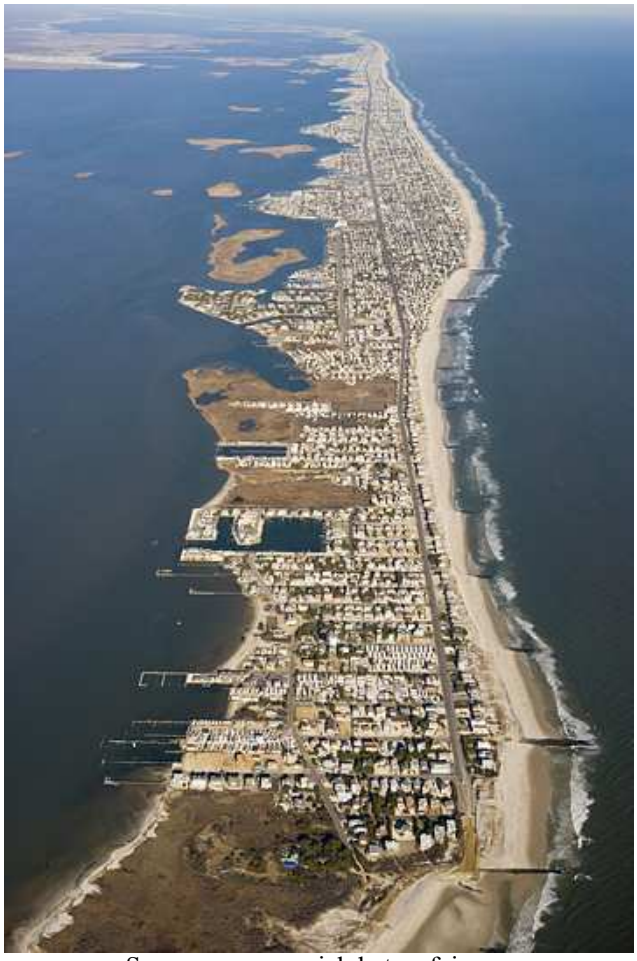
OCEAN WATER QUALITY IN NEW JERSEY:

REDIRECTING THE MANAGEMENT EFFORT



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Executive Summary

If you believe what you read in the newspapers, the quality of the ocean in New Jersey is just fine. In an end of the season story published last September, county health officials declared that, for the second summer in a row, water quality at Monmouth and Ocean County beaches was "exceptional."[1] Like most assessments of New Jersey's ocean waters, these conclusions were based on human health indicators, such as whether the water is swimmable or the shellfish edible. However, a true measure of water quality would also assess the ecological health of ocean waters, not just its suitability for human enjoyment and consumption. Water quality should be assessed through a monitoring program that incorporates bioassessment techniques, utilizes biological indicators and establishes biocriteria as ecological goals to be met in conjunction with the use of traditional physical and chemical criteria and human health indicators. The program must also incorporate an ecosystem-based management approach that recognizes and operates under the premise that the marine ecosystem, and the impacts to that system caused by our land use activities, do not recognize political, jurisdictional or programmatic boundaries. Such an approach will not only protect the marine life that inhabits our near-shore coastal waters, but will significantly enhance the protection of humans who utilize these waters.

The Current Programs Are Not Working

It is time for New Jersey to acknowledge that the current ocean water quality assessment programs are not working. Although water quality may be good enough for swimming, what's

good news for beachgoers is not necessarily good news for the ocean, particularly when faced with the following realities:

- **Impaired Coastal Waters** – The New Jersey Department of Environmental Protection (DEP) has characterized all of New Jersey's coastal waters as "impaired" due to a cell of low dissolved oxygen that extends from Sandy Hook to the Wildwoods – an area more than 100 miles in length – and has admitted that the impacts on benthic marine biota from these hypoxic conditions are unknown.[2]

- **No Nitrogen TMDL** - Despite the fact that the ocean waters have been impaired for at least seven years (testing began in 2002),[3] a coastal Total Maximum Daily Load (TMDL) for nitrogen, the nutrient the U.S. Environmental Protection Agency (EPA) has identified as the cause of the hypoxic conditions,[4] has not been developed , nor is development anticipated in the immediate future.

- **Land Use Impacts to Estuaries -** Estuaries serve as critical spawning, nursery and feeding grounds for a variety of important commercial and recreational fish and shellfish species.[5] They are currently exhibiting a multitude of environmental problems, including degraded natural habitats, declining plant and animal populations, diminishing fish and shellfish harvests, and impaired water quality. EPA has determined that most of the problems observed in Mid-Atlantic estuaries are due to land use practices.[6]

- **Biological Indicators of Reduced Water Quality -** Increased presence of sea grasses, brown tides, sea nettles (jellyfish) and low levels of dissolved oxygen in estuarine and coastal waters are not natural occurrences, but are indicators of water quality problems.[7]

- **Excessive Impervious Surfaces** - Water quality and overall environmental health of a watershed is directly related to the amount of impervious surface in the watershed.[8] At impervious surface levels greater than 10%, surface waters in watersheds show definite signs of impact, while at impervious surface levels of 30%, water quality is typically seriously degraded.[9] Ten watersheds, or 315,351 acres in New Jersey, are currently at 30% or more of impervious surface.[10] Forty watersheds, or 1,372,189 acres, are between 10% and 29.9% impervious surface.[11]

- **Over-Allocated Water Supplies** - The increasing loss of freshwater inputs to the Barnegat Bay Estuary and the simultaneous increase in salinity demonstrate that ecological concerns are not being properly addressed in the Water Supply Master Plan and the Water Allocation Program. This is further demonstrated by saltwater intrusion into public water supplies, such as in Cape May County, where during the 30 year period from 1960 through 1990, saltwater intrusion forced the County to abandon more than 10 public supply wells, 3 industrial supply wells and more than 100 domestic supply wells.[12] As of 2002, water supply levels in the Cohansey Aquifer were below sea level from the town of Burleigh south and coastal stream flows in the same area were reduced to 80% the normal rate.[13]

- **Saltwater Intrusion -** Saltwater intrusion is not just an issue in Cape May County, and is also occurring in coastal aquifers underlying parts of Atlantic, Gloucester, Monmouth, Ocean and Salem Counties.[14] This wide-spread problem is indicative of the failures of the Water Supply Master Plan and Water Allocation Program, but also demonstrates the failure of the DEP Land Use Regulation Program to limit impervious coverage from development and ensure the preservation of adequate aquifer recharge areas.

- **No Wastewater Management Plans -** The majority of New Jersey municipalities or planning entities have failed to update their Wastewater Management Plans in decades or have neglected to prepare a Wastewater Management Plan at all.[15] In addition, these planning entities have faced no consequences for their ongoing infractions, which can only be characterized as a failure of New Jersey's Watershed Management Program.

- **Silo-Based Management** - Water quality management, including decisions regarding habitat and aquatic species, is handled by numerous Divisions within the DEP, including the Division of Land Use Regulation, the Division of Water Quality, the Division of Watershed Management, the Division of Water Supply, the Division of Fish and Wildlife, the Division of Science, Research and Technology and the Office of Coastal Planning and Coordination.[16] In this silo-based management approach, each of these programs has their own authority and decision-making processes and there is often little or no communication between them, even when they are reviewing the same development project.

Federal and State Environmental Statutes Require More for the Ocean

An ecosystem-based management approach that utilizes a combination of biological, chemical and human health indicators is mandated by the Federal and State statutes that entrust New Jersey and, on its behalf, the Department of Environmental Protection (DEP) as the guardian of these waters.

The Clean Water Act Bioassessment Requirements

For example, the Clean Water Act requires New Jersey to continually demonstrate how it is meeting the Act's purpose of "restoring, and maintaining the chemical, physical, and biological integrity" of the waters within its jurisdiction, which includes New Jersey's bays, estuaries and near-shore coastal waters.[17] The EPA has determined that the best means to provide direct and accurate information about the health of a specific water body and to meet the goals of the Clean Water Act is to conduct a biological assessment, or bioassessment, that involves the

identification and study of the presence, condition and numbers of types of fish, algae, plants, benthic and other organisms that exist in a waterbody.[18] The data collected from the bioassessment must then used to derive the biocriteria, which are numerical values and/or narrative criteria that serve as water quality standards and describe the desired condition for the aquatic life in those waters.[19]

The Clean Water Act TMDL Requirements

To improve waters that are already impaired, the Clean Water Act also requires states to incorporate Total Maximum Daily Loads, or TMDLs, into their water quality management programs, which represent the maximum amount of a pollutant that a water body can receive and still be considered healthy.[20] Under the Clean Water Act, TMDLs must be developed for waterbodies that fail to meet established biocriteria or surface water quality standards and are characterized as "impaired."

The Requirements of Other Statutes

Other statutes require DEP to take a more comprehensive approach in its efforts to protect ocean water quality. The Federal Coastal Zone Management Act, the New Jersey Coastal Area Facility Review Act and the New Jersey Coastal and Ocean Protection Council Act make it clear that New Jersey's responsibility goes well beyond public health and extends to the development and implementation of programs that take into account marine life, the ecosystem as a whole and the impacts to coastal resources caused by land use decisions.[21] These statutes create not just the authority for DEP to engage in ecosystem-based management and cumulative impacts analyses, but the obligation for DEP to implement such methodologies and programs.

DEP's Proven Experience in these Methodologies

DEP has proven knowledge and experience in bioassessments and biocriteria through its

use of these methodologies in many of its other programs, including its assessment of freshwater benthic macroinvertebrate populations through the Ambient Biological Monitoring Network; the Fish Index of Biological Integrity used to further assess freshwater streams; the development of phosphorus numeric and narrative surface water criteria for New Jersey's freshwaters; the establishment of TMDLs for pathogens, fecal coliform and phosphorus for numerous lakes and rivers throughout the State as well as for total coliform in shellfish-impaired Atlantic Coastal waters; the water, sediment and benthic samples collect from New Jersey estuaries each summer through the National Coastal Assessment; and the numerous studies conducted through the Barnegat Bay Estuary Program, including the use of biological indicators to measure decline.

Relevant Work of New Jersey Academic Institutions and the U.S. EPA

Much work has been done by scientists at Rutgers University, including extensive research on the importance of biological indicators, such as increased vegetation and nuisance species, in the assessment of coastal waters.[22] Rutgers scientists have also engaged in comprehensive studies of the inexorable link between land use activities and the decline of natural resources, including water quality.[23] The U.S. EPA has also conducted studies that are directly relevant to the assessment of New Jersey's coastal waters, such as its determination that excessive nitrogen is the cause of algal blooms and low oxygen problems in the ocean. This has led the agency to begin developing a TMDL for nitrogen in the New York-New Jersey Harbor which it anticipates will be completed sometime next year.[24] New Jersey must draw from these existing resources and redirect its efforts from management programs and regulatory decisions that focus solely on human health to those that also protect the ecological integrity of the ocean.

Recommendations

New Jersey must develop a comprehensive assessment plan for the ocean that focuses not only

on human health, but on the ecological integrity of the ocean and the marine biota that dwell there and that takes into account the regional and cumulative impacts to these resources that result from our land use activities. Such a plan must include the following elements:

I. An Ecosystem-Based Management Approach

DEP must employ an ecosystem-based management approach to the management of New Jersey's ocean resources. DEP should coordinate its efforts and pool existing resources and data with the federal government, neighboring states and existing research institutions to employ a comprehensive program that recognizes and operates under the premise that the marine ecosystem and the impacts to it caused by our land-use decisions do not recognize political and jurisdictional boundaries. Such an approach is required by the Federal Clean Water Act, the Federal Coastal Zone Management Act, the New Jersey Coastal Area Facility Review Act and the New Jersey Coastal and Ocean Protection Council Act.

II. Bioassessments, Biological Indicators and the Development of Biocriteria

New Jersey's ocean water quality should be assessed through a monitoring program that incorporates bioassessment techniques, utilizes biological indicators and establishes biocriteria as ecological goals to be met in conjunction with the use of traditional physical and chemical criteria and human health indicators. New Jersey's coastal monitoring program should include the following biological indicators:

- Benthic Community Studies and Benthic Indices
- Fish Index of Biologic Integrity
- Sea Grass Abundance And Distribution; Shoot Density, Biomass And Basal Coverage
- Shellfish Surveys of Abundance and Distribution
- Algal Bloom Surveys (Phytoplankton and Macroalgae); and

- Nuisance Species Abundance and Distribution.

III. Surface Water Quality Criteria and TMDLs

Additional Surface Water Quality Criteria (SWQC) must be developed for New Jersey's coastal waters, particularly for nutrients such as nitrogen that, in excessive amounts, cause harmful algal blooms, low dissolved oxygen levels and hypoxia. Such criteria must incorporate both a numerical and narrative component, following the approach DEP used to develop the SWQC for phosphorus in New Jersey freshwaters, and must also utilize Best Management Practices such as requiring 300 foot buffers for development activities that have the potential to impact coastal waters through nonpoint source pollution. In addition, TMDLs must be developed for ocean pollutants, and, in particular for nitrogen, the pollutant the EPA has identified as the cause of low dissolved oxygen levels in the ocean. DEP should coordinate its efforts with the EPA, as that agency is currently developing a nitrogen TMDL for the New York-New Jersey Harbor and has recognized and publicly acknowledged the need to develop a nitrogen TMDL for the entire New York Bight.

IV. Management of Land Use/Land Cover Decisions and Practices

No ocean monitoring and protection program can be effective unless it incorporates the study and management of land use practices that impact the coastal ecology and water quality. The importance of this element is underscored by the indisputable connection between land use activities and water quality made by Congress and the New Jersey legislature in every State and Federal statute adopted to protect the ocean, including the Federal Clean Water Act, the Federal Coastal Zone Management Act, the New Jersey Coastal Area Facility Review Act and the New Jersey Coastal and Ocean Protection Council Act.

THE CURRENT STATE OF THE OCEAN

Although a few beaches were closed to swimming due to high levels of bacteria last summer, such occurrences were few and far between, leading health officials to declare the ocean clean and to celebrate another good season for beach goers.[25] Official State documents echo these declarations and focus on the success of the beach season as a measure of water quality. For example, in a recent document in which DEP assessed its own Coastal Management Program, the section entitled "Ocean Water Quality," highlighted the fact that "the number of beach closings continues to decline" and that "New Jersey continues to have a model program for beach monitoring."[26]

DEP's focus on the health of beach goers as opposed to the health of the ocean was never more evident than during the brown tides of 2007. Heavy algal blooms appeared just in time for Memorial Day weekend, turning the ocean waters from Sandy Hook to the Manasquan inlet brown. When environmental activists urged the State to do more to protect the ocean, instead of acknowledging that the blooms were a sign of water quality problems, DEP took a shoot-the-messenger approach, stating that it was "unsettling that [environmentalists] would choose to sensationalize this algae bloom….at the start of the beach season."[27] Noting that the bloom was neither toxic nor harmful to people and appeared to be dissipating quickly, DEP concluded that this was "good news for the upcoming weekend."[28] The agency's public assessment completely disregarded the ecological implications of the algal bloom.

Contrary to these public pronouncements, there is much more to ocean water quality than whether or not people can go to the beach and take a swim. Although not mentioned in its aforementioned Ocean Water Quality summary, DEP has recently made several additional findings about the quality of New Jersey's ocean waters, including that the threat of habitat degradation and contaminant loading to the ocean's fish stocks is "high" and that New Jersey

faces the threat of increased harmful algal blooms.[29] In addition, due to "a persistent recurrence of low dissolved oxygen measurements in New Jersey's ocean waters during the summer months" DEP has assessed all of the State's ocean waters as being impaired due to low oxygen.[30] DEP explained that this "cell" of low dissolved oxygen extends from Sandy Hook to the Wildwoods – an area more than 100 miles in length – and, although the agency contends the exact reason for it is unknown, it suspects summer algal bloom die-off.[31] Significantly, DEP has admitted that the impacts on benthic marine biota from these hypoxic conditions are "unclear."[32]

As these DEP findings demonstrate, what's good news for beachgoers is not necessarily good news for the ocean, and the focus on the ability of people to swim in the ocean from May through September sends a false message to the public about the quality of our ocean. This message is perpetuated by the testing methodologies employed to monitor that quality, methodologies that either focus solely on human health or that purport to focus on the ecological health of the ocean but fail to actually accomplish this goal.

CURRENT TESTING METHODOLOGIES FOR OCEAN WATER QUALITY

New Jersey currently employs several programs for assessing the quality of the ocean, some of which clearly utilize human health as an indicator and some that purport to measure the ecological health of the waters but fall short.

Programs that Utilize Human Health as an Indicator

The most prevalent of New Jersey's programs in terms of the frequency and number of samples collected as well as public knowledge about them, are the Cooperative Coastal Monitoring Program (CCMP) and the National Shellfish Sanitation Program (NSSP). Both of these programs utilize human health as an indicator of ocean water quality.[33]

The Cooperative Coastal Monitoring Program (CCMP)

The CCMP is administered by DEP with the cooperation and participation of local environmental health agencies.[34] The program involves the weekly collection of water samples from 186 ocean and 139 bay beaches, geographically covering all ocean and bay bathing beaches from Raritan Bay to Cape May.[35] Samples are collected from the middle of May through early September, a period designed to roughly coincide with the summer Memorial-Day-to-Labor-Day beach season.[36] The pre-Memorial day samples, collected two weeks prior to what is considered the official start of the beach season, are intended to identify water quality problems that may have developed over the winter.[37]

Each week, the CCMP samples are analyzed for the presence and concentrations of *Enterococci* bacteria as an indicator of pathogens that may cause illness to swimmers.[38] If the levels of bacteria are deemed to be too high, a bathing beach will be closed to swimming until retesting from the same sampling site demonstrates lower levels that are safe for swimmers.[39]

The National Shellfish Sanitation Program (NSSP)

Under the NSSP, DEP maintains 1600 monitoring stations throughout New Jersey's coastal waters that are sampled between five and twelve times a year.[40] The samples are analyzed for the presence and concentrations of total coliform and fecal coliform bacteria, both indicators of human pathogens in the water that can be transmitted to consumers through the harvest and consumption of shellfish.[41] The NSSP has led to the adoption of New Jersey's regulations that establish when and where shellfish can be safely harvested for human consumption.[42]

Both the CCMP and the NSSP use threats to human health as an indicator of water quality and, as such, are utilized to make decisions that directly impact human behavior; more

specifically, they determine whether people can swim at a certain beach or harvest and eat shellfish from a particular location. As a result, they are the most publicized and well-known programs in the State. However, while the actions that these programs trigger protect human health, they do nothing to protect the ecological health of the ocean waters from which the samples are collected or the organisms that live in those waters.

Programs that Purport to Measure Ecological Health

New Jersey administers other monitoring programs that purportedly measure the ecological health of coastal waters, but they are simply not adequate. In some cases, the sampling protocol is deficient in that there are not enough sampling sites or the samples are collected too infrequently to be meaningful. In others, despite the programs' good intentions, the resultant data does not lead to management or regulatory decisions that focus on improving ocean water quality.

The Coastal Water Quality Monitoring Network

The Coastal Water Quality Monitoring Network was developed to measure the ecological health of New Jersey's ocean, estuarine and tidal river waters.[43] Samples are collected from approximately 270 locations four times a year (once each quarter) and are analyzed for temperature, salinity, suspended solids, dissolved oxygen, chlorophyll *a*, and nutrients such as ammonia, nitrate, phosphate, total nitrogen and total phosphorus.[44] The data collected through the program is intended to "lead to rational goals and policies for coastal water quality management" and to provide the means to assess DEP programs in attaining those goals.[45]

The resultant reports and data from this program demonstrate that, of the 270 sampling sites, only 29 are actually ocean water sites.[46] The data also demonstrates that, contrary to the

program protocol, these ocean sites are not always sampled four times a year and, in some years, were sampled only once.[47] These faults in methodology compromise the integrity of the data and defeat the very purpose of the program.

Most significant, the data that is collected through this program has prompted little or no regulatory action. For example, it is sampling under this program that led DEP to determine that all of New Jersey's ocean waters are impaired due to the persistent recurrence of low dissolved oxygen levels during the summer months.[48] The significance of this problem cannot be overstated, as was summarized by DEP:

> Dissolved oxygen is a fundamental requirement for the maintenance of balanced populations of fish, shellfish and other aquatic organisms. The nature and extent of the organism's response to low oxygen concentrations depends on several factors including the concentrations of oxygen in the water, the duration of the organism's exposure to reduced oxygen, and the age and physical conditions of the organism.
>
> Because dissolved oxygen is so important to marine life, New Jersey has established surface water criteria for oxygen levels in marine waters. The surface water criterion is five milligrams per liter for ocean waters and four milligrams per liter for estuarine waters. Dissolved oxygen concentrations below two milligrams per liter are considered lethal to aquatic life, while concentrations above two but below four or five milligrams per liter designation may support aquatic life, but warrant further study. However, prolonged periods of exposure to below optimum conditions may stress some aquatic life.
>
> Assessment of dissolved oxygen in ocean waters began in 2002 and revealed that 70 percent of the State's ocean waters (bottom waters only) did not meet the State's surface water criterion.[49]

Despite this alarming assessment, to date, no action has been taken to identify and limit the causes of the low oxygen levels or to identify and regulate the activities on land that are contributing to this problem. Instead, DEP has conceded that "the factors responsible for long-term dissolved oxygen trends are not well understood" and that "further study of these factors and their impact on ocean ecosystem health is clearly warranted."[50] After more than seven years,

this is not enough, particularly for a program that is supposed to "lead to rational goals and policies for coastal water quality management."[51]

Benthic Indicator Development for New Jersey Coastal Waters

Fortunately, DEP has recently begun to study some of the impacts of the oxygen conditions in the ocean and, in partnership with EPA Region 2, the EPA Atlantic Ecology Division and Rutgers University, is trying to determine whether the State's near-shore hypoxic coastal waters are biologically impaired.[52] Utilizing a "probalistic" benthic sampling design intended to assess 100% of the State's coastal waters out to a distance of three nautical miles, benthic grab samples, water quality data and underwater video were obtained from 100 designated sampling stations along the entire coast. The project partners plan to evaluate the data and develop an appropriate benthic index for these waters as well as determine the biological condition, *i.e.*, the condition of the benthic community, of New Jersey's coastal and estuarine waters. It is anticipated that an index for nearshore ocean waters will be completed in 2009 and for shallow coastal bays in 2010.[53]

The end-result of this study has been described by the project partners as follows:

> The expected outcome of this study will be a biological assessment of the condition of the waters along the New Jersey coast. Results will be compared to the extent of coastal impairment currently listed in the New Jersey Integrated Water Quality Monitoring and Assessment Report for 2006. <u>We expect that the extent of impairment of the coastal benthic communities will be significantly less than the 100% listed as impaired relative to dissolved oxygen</u>.[54]

Thus, it does not appear as if the goal of this study is to ultimately identify the source of the oxygen depletion and do something about it, but to be able to state that the oxygen depletion is actually not so bad after all.

The New Jersey Nutrient Criteria Enhancement Plan

In May, 2007, the EPA issued a Memorandum to the Directors of all State Water Programs detailing the serious threat to our waterways posed by nutrient pollution and urging every state to make the development of numeric water quality standards for both nitrogen and phosphorus a priority.[55] The Memorandum declared that "now is the time for EPA and its partners to take bold steps, relying on a combination of science, innovation and collaboration."[56]

In response to the EPA Memorandum, DEP released its New Jersey Nutrient Criteria Enrichment Plan (the Plan) in November 2008, which purportedly provides "a detailed description of the Department's strategy for developing nutrient criteria for all water's of the United State's." [57] However, a closer look at the Plan demonstrates that it is almost exclusively focused on New Jersey's freshwaters. In the section entitled "Criteria Development Process," it states "New Jersey's nutrient strategy, as articulated in this Plan, is to refine and expand its existing nutrient policy to better address the complex water quality problems related to over-enrichment of our State's freshwaters."[58] In the section entitled "Prioritization of Waterbody Types for Nutrient Criteria Development," estuarine and marine waters come in dead last, behind lakes, reservoirs, freshwater wadeable streams, freshwater non-tidal rivers and tidal rivers.[59]

The hypoxic conditions in our ocean waters have existed and have been known to the DEP for many years. This combined with the fact that the effect of these conditions on marine life is admittedly unknown demand that the development of the benthic index currently in progress and the use of that index to establish goals to alleviate the problem be given the highest priority.

Coastal Phytoplankton Monitoring Network

In the summer months, DEP, in collaboration with EPA Region 2, monitors the phytoplankton populations along the State's 127 miles of coastline and in its major estuaries.[60] Samples are collected bi-weekly from May through August from 16 stations by EPA via its helicopter.[61] The samples are provided to DEP's Bureau of Marine Monitoring and analyzed for the presence of potentially toxic forms of phytoplankton.[62] Since 2006, Chlorophyll *a* levels, which are indicative of a possible phytoplankton bloom, have also been measured through aerial overflight remote sensing.[63] However, as with the CCMP, this information is essentially used to inform DEP of possible threats to ocean swimmers in the summer months and, in accordance with the NSSP guidelines, of threats to shellfish from biological toxins.[64] Contrary to a true ecological assessment, the data collected has not prompted any action by DEP to identify the cause of the recurrence of phytoplankton blooms, assess the impacts to other marine organisms or to implement management techniques to prevent them.

THE CLEAN WATER ACT REQUIRES MORE FOR THE OCEAN

The measures taken by New Jersey to monitor the health of the ocean do not meet the requirements of the Clean Water Act. The Clean Water Act requires each state to periodically prepare and submit a report to the EPA that describes the overall quality of the state's surface waters.[65] The report, often referred to as the 305(b) report, must include an analysis of the extent to which the state is meeting the Act's purpose of restoring and maintaining the chemical, physical and biological integrity of the Nation's waters. Such waters include New Jersey's bays and estuaries and the near-shore coastal waters under its jurisdiction, which are those ocean waters that extend three miles seaward from the coast.[66]

The Section 305(b) Requirements - Bioassessments and Biocriteria

To demonstrate that this purpose is being achieved, the Act requires states to designate uses, or environmental goals, for its waters that will appropriately address the biological integrity of each water body.[67] The Act further requires states to adopt biological criteria, or biocriteria - - not just chemical and physical criteria - - to protect the designated uses of each water body.[68] EPA has determined that the best means to provide direct and accurate information about the health of a specific water body and to therefore meet the goals of the Act is to conduct a biological assessment, also known as a bioassessment.[69]

A bioassessment involves the identification and study of the presence, condition and numbers of types of fish, algae, plants, benthic and other organisms that exist in a waterbody.[70] The data collected from the bioassessment is then used to derive the biocriteria, which are numerical values and/or narrative criteria that are adopted as water quality standards and that describe the desired condition for the aquatic life in those waters.[71]

The importance of this methodology has perhaps been best described by the EPA itself:

> One of the most meaningful ways to answer basic questions about the quality of the nation's waters is to observe directly the communities of plants and animals that live in them. Because aquatic plants and animals are constantly exposed to the effects of various stressors, these communities reflect not only current conditions, but also stresses and changes in conditions over time and their cumulative impacts. Bioassessment data is invaluable for managing our aquatic resources and ecosytems. We can use it to set protection and restoration goals, to decide what to monitor and how to interpret what is found, to identify stresses to the waterbody and decide how they should be controlled and assess and report on the effectiveness of management actions. [72]

The EPA has also described in detail the dangers of proceeding with just physical or chemical criteria and failing to incorporate biocriteria into an assessment of the ecological integrity of a water body:

> To better serve these key management functions, biological assessments and adoption of biological criteria must become an equal component of water quality management programs along with chemical, physical and toxicity based water quality standards. By themselves, traditional chemical, physical and toxicity assessments cannot fully answer questions about the ecological integrity of a waterbody, or determine whether aquatic resources are being protected. Relying on traditional chemistry alone may lead to situations in which meeting chemical and toxicity standards may not be enough to fully protect the aquatic community…stressors such as poor habitat quality, altered stream flows, high turbidity and sedimentation, low dissolved oxygen concentration and contaminated sediments are proving more important than typically regulated pollutants in limiting the attainment of designated aquatic life uses.[73]

It is only through bioassessment techniques and the development of biocriteria to be used in conjunction with physical and chemical criteria that New Jersey can adequately assess the biological integrity of a water body and determine the water body's capacity to support and maintain the organisms that dwell there.

EPA Definitions for Clean Water Act Compliance

Biological Assessment (Bioassessment): *An evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of the resident living organisms.*

Biological Criteria (Biocriteria): *Numeric values or narrative descriptions that are established to protect the biological condition of the aquatic life inhabiting waters that have been given a certain designated aquatic life use.*

Biological Integrity (Biointegrity): *The capacity of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitat of the region.*

Biocriteria, Physical Criteria and Chemical Criteria

To understand the importance of bioassessments and the development of biocriteria, it is important to understand the difference between biocriteria and the traditional chemical or

physical water quality criteria. First, it must be understood that biocriteria are not alternatives to chemical or physical criteria, but measure completely different things.[74] A bioassessment, provides a direct measure of the cumulative response of the biological community in a water body to all sources of stress.[75] In doing so, a biaossessment measures the condition of the aquatic resource to be protected.[76] The biocriteria developed from the bioassessment set the biological quality goal or target to be achieved through the management of that water body.[77] Physical and chemical water quality criteria on the other hand are designed to protect the biological community of a water body from different categories of stress, such as toxic levels of specific pollutants or unhealthy physical conditions (*e.g.*, low dissolved oxygen, high turbidity).[78] Physical and chemical criteria are designed to prevent harmful effects on aquatic life before they occur.[79] A true assessment of the ecological integrity of a water body requires the assessment of all three components – the chemical integrity, the physical integrity and the biological integrity.[80]

Biological Criteria vs. Physical/Chemical Criteria

Biological Criteria – *Based on true measures of the condition of the aquatic resource to be protected taking into account all sources of stress (bioassessment); Sets the biological quality goal to be achieved through the management of the water body.*

Physical/Chemical Criteria - *Designed to protect the biological community of a water body from different categories of stress (e.g., toxic levels of pollutant, unhealthy physical conditions such as low oxygen) before it occurs.*

Contrary to these Clean Water Act requirements, New Jersey is not utilizing bioassessments or biocriteria to monitor and establish water quality goals for its ocean waters. In

DEP's most recent 305(b) report to EPA, it was explained that all New Jersey waters were assessed for the "aquatic life use" designation, a designation established by DEP that measures each water's ability to sustain the "maintenance, migration and propagation of the natural and established biota."[81] The report concluded that each and every area in the ocean that was assessed failed to attain its designated aquatic life use. This failure was due to the aforementioned levels of low dissolved oxygen stretching from Sandy Hook to the Wildwoods.[82] It was further concluded that "the reason for this benthic low DO cell is not known" and that "the impacts on the benthic marine biota are unclear."[83]

Significantly, these conclusions were based upon physical criteria only – the levels of dissolved oxygen in the water - and were not supplemented with any data from a bioassessment.[84] Despite the significant hypoxic condition of more than 100 miles of its ocean waters, New Jersey currently has no true knowledge of the biological condition of these waters. More important, without bioassessment data, New Jersey cannot develop biocriteria to protect the aquatic life of the ocean, leaving us with no biological quality goal to strive for. As a result, the biological integrity of the ocean waters is and will remain unknown, the admitted unknown impacts on marine biota will continue, and the purpose of the Clean Water Act - - to restore and maintain the chemical, physical and biological integrity of these waters - - will not be achieved.

The lack of bioassessment and biocriteria is not due to a lack of understanding by the DEP. In fact, as the following excerpt from the 305(b) report demonstrates, DEP understands full well the significance of this methodology and is using it in other surface water programs:

> The aquatic life use is assessed by directly evaluating biotic communities and assessing the health of the aquatic biota. When such data are available, the Department bases its aquatic life use assessments upon metrics developed to assess benthic macroinvertebrate data, in conjunction with fin fish IBI (Index of Biotic Integrity) data, supplemented with a broad suite of biologically relevant physical/chemical data (e.g., dissolved oxygen, temperature, toxic pollutants).

> The 2008 Integrated Report uses the results of three new biological assessment metrics based upon benthic macroinvertebrate data. Of note is a new benthic index for the Pinelands region, which is used in conjunction with biological data collected by the Pinelands Commission.[85]

DEP also clearly recognizes the serious shortfalls of a monitoring program that does not include the collection of biological data:

> When biological data are not available, the Department must rely on biologically-relevant chemical water quality data alone, such as dissolved oxygen (DO) to indirectly assess the health of the biota, even thought the chemical water quality data only provide a "snapshot" in time rather than the longer-term assessment supported by biological data.[86]

However, even the low expectations described by DEP in this paragraph cannot currently be achieved. In direct contrast to this statement, DEP has admitted that, at least when it comes to ocean waters, chemical water quality data such as dissolved oxygen cannot even "indirectly" assess the health of the biota. Instead, as it has clearly stated in various publications, the affects of the low dissolved oxygen levels on the benthic biota are currently unknown.[87]

Instead of continuing to rely on inadequate public health indicators or chemical water quality criteria, DEP must aggressively pursue a bioassessment program to evaluate the health of our ocean waters and its biota. Further, it must establish biocriteria that will set a water quality goal that New Jersey can work towards achieving. While the agency is taking steps towards these goals, including working with other agencies to develop a benthic indicator for State coastal waters, it is not being aggressive enough in that it has no immediate plans to establish biocriteria or a TMDL for nitrogen, the nutrient EPA has identified as the cause of the low dissolved oxygen levels in these waters.[88]

The Section 303(d) Requirements – Total Maximum Daily Loads

The Clean Water Act also requires states to incorporate Total Maximum Daily Loads, or TMDLs, into their water quality management program.[89] TMDLs represent the numerical

measurement of the ability of a water body to assimilate a particular pollutant while taking into account point and non-point sources of pollution and natural background levels.[90] In other words, it is the maximum amount of a pollutant that a water body can receive and still be considered healthy.[91] Under § 303(d) of the Clean Water Act, TMDLs are required to be developed for waterbodies that fail to meet established surface water quality criteria (SWQC).[92] The development of a TMDL requires the identification of the contributors to surface water quality impacts and sets goals for the reduction of specific pollutants as necessary to ensure that the waterbody meets the SWQC.[93]

TMDLs can also be established to help maintain or improve the quality of waters that do not exceed SWQC and are therefore not considered impaired.[94] In addition, because a TMDL is established for the pollutant that causes the unhealthy condition, the establishment of a TMDL may be required for a pollutant other than that for which the SWQC was violated.[95] For example, during the summer months in Long Island Sound, the levels of oxygen consistently dropped below the SWQC for dissolved oxygen established by New York and Connecticut.[96] Both States identified nitrogen as being the primary pollutant causing the low dissolved oxygen levels by fueling the growth of algae that eventually decayed, consuming oxygen in the process.[97] Because nitrogen was the primary pollutant causing the violation of the dissolved oxygen SWQC, Connecticut and New York were required by § 303(d) of the CWA to develop a TMDL for nitrogen, which they did in collaboration with the EPA in 2001.[98]

New Jersey is currently experiencing the same low dissolved oxygen problems suffered by the Long Island Sound. DEP has acknowledged that samples from the ocean's waters consistently violate New Jersey's SWQC for dissolved oxygen and has admitted that, like in Long Island Sound, the low dissolved oxygen levels are likely due to a cycle of algal blooms and

die offs, and thus excess nitrogen.[99] Nevertheless, no effort is currently underway to establish a nitrogen TMDL for New Jersey's ocean waters, rendering New Jersey in violation of the 303(d) requirements of the Clean Water Act.

OTHER FEDERAL AND STATE STATUTES REQUIRE A COMPREHENSIVE APPROACH

The Federal Coastal Zone Management Act, the New Jersey Coastal Area Facility Review Act and the New Jersey Coastal and Ocean Protection Council Act make it clear that New Jersey's responsibility goes well beyond public health. These statutes require a more comprehensive approach to the management and protection of ocean waters that takes into account marine life, the ecosystem as a whole and the impacts to these resources caused by our land use decisions. The mandates in these statutes are not just ideas to be considered, but are calls to action; they create not just the authority for DEP to engage in ecosystem-based management and cumulative impacts analyses, but the obligation to develop methodologies and programs to implement and enforce these mechanisms.

The Federal Coastal Zone Management Act

Adopted in 1972, the Coastal Zone Management Act established a voluntary national program to encourage coastal states to develop and implement coastal zone management plans and programs.[100] Today, approximately 34 coastal and Great-Lakes states, including New Jersey, have approved coastal zone management programs.[101] Once a state chooses to participate in the program, it is expected to, among other things:

- Protect natural resources;
- Manage development to achieve quality coastal waters; and
- Comprehensively plan for and manage living marine resources.[102]

These requirements are consistent with the findings and declarations made by Congress when it adopted the Act. Specifically, Congress found that "the habitat area of the coastal zone, and the fish, shellfish, other living marine resources, and wildlife therein, are ecologically fragile and consequently extremely vulnerable to destruction by man's alterations."[103] Congress further found that "land uses in the coastal zone, and the uses of adjacent lands which drain into the coastal zone, may significantly affect the quality of coastal waters and habitats" and, as a result, "efforts to control coastal water pollution from land use activities must be improved."[104]

The Coastal Zone Management Act has been amended several times since its adoption, including in 1998 and 2004 to establish a program for the prevention of harmful algal blooms and hypoxia. In adopting these amendments, Congress officially recognized the significance of these problems, noting that scientists believe they are caused by excessive nutrients in coastal waters and finding that such blooms and low oxygen levels are harmful or fatal to fish, shellfish and benthic organisms.[105]

Thus, under the Coastal Zone Management Act it is New Jersey's responsibility to protect not just coastal waters, but coastal habitat and biota, from problems caused by land use activities that may affect them - - including specifically algal blooms and hypoxia - - through the development and implementation of effective management programs and plans.

The New Jersey Coastal Area Facility Review Act (CAFRA)

In support of the adoption of CAFRA in 1973, the State legislature found and declared that New Jersey's coastal area is "an exceptional, unique, irreplaceable and delicately balanced physical, chemical and biologically acting and interacting natural environmental resource."[106] To protect this special resource, the legislature further declared that land uses in the coastal zone should be dedicated to those that "are reasonably consistent with the natural laws governing the

physical, chemical and biological environment in the coastal area."[107] To accomplish these goals, the legislature specifically went on to state that development in the coastal zone should occur:

> "…within the framework of a comprehensive environmental design strategy which preserves the most ecologically sensitive and fragile areas from inappropriate development and provides adequate environmental safeguards for the construction of any developments in the coastal area."

To carry out these findings and declarations, CAFRA incorporates a two-step process for determining whether development in the coastal zone is appropriate: First, the proposed development must meet all of the applicable Rules on Coastal Zone Management ("Coastal Rules"), which are designed to protect the most important and fragile natural resources from land-use activities; and second, CAFRA mandates that, even if the proposed project meets all of the Coastal Rules, DEP still cannot issue a development permit unless and until it finds that the proposed development:

- Conforms with all applicable water emission and effluent standards and all applicable water quality criteria;
- Prevents water effluents in excess of the existing dilution, assimilative and recovery capacities of the water environments at the site and within the surrounding region;
- Would result in minimal feasible impairment of the regenerative capacity of water aquifers or other ground or surface water supplies; and
- Would cause minimal feasible interference with the natural functioning of plant, animal, fish, and human life processes at the site and within the surrounding region.[108]

These standards are the basis for implementing the "comprehensive environmental design strategy" envisioned by the legislature. They demonstrate that environmental considerations under CAFRA extend to the regional impacts of a development proposal in addition to the impacts to the development site itself, and make it clear that that the cumulative impacts caused by development projects in the coastal zone must be assessed and considered. Significantly, these requirements explicitly apply to and are intended to protect the "natural functioning and

life process of plants, animals and fish" in addition to those of humans. And, as stated in the legislative findings and declarations cited above, CAFRA, like the Clean Water Act, is concerned with the physical, chemical and biological environment – all three components necessary to assess ecological integrity.

The New Jersey Coastal and Ocean Protection Council Act

Signed into law in 2008, the Coastal and Ocean Protection Council Act declares that New Jersey's efforts to protect the ocean must be guided by principles of "ecosystem health" that recognize "the interconnectedness between land and the ocean."[109] The Act further declares that this should be accomplished through an "ecosystem-based management approach," specifically defined as an approach "that integrates biological, social and economic factors into a comprehensive strategy aimed at protecting, restoring, and enhancing the sustainability, diversity and productivity of ecosystems."[110]

To carry out this approach, the Act establishes within the DEP "the New Jersey Coastal and Ocean Protection Council," a nine-member council that includes a representative from the DEP, the New Jersey Economic Development Authority and the New Jersey Division of Travel and Tourism, and six members of the public to be appointed by the Governor.[111] The purpose of the council is to determine how to incorporate ecosystem-based management approaches into New Jersey's existing coastal and ocean protection programs and to recommend and develop new plans for protecting coastal and ocean resources through such an approach. [112] Accordingly, this new statute, like the Coastal Zone Management Act and CAFRA, supports a comprehensive approach to ocean protection that incorporates a bioassessment program designed to study and protect the overall ecological integrity of our ocean resources.

BIOASSESSMENTS AND BIOCRITERIA IN OTHER DEP WATER QUALITY PROGRAMS

DEP has the knowledge and experience to develop bioassessment techniques and biocriteria for its coastal and ocean programs as it currently utilizes these important monitoring and assessment tools in its other water quality programs. For example, DEP utilizes bioassessment data to assess the ecological health of New Jersey surface waters in several of its freshwater monitoring and management programs, including, but not limited to, its use of a benthic index known as the Pinelands Macroinvertebrate Index, or PMI, to assess surface waters of the Pinelands.[113] Much of the biological data collected for these programs and the biocriteria developed as a result can serve as models for New Jersey to develop a similar comprehensive bioassessment program for its ocean waters.

New Jersey Ambient Biological Monitoring Network

Benthic Macroinvertebrates

Recognizing the limitations of chemical monitoring, DEP began supplementing its assessment of the State's freshwater streams with biological monitoring as early as 1996, when it established the Ambient Biological Monitoring Network (AMNET).[114] Through AMNET, DEP collects and assesses benthic macroinvertebrate populations in streams, including insects, worms, mollusks (snails and clams), and crustaceans (scuds and shrimp).[115] The network consists of over 800 sampling stations distributed throughout the State's five water regions (Atlantic, Raritan, Lower Delaware, Upper Delaware and Northeast Regions).[116] The health of the streams and their instream benthic macroinvertebrate communities are evaluated using a combination of biological monitoring data, visual observations, and testing for limited chemical and physical parameters. [117]

As discussed above, DEP is currently working in partnership with EPA Region 2 and others to study the coastal benthic community to determine whether the State's near-shore

hypoxic coastal waters are biologically impaired.[118] By analyzing benthic grab samples and water quality data from 100 designated sampling stations along the entire coast, the project partners intend to define the condition of the benthic community of New Jersey's coastal and estuarine waters and develop a benthic index for nearshore ocean waters sometime in 2009 and for shallow coastal bays in 2010.[119] However, the project documents and other State planning documents, including the New Jersey Nutrient Criteria Enhancement Plan, do not discuss how DEP intends to use this information to remedy the hypoxic conditions. Specifically, the document timelines or priorities do not include goals such as the development of SWQC for causative nutrients like nitrogen or the establishment of a nitrogen TMDL.

Fish Index of Biological Integrity

Years of study have demonstrated that the monitoring of benthic macroinvertebrate populations generally reflects short term and local impairments. Thus, to supplement its benthic assessments with data that reflects more long term and regional impairments, DEP added a fish index of biotic integrity (FIBI) to its freshwater stream monitoring program in 2000.[120] A FIBI measures the health of a stream based on multiple attributes of the resident fish population, such as species type, number and the presence of diseases or other anomalies.[121] Each site is scored based on its deviation from reference conditions that would be found at an un-impacted stream and classified as poor, fair, good or excellent.[122] FIBI data may be used to develop biocriteria for freshwater streams, and to prioritize sites for further study, among other things. [123]

The importance of implementing a similar program for New Jersey's coastal and estuarine waters cannot be overstated. Estuaries serve as critical spawning, nursery and feeding grounds for a variety of important commercial and recreational fish and shellfish species, many of which are experiencing serious population declines.[124] It is without question that our estuaries

exhibit a multitude of environmental problems, the most common of which are degraded natural habitats, declining plant and animal populations, diminishing fish and shellfish harvests, and impaired water quality. EPA has determined that most of the problems observed in Mid-Atlantic estuaries are due to land use practices and are closely linked to human population density.[125]

EPA has determined that the best means to provide direct and accurate information about the health of a specific water body and to meet the goals of the Clean Water Act is to conduct a biological assessment involving the identification and study of the presence, condition and numbers of types of fish, algae, plants, benthic and other organisms that exist in a waterbody.[126] In addition, the Federal Coastal Zone Management Act and CAFRA require DEP to consider the impacts of land use activities, including development and discharge permits, on water quality, habitat and fish and shellfish populations. A fish index of biological integrity for New Jersey's ocean and estuarine waters would be a big step towards meeting these statutory mandates and getting a true assessment of the health of these waters.

New Jersey Surface Water Quality Criteria for Nutrients

To better protect the health of New Jersey's freshwater streams, DEP has established a surface water quality criteria (SWQC) for the nutrient phosphorus.[127] Phosphorus, known as the "limiting nutrient" or the "growth limiting nutrient" in freshwater environments is the nutrient that, in excess, is known to cause excessive algal and other unwanted plant growth, leading to low dissolved oxygen levels that harm fish and other aquatic organisms.[128] The freshwater phosphorus SWQC is comprised of two parts – the numeric criteria and the narrative criteria. The numeric criteria states that the level of phosphorus in any freshwater stream cannot exceed 1.0 mg/l.[129] The narrative criteria, recognizing the biological impacts that excess phosphorus can

have on the ecology of a water body, states that phosphorus shall not be allowed in any freshwater within the State at levels that cause:

- objectionable algal densities;
- nuisance aquatic vegetation;
- abnormal diurnal fluctuations in dissolved oxygen or ph;
- changes to the composition of aquatic ecosystems; or
- that otherwise render the water unsuitable for its designated uses.[130]

The Technical Manual for Phosphorus Evaluations

To implement the numeric water quality criteria for total phosphorus, DEP developed the Technical Manual for Phosphorus Evaluations for NJPDES Discharge to Surface Water Permits.[131] Released in 2003, the Manual is intended as guidance for NJPDES permit holders, consultants and other interested parties, and consists of two parts. Part I provides a step-by-step process for planning and conducting an analysis to determine if phosphorus is a limiting nutrient in a particular waterbody or portion of a waterbody. Part II provides a step-by-step process for planning and conducting an analysis to determine if a designated use for a certain waterbody, such as for recreational purposes, aquatic life support or a water supply, is unsuitable due to the presence of phosphorus or excessive algae caused by phosphorus.[132]

The phosphorus Technical Manual should serve as a guide for DEP to develop a similar manual for nitrogen, the limiting nutrient in estuarine and coastal waters and which EPA has recently identified as the cause of algal blooms and low oxygen levels in New Jersey's near-shore coastal waters.[133]

Total Maximum Daily Loads

New Jersey has established pathogen, fecal coliform and phosphorus Total Maximum Daily Loads, or TMDLs, for numerous lakes and rivers throughout the State, as well as pathogen and total coliform TMDLs for shellfish impaired waters in the Atlantic Coastal Region. However, as described earlier in this report, although DEP has declared all of the State's ocean waters as impaired due to their failure to meet the SWQS for oxygen, no SWQS or TMDL been established for nitrogen, the nutrient that EPA has identified as being responsible for the low oxygen levels. Accordingly, it is imperative that DEP make it a priority to establish the necessary SWQSs and TMDLs to begin to address this serious problem.

In addition, as is suggested in the Clean Water Act, DEP should incorporate certain Best Management Practices (BMPs) into its TMDL program. BMPs are defined by EPA as "reasonable and cost-effective means for a landowner to meet certain nonpoint source pollution control needs." [134] One such reasonable and cost-effective BMP – New Jersey's 300 foot Category One buffers - is already an integral part of several DEP regulatory programs. Currently, a 300-foot buffer is required by the Stormwater Management rules and the Flood Hazard Area Control Act rules for certain activities proposed adjacent to Category One waters to protect the near-pristine integrity of these waters. This BMP should also be utilized to hasten the improvement of State waters that have been deemed impaired. Specifically, 300-foot buffers should also be required for development projects subject to the Coastal Rules that have the potential, through nonpoint source pollution, to further impact or hinder the improvement of the State's impaired coastal and estuarine waters.

The National Coastal Assessment

Through this federally funded program DEP, in cooperation with the EPA, is assessing the ecological health of New Jersey's estuaries.[135] Each summer, water, sediment and benthic invertebrate samples are collected from 35 locations in New Jersey's coastal bays and analyzed for water chemistry, such as nutrient and dissolved oxygen levels, sediment chemistry and sediment toxics and benthic diversity.[136] The objectives of this monitoring program are to assess the health or condition of New Jersey's estuarine waters, to trace changes in that condition over time and to identify reference conditions for estuarine waters.[137]

The Barnegat Bay Estuary Program

Barnegat Bay was accepted into EPA's National Estuary Program in 1996.[138] Since then, the Barnegat Bay Estuary Program has generated more than a decade worth of studies designed to analyze the health of the estuary, determine the factors contributing to its decline and to develop a management plan to restore and protect one of New Jersey's most valuable natural resources. These studies, which relied heavily on the use of biological indicators, bioassessment techniques and underscored the need for biocriteria, resulted in the following significant findings and occurrences.

Acknowledgement of Biological Indicators as Measure of Decline

On June 1, 2008, after engaging in a year-long assessment of the data and research on the ecological conditions of the bay collected over the years by State scientists and academics, then DEP Commissioner Lisa P. Jackson publicly announced the "DEP Barnegat Bay Action Plan".[139] In her public comments, Commissioner Jackson noted several factors - - <u>all of them biological indicators</u> - - that led DEP to conclude that "all is not well in Barnegat Bay," including:

- increased loads of nitrogen to the Bay;

- the decline of historic sea grass beds;
- the decline of shellfish populations; and
- the increased occurrence of sea nettles, a nuisance species.[140]

Based upon these and other findings, DEP concluded that without question, there is evidence of ecological decline in Barnegat Bay and that DEP must take "immediate and measurable steps" to determine the extent and nature of the degradation so that protective measures can be implemented.[141]

Acknowledgement of Nitrogen as Cause of Decline in Coastal Waters

Unlike freshwaters, for which phosphorus is typically the limiting nutrient, the biological productivity of coastal waters is normally limited by the availability of nitrogen.[142] Thus, in coastal waters, an increase in the production of algae or nuisance plant species or a decrease in the levels of dissolved oxygen are usually indicators of increased nitrogen loading. Barnegat Bay is no exception and, as is demonstrated in the research information posted on its Coastal Programs/Barnegat Bay Strategy website, DEP has acknowledged that nitrogen loading is a key factor in the declining health of the Bay.[143] Although DEP further estimates that about 1.5 million pounds of nitrogen enters the Bay annually through a variety of sources, including surface water, groundwater discharge and runoff, it inexplicably did not include the development of a nitrogen TMDL in its Barnegat Bay Action Plan.[144]

Acknowledgment that Nitrogen Loading is the Result of Land Use/ Land Cover Issues

DEP has also acknowledged the relationship between the levels of nitrogen that enter the Bay and the land use decisions that are made in the Barnegat Bay Watershed.[145] More specifically, as land use and land cover have increased over the years in the Barnegat Bay Watershed, the water quality of the Bay has declined.[146] Accordingly, several of the steps

recently announced in DEP's Barnegat Bay Action Plan focus on regulating activities on land that impact the Bay, such as implementing and enforcing better controls on stormwater, engaging in public education regarding the impact that fertilizers, runoff and other non-point sources have on the Bay and outreach to fertilizer industries to encourage formula adjustments to reduce the nutrient load to the Bay.[147]

Development of a Benthic Index

Perhaps the most important part of the Barnegat Bay Action Plan is DEP's acknowledgment of the importance of assessing biological communities within the Bay. Specifically, DEP has committed to developing a benthic index to provide more accurate information about the Bay's ecological health.[148]

BIOASSESSMENTS AND BIOCRITERIA IN ACADEMIC AND FEDERAL PROGRAMS

In addition to the bioassessments and biocriteria that DEP itself has developed and is utilizing in its other water quality programs, there are other academic and federal resources DEP should rely upon to update its coastal programs and develop a more comprehensive plan for the protection of ocean water quality.

Rutgers University Institute of Marine and Coastal Sciences

Many of the studies DEP relied upon in developing its Barnegat Bay Action Plan were conducted by the Rutgers University Institute of Marine and Coastal Sciences ("Rutgers").[149] However, Rutgers' scientists are currently urging DEP to go further in its bioassessment work in Barnegat Bay and in all of New Jersey's coastal waters.[150] Many of Rutgers' recommendations, which are summarized below, are based upon the fact that there are other key biological indicators of the quality and ecological health of New Jersey's coastal waters that must be included in any valid monitoring program.[151]

Key Biological Indicators of Coastal Ecosystem Health

According to extensive studies performed by Rutgers in and around the Barnegat Bay-Little Egg Harbor Estuary, the following biological indicators should be included in the bioassessment programs for all of New Jersey's coastal waters:

Seagrasses – Seagrasses are an important biological component of a healthy coastal ecosystem and one of the most sensitive indicators of long-term water quality in coastal waters.[152] They are key indicators of water quality, sediment quality, the effects of nutrient enrichment and overall coastal ecosystem health and changes in the vitality and distribution of these plants are generally a signal of the decline in aquatic ecosystem health.[153] It is recommended that coastal monitoring programs include the monitoring of seagrass abundance and distribution as well as quantitative measures of shoot density, biomass and basal coverage.[154]

Algal Blooms – Algal blooms in coastal waters are generally an indication of nutrient loading, particularly nitrogen, and can lead to a myriad of negative impacts, including increased occurrence of brown, yellow and red tides, loss of submerged aquatic vegetation due to shading effects and light attenuation and reduced dissolved oxygen levels.[155] These impacts in turn can lead to the deterioration of sediment and water quality, loss of biodiversity, disruption of ecosystem functions and impairment of human uses of the resources.[156] In addition, when algal blooms are toxic, they can be dangerous to shellfish, finfish and humans.[157] Regular surveys of algal blooms, both phytoplankton and macroalgae, must be conducted, including surveys for brown tide and chlorophyll diagnostic photopigment analysis to identify and quantify phytoplankton.[158]

Sea Nettles – Sea nettles are a stinging species of jellyfish whose presence in coastal waters indicates elevated levels of nutrients, particularly nitrogen, associated with fertilizer

runoff and other watershed waste inputs, inferring a direct link between this nuisance species and human activities in coastal watershed areas.[159] Sea nettle blooms are particularly disruptive to estuarine food chains in that they prevent energy flow to the upper trophic level organisms in the chain, resulting in the substantial alteration of the biotic community.[160] Accordingly, population surveys documenting the abundance and distribution of nuisance species such as sea nettles in coastal waters should be included in any monitoring program.[161]

Shellfish – Shellfish, and in particular, the hard clam, can serve as a primary indicator of the overall health of estuarine waters as well as the health of specific portions of a water body.[162] Thus, periodic surveys of the abundance and distribution of clams - - the greater the abundance and distribution, the healthier the water body - - throughout a coastal water should be conducted to serve as reference points and to study the response of this organism to events such as nutrient loading and brown tides.[163]

Benthic Community Studies and Indices – Because of their sedentary nature, their high level of responsiveness to habitat disturbances and, in many cases, their long life spans, benthic species are a reliable indicator of water quality and the overall environmental health of estuarine ecosystems.[164] Because they respond predictably to many natural and manmade stressors, benthic organisms are also good indicators of the effects of specific stressors, such as organic enrichment, hypoxia and chemical contaminants.[165] These effects can be measured by noting changes in species composition, biomass, and diversity, all of which signal shifts in the benthic community structure.[166]

Development of Nitrogen Biocriteria and TMDLs

Rutgers has emphasized that a major goal of the collection of bioassessment data and the study of these biologic indicators is the development of nutrient biocriteria, particularly for

nitrogen, the limiting nutrient in coastal waters.[167] Once the nitrogen biocriteria is established, which, like the phosphorus criteria developed for New Jersey's freshwaters will consist of both a narrative component and a numerical SWQC, a TMDL for nitrogen can be developed that will allow for the development of management techniques to remediate the impacts of nutrient enrichment.[168]

Rutgers University CRSSA Land Resource Impact Indicators

In addition to studying the biological systems within coastal waters, Rutgers has recognized the importance of simultaneously studying activities that occur on land that have the potential to impact these systems. During the 1990's, DEP temporarily utilized an environmental indicator approach to its resource management programs that included several indicators dealing directly with land use/land cover changes in the State.[169] The Rutgers University Grant F. Walton Center of Remote Sensing and Spatial Analysis (CRSSA) expanded upon this approach and developed Land Resource Impact (LRI) indicators as a means of analyzing and communicating trends in land use and land cover in New Jersey and the resultant impacts to the State's ecological resources.[170] The LRI indicators include the increase in developed land, the loss of natural wetlands, the loss of core forest habitat and the increase in impervious surfaces.[171]

In cooperation with DEP and the National Oceanic and Atmospheric Administration, CRSSA conducted a New Jersey Land Cover Change Analysis (NJLCCA) Project that monitored New Jersey's changing landscape over time as measure against the LRIs.[172] One of the main purposes of the study was to provide feedback to various local, state and federal agencies concerned with the success of land use and habitat management policies in New Jersey.[173] This information has been periodically updated and, most recently culminated in the

2008 report "Tracking New Jersey's Dynamic Landscape: Urban Growth and Open Space Loss 1986-1995-2002" (the CRSSA Report).[174]

Utilizing the 2002 New Jersey Land Use/Land Cover digital dataset released by DEP in January 2007, the CRSSA Report provides valuable information about changes to New Jersey's land use and land cover that directly impact ocean water quality, particularly when such changes occur in coastal counties and watersheds that drain into the ocean. The following summaries from the 2008 Report provide insight into the extent of the impacts caused by land use decisions in New Jersey, and demonstrate that a continuous analysis of the changes in land use and land cover is an integral component of the bioassessment and management program of any water body, including the ocean.

Increase in Developed Land

As developed land increases, the quality of water bodies located in and around those developed lands and into which the developed lands drain, typically decline.[175] This fact is significant in light of the dramatic increases in developed land that has occurred in New Jersey over the past two decades. Specifically, from 1986 through 1995, the number of acres of developed land in New Jersey increased by 134,000 acres.[176] From 1995 to 2002, the increase in developed land was 106,000 acres, bringing the total increase in developed land for the entire period from 1986 to 2002 to approximately 240,000 acres.[177]

Impacts to Forests

Forests play an important role in maintaining water quality in that they provide watershed protection, significant ground water recharge area, flood control, soil erosion control and the abatement of climate change.[178] The CRSAA Report demonstrates that New Jersey's forests are suffering significant losses to development, and that the rate of these losses is increasing.[179] For

example, in 1986, New Jersey enjoyed 1,641,297 acres of upland forest.[180] In 1995, the number of acres decreased to 1,616,683, representing a loss of 24,614 acres in a less than ten year period.[181] In 2001, the number of upland forest acres remaining was 1,575,220, representing a loss of 41,463 acres since 1995 and a total loss of 66,077 between 1986 and 2002.[182]

Impacts to Wetlands

Critical in their water purification and flood control capabilities as well as their role as wildlife habitat, wetlands represent nearly 20% of New Jersey's land territory.[183] From 1986 through 1995, New Jersey suffered a total wetlands loss of 15,795 acres.[184] From 1995 through 2002, the total wetlands loss was 12,747 acres, bringing the total loss for the period from 1986 to 2002 to 28,540 acres.[185] Significantly, of the total wetlands lost, the loss of coastal wetlands, which comprise 20% of New Jersey's wetlands, was approximately 161 acres from 1986 to 1995 and 120 acres from 1995 to 2002.[186] The remaining losses during those time periods of approximately 12,500 and 28,400 acres, respectively, were to freshwater wetlands. The CRSAA Report surmises that the large discrepancy between the loss of freshwater and coastal wetlands may be indicative of the success of New Jersey's Coastal Wetlands Act of 1970, particularly since, prior to 1970, the Barnegat Bay area alone lost more than 10,000 acres of coastal salt marsh.[187]

Increase in Impervious Surfaces

The increase in impervious surfaces is one of the most significant influences on water quality because such man-made surfaces alter the function of the natural hydrologic cycle.[188] Specifically, the creation of impervious surfaces impedes the ability of precipitation to infiltrate and recharge the groundwater while at the same time increasing surface water runoff.[189] Research has shown and it is now generally accepted that the water quality and overall

environmental health of a watershed is directly related to the amount of impervious surface in the watershed and declines as impervious surfaces increase.[190] At impervious surface levels greater than 10%, surface waters in watersheds show definite signs of impact.[191] At impervious surface levels of 30%, water quality is typically seriously degraded.[192]

As of 2002, approximately 10 % of New Jersey's total land area, or 490,000 acres, was covered with impervious surface.[193] Ten watersheds, or 315,351 acres in New Jersey, are currently at 30% or more of impervious surface.[194] Forty watersheds, or 1,372,189 acres, are between 10% and 29.9% impervious surface, and 29 watersheds, or 1,006,060 acres of New Jersey's watersheds are between 5% and 9.9% impervious.[195] The CRSSA Report further demonstrates that the amount of impervious surface is increasing in correlation with the increase in urban growth.[196] During the 1995 to 2002 CRSSA Report period, 32 watersheds increased their total impervious surface coverage by 1% to 2%, while nine watersheds increased their total by more than 2%.[197]

Impacts to Coastal Counties

The CRSSA Report also categorizes the impacts of land use/land cover actions on a county-wide basis. The counties that stand out as "growth hotspots" due to significant increases in development rates include the coastal counties of Atlantic, Monmouth and Ocean, which experienced a 24%, 22% and 27% increase in their annual development rates, respectively.[198] Ocean County was also identified as one of the top five rural counties that is rapidly expanding its urban lands.[199] Monmouth County was identified as one of the counties with the greatest percentage of its existing land already developed.[200]

As the CRSAA Report demonstrates, the land use/land cover changes in New Jersey over the last several decades have been dramatic. Such changes are impacting New Jersey water

quality directly and indirectly through their impacts to natural resources that protect and enhance water quality. Accordingly, no water quality monitoring program is valid or complete without a methodology that allows for the continuous monitoring and management of land use decisions that impact the coastal and ocean environment.

US EPA Nitrogen TMDL for New York-New Jersey Harbor

Another resource DEP should rely upon to further develop its coastal program is the work of the EPA regarding nitrogen loading and its causes and impacts in coastal waters. During the summer of 2008, the EPA embarked on an excursion to sample the waters from Massachusetts to Delaware to learn more about the impact of nitrogen pollution, which EPA has identified as the cause of algal blooms and low oxygen problems in the ocean.[201] EPA Regional Administrator Alan J. Steinberg explained the significance of these impacts: "…[W]hen you get a reduction in dissolved oxygen, it is a serious threat to aquatic life and the ecosystem balance."[202] In an effort to alleviate the problem, EPA is developing a TMDL for nitrogen in the New York-New Jersey Harbor and anticipates it will be completed sometime next year.[203] Citing to low oxygen levels in the ocean waters off of New Jersey, EPA officials also acknowledged the need to develop a TMDL for nitrogen in the entire New York Bight, which comprises the ocean waters from Cape May, New Jersey to Montauk, Long Island.[204]

The important work of Rutgers regarding biological indicators in coastal waters and the impact of land use decisions on coastal watersheds and of EPA in the development of a nitrogen TMDL for the New York/New Jersey Harbor can and should be utilized by DEP to develop an effective program to protect and enhance New Jersey's ocean waters.

THE CURRENT MANAGEMENT APPROACH IS NOT WORKING

The state of our ocean and estuarine waters is proof that the current management approach is simply not working. In addition to the problems discussed throughout this report, the

following are just a few of the additional serious problems we are faced with that are due to program failures that must be remedied.

The Silo-Based Management Approach

Water quality management, including decisions regarding habitat and aquatic life, is handled by numerous divisions within the DEP, including the Division of Land Use Regulation, the Division of Water Quality, the Division of Watershed Management, the Division of Water Supply, the Division of Fish and Wildlife, the Division of Science, Research and Technology and the Office of Coastal Planning and Coordination.[205] Unfortunately, each of these programs has their own authority and decision-making processes and there is little to no communication between them, even when they are reviewing the same development project. This silo-based management approach must be replaced with one of open communication that considers impacts to water quality on an ecosystem basis, instead of a project-by-project or programmatic basis.

Water Supply Plan and Allocation Failures

The increasing loss of freshwater inputs to the Barnegat Bay Estuary, and the simultaneous increase in salinity and temperature demonstrate that ecological concerns are not being properly addressed in the Water Supply Master Plan and the Water Allocation Program. Freshwater withdrawals from surface and ground water sources in Ocean County for human uses have increased from about 56 million gallons per day in 1985 to nearly 71 million gallons per day in 2000.[206] Most of the water, or about 70%, is withdrawn for public water supply purposes. During the summer months, about 60 million gallons per day is removed from the Barnegat Bay watershed area and is discharged through the regional sewerage outfall to the ocean, bypassing the estuary entirely. This is the equivalent of about one-third of the freshwater inflow to the estuary under extreme low flow conditions.[207]

In Cape May, New Jersey, unfettered development and the water withdrawals that accompany it have severely endangered the public water supply as well as the habitats and species that depend on the coastal streams in the area. During the 30 year period from 1960 through 1990, saltwater intrusion forced Cape May County to abandon more than 10 public supply wells, 3 industrial supply wells and more than 100 domestic supply wells.[208] As of 2002, water supply levels in the Cohansey Aquifer were below seal level from the town of Burleigh south and coastal stream flows in the same area were reduced and flowing at 80% the normal rate.[209]

Land Use Program Impervious Coverage and Recharge Area Failures

Saltwater intrusion is not just an issue in Cape May County, and is also occurring in coastal aquifers underlying parts of Atlantic, Gloucester, Monmouth, Ocean and Salem Counties.[210] This wide-spread problem is indicative of the failures of the Water Supply Master Plan and Water Allocation Program. However, it also demonstrates the failure of the Land Use Regulation Program to limit impervious coverage from development and ensure the preservation of adequate aquifer recharge areas.

Watershed Management Program Failures

The majority of New Jersey municipalities or planning entities have either not updated their Wastewater Management Plans in decades or have neglected to prepare and submit a Wastewater Management Plan at all, in violation of section 303(d) and 208 of the Clean Water Act.[211] In addition, these planning entities have faced no consequences whatsoever for their ongoing infractions, which can only be characterized as a major failure of New Jersey's Watershed Management Program.

These and other problems facing New Jersey's coastal and estuarine waters and the State's ability to protect the physical, chemical and biological integrity of these waters demonstrate that it is time for DEP to redirect its management efforts.

NEW JERSEY NEEDS A COMPREHENSIVE ASSESSMENT PLAN FOR THE OCEAN

New Jersey must develop a comprehensive assessment plan for the ocean that focuses, not only on human health, but on the ecological integrity of the ocean and the marine biota that dwell there and that takes into account the regional and cumulative impacts to these resources that result from our land use activities. Such an approach is not only mandated by the Clean Water Act, but it is required by other Federal and State statutes that entrust New Jersey to protect these waters. Drawing on the knowledge and experience gained from its use of bioassessments and biocriteria in other State programs as well as relevant studies, data and criteria from other federal and academic programs, New Jersey has the tools and resources to pioneer a workable, valid and ecologically relevant plan for the ocean. Such a plan must include the following elements:

I. An Ecosystem-Based Management Approach

DEP must employ an ecosystem-based management approach to the management of New Jersey's ocean resources. In accordance with the New Jersey Coastal and Ocean Protection Council Act, such an approach "integrates biological, social and economic factors into a comprehensive strategy aimed at protecting, restoring and enhancing the sustainability, diversity and productivity of ecosystems."[212] Through such a process DEP should coordinate its efforts and pool existing resources and data with the federal government, neighboring states and existing research institutions to employ a comprehensive program that recognizes and operates under the premise that the marine ecosystem and the impacts to it caused by our land-use decisions do not recognize political and jurisdictional boundaries. In addition, an

ecosystem-based management approach will ensure that DEP's land use decisions are in accordance with the requirements of CAFRA. CAFRA requires that any development project in the coastal zone must take into account the impacts it has on the water quality and the functioning of plant, animal and fish processes at both the site and the "surrounding region".[213]

II. Bioassessments, Biological Indicators and the Development of Biocriteria

New Jersey's ocean water quality should be assessed through a monitoring program that incorporates bioassessment techniques, utilizes biological indicators and establishes biocriteria as ecological goals to be met in conjunction with the use of traditional physical and chemical criteria. Such an approach will allow for the assessment of the overall ecological health of the ocean and enable New Jersey, through the establishment of biological criteria, to set biological quality goals or targets to be achieved through proper management techniques. This, in turn, will enable New Jersey to move towards compliance with the Clean Water Act 305(b) requirements and towards meeting the Act's purpose of restoring and maintaining the chemical, physical and biological integrity of the ocean.

The use of bioassessments, biological indicators and biocriteria will also ensure that such a program is compliant with the mandates of other Federal and State statutes, such as the Federal Coastal Zone Management Act's expectation that coastal states will protect natural resources and comprehensively plan for and manage living marine resources;[214] the 1998 and 2004 amendments to the Coastal Zone Management Act adopted to establish a program to prevent harmful algal blooms and hypoxia, both of which are documented problems in New Jersey's coastal waters;[215] and the CAFRA requirement that land uses are consistent with "the natural laws governing the physical, chemical and biological environment in the coastal area."[216]

Specifically, New Jersey's coastal monitoring program should include, but not necessarily be limited to, the following biological indicators, several of which are already utilized by DEP in its current freshwater programs and the Barnegat Bay Estuary Program and are recommended as part of any coastal monitoring program by the Rutgers University Institute of Marine and Coastal Sciences:

- Benthic Community Studies and Benthic Indices
- Fish Index of Biologic Integrity
- Sea Grass Abundance And Distribution; Shoot Density, Biomass And Basal Coverage
- Shellfish Surveys of Abundance and Distribution
- Algal Bloom Surveys (Phytoplankton and Macroalgae); and
- Nuisance Species Abundance and Distribution.

III. Surface Water Quality Criteria and TMDLs

Additional Surface Water Quality Criteria must be developed for New Jersey's coastal waters, particularly for nutrients such as nitrogen that, in excessive amounts, cause harmful algal blooms, low dissolved oxygen levels and hypoxia. Such criteria must incorporate both a numerical and narrative component, following the approach DEP used to develop the SWQC for phosphorus in New Jersey freshwaters. In addition, TMDLs must be developed for ocean pollutants, and, in particular for nitrogen, the pollutant EPA has identified as the cause of low dissolved oxygen levels in the ocean and the reason New Jersey's coastal dissolved oxygen SWQC cannot be met. DEP should coordinate its efforts with EPA Region 2, as that agency is currently developing a nitrogen TMDL for the New York-New Jersey Harbor and has recognized and publicly acknowledged the need to develop a nitrogen TMDL for the entire New York Bight. Such an approach would enable New Jersey to move towards compliance with the Clean Water

Act 303(d) requirements and the recent amendments to the Coastal Zone Management Act adopted to establish programs to prevent harmful algal blooms and hypoxia in coastal waters.

IV. The Study and Management of Land Use/Land Cover Decisions and Practices

No ocean monitoring and protection program can be effective unless it incorporates the study and management of land use practices that impact the coastal ecology and water quality. The importance of this element is underscored by the indisputable connection between land use activities and water quality made by Congress and the New Jersey legislature in every State and Federal statute adopted to protect the ocean:

- **The Federal Clean Water Act** generally prohibits unauthorized discharges into waters of the United States and includes wetlands in its definition of these waters.[217] The discharges regulated under the Act all originate on land and include discharges from point source pollution, such as stormwater systems and combined and sanitary sewer overflows, and non-point source pollution, such as runoff caused by impervious surfaces. Accordingly, it is impossible to comply with the Clean Water Act without monitoring and regulating each and every activity on land that causes or contributes to such discharges.
- **The Federal Coastal Zone Management Act** was adopted based on the Congressional findings that "land uses in the coastal zone, and the uses of adjacent lands which drain into the coastal zone, may significantly affect the quality of coastal waters and habitats" and, as a result "efforts to control coastal water pollution from land use activities must be improved."[218]
- **The New Jersey Coastal Area Facility Review Act** was adopted based on the New Jersey legislature's findings and declaration that the coastal area is "suffering serious adverse environmental effects resulting from existing development activity impacts," and

that the "State will suffer continuing and ever-accelerating serious adverse economic, social and aesthetic effects unless the State assists…in the assessment of impacts stemming from the future location and kinds of developments within the coastal area on the delicately balanced environment of that area."[219] Thus, the legislature further found and declared that the coastal area should be dedicated to "those kinds of land uses" that "are reasonably consistent and compatible with the natural laws governing the physical, chemical and biological environment of the coastal area." [220]

- **The New Jersey Coastal and Ocean Protection Council Act** was adopted based on the New Jersey legislature's finding and declaration that the governance of New Jersey's ocean resources must be guided by principles of sustainability and ecosystem health and "of recognition of the interconnectedness between land and ocean…"[221]

Accordingly, a process for studying land use/land cover decisions and impacts, such as the use of Land Resource Impact Indicators and the process developed by CRSSA in its 2008 Urban Growth and Open Space Loss report must be incorporated into any program to protect New Jersey's ocean resources. The data generated will identify the natural resources adjacent to and upland of the ocean that must be protected in order to protect ocean water quality and will serve to better inform and direct the land use and resource management policies in New Jersey that have a direct impact on ocean water quality and the coastal ecosystem.

CONCLUSION

There is much more to ocean water quality than whether the waters are swimmable or the shellfish edible. Contrary to the current monitoring programs developed and implemented by DEP, a valid, scientifically defensible ocean protection and monitoring program must incorporate bioassessment techniques that utilize biological indicators and establish biocriteria as ecological goals to be met in addition to the existing physical and chemical criteria. Further,

once the criteria and goals are established, they must be actively and continually pursued through proactive management practices to ensure that they are achieved. The program must also employ an ecosystem-based management approach that is developed and implemented on the premise that the marine ecosystem and the impacts caused to it by our land use activities do not recognize political, jurisdictional or programmatic boundaries.

This approach is in accordance with the mandate of the Federal and State statutes that entrust New Jersey and the DEP with the responsibility and privilege to serve as the guardian of these waters. Through its existing freshwater monitoring programs and the Barnegat Bay Estuary Program, DEP has gained the knowledge and experience necessary to develop and implement such a program in New Jersey. In addition, by coordinating its efforts and utilizing the resources already developed by New Jersey academic institutions, such as Rutgers University, and other agencies, including the EPA, DEP can supplement its existing knowledge and experience to more readily achieve its goals. New Jersey has the resources and authority necessary to pioneer a strategy that will redirect its efforts from management programs and regulatory decisions that focus solely on human health to those that protect the ecological integrity of the ocean.

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Susan M. Kennedy has more than twenty years of experience in the environmental arena working on land use, water quality and coastal development issues. An attorney since 1992, Kennedy has practiced environmental, land use, zoning and administrative law for more than 15 years. Her understanding of environmental issues extends beyond the courtroom to both the field and the laboratory through her work as a Project Manager/Biologist for the U.S. EPA's Field Investigation Team and Technical Assistance Team, planning and conducting Superfund investigations and remediations, and as a Water Quality Analyst for the Monmouth County Department of Health's Environmental Laboratory, conducting chemical and biological analyses of ground and surface waters via atomic absorption spectrophotometry, ion chromatography and various biological methods. Kennedy has recently started her own consulting business providing regulatory and policy analysis to the environmental, legal and academic community. She received a B.S. in Biology from Delaware Valley College of Science and Agriculture and continued her studies at the Vermont Law School where she received both a Juris Doctor and a Master of Studies degree in Environmental Law.

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[204] Ibid.
[205] Op. Cit., Official DEP Organizational Chart.
[206] Barnegat Bay National Estuary Program, 2005 State of the Bay Technical Report, p. v-vi; p. 35-39.
[207] Barnegat Bay National Estuary Program Strategic Plan, 2008-2011; Op. Cit., Barnegat Bay-Little Egg Harbor Estuary, Kennish, Michael. p. 28.
[208] Op. Cit., Availability of Water Supplies and Saltwater Intrusion, Cape May County, New Jersey, 2002, p.1.
[209] Ibid.
[210] Op. Cit., Sustainability of Ground Water Resources, October 30, 2007.
[211] Op. Cit., Implementing the Water Quality Management Rules, New Jersey Department of Environmental Protection; See, also Clean Water, Sewers, Septic and Sprawl, Association of New Jersey Environmental Commissions (ANJEC), p. 6.
[212] N.J.S.A. 13:19-34.2
[213] N.J.S.A. 13:19-10
[214] Op. Cit., Coastal Programs: Partnering with States to Manage our Coastline, NOAA Office of Ocean and Coastal Resource Management.
[215] Public Law 105-383, 112 Stat. 3447, Title VI, Harmful Algal Blooms and Hypoxia.
[216] N.J.S.A. 13:19-2
[217] Federal Clean Water Act, 33 U.S.C. § 1251.
[218] 16 U.S.C. § 1451, Coastal Zone Management Act, Section 302
[219] N.J.S.A. 13:19-2.
[220] Ibid.
[221] N.J.S.A. 13:19-34.1(f).