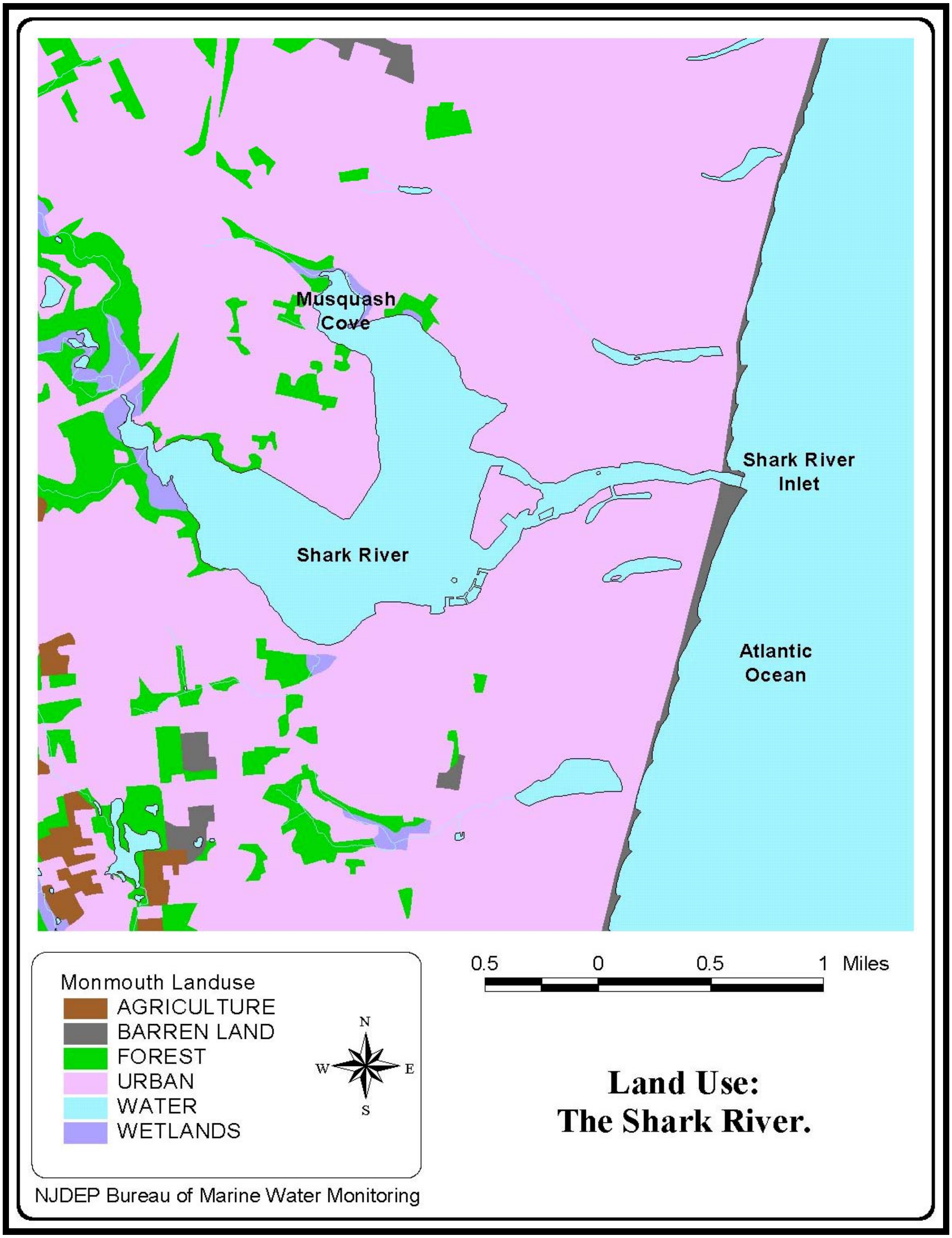


**FIGURE 6: LAND USE PATTERNS FOR SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

## **EVALUATION OF BIOLOGICAL RESOURCES**

This growing area has a wide diversity of biological resources (see Figures 7 and 9). Hard clams (*Mercenaria mercenaria*) exist in great abundance, and are privately and commercially harvested. Soft-shelled clams (*Mya arenaria*) exist in low abundance in this shellfish growing area. However, since this shellfish growing area is classified as *Special Restricted*, it is prohibited to harvest shellfish for direct market unless a special permit is issued in compliance with the State's Relay or Depuration Programs before the shellfish can be used for human consumption. Crabs are also harvested in this area. The Shark River and the Shark River Inlet are also utilized for fishing and boating.

During the Shoreline Survey of the Shark River on October 3, 2001, a flock of gulls were seen feeding near the beach south of Neptune City (see Figure 7). This beach, which is part of a recreation park (Memorial Park), was also covered with a large amount of gull droppings. Wildlife populations of birds and animals are potential contributors to water quality in this area and could have an impact on the water quality by elevating the bacterial counts. Figure 10 shows the location of the vegetation and marsh types around this shellfish growing area, and Figure 11 shows the shore structure and shore type around this shellfish growing area.

**FIGURE 7: LOCATION OF BEACH AT MEMORIAL PARK ON RIVERSIDE DRIVE, NEPTUNE CITY. THIS BEACH IS IN THE NORTH SIDE OF THE SHARK RIVER. A FLOCK OF GULLS WERE FEEDING NEAR THE BEACH, AND THE SHORE AND RECREATIONAL PARK WERE COVERED WITH GULL DROPPINGS. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 11:08 A.M.**

**FIGURE 8: LOCATION OF ERODABLE SHORELINE ON WEST SIDE OF SHARK RIVER ISLAND. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 9:48 A.M.**

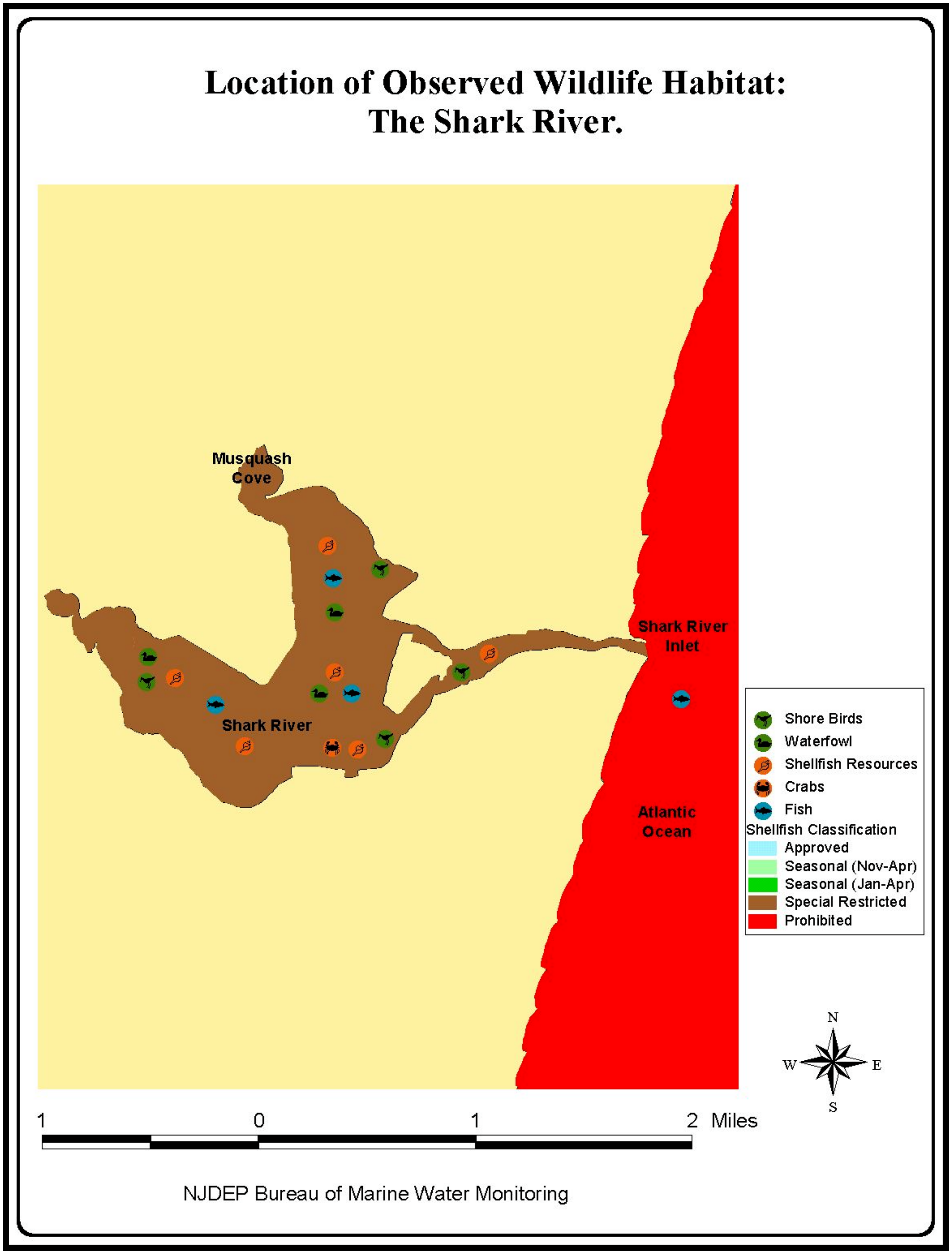


**FIGURE 9: LOCATION OF OBSERVED WILDLIFE HABITAT IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

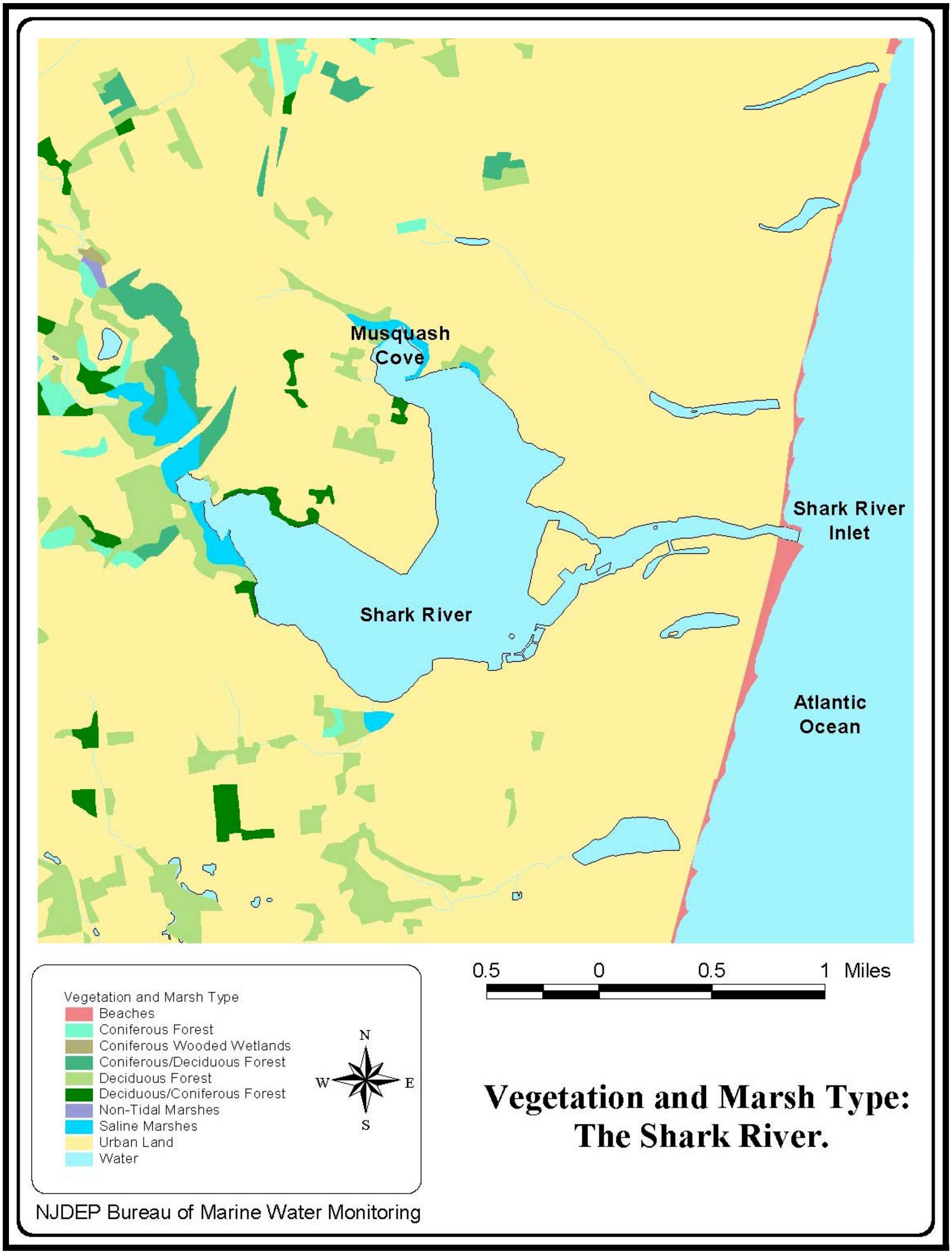


**FIGURE 10: LOCATION OF VEGETATION AND MARSH TYPE IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

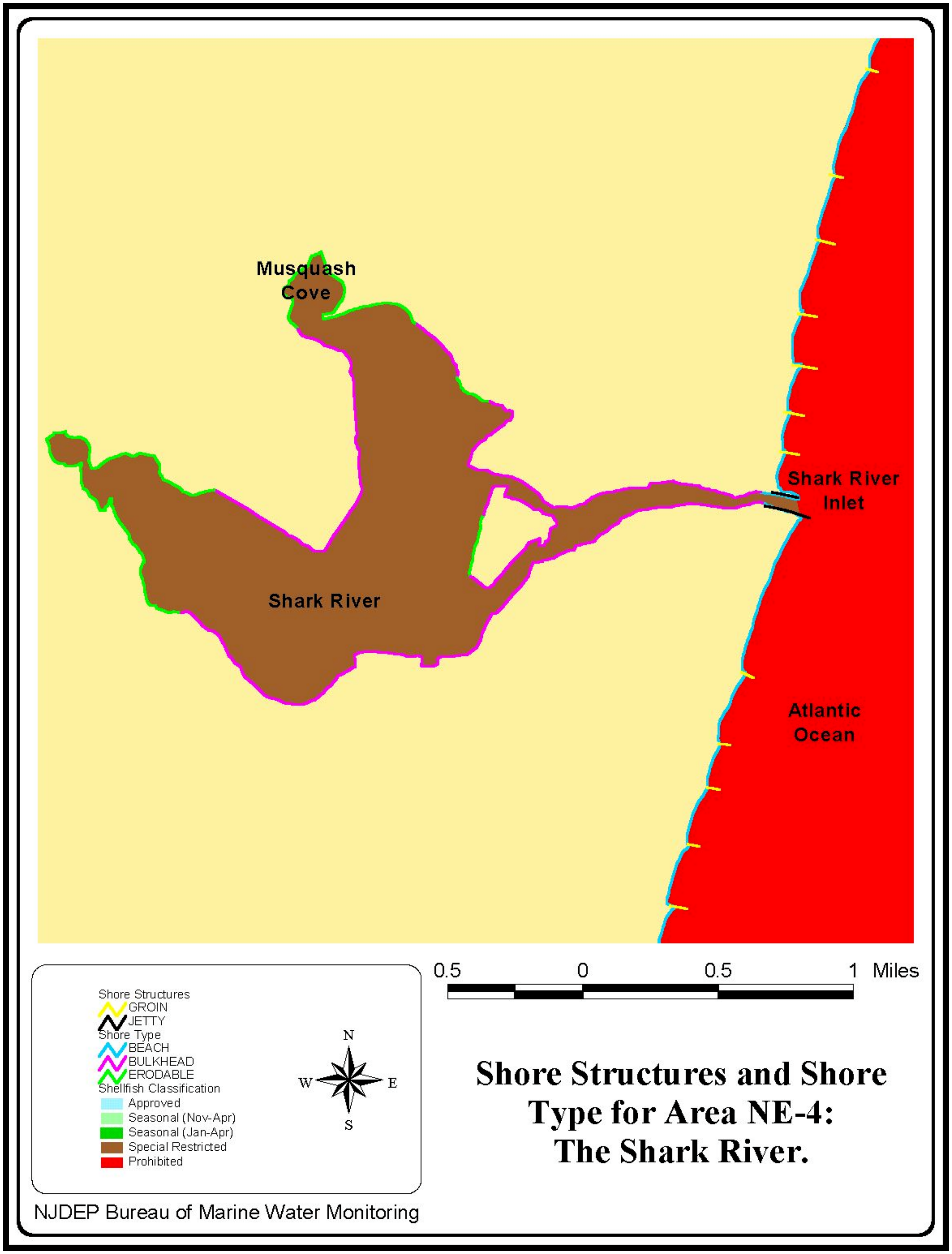


**FIGURE 11: SHORE STRUCTURES AND SHORE TYPE IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

## IDENTIFICATION AND EVALUATION OF POLLUTION SOURCES

There are several indirect ground water discharges and known contaminated sites located in this shellfish growing area (see Figures 12 and 13). However, there is no evidence that they currently impact the shellfish growing water quality (APHA, 1995).

### INDIRECT DISCHARGES

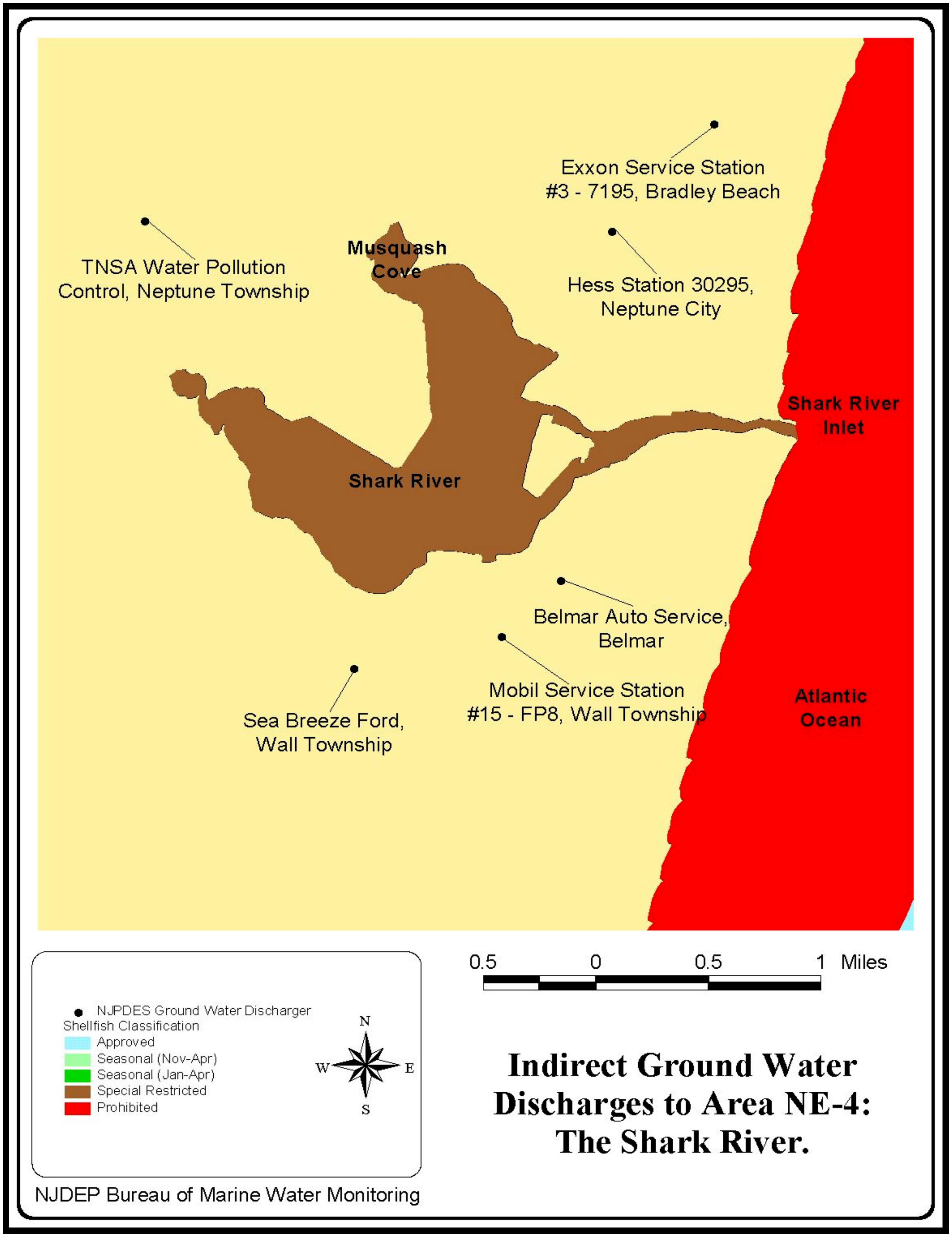


**FIGURE 12: INDIRECT GROUND WATER DISCHARGES TO THE WATERS OF SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

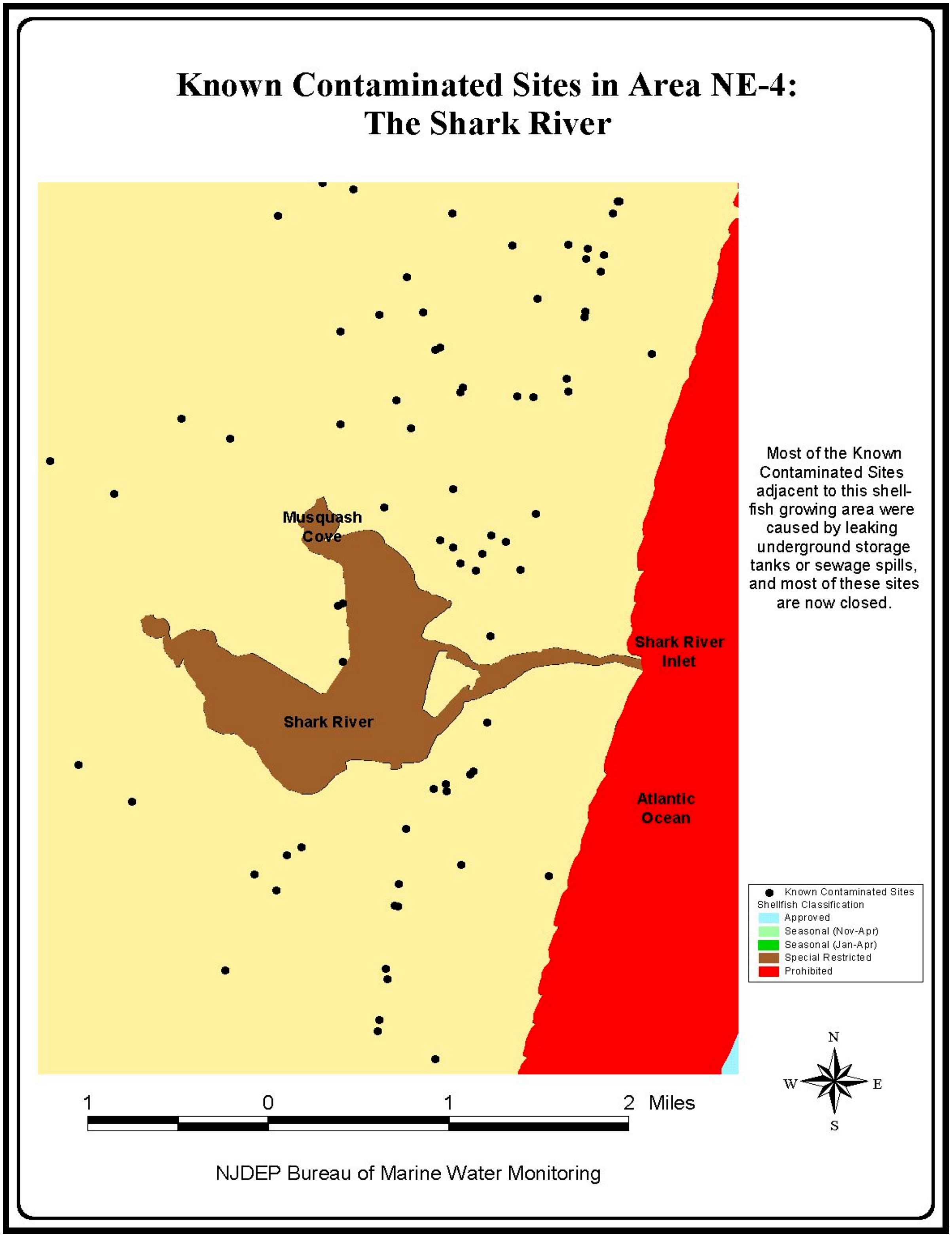


**FIGURE 13: KNOWN CONTAMINATED SITES IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

## STORM WATER INPUTS

There are many storm water outfalls bordering the Shark River, the Shark River Inlet, Musquash Cove, Musquash Brook, and the ocean to the north and south of the Shark River Inlet (see Figure 14, 15, and 16). Some of the highest concentrations of storm water outfalls are located on the shores of the Musquash Cove and Musquash Brook, and the shores east and south of Shark River Hills. There are also many storm water outfalls located on the shores upstream of the Shark River (the Fort Monmouth – Evans Area), at the south side of the Shark River near West Belmar, at the south side of the Shark River Channel near Belmar, and on the north shore of the Shark River south of Neptune City. The Shark River Island also has storm water outfalls located on the north side near the North Channel, and on the southeast side near the South Arm. However, there is no current evidence that these storm water outfalls directly impact the water quality of this shellfish growing area (APHA, 1995).

**FIGURE 14: LOCATION OF STORM WATER OUTFALL UNDER ROUTE 35 GOING INTO THE SOUTH SIDE OF THE SHARK RIVER, WEST OF MACLEARIE PARK. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 9:41 A.M.**

**FIGURE 15: LOCATION OF STORM WATER PIPE NEXT TO BRIDGE ON BRIGHTON AVENUE GOING FROM FORT MONMOUTH- EVANS AREA TOWARDS SHARK RIVER HILLS. CHANNEL IS IN THE SOUTHWEST (UPSTREAM) SIDE OF THE SHARK RIVER. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 10:26 A.M.**

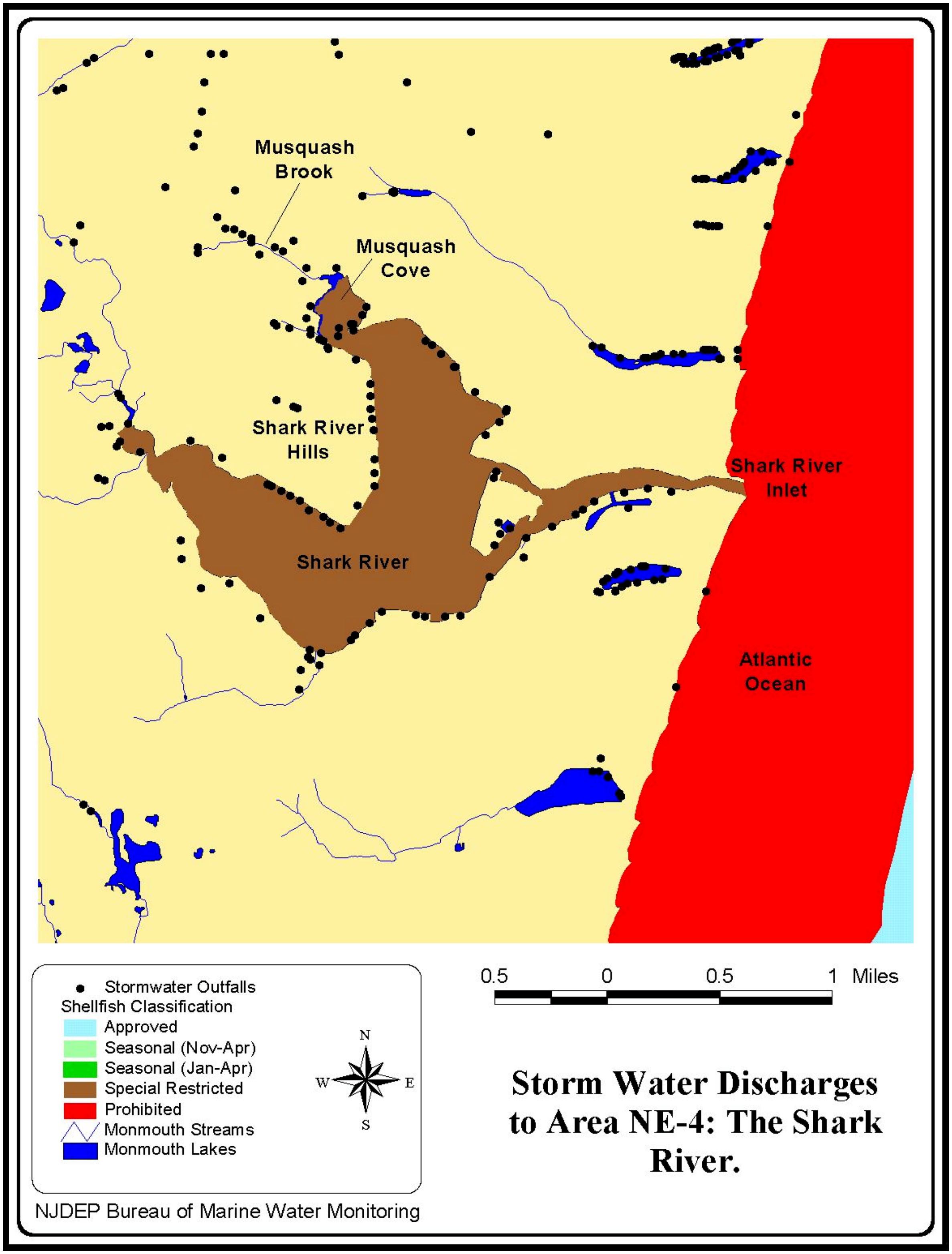


**FIGURE 16: STORM WATER DISCHARGES TO SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

## MARINAS

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. Adjacent waters are classified using a dilution analysis formula.

It is recognized by the NSSP *Guide for the Control of Molluscan Shellfish* (USPHS, 1997 Revision) that there are significant regional differences in all factors that affect marina pollutant loading. The manual therefore allows each state 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: | $2 \times 10^{9}$ |
| 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: | $180^{o}$, 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 may be calculated using the formula above, or may be determined using a dilution analysis computer program developed by the State of Virginia and the USFDA. The formula above considers only dilution and occupancy rates. The computer program, which is used for complex configurations where the formula is unlikely to provide the needed accuracy, also considers tidal exchange and bacterial die-off.

There are 19 marinas in the Shark River area, as shown in Table 4 and Figure 19. The waters enclosed by the marina (the marina basin) are classified as *Prohibited*. Depending on the size of the marina, the water quality, flushing rates, and the depth of the water, water immediately adjacent to each marina may be classified as *Prohibited*, *Special Restricted*, or *Seasonally Approved* (no harvest during summer months when the marina is active). Marina buffer zones were calculated using the New Jersey Marina Buffer Equation (see Equation 1). The size of each buffer zone is shown in Table 4. Figures 17 and 18 show two of the marinas located in this shellfish growing area.

**FIGURE 17: LOCATION OF SHARK RIVER HILLS MARINA & YACHT CLUB ON RIVERSIDE DRIVE IN SHARK RIVER HILLS. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 10:45 A.M.**

**FIGURE 18: LOCATION OF BRY'S MARINA NEAR THE NORTHEAST SIDE OF THE SHARK RIVER ON CONCOURSE ROAD SOUTH. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 11:18 A.M.**

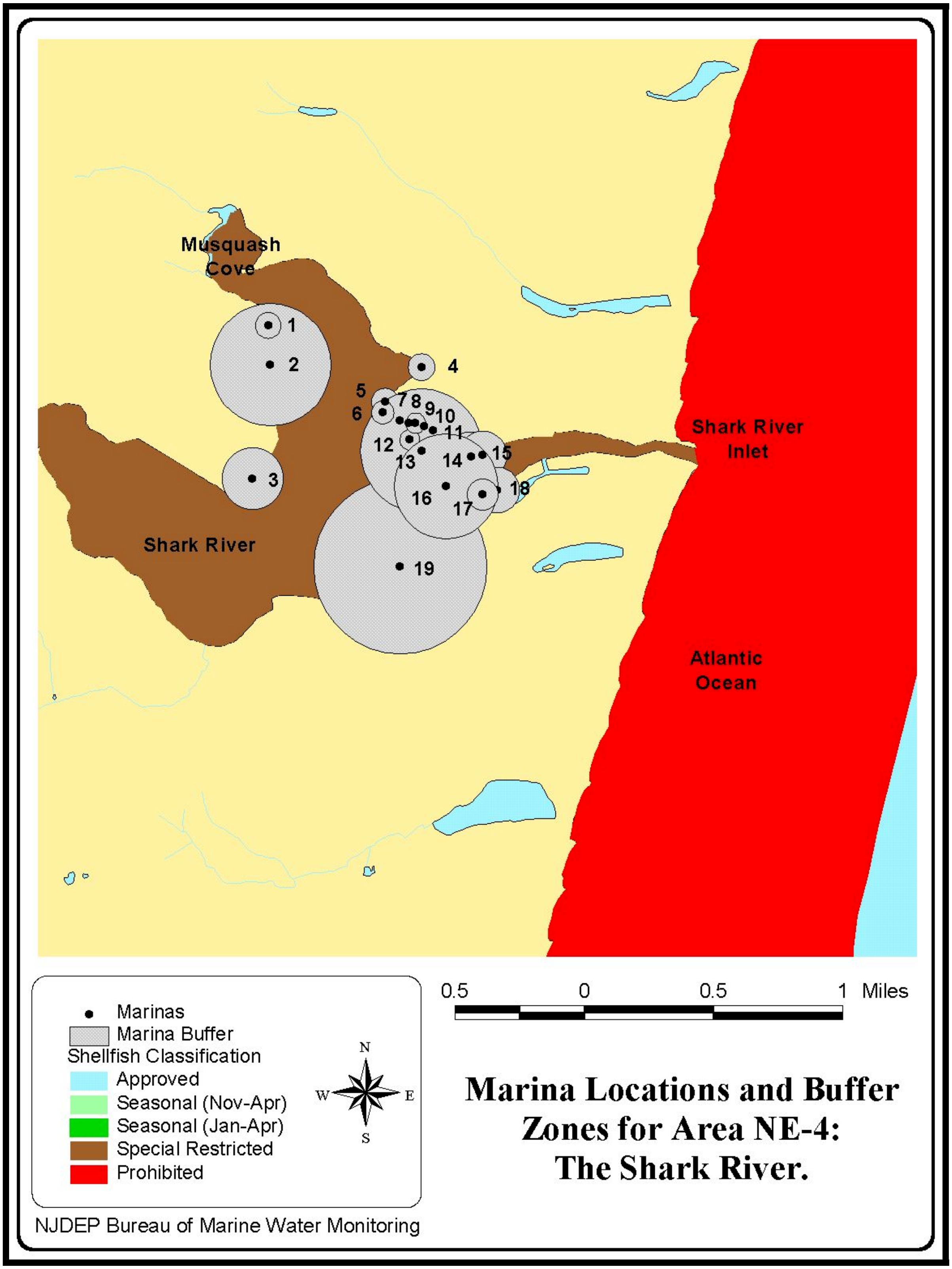

**FIGURE 19 : MARINA FACILITIES LOCATED IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

**TABLE 4: MARINA FACILITIES LOCATED IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

| Map Key | Marina Name | Location | # of Wet Slips Total / Boats > 24 ft. | Size of Buffer Area (radius; feet) | Depth (ft) |
|---|---|---|---|---|---|
| 1 | Oliver's Commercial Pier | Neptune Township | 5/4 | 262 | 5 |
| 2 | Shark River Hills Marina | Neptune Township | 150/75 | 1232 | 5 |
| 3 | Shark River Hills Beach & Yacht Club | Neptune Township | 94/0 | 626 | 5 |
| 4 | Campbell's Boat Yard | Neptune City | 9/3 | 271 | 5 |
| 5 | Kelly's Yacht Club | Neptune Township | 9/3 | 271 | 5 |
| 6 | Southport Condo's | Neptune Township | 7/2 | 230 | 5 |
| 7 | Bry's Marina | Neptune Township | 23/2 | 346 | 5 |
| 8 | Cashman's Dock | Neptune Township | 3/0 | 112 | 5 |
| 9 | Shore Watercraft | Neptune Township | 10/0 | 204 | 5 |
| 10 | Ziegler's Dock | Neptune Township | 3/2 | 190 | 5 |
| 11 | Remmington's Marina | Neptune Township | 40/17 | 607 | 5 |
| 12 | Sunset Water Sports | Neptune Township | 10/0 | 204 | 5 |
| 13 | Shark River Yacht Club | Neptune Township | 158/75 | 1245 | 5 |
| 14 | Main One Marina | Avon-by-the-Sea | 54/2 | 499 | 5 |
| 15 | Avon Fishing Basin | Avon-by-the-Sea | 15/15 | 491 | 5 |
| 16 | Total Marine at Seaview | Neptune Township | 101/59 | 1060 | 5 |
| 17 | Shark River Boat Rental & Water Sports | Belmar | 25/0 | 323 | 5 |
| 18 | Ap's Marina | Belmar | 19/11 | 458 | 5 |
| 19 | Belmar Municipal Marina | Belmar | 325/200 | 1764 | 6 |

# *HYDROLOGY AND METEOROLOGY*

## HYDROLOGY

This shellfish growing area is bordered by extensively developed areas to the north, east, and south, with some forest and wetland areas to the southwest (upstream) side of the Shark River. The main bodies of water include the Shark River, the Shark River Inlet, and Musquash Cove.

The Shark River Estuary typically has depths ranging from 1-12 feet (MLW). The depth of the water in the jetty channel of the Shark River Inlet is about 9 feet. There is an average range of 4 feet for the tides in this area. The tidal cycle is diurnal (twice/day). Tidal flushing is through the Shark River Inlet (USDI- GS, 1989).

## PATTERNS OF PRECIPITATION

Precipitation patterns in the coastal areas of New Jersey are typical of the Mid-Atlantic coastal region (see Table 5). 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.

**TABLE 5: AVERAGE MID-ATLANTIC STORM EVENT INFORMATION.** SOURCES: USEPA; US DEPARTMENT OF COMMERCE

| | |
|---|---|
| Annual Average Number of Storms | 60 |
| Average Storm Event Duration | 10 hours |
| Average Storm Event Intensity | 0.08 – 0.09 inches/hour |
| Average Storm Event Volume | 0.65 inches |

Although the average storm event lasts approximately 10 hours, with an accumulation of 0.65 inches, it is not unusual for an individual storm volume to be 2 – 3 inches. Note the data below show the 2-year return 6-hour storm event to be between two (2) and three (3) inches, while the 2-year 24-hour return volume varies between three (3) and four (4) inches (see Table 6). Storm volumes greater than approximately 3.5 – 4.0 inches are much less frequent.

**TABLE 6: STORM EVENT VOLUME FOR 2-YEAR STORM EVENT RECURRENCE (SOURCE: USGS)**

| Location | 2-Year, 1-Hour Rainfall | 2-Year, 6-Hour Rainfall | 2-Year, 24-Hour Rainfall |
|---|---|---|---|
| **Millville** | 1.33 | 2.33 | 3.02 |
| **Cape May** | 1.33 | 2.41 | 3.10 |
| **Atlantic City** | 1.47 | 2.67 | 3.65 |
| **Long Branch** | 1.55 | 3.02 | 4.15 |
| **Newark** | 1.21 | 2.34 | 3.25 |
| **Sandy Hook** | 1.37 | 2.73 | 3.68 |

The duration and volume of storm events can also be depicted as frequency histograms. This graphical depiction (shown below for 1981-1997) provides insight into the frequency for storm events of a given size or duration.

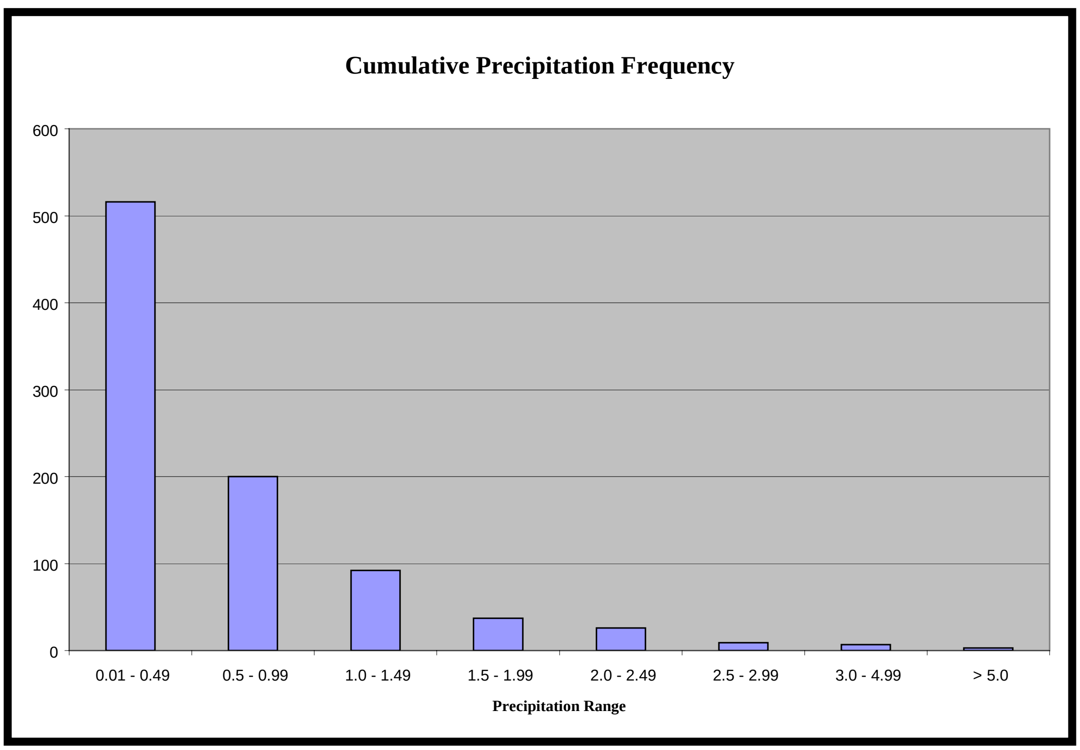


**FIGURE 20: STORM EVENT FREQUENCY HISTOGRAM (1981-1997)** (SOURCE: NOAA CLIMATIC DATA)

Precipitation inputs to the area for the period 1997 through 2000 are shown in Table 7. The rainfall data were incomplete because there was no rainfall amount data for 1994 through 1996. There have been no significant changes in hydrology since 1998. The primary weather station for this area is Long Branch. The secondary weather station for this area is Toms River. The secondary station data are used when data from the primary station are incomplete.

**TABLE 7: CLIMATOLOGICAL DATA**

Rainfall Recorded at NOAA's Long Branch Station

| **Sampling Date** | **Precipitation in Inches** | | |
|---|---|---|---|
| | **Day of Sampling** | **1 day prior** | **2 days prior** |
| 01/23/97 | 0.570 | 0.570 | 0.570 |
| 03/30/98 | 0.000 | 0.000 | 0.000 |
| 04/14/98 | 0.050 | 0.050 | 0.050 |
| 05/06/98 | 0.740 | 0.740 | 0.740 |
| 05/28/98 | 0.000 | 0.000 | 0.000 |
| 06/10/98 | 0.030 | 0.030 | 0.270 |
| 06/22/98 | 0.005 | 0.005 | 0.005 |
| 07/07/98 | 0.000 | 0.000 | 0.000 |
| 07/13/98 | 0.000 | 0.000 | 0.000 |
| 08/05/98 | 0.000 | 0.000 | 0.000 |
| 08/10/98 | 0.000 | 0.000 | 0.000 |
| 09/21/98 | 0.070 | 0.070 | 0.070 |
| 09/23/98 | 0.000 | 0.580 | 0.650 |
| 10/07/98 | 0.000 | 0.000 | 0.000 |
| 11/05/98 | 0.000 | 0.000 | 0.000 |
| 01/06/99 | 0.000 | 0.000 | 0.000 |
| 02/03/99 | 0.000 | 0.480 | 0.480 |
| 03/03/99 | 0.000 | 0.000 | 0.000 |
| 04/06/99 | 0.000 | 0.000 | 0.000 |
| 05/05/99 | 0.220 | 0.400 | 0.405 |
| 06/03/99 | 0.000 | 0.000 | 0.000 |
| 07/07/99 | 0.000 | 0.000 | 0.550 |
| 08/04/99 | 0.000 | 0.000 | 0.000 |
| 09/27/99 | 0.000 | 0.400 | 0.400 |
| 06/20/00 | 0.000 | 0.000 | 0.420 |

# *WATER QUALITY STUDIES*

## BACTERIOLOGICAL QUALITY

The statistical summaries for this area (sampled according to Systematic Random Sampling strategy) are listed in Table 8. This shellfish growing area is composed of one assignment area, Marine Water Sampling Assignment Area 57 (The Shark River). It is sampled using SRS strategy year-round, with an ebb tide preference. Figure 21 shows all of the sampling stations for this area. The raw data listings for each sampling station, in accordance with the National Shellfish Sanitation Program (NSSP) criteria, are given in the Appendix. There were no stations that exceeded the NSSP criteria applicable to the classification of these waters (see Table 3 for the criteria applied) (USPHS, 1997 Revision).


**FIGURE 21: SAMPLING STATIONS IN SHELLFISH GROWING AREA NE-4: THE SHARK RIVER.**

**TABLE 8: WATER QUALITY SUMMARY: SRS STATIONS(11/03/94 – 6/20/00)**

| Station | Depth | Year Round | | | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Geo. Mean | Est. 90th | N | Geo. Mean | Est. 90th | N | Geo. Mean | Est. 90th | N |
| 1200A | Surface | 12.9 | 101.4 | 33 | 15.8 | 113.5 | 22 | 8.6 | 80.3 | 11 |
| 1201A | Surface | 15.8 | 119.0 | 33 | 16.5 | 146.2 | 22 | 14.4 | 82.7 | 11 |
| 1202A | Surface | 20.0 | 167.3 | 33 | 19.8 | 181.5 | 22 | 20.4 | 155.5 | 11 |
| 1202D | Surface | 21.3 | 184.8 | 33 | 22.0 | 180.3 | 22 | 19.9 | 214.2 | 11 |
| 1203A | Surface | 39.1 | 357.4 | 33 | 40.3 | 443.3 | 22 | 36.9 | 244.2 | 11 |
| 1203C | Surface | 46.4 | 427.9 | 33 | 57.6 | 650.1 | 22 | 30.2 | 167.9 | 11 |
| 1203D | Surface | 63.0 | 715.1 | 33 | 83.9 | 999.8 | 22 | 35.6 | 340.3 | 11 |
| 1204 | Surface | 39.9 | 465.8 | 33 | 54.6 | 721.1 | 22 | 21.3 | 168.3 | 11 |
| 1204C | Surface | 28.5 | 221.1 | 33 | 33.6 | 288.3 | 22 | 20.4 | 130.7 | 11 |
| 1205 | Surface | 32.2 | 420.5 | 33 | 44.1 | 724.4 | 22 | 17.1 | 114.6 | 11 |
| 1205B | Surface | 45.0 | 387.6 | 33 | 42.9 | 374.2 | 22 | 49.4 | 459.4 | 11 |
| 1206A | Surface | 91.5 | 684.5 | 33 | 85.1 | 570.5 | 22 | 105.9 | 1057.3 | 11 |
| 1206C | Surface | 48.1 | 366.0 | 33 | 59.2 | 425.5 | 22 | 31.8 | 267.7 | 11 |
| 1206F | Surface | 81.2 | 728.3 | 33 | 97.1 | 997.9 | 22 | 56.7 | 384.1 | 11 |
| 1207 | Surface | 86.0 | 1093.1 | 33 | 99.8 | 1373.8 | 22 | 63.8 | 740.4 | 11 |
| 1207B | Surface | 93.6 | 1040.1 | 33 | 135.1 | 1277.7 | 22 | 44.9 | 574.9 | 11 |
| 1207D | Surface | 73.4 | 601.0 | 32 | 89.5 | 670.7 | 22 | 47.5 | 470.4 | 11 |
| 1208 | Surface | 108.8 | 1076.6 | 33 | 159.7 | 1495.6 | 22 | 50.6 | 442.6 | 11 |
| 1208C | Surface | 132.3 | 1327.7 | 32 | 189.9 | 1474.6 | 22 | 59.7 | 816.7 | 11 |
| 1208E | Surface | 86.8 | 641.8 | 32 | 108.1 | 897.1 | 22 | 53.5 | 278.8 | 11 |
| 1209 | Surface | 102.1 | 991.3 | 32 | 160.6 | 1304.9 | 21 | 43.0 | 419.1 | 11 |
| 1209A | Surface | 121.5 | 929.0 | 32 | 160.8 | 1073.2 | 21 | 71.2 | 641.5 | 12 |
| 1213 | Surface | 57.2 | 570.3 | 33 | 52.8 | 668.4 | 22 | 67.0 | 415.5 | 11 |
| 1213B | Surface | 55.0 | 539.9 | 33 | 65.2 | 740.5 | 22 | 39.2 | 287.9 | 11 |
| 1213D | Surface | 50.8 | 503.1 | 33 | 37.4 | 499.1 | 22 | 93.9 | 345.2 | 11 |
| 1214A | Surface | 34.1 | 295.7 | 33 | 25.7 | 214.5 | 22 | 60.1 | 513.4 | 11 |

| Station | Depth | Year Round | | | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Geo. Mean | Est. 90th | N | Geo. Mean | Est. 90th | N | Geo. Mean | Est. 90th | N |
| 1214B | Surface | 37.6 | 363.2 | 33 | 28.7 | 286.7 | 22 | 64.5 | 544.2 | 11 |
| 1214D | Surface | 38.6 | 397.0 | 33 | 36.4 | 434.6 | 22 | 43.3 | 356.5 | 11 |
| 1215 | Surface | 25.4 | 239.1 | 33 | 26.6 | 331.5 | 22 | 23.2 | 119.7 | 11 |
| 1215A | Surface | 22.4 | 149.5 | 33 | 20.1 | 166.9 | 22 | 28.0 | 113.7 | 11 |
| 1215C | Surface | 26.1 | 212.1 | 33 | 22.0 | 180.8 | 22 | 36.9 | 299.3 | 11 |
| 1215D | Surface | 20.8 | 168.5 | 33 | 23.4 | 217.0 | 22 | 16.5 | 104.8 | 11 |
| 1215E | Surface | 18.6 | 148.6 | 33 | 17.7 | 178.9 | 22 | 20.7 | 100.9 | 11 |
| 1216 | Surface | 49.2 | 502.2 | 33 | 53.7 | 691.3 | 22 | 41.3 | 266.4 | 11 |
| 1216A | Surface | 38.6 | 435.6 | 32 | 43.3 | 499.1 | 21 | 30.8 | 367.7 | 11 |
| 1216C | Surface | 38.8 | 395.3 | 33 | 42.5 | 530.0 | 22 | 32.5 | 225.9 | 11 |
| 1217 | Surface | 69.7 | 706.5 | 33 | 90.3 | 859.9 | 22 | 41.5 | 459.2 | 11 |
| 1217A | Surface | 66.5 | 514.1 | 33 | 62.8 | 565.6 | 22 | 74.5 | 446.8 | 11 |
| 1217B | Surface | 78.7 | 933.8 | 33 | 96.7 | 1483.1 | 22 | 52.1 | 335.6 | 11 |
| 1218 | Surface | 70.7 | 545.9 | 33 | 81.1 | 724.0 | 22 | 53.7 | 312.7 | 11 |
| 1219 | Surface | 55.7 | 667.0 | 32 | 41.5 | 520.0 | 22 | 106.8 | 1041.0 | 10 |
| 1219A | Surface | 41.1 | 339.4 | 32 | 33.9 | 391.5 | 22 | 62.7 | 163.2 | 10 |
| 1220 | Surface | 66.4 | 786.5 | 33 | 62.8 | 704.5 | 22 | 74.3 | 1095.3 | 11 |
| 1220A | Surface | 55.9 | 743.2 | 33 | 56.4 | 854.5 | 22 | 54.8 | 624.3 | 11 |
| 1221B | Surface | 92.0 | 891.4 | 33 | 141.0 | 1380.2 | 22 | 39.1 | 261.4 | 11 |

## TIDAL EFFECTS

Tidal impacts were evaluated by performing a t-test on log- transformed total coliform bacteria MPN values. The total coliform bacteria levels of each sampling station, taken during ebb and flow tides, are given in the Appendix.

Sampling stations that show a correlation between total coliform levels and tidal effects are shown in Figure 22. Table 9 shows the sampling stations that have a tidal correlation to total coliform levels for the ebb and flow tides.

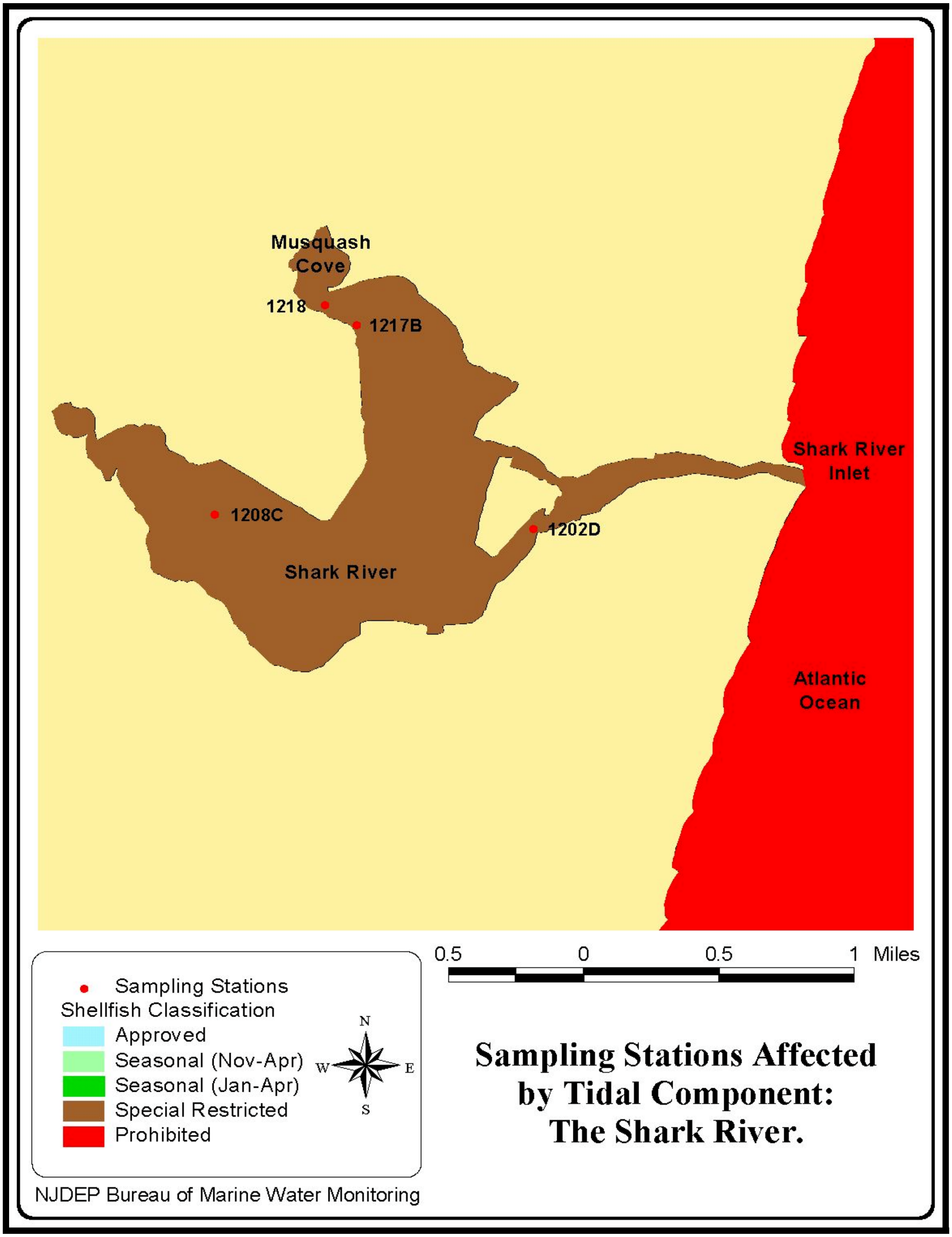


**FIGURE 22: SAMPLING STATIONS AFFECTED BY TIDAL COMPONENT: THE SHARK RIVER.**

**TABLE 9: TIDAL EFFECTS**

| Station | Geometric Mean Total Coliform MPN | | Probability>[T] |
|---|---|---|---|
| | Ebb | Flow | |
| 1202D | 33.4 | 7.4 | 0.005 |
| 1208C | 213.4 | 48.7 | 0.042 |
| 1217B | 135.9 | 33.7 | 0.040 |
| 1218 | 109.9 | 31.2 | 0.023 |

## RAINFALL EFFECTS

Non-point source pressures on shellfish beds in New Jersey originate in materials that enter the water via storm water. These materials include bacteria, as well as other waste that enters the storm water collection system.

Historical data comparing the difference between coliform levels measured after rainfall with those during dry periods were compared to generate the map below (see Figure 23). 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 works with the county and municipality to further refine the source(s) of the contamination and implement remediation activities.

It should be noted that a particular short-term data set may 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, tends to include locally heavy rainfall, the rainfall amounts recorded at the NOAA station may not accurately reflect the rainfall at the sampling station(s).

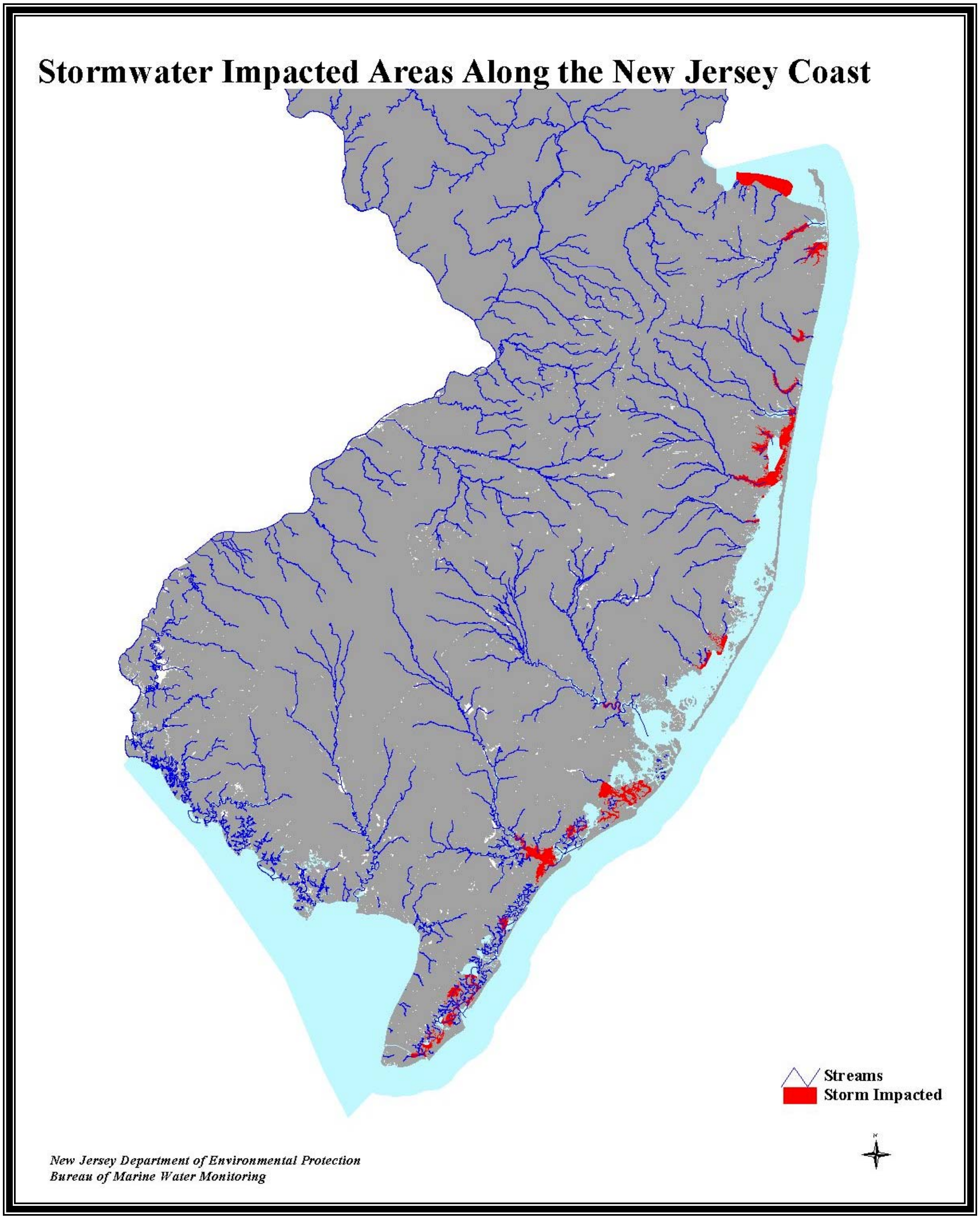


**FIGURE 23 : AREAS IMPACTED BY RAINFALL**

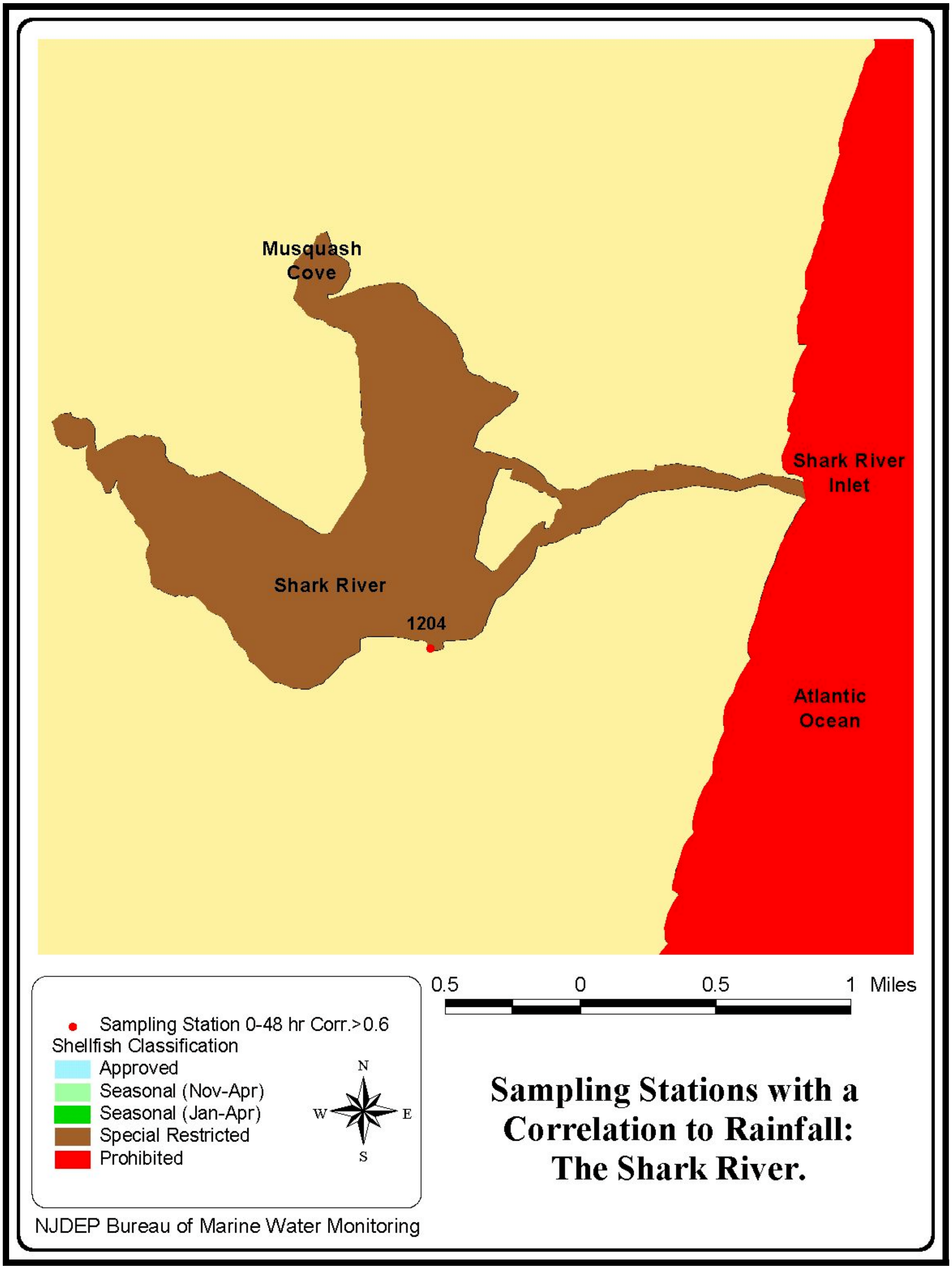


**FIGURE 24: SAMPLING STATIONS AFFECTED BY RAINFALL COMPONENT: THE SHARK RIVER.**

**TABLE 10: CORRELATION OF TOTAL COLIFORM VALUES WITH CUMULATIVE RAINFALL**

| Station | Correlation of Total coliform with rainfall | | | Number of Observations |
|---|---|---|---|---|
| | Day of Sampling | 24 hours prior | 48 hours prior | |
| 1204 | 0.595 | 0.589 | 0.620 | 24 |

**FIGURE 25: LOCATION OF SAMPLING STATION 1204 (THIS STATION HAS A RAINFALL CORRELATION) ON THE EAST SIDE OF MACLEARIE PARK IN THE SHARK RIVER. PHOTOGRAPH WAS TAKEN ON OCTOBER 3, 2001 AT 9:53 A.M.**

## *INTERPRETATION AND DISCUSSION OF DATA*

### BACTERIOLOGICAL

Criteria for bacterial acceptability of shellfish growing waters are provided in the National Shellfish Sanitation Program *Guide for the Control of Molluscan Shellfish* (USPHS, 1997 Revision). Each state must adopt either the total coliform criteria or fecal coliform criteria for growing water classifications. Historically, New Jersey has based growing water classifications on the total coliform criteria and continues to use the total coliform criteria.

While New Jersey does make corresponding fecal determinations for each total coliform determination, these data are viewed as adjunct information and are not directly used for classification. Therefore, the data analysis is based on the total coliform results in which the total coliform median or geometric mean MPN (most probable number) for *Approved* classification does not exceed 70/100 mL and the estimated $90^{th}$ percentile shall not exceed an MPN of 330/100 mL, where the three tube decimal dilution test is used for Systematic Random Sampling (SRS) strategy (see Table 3). Also, the total coliform median or geometric mean MPN for *Special Restricted* classification does not exceed 700/100 mL and the estimated $90^{th}$ percentile shall not exceed an MPN of 3300/100 mL, where the three tube decimal dilution test is used for Systematic Random Sampling (SRS) strategy (USPHS, 1997 Revision).

In this shellfish growing area, water data were evaluated using the Systematic Random Sampling (SRS) strategy. This sampling strategy requires a minimum of 30 sets of data for each sampling station. For the stations in this growing area to meet the Systematic Random Sampling (SRS) strategy, it was necessary to go back to 1994 to get enough sets of data.

Figures 26 and 28 show the sampling stations that exceed the *Approved* criteria, but meet the *Special Restricted* criteria, for water quality after being sampled using the Systematic Random Sampling strategy. These 34 sampling stations are located throughout this shellfish growing area.

Figure 27 shows the 11 sampling stations that meet the *Approved* criteria for water quality after being sampled using the Systematic Random Sampling strategy. These 11 sampling stations are mainly located in the Shark River Inlet, and in the middle part of the Shark River. The relatively low level of coliform bacteria at these sampling stations is probably due to the tidal flushing of the Shark River and the Shark River Inlet from the water flowing in from the Atlantic Ocean. The ocean water outside of the Shark River Inlet is classified as *Prohibited*.

Based on the water data collected, 4 sampling stations showed a significant tidal component (see Figure 22 and Table 9). Sampling stations **1218** and **1217B** are located in the north part of the Shark River, south of Musquash Cove. Sampling station **1208C** is located south of Shark River Hills in the Shark River, and sampling station **1202D** is located east of the Shark River Island in the South Arm of the Shark River. Tidal impacts were evaluated by performing a t-test on log-transformed total coliform MPN values. In this reappraisal of this shellfish growing area, this area was sampled using an ebb tide preference. The ebb tide total coliform levels were greater than the flood tide total coliform levels, indicating higher total coliform levels during the ebb tide when there would be less water to dilute the coliform bacteria counts.

For the 1994-2001 time period, a significant correlation between total coliform MPN and rainfall was found to occur at one (Station 1204) out of 45 of the stations sampled in this shellfish growing area (see Figures 24 and 25, and Table 10). Sampling station **1204** is located in the south part of the Shark River, just west of the Belmar Municipal Marina, and near storm water outfalls. This sampling station showed high levels of total coliform on the day of sampling and 24 hours prior to the day of sampling. However, there was also a correlation between rainfall and total coliform levels 48 hours prior to the day of sampling, with a level of 0.62. Rainfall impacts were assessed by correlating log transformed total coliform MPN values with cumulative rainfall on the day of sampling, one day prior to sampling, and two days prior to sampling. A correlation between rainfall amounts and total coliform levels is indicated if the correlation coefficient is greater than 0.6. Sampling station **1204** is also located near storm water outfalls, and the water flowing from these storm water outfalls could have an impact on the water quality data. In the 2001 Annual Review of this shellfish growing area, there was no significant overall rainfall component (NJDEP, 2001).

There were no sampling stations showing a seasonal correlation for water quality in this shellfish area. Seasonal effects are assessed using a t-test to compare log-transformed total coliform values for summer verses winter data. In the 2001 Annual Review of the Shark River, there were no sampling stations showing a seasonal correlation for water quality in this shellfish area (NJDEP, 2001).

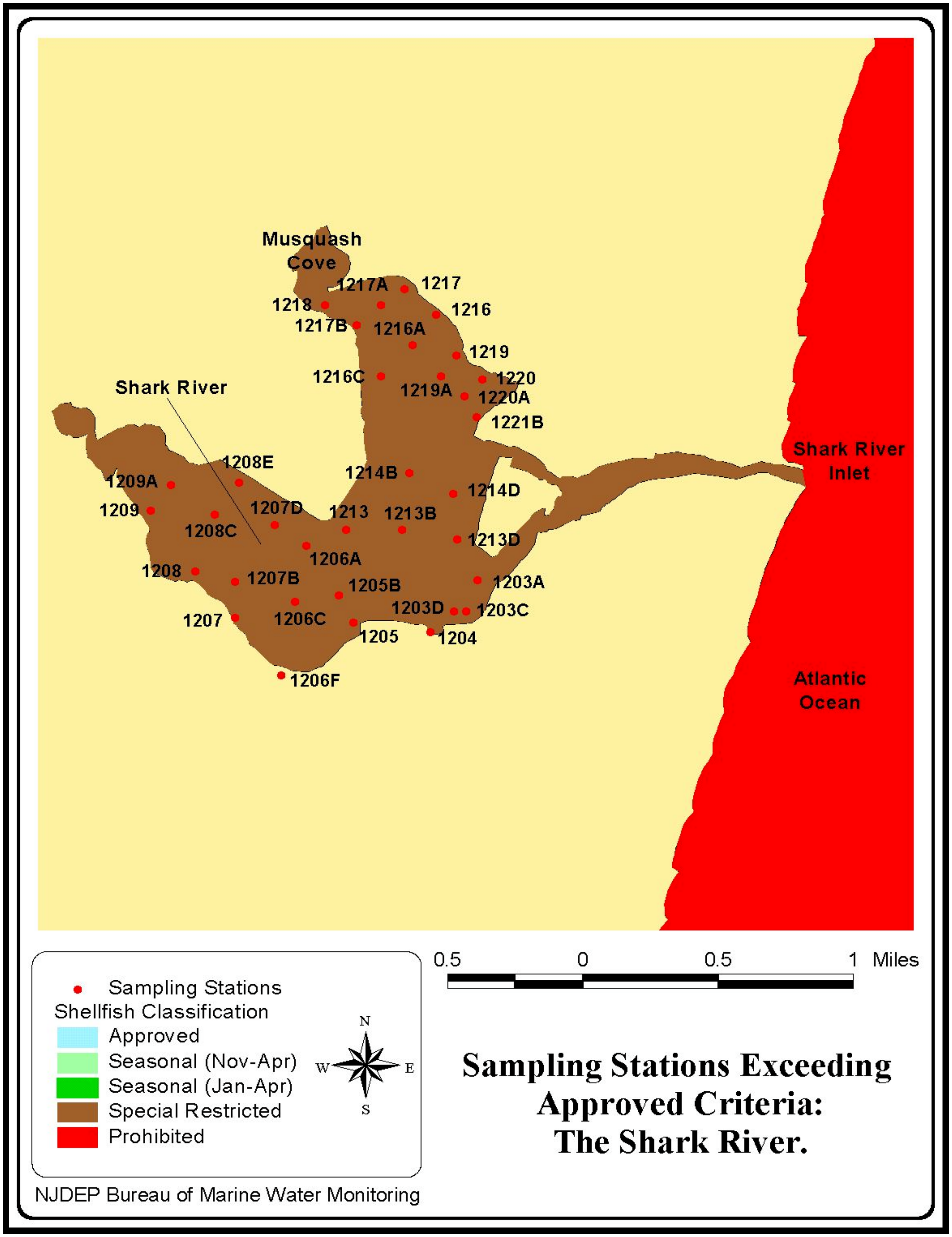


**FIGURE 26: SAMPLING STATIONS EXCEEDING APPROVED CRITERIA: THE SHARK RIVER.**

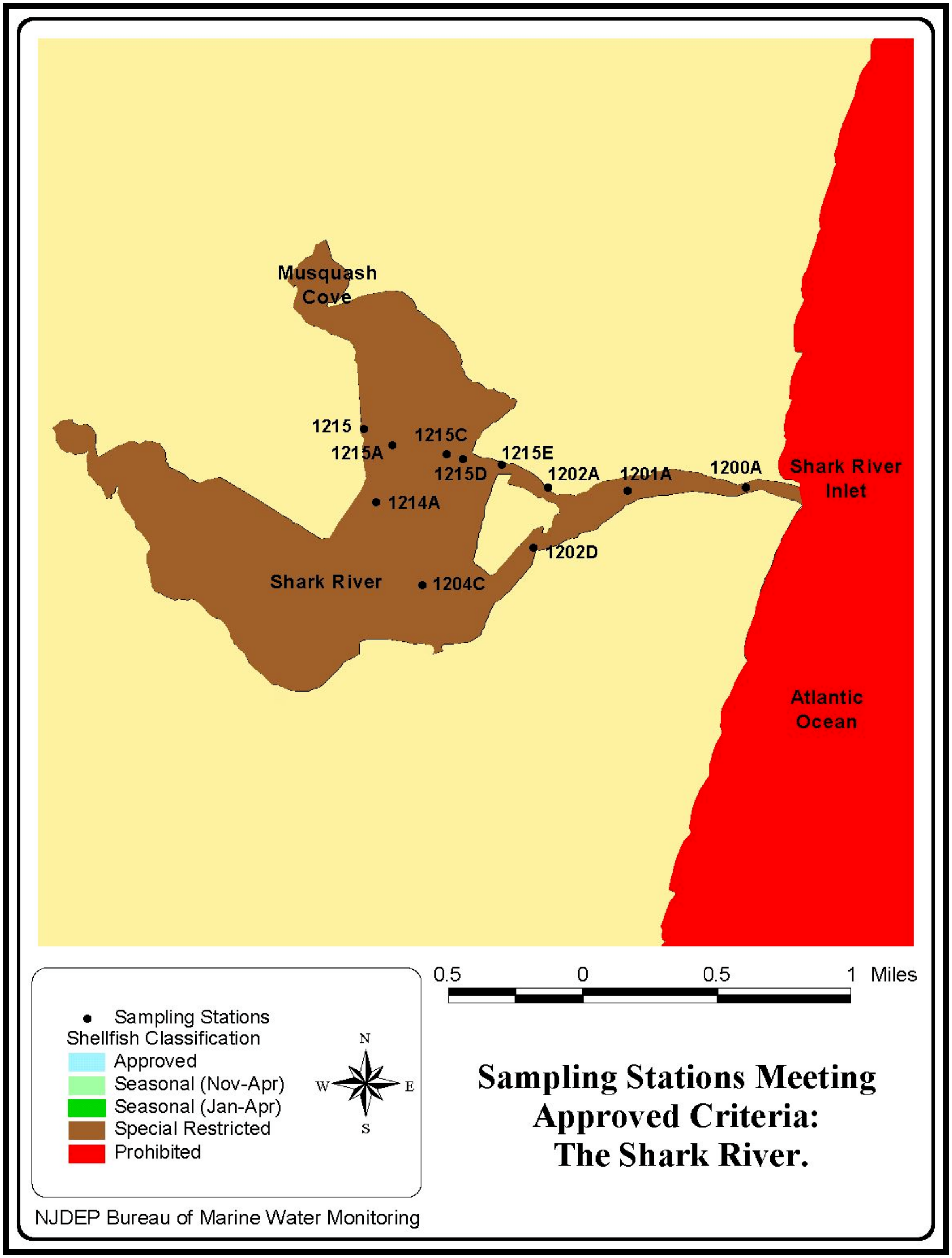


**FIGURE 27: SAMPLING STATIONS MEETING APPROVED CRITERIA: THE SHARK RIVER.**

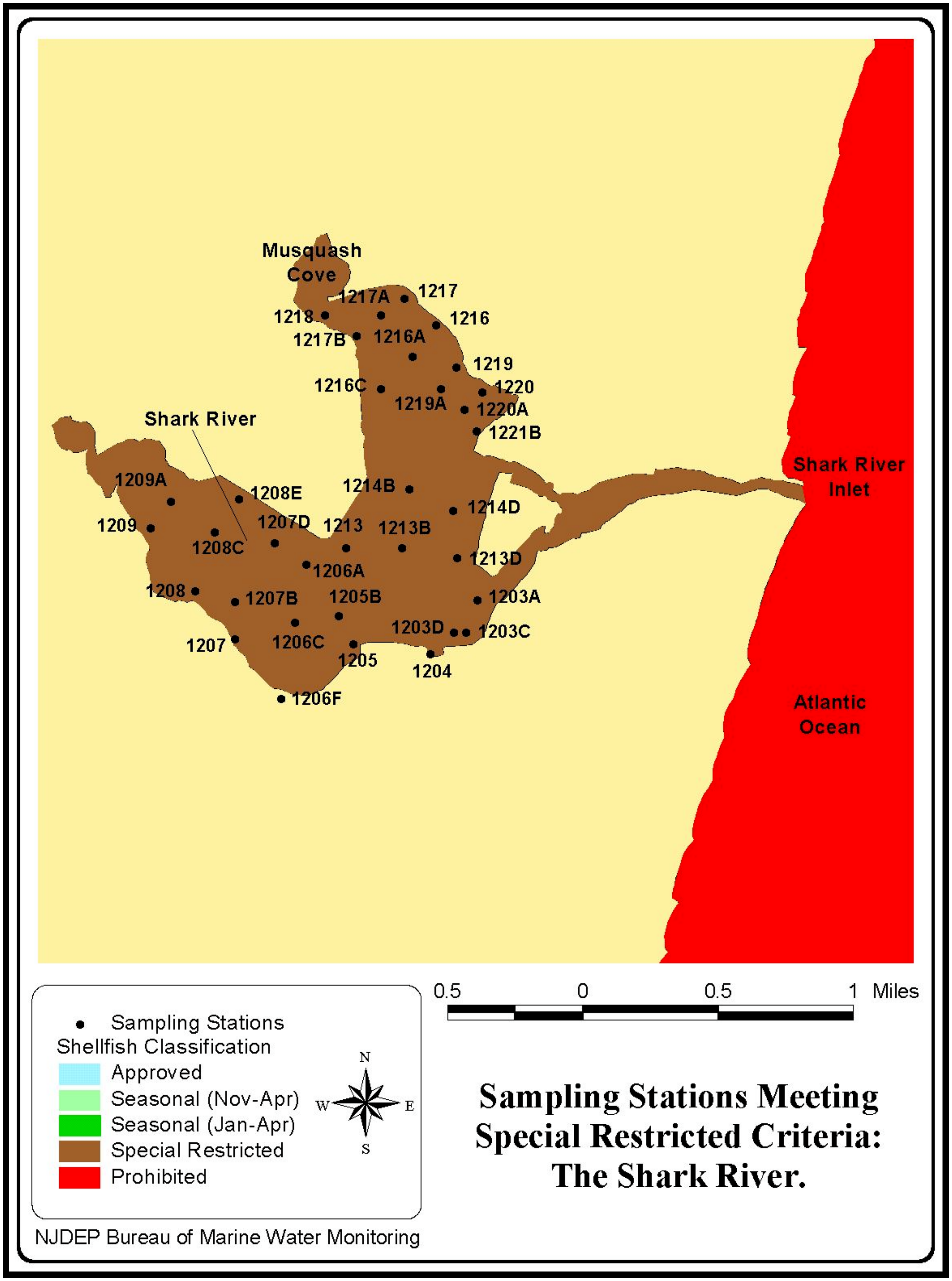
Musquash Cove
Shark River
Shark River Inlet
Atlantic Ocean
1217A
1217
1218
1216
1217B
1216A
1219
1216C
1220
1219A
1220A
1221B
1209A
1208E
1214B
1214D
1209
1207D
1213
1213B
1208C
1213D
1206A
1208
1207B
1205B
1203A
1203D
1203C
1207
1206C
1205
1204
1206F
0.5
0
0.5
1 Miles
Sampling Stations
Shellfish Classification
Approved
Seasonal (Nov-Apr)
Seasonal (Jan-Apr)
Special Restricted
Prohibited
N
W
E
S
Sampling Stations Meeting Special Restricted Criteria: The Shark River.
NJDEP Bureau of Marine Water Monitoring

**FIGURE 28: SAMPLING STATIONS MEETING SPECIAL RESTRICTED CRITERIA: THE SHARK RIVER.**

## RELATED STUDIES

## NUTRIENTS

There are five stations in this area that are sampled under the estuarine monitoring program for chemical parameters including nutrients. These five nutrient stations are **1201A**, **1203A**, **1206C**, **1215E**, and **1217A** (see Figure 29).

Table 11 and Table 12 list the various parameters measured, such as water temperature (in Celsius), salinity levels, Secchi Depth, total suspended solids, dissolved oxygen levels, ammonia levels, nitrate and nitrite levels, orthophosphate levels, total nitrogen levels, and the inorganic nitrogen to phosphorus ratios for the Shark River from 1997 to 1999 (Table 11) and the year 2000 (Table 12) (Zimmer, 2000) (Zimmer, 2001).

Water temperature (measured in degrees Celsius) is taken for each nutrient station. Water temperature is very important because warmer water has less dissolved oxygen, which can trigger certain life processes (such as spawning and setting of shellfish larvae), or cause the shellfish to die. Oysters (Crassostrea virginica) can tolerate water temperatures ranging from –1.7°C to 36.0°C but has an optimum temperature range of 20.0°C to 30.0°C (Zimmer, 2000) (Zimmer 2001).

Salinity levels (measured in parts per thousand) are also taken for each nutrient station because different species of shellfish require very specific salinity levels for survival. Since salinity levels can have an effect on the species found in these waters, the salinity data collected at these nutrient stations is important for a complete

understanding of the complex ecological balance in these coastal waters. Oysters have a tolerance for salinity levels from 5.0 to 30.0 ppt but require salinity levels of 10.0 to 28.0 ppt for optimum growth. Oysters also grow better in waters with fluctuations in salinity levels (Zimmer, 2000) (Zimmer 2001).

Secchi Depth (measured in feet) is an indicator of the relative turbidity of the coastal waters. When Secchi Depths are low, less sunlight can penetrate the water column and this sunlight is not available as an energy source for photosynthesis. The turbidity is affected by many sources, such as sediment load from anthropomorphic sources and algal cell concentrations in the water. Secchi Depth tends to be somewhat higher in the winter months (when the concentration of algal cells is diminished) and lower in the summer. The pumping rate of oysters will also decrease with the increased turbidity of the surrounding waters (Zimmer, 2000) (Zimmer 2001).

Total Suspended Solids (measured in mg/L) are usually composed of clay, silt, sand, and biological sediments from many sources. An increase in the total suspended solid concentrations in the water column will cause turbidity levels to rise and Secchi Depth levels to lower.

Dissolved oxygen (measured in mg/L or as percent saturation in conjunction with temperature and salinity) is an important component for the life processes of aerobic organisms such as shellfish. Oysters can survive in anaerobic (absence of oxygen) conditions for only three days. Even though oysters can survive at oxygen concentrations of only 1.0 ppm, shellfish located in waters of low dissolved oxygen concentrations will usually have a greater potential for biological stress from insufficient oxygen levels in the water column and have a greater potential for hypoxia and death of the organism. New Jersey has a minimum standard of 4.0 mg/L for dissolved oxygen levels in marine water (N.J.A.C. 7:9B). If the percent saturation of dissolved oxygen levels drops below 50%, there is a greater potential for biological stress. Levels of percent saturation of dissolved oxygen over 100% are an indicator of algal material in the water column (Zimmer, 2000) (Zimmer 2001).

The nutrient parameters that are measured include ammonia (measured in μg N/L), nitrate and nitrite (measured in μg N/L), orthophosphate (measured in μg P/L), total nitrogen (measured in μg N/L), and inorganic nitrogen to phosphorus ratios. These parameters affect the primary productivity of shellfish (Zimmer, 2000) (Zimmer 2001).

The nitrogen present in the form of inorganic nitrogen (ammonia, nitrate and nitrite) is the form most readily utilized by phytoplankton. Certain planktonic species have the potential to adversely affect the suitability of shellfish for human consumption. These planktonic species cause algal blooms that deplete the dissolved oxygen levels in the water. Algal blooms were reported each year for the period 1993 – 1997. The areas most severely impacted include the Raritan / Sandy Hook Bay, the Barnegat Bay, and sporadic offshore areas (Zimmer, 2000).

Total nitrogen includes the organic nitrogen component, which often results from the discharge of pollutants from anthropogenic sources, from high levels of algal growth, the decay of organic material and other related sources. High concentrations of orthophosphate and phosphorus are usually found in waters that receive discharges from areas that use chemical fertilizers. In the Shark River, the inorganic nitrogen to phosphorus ratio is quite low, indicating that these shellfish waters are potentially nitrogen-limited (Zimmer, 2000) (Zimmer 2001).

Water quality at the nutrient stations in the Shark River and the Shark River Inlet is consistent with the water results found throughout the state. More detailed information concerning dissolved oxygen and nutrient levels can be found in *New Jersey Ambient Monitoring Program: Report on Marine and Coastal Water Quality – 2000* (Zimmer, 2001).

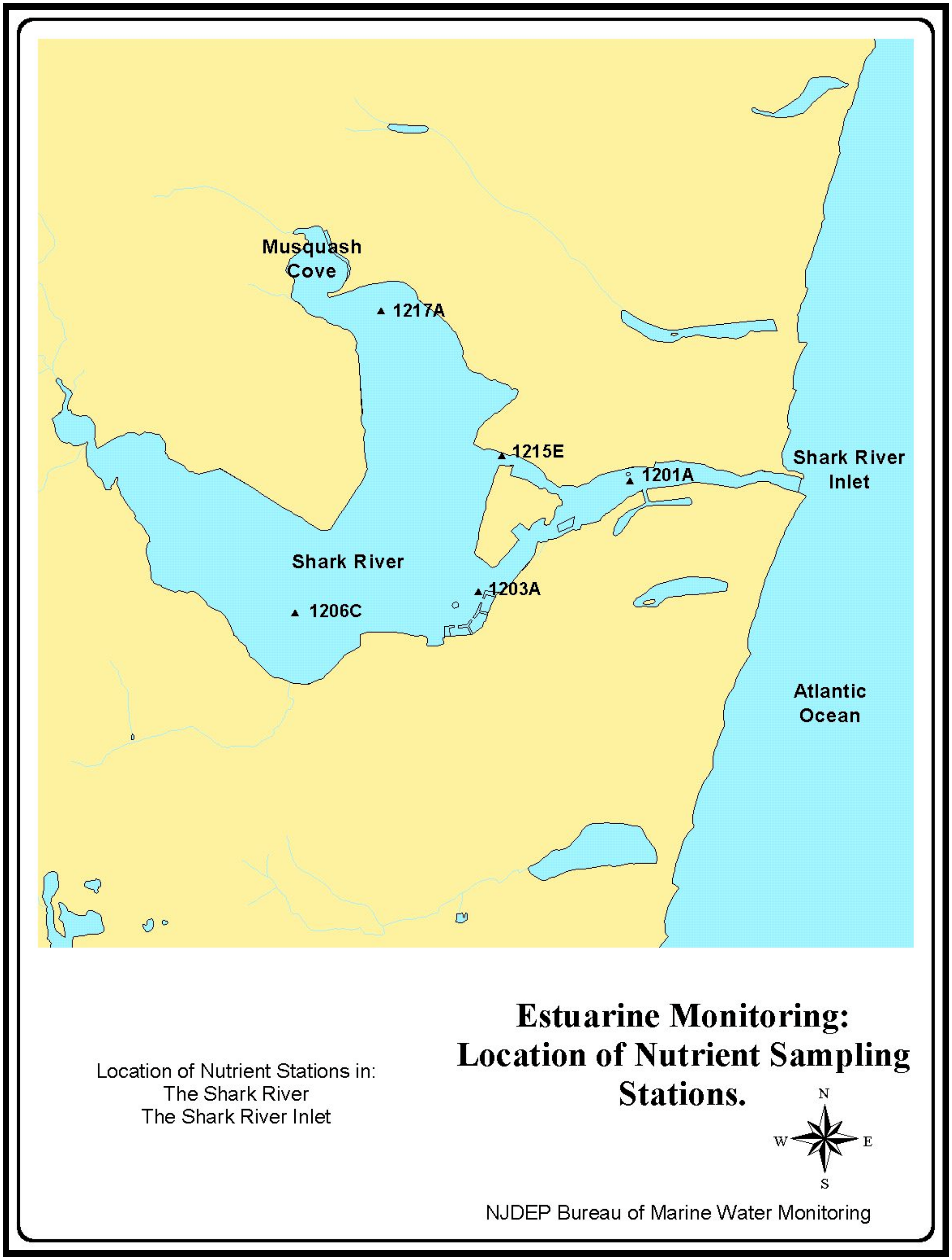


**FIGURE 29: SAMPLING STATIONS WHERE ADDITIONAL DATA HAVE BEEN COLLECTED FOR NUTRIENTS.**

# *CONCLUSIONS*

## BACTERIOLOGICAL EVALUATION

Water quality in this shellfish growing area, the Shark River, complies with the requirements for the *Special Restricted* classification based on NSSP criteria. This area was sampled using Systematic Random Sampling strategy, and this is consistent with an area that has no direct impacts from point sources. Also, all of the sampling stations in this shellfish area meet the *Special Restricted* classification for total coliform, according to the State of New Jersey total coliform criteria (USPHS, 1997 Revision).

Shellfish Growing Area NE-4, the Shark River, is correctly classified as *Special Restricted*. No classification changes are recommended. Shellfish in this area can only be harvested in compliance with the State's Relay or Depuration Programs.

# *RECOMMENDATIONS*

## BACTERIOLOGICAL EVALUATION

### RECOMMENDED CHANGES IN MONITORING SCHEDULE

It is recommended that the number of sampling stations in this shellfish growing area be decreased from the 45 sampling stations currently sampled to about 25 to 30 sampling stations for the 2002-2003 sampling year. The Shark River Shellfish Growing Area is an area of only 792 acres. The current 45 sampling stations are no longer deemed necessary for the proper classification of this body of water.

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