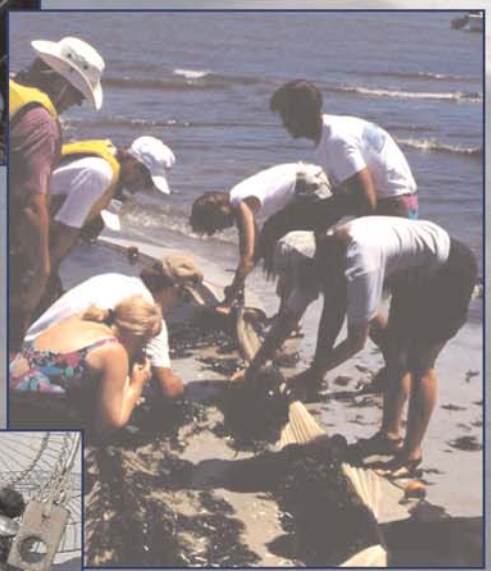
Barnegat Bay National Estuary Program

Monitoring Program Plan



May 2003

Barnegat Bay Estuary Program

ACKNOWLEDGEMENTS

Many individuals contributed a wide variety of efforts to produce the Monitoring Program Plan for the Barnegat Bay Estuary Program. Its beginnings can be traced to the highly successful Barnegat Bay Ecosystem Workshop, held at Toms River on November 14, 1996, where scientists and other stakeholders exchanged a wealth of information about ongoing work to characterize the structure, function, issues, and management challenges of the estuary and watershed. This document represents the outcome of many focused efforts since then, including the development of the Scientific Characterization and CCMP documents, the First Monitoring Workshop, held on October 17, 2001 at Georgian Court College in Lakewood, New Jersey, and subsequent focused monitoring workshops. A Monitoring Subcommittee of the BBEP Science and Technical Advisory Committee was then appointed and tasked with planning and arranging for the preparation of this document. Monitoring Subcommittee members and others who contributed to the preparation of this document and their affiliations are listed below. Numerous other individuals contributed content to the document or provided valuable feedback, and their contributions are gratefully acknowledged.

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I. EXECUTIVE SUMMARY

A Monitoring Program Plan for Barnegat Bay/Little Egg Harbor

This Monitoring Program Plan is a comprehensive blueprint for monitoring activities in the Barnegat Bay/Little Egg Harbor estuary and watershed that relate to the mission of the Barnegat Bay Estuary Program. The document describes plans for critical activities that will track progress and achievement of the Comprehensive Conservation and Management Plan (CCMP) objectives and guide decisions on land acquisition, resource restoration, and research programs that contribute to these objectives. The plan presents a description of the monitoring workshops that helped in formulating plans, the monitoring objectives that the plan facilitates, a comprehensive series of primary and secondary environmental indicators, and a work plan for each indicator. Work plans include procedures, timetables, and strategies for evaluating and communicating indicator status and answering key monitoring questions. Monitoring objectives are partly achieved through existing monitoring programs, which are described in an appendix. Additional monitoring needs and data gaps are also described.

Appropriate Indicators for Effective Communication of Progress

The heart of the monitoring program plan is a series of environmental and programmatic indicators that provides an effective mechanism for evaluating progress toward the full achievement of CCMP goals. A group of nine primary indicators that are easily communicated to the public have been selected to provide a broad basis for evaluating a range of CCMP actions. A group of twenty-one secondary indicators provide an additional basis for evaluating the programmatic output and specific environmental outcomes of CCMP implementation.

Milestones in Monitoring Plan Development

The Monitoring Program Plan for the Barnegat Bay estuary and watershed is an outgrowth of a six-year process by which the Barnegat Bay Estuary Program partners have exchanged information, characterized and assessed the estuary and watershed, and formulated a comprehensive plan (CCMP) for managing important living and nonliving resources. Through this process several milestones were reached: critical resource values and problems were identified; management goals and actions were established; sixty-two existing monitoring programs and fifteen data gaps were communicated and documented; and the thirty key environmental and programmatic indicators were developed. This Monitoring Program Plan provides an important linkage between these accomplishments by mapping out the key relations among them, and it provides the structure for evaluating progress toward CCMP goals.

Sound Guidance

Documents that were considered in developing this plan include the Scientific Characterization of the Barnegat Bay-Little Egg Harbor Estuary and Watershed, the Barnegat Bay Comprehensive Conservation and Management Plan, EPA monitoring guidance, the New Jersey Environmental Performance Partnership Agreement under the National Environmental Performance Partnership System, and the counterpart monitoring

program document of the Tillamook Bay (Oregon) National Estuary Project, which provided the model format for the monitoring work plans.

Successful Plan Implementation—A Critical Need for Funding Commitments

The overall success of the implementation of monitoring plans, and the cascading effect of monitoring on the success of the CCMP, ultimately will depend on the successful acquisition of appropriate levels of funding to complete monitoring surveys. Most of the monitoring efforts advanced in this plan require periodic sampling and critical interpretive evaluations at intervals of one to ten years. These efforts will be labor intensive and costly. As such, they will only be successfully completed with consistent and adequate levels of funding. Many of the data needs for meeting monitoring objectives are expected to be met by the many ongoing monitoring programs of various agencies and other groups, as described in the Appendix to this document. However, the monitoring that is necessary to meet some of these needs is not presently funded. Unless this funding is obtained for the major monitoring components of the program, the prospects for attaining the objectives and goals of the Barnegat Bay-Little Egg Harbor CCMP may be jeopardized.

II. MONITORING WORKSHOPS

A core element of the Barnegat Bay Estuary Program (BBEP) is development of a monitoring plan to evaluate the success of action items contained in the Comprehensive Conservation and Management Plan (CCMP), and to assess change in the structure and function of the Barnegat Bay estuary and surrounding watershed. Initial activity to stimulate this development occurred early in the Program: aspects of ongoing work to assess the structure and function of the estuary, as well as multiple user needs and ecosystem health and sustainability, were the focus of the Barnegat Bay Ecosystem Workshop, conducted on November 14, 1996 at Toms River, New Jersey (Flimlin and Kennish, 1996). A multi-year effort by many program partners followed which resulted in the scientific characterization and assessment the estuary and watershed (Kennish, 2001a; 2001b). Following the adoption of the CCMP in 2001, three key requirements had to be addressed in the formation of a supportive monitoring program plan. First, an assessment of existing monitoring efforts focused on Barnegat Bay and the surrounding watershed needed to be conducted. Second, environmental indicators needed to be developed to track change in habitat use and quality, water use and quality, and human use of the Barnegat Bay system. Third, results of the first workshop needed to be evaluated and developed into a comprehensive monitoring plan—the subject of this document. Three workshops were held to assemble the information required to meet the monitoring program requirements. A brief summary of these meetings is provided below. In addition, data gaps also were identified from this process that need to be filled in order to evaluate program success and environmental change. These data gaps are presented in Chapter V of this document.

WORKSHOP 1

On October 17, 2001, the BBEP sponsored the *First Monitoring Workshop for the Barnegat Bay National Estuary Program.* Participants included representatives from the BBEP, resource managers from state and federal agencies, members of the academic community, Barnegat Bay stakeholders and interested citizens, and members of the Science and Technical Advisory Committee for the BBEP. The workshop focused on stakeholders that currently conduct monitoring, research, and assessment programs in the Barnegat Bay estuary. Prior to the workshop, survey forms were distributed to participants in an effort to collect uniform information on environmental parameters, sampling locations, sample frequency, data format and storage, and an indication of commitment to future monitoring. Survey results were included in a workshop summary document. The results were supplemented with additional information about existing monitoring activities, and these more complete summaries are presented in Appendix A.

At the workshop, participants were asked to present a brief overview of measurements being made throughout the watershed and to determine how these efforts can be included or integrated into the BBEP Monitoring Plan. Workshop participants also identified a variety of data gaps that should be considered as part of a future monitoring program.

WORKSHOP 2 - ENVIRONMENTAL INDICATORS

On January 14, 2002, the Science and Technical Advisory Committee sponsored a workshop at Rutgers University with Barnegat Bay stakeholders to develop a list of environmental indicators. Indicators were discussed in three broad categories—habitat, water resources, and human use. Candidate indicators had to meet three criteria for further consideration by the BBEP. These were public acceptability, availability of data from existing monitoring efforts, and relevance to the goals and objectives of the Comprehensive Conservation and Management Plan. A detailed presentation of environmental indicators is presented in Chapter IV of this document.

WORKSHOP 3 - SECOND MONITORING WORKSHOP

On July 23, 2002, the U.S. Geological Survey sponsored the *Second Monitoring Workshop for the Barnegat Bay National Estuary Program* with watershed stakeholders and the Science and Technical Advisory Committee. This meeting aimed to incorporate results of the First Monitoring Workshop into plans for developing a final Monitoring Program Plan. At this workshop, participants developed an outline for the plan, reviewed key monitoring goals and objectives, developed a timetable for preparation of the final monitoring plan, and developed writing assignments.

Particular importance was given to action items and trend analysis. With respect to action items, the participants emphasized that the monitoring program must be designed to determine the success with implementation of action items, and to make mid-course corrections where necessary. The trend analysis was deemed essential to support public outreach efforts and to keep the resource management community engaged in the program. For example, engagement of the public requires periodic "State of the Bay" reports that convey information on the health of the estuary in terms that can be easily interpreted by a diverse assemblage of Bay users, supporters, and other stakeholders. In addition, a science-based trend analysis was viewed as a useful service for the resource management community to inform their decision-making about Bay resources and processes.

III. MONITORING PROGRAM OBJECTIVES

A basis for the development of a Monitoring Program Plan is a list of monitoring program objectives that can guide the selection of environmental indicators and appropriate monitoring protocols and activities. The BBEP Comprehensive Conservation and Management Plan (CCMP) identifies a series of Program Objectives for each of the Action Plan Chapters. These Program Objectives are used in the discussion that follows to link monitoring objectives and performance criteria to monitoring needs. This discussion forms part of the logical progression from implementation of Program action items to a comprehensive management strategy to measure the success of those action items.

CCMP Chapter 5 - Water Quality/Water Supply Action Plan

Chapter 5 of the BBEP CCMP includes descriptions of 25 actions targeted to water quality and water supply issues for Barnegat Bay and its watershed. The individual action items range in scope from the development of a comprehensive water supply plan for the Barnegat Bay watershed (Action Item No. 5.20) to the development of a management strategy to reduce the congregation of Canada geese in urban areas (Action Item No. 5.10). In the aggregate, these action items are intended to meet five Program Objectives:

1. Restore and maintain a productive ecosystem with no adverse effects due to pollution.
2. Ensure that edible seafood is safe for unrestricted human consumption.
3. Minimize health risks to contact water uses.
4. Estimate adverse impacts of eutrophication, including hypoxia resulting from human activities.
5. Provide a sustainable water supply to the human population without adversely impacting natural water regimes.

The monitoring plan to support the implementation of the BBEP CCMP will use measures and criteria that will document the achievement of these overall Program Objectives. For most of the action items in Chapter 5, performance criteria will begin with the tangible steps taken towards implementation, such as discrete implementation projects initiated or number of water quality measures in place. These will constitute output monitoring, the documentation of actions completed over time. A follow-up to this early-stage monitoring activity will be outcome monitoring, using environmental parameters and their status and trends to measure the real-world performance of action item implementation. Performance criteria for outcome monitoring will focus on such parameters as nitrogen levels and hypoxia, pathogenic indicators, the health of shellfish populations, and prevailing water demand and watershed hydrological conditions. In the case of Program Objective 4, regarding eutrophication and hypoxia, additional preparatory research will be needed in order to establish an appropriate baseline that can be used to help draw cause and effect conclusions in regard to nutrient enrichment and

environmental degradation, and in so doing, provide impetus for the implementation of any necessary nutrient control measures and the means to measure the success of Program implementation. The identification of performance criteria and appropriate indicators then leads to the issue of monitoring needs and necessary protocols. The attached table outlines each of the Program Objectives and their associated performance criteria and monitoring needs.

CCMP Chapter 6 - Habitat and Living Resources Action Plan

Chapter 6 of the BBEP CCMP lists 12 action items towards achieving 2 primary Program Objectives:

1. Maintain on a landscape level the natural environment of the Barnegat Bay watershed.
2. Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve regional biodiversity.

Similar to Chapter 5, action items in Chapter 6 range in scope from expansive (Maintain intact large blocks of Pinelands habitat - Action Item 6.5) to more targeted (Control erosion in threatened shoreline areas - Action Item 6.3). These two Program Objectives also come with staged performance criteria similar to those in Chapter 5. The number and types of implementation action steps taken will be the measure of success in the early stages. More broadly, documenting the environmental health and sustainability of Barnegat Bay and its watershed will be the ultimate test of Program success. In terms of Program Objective 2, preserving and improving regional biodiversity, more baseline research is required to establish an appropriate benchmark by which Program results can be measured. From the performance criteria, appropriate indicators can be selected and monitoring needs determined. The attached table outlines the two Program Objectives for Chapter 6 and their associated performance criteria and monitoring needs.

CCMP Chapter 7 - Human Activities and Competing Uses Action Plan

Chapter 7 integrates the water resource and biological values of the Barnegat Bay watershed with its human use component, and as a result, much of the discussion for a monitoring strategy overlaps with the discussion in the previous two Action Plan chapters. Chapter 7 list an additional 10 action items meeting five Program Objectives:

1. Support water-related recreation while preserving the economic viability of commercial endeavors.
2. Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.
3. Empower citizens in the protection and stewardship of the Barnegat Bay and its watershed.

4. Establish a consensus-based agreement to restrict uses of personal watercraft (PWCs) in sensitive shallow nearshore waters.
5. Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

As in the previous Action Plan chapters, the initial phase of output monitoring will entail the tabulation of action items and steps implemented by the Program. Action Items in Chapter 7 typically contain some element of public education and outreach (e.g., Use the Natural Resources Inventory to promote the use of best management practices - Action 7.7), but they also generally promote direct action to support the Program Objectives (e.g., Draft a Barnegat Bay personal watercraft (PWC) management strategy, thereby setting an example for statewide policy - Action 7.1). In this regard, performance criteria for output monitoring will include the target population that is reached through the action items and the follow-up that is conducted to measure the motivation to act. Because half of the human use equation is the sustainability of the natural resource of the Bay and watershed, outcome monitoring performance criteria overlap with those of Chapters 5 and 6, but economic and demographic criteria are also part of the outcome monitoring to account for the sustainable value of direct human uses of the estuary. The attached table briefly outlines the Chapter 7 Program Objectives and their associated performance criteria and monitoring needs.

Table 1. Monitoring Program Objectives

	CCMP CHAPTER 5 – OBJECTIVES	PERFORMANCE CRITERIA	MONITORING NEEDS
1.	Restore and maintain a productive ecosystem with no adverse effects due to pollution	• Phase 1 – Output Monitoring o Number of actions/percentage of implementation in support of Action Item implementation • Phase 2 – Outcome Monitoring o Restoration of pre-pollution environmental conditions o Percentage reduction in excess nitrogen levels o Reduced number of harmful algal blooms (HABs)	1. Action item tracking system 2. Ambient WQ monitoring for Nitrogen and other nutrients 3. Summer surveys of algal populations
2.	Ensure that edible seafood is safe for unrestricted human consumption.	• Phase 1 – Output Monitoring o Area of open shellfish waters o Incidence of shellfish water closures • Phase 2 – Outcome Monitoring o Health of shellfish resource o Sustainable yield of edible shellfish	1. Ambient WQ monitoring 2. Shellfish resource sampling 3. Resource management inventory
3.	Minimize health risks to contact water uses.	• Phase 1 – Output Monitoring o Number and extent of approved bathing bay beaches o Annual number and duration of bay beach closures • Phase 2 – Outcome Monitoring o Ambient concentration of pathogenic indicators o Reduction in pathogenic pollution sources	1. Bathing Beach WQ monitoring 2. Beach closure inventory 3. Pathogen source monitoring and inventory
4.	Estimate adverse impacts of eutrophication, including hypoxia resulting from human activities	• Pre-Phase 1 – Characterization o Develop understanding of relationship between nutrients and eutrophication/hypoxia • Phase 1 – Output Monitoring o Number of incidences of hypoxia/nuisance water conditions o Ambient concentrations of nutrient species • Phase 2 – Outcome Monitoring o Develop balanced nutrient cycling to minimize hypoxia/nuisance water conditions	1. Analysis relating nutrients to harmful water conditions 2. Seasonal surveys of ambient water conditions 3. Nutrient water-quality monitoring
5.	Provide a sustainable water supply to the human population without adversely impacting natural water regimes	• Phase 1 – Output Monitoring o Number of new water conservation measures o Incrementally moderate demand on water supply – reduce per capita water usage o Number of new steps to protect groundwater quality/reduce saltwater intrusion • Phase 2 – Outcome Monitoring o Develop sustainable balance between water demand and supply o Ensure long-term protection of riparian systems/ground-water levels o No loss of water supply due to saltwater intrusion	1. Action item tracking system 2. Water supply monitoring, to include chloride monitoring 3. Water demand monitoring 4. Ground-water level monitoring 5. Streamflow monitoring 6. Salinity monitoring in bay

	CCMP CHAPTER 6 – OBJECTIVES	**PERFORMANCE CRITERIA**	**MONITORING NEEDS**
6.	Maintain, on a landscape level, the natural environment of the Barnegat Bay watershed	• Phase 1 – Output Monitoring o Number of actions to preserve and restore natural habitat values o Number of actions to prevent further degradation of watershed habitats (e.g., water management, land use zoning). • Phase 2 – Outcome Monitoring o Recovery and long-term sustainability of endangered and threatened species populations o Unbroken continuity of watershed and estuarine habitats o Develop a sustainable balance between resource use (e.g., water, fisheries, agriculture) and resource abundance	1. Action item tracking system 2. Comprehensive habitat inventory and mapping 3. Trends in land use changes 4. Wildlife population monitoring 5. Status and trends analysis of resource use
7.	Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity	• Pre-Phase 1 – Characterization o Develop a status and trends analysis of wildlife populations • Phase 1 - Output Monitoring o Number of actions to manage important populations and resources • Phase 2 – Outcome Monitoring o Maintain long-term sustainability of wildlife populations and watershed resources.	1. Population inventories of targeted species 2. Action item tracking system 3. Periodic species population monitoring
	CCMP CHAPTER 7 – OBJECTIVES	**PERFORMANCE CRITERIA**	**MONITORING NEEDS**
8.	Support water-related recreation while preserving the economic viability of commercial endeavors	• Phase 1 – Output Monitoring o Attendance records for water-based recreation in the watershed and estuary o Number of participants in BBEP public outreach activities (e.g., Barnegat Bay Festival) • Phase 2 – Outcome Monitoring o Long-term sustainability of recreation-oriented business enterprises in the watershed and estuary (e.g., summer house rentals, marinas, party fishing boats)	1. Action item tracking system 2. Public outreach accounting inventory 3. Monitoring of recreation-oriented economic activity in the watershed
9.	Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection	• Phase 1 – Output Monitoring o Number actions to educate the public on sustainable methods of living o Number of participants in public education and outreach activities • Phase 2 – Outcome Monitoring o Develop sustainable balance between water demand and supply o Maintain long-term sustainability of wildlife populations and watershed resources o Stability in economic indicators to support a preferred standard of living	1. Action item tracking system 2. Public outreach accounting inventory 3. Water supply monitoring 4. Water demand monitoring 5. Periodic species population monitoring 6. Monitoring of economic indicators

	CCMP CHAPTER 7 – OBJECTIVES (Continued)	**PERFORMANCE CRITERIA**	**MONITORING NEEDS**
10.	Empower citizens to protect Barnegat Bay and its watershed.	• Phase 1 – Output Monitoring o Number actions targeted to public education and outreach o Geographical scope of public outreach activities • Phase 2 – Outcome Monitoring o Public participation in regional planning and decision making o Active public constituencies throughout the Barnegat Bay watershed	1. Action item tracking system 2. Public outreach monitoring
11.	Establish a workable agreement to restrict uses of PWCs in sensitive shallow, nearshore waters; encourage local initiatives to zone and enforce uses and misuses of PWCs.	• Phase 1 – Output Monitoring o Number of actions to balance recreational demand with resource protection • Phase 2 – Outcome Monitoring o Develop a reasonable balance between recreational opportunities and resource protection	1. Action item tracking system. 2. Outcome assessment of action item implementation
12.	Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest	• Pre-Phase 1 – Characterization o Develop a status and trends analysis of recreationally and commercially important fish and shellfish populations • Phase 1 - Output Monitoring o Number of management actions/policies to support sustainable fish and shellfish populations • Phase 2 - Outcome Monitoring o Sustainable yield of fish and shellfish in Barnegat Bay	1. Population inventories of targeted species 2. Action item tracking system 3. Periodic species population monitoring. 4. Summary of economic analysis of fish and shellfish harvesting

IV. ENVIRONMENTAL INDICATORS AND MONITORING WORKPLANS

PRIMARY INDICATORS

Primary indicators are environmental or other resource characteristics that will provide the most effective subject areas for communicating CCMP progress to the public. Primary indicators were identified through the monitoring workshop process by evaluating how well the suggested indicators met three criteria: public acceptability, availability of data from existing monitoring efforts, and relevance to the goals and objectives of the Comprehensive Conservation and Management Plan. The primary indicators listed in table 2 above were considered to meet these criteria. A monitoring workplan for each of the nine Primary Indicators follows. The monitoring program document of the Tillamook Bay (Oregon) National Estuary Project (Tillamook Bay National Estuary Project, 1999) provided the model format for the monitoring work plans for individual indicators.

These indicators were developed with an understanding that a set of statewide indicators have been identified in the Performance Partnership Agreement (PPA) between USEPA Region II and the NJDEP under the National Environmental Performance Partnership System (NEPPS), which aims to strengthen public health and environmental protection statewide through management for environmental results. Where appropriate, the correspondence between primary indicators and those identified under the NEPPS PPA is noted.

Table 2. Environmental Indicators

Primary Indicators (high profile indicators)	**Secondary Indicators** (Internal-use indicators)
• SAV Distribution, Abundance, and Health • Land Use/Land Cover Change • Signature Species • Watershed Integrity • Shellfish Beds • Bathing Beaches • Water-supply wells/drinking water • Harmful Algal Blooms • Freshwater Inputs	• Temperature • pH • Salinity • Dissolved oxygen • Nutrients • Turbidity • Fecal Coliform/Enterococcus bacteria • Phytoplankton abundance and composition & chlorophyll a concentrations • Macrophyte abundance • Shellfish & finfish abundance • Benthic community structure • Toxic contaminants in aquatic biota and sediments • Floatables • Shoreline habitat/sensitive areas • Boating use • Atmospheric and other pollutant inputs • Rare plant & animal populations • Stream Flow • Water allocations • Salt water intrusion • Turf grass

SAV Distribution, Abundance, and Health

Overview - Submerged aquatic vegetation (SAV) is a term used to describe a variety of bottom-dwelling marine plants including seagrasses. SAV provides a substantial amount of primary production for the Barnegat Bay-Little Egg Harbor estuary, and it serves as critically important habitat for benthic epifauna and infauna. Some organisms graze on SAV (e.g., gastropods, fish, ducks, muskrats). Benthic macrovegetation (e.g., *Zostera marina*) also provides valuable spawning, nursery, and feeding grounds for finfish populations in the estuary. They likewise stabilize the benthic habitat by baffling waves and currents and mitigating substrate erosion. In addition, they play a role in nutrient transformation. The occurrence of SAV species in the estuary strongly depends on environmental conditions. Each species has its own requirements for and tolerances of physical characteristics, such as temperature, salinity, sediment composition, water velocity, and turbidity. The location of SAV beds is often dynamic and patchy due to naturally occurring cycles, as well as changing distribution and abundance through the growing season and between years. External stresses due to disease, algal infestation, dredging, boating, and water quality problems are contributing to a long-term decline in SAV abundance and distribution.

The spatial distribution, abundance and health of SAV are important environmental indicators of the overall status of the Barnegat Bay-Little Egg Harbor system. Existing GIS maps provide a baseline of information concerning the spatial distribution of SAV in the estuary over the past four decades. Continued monitoring should include mapping efforts to chart changes in the spatial distribution of SAV and permanent plot studies to track the health status (i.e. disease, algal infestation) of these plants. This indicator is consistent with the NEPPS PPA condition indicator "Status and trends in SAV acreage in NJ's tidal waters" and the cause indicator "Status and trends of SAV diseases, such as wasting disease in eelgrass beds."

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity

CCMP Actions—6.2, 6.6, 6.8, 7.1, 7.2, 7.5

Monitoring Questions

- Is the distribution of SAV beds in the estuary changing?
- Is the abundance of SAV beds in the estuary changing?
- If the abundance of SAV beds is changing, to what extent is it changing?
- Is the health of SAV beds in the estuary changing?

Specific measures- The change in the distribution, abundance and health of SAV beds.

Existing Monitoring Programs (Reference Numbers)— 26, 37, 51, 52

Information needs/data gaps- Remote sensing (aerial photography and digital scanners) in combination with in situ sampling is needed to undertake comprehensive monitoring of SAV. Remote sensing is useful in providing a synoptic picture of the spatial distribution of SAV and should be conducted on a five to ten year basis. Present statewide aerial photographic monitoring is oriented to land surface mapping and is inadequate for benthic/SAV mapping purposes. Special SAV-oriented remote sensing acquisitions along with spot field checking are required to adequately map SAV distribution and abundance. The remote sensing mapping efforts should be supplemented with more frequent field sampling of permanent plots to document SAV stress factors (e.g., incidence of disease, algal infestation, etc.). There is no ongoing comprehensive monitoring program of SAV in Barnegat Bay.

Indicator Criteria – SAV is an indicator of ecosystem health that the public can relate to easily as it is a highly visible component of the Barnegat Bay ecosystem. SAV has been used successfully as an environmental indicator elsewhere (Chesapeake Bay). When an individual applies for a permit to construct a dock or a bulkhead, SAV habitat is a consideration when receiving the permit. Further explanations might be necessary to emphasize the value associated with this type of habitat. There do exist GIS data and monitoring of SAVs by the state, but these elements may not fit program needs.

Strategy for promoting /marketing- Public outreach fliers with a similar design to the Delaware Estuary Program, including cartographic products delineating changes will be produced and distributed.

Land Use / Land Cover Change

Overview- Land use by humans is a primary cause of ecological change at many scales. The effects of some land use change on water quality and habitat quality may not be evident for decades. Poorly planned growth of urban areas throughout the nation has been responsible for fragmentation of landscapes and disruption of hydrologic and other natural cycles. Research has linked the degradation of estuarine habitat quality, as measured by the condition of benthic communities, sediment contamination and the frequency of hypoxia, to increased urbanization and loss of forested uplands within the nearby watershed. High-resolution, remotely-sensed imagery can be used to classify and map land use/land cover and to allow analysis of land use/land cover changes.

Examination of the extent and fragmentation of habitats as it relates to land cover and land use is important to understand long-term change in estuarine systems. Specific land use/land change indicators have been identified as potentially valuable to the Barnegat Bay Estuary Program. These land use / land change indicators include changes in the extent of: 1) altered vs. unaltered land, 2) interior forestland, 3) public open space, and 4) impervious surface cover. Altered land would be defined as land that has been altered by humans, such as developed land or land used for agriculture or surface mining. Unaltered land refers to forests and wetlands. The interior forest indicator looks at the amount of both the upper watershed and wetland areas and excludes a 90-meter boundary around these areas adjacent to altered land. The public open space indicator tracks that amount of publicly owned land, both land that is developed and undeveloped. The impervious surface cover indicator reflects the extent of surfaces that are covered by impervious materials including such things as parking lots, roadways, and building structures. This indicator is consistent with the NEPPS PPA cause indicator "Status and Trends of Land Use/Land Cover Change."

Existing Land Use/land Cover Monitoring Programs in the Barnegat Bay Watershed

NJDEP Land Use Mapping Program

This program was established by the New Jersey Department of Environmental Protection (NJDEP) to map land use statewide. Land use is how humans use the land and includes such categories as residential land, industrial land, commercial and services, etc. The NJDEP has either contracted out or cooperated with the U.S. Geological Survey to have color-infrared aerial photography acquired statewide on an approximately 5-10 year time cycle. This aerial photography has then been further processed to produce digital orthophotography. Based on this aerial photographic data, the NJDEP has then contracted out the detailed mapping of land use. The first land use mapping for the Barnegat Bay watershed is for 1986. This data set has been recently updated with 1995 photography. In addition, to mapping land use type, the 1995 data includes estimates of impervious surface cover. These two land use maps are available from the NJDEP in digital geographic information system form on CD-ROM or directly downloadable through the Internet. The NJDEP has plans to update this data set in 2002-2003. The data set has several applications, including identifying trends in altered vs. unaltered land use and impervious surface cover.

CRSSA Land Cover Mapping Program

The Rutgers University Center for Remote Sensing & Spatial Analysis (CRSSA) has an ongoing land cover mapping and monitoring program for the Barnegat Bay watershed and adjacent Jacques Cousteau National Estuarine Research Reserve. Land cover represents the biophysical material or features covering the land surface and includes such categories as High Intensity developed, grassland, forestland, etc. Greater detail as to the vegetation community or habitat type is also mapped (e.g., Pitch pine lowland, high salt marsh). Based on satellite imagery, CRSSA has mapped land cover at varying levels of detail for the Barnegat Bay watershed for the years of 1972, 1984 and 1995. CRSSA has plans to update the land cover for the Barnegat Bay watershed in 2001-2002. This data set has several applications, including: 1) identifying trends in land use and impervious surface cover; and 2) monitoring habitat loss, alteration and fragmentation.

CCMP Objectives

- Maintain on a landscape level the natural environment of the watershed
- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity

CCMP Actions—6.1-6.10, 7.5

Monitoring Questions

Are the extents of the following land use/land cover categories in the estuary watershed changing over the time scale of years to decades?

- Unaltered land
- Interior forest areas
- Public open space
- Impervious surface cover

Specific Measures- Changes in the actual extent of coverage for the above mentioned land use/ land cover change indicators (altered vs. unaltered land, interior forest areas, public open space, and impervious surface cover).

Existing Monitoring Programs (Reference Numbers)— 30, 58

Information needs / Data gaps- Land use/land cover data for the Barnegat Bay-Little Egg Harbor estuary and watershed are available from several sources (see above). This land use/land cover data can then be synthesized at a sub-watershed scale to track the desired indicators: altered and unaltered indicator, the interior forest indicator and the impervious surface cover indicator. For the public open space indicator, mapped data

concerning publicly owned open space properties are archived through the Office of Planning for Ocean County, as well as data that can be obtained through regional agencies such as transaction records, deeds and tax maps.

Indicator Criteria- The habitats listed above are those that the public can relate to easily. Results of land use / land cover change indicators can be placed in a context and format both easily read and understood. These data layers can be obtained by satellite imagery and aerial photography, but must be ground-truthed with *in situ* field data.

Strategy for promoting /marketing- Public outreach fliers with a similar design to the Delaware Estuary Program, including cartographic products delineating the changes will be produced and distributed.

Signature Species

Overview – Signature species are those that the public will readily associate with and identify with the Barnegat Bay watershed. By selecting a range of freshwater, estuarine, and terrestrial indicator species, the public can be engaged from the range of habitats that comprise the Barnegat Bay system. Selection of an indicator species within each of these habitats represents the vital step to choosing indicators that will determine the integrity of the Barnegat Bay system. By tracking certain signature species, it may be possible to determine which habitats are in need of restoration or what habitats are benefiting from improvements that have already been made. Indicator species are derived from the following potential categories: avian species, anuran species, finfish species, potential estuarine macroinvertebrates, and terrestrial plant species.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Ensure that edible seafood is safe for unrestricted human consumption.
- Maintain on a landscape level the natural environment of the watershed.
- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Actions—6.5-6.9, 7.1, 7.2, 7.5, 7.10

Indicator Criteria – This is an indicator that should be readily understood by the public, which should be familiar with signature species as integral and visible parts of the Barnegat Bay-Little Egg Harbor estuarine system. Monitoring some of these species may prove to be problematic due to large data gaps, but there are other species for which monitoring data already exists. This is an area that needs to be examined in greater detail.

Hard Clam (*Mercenaria mercenaria*)-Signature Species (Shellfish Resource Surveys)

Overview -- A response indicator. The hard clam, Mercenaria mercenaria is the dominant long-lived filter feeding species that lives in fine-grained sediments and eelgrass (*Zostera marina*) beds in high salinity coastal bay (lagoon) ecosystems. It is also an important commercial and recreational fishery species and important for aquaculture. There is a considerable body of information on the general biology of the species, and this information has recently been compiled into one document. *Mercenaria mercenaria*, is a species that would serve as a good indicator of the overall health of the Barnegat Bay-Little Egg Harbor Estuary because of its wide distribution in relation to temperature, salinity and sediment type, as well as its long life. Stock assessment of this species would

provide valuable information on the areas that are available for harvesting and could be safely harvested in the estuary. These data would identify specific areas where hard clam populations have been restored and would also serve to prioritize those areas that could benefit from hard clam restoration projects. The public can easily relate to the importance of the hard clam as an indicator of the health of estuarine habitat because of its commercial and recreational importance. In addition, population assessment of the hard clam would enhance the shellfish beds classification water quality indicator because it would incorporate information on the abundance and availability of hard shell clams in areas that are approved for harvesting. Classification of New Jersey's shellfish waters is performed in accordance with the National Shellfish Sanitation Program (NSSP) and has been selected as one of the water quality indicators. A major focus of this signature species is as an indicator of the ecological health of the estuary. For example, stock assessment of the hard clam as a signature species will not only enhance the environmental health indicator to be obtained through the shellfish classification program but also provide direct assessments of the level of abundance of the dominant filter feeder of the estuary and the level of abundance of the harvestable resource. If size-frequency distributions, box counts, and size-at-age are added to the basic population survey information, long-term trends in the population resource can be determined. Thus, a record of ecosystem performance can be delineated. Though a hard clam population assessment was recently completed by the NJDEP, Division of Fish and Wildlife in 2001, such an assessment is performed too infrequently and not at the same level and frequency as that of the shellfish classifications. In addition to performing actual stock assessments, the Division of Fish and Wildlife also compiles information on shellfish harvesting. This information may also assist the Barnegat Bay Estuary Program in measuring the effectiveness of action items in the CCMP.

Newly set hard clams have been shown to be more sensitive to some environmental contaminants than many test organisms. In standard bioassay test, for example, newly set clams were shown to be more sensitive than *Ampelisca abdita*, *Ampelisca verrilli*, *Palamonetes pugio*, *Rhepoxynius abronius* and *Amphiiascus tenuiremis* to the heavy metal cadmium and the hydrocarbon fluoranthene. A physiological based model of hard clam population dynamics is currently being developed for Great South Bay, New York, because of the drop in clam populations in that system. The model will have the clam's responses to brown tide (an important phenomenon in the Barnegat Bay-Little Egg Harbor system) incorporated. If the base environmental data are available, it could be run to compare the responses of the hard clam in New Jersey system to that in New York. This hard clam signature species indicator is consistent with the NEPPS PPA Response Indicator "Status and Trends of Shellfish Inventories within New Jersey's Coastal Estuaries," NEPPS PPA condition indicators "Status and Trends of Shellfish Populations within New Jersey's Coastal Estuaries including Raritan/Sandy Hook Bays," and the "Status and Trends of Shellfish Harvest within New Jersey's Coastal Waterways," and with the NEPPS PPA cause indicator "Status and Trends of Shellfish Harvest Activities."

Monitoring Questions

- Is the population of hard clam stocks in the estuary changing?
- Is the distribution of clam stocks changing in relation to areas that are open for harvesting?

Specific Measures: Population estimates of hard clam stocks and location in relation to the areas that are open for harvesting as a function of time.

Existing Monitoring Programs (Reference Number) – 37

Information needs/data gaps: Stock and population assessments of the hard clam is needed to be performed throughout the estuarine portions of the watershed at least every five years or more frequently to effectively measure the health of the resource. Information needs to be gathered in conjunction with the ongoing shellfish beds monitoring program to support the habitat restoration objectives of the CCMP.

Indicator criteria: The public probably more readily understands the indicator and in conjunction with the SAV indicators will enhance our ability to measure the effectiveness action items that are meant to address the estuarine portions of the estuary. It can be effectively measured through NJDEP surveys (Division of Fish and Wildlife), but must be coordinated with the ongoing shellfish monitoring programs. It relates to those action items specifically addressing habitat restoration and the action items addressing the need for such surveys.

Strategy for promoting/marketing: Multimedia approach. The results of hard clam population surveys could be compiled and reported to the public and to watershed partners in the same manner as the SAV assessments are to be performed. In addition, the hard clam population surveys could also be marketed with the data from the shellfish beds indicator. This information can also be presented through the Barnegat Bay Estuary Program, in local and regional newspapers, outreach fliers (e.g., Rutgers Cooperative Extension and/or the New Jersey Sea Grant College Program), and radio broadcasts.

Colonial Nesting Waterbird Monitoring

Overview -- Barnegat Bay supports large and diverse breeding colonies of birds. Twenty species of colonial waterbirds nest within Barnegat Bay-Little Egg Harbor estuarine habitats, including ten species of long-legged wading birds, six species of terns, three species of gulls, black skimmers and the beach-nesting piping plover. These avifauna are valuable bioindicators of environmental quality, notably the concentrations of chemical contaminants, levels of human disturbance, resource abundance, and habitat health in the system. They feed near the top of the food chain on numerous species of fish and invertebrates. A regular census of shorebirds and seabirds has revealed important long-term changes in population abundance, as well as recent changes associated with the degradation of critical habitat areas. Declines in population abundance of some species during the past two decades have been attributed to the loss of habitat, increased human disturbance, and predation effects (e.g., from herring gulls and red foxes).

The New Jersey Department of Environmental Protection, Division of Fish and Wildlife has monitored nesting populations of colonial waterbirds (long-legged waders, gulls, terns and black skimmers) for the past two decades through a combination of ground and aerial surveys. Aerial surveys have been conducted in 2001, 1995, 1989, and 1985. Ideally the aerial surveys should be done annually or biannually. Terns and skimmers are surveyed each year by multiple ground counts. The aerial counts are of adults present at colony, i.e., not nests or even nesting pairs. For ground surveys, sitting adults are counted to estimate nests. Ground count data also yield gross estimate of success. In addition, Dr. Joanna Burger of Rutgers University has conducted annual surveys of nesting terns and skimmers over the same period of time.

This indicator is consistent with the NEPPS PPA condition indicator "Status and trends in populations of each Colonial Water Bird spp."

Monitoring Questions

- Is the population abundance of colonial nesting waterbirds changing?
- If changes are occurring, are they associated with corresponding changes in habitat?

Specific measures – Population estimates of colonial nesting waterbirds.

Existing Monitoring Programs (Reference numbers) --16, 31, 32, 38, 39, 40, 41, 42, 43

Osprey Monitoring

Overview -- The NJDEP has an ongoing program to monitor the status of Barnegat Bay's osprey population. These 'fish hawks' are near the top of the bay's food chain and serve as valuable bioindicators of environmental quality, notably the concentrations of

chemical contaminants, levels of human disturbance, resource abundance, and habitat health in the system. The NJDEP annually censuses known osprey nesting sites and records the number of nesting pairs and fledging success.

Monitoring Questions –

- Is the number of known osprey nesting sites changing?
- Is the success rate of osprey fledglings changing?

Specific measures – Estimates of osprey nesting sites and fledgling success.

Existing Monitoring Program (Reference Number) - 38

Breeding Bird Survey

Overview -- The U.S. Geological Survey's Patuxent Wildlife Research Center coordinates the Breeding Bird Survey (BBS) to monitor the status and trends of North American bird populations. Each year during the height of the avian breeding season, June for most of the U.S. and Canada, participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen or heard within a 0.25-mile radius is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Once analyzed, BBS data provide an index of population abundance that can be used to estimate population trends and relative abundances at various geographic scales. Professional BBS coordinators and data managers work closely with researchers and statisticians to compile and deliver these population data and population trend analyses for use by conservation managers, scientists, and the general public. Trend estimates for more than 420 bird species and all raw data are currently available via the BBS web site. If significant declines are detected, their causes can then be identified and appropriate actions taken to reverse them before populations reach critically low levels. Within the Barnegat Bay Estuary and Watershed, there are portions of 5 BBS routes. While BBS data has been collected in the Barnegat Bay area back to 1966, the data records for these five routes are not complete in that some routes have been discontinued and other routes have not been censused annually. The BBS data set provides the best available information on long-term trends in forest-dependent breeding birds for the Barnegat Bay area. This indicator is consistent with the NEPPS PPA condition indicator "Status and trends of the number of breeding waterfowl by species and area."

Monitoring Question –

- Are breeding bird populations changing over the time scale of years to decades?

Specific measures – Population estimates of breeding birds.

Existing Monitoring Programs (Reference numbers) – 31, 32, 33, 38, 39, 41, 42, 43, 47

Watershed Integrity Measures

Overview- As part of its Pinelands-wide watershed monitoring effort, the Pinelands Commission monitors several sites in the Toms River and Cedar Creek to assess the ecological status of surface waters in the Barnegat Bay drainage system. Over the past five years the Commission established an extensive database on the status of surface waters and wetland and aquatic communities in the Mullica River basin. These studies clearly demonstrate the relationship between these resources and land-use related watershed disturbances. These findings provide the basis for future assessments of the status of the Mullica River basin and for evaluating the status of other Pinelands stream systems such as the Barnegat Bay tributaries. This indicator is consistent in part with the NEPPS PPA condition indicator "SWQS attainment status and trends for conventional water quality parameters (DO, pH, TP, TDS) in assessed non-tidal waters" and cause indicator "Status and trends of occurrences and reproduction of non-native fishes that compete with native fishes."

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Maintain on a landscape level the natural environment of the watershed.
- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity.

CCMP Actions – 5.1-5.14, 7.5

Monitoring Questions -- Is the status of watershed integrity changing (as measured by the following parameters)?

- pH
- specific conductance
- presence of disturbance indicator species
- presence of non-native fish
- presence of bullfrogs

Specific measures – Changes in pH, Specific conductance; presence/absence of disturbance indicator species, non-native fish, and bullfrogs.

Indicator Criteria -- These indicators, which distinguish the acid, nutrient poor conditions and native plant and animal communities of relatively undisturbed Pinelands watersheds from altered watersheds, are tailored to the unique characteristics of the ecosystem and the goals of the Comprehensive Management Plan.

Existing Monitoring Programs (Reference numbers) – 6, 9, 12, 14, 15, 16, 17, 18, 19, 20, 21, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51

Information needs / Data gaps: In addition to water quality (pH and specific conductance), the presence of disturbance indicator plants, non-native fish, and bullfrogs are measured. These indicators, which distinguish the acid, nutrient poor conditions and native plant and animal communities of relatively undisturbed Pinelands watersheds from altered watersheds, are tailored to the unique characteristics of the ecosystem and the goals of the Comprehensive Management Plan. As such, these indicators should also have great utility as part of the Barnegat Bay Estuary and Watershed monitoring efforts. A number of Barnegat Bay major drainages, including the Toms River and Cedar Creek, will be sampled. Some of these sites were first measured in the mid 1990's and are scheduled to be revisited in 2003-2004.

The New Jersey Department of Environmental Protection operates an ambient biomonitoring network (AMNET) throughout the state. Benthic macroinvertebrate (aquatic insects and other aquatic macroscopic invertebrates) data collected through this program are used in the development of the required 305(b) water quality inventory and other watershed-based regulatory and planning programs. The Pinelands Commission monitoring sites will be co-located with NJDEP AMNET (Ambient Biomonitoring Network) and IBI (Index of Biotic Integrity) monitoring sites to assist in a better characterization of the status of Pinelands surface waters.

Strategy for promoting/marketing: Public outreach fliers with a similar design to the Delaware Estuary Program, including cartographic products delineating the changes.

Shellfish Beds

Overview: A response indicator. This indicator tells us the acreage from which shellfish can be safely harvested in Barnegat Bay-Little Egg Harbor estuarine waters. It is a good indicator of progress in improving estuarine water quality because it incorporates water quality testing and pollution source surveys to establish the shellfish water classifications. A limitation of this indicator is that it is a measure of water quality in terms of public health and potential for disease transmission, but it is not geared towards measuring the ecological health of the estuary. Classification of New Jersey's shellfish waters is performed in accordance with the National Shellfish Sanitation Program (NSSP). In order to maintain compliance with the NSSP, New Jersey collects and analyzes about 15,000 samples of its coastal waters each year. Results of this monitoring are compared to national standards for safe shellfish harvest. The Bureau of Marine Water Monitoring collects and analyzes samples throughout the year. The Bureau then evaluates these results relative to national standards and produces an annual evaluation of the state's coastal water quality. Results of this bacteriological evaluation are used to classify the state's shellfish harvesting acreage and are published each year in the New Jersey Shellfish Growing Water Classification charts. Detailed surveys of each coastal area are performed once every three years under the National Shellfish Sanitation Program. Intensive sanitary surveys are performed at least once every 12 years under the same program. This proposed indicator is consistent with NEPPS PPA Response Indicator "Status and Trends of Shellfish Harvest Classifications in Acres and % of Total Resource Available, A. Unrestricted, B. Special Restricted, C. Prohibited".

CCMP Objectives --

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Ensure that edible seafood is safe for unrestricted human consumption.
- Estimate adverse impacts of eutrophication, including hypoxia, resulting from human activities.
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Actions — 5.1-5.10, 5.13, 5.14, 5.16-5.19, 5.25, 7.5

Monitoring Question –

- Is the acreage of shellfish beds open for harvest changing?

Specific Measures: Acreage of shellfish beds open for harvest as a function of time.

Existing Monitoring Programs (Reference numbers) – 13, 37

Information needs/data gaps: None

Indicator criteria: The indicator is readily understood by much of the public, but a less visible problem than that of the bathing beaches. It is effectively measured by NJDEP surveys. It relates to those action items specifically addressing microbial (bacterial) degradation of water quality. Action Item 5.25.

Strategy for promoting/marketing: Multimedia approach. For example, results of surveys should be covered in local and regional newspapers, outreach fliers (e.g., Rutgers Cooperative Extension), and radio broadcasts.

Bathing Beaches

Overview: A response indicator. The NJDEP has used fecal coliform concentrations to detect the presence of sewage and/or nonpoint source pollution at recreational beaches. The New Jersey Department of Health and Senior Services adopted a primary contact standard of 200 fecal organisms in 100 milliliters of water. In the near future, the standard may be changed to use enterococcus bacteria instead of fecal coliform. The Enterococcus standard is 104 organisms in 100 milliliters of water.

When indicator bacteria concentrations exceed the standard, the waters are considered unsafe for swimming and are closed. Trends in bacteria concentrations are used to identify locations where water quality is improving, declining or remaining stable and the effectiveness of remediation actions. Recreational designated use attainment provides a measure of miles supporting recreational uses of the beaches, based on the frequency of closings during the 100-day beach season. The Cooperative Coastal Monitoring Program (CCMP) evaluates water quality for swimming using data collected during the summer. Fecal coliform data have been collected consistently since 1986, providing a rich source of information. Trained personnel collect all samples using standard procedures. Samples are analyzed at certified laboratories. Analysis methods and detection limits for this parameter have remained consistent since the beginning of the CCMP.

In addition to the Cooperative Coastal Monitoring Program, the Ocean County Health Department monitors freshwater recreational beaches in the Barnegat Bay-Little Egg Harbor watershed during the summer. OCHD monitors 15 beach sites at 11 lakes. Two freshwater streams are also monitored. All results are submitted electronically to NJDEP on a daily basis.

This proposed indicator is consistent with NEPPS PPA condition indicator "Status of Beach Closings at Tidal Water Beaches Due to A. Fecal Coliform, B. Floatables, C. Other Causes."

CCMP Objectives –

- Minimize health risks to contact water uses.
- Support water-related recreation while preserving the economic viability of commercial endeavors.

CCMP Actions—5.1-5.4, 5.6, 5.7-5.10, 5.13-5.19, 5.25,7.5

Monitoring Questions –

- Is the number of bathing beach closures changing?

Specific Measures: Number of bathing beach closings each month.

Existing Monitoring Programs (Reference numbers) – 25, 54, 55

Information needs/data gaps: None

Indicator criteria: Highly important and clearly understood to/by the public. Coliform bacteria are readily measured; the program is well established. It relates specifically to microbial (bacterial) degradation of water quality. Action Item 5.25.

Strategy for promoting/marketing: Similar multimedia approach discussed for shellfish beds above.

Water-supply wells/drinking water

Overview: A condition/response indicator. The status of the quality of source waters for drinking water supply throughout the watershed is determined through existing monitoring programs administered by the NJDEP, USGS, and local health departments. In addition to serving public health needs, the status of source-water quality also gives an indication of contaminant inputs to estuarine receiving waters. Ground water is the source of most of the drinking water used in the watershed as well as most of the fresh water input to the estuary, and subsurface flow represents a significant contaminant transport pathway from the land surface to the estuary. Therefore, tracking the status of ground-water quality is an important means for tracking success in meeting a Primary CCMP Goal to "…a) protect the quantity and quality of public water supplies and b) maintain or restore ecological conditions to support living aquatic resources in the estuary and watershed." The Ocean County Health Department administers Ocean County ordinance 94-1, under which private wells must be tested, under certain circumstances, for a wide range of contaminants. The massive database maintained by OCHD lends itself to establishing a practical environmental indicator of this type. This proposed indicator is consistent with NEPPS PPA Condition Indicators "status and trends of [VOC/metals/pesticides/nitrate levels] [fecal coliform contamination]in ground water and extent monitored A. public water systems and B. private and other wells".

CCMP Objectives –

- Provide a sustainable water supply to the human population without adversely impacting natural water regimes.
- Restore and maintain a productive ecosystem with no adverse effects due to pollution.

CCMP Actions--5.20-5.22, 5.24, 7.5

Monitoring Questions –

- Is the quality of ambient shallow ground-water changing with respect to established drinking water standards?

Specific Measures: Number (%) of private wells tested annually under Ocean County Ordinance 94-1 for which raw water meets drinking water standards for anthropogenic contaminants (exclude pH, iron, manganese).

Existing Monitoring Programs (Reference numbers) – 7, 8, 15, 56

Information needs/data gaps: Existing programs are generating sufficient data to implement this indicator. A statewide program will likely result in more contaminants being tested.

Indicator criteria: The importance of safe drinking water is readily understood by, and visible to, the public after problems with Ciba Geigy, Reich Farm, local dumpsites, and other incidences of contamination. Extensive databases are available via USGS, NJDEP, and OCHD.

Strategy for promoting/marketing: A public education effort will be needed to ensure a proper understanding of various contaminants and the indicator. Consumer Confidence Reports from purveyors to the public could help in this regard.

Harmful Algal Blooms (HABs)

Overview: A condition/response indicator. Harmful Algal Blooms (HABs) are a growing concern in New Jersey coastal waters, because they have caused great environmental damage in other mid-Atlantic coastal waters. In particular, "brown tide", which is caused by massive blooms of *Aureococcus anophagefferens,* has had severe impacts on eelgrass populations, and it has occurred with increasing frequency in New Jersey estuaries. Although brown tide does not appear to pose a health threat to humans, the presence of brown tide may reduce recreational fishing, boating and swimming in affected waters. Although the causes of brown tide are not completely understood, organic nutrients are thought to play an important role; and therefore, brown tide may be an effective response indicator for nutrient loading. This proposed indicator is consistent with NEPPS PPA condition indicator "Status and Trends in Phytoplankton Blooms in Assessed Tidal Waters and Extent of Assessment".

CCMP Objectives –

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Ensure that edible seafood is safe for unrestricted human consumption.
- Minimize health risks to contact water uses.
- Estimate adverse impacts of eutrophication, including hypoxia, resulting from human activities.
- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity.
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Actions-- 5.1-5.14, 5.16-5.19, 5.25, 7.5

Monitoring Questions –

- Is the frequency, area, or intensity of HAB occurrence changing?
- Is the species composition of HABs changing?

Specific Measures: Number of HAB occurrences per year. Area of occurrence of HABs. Species composition of HABs. Abundance (density) of phytoplankton groups.

Existing Monitoring Programs (Reference numbers) – 6, 17, 18, 26, 27, 28

Information needs/data gaps: Additional information is needed on the causes of HABs. Additional monitoring of HABs is needed. More data are needed on species composition of HABs.

Indicator Criteria: The public generally has a poor understanding of HABs. They have not been effectively monitored in the past; however, new monitoring efforts are underway. HABs relate to important Action Items, such as those relating to reduction of nitrogen loading from the watershed.

Strategy for promoting/marketing: Educating the public about HABs will be a challenge, as the present scientific understanding of HABs in general is incomplete and the severity of the consequences of HABs in Barnegat Bay is not well understood. Educational news items in newspapers and outreach articles from Rutgers Cooperative Extension will be helpful. Educational news items from ongoing HAB research at the national level will be utilized as appropriate.

Freshwater inputs

Overview: A condition indicator. The Barnegat Bay-Little Egg Harbor watershed provides needed fresh water, through streams, lakes, and ground water, for the many freshwater aquatic uses, including fish and wildlife, aquatic invertebrates, drinking water, recreational use, and industrial and commercial uses. Fresh water from the watershed is also needed as inflow to the estuary, to maintain the unique ecosystem where fresh and salt water mix and create the vital nursery for life along the Atlantic coast. However, the state's Water Supply Master Plan has identified the Barnegat Bay watershed as an area of significant water supply deficit by the year 2040. At the same time, the withdrawal of potable water for this area is almost totally consumptive to the watershed, as most of the wastewater is discharged to the ocean resulting in reduced streamflow and saltwater intrusion. Additionally, current modifications to the landscape change the natural hydrology of the watershed by reducing recharge and increasing runoff. Tracking freshwater inputs is an important means for tracking success in meeting a primary CCMP goal to balance the natural water cycle. Monitoring surface water discharge is the most cost effective means to monitor freshwater inputs. This indicator is consistent with NEPPS PPA condition indicator "Status and Trends of Stream Flows and Extent Monitored".

CCMP Objectives –

- Provide a sustainable water supply to the human population without adversely impacting natural water regimes.
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.

CCMP Actions—5.3-5.5, 5.13, 5.15, 5.20-5.24, 7.5

Monitoring Questions –

- **Is the base flow of tributary streams changing over the time scale of decades?**
- **Is water consumption changing?**

Specific Measures: Short and long-term changes in base flow and water consumption.

Existing Monitoring Programs (Reference numbers) – 2, 5, 15, 22, 56

Information needs/data gaps: Continuous gaging needed in southern part of the watershed.

Indicator Criteria: This indicator is not well understood by the public as it relates to the estuary, however, it relates to important CCMP Objectives and Actions. A public

education program will be needed in order to develop an adequate public understanding of the importance of freshwater inputs. Freshwater flows are adequately measured by USGS in the northern part of the watershed, but continuous gaging needed in southern part.

Strategy for promoting/marketing: As in the case of drinking water above, water companies could provide educational information to county residents.

SECONDARY INDICATORS

Secondary indicators are environmental or other resource measures that are necessary for effective evaluation of CCMP progress, but that are considered less appropriate than the primary indicators as subject areas for effective communications to the public. A particular indicator may be relevant to the evaluation of particular CCMP programs, but for any of a variety of reasons, it may not meet the established criteria for primary indicators, and is therefore considered secondary. In most cases, secondary indicators (or their ecological relevance) are poorly understood by the public, and therefore attempts to communicate secondary indicator status through public outreach would likely be ineffective. In some cases, existing monitoring efforts are inadequate, or the indicator has only minor relevance to CCMP goals and objectives. Excluding the monitoring of DO by the water-quality monitoring programs of the NJDEP and Rutgers, some data gaps exist for essentially all of the other secondary indicators for water quality with respect to both spatial and temporal databases.

Temperature

Overview --Temperature is one of the more important measurements to be considered when examining water quality. Many biological, physical and chemical parameters are dependent on temperature. It can dramatically affect the rates of chemical and biological reactions. Some of the more common things which temperature can effect are the solubility of chemical compounds in water, the distribution and abundance of organisms, the rate of growth of biological organisms, water density, mixing of different water densities and current movements. The amount of oxygen that can dissolve in water is dependent upon temperature. As the temperature of a body of water increases, the amount of dissolved oxygen decreases. Temperature, specific gravity, and salinity are also interrelated. For a body of water at a given salinity, as the temperature of that water decreases, the specific gravity will increase and the water becomes more dense. Conversely, as the same water warms up, the water will expand and the specific gravity will decrease. This can be an important consideration in evaluating the mixing of waters of different densities.

CCMP Objectives

- Maintain on a landscape level the natural environment of the watershed
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Actions- 5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7

Monitoring Questions

- Is water temperature in the estuary increasing, decreasing, or unchanged?
- If water temperature is changing in the estuary, what is the magnitude of this change?

Specific Measures- Spatial and temporal temperature differences.

Existing Monitoring Programs (Reference numbers) 6, 9, 10, 12, 14, 15, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 51

Information needs/data gaps- Continuous temperature measurements at selected sites in different sections of the estuary.

Salinity

Overview- Salinity is the concentration of salt dissolved in water. It is normally expressed in parts per thousand or the grams of salt per 1000 grams of water sample (^{o}/oo, ppt). An important characteristic of seawater is the property of "Constant Composition". This means that the ratio of the concentration of the major components is constant and is the same everywhere in the ocean. The salinity of the water may increase or decrease due to the loss or gain of water from evaporation, rainfall, freezing, melting, or other processes. During a rainstorm, freshwater will dilute the concentration of these components and the salinity will decrease. If water evaporates, these components are left behind causing the salinity of the remaining water to increase. Seawater has an average salinity of 35^{o}/oo. Probably the most important aspect of salinity with regards to water quality is its effect on aquatic organisms. Salinity changes can affect the well-being and distribution of biological populations.

CCMP Objectives

- Provide a sustainable water supply to the human population without adversely impacting natural water regimes
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection

CCMP Actions- 5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7

Monitoring Questions

- Is salinity in the estuary increasing, decreasing, or unchanged?
- Are drought conditions during the past several years affecting salinity levels in the bay?
- How are salinity changes related to the changes in tidal prism associated with the restructuring of Barnegat Inlet?

Specific Measures- Temporal and spatial changes in salinity estuary-wide.

Existing Monitoring Programs (Reference Numbers)- 12, 14, 15, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 51

Information needs/data gaps- Continuous salinity measurements at selected sites in different sections of the estuary.

pH

Overview -- How acidic or alkaline (basic) a water sample is can be determined by a measurement of the water's pH. When an acid dissolves in water, it releases positively charged hydrogen ions. pH is defined as the negative logarithm of the concentration of these hydrogen ions in the water. It is actually simple, the scale runs from 1 to 14. Pure water is said to be neutral and has a pH of 7.0. A lower pH means more acid is dissolved in the sample. Thus, a pH value less than 7 indicates the water sample is acidic. A pH greater than 7 means the water has excess alkali (base) dissolved in it. pH is an important water quality parameter. The pH affects the solubility of minerals in water. Human activities including chemical spills, agricultural runoff, storm water runoff and sewage effluent can all affect the pH of water. The solubility of trace metals, some of which are toxic, are affected by changes in pH, generally becoming more soluble as the pH decreases. The buffering capacity of water, its ability to resist changes in pH, is critical to aquatic life. Aquatic organisms survival greatly diminishes as pH falls below 5 or increases above 9. On the pH scale of 0-14, a reading of 7 is considered to be "neutral". Readings below 7 indicate acidic conditions, while readings above 7 indicate the water is alkaline, or basic. Naturally occurring fresh waters have a pH range between 6 and 8. The normal pH range for fresh waters originating in the Pinelands region of New Jersey is more acidic (typical range of between 3 and 6); however, the ecological community of the Pine Barrens region is adapted to these low pH conditions. The pH of the water is important because it affects the solubility and availability of nutrients, and how they can be utilized by aquatic organisms.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Maintain on a landscape level the natural environment of the watershed.

CCMP Action Items -- 5.9, 5.10, 5.14- 5.19, 7.5, 7.7

Monitoring Question

- Are pH levels increasing, decreasing, or unchanged in the estuary?

Indicator Criteria – This indicator is readily understood by the public; however, the factors that contribute to changes in pH levels and the implications that may result from changes in pH are not well understood by the public.

Specific Measures – The change or stability of pH levels as measured over time within varied locations throughout the estuary and upper regions of the watershed.

Existing Monitoring Programs (Reference Numbers) – 9, 10, 12, 14, 15, 17, 19, 20, 21, 26

Information Needs/Data Gaps – There are a number of existing programs that are measuring pH levels in conjunction with other types of data. A number of cooperative

NJDEP and USGS programs are routinely collecting pH levels in the freshwater streams as well as groundwater throughout the watershed. In addition, many estuary/coastal-based programs are collecting pH data within the estuary portion of the watershed. The US Geological Survey also maintains a historical database that will assist in providing baseline data for the purpose of determining if pH levels are changing.

Dissolved Oxygen

Overview -- Dissolved oxygen (DO) is one of the most important indicators of water quality. It is essential for the survival of fish and other aquatic organisms. Oxygen dissolves in surface water due to the aerating action of winds. Oxygen is also introduced into the water as a by-product of aquatic plant photosynthesis. When dissolved oxygen becomes too low, fish and other aquatic organisms cannot survive. The DO test tells how much oxygen is dissolved in the water. However, it does not tell you how much oxygen the water is capable of dissolving at the temperature at which it was measured. When water dissolves all of the oxygen it is capable of holding at a given temperature it is said to be 100% saturated. The colder the water is, the greater the amount of oxygen the water can hold. As the water becomes warmer, less oxygen can dissolve in the water. Salinity is also an important factor in determining the amount of oxygen a body of water can hold. As the amount of dissolved salts in the water increases, the amount of oxygen the water can hold decreases. Conversely, as the water becomes less saline, more oxygen can dissolve into the water. Oxygen levels may be reduced because the water becomes too warm or because there are too many bacteria or algae in the water. After the algae complete their life cycle and die bacteria consume the dead algae. During this decay process the bacteria also consume the oxygen dissolved in the water. This consumption of oxygen by the bacteria can lead to decreased levels of dissolved oxygen and in some cases completely strip the water of all DO. This process is termed eutrophication. This decrease in dissolved oxygen can cause fish kills and death to other aquatic organisms. When the dissolved oxygen drops below 3 mg/L is when fish kills can occur. Dissolved oxygen is the amount of oxygen dissolved in water, measured in milligrams per liter (mg/L). This component in water is critical to the survival of various aquatic life in streams, such as fish. The ability of water to hold oxygen in solution is inversely proportional to the temperature of the water. For example, the cooler the water temperature, the more dissolved oxygen it can hold.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution
- Estimate impacts of eutrophication, including hypoxia, resulting from human activities
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.

CCMP Actions- 5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7

Monitoring Questions

- Is oxygen depletion affecting any areas of the estuary?
- Are there any occurrences of hypoxic events in the estuary?

Specific Measures- Percent saturation and absolute values in mg/l of dissolved oxygen.

Existing Monitoring Programs (Reference numbers)- 6, 9, 10, 12, 15, 17, 18, 19, 20, 21, 26, 27, 28, 51

Information needs/data gaps- NJDEP measures dissolved oxygen at an array of stations in the estuary as part of an ongoing water quality assessment program. The JCNERR monitors dissolved oxygen levels in Little Egg Harbor.

Nutrients

Phosphorus:

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals. There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations.

Nitrates:

Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Estimate adverse impacts of eutrophication, including hypoxia, resulting from human activities.
- Maintain on a landscape level the natural environment of the watershed.
- Encourage sustainable methods of living in the watershed, whereby human uses are balanced with ecosystem production.

CCMP Action Items -- 5.1, 5.2, 5.9-5.11, 5.14-5.19, 6.1, 6.3, 7.1, 7.2, 7.5, 7.7

Monitoring Questions

- Are nitrogen and phosphorus concentrations increasing in the estuary?
- Are nutrient levels changing in the more heavily developed northern estuary?

Indicator Criteria – Excess nutrients can sometimes be a visible indicator of the health of the estuary because they may contribute to eutrophication and harmful algal blooms which may be visible and can cause very visible events such as fish kills. This indicator has recently become better understood by the public as people are becoming aware of the link between excess nutrients and eutrophication/algal blooms; however, many people do not fully understand the impact they have on the estuary by engaging in such routine activities as fertilizing their lawn.

Specific Measures – The change in phosphorous and nitrogen levels within the estuary. The change in nutrient levels within the more heavily developed northern portion of the estuary.

Existing Monitoring Programs (Reference Numbers) – 9, 10, 12, 15, 17, 18, 23, 26, 27, 28

Information Needs/Data Gaps – Data on nutrient concentrations within the estuary is being collected as part of the Brown Tide Monitoring projects and as part of EPA's National Coastal Assessment and the Regional Monitoring and Assessment Program. In addition, the Barnegat Bay Watch Monitoring Program collects data on nutrients for 55 sites within these areas once every two weeks from April to November; however, not every site is sampled every year because it is a volunteer program. Data have been collected for almost 250 sites within the estuary and lower portions of freshwater tributaries by the above-mentioned programs and this provides a fairly comprehensive coverage of nutrient concentrations. While this provides a decent baseline coverage of the estuary, very little monitoring of nutrients is conducted within the upper portions of the watershed. Cooperative monitoring by USGS and NJDEP provide nutrient data for approximately 20 freshwater sites and a portion of these sites are located in the headwater areas of the watershed. A more comprehensive coverage of nutrient concentrations within inland freshwater tributaries to the bay is needed to effectively determine the source of nutrient inputs to the Barnegat Bay.

Turbidity

Overview -- Material that becomes mixed or suspended in water will cause the water to become more turbid and reduce the clarity of the water. As the water clarity decreases, light will not be able to penetrate as far below the water's surface. Many factors can contribute to decreasing water clarity. During periods of rain, storm water runoff contains silt and sand washed from the streets, yards, and construction sites are carried into the water. In shallow water winds, boats and people may stir up bottom sediments contributing to decreasing water clarity. Decreases in water clarity can have a profound effect on penetration of sunlight below the surface of the water. Plants need sunlight in order for photosynthesis to occur. The plants that live on the bottom, typically seagrasses, are particularly affected by reduced penetration of sunlight. If light levels become too low photosynthesis may stop altogether and the plants will die. These plants produce oxygen for fish and other aquatic life, as well as providing food, shelter, nurseries, and habitat. Less seagrass in turn means a lower population of aquatic organisms. The Secchi disk provides a convenient method for measuring the penetration of light below the water surface, and thus limit of visibility in the water. The Secchi disk is either all white or has alternating black and white quadrants with a premeasured line attached. The disk is lowered into the water until an observer at the surface can no longer see it. This depth is known as the Secchi disk transparency. As the amount of suspended matter in the water decreases, the deeper you will be able to still see the disk. Shallow Secchi disk readings will occur during times when large amounts of suspended solids are present. Turbidity is measured in Nephelometric Turbidity Units (NTU).

CCMP Objectives

- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection

CCMP Actions- 5.9, 5.10, 5.14-5.19, 6.1, 6.3, 7.1, 7.2, 7.5, 7.7

Monitoring Questions

- Are turbidity levels in the northern estuary increasing with ongoing watershed development?
- Is turbidity increasing estuary-wide?
- What are the turbidity levels above SAV beds?

Specific Measures- Values of suspended solids estuary-wide.

Existing Monitoring Programs (Reference Numbers)**-** 6, 17, 18, 19, 20, 21, 24, 26, 27

Information needs/data gaps- In the future there will be the need for both seasonal and spatial variation of turbidity throughout the estuary.

Bacteria

Overview -- Fecal coliform bacteria are a group of bacteria that are passed through the fecal excrement of humans, livestock and wildlife. A specific subgroup of this collection is the fecal coliform bacteria, the most common member being Eschericia coli. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals. By growing and counting colonies of fecal coliform bacteria from a sample of stream water, we can determine approximately how many bacteria were originally present. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. Fecal coliform bacteria can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from untreated human sewage. Individual home septic tanks can become overloaded during the rainy season and allow untreated human wastes to flow into drainage ditches and nearby waters. Agricultural practices such as allowing animal wastes to wash into nearby streams during the rainy season, spreading manure and fertilizer on fields during rainy periods, and allowing livestock watering in streams can all contribute fecal coliform contamination. At the time this occurs, the source water may be contaminated by pathogens or disease producing bacteria or viruses, which can also exist in fecal material. Some waterborne pathogenic diseases include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. While these bacteria do not directly cause disease, high quantities of fecal coliform bacteria suggest the presence of disease causing agents. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. During high rainfall periods, the sewer can become overloaded and over flow, bypassing treatment. As it discharges to a nearby stream or river, untreated sewage enters the river system. Runoff from roads, parking lots, and yards can carry animal wastes to streams through storm sewers. In the future, State regulations may be shifting emphasis from fecal coliform bacteria to enterococcus, and so the process for evaluating the status of this indicator will also need take this shift into consideration.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Minimize health risks to contact water uses.
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.

CCMP Action Items -- 5.1, 5.2, 5.4, 5.9, 5.10, 5.14, 5.16, 5.17, 5.18, 5.19, 5.25, 7.2, 7.5, 7.10

Monitoring Questions

- Are fecal coliform/enterococcus bacteria levels in the estuary increasing, decreasing or unchanged during the past decade?

- Have drought conditions resulted in reduced inputs of fecal coliform/enterococcus bacteria to the estuary?

Specific Measures – The change in fecal coliform/enterococcus bacteria levels within the estuary over the past ten years. The effect that drought conditions have had in reducing flow inputs to the estuary and how much this has reduced fecal coliform/enterococcus bacteria inputs to the estuary.

Existing Monitoring Programs (Reference Numbers) – 9, 10, 15, 18, 25

Information Needs/Data Gaps – The Coastal Cooperative Water Quality Monitoring Program samples 34 sites in the Barnegat Bay Estuary for the presence of fecal coliform once a week from May through September of each year since 1996. This ongoing collection of fecal coliform data provides a fairly comprehensive overview of fecal coliform concentrations over time. The Regional Environmental Monitoring and Assessment Program developed by EPA will provide fecal coliform data for 80 sites within the estuary. This purpose of this program is to provide a comprehensive comparison of environmental stressors and their effects on the biological communities within the Bay. Even though the data was collected on a one-time basis, it may provide a valuable link between fecal coliform concentrations and effects upon aquatic life in the estuary. The Cooperative Coastal Monitoring Program will most likely switch from the collection of fecal coliform data to collection of enterococcus data in the near future. Again, fecal coliform data in the upper portions of the watershed is severely lacking. Fecal coliform or enterococcus monitoring in the upper portions of the watershed is important in locating the source of these bacteria.

Phytoplankton/Macrophyte Abundance, Chlorophyll a

Overview -- Algae dominate the primary production of most lake ecosystems, occurring as free-floating phytoplankton or attached periphyton. Phytoplankton is the base of most lake food webs, and fish production is linked to phytoplankton primary production. Excessive nutrient and organic inputs from human activities in lakes and their watersheds lead to eutrophication, characterized by increases in phytoplankton biomass, macrophyte biomass, nuisance algae blooms, loss of water clarity, and loss of oxygen from bottom waters. From a human perspective, problems may also include loss of aesthetic appeal, decreases in desirable gamefish, loss of accessibility from increased macrophyte production, and increased cost of treating drinking water.
Measurements of algae include estimation of total biomass with water column chlorophyll a concentration, and identification and counts of individual species within several subgroups, including periphyton (attached forms), periphytic diatoms, phytoplankton (free-living, floating), phytoplankton diatoms, and sediment diatoms.

CCMP Objectives

- Ensure that edible seafood is safe for unrestricted human consumption
- Estimate adverse impacts of eutrophication, including hypoxia, resulting from human activities
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Actions- 5.9-5.11, 5.14, 5.16-5.19, 7.5

Monitoring Questions

- Are phytoplankton abundance, biomass, and productivity increasing, decreasing, or unchanged?
- What is the relative importance of diatoms and dinoflagellates in the estuary?
- Are picoplankton and nannoplankton the numerically dominant elements of the phytoplankton community?

Specific Measures -- Phytoplankton cell counts and biomass values as well as species composition of the community.

Existing Monitoring Programs (Reference numbers)- 6, 17, 18, 26, 27, 28

Information needs/data gaps -- Periodic phytoplankton community surveys, including measures of abundance (cells/ml), biomass (chlorophyll a) and phytoplankton blooms.

Macrophyte abundance

Overview -- The scientific literature is replete with reference to the species-poor condition of benthic macroalgae in estuaries. When observed, seaweeds often cover only a relatively small area of the estuarine bottom, with populations commonly isolated on rocks, bulkheads, piers, and other hard surfaces. Benthic macroalgae usually require attachment to a solid substrate to prevent them from being dislodged and carried away by bottom currents. This attachment is accomplished by adhesive, root-like holdfasts or basal disks that enable the plants to live on hard surfaces. However, many estuaries harbor free-floating macroalgal forms that are part of a "drift" community. These benthic forms typically are observed drifting along the bottom of estuaries, such as in Barnegat Bay and Little Egg Harbor. High turbidity and sedimentation in many estuarine systems limit light penetration, which impacts benthic macroalgal productivity and abundance. The abundance of macroalgae is largely dependent on light intensity, nutrient concentrations, and availability of favorable substrate.

Seagrasses are anchored to the estuarine bottom via a root and rhizome system. The abundance of seagrasses is contingent upon light intensity and attenuation in the water column, turbidity levels, nutrients, and the strength of bottom currents. They are most abundant at water depths of less than a meter. When conditions are favorable, seagrasses often form dense meadows with high levels of production and biomass.

CCMP Objectives

- The natural water cycle will be balanced to: a)protect the quantity and quality of public water supplies; and b) maintain or restore ecological conditions to support living aquatic resources in the estuary and watershed.
- Water quality in the estuary and watershed will support recreational bathing, direct shellfish harvesting, and the integrity of the fresh water and tidal benthic communities.

CCMP Actions-5.9-5.11, 5.14, 5.16-5.19, 7.5

Monitoring Questions

- Are the abundance, biomass (chlorophyll a), and distribution of SAV (eelgrass) increasing, decreasing, or unchanged?
- Are the abundance, biomass (chlorophyll a), and distribution of benthic macroalgae increasing, decreasing, or unchanged?
- Is there an inverse relationship between benthic macroalgal abundance and abundance of eelgrass beds in the estuary?
- If changes in abundance of macrophytes are occurring, are they associated with nutrient flux or a change in habitat?

Specific Measures- Change in species composition, abundance and distribution of macroalgae in Barnegat Bay and Little Egg Harbor.

Existing Monitoring Programs (Reference Numbers)- 17, 18

Information Needs/Data Gaps- There are large information needs on abundance and distribution of macroalgae in the estuary. Data are needed on species composition, distribution, and spatial and temporal variation and abundances of the various populations both in the bays as well as the tributaries. Data should be collected at 5-10 year intervals.

Shellfish and Finfish Abundance

Overview -- The abundance of shellfish and marine finfish within an estuary is an important indicator of habitat integrity. The degradation of suitable habitat will result in lower abundance of these organisms. Periodic inventories of these shellfish and marine finfish would create a time series data set that could be used to track abundance over time. This data could also be evaluated spatially. If a data set indicates a significant drop in abundance for a particular organism, then it could indicate a decline in habitat integrity. Due to lack of funding, only a few shellfish and marine fish surveys have been conducted. The Bureau of Shellfisheries has only conducted a shellfish survey of the entire Barnegat Bay for the period of 1985-1987, and just recently re-sampled Little Egg Harbor in 2001. These are the most recent marine shellfish and finfish inventory surveys that the New Jersey Department of Environmental Protection, Bureau of Marine Fisheries has conducted in Barnegat Bay since the 1970's.

CCMP Objectives

- Estimate adverse impacts of eutrophication, including hypoxia, resulting from human activities
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Actions- 6.2, 6.3, 6.5, 6.7, 6.9, 6.10, 7.5, 7.10

Monitoring Questions

- Is the abundance of blue crabs in the estuary changing?
- Is the population abundance of the dominant finfish species changing?

Specific Measures- Abundance and distribution of finfish and shellfish, as well as surveys of shellfish to assess stocks.

Existing Monitoring Programs (Reference Number)- 17

Information needs/data gaps- Rutgers Marine Field Station has been conducting ongoing studies of various finfish species in Little Egg Harbor and other estuarine waters. The NJDEP (shellfisheries) has recently completed a survey of hard clam abundance and distribution in Little Egg Harbor. Data gaps remain, however, for finfish and shellfish abundance in Barnegat Bay. Except for a recent survey of hard clams in Little Egg Harbor by the shellfish group at Nacote Creek (DEP), the stocks of finfish and shellfish populations in other areas of the system are lacking. Jivoff and Able (2001) provided some information on the species composition of finfish in Little Egg Harbor. However, new (monitoring) surveys are needed as part of the monitoring program for shellfish (hard clams) in Barnegat Bay and Little Egg Harbor as well as essentially all finfish species in the estuary. All of this survey work should be conducted at ~10-year intervals.

Benthic Community Structure

Overview -- The species composition and abundance of benthic invertebrate communities in estuaries vary markedly over time. Consequently, long-term monitoring provides the most insight for assessing the structure and dynamics of these communities. Estuarine benthic communities usually have low species richness, although the density of populations can be very high. The number of species decreases when proceeding from the lower reaches into brackish-water areas. The biomass and productivity of the benthos also vary widely in estuarine systems. Local distribution patterns of benthic organisms within estuarine habitats have been related to physical factors, notably waves and currents, sediment characteristics, and depth. Biotic factors (e.g., predation and competition) and chemical factors (e.g., dissolved oxygen and salinity) clearly influence the distribution of benthic fauna. In addition, the spatial distribution of benthic fauna is a function of larval dispersal and recruitment success. The species composition of the fauna within habitats is strongly dependent on sediment type. The concentration of organic matter in bottom sediments is important in regulating benthic community structure as well. The abundance of such forms as the lugworm (Arenicola marina), mud snail (Hydrobia ulvae), and bivalve (Macoma balthica) has been coupled to the amount of organic matter in the bottom sediments. Aside from physical disturbances caused by wave and current action, sediment deposition and erosion, as well as other factors, biological disturbances due to grazing, predation, and competition control the vertical distribution of infauna within the bottom sediments and likewise play a significant role in regulating the dynamics of epifauna. Disturbances are important factors in generating the patchy spatial distribution patterns observed in benthic communities within estuaries.

CCMP Objectives

- Estimate adverse impacts of eutrophication, including hypoxia, resulting from human activities
- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest

CCMP Actions- 6.2, 6.3, 6.5, 6.7, 6.9, 6.10, 7.5

Monitoring Questions

- Is the species composition, abundance and distribution of benthic flora and fauna changing?
- Is diversity of benthic organisms changing in the estuary?

Specific measures- Specific composition, abundance of populations, diversity and distribution.

Existing Monitoring Programs (Reference Numbers)- 17, 18, 19, 20, 51

Information needs/data gaps- Comprehensive data has been collected from about 1968 to 1972. The data is sparse from 1972 to present. In the future, detailed benthic community surveys will be required.

Toxic Contaminants in Aquatic Biota and Sediments

Overview -- Stream bed and estuarine bottom sediments can be a source or sink of toxic chemicals such as trace elements and chlorinated organic chemicals depending on the physiochemical conditions in the water column and bottom sediments. Many trace elements in aquatic systems are strongly associated with iron and manganese oxide coatings on sediments. Chlorinated organic chemicals are extremely hydrophobic and therefore tend to sorb to organic matter, which is either dissolved in the water or associated with suspended and bottom sediments. As a result, sediments can provide a mechanism for these toxic chemicals to remain in surface water systems for many years after their input. When bed sediments are disturbed and transported downstream, re-equilibration with surrounding waters may release the chemicals to the water column.

Suspended sediment can be a transport mechanism for nutrients, organic chemicals, and metals to the estuary. Some hydrophobic organic chemicals and charged inorganic species such as phosphates, ammonium and organic nitrogen, as well as metals become associated with particle surfaces and are mobilized in the stream. Data on suspended sediment (quantity and quality) in streams of the bay watershed are limited.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Ensure that edible seafood is safe for unrestricted human consumption
- Provide a sustainable water supply to the human population without adversely impacting natural water regimes
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.
-

CCMP Actions- 5.1, 5.4, 5.9, 5.11, 5.12, 5.14, 5.19, 6.6, 7.5

Monitoring Questions

- What are the concentrations of chemical contaminants (Heavy metals, PAHs and halogenated hydrocarbon) in bottom sediments and biota?

- Are the concentrations of contaminants in bottom sediments and biota increasing, decreasing, or unchanging?

Specific Measures -- Changes in the concentration of heavy metals, PAHs and halogenated hydrocarbons in bottom sediments and target organisms (i.e. flatfish, demersal fish and finfish).

Existing Monitoring Programs (Reference Numbers)- 16, 17, 18, 53

Information needs/data gaps -- Currently there is little available data. Information needs to be gathered on the bioavailiabity of chemical contaminants and on the concentration of contaminants in bottom sediments, benthic organisms, and the water column. Some data on concentrations of contaminants is being collected by the EPA program, Coastal 2000/National Assessment.

Floatables

Overview - Floatables are trash and debris items that are washed into the bay, estuary and ocean waters and are often deposited on beaches and marsh islands or can sometimes be seen floating in the water column. Generally, these items are deposited into the bay, estuary and ocean through stormwater infrastructure during rainfall events. In some cases, these items can be deposited by illegal dumping activities or careless recreational uses whereby people do not properly dispose of trash items. Some floatables, such as large tree limbs, are natural in origin; however, these items still present an unsightly safety hazard if not removed from recreational beaches.

Generally, the presence of floatables indicates a lack of public awareness of the importance of properly disposing of trash items. In many instances, people do not understand that stormwater structures generally drain to nearby streams, which drain to nearby rivers and ultimately drain to the bay and ocean. When trash is disposed of improperly, it is washed into storm drains and into the bays and ocean. The increased presence of floatables may also indicate an abundance of rainfall events or illegal dumping activities.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse impacts due to pollution.
- Empower citizens in the protection of Barnegat Bay and its watershed.
- Maintain on a landscape level the natural environment of the watershed.

CCMP Action Items -- 7.2, 7.5

Monitoring Question

- What are the types of floatables found in the estuary?
- Are floatables increasing, decreasing, or unchanged in the system?

Specific Measures – The type of floatable debris items found in the estuary. The change in the number of debris items found within the estuary.

Existing Monitoring Programs (Reference Numbers) – 54, 55, 61

Information Needs/Data Gaps – The Adopt-A-Beach program collects data on floatable debris collected from beaches along Barnegat Bay and maintains a database identifying the type and number of items collected from each cleanup. The Clean Shores program also maintains a database of pounds of heavy debris collected from each beach cleaned. Data on floatable debris for the Barnegat Bay beaches along the oceanside barrier island is fairly comprehensive; however, data within the estuary portions of the Bay is lacking.

Shoreline Habitat/Sensitive Areas

Overview - Some of the more notable sensitive habitat areas in the Barnegat Bay system include shoreline habitats and bay island nesting areas. The status of these two categories of lands should be monitored and serve as a secondary indicator of environmental quality.

Large portions of the Barnegat Bay shoreline and adjacent shallow water habitats have been altered by bulkheading and near-shore development. The impact of bulkheading on estuarine ecological communities has not been thoroughly investigated; however, there are some obvious effects. Bulkheading deepens water depths, thereby reducing the areal extent of shallow water near-shore habitats such as intertidal flats and associated submerged aquatic vegetation beds, which are important habitats for a variety of fishes and estuarine invertebrates (Able et al., 1996). Bulkheading eliminates shoreline beach habitat important for shorebirds and terrapin turtles. In addition, the wooden timbers used in bulkheading is generally treated with toxic materials that may have negative impacts on the estuarine biota (Weis and Weis, 1996). Bulkheading is usually associated with marsh infilling/lagoonal development and other types of near-shore development as bulkheading of the shoreline helps stabilize the fill and provide mooring facilities for watercraft.

Near-shore development (with or without bulkheading) impacts habitat value of the bay/upland ecotone by directly displacing native plant vegetation communities that may serve as feeding, nesting and migrating habitat, as well as indirectly impacting the habitat value of adjacent shallow water, shore or salt marsh communities by increasing human/pet-wildlife encounters leading to a chronic disruption of feeding, resting or nesting activity. Human development and its associated impervious surfaces and horticultural practices directly upland of the bay also tend to exacerbate runoff, sedimentation and nonpoint source pollution. With over 70% of Barnegat Bay shoreline already developed, the remaining undeveloped shoreline areas are especially valuable as open space. These undeveloped shorelines serve to buffer the bay from upland development as well as serve as valuable wildlife habitat.

A number of Barnegat Bay islands serve as nesting places for a variety of shorebirds and colonial nesting birds. Colonial nesting birds such as common terns (Sterna hirundo), black skimmers (Rhynchops niger) and Forster's terns (Sterna forsteri) normally build their nest on the ground. These colonial nesting birds nest almost exclusively salt marsh or dredge spoil islands to minimize disturbance by mammalian predators (Burger, 1997). As part of BBEP Characterization, sixty one Barnegat Bay islands were ranked as to their importance as nesting habitat for common terns (Sterna hirundo), black skimmers (Rhynchops niger) and Forster's terns (Sterna forsteri) based on Dr. Joanna Burger's over 20 year record (from the mid-1970's to the present) of personal observations (Burger, personal communication). Additionally, a subset of Barnegat Bay islands used as nesting sites for wading birds (herons, egrets and ibises) was listed by Burger (1997). The nesting success of these islands is a function of in situ factors of nesting substrate quality

and human disturbance, as well as external factors such as weather disturbance, pollution, food availability, etc.

CCMP Objectives

- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.

- Maintain on a landscape level the natural environment of the watershed.

CCMP Actions- 6.1- 6.10, 7.5

Monitoring Questions

- Is physical alteration/habitat loss of shoreline habitat increasing, decreasing, or unchanged?

Specific Measures- Changes in the actual extent of coverage for the above mentioned shoreline alteration/sensitive habitat indicators: Alteration of shoreline buffer zone, Bulkheaded / rip-rapped shoreline, Alteration of bay island habitat

Existing Monitoring Programs (Reference Numbers)- 30, 44, 51

Information needs/data gaps- Data on the alteration of the immediate shoreline buffer zone may be derived from a GIS analysis of standard land use/land cover data collected as part of the BBEP Land Use/Land Cover monitoring program (see above).

Data on bulkheading and riprapping will require specific aerial photographic interpretation to update existing GIS coverages of bulkheading. The original data was extracted from USGS topographic quadrangles and digital hydrological coverages. It is unclear whether the USGS will be doing photo-interpreted updates of this data as a standard practice. Additional information on bulkheading/riprapping may be acquired from NJDEP and the Office of Planning for Ocean County as it relates to dock/pier or other shoreline alteration permits.

Data on the status of the bay nesting islands will require specific aerial photographic interpretation to document habitat changes due to rising sea levels, storm disturbance/flooding, vegetation succession, dredge spoil dumping, or other alterations. This remote sensing monitoring will need be supplemented with field surveys to document other possible disturbances or alteration to the nesting habitat.

At present, there is no entity identified that monitors these above indicators on a routine basis as part of any ongoing monitoring program.

Boating Use

Overview -- Boating, fishing, waterborne recreation, ecotourism and the local businesses that support these activities in the Barnegat Bay Estuary Program Region significantly contribute to the local economy and quality of life. Boating provides residents and visitors alike with countless hours of recreational activities and enjoyment. Boating activities include fishing, water skiing, the use of personal watercrafts, sailing, hunting, shell fishing, nature observancy and cruising. Marinas, Yacht Clubs and private slips are located throughout the Barnegat Bay-Little Egg Harbor region along the East and West sides of Barnegat Bay, Manahawkin Bay, Little Egg Harbor, as well as along all of the major navigable tributaries. Recreational boating activities within the BBEP Region have grown tremendously in the past decade.

According to the National Marine Manufacturers Association (NMMA), recreational boating in New Jersey has shown a continued increase in the last decade. NMMA reports that from 1995 (183,569 registered vessels) to 2000 (243,281 registered vessels) there has been a 32% rise in the number of vessels registered. New Jersey is ranked 20th in the nation based on the number of vessels registered in the State. The Barnegat Bay Estuary Program Region is home to a significant portion of these registered boaters. In addition, every year a large number of vessels transit to the area for recreation or through the area in their travels. It was reported by NJDEP that in 1980- that Ocean County alone accounted for approx. 37% of the total boating activity statewide, with nearly 80% of this activity in Barnegat Bay or rivers within the county.

As boating related activities continue to grow, there is an increasing need to protect and enhance the waters of the Barnegat Bay Estuary Program Region. In an effort to fully understand the use of the area, the number and size of vessels needs to be captured and monitored each year. Data also needs to be collected from boating access and service providers to the Region to ensure that boating facilities are adequate and can provide the necessary resources to its users. This type of information will be useful to both managers and the boating community to identify areas where improvements are needed or areas of potential growth. In addition, extensive education and outreach activities are necessary to promote clean boating practices and provide boaters and business owners with the information and resources they need to minimize pollution.

CCMP Objectives

- Establish a workable agreement to restrict uses of power watercraft in sensitive, shallow, near-shore waters. Encourage local initiatives to zone and enforce uses and misuses of power watercraft.
- Support water-related recreation while preserving the economic viability of commercial endeavors.
- Empower citizens in the protection of Barnegat Bay and its watershed.

CCMP Action Items -- 7.1, 7.2, 7.5

Monitoring Questions

- Is boating activity increasing in the estuary? Where is most boat use observed?
- Are there any indicators of boating impacts (e.g., SAV scarring) in shallow water habitats?

Specific Measures – The change in level of boating activity within the estuary; the locations of the highest levels of boating activity; indications that boating activities are adversely impacting shallow water habitats.

Existing Monitoring Programs (Reference Number) – 59

Information Needs/Data Gaps – There are currently no programs actively monitoring boat use within the estuary, aside from municipal and county boat registry information and entities with a business interest who may monitor certain aspects of boat use for business purposes. The Ocean County Planning Department conducted a one-time boat count survey in 2001; however, this was part of an application to designate Barnegat Bay as a no-discharge zone and there are no plans to repeat such a survey at this time. No programs are studying the links between boat use and shallow water habitat destruction or the links between boat use and waterfowl/aquatic life within the estuary.

Atmospheric and other pollutant inputs

Overview – Air deposition of pollutants such as organic pesticides, PCB's, trace metals and byproducts of combustion processes in industry represent potential sources of air toxics to the Barnegat Bay Estuary system. Some of these chemicals become biologically available for organism uptake and bioaccumulate within the food chain. Bioaccumulation of these chemicals may cause problems for the aquatic organisms and may cause human health problems as well. Bioaccumulation of methylmercury within fish has led to advisories limiting or suggesting cessation of the consumption of certain species of fish depending upon where in New Jersey the fish was harvested. Toxic contamination of shellfish beds in New Jersey has led to a large number of closures of these beds.

Air deposition of nitrogen and phosphorous may contribute to eutrophication within the Barnegat Bay. Although sulfur has been studied for years because of its contribution to acid rain; air deposition of nitrogen and phosphorous has not been extensively studied. The role that air deposition of nitrogen and phosphorous plays in eutrophication within the Bay is not yet well understood, but it is currently being researched in New Jersey.

The New Jersey Atmospheric Deposition Network (NJADN) is a cooperative research and monitoring project being undertaken by the NJDEP and Rutgers University that is now in the fourth year-stage of monitoring and analysis. The objectives of the program are to quantify concentrations of atmospheric toxic chemicals and the quantity being deposited to aquatic and terrestrial systems in conjunction with assessment of seasonal and spatial trends. The identification of sources of atmospheric pollutants as well as identification of the potential impacts to ecosystems and human health from these atmospheric pollutants are also major goals of this collaborative project. The New Jersey Atmospheric Deposition Program (NJADP) is currently collecting air concentration and deposition data regarding 116 organic compounds (PAH's, PCB's and organo-chlorine pesticides), trace metals (Ag, Al, As, Cd, Co, Cr, Cu Fe, Mg, Mn, Ni, Pd, Pb, Sb, V, Zn), mercury, sulfate, phosphate and nutrient nitrogen (NO3-, NO2-). There are nine monitoring stations in New Jersey and the closest stations to the Barnegat Bay are located in Tuckerton to the south, the Pinelands to the west and Sandy Hook to the north.

The research currently being conducted by the New Jersey Atmospheric Deposition Program (NJADP) closely parallels the objectives of the CCMP. Preliminary analyses of the data collected indicates that air deposition of nitrogen into aquatic ecosystems may be more significant than previously thought, and it appears that the source may be regional (i.e. multi-state) rather than localized. Phosphorous inputs to the estuary via air deposition appear to be relatively insignificant in terms of volume; however, further research needs to be conducted on the air-form of phosphorous because it may be more biologically available for organism uptake and subsequent bioaccumulation. Similar to nitrogen, sources of phosphorous appear to be regional rather than from local sources. Concentration of trace metals tended to vary more between sites in New Jersey, indicating that localized sources play a greater role in deposition of metals. Deposition of metals to terrestrial and aquatic ecosystems appears to be greater during rainfall events.

CCMP Objectives

- Restore and maintain a productive ecosystem with no adverse effects due to pollution.
- Ensure that edible seafood is safe for unrestricted human consumption.
- Manage recreationally and commercially important fish and shellfish species for sustainable and safe harvest.

CCMP Action Items -- 5.1, 5.2, 5.15, 5.16, 7.5

Monitoring Questions

- What are the specific pollutant sources in the estuary and watershed?
- How much nitrogen enters the estuary via atmospheric deposition though time?
- What is the relative importance of surface runoff vs. atmospheric deposition for major pollutant groups?

Specific Measures – Identify the specific pollutant sources within the estuary and watershed. Quantify the level of nitrogen entering the estuary through atmospheric deposition over time. Determine if surface runoff or atmospheric deposition is the major contributor within the estuary for each group of relevant pollutants.

Existing Monitoring Programs (Reference Number) –10, 16, 17, 18, 29, 37, 50, 60

Information Needs/Data Gaps – The research currently being conducted by the New Jersey Atmospheric Deposition Program (NJADP) closely parallels the objectives of the CCMP. This NJADP project will provide a significant source of data regarding air deposition of nutrients as well as toxics within the Barnegat Bay region. The Ambient Groundwater Quality Network is collecting data on pesticides and volatile organic compounds in shallow groundwater at four sites within the estuary. Some specific chemical contaminant studies have been undertaken within the Bay including trace metals, PCB's, PAH's, and radiological monitoring surveys in specific locations within the Bay as well as freshwater tributaries to the Bay and these results are available through the Institute of Marine and Coastal Sciences. As part of the National Coastal Assessment being coordinated by EPA, fish tissue chemical analyses and fish external pathology studies are being conducted and this may help link pollutant inputs to adverse impacts to fish communities within the Bay. As part of the EPA REMAP program, statistical associations between sediment contaminants and degraded benthic communities are being evaluated. In addition, NJDEP is developing a Fish Index of Biotic Integrity, a hard clam stock assessment and is continuing to investigate the sources of contamination that are causing shellfish bed closures along the New Jersey coast. These studies may link suspected atmospheric pollutant inputs (i.e. mercury) with fish/shellfish contamination.

Rare Plant and Animal Populations

Overview -- The presence or absence of rare plant and animal populations may indicate the quality of habitat present for these particular species. In general, plant and animal populations that are classified as rare, have been classified as such due to decreased numbers of these species being present as documented over time. In many instances, the decrease in population can be attributed to a decrease in habitat. Decreases in habitat are often caused by some type of disturbance, most often as a natural area is altered through development. In general, rare populations of plants and animals depend upon what would be classified as "high" quality habitat; habitat that has been relatively undisturbed by anthropogenic activities and has high water quality, particularly for water-dependent species. Generally, the presence of rare plant and animal species would indicate high water quality conditions. The increase of these rare populations would serve to indicate that habitat and water quality conditions are improving within the bay and estuary.

CCMP Objectives

- Protect existing habitat categories within the Barnegat Bay watershed to preserve and improve native wildlife populations and regional biodiversity.
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.
- Restore and maintain a productive ecosystem with no adverse effects due to pollution.

CCMP Action Items – 6.1-6.12, 7.5

Monitoring Questions

- What are the rare, endangered, and threatened plant and animal species that inhabit Barnegat Bay, Little Egg Harbor, and the watershed?
- What are the habitats occupied by these populations?
- Are the population numbers increasing, decreasing, or unchanged?

Specific Measures – Determine the rare, endangered and threatened species that inhabit the entire watershed as well as the estuary. Determine the habitats that each of these species requires. Determine if the population numbers of each of these species is changing over time.

Existing Monitoring Programs (Reference Numbers) – 16, 17, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 58

Information Needs/Data Gaps – Monitoring of rare, threatened and endangered species within the estuary is fairly comprehensive as evidenced by the number of programs of the US Fish and Wildlife as well as those of NJDEP Fish and Wildlife/Endangered and

Nongame Species Program (ENSP) that are collecting data within the region. The majority of these programs are relatively new, so a historical baseline does not exist in may cases; however, data on Osprey, Pergrine Falcon, Piping Plover, Least Tern and Black Skimmer avian species has been collected since the late 70's – early 80's and is fairly comprehensive. Migratory shorebird Monitoring, Saltmarsh Nesting Songbirds and Diamondbacked Terrapin studies are recommended by the NJDEP ENSP but are not yet underway. The NJDEP Landscape Project has mapped habitat areas for rare, threatened and endangered species in New Jersey and this information is available in GIS format.

Streamflow

Overview -- The streamflow, or discharge, is the volume of water passing a single point in the stream over time. It is measured by determining the cross-sectional area and velocity (speed and direction) of the flowing water. The measurement is usually expressed in cubic feet per second (cfs). Streamflow is the primary means by which freshwater is delivered to the estuary.

CCMP Objectives

- Provide a sustainable water supply to the human population without adversely impacting natural water regimes.
- Maintain on a landscape level the natural environment of the watershed.

CCMP Action Items -- 5.3, 5.14, 5.15, 5.20- 5.24, 7.5, 7.6, 7.8, 7.9

Monitoring Question

- Is stream flow in the watershed declining due to less precipitation and more frequent drought conditions?
- Are the inputs of coliform bacteria, nutrients, and other pollutants decreasing in the estuary due to reduced stream inflow?

Specific Measures – Determine if stream flow is decreasing due to more frequent drought conditions and less precipitation. Determine if coliform bacteria, nutrients and pollutants are decreasing as a result of reduced stream flows.

Existing Monitoring Programs (Reference Numbers) – 2, 3, 5, 12, 15

Information Needs/Data Gaps – The four joint programs between USGS and the NJDEP that collect streamflow data within the watershed collect data at a total of 27 sites throughout the watershed. In addition, some site-specific data regarding streamflow may be located in the USGS NWIS historical database. In general, this data should give an overview of streamflow trends over time throughout various points within the watershed; however, each of these programs collects only streamflow data, which is not sufficient to determine if bacteria, nutrients and other pollutants are changing in relation to changing streamflows.

Water Allocation

Overview -- The water allocation program regulates all ground and surface water diversions in New Jersey that are in excess of 100,000 gallons of water per day. This includes water diverted for public water supply, industrial processing and cooling, irrigation, sand and gravel operations, remediation, and power generation. The regulation could take the form of a permit, certification, registration, or permit-by-rule. Implementing regulations are N.J.A.C. 7:19-1 et seq: Water Supply Allocation Rules and N.J.A.C. 7:20A-1 et seq. Agricultural, Aquacultural or Horticultural Water Usage Certification Rule.

The Program maintains a data base system that includes a listing of diversion sources, including their capacities, locations, water source, use of supply, and unique permit identification numbers for each regulatory diversion category. Water quality data (raw water chloride and sodium content) is periodically required of some permitees and reports on the status of the major reservoir levels are compiled and maintained.

CCMP Objectives

- Provide a sustainable waters supply to the human population without adversely impacting natural water regimes.
- Maintain on a landscape level the natural environment of the watershed.
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.

CCMP Action Items -- 5.3, 5.8, 5.13, 5.20, 5.21, 5.22, 5.23, 6.9, 6.11, 7.8

Monitoring Questions

- How much water is allocated in the watershed and how much is used?
- How much have water allocations and use increased?

Specific Measures -- Determine how much water allocation exists within the watershed and determine how much is currently being used. Determine the increase in water allocation and use over time.

Existing Monitoring Programs (Reference Numbers) – 7, 8, 14, 15, 56

Information Needs/Data Gaps – Essentially, the NJDEP Water Allocation program adequately monitors and controls use of groundwater and freshwater within New Jersey.

Saltwater Intrusion

Overview -- The fresh ground-water resource utilized for human use in the Barnegat Bay watershed area is in contact laterally and vertically with saline water. Freshwater is less dense than saline water and tends to flow on top of the surrounding or underlying saline water. Under natural conditions, the boundary between freshwater and saltwater maintains a stable equilibrium. When water is pumped from an aquifer that contains or is near saline water, the saltwater/freshwater boundary will move in response to this pumping. If the boundary moves far enough, some wells become saline, thus contaminating the water supply. The diversion of water from a replacement source of fresh water may divert some of the input of freshwater to the bay. Therefore, monitoring chloride concentrations in confined aquifers used for water supply serves as a means to evaluate the sustainability of the confined aquifer resource and, conversely, the potential necessity of alternative, depletive uses of surficial aquifers and fresh surface water that sustain the freshwater inputs to the estuary.

CCMP Objectives

- Provide a sustainable water supply to the human population without adversely impacting natural water regimes.
- Encourage sustainable methods of living within the watershed, whereby human uses are balanced with ecosystem protection.

CCMP Action Items -- 5.3, 5.8, 5.13, 5.20- 5.23, 6.9, 6.11, 7.5, 7.8

Monitoring Questions

- Is saltwater intrusion into area aquifers increasing or unchanged?
- Are saltwater intrusion problems arising in specific areas of the watershed where groundwater use is excessive?

Specific Measures – Determine if saltwater intrusion in area aquifers is increasing. Determine if saltwater intrusion into area aquifers is occurring in areas where groundwater use may be considered excessive.

Existing Monitoring Programs (Reference Numbers) – 8, 15, 56

Information Needs/Data Gaps – The NJDEP Water Allocation program is monitoring groundwater withdrawals to prevent further saltwater intrusion into groundwater aquifers.

Turf Grass

Overview -- Turf grass is the largest single crop in the estuary. It serves to stabilize soil around homes, parks, athletic fields, cemeteries, and golf courses. When properly managed and in combination with practicing soil health, turf grass can enhance environmental quality by reducing runoff, and promoting infiltration. Turf grass areas have recreational, aesthetic and economic values to local watershed communities.

Maintaining green healthy turf grass requires knowledge and skill. During the growing season turf grass places demands on water supplies to irrigate increasing acreage. Turf grass irrigation can exacerbate water supply problems and lawn wastes are a major contributor to an increasingly severe solid waste problem in the watershed.

GIS maps could provide baseline information on the spatial distribution of turf grass. Monitoring should include mapping efforts to chart changes in growth of turf grass under categories that include cemeteries, golf courses, athletic fields, parks, and lawns. Further assessment of irrigation systems is needed to verify usage under various categories.

CCMP Actions - 5.5, 5.6, 5.21, 5.23,7.5, 7.6, 7.9

Monitoring Questions

- What is the extent of turf grass use in the watershed under various categories?
- Is turf grass use increasing, decreasing, or unchanged
- What is the relationship to water withdrawals in areas of heavy turf grass use?
- What is the relationship between turf grass use and runoff, irrigation usage, nutrient loading, and number of wells in the watershed?

Specific Measures -- Acreage of turf grass in the watershed; Groundwater use in relation to areas with heavy turf grass use; the relation between turf grass use and runoff in the watershed

Existing Monitoring Programs (Reference Numbers) - 30, 58

Information needs/data gaps- Application of remote sensing to monitor changes in turf grass areas by various categories. Remote sensing mapping efforts need to be supplemented by in situ sampling of soil below turf grass to monitor soil health conditions for infiltration, soil ph, nutrient levels and soil bulk density.

It would be beneficial to conduct an assessment of irrigation systems and sources to verify sources where water is withdrawn; to estimate water usage by source and turf grass category; and explore re-use of treated wastewater for irrigation purposes.

Table 3. Primary Indicators, related environmental monitoring programs (EMPs), and CCMP Actions.

Indicator	Monitoring Programs Collecting Relevant Data	EMP Index Refer-ence #	Correspondence with CCMP Action Items
1. Submerged Aquatic Vegetation Distribution	• Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University) • Submerged Aquatic Vegetation (SAV) Mapping of New Jersey's Coastal Bays (CRSSA – Rutgers) • Hard Clam Stock Assessment of Barnegat Bay (NJDEP – Div. of Fish and Wildlife- Bureau of Shellfisheries) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean)	• 51 • 52 • 37 • 26	6.2, 6.6, 6.8, 7.1, 7.2, 7.5
2. Land Use/Land Cover Change	• New Jersey Landscape Change Analysis (CRSSA – Rutgers) • Landscape Project (NJDEP)	• 30 • 58	6.1-6.5, 6.7-6.10 7.5
3. Signature Species			
a. Hard Clam	• Hard Clam Stock Assessment of Barnegat Bay (NJDEP – Div. of Fish and Wildlife- Bureau of Shellfisheries)	• 37	7.5, 7.10
b. Colonial Nesting Waterbirds	• Chemical Contaminant Studies in the Barnegat Bay – Little Egg Harbor Estuary (Rutgers – Institute of Marine and Coastal Sciences) • Piping Plover Monitoring (USFWS) • Black Skimmer/Least Tern Monitoring (USFWS) • Osprey Population Monitoring (NJDEP – ENSP) • Peregrine Falcon Monitoring (NJDEP – ENSP) • Migratory Shorebird Monitoring (NJDEP – ENSP) • Colonial Waterbird Surveys (NJDEP – ENSP) • Beach Nesting Bird Monitoring: Piping Plover (NJDEP – ENSP) • Beach Nesting Bird Monitoring: Least Tern And Black Skimmers (NJDEP – ENSP)	• 16 • 31 • 32 • 38 • 39 • 40 • 41 • 42 • 43	6.5-6.9, 7.1, 7.2, 7.5
c. Osprey Monitoring	• Osprey Population Monitoring (NJDEP)	• 38	6.5-6.9, 7.5
d. Breeding Birds	• Songbird Point Count Survey (USFWS) • Piping Plover Monitoring (USFWS) • Black Skimmer/Least Tern Monitoring (USFWS) • North American Breeding Bird Survey (NJDEP) • Peregrine Falcon Monitoring (NJDEP – ENSP) • Osprey Population Monitoring (NJDEP – ENSP) • Colonial Waterbird Surveys (NJDEP – ENSP) • Beach Nesting Bird Monitoring: Piping Plover (NJDEP – ENSP) • Beach Nesting Bird Monitoring: Least Tern And Black Skimmers (NJDEP – ENSP) • Chemical Contaminant Studies in the Barnegat Bay – Little Egg Harbor Estuary (Rutgers – Institute of Marine and Coastal Sciences)	• 33 • 31 • 32 • 47 • 39 • 38 • 41 • 42 • 43 • 16	6.5-6.9 7.1, 7.2, 7.5

4. Watershed Integrity Measures	• Brown Tide Assessment Project (NJDEP/DRST) • Brown Tide Monitoring (NJMSC) • Real-Time Brown Tide Water Quality Monitoring Program (USGS) • Chloride Monitoring Network (USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Chemical Contaminant Studies in the Barnegat Bay – Little Egg Harbor Estuary (Rutgers – Institute of Marine and Coastal Sciences) • Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Water Quality Monitoring in the Jacques Cousteau National Estaurine Research Reserve System (JCNERR and Rutgers University) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean) • Ambient Stream Monitoring Network (AMNET – NJDEP and USGS) • Existing Water Quality Monitoring Network (NJDEP and USGS) • Piping Plover Monitoring (USFWS) • Black Skimmer/Least Tern Monitoring (USFWS) • Songbird Point Count Survey (USFWS) • Anuran Call/Count Survey (USFWS) • Seabeach Amaranth Population Monitoring (USFWS) • Swamp Pink, Bog Asphodel And Curly-Grass Fern Population Monitoring (Associates for Conservation and Environmental Studies and USFWS) • Hard Clam Stock Assessment of Barnegat Bay (NJDEP – Div. of Fish and Wildlife- Bureau of Shellfisheries) • Osprey Population Monitoring (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Peregrine Falcon Monitoring (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Migratory Shorebird Monitoring (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Colonial Waterbird Surveys (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Beach Nesting Bird Monitoring: Piping Plover (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Beach Nesting Bird Monitoring: Least Tern And Black Skimmers (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Monitoring Trend In Neotropical Migrant Land Bird Populations And Their Habitats (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Herp Atlas Project (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Calling Amphibian Monitoring Program (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • North American Breeding Bird Survey (USGS NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Saltmarsh Nesting Songbirds (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Diamonbacked Terrapin Population Monitoring • Freshwater Mussels (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University) • New Jersey Landscape Change Analysis (CRSSA – Rutgers)	• 27 • 28 • 6 • 14 • 15 • 16 • 17 • 18 • 19 • 20 • 21 • 26 • 9 • 12 • 31 • 32 • 33 • 34 • 35 • 36 • 37 • 38 • 39 • 40 • 41 • 42 • 43 • 44 • 45 • 46 • 47 • 48 • 49 • 50 • 51 • 30	5.1-5.14, 7.5

5. Shellfish Beds	• Marine Monitoring Network – (NJDEP - Bureau of Shellfisheries) • Hard Clam Stock Assessment of Barnegat Bay (NJDEP – Div. of Fish and Wildlife- Bureau of Shellfisheries)	• 13 • 37	5.1-5.10, 5.13, 5.14, 5.16-5.19,5.25, 7.5
6. Bathing Beaches	• Adopt-A-Beach (NJDEP) • Clean Shores (NJDEP) • Cooperative Coastal Monitoring Program (CCMP) (NJDEP and OCHD)	• 54 • 55 • 25	5.1-5.4, 5.6, 5.7-5.10, 5.13-5.19,5.25 7.5
7. Water Supply Wells/Drinking Water	• Water Allocation (NJDEP) • Ground Water Levels Network (USGS) • Synoptic Ground Water Level Network (USGS) • Historical Water Quality Data in USGS NWIS Database (USGS)	• 56 • 7 • 8 • 15	5.20-5.22,5.24 7.5
8. Harmful Algal Blooms	• Coastal 2000 – National Coastal Assessment (NJMSC) • Brown Tide Monitoring (NJMSC) • Real-Time Brown Tide Water Quality Monitoring Program (USGS) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean) • Brown Tide Assessment Project (NJDEP/DRST)	• 17 • 28 • 6 • 18 • 26 • 27	5.1-5.14, 5.16-5.19, 5.25 7.5
9. Freshwater Inputs	• Water Allocation (NJDEP) • Surface Water – Streamflow Network (USGS) • Low Flow Network (USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Hydrographic Study of Barnegat Bay (IMCS and Dept. of Civil and Environmental Engineering - Rutgers)	• 56 • 2 • 5 • 15 • 22	5.3-5.5, 5.13, 5.15, 5.20-5.24, 7.5

Table 4. Secondary Indicators, related environmental monitoring programs (EMPs), and CCMP Actions.

Indicator	Monitoring Programs Collecting Relevant Data	EMP Index Refer-ence #	Correspondence with CCMP Action Items
1. Temperature	• Real-Time Brown Tide Water Quality Monitoring Program (USGS) • Brown Tide Monitoring (NJMSC) • Brown Tide Assessment Project (NJDEP/DRST) • Chloride Monitoring Network (USGS) • Coastal 2000 – National Coastal Assessment (NJMSC) • Ambient Stream Monitoring Network (USGS & NJDEP) • Ambient Ground Water Qulaity Network (NJDEP & USGS) • Existing Water Quality Network (NJDEP &USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Water Quality Monitoring in the Jacques Cousteau National Estaurine Research Reserve System (JCNERR and Rutgers University) • Hydrographic Study of Barnegat Bay (IMCS and Dept. of Civil and Environmental Engineering - Rutgers) • Nitrogen Flux through Barnegat Inlet (IMCS and Dept. of Civil and Environmental Engineering - Rutgers) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University)	• 6 • 28 • 27 • 14 • 17 • 9 • 10 • 12 • 15 • 18 • 19 • 20 • 21 • 22 • 23 • 26 • 51	5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7
2. Salinity	• Chloride Monitoring Network (USGS) • Existing Water Quality Network (NJDEP &USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Coastal 2000 – National Coastal Assessment (NJMSC) • Brown Tide Monitoring (NJMSC) • Brown Tide Assessment Project (NJDEP/DRST) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Water Quality Monitoring in the Jacques Cousteau National Estaurine Research Reserve System (JCNERR and Rutgers University) • Hydrographic Study of Barnegat Bay (IMCS and Dept. of Civil and Environmental Engineering - Rutgers) • Nitrogen Flux through Barnegat Inlet (IMCS and Dept. of Civil and Environmental Engineering - Rutgers) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University)	• 14 • 12 • 15 • 17 • 28 • 27 • 18 • 19 • 20 • 21 • 22 • 23 • 26 • 51	5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7

3. pH	• Chloride Monitoring Network (USGS) • Ambient Stream Monitoring Network (USGS & NJDEP) • Ambient Ground Water Quality Network (NJDEP & USGS) • Existing Water Quality Network (NJDEP &USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Brown Tide Monitoring (NJMSC) • Coastal 2000 – National Coastal Assessment (NJMSC) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Water Quality Monitoring in the Jacques Cousteau National Estaurine Research Reserve System (JCNERR and Rutgers University) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean)	• 14 • 9 • 10 • 12 • 15 • 28 • 17 • 19 • 20 • 21 • 26	5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7
4. Dissolved Oxygen	• Real-Time Brown Tide Water Quality Monitoring Program (USGS) • Brown Tide Assessment Project (NJDEP/DRST) • Ambient Stream Monitoring Network (USGS & NJDEP) • Ambient Ground Water Qulaity Network (NJDEP & USGS) • Existing Water Quality Network (NJDEP &USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Brown Tide Monitoring (NJMSC) • Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Water Quality Monitoring in the Jacques Cousteau National Estaurine Research Reserve System (JCNERR and Rutgers University) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University)	• 6 • 27 • 9 • 10 • 12 • 15 • 28 • 17 • 18 • 19 • 20 • 21 • 26 • 51	5.9, 5.10, 5.14-5.19, 7.2, 7.5, 7.7
5. Nutrients	• Ambient Stream Monitoring Network (USGS & NJDEP) • Ambient Ground Water Quality Network (NJDEP & USGS) • Existing Water Quality Network (NJDEP &USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Coastal 2000 – National Coastal Assessment (NJMSC) • Brown Tide Monitoring (NJMSC) • Brown Tide Assessment Project (NJDEP/DRST) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Nitrogen Flux through Barnegat Inlet (IMCS and Dept. of Civil and Environmental Engineering - Rutgers) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean)	• 9 • 10 • 12 • 15 • 17 • 28 • 27 • 18 • 23 • 26	5.1, 5.2, 5.9-5.11, 5.14- 5.19, 6.1, 6.3, 7.1, 7.2, 7.5, 7.7

6. Turbidity	• Real-Time Brown Tide Water Quality Monitoring Program (USGS) • Brown Tide Assessment Project (NJDEP/DRST) • Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Water Quality Monitoring in the Jacques Cousteau National Estaurine Research Reserve System (JCNERR and Rutgers University) • Suspended Solids Flux through Schooner Creek (IMCS and Dept. of Civil and Environmental Engineering - Rutgers) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean)	• 6 • 27 • 17 • 18 • 19 • 20 • 21 • 24 • 26	5.9, 5.10, 5.14-5.19, 6.1, 6.3, 7.1, 7.2, 7.5, 7.7
7. Bacteria	• Ambient Stream Monitoring Network (FECAL coliform) (NJDEP & USGS) • Ambient Groundwater Monitoring Network (TOTAL coliform) (NJDEP & USGS) • Historical Water Quality Data in USGS NWIS Database (USGS) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Coastal Cooperative Water Quality Monitoring (OCUA)	• 9 • 10 • 15 • 18 • 25	5.1, 5.2, 5.4, 5.9, 5.10, 5.14, 5.16, 5.17, 5.18, 5.19, 5.25, 7.2, 7.5, 7.10
8. Phytoplankton/ Chlorophyll a	• Coastal 2000 – National Coastal Assessment (NJMSC) • Brown Tide Assessment Project (NJDEP/DRST) • Brown Tide Monitoring (NJMSC) • Real-Time Brown Tide Water Quality Monitoring Program (USGS) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Barnegat Bay Watch Monitoring Program (Alliance for a Living Ocean)	• 17 • 27 • 28 • 6 • 18 • 26	5.9-5.11, 5.14, 5.16-5.19 7.5
9. Macrophyte Abundance	• Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II)	• 17 • 18	5.9-5.11, 5.14-5.19, 7.5
10. Shellfish and Finfish Abundance	• Coastal 2000 – National Coastal Assessment (NJMSC)	• 17	6.2, 6.3, 6.5, 6.7, 6.9, 6.10, 7.5, 7.10
11. Benthic Community Structure	• Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Development of an Index of Biotic Integrity for Small Estuaries (EPA – Region II – Monitoring and Assessment Branch) • Application and Validation of Macroinvertebrate Protocols on Estuaries in New Jersey (EPA – Region II – Monitoring and Assessment Branch) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University)	• 17 • 18 • 19 • 20 • 51	6.2, 6.3, 6.5, 6.7, 6.9, 6.10 7.5
12. Toxic Contaminants in Aquatic Biota and Sediments	• Chemical Contaminant Studies in the Barnegat Bay – Little Egg Harbor Estuary (IMCS) • Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Sediment Sampling in Barnegat Bay (IMCS)	• 16 • 17 • 18 • 53	5.1, 5.4, 5.9, 5.11, 5.12, 5.14, 5.19, 6.6, 7.5
13. Floatables	• Clean Shores (NJDEP) • Adopt-A-Beach (NJDEP) • Cooperative Coastal Monitoring Program	• 55 • 54 • 61	7.2, 7.5
14. Shoreline Habitat/Sensitive Areas	• New Jersey Landscape Change Analysis (CRSSA – Rutgers) • Monitoring Trend in Neotropical Migrant Land Bird Populations and their Habitats (NJDEP – Div. of Fish and Wildlife –	• 30 • 44	6.1- 6.10, 7.5

	Endangered and Nongame Species Program) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University)	• 51	
15. Boating Use	• New Jersey Clean Vessel Act Program (NJDEP & OCPD)	• 59	7.1, 7.2, 7.5
16. Atmospheric and Other Pollutant Inputs	• Ambient Ground Water Quality Monitoring Network (NJDEP & USGS) • Chemical Contaminant Studies in the Barnegat Bay – Little Egg Harbor Estuary (IMCS) • Coastal 2000 – National Coastal Assessment (NJMSC) • Regional Environmental Monitoring and Assessment Program (REMAP - EPA – Region II) • Fish Index of Biotic Integrity (NJDEP) • Hard Clam Stock Assessment (NJDEP) • Freshwater Mussels (NJDEP)	• 10 • 16 • 17 • 18 • 29 • 37 • 50	5.1, 5.2, 5.15, 5.16, 7.5
17. Rare Plant and Animal Populations	• Chemical Contaminant Studies in the Barnegat Bay – Little Egg Harbor Estuary (Rutgers – Institute of Marine and Coastal Sciences) • Coastal 2000 – National Coastal Assessment (NJMSC) • Piping Plover Monitoring (USFWS) • Black Skimmer/Least Tern Monitoring (USFWS) • Songbird Point Count Survey (USFWS) • Anuran Call/Count Survey (USFWS) • Seabeach Amaranth Population Monitoring (USFWS) • Swamp Pink, Bog Asphodel And Curly-Grass Fern Population Monitoring (Associates for Conservation and Environmental Studies and USFWS) • Hard Clam Stock Assessment of Barnegat Bay (NJDEP – Div. of Fish and Wildlife- Bureau of Shellfisheries) • Osprey Population Monitoring (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Peregrine Falcon Monitoring (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Migratory Shorebird Monitoring (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Colonial Waterbird Surveys (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Beach Nesting Bird Monitoring: Piping Plover (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Beach Nesting Bird Monitoring: Least Tern And Black Skimmers (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Monitoring Trend In Neotropical Migrant Land Bird Populations And Their Habitats (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Herp Atlas Project (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Calling Amphibian Monitoring Program (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • North American Breeding Bird Survey (USGS NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Saltmarsh Nesting Songbirds (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Diamonbacked Terrapin Population Monitoring • Freshwater Mussels (NJDEP – Div. of Fish and Wildlife – Endangered and Nongame Species Program) • Submerged Aquatic Vegetation Monitoring (Fairleigh Dickinson University) • Landscape Project (NJDEP)	• 16 • 17 • 31 • 32 • 33 • 34 • 35 • 36 • 37 • 38 • 39 • 40 • 41 • 42 • 43 • 44 • 45 • 46 • 47 • 48 • 49 • 50 • 51 • 58	6.1-6.12, 7.5
18. Stream Flow	• Surface Water Stream Flow Network (USGS) • Low Flow Network (USGS) • Crest Stage Gage Network (USGS) • Existing Water Quality Network • Historical Water Quality Data in USGS NWIS Database	• 2 • 5 • 3 • 12 • 15	5.3, 5.14, 5.15, 5.20-5.24, 7.5, 7.6, 7.8, 7.9
19. Water Allocations	• Groundwater Levels Network (USGS) • Synoptic Groundwater Level Network (USGS) • Chloride Monitoring Network (USGS)	• 7 • 8 • 14	5.3, 5.8, 5.13, 5.20, 5.21, 5.22, 5.23, 6.9, 6.11,

	• Historical Water Quality in USGS NWIS Database (USGS) • Water Allocation (NJDEP)	• 15 • 56	7.5, 7.8
20. Saltwater Intrusion	• Synoptic Groundwater Level Network (USGS) • Historical Water Quality in USGS NWIS Database (USGS) • Water Allocation (NJDEP)	• 8 • 15 • 56	5.3, 5.8, 5.13, 5.20-5.23, 6.9, 6.11, 7.5, 7.8
21. Turf Grass	• New Jersey landscape Change Analysis (CRRSA – Rutgers) • Landscape Project (NJDEP)	• 30 • 58	5.5, 5.6, 5.21, 5.23, 7.5, 7.6, 7.9

V. FUTURE MONITORING NEEDS/DATA GAPS

Data gaps were identified throughout the development of the Barnegat Bay Estuary Program and CCMP. Many of these emerged from discussions centered on development of the Scientific Characterization, and from discussions at the various monitoring workshops and regular meetings of the Science and Technical Advisory Committee. These are presented briefly below.

HABITAT AND LIVING RESOURCES

Fish and Fishery Resources of Barnegat Bay: A Plan for Long-Term Data Gathering

Recently, few assessments have been undertaken to evaluate the status of fishery resources in Barnegat Bay. Given the declining status of many fisheries, and the lack of information to support informed fishery management programs, the BBEP recommends an assessment of the seasonal availability, species composition, and habitat use patterns associated with finfish and blue crab resources be conducted for Barnegat Bay.

Predator-Prey Interactions Between Blue Crabs and Hard Clams in the Little Egg Harbor Portion of Barnegat Bay

Significant declines in hard clam abundance have occurred in Barnegat Bay since the 1960s. Potential reasons for this decline range from the closure of shellfish grounds because of poor water quality, reduced larval settlement, and an increase in predation. To ensure a sustainable stock of clams, the BBEP recommends that a determination of the array of natural predators that juvenile clams face and the factors governing predator prey interactions be undertaken.

Bay Scallop Restoration and Enhancement in Barnegat Bay

The bay scallop is a common and often abundant member of shallow marine communities along the Atlantic and Gulf coasts. Because bay scallops recruit to seagrasses and use them as attachment sites, the loss of this habitat severely limited populations in some areas like Barnegat Bay. Although eelgrass has recovered in Barnegat Bay, bay scallop populations have not recovered. The BBEP recommends a reseeding of bay scallops be conducted at selected sites throughout Barnegat Bay to determine the potential for restoring this fishery.

Sediment Contamination/Toxicity

Little is known about the distribution, concentration, or toxicity of sediments throughout Barnegat Bay. Such information is needed for future bay management if sediment contamination or toxicity is found to be significant. The BBEP recommends that future monitoring should aim to analyze benthic infaunal communities as an indicator of sediment toxicity.

Brown Tide Blooms in Barnegat Bay

Brown tides are caused by a variety of organisms including *Aureococcus anophagefferens*, brown algae and or other algae that can impart a brownish color to the water. Brown tides caused by *A. anophagefferens* have no known human health effects but may have ecological effects on the health of bay systems. These include shellfish mortality, reduction in shellfish growth, and the destruction of critical habitat such as eel grass. Save for the documented association between occurrence of brown tide blooms and the reported reduction in growth of juvenile hard clams in a commercial aquaculture facility in 1995, no other effects have been reported for natural resources in New Jersey. Most of the information relating to the deleterious effects of brown tides results from studies conducted on brown tide blooms located in Long Island bays.

Although brown tides caused by *A. anophagefferens* were first documented in New Jersey in 1995, limited data exist for subsequent blooms including the bloom reported in 1999. Recently, the N.J. Department of Environmental Protection established a Brown Tide Assessment Project to determine the spatial and temporal occurrence of these blooms. The assessment will include collection of water samples from up to 44 stations throughout the year and the enumeration of *A. anophagefferens* using a newly developed monoclonal antibody analysis technique. Ultimately, the NJDEP expects to develop a predictive model leading to control strategies. The BBEP recommends that this assessment effort be continued on a long-term basis to develop a better understanding of the factors regulating incidence and bloom development.

Establishment of a Subaqueous Soil Classification System for Effective Management of Shallow Water Habitat

The BBEP recommends a study be undertaken to develop information on the properties of subaqueous and tidal soils in order to enhance the reestablishment of emergent and submergent vegetation. Emergent and submergent vegetation provide nutrients and shelter for finfish and shellfish, and help to mitigate shoreline erosion.

Habitat and Biotic Community Changes at Barnegat Inlet

The stabilization of Barnegat Inlet and the maintenance of a navigable channel into Barnegat Bay associated with the reconfiguration of the north and south jetty system have been linked to an array of environmental disturbance including shoreline erosion, dune destruction, the loss and alteration of wetlands habitat, and changes in biotic communities. These impacts are manifested most acutely at the southern extremity of Island Beach State Park, in the Sedge Islands area, and near the Barnegat Lighthouse. A time series investigation is necessary to assess the ongoing changes in sensitive habitat and biotic communities of the region and to develop plans for environmental restoration.

Sediments and Geomorphology of Barnegat Bay.

Barnegat Bay is comprised of a broad variety of sediments and sedimentary features that support diverse habitat assemblages. A detailed characterization of these features can be used to develop a better understanding of habitat value, its relationship to water quality and to prepare a sea level rise curve for the bay.

Periodically Update the Buildout Analysis for Barnegat Bay

A detailed analysis of population in the watershed, based on existing (2001) land use and zoning has been conducted in order to estimate the human population and number of housing units under buildout conditions. As land use and zoning regulations change, there will be a need to periodically update the buildout analysis to determine what the overall effect of such changes will have on the population and concomitant environmental effects throughout the watershed.

WATER RESOURCES AND WATER QUALITY

Nonpoint Source Toxics in Barnegat Bay and the Surrounding Watershed

The lack of data on toxic chemical compounds in groundwater and streams contributing freshwater inflow to Barnegat Bay could be improved by expanding ongoing efforts aimed at quantifying nonpoint source contaminants. Current studies focus on the evaluation of nutrients, sediment, and bacteria in surface waters that originate from nonpoint sources. Additional samples could be analyzed for volatile organic compounds, pesticides, and/or trace elements.

Identify the source of phosphorous inputs to Barnegat Bay

Phosphorus ranks among the most important nutrient elements necessary for plant growth in aquatic systems. In excess amounts, it may contribute to eutrophic conditions. Phosphorus enters streams, rivers, and estuaries in dissolved inorganic form principally as the phosphate anion derived from the weathering of rocks and leaching of soils, from domestic and industrial wastewater discharges, as well as from detergents and fertilizers. The concentration of phosphate in waters draining pristine regions is rather low, but the addition of organic waste material significantly increases the amount of phosphorus in estuarine tributaries. Phosphorus also exists in aquatic systems in dissolved organic and particulate forms, although phytoplankton and other autotrophs rapidly assimilate the dissolved inorganic forms. By processes of excretion, death of organisms, and sedimentation, phosphorus bound to particulate organic matter accumulates in bottom sediments of estuaries. Phosphorus stored in bottom sediments can be remobilized to the water column via various processes such as bioturbation and bottom shear stresses. The

flux of phosphorus across the sediment-water interface supplies an additional nutrient source for primary producers.

There are several primary sources of phosphorus inputs to Barnegat Bay. These include groundwater influx, surface water discharges, atmospheric deposition (both wet and dry), boats, and the Atlantic Ocean. While phosphorus concentrations have been measured periodically in the bay as well as the watershed during the past decade by S. Seitzinger and the U.S. Geological Survey (see Barnegat Bay Characterization Report), there is essentially no data available on phosphorus inputs from atmospheric fallout, boats, and the ocean. In addition, phosphorus inputs from fertilizers and other anthropogenic sources have not been characterized. As a result, the database on phosphorus inputs from groundwater and surface water influx is not comprehensive. Because of the limited data available on phosphorus sources and the importance of this nutrient element to plant growth in the estuary and its tributaries, a significant data gap exists which must be addressed by future monitoring efforts. The BBEP recommends phosphorus as well as nitrogen monitoring and assessment over 5- to 10-year periods in the estuary.

Quantify riverine inputs to Barnegat Bay

Stream and river flow supplies nutrients, sediments, organic material, groundwater products, as well as other substances to estuaries. Therefore, it is essential not only to quantify the rate and volume of water flow in the tributary systems of the Barnegat Bay-Little Egg Harbor Estuary, but also to measure the inputs of the aforementioned materials. To date, the U.S. Geological Survey has focused attention on measurements of riverine inputs in northern watershed areas. Few measurements have been made in the southern watershed region. Considering the critical importance of chemical inputs to the bay from streams and rivers draining the Barnegat Bay watershed, it is necessary to conduct further assessment of the tributary systems. The BBEP recommends periodic (every 5 years) monitoring of riverine inputs to the Barnegat Bay-Little Egg Harbor system.

Identify factors controlling turbidity in Barnegat Bay

The attenuation of light in estuarine waters of the Barnegat Bay-Little Egg Harbor system has an important effect on primary producers. High turbidity not only reduces phytoplankton production but also can eliminate seagrass beds and other benthic flora via shading impacts. There are several sources of turbidity in the estuary, most notably sediment and particulate organic matter. Suspended sediment, particularly clay and silt, accounts for much turbidity. In addition, organic material transported to the bay from streams, rivers, and nearby marsh habitats may be significant. Turbidity enters from both allochthonous and autochthonous sources. During storms, more turbidity may derive from the roiling of bottom sediments by winds and currents than from external sources.

The BBEP recommends future monitoring of turbidity conditions in the estuary. This work should include assessment of the factors controlling turbidity inputs to the system.

Because of the negative impacts of high turbidity on seagrass beds and the apparent loss of seagrass beds in the estuary during the recent past, it is imperative to obtain data on this subject.

Conduct a toxics assessment for Barnegat Bay

The list of chemical contaminants found in the Barnegat Bay-Little Egg Harbor estuary is extensive and includes numerous petroleum hydrocarbons, halogenated hydrocarbons, metals, radionuclides, and many other substances. Many of these contaminants may pose a potential health threat to organisms in the estuary. Although the sources of these contaminants have not been unequivocally established, it is likely that they derive from a variety of sources such as stormwater runoff, groundwater seepage, boats, and atmospheric deposition. Sediment and biotic samples from the estuary have been collected and are now being processed for contaminants by EPA's National Coastal Assessment Program (also known as Coastal 2000 or C2000). Data derived from this effort will greatly advance our understanding of contaminant problems in the system.

It will be necessary, however, to periodically conduct future surveys of toxic contaminants in the estuary to determine if conditions are improving, worsening, or remaining unchanged through time. These data will also be critical to delineating the sources of the contaminants, which will be an initial step in planning remedial action. The BBEP, therefore, recommends monitoring and assessment of chemical contaminants in the estuary over 5- to 10-year periods.

HUMAN USE

Economic Valuation of Barnegat Bay Resources

Very little quantitative information is available on the natural resource value of Barnegat Bay and its surrounding watershed. Data do exist on the economic impact of activities occurring throughout the bay such as boating, fishing, and tourism. However, the resources upon which these activities rely—open space, habitat quality, water quality—are not easily quantified. Efforts need to define the value of the bay's natural resources in terms that can be used to support informed decisions on the future character of Barnegat Bay.

ADDITIONAL DATA GAPS TO BE ADDRESSED

Periodically Update the Data Synthesis for the Barnegat Bay Estuary

One of the key products identified by the BBEP is to periodically update information used to characterize the health of habitat, living resources, and water resources of the

Barnegat Bay. Ideally, the monitoring program will help support a periodic data synthesis. For example, the Science and Technical Advisory Committee has recommended that the distribution and abundance of submerged aquatic vegetation, one of the primary environmental indicators developed by the BBEP, be updated with aerial photography, satellite remote sensing, and field surveys every 5 to 7 years. This information is required to evaluate action plan success, support public outreach programs, and to assist the resource management community with information to make informed choices about bay management including human use of the system.

VI. MONITORING PROGRAM PERFORMANCE EVALUATION AND UPDATE

DATA MANAGEMENT STRATEGY

Evaluation of the status of key environmental indicators and other program outcomes will depend on an effective data management system, which will provide for the storage, management, and availability of key information collected as part of the Monitoring Program. The Data Management Strategy outlined in the CCMP is reiterated below:

Data Management

Residents and visitors to Barnegat Bay represent many diverse interests, each of which have different information needs. These groups include but are not limited to:

- Homeowners;
- Local elected officials;
- Federal, state, and local watershed managers;
- Academia;
- Pre-college educators and students;
- Visitors and vacationers;
- Special-interest groups; and
- Business and industry.

Although substantial information exists on the ecology and resources of Barnegat Bay, much of this information is scattered, exists in many diverse forms or formats, and is not generally accessible to the groups listed above. The objective of the Data Management Action Plan for Barnegat Bay is to archive diverse data sets and make these data available in easily accessed computer format via the Internet and the Ocean County library system.

This data management system will be used to inform, guide, and improve local decision making, foster stewardship of the bay, raise environmental awareness, enrich educational programs, support the public outreach effort, and implement the Barnegat Bay CCMP. Where possible, the data management system will build upon the existing capacities of large-scale data management programs and will include historical, cultural, and socioeconomic information, as well as data on the estuary's physical and biological resources. As funding permits, the data management system will include an interactive multimedia component that enables users to access frequently updated information from remote sites.

Data Management Goals

As a result of a needs assessment, five goals for a suitable data management system for Barnegat Bay have been identified. They are:

- Develop a comprehensive database that enables user groups to readily access information that can be used to support BBEP management goals and objectives.

- Link information management with the BBEP public outreach effort to promote interaction among bay user groups and to disseminate information broadly.

- Manage and classify information from many sources and formats.

- Identify the equipment needs, delivery systems, personnel requirements, and a dedicated funding source that ensures broad public dissemination of Barnegat Bay information.

- Support an environmental monitoring program for assessing water quality and living resources of the bay.

System Elements

This data management system is designed to put different types of relevant information into an accessible location for many users and, where appropriate, present users with information that describes the quality or utility of the data.

A key feature of the Barnegat Bay Information System and Resource Guide will be its capacity to provide data spatially and temporally from disparate data sets. The data system will include a data server connected to the Internet with World Wide Web access, file transfer protocol (FTP), e-mail, and bulletin boards. Local storage of data sets and programs also must be accommodated and is described in more detail on the following page:

- World Wide Web access for the public – The site will have links to data sets stored on a BBEP server and to non-local data sets. The site will also have links to sites at the NJDEP, USEPA, Grant Walton Center for Remote Sensing and Spatial Analysis at Rutgers University, USGS, and Ocean County. Multimedia capacity will allow use of a full range of data visualization for both technical and non-technical users. Hot links also will be available to relevant sites, such as the BBEP homepage.

- Computer bulletin boards to foster information exchange – Bulletin boards will be organized by topic, and will enable users to electronically disseminate their work on the estuary and watershed.

- FTP – Establishment of File Transfer Protocol (FTP) capabilities will enable easy transfer of documents and files between Internet users.

- E-mail – E-mail capability will permit the convenient exchange of information among users who will be able to interface with the Web site in order to communicate with the Web manager and other data sources.

- On-line data sets and information files – Where necessary, data sets developed during the BBEP characterization and synthesis phase will be stored on-line.

- Information sources index and index of on-line and off-line files – This index will provide brief descriptions of estuary and watershed data, including the temporal and spatial ranges of data sets, information on how to obtain files, data sources, and metadata.

- Geographic Information System (GIS) – Geographic information on land use, land cover, water resources, and living resources will be presented in a GIS format.

- Distributed Data System – A distributed data system will be constructed to access data sets that have various formats and are at various locations, eliminating the need to modify the disparate formats.

Next Steps

Following the completion of the final Monitoring Plan, the BBEP STAC will hold a data management workshop to evaluate options for a long-term data management strategy. The purpose of the workshop is to gather technical input and recommendations from stakeholders. The results of the workshop will ultimately be used to fully develop and implement the data management plan, which will be contingent on appropriate funding to maintain the system.

PROCEDURES FOR PROGRAM EVALUATION

Different indicators require different procedures for the analysis of monitoring information in order to answer the respective questions about the status of the indicator. Some indicators require a rigorous quantitative statistical analysis, while others require a more qualitative, descriptive analysis. The following is a summary of the different categories of evaluation procedures that are required for the various indicators.

1. General quantitation. Some indicators require a basic quantitative analysis in order to assess the status and relative importance of the indicator. An example of an indicator requiring a general quantitation is the amount of nitrogen entering the estuary from atmospheric deposition. Available records of atmospheric deposition measurements are compiled, evaluated, reduced, interpolated, and synthesized to obtain quantitative estimates of atmospheric loading. The quantitation is expressed in appropriate units, such as kilograms N/year. Comparison of various quantitative estimates of nitrogen inputs from different sources can then provide the basis for re-evaluating the relative importance of the various nitrogen sources.

2. Trend significance. Many indicators require a rigorous statistical trend analysis in order to determine if observed differences in measurements over time (such as median nitrate-nitrogen concentration) are statistically significant ($p < 0.05$). In cases where measurements change over time, but the changes are not statistically significant, the differences may be reported, but not described as significant. All water quality indicators require trend analysis, as well as several biological indicators.

3. Quantitative changes. Some indicators require the determination of the magnitude of change in the status of a particular indicator. An example is the magnitude of change in temperature, in degrees C. Changes may be reported as differences in mean values for contrasting periods of time, or as rates of change over time.

4. Frequency of occurrence. Some indicators require an evaluation of the frequency with which a condition occurs. The evaluation considers data collected at an appropriate time interval, over an adequate period of time. Examples are the frequency of the occurrence of Brown Tide and hypoxia

5. Occurrence / nonoccurrence. Some indicators require a simple determination of whether or not a particular condition is present or has occurred, such as SAV scarring, brown tide, and hypoxia.

6. Areal distribution. Some indicators require an evaluation of changes in the areal distribution of a resource attribute. Examples are SAV and shellfish beds. Evaluations for these types of indicators require a systematic procedure for mapping the attribute and comparing distributions for different time periods. In cases where procedures change over time, additional information processing is generally required in order to compare data sets that are as comparable as possible. Evaluation of changes in areal distributions

can be quantitative (change in the number of acres) and geographic (mapped areas of change in status).

7. Biological metrics. These apply to biological indicators, and may include such metrics as species abundance, species diversity, species composition, and dominant species. May also include biological health assessments (i.e., SAV health).

8. Relational evaluation. Some indicators require the determination of whether the status of the indicator is associated with some other indicator or factor. An example is whether changes in the macrophyte abundance are associated with changes in nutrient fluxes or changes in habitat. These kinds of questions require adequate data for both the indicator in question and the potentially associated indicator or factor. A relational evaluation will typically require other kinds of quantitative evaluation of the indicator(s) and potentially related factors.

9. Qualitative evaluation. For some indicators, the appropriate evaluation is not quantitative but qualitative descriptive assessments. Examples are the type of floatables present; the location of boat use; the names of rare, endangered, and threatened plant and animal species. A qualitative evaluation is needed in order to determine if qualitative changes in the indicator are occurring.

Table 5. Specific questions to be addressed by the evaluation of monitoring data (Primary indicators).

INDICATOR	SPECIFIC QUESTIONS TO BE ADDRESSED[1]
PRIMARY INDICATORS	
SAV DISTRIBUTION, ABUNDANCE, AND HEALTH	**1. Is the distribution of SAV beds in the estuary changing?** **2. Is the abundance of SAV beds in the estuary changing?** **3. If the abundance of SAV beds is changing, to what extent is it changing?** **4. Is the health of SAV beds in the estuary changing?**
LAND USE/LAND COVER CHANGE	**1. Are the extents of the following land use/land cover categories in the estuary watershed changing over the time scale of years to decades?** • **Unaltered land** • **Interior forest areas** • **Public open space** • **Impervious surface cover**
SIGNATURE SPECIES	
HARD CLAMS	**1. Is the population of hard clam stocks in the estuary changing?** **2. Is the distribution of clam stocks changing in relation to areas that are open for harvesting?**
COLONIAL NESTING WATERBIRDS	**3. Is the population abundance of colonial nesting waterbirds changing?** **4. If changes are occurring, are they associated with corresponding changes in habitat?**
OSPREY	**5. Is the number of known osprey nesting sites changing?** **6. Is the success rate of osprey fledglings changing?**
BREEDING BIRDS	**7. Are breeding bird populations changing over the time scale of years to decades?**
WATERSHED INTEGRITY	**1. Is the status of watershed integrity changing (as measured by the following parameters)?** • **pH** • **specific conductance** • **presence of disturbance indicator species** • **presence of non-native fish** • **presence of bullfrogs**
SHELLFISH BEDS	**1. Is the acreage of shellfish beds open for harvest changing?**
BATHING BEACHES	**1. Is the number of bathing beach closures changing?**
WATER SUPPLY WELLS/ GROUND WATER	**1. Is the quality of ambient shallow ground-water changing with respect to established drinking water standards?**
HARMFUL ALGAL BLOOMS	**1. Is the frequency, area, or intensity of HAB occurrence changing?** **2. Is the species composition of HABs changing?**
FRESHWATER INPUTS	**1. Is the base flow of tributary streams changing over the time scale of decades?** **2. Is water consumption changing?**

[1] A time scale of years applies to questions regarding trends, unless otherwise indicated.

Table 6. Specific questions to be addressed by the evaluation of monitoring data (Secondary indicators).

INDICATOR	SPECIFIC QUESTIONS TO BE ADDRESSED
SECONDARY INDICATORS	
TEMPERATURE	**1. Is water temperature in the estuary increasing, decreasing, or unchanged?** **2. If water temperature is changing in the estuary, what is the magnitude of this change?**
SALINITY	**1. Is salinity in the estuary increasing, decreasing, or unchanged?** **2. Are drought conditions during the past several years affecting salinity levels in the bay?** **3. How are salinity changes related to the changes in tidal prism associated with the restructuring of Barnegat Inlet?**
pH	**1. Are pH levels increasing, decreasing, or unchanged in the estuary?**
DISSOLVED OXYGEN	**2. Is oxygen depletion affecting any areas of the estuary?** **3. Are there any occurrences of hypoxic events in the estuary?**
NUTRIENTS	**1. Are nitrogen and phosphorus concentrations increasing in the estuary?** **2. Are nutrient levels changing in the more heavily developed northern estuary?**
TURBIDITY	**1. Are turbidity levels in the northern estuary increasing with ongoing watershed development?** **2. Is turbidity increasing estuary-wide?** **3. What are the turbidity levels above SAV beds?**
ENTEROCOCCUS BACTERIA	**1. Are enterococcus bacteria levels in the estuary increasing, decreasing or unchanged during the past decade?** **2. Has drought conditions resulted in reduced inputs of enterococcus bacteria to the estuary?**
PHYTOPLANKTON	**1. Are phytoplankton abundance, biomass, and productivity increasing, decreasing, or unchanged?** **2. What is the relative importance of diatoms and dinoflagellates in the estuary?** **3. Are picoplankton and nannoplankton the numerically dominant elements of the phytoplankton community?**
MACROPHYTE ABUNDANCE	**1. Are the abundance, biomass (chlorophyll a), and distribution of SAV (eelgrass) increasing, decreasing, or unchanged?** **2. Are the abundance, biomass (chlorophyll a), and distribution of benthic macroalgae increasing, decreasing, or unchanged?** **3. Is there an inverse relationship between benthic macroalgal abundance and abundance of eelgrass beds in the estuary?** **4. If changes in abundance of macrophytes are occurring, are they associated with nutrient flux or a change in habitat?**
BLUE CRAB AND FINFISH ABUNDANCE	**1. Is the abundance of blue crabs in the estuary changing?** **2. Is the population abundance of the dominant finfish species changing?**
BENTHIC COMMUNITY STRUCTURE	**1. Is the species composition, abundance, and distribution of benthic flora and fauna changing?** **2. Is diversity of benthic organisms changing in the estuary?**

INDICATOR	SPECIFIC QUESTIONS TO BE ADDRESSED BY THE EVALUATION OF MONITORING DATA
SECONDARY INDICATORS (Continued)	
TOXIC CONTAMINANTS IN AQUATIC BIOTA AND SEDIMENTS	**1. What are the concentrations of chemical contaminants (heavy metals, PAHs, and halogenated hydrocarbons) in bottom sediments and biota?** **2. Are the concentrations of contaminants in bottom sediments and biota increasing, decreasing, or unchanging?**
FLOATABLES	**1. What are the types of floatables found in the estuary?** **2. Are floatables increasing, decreasing, or unchanged in the system?**
SHORELINE HABITAT/SENSITIVE AREAS	**1. Is physical alteration/habitat loss of shoreline habitat increasing, decreasing, or unchanged?**
BOATING USE	**1. Is boating activity increasing in the estuary? Where is most boat use observed?** **2. Are there any indicators of boating impacts (e.g., SAV scarring) in shallow water habitats?**
ATMOSPHERIC AND OTHER POLLUTANT INPUTS	**1. What are the specific pollutant sources in the estuary and watershed?** **2. How much nitrogen enters the estuary via atmospheric deposition though time?** **3. What is the relative importance of surface runoff vs. atmospheric deposition for major pollutant groups?**
RARE PLANT AND ANIMAL POPULATIONS	**1. What are the rare, endangered, and threatened plant and animal species that inhabit Barnegat Bay, Little Egg Harbor, and the watershed?** **2. What are the habitats occupied by these populations?** **3. Are the population numbers increasing, decreasing, or unchanged?**
STREAM FLOW	**1. Is stream flow in the watershed declining due to less precipitation and more frequent drought conditions?** **2. Are the inputs of coliform bacteria, nutrients, and other pollutants decreasing in the estuary due to reduced stream inflow?**
WATER ALLOCATIONS AND USE	**1. How much water is allocated in the watershed and how much is used?** **2. How much have water allocations and use increased?**
SALT-WATER INTRUSION	**1. Is salt-water intrusion into area aquifers increasing or unchanged?** **2. Are salt-water intrusion problems arising in specific areas of the watershed where groundwater use is excessive?**

TURF GRASS	**1. How much turf grass use occurs in the watershed?** **2. Is turf grass use increasing, decreasing, or unchanged?** **3. Are groundwater supplies changing in relation to areas with heavy turf grass use?** **4. What is the relation between turf grass use and runoff in the watershed?**

TIMETABLE

The timetable for the evaluation of the program is detailed below. A matrix indicates the specific time intervals for evaluating different aspects of the program. The initial evaluation after year 1 of CCMP implementation will provide a baseline for future evaluations and the format for presenting evaluation results. The planned interval between successive evaluations will depend upon a number of factors, including the anticipated schedule of data collection, anticipated complexity of the evaluation, and the anticipated rate of change in the indicator.

Table 7. Timetable For Monitoring Program Evaluation (Primary Indicators).

INDICATOR	EVALUATION PROCEDURE CATEGORIES	EVALUATION INTERVAL					
		INITIAL EVALUATION AFTER YEAR 1 OF IMPLEMENTA-TION	ANNUAL	2-YEAR	3-YEAR	5-YEAR	5-10 YEAR
PRIMARY INDICATORS							
SAV DISTRIBUTION	6,7	X				X	
LAND USE/LAND COVER CHANGE	6	X					X
SIGNATURE SPECIES							
HARD CLAMS	6,7	X				X	
COLONIAL NESTING WATERBIRDS	7	X				X	
OSPREY	7	X			X		
BREEDINGBIRDS	7	X				X	
WATERSHED INTEGRITY	3	X				X	
SHELLFISH BEDS	6,9	X	X				
BATHING BEACHES	3	X	X				
WATER SUPPLY WELLS/ GROUND WATER	4	X				X	
HARMFUL ALGAL BLOOMS	4,5,6	X			X		
FRESHWATER INPUTS	2,3	X					X

Table 8. Timetable For Monitoring Program Evaluation (Secondary Indicators).

INDICATOR	EVALUATION PROCEDURE CATEGORIES	EVALUATION INTERVAL					
		INITIAL EVALUATION AFTER YEAR 1 OF IMPLEMENTA-TION	ANNUAL	2-YEAR	3-YEAR	5-YEAR	5-10 YEAR
SECONDARY INDICATORS							
pH	1,2,3	X				X	
TEMPERATURE	1,2,3	X				X	
SALINITY	1,2,3					X	
DISSOLVED OXYGEN	1,2,5	X					X
NUTRIENTS	1,2	X	X				
TURBIDITY	1,2,8	X				X	
ENTEROCOCCUS BACTERIA	1,2,8	X	X				
PHYTOPLANKTON ABUNDANCE AND COMPOSITION & CHLOROPHYLL a CONCENTRATIONS	1,2,7	X				X	
MACROPHYTE ABUNDANCE	1,2,7,8	X				X	
SHELLFISH AND FINFISH ABUNDANCE	1,2,	X					X
BENTHIC COMMUNITY STRUCTURE	1,2,7	X				X	
TOXIC CONTAMINANTS IN AQUATIC BIOTA AND SEDIMENTS	1,2	X				X	
FLOATABLES	2,9	X				X	
SHORELINE HABITAT/SENSITIVE AREAS	2	X					
BOATING USE	2,5,9	X				X	
ATMOSPHERIC AND OTHER POLLUTANT INPUTS	1,9	X				X	
RARE PLANT AND ANIMAL POPULATIONS	2,9	X				X	
STREAM FLOW	2,8	X				X	
WATER ALLOCATIONS	1,3	X				X	
SALT WATER INTRUSION	2,5,8	X				X	
TURF GRASS	1,2,8	X				X	

COMMUNICATION OF RESULTS/RECOMMENDATIONS

Upon completion of the initial Monitoring Program evaluation, a written summary report will be produced that includes a description of results of individual components of the monitoring program, the overall adequacy of the monitoring program, and recommendations for changes to the monitoring program. This summary report will serve as a tool to effectively communicate information on the effectiveness of the actions taken under the management plan, and to build public awareness of actions taken by the Barnegat Bay Estuary Program. Demonstration materials that summarize program results will be produced for use by the Program Office in newsletters, workshops, poster sessions, and public forums. The results of the monitoring effort and the data analyses will also be made available to the scientific community, and use of the monitoring data will be encouraged.

Data analyses will be conducted to test for trends, test and generate new hypotheses, evaluate the uncertainties associated with the data, and to identify the source of these uncertainties. These analyses can serve as a basis for extending existing knowledge of the estuary, making refinements to future conceptual and numerical models of the system, and identifying new research. Collectively, the analytical results will provide the necessary information for redirecting and refocusing the CCMP.

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APPENDIX A. EXISTING MONITORING ACTIVITIES

Table of Contents

1. NEW JERSEY TIDE TELEMETRY SYSTEM

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: 9

Sampling Period: 10/97 – continuing.

Sampling Frequency: 6 minutes, weather data hourly.

Environmental Media: Tidal water levels, meteorological data.

Parameters/Metrics Collected:
9 sites: Water level.
2 sites: Precipitation, air temperature, barometric, pressure, wind speed, wind direction, peak wind gust.

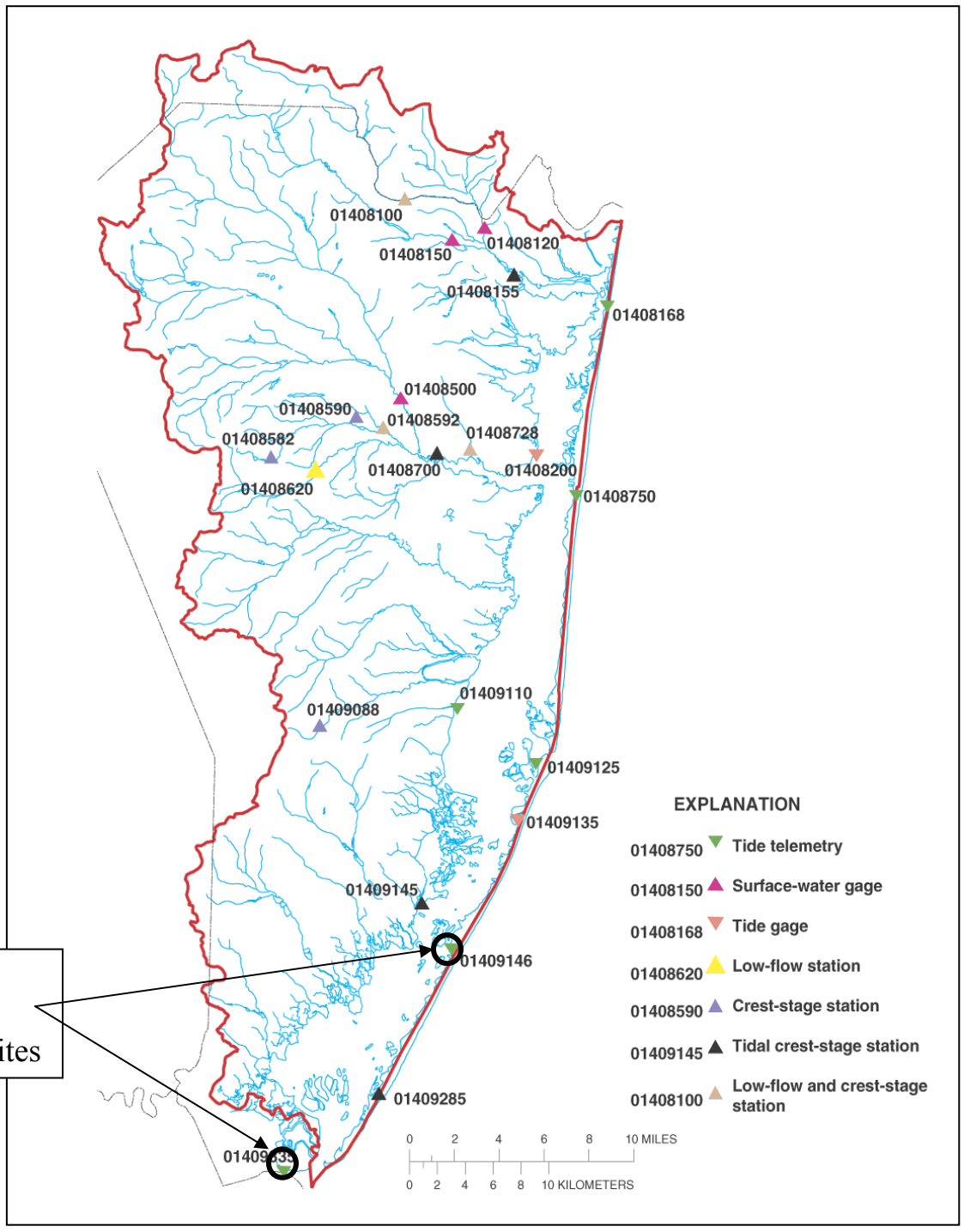
Type of Database Used for Data Management and Data Reporting Outlet:
Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication- Water Resources Data, New Jersey, Volume 1

Quality Assurance/Control Procedures: Daily operational checks, scheduled onsite maintenance at 8-week intervals, all data records reviewed annually, USGS District QA plan.

Estimated Cost: $90,000 per year

Narrative Description of Project: The New Jersey Tide Telemetry System (NJTTS) is designed to record and relay real-time water level and meteorological data to the USGS, National Weather Service, NJ State Office of Emergency Management and County and local emergency management offices. Tidal water level data is collected at 6-minute intervals via acoustic depth sounder, logged onsite and also relayed by satellite, telephone and VHF radio telemetry to the aforementioned agencies. Six of these sites are part of a statewide system made up of 28 tidal water level stations and 4 standard National Weather Service weather stations. These data are funneled to the National Weather Service and USGS computer base stations that upload the data to a government server. Computers throughout New Jersey then download these data from the Government server

at 15-minute intervals for display on custom designed software on computers at local emergency management offices.



Proposed real-time brown tide water quality monitoring sites

Active U.S. Geological Survey surface-water networks (stage and flow) and proposed real-time monitoring sites.

2. SURFACE WATER/STREAMFLOW NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: 2

Sampling Period: Various years-continuing.

Sampling Frequency: 15 minutes

Environmental Media: Streamflow.

Parameters/Metrics Collected: Water stage.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication - Water Resources Data, New Jersey, Volume 1

Quality Assurance/Control Procedures: Various USGS publications & USGS District QA plan.

Estimated Cost: $27,000 per year

Narrative Description of Project: The Surface Water Streamflow Network provides streamflow data for use by water ands emergency management authorities and regulatory agencies to forecast floods, manage reservoirs, and to ensure compliance with legal minimum streamflow requirements.

3. CREST-STAGE GAGE NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Three.

Sampling Period: Various years - continuing.

Sampling Frequency: Bi-monthly.

Environmental Media: Stream.

Parameters/Metrics Collected: Peak stage and discharge.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 1

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $6,500 per year

Narrative Description of Project: The statewide Crest-Stage network provides information about stream flow flood peaks for use in flood forecasting.

4. TIDE CREST-STAGE GAGE NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Four.

Sampling Period: Various years-continuing.

Sampling Frequency: Bi-monthly.

Environmental Media: Tidal reaches.

Parameters/Metrics Collected: High tide elevations.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 1

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $5,000 per year

Narrative Description of Project: The Tide Crest-Stage network provides information about peak tidal stage events or emergency management planning and forecasting.

5. LOW-FLOW NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Four.

Sampling Period: Various years-continuing.

Sampling Frequency: 2 times per year.

Environmental Media: Stream flow.

Parameters/Metrics Collected: Base flow.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 1

Quality Assurance/Control Procedures: Various USGS publications and USGS District QA plan.

Estimated Cost: $5,600 per year

Narrative Description of Project: The Low-Flow network provides information about flow during periods of relatively little precipitation, during which streamflow is expected to be derived primarily from ground-water inputs and point source discharges.

6. REAL-TIME BROWN TIDE WATER QUALITY MONITORING PROGRAM

Status: Recommended for implementation by a funding agency but not yet underway.

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Two (initially).

Sampling Period: Proposed 3/02 – continuing.

Sampling Frequency: 15 minutes

Environmental Media: Water quality parameters related to brown tide occurrence.

Parameters/Metrics Collected: At two sites, initially: water temperature, conductivity dissolved oxygen, turbidity, depth, and chlorophyll-a.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
Anticipated: USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication: Water Resources Data, New Jersey, Volume 3

Quality Assurance/Control Procedures: Daily operational checks, scheduled onsite maintenance at 2-week intervals, all data records reviewed annually, District QA plan.

Estimated Cost: $35,000 per year

7. GROUND WATER LEVELS NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: 12 - Continuous
4 - Maximum/Minimum
5 - manual

Sampling Period: Various years - continuing.

Sampling Frequency: Continuous Sites - hourly
Maximum/Minimum - 4 times per year
Manual - 2 times per year

Environmental Media: Ground-water levels in wells.

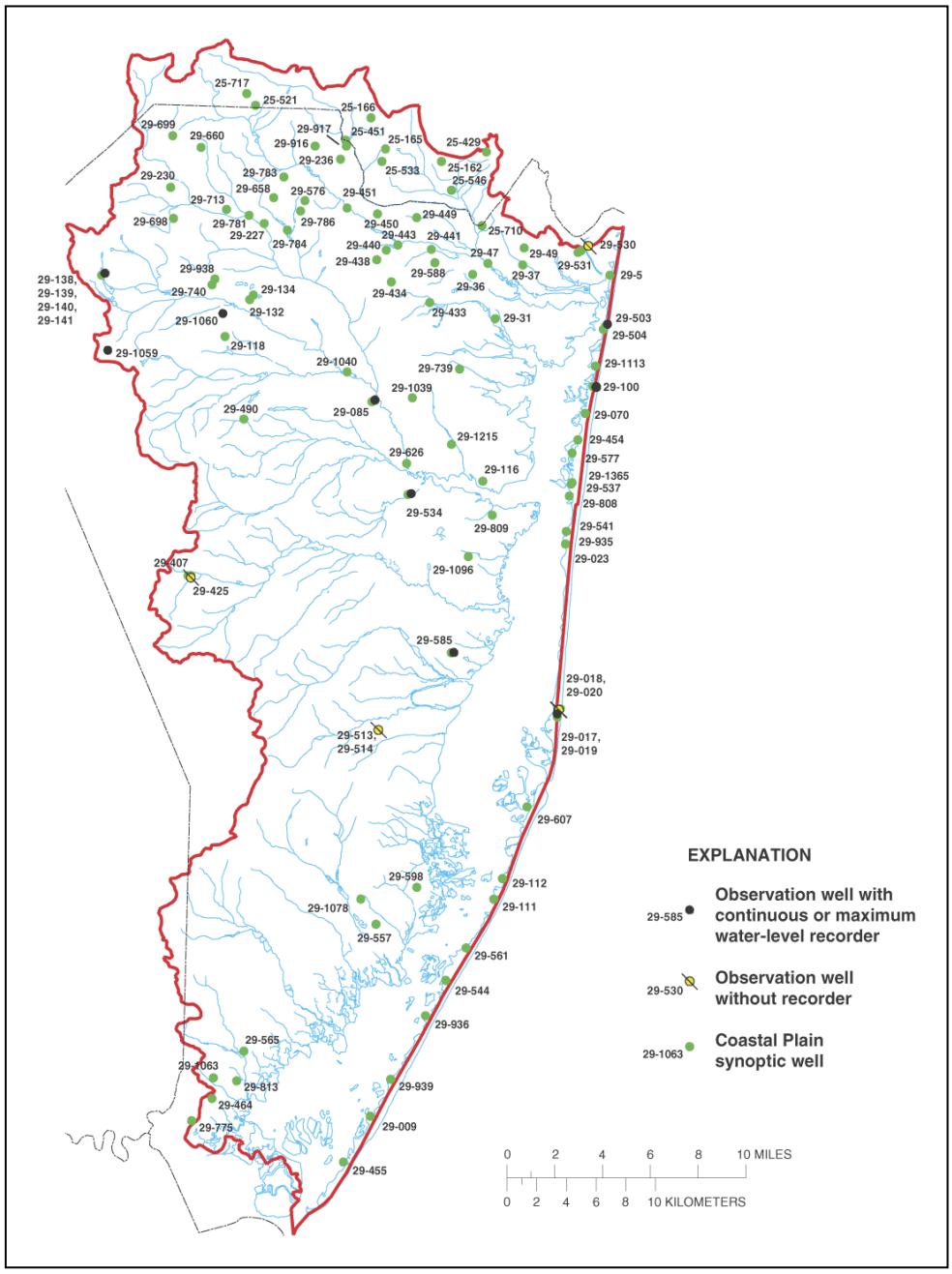
Parameters/Metrics Collected: Ground-water levels in wells.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 2

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $42,000 per year

Narrative Description of Project: The USGS Ground Water Level network provides information on ground-water levels in both confined and unconfined aquifers statewide. Long-term water level records are needed to evaluate the effects of climate changes on ground-water systems, to develop a database that can be used to measure the effects of development, to facilitate the prediction of future ground-water supplies, and to provide data for ground-water resource management.



Active U.S. Geological Survey ground-water networks (water levels).

8. SYNOPTIC GROUND WATER LEVEL NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: 98

Sampling Period: 1983 – continuing.

Sampling Frequency: Five-year interval.

Environmental Media: Groundwater in confined aquifers.

Parameters/Metrics Collected: Water level.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database:
USGS web site http://water.usgs.gov/nj/nwis/
USGS Water-Resources Investigation Reports

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $24,000 per year (average cost over 5-year cycle)

Narrative Description of Project: The USGS Synoptic Ground-Water Level network provides a "snapshot" of water levels in confined aquifers every five years. This information is used to evaluate present water supplies, predict future water supplies and to evaluate water management strategies.

9. AMBIENT STREAM MONITORING NETWORK

Status: Ongoing

Lead Entity: New Jersey Department of Environmental Protection (NJDEP) and US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Three

Sampling Period: Various years – continuing.

Sampling Frequency: Four times per year.

Environmental Media: Stream.

Parameters/Metrics Collected: Field parameters, bacteria, major ions, nutrients, and trace elements.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 3

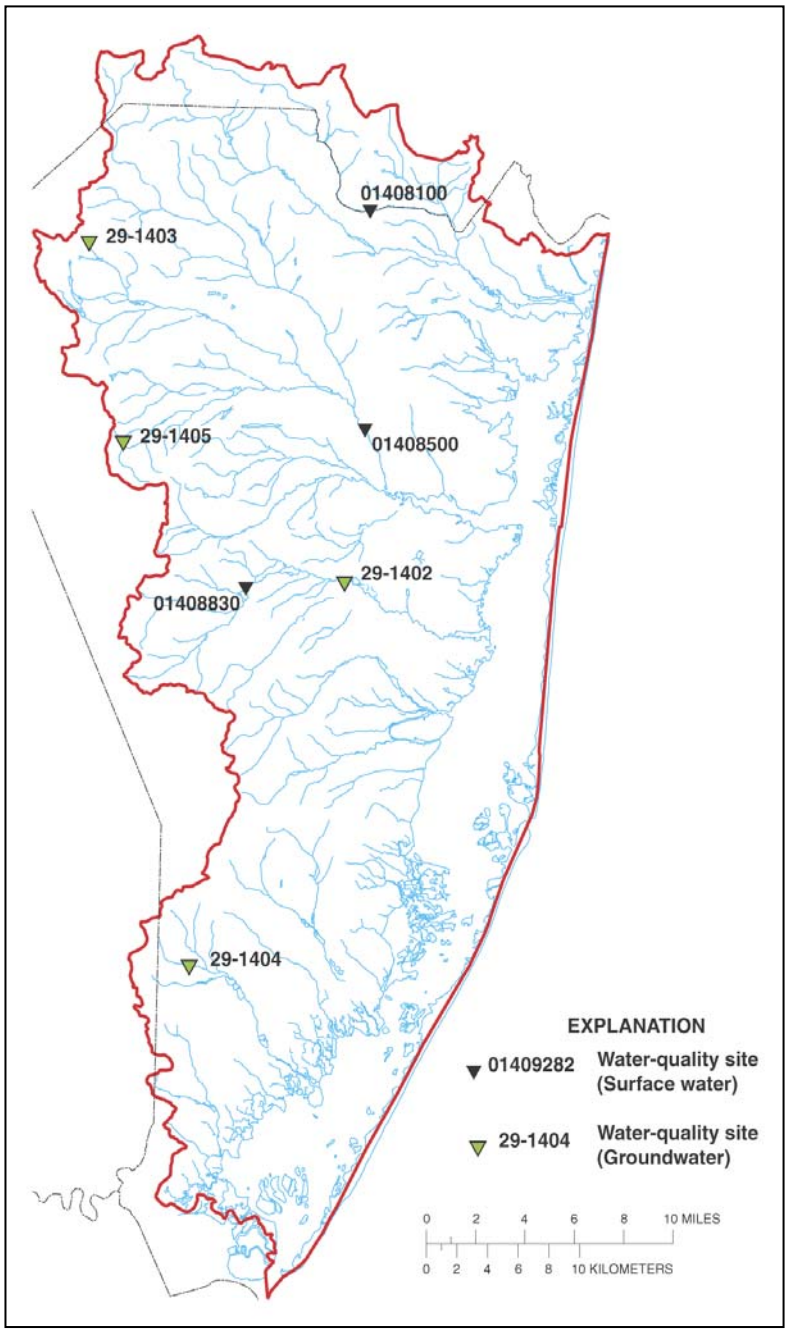
Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $21,000 per year

Narrative Description of Project: The NJDEP/USGS Cooperative Ambient Stream Monitoring Network (ASMN) has four goals:

a) Assess the status (distribution and occurrence) of stream water quality by examining the concentrations of various constituents that can be used as environmental indicators. Stream discharge is also measured at the time of sampling. Depth and width-integrated samples are also collected.
b) Assess water quality trends seasonally and loads by examining data collected four times annually.
c) Determine the effects of land use on stream quality.
d) Additional sites within the watershed may be selected randomly from the NJDEP AMNET Network as part of a 40-site Statewide water quality assessment network focusing on nutrients, trace elements, dissolved pesticides, VOC's, and stream sediment analysis for nutrients, PCB's, PAH's and trace elements. The purpose of this separate network is to assess the status of additional constituents on a

statewide basis and to identify threats from non-point sources and to identify new or emerging issues of concern to the public.



Active NJDEP/USGS cooperative water-quality networks (Surface water and ground water).

10. AMBIENT GROUNDWATER QUALITY NETWORK

Status: Ongoing

Lead Entity: NJ Department of Environmental Protection & US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Four

Sampling Period: Various years - continuing.

Sampling Frequency: One time every five years.

Environmental Media: Shallow ground water.

Parameters/Metrics Collected: Field measurements, bacteria, major ions, nutrients, gross alpha and gross beta radioactivity, dissolved pesticides (48 compounds) and volatile organic compounds (60 compounds).

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 3

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $2,600 per year (average cost over five-year cycle).

Narrative Description of Project: The NJDEP/USGS Cooperative Ambient Ground-Water Quality Network (AGWQN) was designed to monitor the quality of ground-water at or near the water table. The NJDEP/USGS AGWQN has four goals:

a) Assess the status (distribution and occurrence) of ground-water quality by examining the concentrations of various constituents that can be used as environmental indicators.
b) Assess water quality trends by examining data collected on a 5-year cycle.
c) Determine the effects of land use on ground-water quality.
d) Identify threats from non-point sources and to identify new or emerging environmental issues of concern to the public.

11. AMBIENT BIOMONITORING NETWORK (AMNET)

Status: Ongoing

Lead Entity: NJDEP

Contact Person: New Jersey Department of Environmental Protection
Bureau of Freshwater and Biological Monitoring

Number of Sampling Sites: 820 statewide.

Sampling Period: 1992 – continuing.

Sampling Frequency: Once every five years at each station.

Environmental Media: Benthic macroinvertebrate data.

Parameters/Metrics Collected: Benthic macroinvertebrates (bottom dwelling organisms visible to the naked eye) are sampled on a rotational schedule of once every five years. Visual observations, stream habitat assessments and limited physical/chemical parameters are performed on each site.

Type of Database Used for Data Management and Data Reporting Outlet: The results of the program have been incorporated into the National Environmental Performance Partnership System (NEPPS) as a primary environmental indicator of water quality impairment. AMNET reports of results are published by the BFBM annually; copies are available from the web site http://www.state.nj.us/dep/wmm/bfbm/publications.html. The chemical and biological data will also be available from STORET; EPA's computerized data system.

Quality Assurance/Control Procedures: USEPA-developed statistical methodology referred to as Rapid Bioassessment Protocol (RBP).

Estimated Cost: N/A

Narrative Description of Project: Since the early 1970s the New Jersey Department of Environmental Protection (NJDEP) has conducted biological monitoring of the State's water bodies. These biomonitoring studies, currently conducted by the Bureau of Freshwater and Biological Monitoring (BFBM), have included both long-term ambient monitoring and short-term intensive surveys. The information gathered contributes significantly to State water quality management and pollution mitigation efforts. The United States Environmental Protection Agency (USEPA) has recognized that a thorough program of monitoring aquatic biota can be a cost-efficient means of gauging the quality of water and watershed areas. Because flora and fauna of various trophic levels can integrate the effects of water quality or habitat changes over time, they become very effective pollution indicators. For lotic (running water) systems, analysis of benthic macroinvertebrate communities provides the principal means of achieving this,

particularly since macroinvertebrates are more stationary than fish, and less temporal than periphytic, or attached microscopic communities.

Initiated in 1992, AMNET sampled over 800 stream sites statewide, with approximately 200 sites in each of five major drainage basins (upper and lower Delaware, greater Passaic, Raritan and Atlantic) once every five years. This ambitious project is facilitated by the use of Rapid Bioassessment Protocol II (RBPII) methods, devised by the USEPA, which provide an expedient tool for site ranking, screening and trend monitoring.

The major goal of AMNET is to establish a network of stream sites that would adequately represent New Jersey's major drainage basins and NJDEP's Watershed Management Areas (WMA). Twenty WMA's have been delineated within New Jersey's five basins. Each basin constitutes a "Water Region." Within each WMA are several sub-basins, delineated by the United States Geological Survey (USGS) as "hydrologic units," scale 11 (HUC11). The sampling frequency reflects a realistic temporal lag between cessation of an environmental perturbation and recovery of the impacted biological community. The 305b Water Quality Inventory, which reexamines changes in New Jersey's stream systems on a two-year cycle, has indicated that five years is an optimum period for long-term biomonitoring. An ample network of stations is required for the creation of a long-term database, which in turn, is necessary for trend analysis and operation of predictive water quality models.

On the smallest tributaries, sampling sites were located as close to headwaters as practical. To ensure enough flow for sampling, sites on "first-order" streams were situated at least three miles downstream of headwaters (first order streams are those with no tributaries). Since most streams at this level have very little, or only intermittent, flow, most sites were situated on second-order streams (with only first-order streams as tributaries) and higher (with a greater hierarchy of tributaries). All sites were located in reasonably accessible and primarily wadable segments of a stream.

To maximize data correlation wherever possible, AMNET incorporated existing stations of the ambient Surface Water Chemical Monitoring Network, which is administered jointly by NJDEP and the USGS. Furthermore, so as to gauge the effects of major tributaries and larger lakes, many AMNET sites were located near their confluence or outlet. Also considered when selecting sites were known sources of contamination (e.g. point-source discharges, agricultural operations) and significant natural features such as wetlands, parks or wildlife management areas.

12. EXISTING WATER QUALITY NETWORK

Status: Recommended with funding commitment, but not yet underway.

Lead Entity: NJ Department of Environmental Protection & US Geological Survey

Contact Person: Paul Burt
NJDEP – Freshwater and Biological Monitoring
Phone: (609) 633-7039

Number of Sampling Sites: 18 sites proposed within the Barnegat Bay watershed. 200 sites are to be added to the existing 115 stations located throughout the State over the four-year implementation of the Existing Water Quality Network program.

Sampling Period: October 2000 through September 2004.

Sampling Frequency: One time per year at each station.

Environmental Media: Water quality data.

Parameters/Metrics Collected:
FW Waters: Specific conductance, pH, water temperature, dissolved Oxygen, Sulfate, Chloride, total suspended solids, total dissolved solids, total Phosphorous, Nitrate, Nitrite, Ammonia, total Kjeldahl Nitrogen, flow, turbidity, total ortho-Phosphorous.
SE Waters: Specific conductance, pH, water temperature, dissolved Oxygen, Ammonia, total suspended solids, sample at low tide, turbidity.

Type of Database Used for Data Management and Data Reporting Outlet: EPA STORET database and in GIS format through the NJDEP website.

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: Year 1: $467,320
Years 2 - 4: $364,570
Year 5: $111,117
Total: $1,672,147

Narrative Description of Project: In 1976, NJDEP and USGS initiated a statewide ambient stream-monitoring network. The number of monitoring stations varied over the years and a major revision in 1997 resulted in a 115-station network. The current network was deemed insufficient to accurately assess existing water quality in each of the watershed management areas. In 2000, a proposal from the Division of Watershed Management was approved by the Commissioner of NJDEP to enhance the Surface Water Quality Monitoring Network. The Existing Water Quality Network was created to nearly triple the number of stations being monitored to 315. The goal of the EWQ Program is to put a station in every HUC-11 watershed area and to put 15 percent of the new stations in saltwater (SE) waters.

EWQ sites were colocated with existing AMNET stations whenever possible so that biological and chemical data are collected at the same location. EWQ sites were also located at the more downstream portions of the HUC-11 geographical watershed delineations so they would reflect a larger portion of the watershed area. Stations were located in headwater portions of streams for the purpose of measuring stream segments that have been impacted relatively little to provide a 'baseline" for comparing data from further downstream. The minimum drainage area for these headwater reference stations is five square miles to ensure dependable water flow in a variety of conditions for the purposes of sampling.

13. MARINE MONITORING NETWORK

Status: Ongoing

Lead Entity: NJ Department of Environmental Protection

Contact Person: Robert Connell
NJDEP – Marine Monitoring
Email: rconnell@dep.state.nj.us

Number of Sampling Sites: Approximately 40 sites in the Barnegat Bay Estuary.

Sampling Period: N/A

Sampling Frequency: Varies.

Environmental Media: Salinity, dissolved oxygen, suspended solids and nutrients. At certain stations in the tidal portion of New Jersey's rivers, monitoring is performed using automated data loggers. These instruments make almost continuous measurements for 24 - 72 hours. These locations are available at http://www.state.nj.us/dep/watershedmgt/bmw/serv02.htm. Graphs will be displayed of the results of the most recent deployment of the data logger at that location.

Parameters/Metrics Collected: Sample Collection Date, Sample Collection Time Marine Water Monitoring Sampling Station ID, Sample Depth (ft), Temperature, Secchi Depth, Salinity, Dissolved Oxygen , Total Suspended Solids, Ammonia (total), Nitrate + Nitrite (total), Orthophosphate (total), Total Nitrogen, Fecal Coliform, Total Phosphorus, Chlorophyll a, Enterococcus, E. coli.

Type of Database Used for Data Management and Data Reporting Outlet: Data from specific sampling points is available at:
http://www.state.nj.us/dep/watershedmgt/bmw/serv02.htm

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

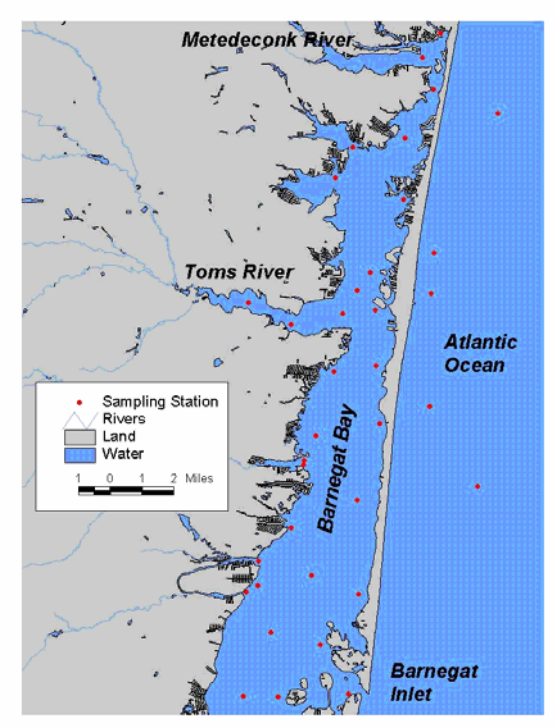
Narrative Description of Project: These datasets are the result of an ongoing monitoring program for key chemical parameters in estuarine and coastal waters throughout New Jersey. This program monitors basic parameters such as temperature, salinity, dissolved oxygen, and also for parameters relating to the major nutrients effecting primary productivity. Fecal coliform bacteria have been included as a means to assess the sanitary quality of the waters and to test for correlations with the other parameters being analyzed.

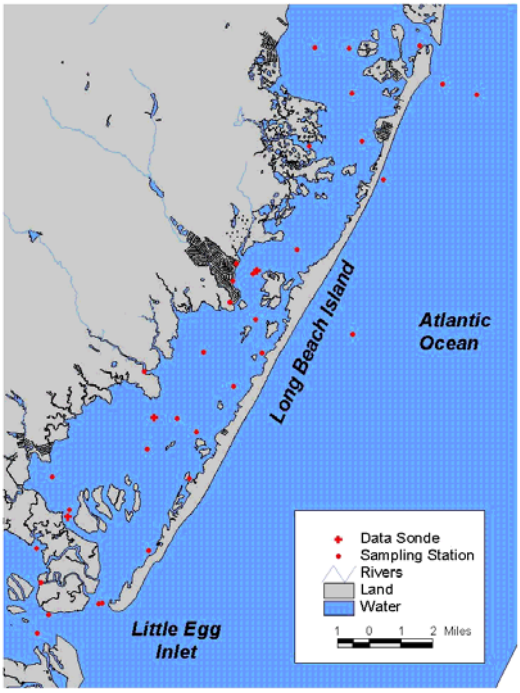
In addition to regular monitoring of water quality, the Bureau of Marine Water Monitoring is involved in a number of studies to provide better assessment of the causes of coastal water quality degradation. These activities currently include the following:

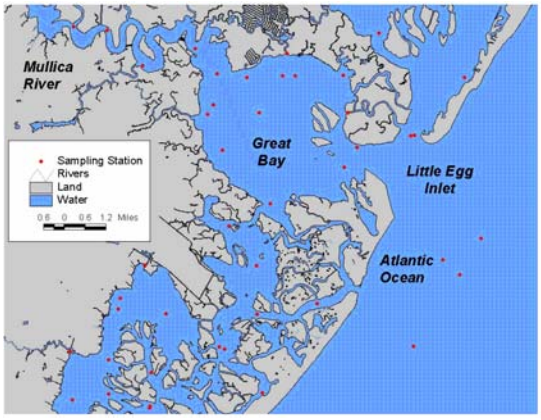
1) performing water quality investigations pertaining to identification and control of point and non-point pollution sources in bay and ocean locations;
2) conducting shellfish-related research studies in conjunction with State, Federal and academic institutions; and
3) conducting a multi-year study of pollutant loads from storm water. The study is being conducted in the Toms River basin. It will provide the Department with information on the amount of certain pollutants being carried in storm water and how those pollutant loads are related to land use. It is a cooperative study between the U.S. Environmental Protection Agency, the New Jersey Department of Environmental Protection and the U.S. Geological Survey.

Monitoring coastal water quality involves the use of sensitive laboratory procedures for detection of nutrients, salinity, oxygen, bacteria and viruses. The Bureau of Marine Water Monitoring provides analytical and technical support to other governmental agencies involved in coastal water issues. Such support includes:

- Microbiological sample analysis for bacterial indicators such as total coliform, fecal coliform, fecal strep, *Enterococcus* and *Clostridia*. Specialized capability in analysis of coastal water and shellfish tissue samples for public health concerns.
- The Bureau routinely provides support to the New Jersey Department of Health on issues relating to seafood safety. Specialized capability in low-level nutrient and metals analysis required for marine samples.
- The Bureau also is working closely with the academic community in the development of a viral indicator of human waste known as coliphage. These sensitive tests are providing the state with a better means of assessing the sources of coastal pollution.







NJDEP Marine Monitoring Network

14. SALTWATER-MONITORING NETWORK

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: Various annually; Recently between 0-6 wells.

Sampling Period: 1940's – continuing.

Sampling Frequency: Annual.

Environmental Media: Groundwater.

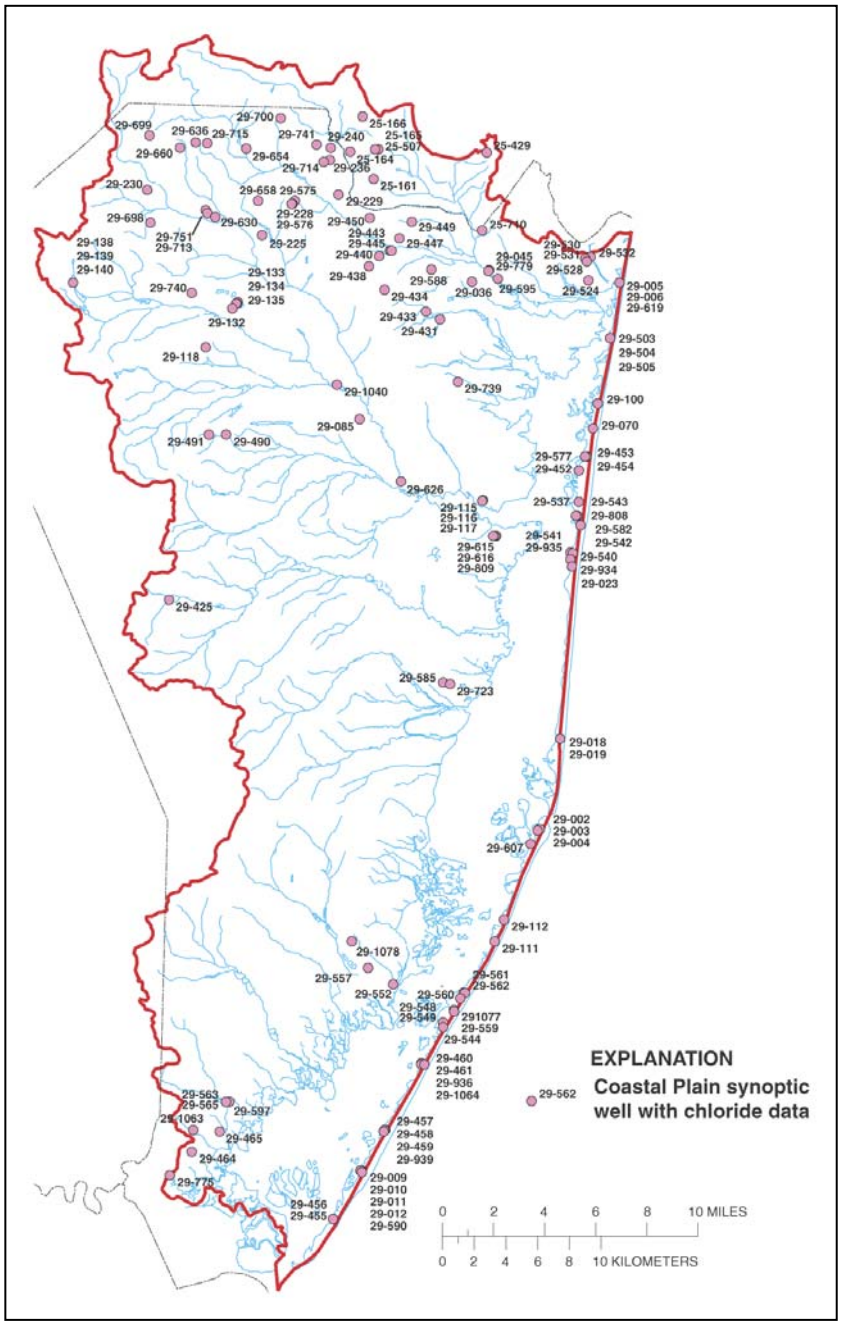
Parameters/Metrics Collected: Chloride, Sodium, Specific conductance, temperature, and pH.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: $7,000 per year

Narrative Description of Project: The NJDEP/USGS Chloride Monitoring Network documents the movements of saltwater into freshwater aquifers. Each year, a number of wells are selected for sampling from a pool of about 135 wells for which historical data and chloride data are available.



NJDEP/USGS chloride monitoring network site pool (Zero to six wells sampled each year are selected from this pool of 135 wells).

15. HISTORICAL WATER QUALITY DATA IN USGS NWIS DATABASE

Status: Ongoing

Lead Entity: US Geological Survey

Contact Person: Richard H. Kropp, District Chief
US Geological Survey
810 Bear Tavern Road
W. Trenton, NJ 08628
Phone: (609) 771-3900
Email: rkropp@usgs.gov

Number of Sampling Sites: 121 surface water sites; 440 groundwater sites.

Sampling Period: Various years.

Sampling Frequency: Various

Environmental Media: Surface water quality and groundwater quality.

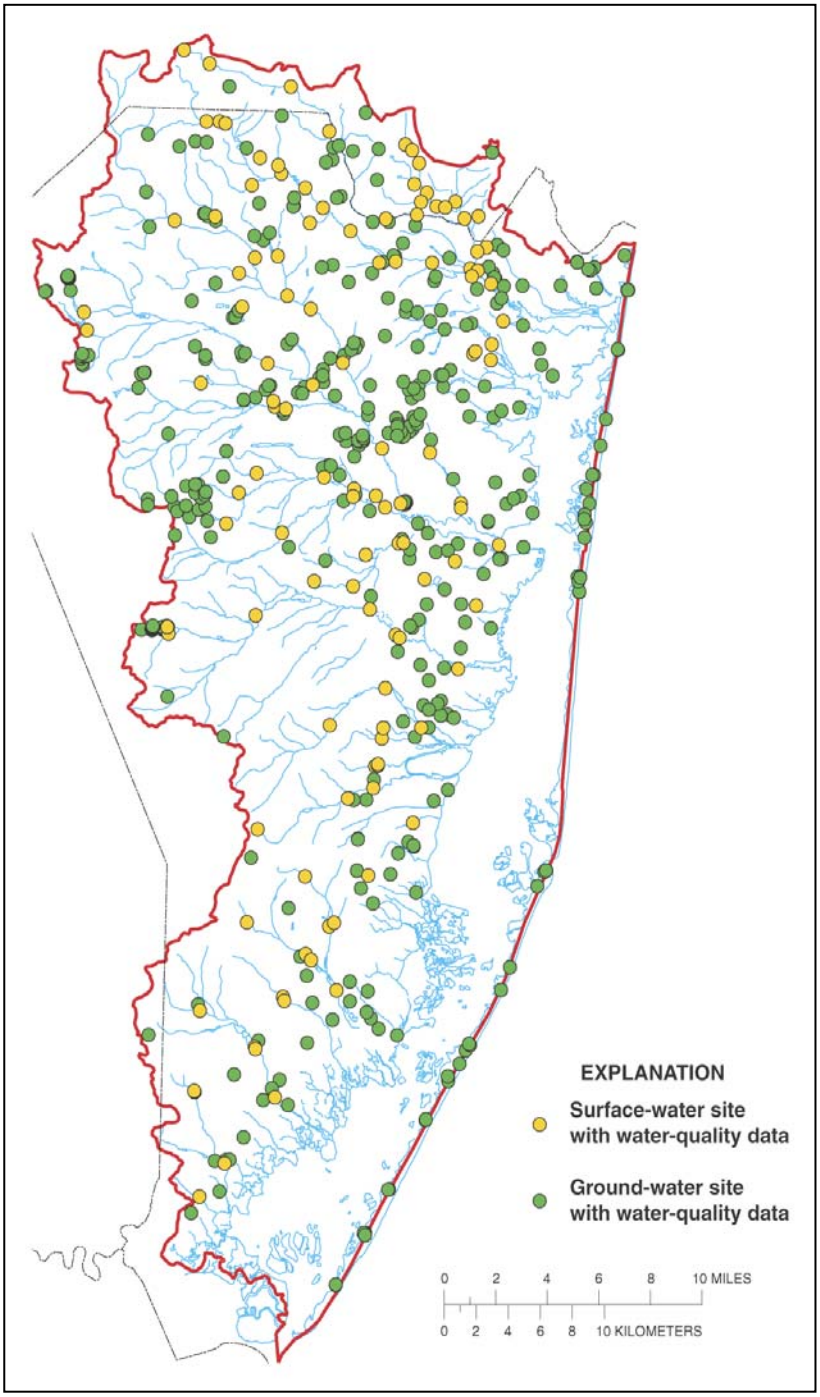
Parameters/Metrics Collected: Field measurements and parameters, bacteria, major ions, nutrients, trace elements, gross alpha and gross beta radioactivity, dissolved pesticides (48 compounds) and volatile organic compounds (60 compounds). Data collected varies by site.

Type of Database Used for Data Management and Data Reporting Outlet: Relational database
USGS web site http://water.usgs.gov/nj/nwis/
Annual Publication-Water Resources Data, New Jersey, Volume 3

Quality Assurance/Control Procedures: USGS District QA plan.

Estimated Cost: N/A

Narrative Description of Project: Historical data on surface water and groundwater quality has accumulated in the USGS NWIS database for decades. The data were collected for a variety of purposes, in cooperation with numerous local, state and federal agencies. Parameters of record vary widely by site.



Sites with historical water-quality data in USGS NWIS database.

16. CHEMICAL CONTAMINANT STUDIES ONGOING IN THE BARNEGAT BAY-LITTLE EGG HARBOR ESTUARY

Status: Ongoing

Lead Entity: Different lead entity for each of eight studies. Oyster Creek Nuclear Generating Station (OCNGS), Olsen et al., Renwick, NJDEP, Koehnken, Simpson and Bopp, Moser & Bopp, Burger

Contact Person: Michael J. Kennish
Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick, New Jersey 08901
Phone: (732) 932-8959 ext. 240

Number of Sampling Sites: Multiple sites.

Sampling Period: Study specific.

Sampling Frequency: Variable.

Environmental Media: Air, water, sediments, and biota.

Parameters/Metrics Collected: Radionuclides, metals, PAH's, PCB's, DDT's, Chlordane.

Type of Database Used for Data Management and Data Reporting Outlet: Varies; Annual Reports, Academic Theses, Science Journals

Quality Assurance/Control Procedures: Variable

Estimated Cost: Varies

Narrative Description of Project: An overview of previous investigations of chemical contaminants in the Barnegat Bay – Little Egg Harbor estuary is provided as a basis for comparison to Coastal 2000 and Coastal 2001 projects. Eight investigations are reported:

1) Oyster Creek Nuclear Generating Station (1969 – Present; radiological monitoring surveys). Oyster Creek Nuclear Generating Station surveys have revealed low levels of radionuclides (e.g. Co, Cs, Mn, Sr) in biotic sediment samples from Barnegat Bay.
2) Olsen et al. (1980; trace metals).
3) Renwick (1983; trace metals). Renwick recorded moderate to high levels of trace metals in the Metedeconk River (Arsenic, Copper, Lead and Mercury), Double Creek Channel (Arsenic and Lead), and West Creek (Arsenic).
4) NJDEP (1988; PAH's).
5) Koehnken (1990; trace metals).
6) Simpson and Bopp (1992; trace metals, PAH's and PCB's).

7) Burger (1997; trace metals).
8) Moser and Bopp (2001; trace metals PAH's and PCB's).

Results of Olsen et al. (1980), NJDEP (1988), Koehnken (1990), Simpson and Bopp (1992), and Moser and Bopp (2001) indicate that chemical contaminants (trace metals, PAH's and PCB's) are substantially higher in marina sediments and sediments of the northern estuary than elsewhere in the system. Mercury is a growing concern.

Burger (1997) documented Mercury levels in eggs and feathers of birds nesting in Barnegat Bay ranging up to 3.8 ppm and 10.3 ppm, respectively. High levels of Mercury have been found in the eggs of Forster's tern and black skimmer, and in the feathers of the Great egret, Snowy egret and black skimmer. These mercury levels are in the range known to reduce the hatchability of eggs, increase sterility and behavioral abnormalities of adults, and raise embryo and chick mortality. Relative to other lagoon-type estuaries, the Barnegat Bay – Little Egg harbor system exhibits elevated concentrations of some chemical contaminants (e.g. certain trace metals and PCB's). These findings justify the need for conducting national coastal assessment surveys in the estuary.

17. NATIONAL COASTAL ASSESSMENT ("COASTAL 2000")

Development of a probabilistic design and common survey indicators for assessing the health and condition of New Jersey coastal bays

Status: Ongoing

Lead Entity: New Jersey Marine Sciences Consortium

Contact Person: Michael P. Weinstein, Michael Danko and Steven Y. Litvin
Sandy Hook Field Station, Bldg. #22
Fort Hancock, New Jersey 07732
Phone: (732) 872-1300, ext. 21
Email: mweinstein@njmsc.org

Number of Sampling Sites: 37

Sampling Period: July - November

Sampling Frequency: Once per year

Environmental Media: Water, sediment, biota.

Parameters/Metrics Collected: Water: Temperature, Dissolved Oxygen, Salinity, Suspended Solids, Light Transmission, Chlorophyll a, Nitrogen [(Nitrate (NO3), Nitrite (NO2), Ammonia (NH4)] and Phosphorous [Orthophosphate, Suspended Phosphate (SP), Total Phosphate (TP)]
Sediment: Volatiles, Semivolatiles, Metals, Pesticides
Sediment Toxicity: Amphipod bioassay
Fish Community Analysis: Fish Pathology
Benthic Community Analysis

Type of Database Used for Data Management and Data Reporting Outlet: Computer files, web based, annual report prepared.

Quality Assurance/Control Procedures: EPA QA/QC Manuals, Region II.

Estimated Cost: $ 1 million/year

Narrative Description of Project: To rigorously assess the condition of New Jersey's estuaries, the New Jersey Marine Sciences Consortium (NJMSC) has implemented "Coastal 2000", a five-year program to develop common survey indicators and methods to advance the science of ecosystem condition monitoring. Coastal 2000 focuses on a strategic partnership among NJMC, NJDEP and the USEPA to conduct a probabilistic sampling design, with a common set of survey indicators that are comparable across the nation. Sampling populations are randomly allocated within a grid overlay, usually three stations per polygon, with grid dimensions a function of areas of concern. For Barnegat

Bay, 37 stations are sampled over an approximately three-week period during periods of peak faunal diversity to:

1) Measure routine water quality parameters, (temperature, salinity, dissolved oxygen, suspended sediments, water depth, Secchi depth) and light attenuation (PAR, transmittance).
2) Collect sediments for measuring contaminant concentrations (metals, organics), TOC toxicity (amphipod bioassays), sediment composition and macrobenthic community structure.
3) Collect nekton for community structure and tissue analysis using 10 minute tows with a 4.5 meter otter trawl.
4) Qualitatively characterize the area around each sampling station for marine debris (presence/absence), dominant vegetation (SAV, macrophytes, macroalgae), substrate type and physiographic setting (harbor, tidal creek, tidal flat, etc.).
5) Conduct QA/QC analyses on a subset of data in accordance with established USEPA procedures.
6) Prepare a data report that will be used to create a "snapshot" of existing conditions (physio/chemical and biological) in the Bay.
7) Publish study results in peer-reviewed journals.

A companion brown tide monitoring program is also being conducted at a subset of Coastal 2000 stations including 6 new sites, and additional measurement parameters (cell counts and monoclonal antibody analysis).

18. BARNEGAT BAY ESTUARY ASSESSMENT (REMAP)

An investigation under the Regional Environmental Monitoring and Assessment Program

Status: Recent (2001)

Lead Entity: Monitoring & Assessment Branch (MAB), Division of Environmental Science & Assessment (DESA), US EPA Region 2.

Contact Person: Darvene Adams, Project Leader or Paula Zevin
DESA-MAB (MS-220)
US EPA Region 2
2890 Woodbridge Avenue
Edison, NJ 08837
Email: Adams.Darvene@epa.gov
Email: Zevin.paula@epamail.epa.gov

Number of Sampling Sites: 80

Sampling Period: June 2001- August 2001

Sampling Frequency: Once per year.

Environmental Media: Water sediment, benthic macroinvertebrates.

Parameters/Metrics Collected: Water: Total suspended solids, Ammonia (total & dissolved), Orthophosphate (total & dissolved), Nitrate and Nitrite (total and dissolved), Fecal coliforms, Dissolved Oxygen, Salinity, Temperature, Secchi depth, Field observation for the presence of Submerged Aquatic Vegetation, Macroalgae, Floating debris.
Sediment: Total organic Carbon, Percent silt and clay, metals, PAHs, PCBs, organotins, Ampelisca Toxicity, field characteristics (color, texture, smell and biology)
Benthic Macroinvertebrates: species identification and enumeration.

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Excel; Final Report available on the Internet.

Quality Assurance/Control Procedures: National Coastal Assessment Coastal 2000; USEPA Office of Research & Development Washington, DC, August 2000.

Estimated Cost: $270,000 - direct costs
$392,000 - in-kind services

Narrative Description of the Project: The purpose of the proposed investigation is to generate a comprehensive biological and chemical assessment of Barnegat Bay to provide federal, State and local representatives to the Management Conference with scientific data that will assist in prioritizing watershed problems and support resource decisions. It will also provide an objective baseline to determine how conditions change over time.

This comprehensive assessment will fill needs identified by previous investigators by documenting pollutant effects on the biological community and the extent and nature of degradations. The project will characterize the entire bay for the health of its water, sediment and biota, and as a separate analysis will characterize the areas around marinas, since they are believed to be currently affected by metals and petroleum hydrocarbon contamination. Statistically generated associations between degraded aquatic life and particular stressors and could confirm the findings of earlier studies and lead to new insights.

Project Objective 1: Estuary-wide assessment. Evaluate statistically the current conditions of the Bay with respect to sediment quality, sediment toxicity, biological condition and water quality. The end results will also provide indicator baselines from which trends can be determined as a way to mark improvements in the Bay as better land use practices are implemented within the watershed.

1) What percentage of Bay sediment would be considered degraded when compared to guidelines derived from effects on life for organic contaminants and metals?
2) What percentage of Bay water is not supportive of healthy aquatic life or recreational use because of levels of dissolved oxygen, pathogens, nitrogen, phosphorous, suspended solids, chlorophyll a and other water quality parameters?
3) What percentage of the Bay shows degraded benthos as indicated by lack of abundance, species richness or sensitive species?

Project Objective 2: Marina sub-area assessment. Evaluate statistically the current conditions of areas within the influence of active marinas, using the indicators listed above, and identify the typical stressors.

Project Objective 3: Statistical associations. Determine which contaminants in sediment or which water quality conditions can be associated with biological effects.

19. DEVELOPMENT OF AN INDEX OF BIOTIC INTEGRITY FOR SMALL ESTUARIES

Status: Recommended with adequate funding commitment, but not yet underway (2000).

Lead Entity: Monitoring & Assessment Branch (MAB), Division of Environmental Science & Assessment (DESA), US EPA Region 2.

Contact Person: James Kurtenbach, Project Leader
DESA-MAB (MS-220)
US EPA-Region 2
2890 Woodbridge Ave.
Edison, NJ 08837
Email: Kurtenbach.James@epa.gov

Number of Sampling Sites: 138

Sampling Period: July 1999 – September 1999

Sampling Frequency: Once per site

Environmental Media: Water, sediment, epibenthos, Benthic infauna.

Parameters/Metrics Collected: Water: Conductivity, Dissolved Oxygen, Nitrate-Nitrogen, pH, salinity, temperature, water depth, water clarity.
Sediment: Color, odor, texture, metals, PAH's, composition.
Land Use: Benthos identification and enumeration.

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Excel

Quality Assurance/Control Procedures: Quality Assurance Project Plan.

Estimated Cost: N/A

Narrative Description of Project: The purpose of this project was to develop a biological index for epibenthic macroinvertebrates of the low intertidal-subtidal shallow estuarine waters in New Jersey, from Newark Bay to Cape May Harbor, including southern Barnegat Bay. A total of 138 sites were sampled for benthic macroinvertebrates, water quality, sediment composition, and nearby land use as characterized by field personnel. Thirty-six sites from the least altered estuaries were identified as reference sites. Benthic macroinvertebrates from the samples were identified and enumerated.

Taxonomic identifications and abundance of organisms were used to calculate a set of ecological attributes, called metrics, for use in index development. The 42 calculated metrics were in four categories of species richness; taxonomic composition; tolerance/intolerance; and ecological feeding groups.

Individual metrics were evaluated based on their ability to discriminate between reference and non-reference sites. Six non-redundant metrics were selected for incorporation into the index: total taxa, percent of taxa as amphipoda, percent of individuals as decapods, number of polychaete taxa, number of amphipod plus caridean shrimp taxa and percent individuals as carnivores/omnivores. Using this shallow water estuarine Index of Biotic Integrity (IBI), sixty-one percent of non-reference sites scored below the lower quartile of the reference site distribution.

The shallow water IBI shows promise as an effective assessment methodology for mid-Atlantic estuaries. It is economical to implement because of the sampling methodology, and it yields results similar to stream indexes already in use by New Jersey and other mid-Atlantic states. This work demonstrates that an estuarine-benthic IBI based on dip-net samples is effective and sensitive to perturbation gradients. Previously developed estuarine benthic indexes have been based on dredge or core samples of benthic infauna in water deeper than one meter.

20. APPLICATION AND VALIDATION OF MACROINVERTEBRATE PROTOCOLS ON ESTUARIES IN NEW JERSEY

Status: Ongoing, (2001).

Lead Entity: Monitoring and Assessment Branch (MAB) Division of Environmental Science and Assessment (DESA), U.S. Environmental Protection Agency, Region 2

Contact Person: James Kurtenbach, Project Leader
DESA-MAB (MS-220)
US EPA-Region 2
2890 Woodbridge Ave.
Edison, NJ 08837
Email: Kurtenbach.James@epa.gov

Number of Sampling Sites: 30

Sampling Period: Once per site.

Sampling Frequency: June 2001 – August 2001

Environmental Media: Water quality data, epibenthic macroinvertebrates, routine physical habitat.

Parameters/Metrics Collected: N/A

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Excel

Quality Assurance/Control Procedures: Quality Assurance Project Plan.

Estimated Cost: N/A

Narrative Description of Project: This project takes the development of the shallow water IBI (afore-referenced project) and validates it.

The study has three objectives:
1) To validate the epifaunal index.
2) To examine the relationships among several variables of epibenthic macroinvertebrates, land use, physical habitat and water quality data.
3) To compare an infaunal index with the epifaunal index.

Approximately thirty sites will be used to validate the proposed epibenthic index. Routine physical habitat and water quality data will be collected. A number of sites overlap the REMAP Barnegat Bay assessment. Samples from the field study, along with archived macroinvertebrate samples will be analyzed.

21. JACQUES COUSTEAU NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM WIDE MONITORING PROGRAM

Status: Ongoing

Lead Entity: Jacques Cousteau National Estuarine Research Reserve (JCNERR)

Contact Person: Sharon O'Donnell
Rutgers University Marine Field Station
132 Great Bay Boulevard
Tuckerton, New Jersey 08087

Michael J. Kennish
Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick, New Jersey 08901

Number of Sampling Sites: Seven currently and thirteen that have been recently terminated but may still provide relevant and timely information to the monitoring program for Barnegat Bay.

Sampling Period: 1996- Present

Sampling Frequency: 30 minutes**.**

Environmental Media: Water quality, meteorological data.

Parameters/Metrics Collected: Temperature, salinity, dissolved Oxygen, pH, turbidity, depth, air temperature, wind velocity.

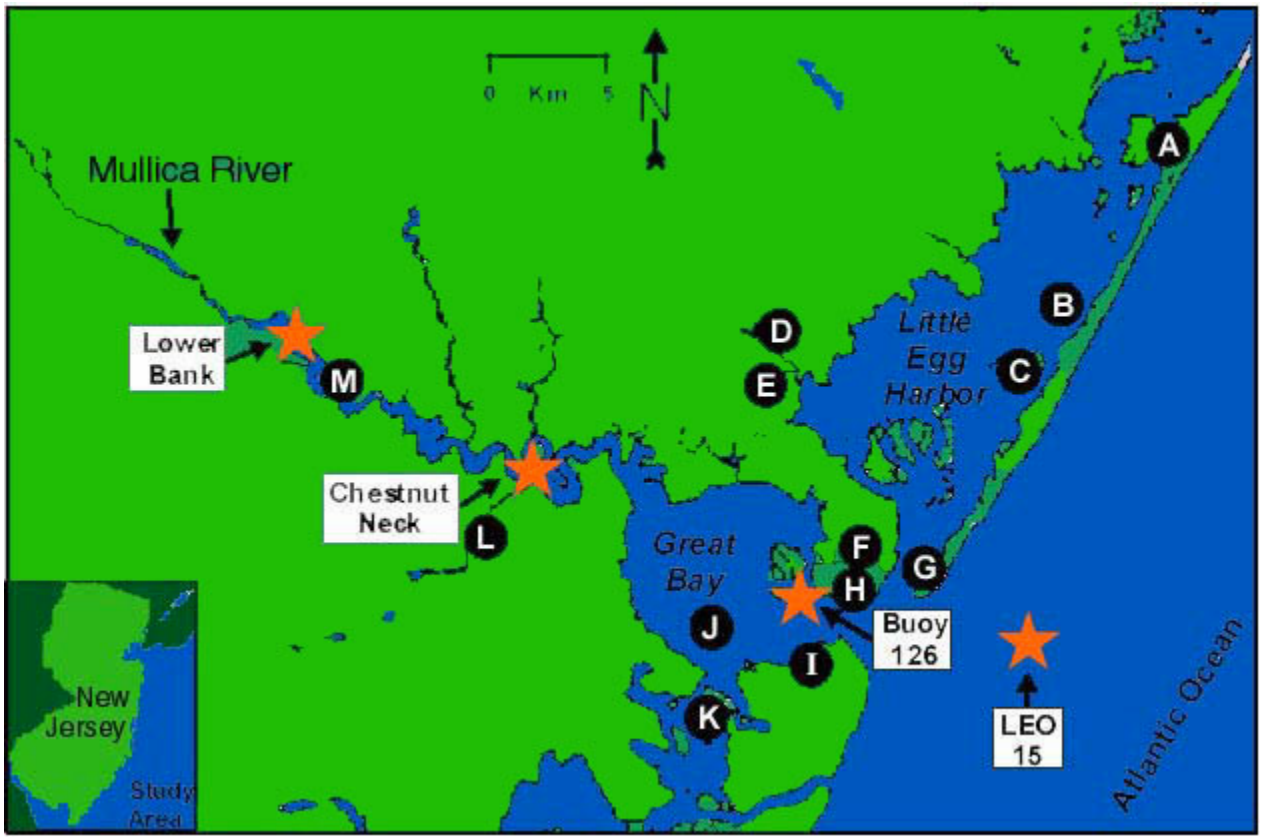
Type of Database Used for Data Management and Data Reporting Outlet:
NOAA/NERR national database;
CDMO: http://cdmo.baruch.sc.edu/
RUMFS: http://marine.rutgers.edu/rumfs/pg1.htm

Quality Assurance/Control Procedures: Biweekly operational check, data reviewed seasonally on-site, QA/QC nationally at the end of every year.

Estimated Cost: $66,000/year

Narrative Description of the Project: One of the primary objectives of the Jacques Cousteau National Estuarine Research Reserve (JCNERR) is to conduct long-term monitoring and research to characterize the natural and anthropogenic processes governing stability and change in the Mullica River, Great Bay, Little Egg Harbor, Little Bay and contiguous nearshore ocean waters (including the Long-Term Ecosystem Observatory at 15 m). Acquisition of these data is necessary to effectively address coastal resource management problems in this region of the State. Located in southern

New Jersey at ~39°, 74°W, the JCNERR system encompasses more than 27,000 hectares of open water habitat. Between 1976 and 1996, Rutgers University monitored temperature, salinity and turbidity at a single site (i.e. Rutgers University Marine Field Station) in the JCNERR. Since 1996, the most comprehensive database on water quality in the system has been collected as part of the System-Wide Monitoring Program (SWMP) established by the National Estuarine Research Reserve System. The JCNERR currently monitors six water quality variables (i.e. water temperature, salinity, dissolved Oxygen, turbidity, pH and depth) at five sites using YSI 6-series data loggers. These instruments record data semi-continuously (every 30 minutes) throughout the year and must be switched with newly programmed data loggers at the end of each deployment period (about every two weeks). Three SWMP monitoring sites are located along a salinity gradient in the Mullica River – Great Bay system. Two of the sites in the Mullica River include Lower Bank (~25 km. upriver) and Chestnut Neck (~13 km. Upriver). The Great Bay site is located at Buoy 126 approximately 3 km. West of Little Egg Inlet. In addition to these three sites, water quality is monitored with data loggers deployed at sites on Tuckerton Creek and Little Sheepshead Creek. Water quality is also monitored at the Long-Term Ecosystem Observatory (LEO-15), but not with the 6-series data loggers. In the past, data loggers were also deployed at Buoy 139 in Great Bay and Lake Pohatcong and Mill Run. Water quality monitoring using 6-series data loggers was scheduled to resume at Buoy 139 in Great Bay, as well as Buoy 115 in Little Egg Harbor in Spring 2002. The long-term SWMP data sets are being compiled at the JCNERR, which will enable both intra-annual (seasonal) and inter-annual patterns of physical-chemical variables to be accurately determined.



Location	Symbol	Duration of Study	Status	Objective
Lower Bank	Star	10/96-present	Ongoing	Permanent NERR Monitoring Site
Chestnut Neck	Star	9/96-present	Ongoing	Permanent NERR Monitoring Site
(B126) Intracoastal Waterway	Star	8/96-present	Ongoing	Permanent NERR Monitoring Site
LEO 15	Star	6/97-present	**Ongoing**	Permanent NERR Monitoring Site
Ship Bottom	A	2/97-5/97	Terminated	Larval Winter Flounder Transport
Ham Island	B	Summer 94 & 95	Terminated	Fish Habitat Quality
Marshelder Island	C	Summer 94 & 96	Terminated	Fish Habitat Quality
Tuckerton Seaport	D	11/98-present	Ongoing	Restoration of Anadromous Fish
Rutgers Dorm Pocket Marsh	E	1/96-7/96	Terminated	Marsh Characterization
Little Sheepshead Creek Bridge	F	2/96-5/96, 4/97-present	Ongoing	Ingress of Larval Fish
New Cove – Holgate	G	Summer 1997	Terminated	Winter Flounder Settlement

Rutgers Field Station Creek	H	11/95-present	Ongoing	Monitoring RUMFS Seawater Intake
Station Creek Upper End	H	9/96-11/96	Terminated	Fish Habitat Quality
Marsh Pool Surface and Bottom	H	1/96-5/97	Terminated	Marsh Pool Fish Microhabitat
Rutgers Field Station – Boat Dock	H	Summer 94 & 95	Terminated	Long Term Variation in Juvenile Fish Abundance
Little Beach	I	8/96-7/99	Terminated	Fish Habitat Quality
(B139) Intracoastal Waterway	J	Summer 94 & 95	Terminated	Temporary NERR Monitoring Site
Little Bay	K	8/96-7/99	Terminated	Fish Habitat Quality
Nacote Creek	L	5/97-4/98	Terminated	Temporary NERR Monitoring Site
Hog Island	M	5/97-10/97	Seasonal	Impact of Phragmites on Marsh Fishes
Lower Mullica River	N	6/99-1/00	Ongoing	Permanent NERR Monitoring Site

22. HYDROGRAPHIC STUDY OF BARNEGAT BAY

Status: Recent (completed 1998).

Lead Entity: Rutgers University Institute of Marine and Coastal Sciences and the Department of Civil and Environmental Engineering

Contact Person: George Guo
Rutgers University
Department of Civil and Environmental Engineering
623 Bowser Road
Piscataway, New Jersey 08873
Phone: (732) 445-4444
Fax: (732) 445-0577

Norb Psuty
Rutgers University
Institute of Marine and Coastal Sciences
71 Dudley Road
New Brunswick, New Jersey 08901
Phone: (732) 932-6555
Fax: (732) 932-8578

Number of Sampling Sites: 6 sites in 1995 and 1 site in Barnegat Inlet in 1997.

Sampling Period: 1/95, 5/95, 6/95, 7/95, 5/97.

Sampling Frequency: Continuous monitoring every 15 minutes.

Environmental Media: Estuarine water.

Parameters/Metrics Collected: Current velocity and direction, water depth, salinity, temperature.

Type of Database Used for Data Management and Data Reporting Outlet: Spreadsheet, project reports to NJDEP, student thesis, conference proceedings, journal papers. Additional information is available at: http://www.civeng.rutgers.edu/water/est/barnegat.htm

Quality Assurance/Control Procedures: Laboratory calibration of field instruments prior to deployment.

Estimated Cost: N/A

Narrative Description of the Project: The objective of the study was to conduct field data collection, statistical analysis and numerical modeling to quantify circulation patterns in Barnegat Bay. An s-4 meter was deployed to continuously (every 15 minutes) measure current velocity and direction, water depth (along with NOS and USGS tidal

gauge measurements), salinity and temperature over a one-month period. In addition, CTD was used to measure salinity and temperature distributions in the water column along transects for less than a tidal cycle and ADCP and Marsh-McBirney current meters were deployed to measure current velocity and direction along transects over less than a tidal cycle.

23. NITROGEN FLUX THROUGH BARNEGAT INLET

Status: Recent (completed in 2000)

Lead Entity: Rutgers University Institute of Marine and Coastal Sciences and the Department of Civil and Environmental Engineering

Contact Person: George Guo
Rutgers University
Department of Civil and Environmental Engineering
623 Bowser Road
Piscataway, New Jersey 08873
Phone: (732) 445-4444
Fax: (732) 445-0577

Norb Psuty
Rutgers University
Institute of Marine and Coastal Sciences
71 Dudley Road
New Brunswick, New Jersey 08901
Phone: (732) 932-6555
Fax: (732) 932-8578

Number of Sampling Sites: One site at Barnegat Inlet.

Sampling Period: 7/99-8/99, 8/99-10/99, 3/00-4/00, 6/00-7/00.

Sampling Frequency: Continuous (every hour).

Environmental Media: Estuarine water.

Parameters/Metrics Collected: Current velocity, water depth, salinity, temperature, Nitrate, Ammonia, dissolved organic Nitrogen and particulate organic Nitrogen.

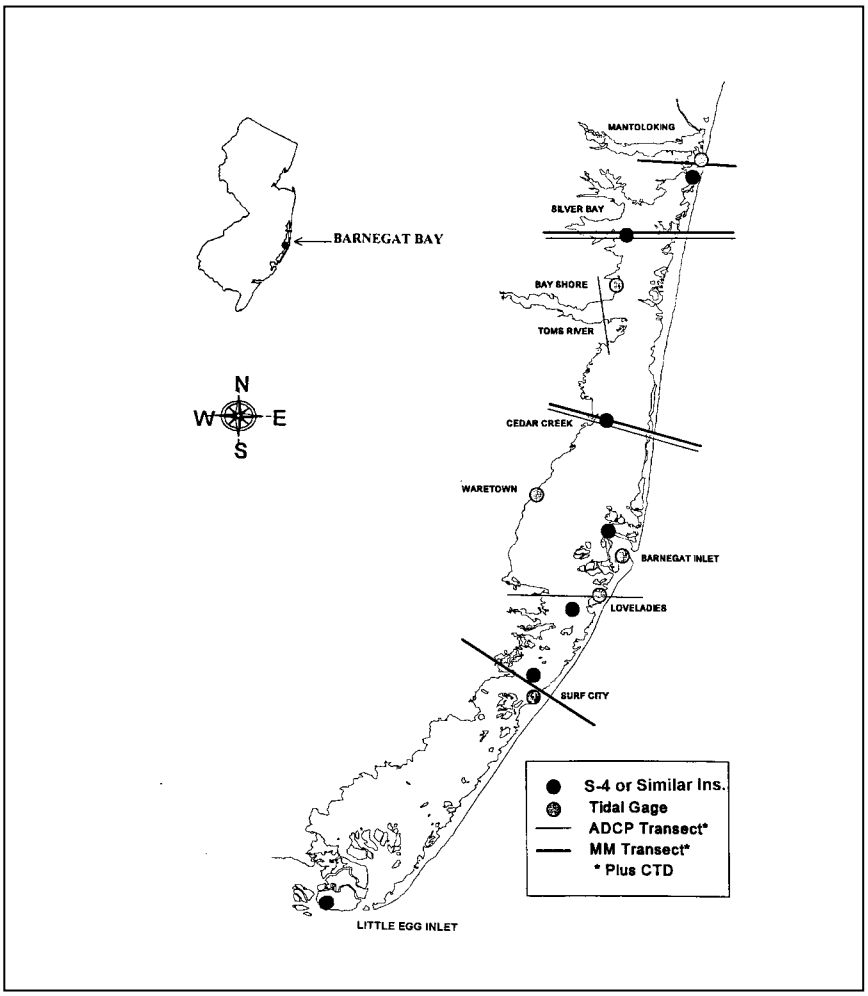
Type of Database Used for Data Management and Data Reporting Outlet: spreadsheet, New Jersey Sea Grant Newsletters, student thesis, conference proceedings, journal papers. Additional information is available at: http://www.civeng.rutgers.edu/water/est/barnegat.htm

Quality Assurance/Control Procedures: Laboratory calibration of field equipment prior to deployment.

Estimated Cost: N/A

Narrative Description of the Project: The objectives of the study were to conduct field data collection and statistical analysis to quantify Nitrogen flux through Barnegat Inlet. A RCM-9 current meter was deployed to continuously (every ten minutes) measure current velocity and direction, water depth, salinity and temperature over a one month

period. An *in situ* nutrient analyzer, NAS-2E, was deployed continuously (every hour) to measure Nitrate concentrations over a one month period. Concentrations of Nitrate, Ammonia, dissolved inorganic Nitrogen and particulate organic Nitrogen were measured in the laboratory from water samples taken every hour over a tidal cycle.



Distribution of Data Collection Points and Transects in Barnegat Bay System

24. SUSPENDED SOLID FLUX THROUGH SCHOONER CREEK

Status: Recent (completed in 1998).

Lead Entity: Rutgers University Institute of Marine and Coastal Sciences and the Department of Civil and Environmental Engineering

Contact Person: George Guo
Rutgers University
Department of Civil and Environmental Engineering
623 Bowser Road
Piscataway, New Jersey 08873
Phone: (732) 445-4444
Fax: (732) 445-0577

Norb Psuty
Rutgers University
Institute of Marine and Coastal Sciences
71 Dudley Road
New Brunswick, New Jersey 08901
Phone: (732) 932-6555
Fax: (732) 932-8578

Number of Sampling Sites: One site in Schooner Creek.

Sampling Period: 3/96-10/96.

Sampling Frequency: Continuous (every five minutes).

Environmental Media: Tidal Creek water.

Parameters/Metrics Collected: Current velocity and direction, water depth, turbidity, total suspended solids.

Type of Database Used for Data Management: Spreadsheet, student thesis, journal papers. Additional information is available at:
http://www.civeng.rutgers.edu/water/est/barnegat.htm

Quality Assurance/Control Procedures: Laboratory calibration of field equipment prior to deployment.

Estimated Cost: N/A

Narrative Description of the Project: The objective of the study on suspended solids flux through Schooner Creek was to conduct field data collection and statistical analysis to establish a methodology for continuously monitoring exchange of suspended solids between Schooner salt marsh and Great Bay (west of Little Egg Inlet) and to quantify the

salt marsh as a sink or source of suspended solids. (A map of locations was included in workshop materials.) A Marsh-McBirney current meter was deployed to measure current velocity and direction every five minutes. A field infrared nephelometric turbidimeter was used to measure turbidity every five minutes. Water samples were taken every hour for a total of about 50 tidal cycles to measure total suspended solids concentrations.

25. COASTAL COOPERATIVE WATER QUALITY MONITORING

Status: Ongoing

Lead Entity: Ocean County Health Department, Ocean County Utilities Authority

Contact Person: Ocean County Health Department
Robert Ingenito or Rae Ferrara
Phone: (732) 341-9700

Number of Sampling Sites: 34

Sampling Period: Seasonal, 1996 to date, May through September of each year.

Sampling Frequency: 1 sample per week, if fecal coliform count exceeds 201 Colonies/100mL, then sampling is repeated the following day until the level falls below. If the site requires enterococci and count exceeds 105, then the site is repeated the following day until the level falls below the standard. In both cases, this procedure is followed only if the sampling site is designated recreational.

Environmental Media: Recreational waters of the Barnegat Bay.

Parameters/Metrics Collected: Fecal Coliform and Enterococci counts

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Excel, will be converting to MSSQL using Microsoft Access as front end.

Quality Assurance/Control Procedures:
a) Sample bottle – sterility check
b) Filters and pads – each batch lot checked prior to use
c) Rinse water – sterility and pH check
d) Agar, broth – pH check, performance check (positive/negative recovery)
e) Duplicates – 10 percent of samples
f) Cross checks – 10 percent of samples (counts compared by two laboratory technicians)
g) MPN test monthly
h) Run initial enterococcus verification
i) Daily positive and negative checks
j) Temperature checks on baths twice daily as per NJDEP
k) Flow NJDEP (SM 18th, 19th Ed.) guidelines on expiration dates for agars and broths

Estimated Cost: $10 per analysis, does not cover sampling.

Narrative Description of Project: Bacterial monitoring of select recreational and environmental sites located within Ocean County during the summer season (May through September of each year). All sampling performed by the Ocean County Health Department personnel. The samples are then turned over to Ocean County Utilities

Authority's NJDEP-certified laboratory that performs all bacterial analyses under an Intra-Local Services Agreement (contract). The data is reported on a daily basis to the Ocean County Health Department who make the determination of whether to resample or close a recreational area due to bacterial contamination, currently fecal coliform.

26. BARNEGAT BAY WATCH MONITORING PROGRAM

Status: Ongoing

Lead Entity: Alliance for a Living Ocean

Contact Person: Carol Elliott
P.O. Box 95
Ship Bottom, New Jersey, 08008
Phone: (609) 492-0222
Livingocean@world.att.net

Number of Sampling Sites: 55 (not every station is sampled each year or each sampling period).

Sampling Period: 1992- Continuing.

Sampling Frequency: April to November – once every two weeks.

Environmental Media: Estuarine water quality.

Parameters/Metrics Collected: Wind direction, tidal stage, current flow, transparency, water depth, water temperature, pH, salinity, dissolved Oxygen, Nitrate, algal blooms, submerged aquatic vegetation, wildlife, precipitation.

Type of Database Used for Data Management and Data Reporting Outlet: Excel, data available upon request.

Quality Assurance/Control Procedures: Adherence to Environmental Protection Agency's volunteer monitoring procedures.

Estimated Cost: $5,000/year

Narrative Description of Project: The Barnegat Bay Watch Monitoring Program was designed to produce data that will aid in detection of episodic events and identification of trends or changes in habitats and water quality in order to provide interested agencies with information on the health and vitality of the Barnegat Bay ecosystem. It provides for ongoing monitoring of ecological conditions in the Bay by citizen volunteers. The NJDEP endorsed the usefulness of this volunteer-based water quality monitoring program as an integral component of the overall Barnegat Bay ambient biomonitoring program that was developed as part of the Management Plan for the Barnegat Bay watershed.

The sampling procedure consists of the monitors going to designated stations twice a month from April through November. The instruments and methods used for sampling were selected based on simplicity of use, cost and accuracy. The monitors use a Secchi disk for depth and transparency, thermometer (Centigrade), pH meter, LaMotte Chemical modified Winkler titration test kit for dissolved Oxygen and a Lamotte kit for Nitrates. Other observations such as algal bloom and submerged aquatic vegetation are rated by a

scale included in the monitors' handbook. Each new monitor is required to attend a testing session prior to monitoring a station. In addition to training sessions, QA/QC workshops are held twice a year to ensure the continued accuracy of data collected and to calibrate and replace faulty equipment.

27. BROWN TIDE ASSESSMENT PROJECT

Status: Ongoing

Lead Entity: New Jersey Department of Environmental Protection

Contact Person: Mary Downes Gastrich, Ph.D.
New Jersey Department of Environmental Protection - DRST
P.O. Box 409
Trenton, New Jersey 08625
Phone: (609) 292-1895
Email: mdownesg@dep.state.nj.us

Number of Sampling Sites: 2000: 44
2001: 11

Sampling Period: 4/00 – Continuing.

Sampling Frequency: in 2001: April (1), May (1), June (4), July (2), August (1), September (1).

Environmental Media: Aureococcus concentrations; water quality data.

Parameters/Metrics Collected: Salinity, temperature, dissolved oxygen, Secchi depth, chlorophyll a, NH3 (ammonia), NO3 (nitrate), NO2 (nitrite), orthophosphate, wind direction, wind speed, air temperature, water temperature, weather conditions, DIN (dissolved inorganic nitrogen), DON (dissolved organic nitrogen), TN (total nitrate) and TP (total phosphorous).

Type of Database Used for Data Management and Data Reporting Outlet: Excel database, Brown Tide Newsletters on NJDEP/DRST, project reports, scientific journals
Website: http://www.state.nj.us/dep/dsr/

Quality Assurance/Control Procedures: STD QA

Estimated Cost: $49,750/year

Narrative Description of Project: Brown tide blooms have recurred in Barnegat Bay and Little Egg Harbor, New Jersey since the mid-1990's. In 1999, a significant brown tide bloom was reported in these bays (NJDEP 2000; Gastrich 2000a, 2000b). The Brown Tide Assessment Project was developed in 1999 by the NJDEP because there are limited available data on these blooms (Gastrich, 2000b). The NJDEP/DRST established the Brown Tide Assessment Project in 1999 and is monitoring the brown tide blooms, caused by the minute algae *Aureococcus anophagefferens*, in coastal bays, including Barnegat Bay and Little Egg Harbor in New Jersey in 2000 and 2001. The three main objectives of the program are:

1) Characterize the spatial and temporal occurrence of brown tide blooms in little Egg Harbor and other coastal bays and to identify environmental factors and other physical-chemical data (that were not considered in 2000) that may promote the incidence and development of these blooms.
2) Utilize data from 2000 and 2001 to develop a suite of environmental indicators (e.g. concentration of A. anophagefferens, salinity, temperature, nutrients, mean tidal data, flushing times, nutrient loadings, etc.) that can be used to develop a predictive model to more fully predict the occurrence of blooms in Barnegat Bay and possibly other shallow estuaries with similar characteristics and to identify strategies to regulate and/or minimize brown tide blooms. Other data from groundwater sources that discharge to the Bay (e.g. iron and other micronutrients) if available from other agencies, such as USGS, will be included for analysis.
3) Continue to quantify the presence of viral-like particles (VLP's) before, during and at the end of brown tide blooms in Little Egg Harbor.

Water samples are collected by boat (NJ Marine Sciences Consortium/NJ Sea Grant) and helicopter (USEPA) and enumerated for A. anophagefferens by monoclonal analysis (USC). Environmental water quality data (e.g. salinity, temperature, nutrients, etc.) are also collected during sampling. Brown tide counts are compiled and summarized by stations and month of collection in graphs and discussed in the Brown Tide Newsletter on the NJDEP website: http://www.state.nj.us/dep/dsr/. Environmental data are being analyzed in relation to brown tide counts by Rutgers University. Additional sampling for brown tide counts is needed seasonally throughout the year. Additional data on nutrients (esp. dissolved organic Nitrogen) are needed during sampling as well. In addition, studies are needed to document impacts of brown tide blooms on natural resources (e.g. hard clams and eelgrass).

The State of New Jersey is enhancing its implementation of results-based environmental management through its continued participation in the National Environmental Performance Partnership Program (NEPPS). NEPPS emphasizes management of environmental results through its use of long-term indicators as measures of environmental progress. The NJDEP has also developed a strategic plan with specific goals and milestones. The following NEPPS/Strategic Plan goals and indicators are related to brown tide blooms:

1) Strategic Goal: Healthy ecosystems.
2) NEPPS Goal/subgoal: Water Quality – Surface; aquatic life designated use; Land and Natural Resources; coastal resources and flood-prone areas.
3) Indicator: S9. Status/Trends in phytoplankton blooms in assessed tidal waters.

28. BROWN TIDE MONITORING

Status: Ongoing

Lead Entity: New Jersey Marine Sciences Consortium

Contact Person: Michael P. Weinstein
Sandy Hook Field Station, Bldg. #22
Fort Hancock, New Jersey 07732
Phone: (732) 872-1300, ext. 21
Email: mweinstein@njmsc.org

Number of Sampling Sites: 11

Sampling Period: May - October

Sampling Frequency: Bi-weekly

Environmental Media: Estuarine water

Parameters/Metrics Collected: Routine water chemistry, nutrient analysis, cell counts, TEM.

Type of Database Used for Data Management and Data Reporting Outlet: Computer files, web-based annual report.

Quality Assurance/Control Procedures: EPA QA/QC Manuals, Region II

Estimated Cost: $19,000

29. FISH INDEX OF BIOTIC INTEGRITY

Status: The current IBI is only applicable to streams in northern New Jersey. However, the BFBM is collaborating with the Bureau of Freshwater Fisheries, the Division of Science, Research and Technology and the EPA (Region 2) to develop an IBI for coastal plain streams in southern New Jersey.

Lead Entity: NJDEP - Bureau of Freshwater and Biological Monitoring

Contact Person: Bud Cann
Phone: 609-292-0427

Number of Sampling Sites: 0 in the Barnegat Bay area currently.

Sampling Period: 2000 – continuing.

Sampling Frequency: N/A

Environmental Media: Variety, abundance, health of fish species.

Parameters/Metrics Collected: The current IBI measures the following metrics:

1. total number of fish species
2. number of benthic insectivorous species
3. number of trout and/or sunfish species
4. number of intolerant species
5. proportion of individuals as white suckers
6. proportion of individuals as generalists
7. proportion of individuals as insectivorous cyprinids
8. proportion of individuals as trout or proportion of individuals as piscivores (top carnivores)- excluding American Eel
9. number of individuals in the sample
10. proportion individuals with disease or anomalies (excluding blackspot disease)

Type of Database Used for Data Management and Data Reporting Outlet: Aerial photographs (as Windows Meta Files - pdf) and detailed data (in .pdf format) for each site can be viewed or downloaded by clicking on the links found at http://www.state.nj.us/dep/watershedmgt/bfbm/fishibi.html. A summary report is available at http://www.state.nj.us/dep/watershedmgt/bfbm/publications.html. Electronic versions (.pdf) of individual site reports are available by contacting Brian Margolis at bmargoli@dep.state.nj.us. Fish IBI network data is also available from EPA's computerized data system called "STORET".

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project:
The Bureau of Freshwater and Biological Monitoring recently implemented a fish monitoring program based on an Index of Biotic Integrity (IBI) developed by the EPA. An IBI is an index that measures the health of a stream based on multiple attributes (also referred to as metrics) of the resident fish assemblage.

During the summer of 2000, BFBM staff sampled fish assemblages at twenty sites in northern New Jersey using an electrofishing unit that momentarily stuns fish with an electric current. Stunned fish were collected in dip nets, identified, counted and released and an IBI score was calculated for each site. The BFBM plans to sample 80 more sites in northern New Jersey over the next four summers to establish a 100-site network.
The current IBI is only applicable to streams in northern New Jersey. However, the BFBM is collaborating with the Bureau of Freshwater Fisheries, the Division of Science, Research and Technology and the EPA (Region 2) to develop an IBI for coastal plain streams in southern New Jersey.

30. NEW JERSEY LANDSCAPE CHANGE ANALYSIS

Status: Ongoing

Lead Entity: Rutgers University Center for Remote Sensing and Spatial Analysis

Contact Person: Richard Lathrop
Center for Remote Sensing and Spatial Analysis
College Farm Road
Rutgers University
New Brunswick, New Jersey 08901-8551

Number of Sampling Sites: Entire watershed

Sampling Period: N/A

Sampling Frequency: 10/72 to present at approximately five to ten year intervals.

Environmental Media: Land cover

Parameters/Metrics Collected: Land cover type

Type of Database Used for Data Management: ERDAS IMAGINE and ESRI ArcView Geographic Information Systems
Website: http://www.crssa.rutgers.edu/projects/runj/bbay.htm
Quality Assurance/Control Procedures: Field reference checking using standard remote sensing protocols.

Estimated Cost: $50,000/year

Narrative Description of Project: This project is one component of CRSSA's New Jersey Landscape Change research program and more information is available at www.crssa.rutgers.edu/projects/lc. The goal of the program is to monitor New Jersey's changing landscape and provide feedback to the various local, State and Federal agencies concerned with the success or failure of land use and habitat management policies across the State and larger region. The more immediate objective of this project is to develop a standardized information base on the present land cover of the Barnegat Bay watershed and to map trends in land cover change during the 1970-1980-1990-2000 time periods. Using a combination of satellite imagery and aerial photography, land cover at varying levels of categorical specificity is mapped. This information is integrated into the Barnegat Bay GIS maintained by Rutgers CRSSA to monitor trends in habitat loss and alteration.

31. PIPING PLOVER MONITORING

Status: Ongoing

Lead Entity: U.S. Fish and Wildlife Service

Contact Person: Vinny Turner

Number of Sampling Sites: One

Sampling Period: 1987 to present (4/1 to 9/1)

Sampling Frequency: 3 days per week from April 1st to September 1st.

Environmental Media: Production (number of chicks successfully produced).

Parameters/Metrics Collected: Number of chicks per adult pair, estimate of fledged birds.

Type of Database Used for Data Management and Data Reporting Outlet: Excel spreadsheet, Microsoft 2000, Annual narrative, Report to Piping Plover – Atlantic Population Recovery Team.

Quality Assurance/Control Procedures: Wildlife Inventory Protocol (follow breeding history of all marked nests).

Estimated Cost: $2,993.28

32. BLACK SKIMMER/LEAST TERN MONITORING

Status: Ongoing

Lead Entity: U.S. Fish and Wildlife Service

Contact Person: Vinny Turner

Number of Sampling Sites: One

Sampling Period: 1987 – Present (5/15 – 9/15)

Sampling Frequency: 3 days per week from May 15th to September 15th

Environmental Media: Production of chicks.

Parameters/Metrics Collected: Number of chicks per adult pair, number of eggs per nest, total number of eggs, estimate of fledged birds.

Type of Database Used for Data Management and Data Reporting Outlet: paper files only, annual narrative, report to NJDEP – Division of Fish and Wildlife.

Quality Assurance/Control Procedures: Wildlife Inventory Protocol (follow breeding history of all marked nests).

Estimated Cost: $1,313.16

33. SONGBIRD POINT COUNT SURVEY

Status: Recent

Lead Entity: U.S. Fish and Wildlife Service

Contact Person: Gregory Gates

Number of Sampling Sites: 125

Sampling Period: 1997 – Present (5/25 to 6/10)

Sampling Frequency: Once per year

Environmental Media: Breeding songbirds

Parameters/Metrics Collected: Index of abundance (number of detections per time period).

Type of Database Used for Data Management and Data Reporting Outlet: Rbase 4.5 (relational database), annual narrative produced.

Quality Assurance/Control Procedures: Wildlife Inventory Protocol

Estimated Cost: $682.50

34. ANURAN CALL/COUNT SURVEY

Status: Recent

Lead Entity: U.S. Fish and Wildlife Service

Contact Person: Vinny Turner

Number of Sampling Sites: 13

Sampling Period: 1999- Present (2/20 to 5/30)

Sampling Frequency: 3 surveys
2/20-3/20
4/10-4/30
5/10-5/30

Environmental Media: Number of breeding frogs

Parameters/Metrics Collected: Index to abundance (number of detections per survey).

Type of Database Used for Data Management and Data Reporting Outlet: Rbase 4.5 (relational database), annual narrative, report to zone biologist.

Quality Assurance/Control Procedures: Wildlife Inventory Protocol

Estimated Cost: $196.98

35. SEABEACH AMARANTH POPULATION MONITORING

Status: Recent

Lead Entity: U.S. Fish and Wildlife Service

Contact Person: Annette Scherer

Number of Sampling Sites: 1 (Holgate Unit)

Sampling Period: 2001 – Present (8/01 – 9/01)

Sampling Frequency: Once per year

Environmental Media: Individual plants, patches of plants.

Parameters/Metrics Collected: Total number of plants per site, GPS locations.

Type of Database Used for Data Management and Data Reporting Outlet: New Jersey Heritage Program Database (internal use only); GIS map is planned to be produced by the New Jersey Field office; annual narrative, New Jersey Field Office reports.

Quality Assurance/Control Procedures: Search and mark all plants.

Estimated Cost: $46.60

36. SWAMP PINK, BOG ASPHODEL AND CURLY-GRASS FERN POPULATION MONITORING

Status: Recent

Lead Entity: Associates for Conservation and Environmental Studies (ACES)

Contact Person: Dr. E. Vivian and Terry O'Leary

Number of Sampling Sites: One (Oxycoccus property)

Sampling Period: 1998-Present

Sampling Frequency: Once per year

Environmental Media: Individual plants, patches

Parameters/Metrics Collected: Total number of plants per site, plans to GPS plant locations

Type of Database Used for Data Management and Data Reporting Outlet: New Jersey Natural Heritage Program database (internal use only) and ACES paper files; New Jersey Field Office Reports.

Quality Assurance/Control Procedures: Search and mark all plants.

Estimated Cost: N/A

37. HARD CLAM STOCK ASSESSMENT

Status: Not presently funded.

Lead Entity: New Jersey Department of Environmental Protection – Division of Fish and Wildlife – Bureau of Shellfisheries.

Contact Person: Mike Celestino
Nacote Creek Research Center
P.O. Box 418
Port Republic, New Jersey 08241

Number of Sampling Sites: 304

Sampling Period: Data have been collected from 5/85 – 8/86
Data were proposed to be collected 4/02 – 10/02

Sampling Frequency: One sample per station.

Environmental Media: Benthic fauna (Hard clam) and Flora (Eelgrass)

Parameters/Metrics Collected: Hard clams: species abundance and distribution
Eelgrass: presence/absence

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Excel 97 and ArcView GIS, completion report submitted to regulatory agencies; data is available upon request.

Quality Assurance/Control Procedures: Adherence to National Marine Fisheries Service approved methods.

Estimated Cost: $45,195

Narrative Description of Project: The objectives of the project are to quantitatively assess hard clam populations and map the distribution of eelgrass in Barnegat Bay. There has not been a hard clam stock assessment of Barnegat Bay since 1985/1986.

The sampling procedure consists of towing a miniature hydraulic clam dredge (knife width of one foot) from a 32-foot research vessel to collect adult shellfish. The dredge is constructed to collect all hard clams 30 mm. in length or greater. Stations to be sampled will be located with a differential Global positioning System (GPS). One 100-foot tow will be made at each station. All hard clams and paired hard clam valves collected will be measured to the nearest millimeter. Other commercially important shellfish species collected will be noted. In addition, data will be collected on the distribution of eelgrass, *Zostera marina*, throughout the Bay.

38. OSPREY POPULATION MONITORING

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: K. Clark
Phone: (609) 628-2103
Email: kclark2@dep.state.nj.us

Number of Sampling Sites: All nests within the state

Sampling Period: May – June; since 1975 and continuing.

Sampling Frequency: Once per year.

Environmental Media: Osprey nesting population.

Parameters/Metrics Collected: Number of occupies nests, nest productivity.

Type of Database Used for Data Management and Data Reporting Outlet: Spreadsheet, Unpublished annual report, occasional journal papers.

Quality Assurance/Control Procedures: Aerial and ground surveys; Natural Heritage Database.

Estimated Cost: $ 20,000 per year

39. PEREGRINE FALCON MONITORING

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: K. Clark
Phone: (609) 628-2103
Email: kclark2@dep.state.nj.us

Number of Sampling Sites: All nests within the Barnegat Estuary (approximately 3 to 4)

Sampling Period: April - June; since 1980 – continuing.

Sampling Frequency: Once per year.

Environmental Media: Peregrine falcon nesting population.

Parameters/Metrics Collected: Number of occupies nests; nest productivity.

Type of Database Used for Data Management and Data Reporting Outlet: Spreadsheet, Unpublished annual report, occasional journal paper; U.S. Fish and Wildlife Service.

Quality Assurance/Control Procedures: Ground surveys; Natural Heritage Database.

Estimated Cost: $15,000 per year

40. MIGRATORY SHOREBIRD MONITORING

Status: Recommended for implementation by a funding agency, but not yet underway.

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: A. Dey
Phone: (609) 628-9451
Email: adey@dep.state.nj.us

Number of Sampling Sites: To be determined; at least two.

Sampling Period: May/June and August/September

Sampling Frequency: Weekly or biweekly

Environmental Media: Migrating shorebirds

Parameters/Metrics Collected: Species abundance and diversity.

Type of Database Used for Data Management and Data Reporting Outlet: Spreadsheet, Northeast Regional Shorebird Working Group, International Shorebird Survey.

Quality Assurance/Control Procedures: N/A

Estimated Cost: Estimated $7,500 per year

41. COLONIAL WATERBIRD SURVEYS

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: D. Jenkins
Phone (609) 984-1581
Email:djenkins@dep.state.nj.us

Number of Sampling Sites: All active colonies within the Estuary.

Sampling Period: June

Sampling Frequency: Irregular; currently done approximately every five years.

Environmental Media: Populations of 17 species of colonial nesting waterbirds. Nesting sites.

Parameters/Metrics Collected: Aerial survey. Counts of adults present at nesting sites and number of active nesting sites.

Type of Database Used for Data Management and Data Reporting Outlet: Dbase used previously, in the process of converting to Microsoft Access and ArcView GIS; Unpublished report; US Geological Survey – BRD (occasionally); NHP (Natural Heritage Program)/BCD database; NEPPS (USEPA and NJDEP).

Quality Assurance/Control Procedures: Aerial survey. Count procedure has been standardized and used consistently since 1979. Some cross checking with ground counts is also done.

Estimated Cost: $35,000 per survey

42. BEACH NESTING BIRD MONITORING: PIPING PLOVER

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: D. Jenkins
Phone (609) 984-1581
Email:djenkins@dep.state.nj.us

Number of Sampling Sites: All active nesting sites within the Estuary. All suitable habitat for Piping Plovers every five years.

Sampling Period: April - August

Sampling Frequency: Annual (all active nesting areas). Every five years (all potentially suitable habitat).

Environmental Media: Piping plover nesting populations.

Parameters/Metrics Collected: Adults present, nesting pairs, nesting attempts, nesting success, productivity.

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Access and Excel spreadsheet; U.S. Fish and Wildlife Service, Federal Aid Report, Five-year survey data reported to coordinator of International Piping Plover Census. Natural Heritage Program (NHP) -–BCD

Quality Assurance/Control Procedures: Training of seasonal observers by ENSP staff.

Estimated Cost: $30,000 per year

43. BEACH NESTING BIRD MONITORING: LEAST TERN AND BLACK SKIMMERS

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: D. Jenkins
Phone (609) 984-1581
Email:djenkins@dep.state.nj.us

Number of Sampling Sites: All active nesting sites within the Estuary. All suitable habitat every five years.

Sampling Period: May - August

Sampling Frequency: Annual (all active nesting areas). Every five years (all potentially suitable habitat).

Environmental Media : Least tern and Black Skimmer populations.

Parameters/Metrics Collected: Adults present, number of nests, number of colonies, qualitative assessment of productivity.

Type of Database Used for Data Management and Data Reporting Outlet: Excel spreadsheet; Unpublished annual report; Natural Heritage Program – BCD, NEPPS (USEPA and NJDEP).

Quality Assurance/Control Procedures: Training of seasonal observers by ENSP staff. Periodic cross checking among observers. Beginning to experiment with mark/recount technique.

Estimated Cost: $15,000 per year

Narrative Description of Project: For more than a decade the Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP), has focused considerable attention on the research, monitoring, protection, and management of three species of beach nesting birds. Included in this group are the least tern, the black skimmer and the piping plover. All three species are listed as endangered by the N.J. Department of Environmental Protection and the piping plover has been listed as threatened by the U.S. Fish and Wildlife Service since 1986.

Each of these species makes their nests on the barrier beaches by scraping a shallow depression in the sand just above the high tide line. Skimmers and terns nest in colonies ranging size from a few to several hundred birds, while piping plovers are solitary nesters. All three species occasionally nest on the same beaches. The nesting habits and habitats of these three species have placed them in jeopardy because human uses of the

barrier beaches are often incompatible with successful nesting. The factors contributing to the endangerment of these birds in New Jersey include loss of suitable nesting habitats to development and erosion, disturbance of nesting activities by beach-goers and their pets, and excessively high levels of predation exacerbated by human disturbance.

44. MONITORING TREND IN NEOTROPICAL MIGRANT LAND BIRD POPULATIONS AND THEIR HABITATS

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: Amanda Dey and Sharon DeFalco
Phone: (609) 292-3451
Email: adey@dep.state.nj.us

Number of Sampling Sites: 352 within Barnegat Bay (Total number: 1,411 in Pinelands Landscape Area).

Sampling Period: Late May to June of 1999.

Sampling Frequency: Every five years.

Environmental Media: Land bird populations and habitats.

Parameters/Metrics Collected: Species abundance; species diversity; landscape composition, configuration, edge and patch characteristics.

Type of Database Used for Data Management and Data Reporting Outlet: ArcView GIS and spreadsheet; data is available through the Landscape Project (ENSP) and through NEPPS (ESEPA and NJDEP).

Quality Assurance/Control Procedures: Contractors skilled in bird identification by sight and song. Survey data is proofed. Digitizing of survey locations into and ArcView coverage is performed by the Endangered and Nongame Species Program (ENSP).

Estimated Cost: $12,000 per survey

Narrative Description of Project: Neotropical migrants are birds of the Western Hemisphere that migrate long distances from wintering grounds in the New World Tropics (or "Neotropics") to breeding grounds in North America. The Neotropics are generally defined as the tropical regions of Mexico, and Central and South America that lie south of the Tropic of Cancer.

There are 361 species of Neotropical migrant birds ranging from herons and raptors to swallows and warblers. Over 130 species breed right here in New Jersey, and nearly 80 of these are songbirds.

Over the past 20 to 30 years, biologists have been documenting the alarming declines of many Neotropical migrant bird populations. Habitat loss and fragmentation, caused by development and other human activities, are the main causes of population declines.

Many species of Neotropical migrant birds are experiencing population declines mainly because of the loss and fragmentation of breeding, wintering, and migratory stopover habitats. These long distance migrants generally tend to be more vulnerable to habitat loss and fragmentation than birds that are resident or those that migrate only short distances within North America.

Over the past 30 years, extensive research in North American breeding areas, particularly in northeastern forests, has clarified the major factors that make Neotropical migrants vulnerable to population declines. Many species require particular habitat types for breeding (i.e., "habitat specialists"), require large tracts of habitat for successful breeding, or share both of these characteristics. As habitats are lost and become more fragmented, there is less suitable habitat available, and threats to adult birds and their young increase. Mammalian and avian predators and brown-headed cowbirds tend to be more abundant in fragmented landscapes. In addition, tower strikes during migration and predation by free-ranging house cats have been estimated to kill tens of millions of birds each year.

Migration itself is hazardous - bad weather, predators, radio towers, and tall buildings with reflective glass claim very large numbers of birds each year. Migration is physically demanding - birds require quality habitats along migration routes to rest, replenish fat reserves and escape predators. The loss of habitat along migration routes reduces chances for survival. Migration is also very time consuming - this means that migrants have little time in which to breed, generally late April to mid-June. Many species usually have only one chance at successfully fledging young. If the first nest is destroyed or preyed upon, a second nesting attempt usually has a much lower probability of success.

Research on Neotropical wintering grounds has revealed that, as with breeding habitat, many species require specific habitat types during winter months. Males and females of many species, individually, defend their own winter foraging territories and return to these same territories year after year; this is called "site fidelity". The continuing loss of habitat in the Neotropics has a grave impact on overwinter survival of birds and decreases the probability of successful migration and breeding the following spring.

As part of Landscape Project protection efforts, Endangered and Nongame Species Program (ENSP) Biologists commenced systematic surveys in 1994 to document statewide distribution and abundance of bird populations. As of the fall of 1999, the ENSP has completed bird and habitat surveys in three study areas: The Delaware Bay, Highlands and Pinelands Landscapes. The surveys covered a land area of approximately 2.5 million acres and generated 4,564 samples in a variety of habitat types.
ENSP biologists used this bird survey data in two ways. First, survey data for forest-dwelling Neotropical migrants was combined with location data for endangered and threatened forest species to identify and map critical forest habitats in the Delaware Bay and Highlands Landscapes. These forested areas are critical because they provide habitat for a diversity of species with many different life-history requirements. Species diversity is an indicator that a habitat is a healthy, functioning ecosystem -- these are the areas where conservation efforts are focused first. Over the last two decades the Northeast has experienced an increase in forested land, however, forested land now generally tends to be more fragmented. This has serious consequences for bird species that require large, contiguous forest tracts for successful breeding like worm-eating and Kentucky warblers,

as well as threatened and endangered raptors like the barred owl and red-shouldered hawk.

In addition to mapping critical areas for multiple species, the Neotropical migrant survey data will be used as a predictive tool for identifying suitable habitat for forest, scrub-shrub, and grassland birds. This process involves using Geographic Information Systems (GIS) Software to quantify the characteristics of the habitat patches surrounding each survey location. Statistical methods are then used to determine if there is a pattern of habitat use by individual bird species detected at the survey locations. Using this pattern (or model) as a guide, areas that have the same favorable habitat characteristics can be identified and mapped, and thus have a high probability of species occurrence. The areas predicted to have "high occurrence probability" would be targeted for survey, long-term monitoring, and conservation efforts. ENSP biologists have performed this analysis for forest species. The next two groups targeted for analysis are scrub-shrub and grassland birds.

Mapping of critical areas for endangered and declining wildlife, as well as mapping of suitable habitats for forest birds, are available through the ENSP's Landscape Project web page.

45. HERP ATLAS PROJECT

Status: Some projects are ongoing and some are recommended by a funding entity but are not yet underway.

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: D. Golden
Phone: (609) 628-2103
Email: dgolden@gtc3.com

Number of Sampling Sites: Sampling unit is 1/6 of a US Geological Survey Quadrangle map.

Sampling Period: Year-round.

Sampling Frequency: To be determined.

Environmental Media: Occurrence of herpetile species within 1/6 of a USGS Quadrangle map.

Parameters/Metrics Collected: Varies

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Access, unpublished annual report, a book and website containing survey information is planned in the future.

Quality Assurance/Control Procedures: Training of volunteers.

Estimated Cost: $10,000 per year

46. CALLING AMPHIBIAN MONITORING PROGRAM

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP) and U.S. Geological Survey - BRD

Contact Person: Jason Tesauro
Phone: (908) 735-8975
Email: tesaurj@worldnet.att.net

Number of Sampling Sites: There are survey routes that have stops in Ocean County.

Sampling Period: March - June

Sampling Frequency: Three times per year.

Environmental Media: Calling frogs.

Parameters/Metrics Collected: Occurrence and index of abundance.

Type of Database Used for Data Management and Data Reporting Outlet: N/A; information available on the ENSP website, available in USGS reports and other journal publications as well.

Quality Assurance/Control Procedures: U.S. Geological Survey – BRD handles QA/QC.

Estimated Cost: N/A

47. NORTH AMERICAN BREEDING BIRD SURVEY

Status: Ongoing

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP) and USGS - BRD

Contact Person: D. Jenkins
Phone (609) 984-1581
Email:djenkins@dep.state.nj.us

Number of Sampling Sites: There are three survey routes that have survey points within Ocean County.

Sampling Period: June

Sampling Frequency: Annual

Environmental Media: Bird occurrence within survey location.

Parameters/Metrics Collected: Number of birds seen and heard.

Type of Database Used for Data Management and Data Reporting Outlet:
Information is available on the ENSP website, USGS reports and journal publications.

Quality Assurance/Control Procedures: USGS – BRD handles QA/QC.

Estimated Cost: N/A

48. SALTMARSH NESTING SONGBIRDS

Status: Recommended for implementation by a funding entity but not yet underway.

Lead Entity: NJDEP – Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP)

Contact Person: N/A

Number of Sampling Sites: N/A

Sampling Period: May - June

Sampling Frequency: Every 3 – 5 years.

Environmental Media: Sharptailed sparrow, Seaside sparrow and Marsh wren populations.

Parameters/Metrics Collected: Calling males or number of nests.

Type of Database Used for Data Management and Data Reporting Outlet: N/A

Quality Assurance/Control Procedures: N/A

Estimated Cost: $12,000 per survey

49. DIAMONBACKED TERRAPIN POPULATION MONITORING

Status: Recommended by a funding entity but not underway.

Lead Entity: Division of Fish, Game and Wildlife, Endangered and Nongame Species Program (ENSP) and Bureau of Marine Fisheries (BMF)

Contact Person: N/A

Number of Sampling Sites: N/A

Sampling Period: N/A

Sampling Frequency: N/A

Environmental Media: N/A

Parameters/Metrics Collected: N/A

Type of Database Used for Data Management: N/A

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: Bycatch in commercial crab traps is believed by many experts to present a significant and unsustainable source of mortality for diamondback terrapins. The Division of Fish, Game and Wildlife, Endangered and Nongame Species Program (ENSP) and Bureau of Marine Fisheries (BMF) have been working to test and modify excluder devices originally developed by Dr. Roger Wood of the Wetlands Institute. In 1997, ENSP and the Bureau of Marine Fisheries completed testing of two types of terrapin excluder devices modified from Dr. Roger Wood's original design. The results of this study showed that the 5 x 15 cm (2" x 6") rectangular device did not significantly affect the number or size of crabs captured when compared to traditional (no excluder) crab pots. A 5 x 15 diamond-shaped device, however, did appear to reduce the number of larger crabs. The results of this study have been submitted for publication in the North American Journal of Fisheries Management. Excluders are now required on commercial crab pots set in creeks less than 100' wide or in manmade lagoons. Based on the findings of the ENSP / BMF study and other studies completed in Maryland and Louisiana, the Division of Fish, Game and Wildlife is confident that the excluder devices provide an efficient means to reduce the terrapin bycatch without undue burden on New Jersey's commercial crabbers.

Future work on diamondback terrapin populations will look more closely at the their distribution in our coastal estuaries with respect to water depth, distance from shore and association with particular habitats. The program also hopes to undertake studies to evaluate the cumulative impacts on terrapin populations in New Jersey of road mortality, predation, drowning in crab traps and reduced access to nesting habitat.

50. FRESHWATER MUSSELS

Status: Recommended by a funding entity but not underway.

Lead Entity: Division of Fish, Game and Wildlife, Endangered and Nongame Species Program (ENSP) and Bureau of Marine Fisheries (BMF)

Contact Person: N/A

Number of Sampling Sites: N/A

Sampling Period: N/A

Sampling Frequency: N/A

Environmental Media: N/A

Parameters/Metrics Collected: N/A

Type of Database Used for Data Management: N/A

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: Freshwater mussels, or pearly mussels as they are sometimes called, are among the oldest living organisms on Earth. Individuals are thought to reach ages in excess of a century. As vital ecosystem components, they are food sources for wildlife such as raccoons and muskrats. Young mussels are eaten by ducks, herons and fishes. Often referred to as nature's vacuum cleaners, they improve water quality by straining particles and pollutants from rivers. In addition, since mussels have a low tolerance for water-borne pollutants, they are excellent indicators of water quality.

Although freshwater mussels are most diverse in North America, where there are 281 species and 16 subspecies, they are among the most rapidly declining animal groups on the continent. The Nature Conservancy recognizes 55% of North America's mussel species as extinct or imperiled compared to only 7% of the continent's mammal and bird species. In North America above Mexico, there are 19 taxa presumed extinct, 44 species listed or proposed as federally endangered, and 60 species that may be endangered. In addition, a number of the endangered species are functionally extinct, with individuals of a species surviving but not reproducing. Freshwater mussel extinctions and declines can be attributed to several factors, including habitat degradation, construction of dams and subsequent loss of host fishes, and expansion of exotic mollusks such as the zebra mussel and Asian clam.

New Jersey is home to twelve native species of freshwater mussels, including the federally endangered dwarf wedgemussel (*Alasmidonta heterodon*) and three federal species of special concern - the brook floater (*Alasmidonta varicosa*), green floater (*Lasmigona subviridis*) and yellow lampmussel (*Lampsilis cariosa*). Although the dwarf wedgemussel was thought to be extirpated in the state, a recent finding of live individuals in the Paulins Kill River, Sussex County has prompted intensive surveys of the waterway. The brook floater is only known from small, most likely non-breeding occurrences in three areas of the state, whereas the yellow lampmussel is restricted to the Delaware River. The green floater is by far the most endangered mussel in the state, represented only by a single individual in the Stony Brook, Mercer County. Other species that are under consideration for state endangered or threatened status are the eastern lampmussel (*Lampsilis radiata*), eastern pondmussel (*Ligumia nasuta*), tidewater mucket (*Leptodea ochracea*), and triangle floater (*Alasmidonta undulata*).

Recognizing national and regional declines, as well as impending threats such as zebra mussel infestation, Endangered and Nongame Species Program biologists have been searching the state's waterways for freshwater mussels. Since 1993, Program biologists have been conducting freshwater mussel surveys for rare species by targeting historic locations, suitable habitats and areas with host fishes present. Viewing scopes and sometimes snorkeling gear are used by staff and volunteers to search for mussels in New Jersey’s streams, rivers and ponds. In addition to wading in water, biologists inspect shorelines for shells and relicts (very old shells) at all survey sites. Locating populations, however, is only the first step to protecting these inconspicuous, yet vitally important mollusks.

As part of the Landscape Project, critical areas for freshwater mussels are now being mapped using criteria designed specifically for aquatic species. Program biologists will develop protection strategies for endangered and threatened species by working with local municipalities, landowners, other state and federal agencies, planners, and organizations such as water watch and conservation groups. In addition, plans are underway to produce an atlas of New Jersey's freshwater mussels which will include life history narratives, color plates of shells, location maps, and information on national and state range, status, shell description and host fishes for each of the state's twelve species.

51. SUBMERGED AQUATIC VEGETATION MONITORING

Status: Ongoing

Lead Entity: Fairleigh Dickinson University – Submerged Aquatic Vegetation

Contact Person: Paul Bologna
Fairleigh Dickinson University
285 Madison Avenue
MEC1-01
Madison, New Jersey 07940
Phone: (973) 443-8758
Email: bologna@fdu.edu

Number of Sampling Sites: Two to five.

Sampling Period: June 1998 and continuing.

Sampling Frequency: Monthly, May through September.

Environmental Media: Submerged aquatic vegetation flora and fauna, estuarine water quality.

Parameters/Metrics Collected: Eelgrass health and biomass, Widgeon grass biomass, benthic invertebrate density and community structure, salinity, temperature and dissolved oxygen.

Type of Database Used for Data Management and Data Reporting Outlet: Microsoft Excel; Institute of Marine and Coastal Sciences Technical Report #2001-11.

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: Most of New Jersey's Submerged Aquatic Vegetation (SAV) is located within Barnegat Bay. It is dominated by eelgrass (*Zostera marina*) with lesser amounts of widgeon grass (*Ruppia maritima*). During the last 30 years, significant declines have occurred in regions of the Bay (Bologna et al., 2000). Some possible mechanisms include reduced water quality due to excessive sediment loading, coastal eutrophication, brown tides and eelgrass "wasting disease". Currently, four populations of eelgrass and 1 population of widgeon grass are being monitored. Principal assessments include plant demographic patterns (i.e. shoot density and biomass), relative health and distribution and abundance of associated fauna.

52. SUBMERGED AQUATIC VEGETATION (SAV) MAPPING OF NEW JERSEY'S COASTAL BAYS

Status: Recommended for implementation by a funding entity, but not yet underway.

Lead Entity: CRSSA - Center for Remote Sensing and Spatial Analysis - Rutgers University

Principal Investigator: Richard Lathrop, Rutgers Univ.
Co-Prinicipal Investigators: Paul Bologna (FDU), Ken Abel (Rutgers), Michael Celestino (NJDEP)
Project Manager: Mary Downes Gastrich (NJDEP)

This project will be undertaken in cooperation with the NOAA Coastal Services Center, the New Jersey Department of Environmental Protection (NJDEP), and the Jacques Cousteau National Estuarine Research Reserve (JCNERR) at Mullica River-Great Bay. CRSSA would serve as overall project coordinator. Dr. Richard Lathrop of Rutgers University will serve as Principal Investigator. Dr. Paul Bologna of Fairleigh Dickinson University, Dr. Ken Able of the Rutgers University Marine Field Station, and Mike Celestino of the NJDEP Division of Marine Fisheries will serve as co-investigators and provide logistical support to the field study component. Dr. Mary Gastrich will be the NJDEP Project Manager. The NOAA Coastal Services Center will assist in the design specifications, contracting of aerial mission and interpretation services and the data QA/QC. CRSSA will coordinate with researchers at Rutgers Marine and Coastal Sciences to integrate the remote sensing mapping with existing data sets concerning bottom sediments to aid in developing a wall-to-wall mapping of the bay's benthic habitats.

Contact Person: Rick Lathrop, Grant Walton Center for Remote Sensing and Spatial Analysis - Rutgers University

Number of Sampling Sites: N/A

Sampling Period: N/A

Sampling Frequency: Five to ten year mapping intervals are proposed.

Environmental Media: Conduction of a comprehensive survey of the bay's bottom habitats and the spatial distribution and areal coverage of submerged aquatic vegetation communities.

Parameters/Metrics Collected: N/A

Type of Database Used for Data Management and Data Reporting Outlet: N/A

Quality Assurance/Control Procedures: Established NOAA protocols for benthic habitat and SAV mapping would be applied. More information on these NOAA protocols is available at: http://www.csc.noaa.gov/crs/bhm/methods.html

Estimated Cost: $100,000

Narrative Description of Project: Submerged aquatic vegetation (SAV) is a term used to describe a variety of marine plants including seagrasses. SAV provides a substantial amount of primary production for the Barnegat Bay estuary, and it serves as critically important habitat for benthic epifauna and infauna. The areal coverage, abundance and health of SAV comprise an important environmental indicator of the overall status of New Jersey's coastal bays. External stresses due to disease, algal infestation, dredging, boating, water quality problems are contributing to a long-term decline in SAV abundance and distribution. The areal coverage, abundance and health of SAV is an important environmental indicator of the overall status of Barnegat Bay and New Jersey's other coastal bays (e.g., Manasquan, Shark, Navesink and Shrewsbury river bays). While existing GIS maps provide a baseline of information concerning the spatial distribution of SAV in Barnegat Bay over the past four decades, a comprehensive mapping of the Barnegat Bay and other coastal bays has not been conducted since 1979.

More recent projects either conducted or funded by the NJDEP concerning the status of SAV in New Jersey's coastal bays have focused on the eastern side of the main body of Barnegat Bay. Additional surveys and mapping efforts are needed on the western tributaries and shoreline of Barnegat and Little Egg Harbor bays, as well as other estuaries further north along the New Jersey coast (e.g., Manasquan, Shark River, Shrewsbury and Neversink bays). These areas represent a major data gap in our understanding of the status of New Jersey's SAV communities.

Remote sensing (aerial photography and digital scanners) in combination with *in situ* sampling are needed to undertake a comprehensive monitoring of SAV. Remote sensing is useful in providing a synoptic picture of the spatial distribution of SAV and should be conducted on a five to ten year basis. Present statewide aerial photographic monitoring is oriented to land surface mapping and is inadequate for benthic/SAV mapping purposes. Special SAV-oriented remote sensing acquisition along with remotely operated vehicles (ROV's) and spot field checking are required to adequately map SAV species distribution and areal coverage. The field sampling effort will be stratified with sites in the northern, central and southern (i.e., Little Egg Harbor) portions of the Bay system. Color aerial photography will be acquired at a scale and time of year (either late spring and/or early fall) to image the SAV beds during periods of low water turbidity. The photography will be rectified to a standard geographic coordinate system and interpreted photogrammetrically to produce a planimetric base map with high spatial accuracy. Photogrammetric interpretation of color aerial photography is generally considered the optimal method for comprehensive mapping and change detection of seagrasses and other submersed rooted vascular plants (Dobson et al., 1995).

The objectives of the proposed program are to provide a comprehensive survey of the spatial distribution and areal coverage of submerged aquatic vegetation communities. The change in the spatial distribution, areal coverage, and health of SAV beds will be assessed. The spatial distribution and areal coverage of SAV in the 1970's (mapped as part of the comprehensive statewide SAV mapping conducted in 1979 and used by the state to this day in their dock permit evaluation process) provides a suitable benchmark to present SAV spatial distribution and areal coverage.

The field sampling effort will be stratified with sites in the northern, central and southern portions of the New Jersey's coastal bay study area. Field sampling will assess the species of SAV present, the percent cover and health status. Surface and underwater photos will be taken, conditions permitting. Latitude and longitude coordinates of the sampling points will be fixed using differentially corrected global positioning equipment. Additional field survey points collected by the cooperators for other ongoing or recently completed benthic and SAV survey work will be included as well.

53. SEDIMENT SAMPLING IN BARNEGAT BAY

Status: Ongoing

Lead Entity: Rutgers University and the Institute of Marine and Coastal Sciences.

Contact Person: Dr. Norbert Psuty
Institute of Marine and Coastal Sciences
71 Dudley Road
Rutgers University
New Brunswick, New Jersey 08901
Phone (732) 932-6555 ext. 506

Number of Sampling Sites: Over 600.

Sampling Period: Summers beginning in 1995.

Sampling Frequency: Single instance at each sampling point.

Environmental Media: Bottom sediments in bay and minor estuaries, bayside beaches.

Parameters/Metrics Collected: Grain size distribution, mean standard deviation, skewness, kurtosis, depth, location.

Type of Database Used for Data Management and Data Reporting Outlet: Spreadsheet and Geographic Information System, reports to funding agencies, professional papers and presentations given.

Quality Assurance/Control Procedures: Replication and tests against controls.

Estimated Cost: N/A

Narrative Description of Project: The objective of this project is to develop a detailed representation of the types of patterns of sediments in Barnegat Bay. Several areas of intense investigation include the micro-estuaries of the northeast sector and the large sediment lobe at the northern margin of Island Beach State Park. Most of the sediment sampling was done from a boat using GPS coordinates for the X – Y location. Depth was determined on site at the time of sampling. Grain size characteristics are related to the processes mobilizing and transporting the materials. Coarser sediments are found in areas of high turbulent flows whereas fine-grained sediments tend to be found in relatively low flow situations. Sediments can be used as surrogates for the gradients of flows in areas where long-term flow measurements are not available. Exceptions include sediments that are not related to present day processes. There are many locations of relict sediments that are part of the submerged continental margin and some sediments which are the product of human disturbance. Knowledge of the conditions related to the accumulation of sediments extends to the creation of bottom habitats and to the water flows in these habitats.

54. ADOPT-A-BEACH

Status: Ongoing

Lead Entity: NJDEP and The Ocean Conservancy

Contact Person: Virginia Loftin
Phone: (609) 984-5599
Email: Virginia.Loftin@dep.state.nj.us

Number of Sampling Sites: Varies.

Sampling Period: Two days per year, one in spring and one in fall.

Sampling Frequency: It is a volunteer trash collection program.

Environmental Media: Beach cleanliness and safety.

Parameters/Metrics Collected: Trash items that are small enough to be easily removed by volunteers (including children). Large items (large driftwood, pallets, trash etc.) can be arranged to be removed by Clean Shores (NJDEP program). Items are recorded on data sheets provided by The Ocean Conservancy and these items include:
Shoreline and Recreational Activities: bags/food wrapper, balloons, beverage bottles (plastic), beverage bottles (glass), beverage cans, caps/lids, clothing/cloth, cups/plates/forks/knives/spoons, diapers, fast-food containers, 6-pack holders, pull tabs, shotgun shells/wadding, straws stirrers, toys
Ocean/Waterway Activities: bait containers/packaging, bleach/cleaner bottles, buoys/floats, crab/lobster/fish traps, crates, fishing line, fishing lures, fishing nets, light bulbs/tubs, oil/lube bottles, pallets, plastic sheeting/tarps, rope, strapping bands
Smoking Related Activities: cigarettes/cigarette filters, cigarette lighters, cigar tips, tobacco packaging/wrappers
Medical/Personal Hygiene: syringes, condoms, tampons/tampon applicators
Dumping Activities: appliances (refrigerators, washers etc.), batteries, cars/car parts, construction materials, 55-gallon drums, tires. Note: These items may be tabulated by volunteers, but not necessarily removed by the volunteers.

Type of Database Used for Data Management and Data Reporting Outlet: Recorded on data forms, which are tabulated as to type of trash item collected. Results are also reported to The Ocean Conservancy.

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: The New Jersey Department of Environmental Protection's Adopt A Beach program fosters volunteer stewardship of the State's coastal beaches and reduces the threat of marine debris to fish and wildlife. The DEP selects two

days per year, one in the spring and one in the fall, for coast-wide clean-ups. Program volunteers adopt beaches for one year, agreeing to clean the beach of litter and debris on designated clean-up days. Adopt A Beach volunteers have been removing marine debris from the State's shorelines since 1993. During the two statewide clean-ups in 2001, more than 1,000 volunteers at 60 beaches collected over 79,000 items of trash.

55. CLEAN SHORES

Status: Ongoing

Lead Entity: NJDEP

Contact Person: Thomas Harrington
Phone: (609) 984-7949
Email:Thomas.Harrington@dep.state.nj.us

Number of Sampling Sites: Varies.

Sampling Period: Varies.

Sampling Frequency: Varies.

Environmental Media: Beach cleanliness and safety.

Parameters/Metrics Collected: Large trash and debris items.

Type of Database Used for Data Management and Data Reporting Outlet: N/A

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: Clean Shores is a statewide effort by the New Jersey Department of Environmental Protection to remove floatables such as wood, garbage, medical waste and recyclables from tidal shorelines with the use of inmate labor. In cooperation with the New Jersey Department of Corrections, inmate work crews have removed over 85 million pounds of floatables from the shorelines of the state. The funding for the Clean Shores program comes entirely from the sale of the Shore Protection "Shore to Please" motor vehicle license plates.

Most of the trash on beaches is not left there by beachgoers, but is deposited onto the beach by wind and tides. Rainwater runoff from streets into storm sewers is a significant source of this trash.

A locality with tidal shorelines that would like to sponsor a cleanup is asked to provide rental containers for the disposal of the removed floatables, a front-end loader with an operator to pick up large material from the beach and a lunch for the inmates.

56. WATER ALLOCATION

Status: Ongoing

Lead Entity: NJDEP

Contact Person: Fred Sickels
Bureau of Water Allocation
401 East State Street
P. O. Box 426
Trenton, New Jersey 08625-0426
Phone: (609) 984-3661

Number of Sampling Sites: N/A

Sampling Period: N/A.

Sampling Frequency: N/A.

Environmental Media: Ground water and surface water

Parameters/Metrics Collected: Water diversion permits, certifications, registrations, reported water-quality data, reported water-level data

Type of Database Used for Data Management and Data Reporting Outlet: N/A

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Program: The water allocation program regulates all ground and surface water diversions in New Jersey that are in excess of 100,000 gallons of water per day. This includes water diverted for public water supply, industrial processing and cooling, irrigation, sand and gravel operations, remediation, and power generation. The regulation could take the form of a permit, certifcation, registration, or permit-by-rule. Implementing regulations are N.J.A.C. 7:19-1 et seq: Water Supply Allocation Rules and N.J.A.C. 7:20A-1 et seq. Agricultural, Aquacultural or Horticultural Water Usage Certification Rule.

The Program maintains a data base system that includes a listing of diversion sources, including their capacities, locations, water source, use of supply, and unique permit identification numbers for each regulatory diversion category. Water quality data (raw water chloride and sodium content) is periodically required of some permitees and reports on the status of the major reservoir levels are compiled and maintained.

57. THE NATURAL HERITAGE DATABASE

The New Jersey Natural Heritage Program identifies the state's most significant natural areas through a comprehensive inventory of rare plant and animal species and representative natural communities. From the inventory, the Natural Heritage Database compiles information on the distribution, biology, status, and preservation needs of these species and communities. Established in 1984 through a cooperative agreement between The Nature Conservancy, a private conservation organization, and the Department of Environmental Protection, full administration of the program was assumed by the DEP in 1986.

The New Jersey Natural Heritage Program is part of an international network including State Natural Heritage Programs and Conservation Data Centers, all building on the same data collection methodology. The Database is updated continuously and is used to set state, national, and global priorities for the preservation of natural diversity.

The Natural Heritage Database is a continuously updated inventory of rare plants and animal species and representative natural communities in New Jersey. It is the state's most comprehensive, centralized source of information on rare plants, animals, and natural communities. The Database is a compilation of information from a broad range of sources including museum and herbarium collection records, publications, knowledgeable experts, and fieldwork. It contains information collected by the Office of Natural Lands Management on rare plants, animals, and natural communities as well as data on rare animals provided by the Endangered and Nongame Species Program. The Database is continuously updated and improved as new data is obtained. Information from this database is available to assist individuals in the preservation of habitat for rare species and natural communities. The database tracks the status of more than 1000 species of plant and animals and more than 50 natural communities that are exemplary, rare, or imperiled at the state or global level. It also contains more than 7,000 records of locations for rare plants, animals, and natural communities in addition to offering detailed, centralized information to help make land-use decisions. The database includes officially listed endangered species from the Federal Endangered Species Act, the State Endangered Species Act, the State Endangered Plant Species List Act, the State Endangered and Nongame Wildlife Act, and additional rare species that have not been listed officially.

58. NJDEP LANDSCAPE PROJECT

The Landscape Project for Rare Species Protection began in 1994 as a method to help stem the decline of wildlife populations in New Jersey. The mission of the Landscape Project is to:

- Document the distribution and abundance of wildlife populations in New Jersey,
- Identify the critical habitats that these populations rely on, and
- Produce mapping that shows where these critical habitats are.

The Landscape Project is a pro-active, ecosystem-level approach for the long-term protection of rare species and their important habitats in New Jersey.

The Landscape Project focuses on large land areas called "landscape regions" that are ecologically similar with regard to their plant and animal communities. Using an extensive database that combines rare species location information with land cover data, the Endangered and Nongame Species Program has identified and mapped areas of critical habitat for rare species within each landscape region.

59. CLEAN VESSEL ACT PROGRAM

Congress passed the Clean Vessel Act (CVA) in 1992 to help reduce pollution from vessel sewage discharges. The Act established a five-year federal grant program administered by the U.S. Fish and Wildlife Service and authorized $40 million from the Sport Fish Restoration Account for use by the states. Federal funds may constitute up to 75% of all approved projects with the remaining funds provided by the states or marinas. Grants are available to the states on a competitive basis for the construction and/or renovation, operation and maintenance of pumpout and portable toilet dump stations. All recreational vessels must have access to pumpouts funded under the Clean Vessel Act. NOAA will mark pumpout and dump station locations on its nautical charts. Halfway through the program, grants have been awarded to install 1,200 pumpout stations and 630 dump stations.

The Clean Vessel Act Program is made up of various professionals in the state that help direct and oversee any projects related to the Clean Vessel Act Program. Public monthly meetings are held, usually along coastal cities, where application updates, the status of contracts and subcontracts, budget funding issues, CVA information and education efforts regarding public outreach, and any other issues concerning the Clean Vessel Act Program.

The Manasquan, Shark, Navesink and Shrewsbury Rivers were designated as No Discharge Zones for boat sewage. This designation means that the discharge of any boat sewage, treated or untreated, is forbidden in these areas. These waterways have sufficient boat sewage pumpout facilities to accommodate all boaters using the areas. Current law for the Manasquan, Shark, Navesink, and Shrewsbury Rivers now makes it illegal to dump boat sewage within 3 miles of the shorelines of these areas. Fines for illegal dumping may reach $2,000 or more. In order for a body of water to become designated as a no discharge zone, there should be 1 pumpout station per 200 to 300 slips.
The New Jersey Department of Environmental Protection has approved the Barnegat Bay for the No Discharge designation. If approval is given by the US EPA, Barnegat Bay will also become a No Discharge Zone. As part of the application to designate Barnegat Bay as a No Discharge Zone, the Ocean County Planning Department (OCPD) developed an estimate of the number of boats docked at private slips and waterfront homes with access to the Barnegat Bay Estuary in January 2002.

In addition to providing pumpout facilities at marinas, three CVA pumpout boats are in service in New Jersey. They are operated by the Borough of Seaside Park, by Monmouth County and by Ocean County. New Jersey's first pumpout boat, ""The Circle of Life" is a 20-foot open scow type boat, that can carry up to 300 gallons of boat sewage from vessels that are moored and anchored in Barnegat Bay. It was purchased with funds allocated under the Clean Vessel Act Program and NJDEP environmental grants. Pumpout boats can pull up along side a recreational boat and pump out its sewage holding device with a suction hose. Once a pumpout boat is full of waste, it discharges the waste into a sewage treatment facility for proper disposal.

The Clean Vessel Act Program also developed a waterproof map delineating the locations of all pumpout facilities in New Jersey. A current version of A Boater's Guide To

Barnegat Bay And Little Egg Harbor is available from the Rutgers Cooperative Extension of Ocean County. The pumpout stations along these waterways are clearly delineated with the CVA symbol.

60. NEW JERSEY ATMOSPHERIC DEPOSITION NETWORK (NJADN)

Status: Ongoing

Lead Entities: NJDEP and Rutgers University. The Hudson River Foundation and New Jersey Sea grant assisted in the commencement of the project, which was expanded from four to nine sampling sites in 1998 with additional funding from NJDEP.

Contact Person: Michael Aucott
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Number of Sampling Sites: Nine. Initially four sites were monitored in 1997 and the network was expanded to include nine sites in 1998. The nearest sampling sites with respect to the Barnegat Bay are located in Tuckerton to the south, the Pinelands (Burlington County) to the west and Sandy Hook to the north.

Sampling Period: Year-round sampling at all nine sites.

Sampling Frequency: Air samples of the organic compounds were collected over 24 hours every 12th day and wet deposition data was collected during rainfall events over a 12-24 day cycle.

Environmental Media: Atmospheric deposition of semi-volatile organic compounds and trace elements known to adversely affect aquatic and terrestrial ecosystems as well as human health. The purpose is to assess the magnitude and sources (in-state vs. out-of-state) of air toxics deposition in New Jersey.

Parameters/Metrics Collected: Mercury, Phosphorous, Sulfur, nutrient Nitrogen, PAH's (polycyclic aromatic hydrocarbons derived from combustion processes), PCB's (polychlorinated biphenyls derived from remobilization of chemicals that were historically used in urban/industrial areas), OC's (organo-chlorine pesticides derived from past agricultural practices, current agricultural practices outside New Jersey and as byproducts of industrial processes), trace metals (Silver, Aluminum, Arsenic, Cadmium, Cobalt, Chromium, Copper, Iron, Magnesium, Nickel, Lead, Tin, Zinc, Vanadium and Palladium).

Type of Database Used for Data Management and Data Reporting Outlet: NJDEP and Rutgers University databases; scientific paper to be published in the near future. Draft results may be obtained through Michael Aucott of the Division of Science, Research and Technology at NJDEP.

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: The NJADN is a cooperative research and monitoring project being undertaken by the NJDEP and Rutgers University that is now in the fourth

year-stage of monitoring and analysis. The objectives of the program are to quantify concentrations of atmospheric chemicals and the quantity being deposited to aquatic and terrestrial systems in conjunction with assessment of seasonal and spatial trends. The identification of sources of atmospheric pollutants as well as identification of the potential impacts to ecosystems and human health from these atmospheric pollutants are also major goals of this collaborative project.

The research currently being conducted by the New Jersey Atmospheric Deposition Program (NJADP) closely parallels the objectives of the CCMP. Preliminary analyses of the data collected indicates that air deposition of nitrogen into aquatic ecosystems may be more significant than previously thought, and it appears that the source may be regional (i.e. multi-state) rather than localized. Phosphorous inputs to the estuary via air deposition appear to be relatively insignificant in terms of volume; however, further research needs to be conducted on the air-form form of phosphorous because it may be more biologically available for organism uptake and subsequent bioaccumulation. Similar to nitrogen, sources of phosphorous appear to be regional rather than from local sources. Concentration of trace metals tended to vary more between sites in New Jersey, indicating that localized sources play a greater role in deposition of metals. Deposition of metals to terrestrial and aquatic ecosystems appears to be greater during rainfall events.

The NJADN has not secured funding to continue monitoring and research of air toxics in New Jersey after 2002 but recommends that the program be continued.

61. COOPERATIVE COASTAL MONITORING PROGRAM (CCMP)

Status: Ongoing

Lead Entity: NJDEP and US Environmental Protection Agency

Contact Person: Virginia Loftin
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Email:Virginia.Loftin@dep.state.nj.us

Number of Sampling Sites: Two. The flight is conducted from Raritan Bay south to Barnegat Lighthouse four days per week. The flight is conducted from Raritan Bay south to the tip of Cape May two days per week.

Sampling Period: Recreational bathing beach season (approximately Memorial Day to Labor Day).

Sampling Frequency: Six days per week.

Environmental Media: Beach cleanliness and safety.

Parameters/Metrics Collected: The surveillance enables the routine evaluation of coastal water quality and the assessment of the nature and extent of public reports of ocean pollution. The surveillance also enables the capture floating solid waste and debris, also known as floatables.

Type of Database Used for Data Management and Data Reporting Outlet: NJDEP database; USEPA

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: The Cooperative Coastal Monitoring Program (CCMP) between the Department and ten coastal communities designed to collect data needed to determine beach closings also provides for aerial surveillance of near shore coastal waters. The surveillance enables the routine evaluation of coastal water quality and the assessment of the nature and extent of public reports of ocean pollution. Six flights per week, with no flights on Wednesdays, include Raritan Bay, the Lower New York Bay, and the Atlantic coast from Sandy Hook to Barnegat Inlet. Flights on Thursdays and Sundays are extended to include the area from Barnegat Inlet to Cape May Point.

Flight activities are coordinated with the United States Army Corps of Engineers for the NY-NJ Harbor Estuary Program Floatables Action Plan in an effort to capture floating solid waste and debris, also known as floatables, with water-skimming vessels. Sources of floatables that have affected the state's coastal shores include stormwater outfalls, combined sewer overflows, operational landfills, and illegal dump sites.

62. NATIONAL SHELLFISH SANITATION PROGRAM

Status: Ongoing

Lead Entity: NJDEP, Bureau of Marine Water

Contact Person: Robert Connell
NJDEP – Marine Monitoring
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Number of Sampling Sites: 734

Sampling Period: N/A

Sampling Frequency: coliform bacteria 5 – 12 times per year; phytoplankton biweekly from May - September

Environmental Media: Tidal waters

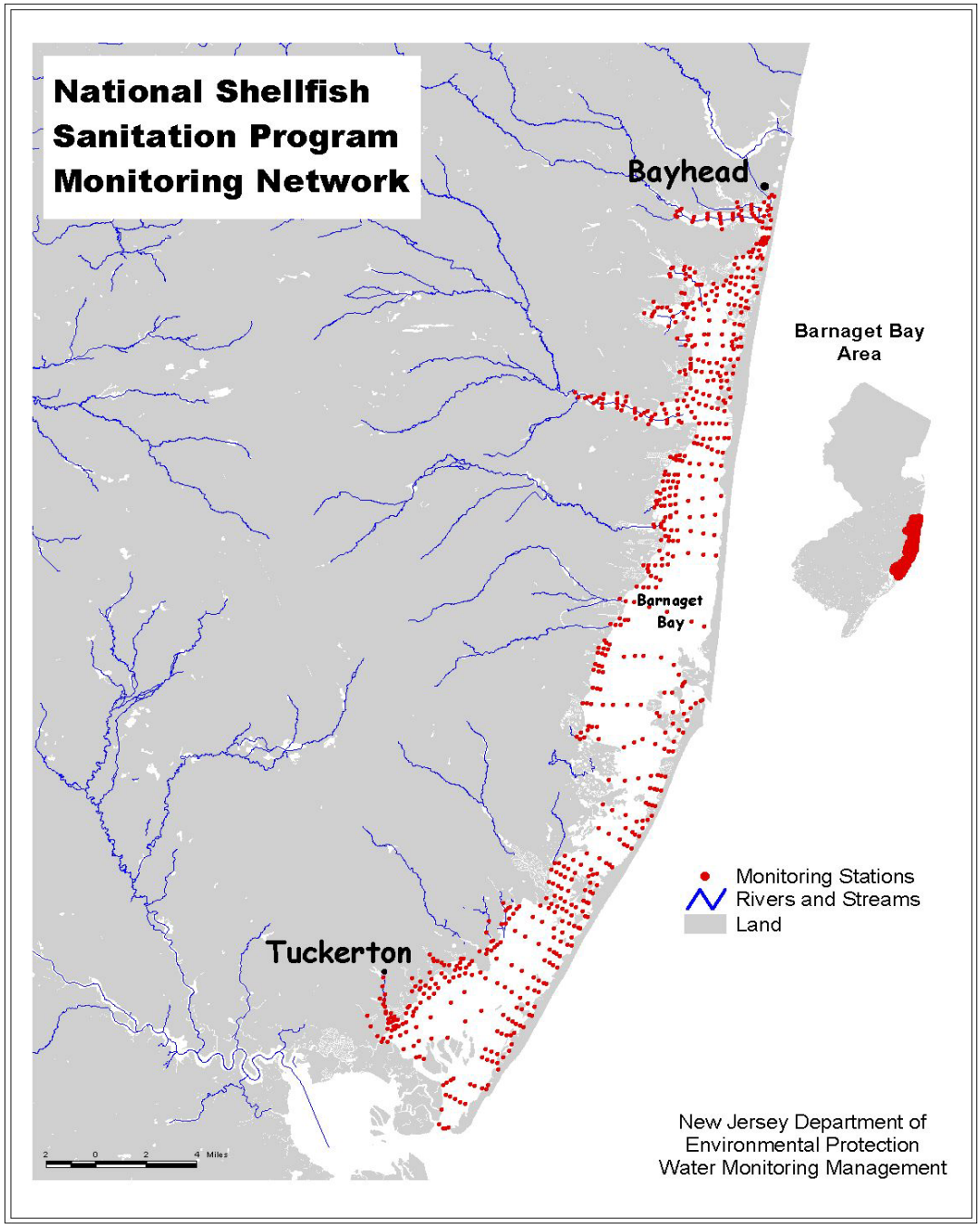
Parameters/Metrics Collected: Total and fecal coliform bacteria, phytoplankton

Type of Database Used for Data Management and Data Reporting Outlet: Shellfish water classification maps available at http://www.state.nj.us/dep/wmm/bmw/

Quality Assurance/Control Procedures: N/A

Estimated Cost: N/A

Narrative Description of Project: The National Shellfish Sanitation Program (NSSP) was established in 1925 and is required by the Food and Drug Administration for the safe harvest and consumption of shellfish. Its purpose is to regulate the harvest and sale of shellfish to safeguard the public health from the consumption of contaminated shellfish. The relevant portion of this program to the Barnegat bay Estuary Program is the shellfish growing water classification requirements of the NSSP. This portion of the program requires shellfish producing states to classify their coastal waters according to suitability for safe shellfish harvest. Classifications are based on three types of assessments: 1) Pollution source surveys; 2) Water quality monitoring; 3) Hydrographic surveys. Monitoring for this program in New Jersey is conducted by the Bureau of Marine Water Monitoring of the New Jersey Department of Environmental Protection. A total of approximately 4,404 samples are collected annually at 734 sites in the Barnegat Bay estuary and watershed. Phytoplankton monitoring as required by NSSP is also conducted annually in New Jersey coastal waters and major estuaries for the presence and abundance of potentially harmful algal species. The sampling has historically been conducted biweekly from May to September. This information is reviewed each year in order to update the classification of the state's coastal waters for shellfish harvest.


National Shellfish
Sanitation Program
Monitoring Network
Bayhead
Barnaget Bay
Area
Barnaget
Bay
Tuckerton
Monitoring Stations
Rivers and Streams
Land
2 0 2 4 Miles
New Jersey Department of
Environmental Protection
Water Monitoring Management

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