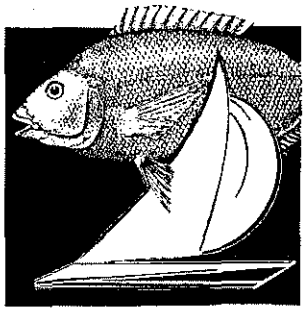

LONG ISLAND SOUND STUDY

A Partnership to Restore and Protect the Sound

THE COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN

March 1994

The Long Island Sound Study

Estuary of National Significance

The Long Island Sound Study Management Conference involves federal, state, interstate, and local agencies, universities, environmental groups, industry, and the public. The Long Island Sound Study began in 1985 when Congress appropriated funds for the U.S. Environmental Protection Agency and the states of Connecticut and New York to research, monitor, and assess the water quality of Long Island Sound. With the Clean Water Act Amendments in 1987, Section 320 of the Act officially established a *National Estuary Program*. At the request of the states of Connecticut and New York, Long Island Sound was officially designated an *Estuary of National Significance* under this new program, and a Management Conference for the Long Island Sound Study was convened in March of 1988.

Purpose of the Long Island Sound Study

The Management Conference was charged with developing a Comprehensive Conservation and Management Plan for protecting and improving the health of Long Island Sound while ensuring compatible human uses within the Sound ecosystem. The plan characterizes the priority problems affecting Long Island Sound and identifies specific commitments and recommendations for actions to improve water quality, protect habitat and living resources, educate and involve the public, improve the long-term understanding of how to manage the Sound, monitor progress, and redirect management efforts. Wherever possible, the plan contains agency commitments to take actions addressing these issues. Where current staffing and funding are inadequate, recommendations for action are presented.

Priority Areas of Concern

While progress has been made during the past 20 years in improving the quality of the waters, the health of Long Island Sound is still at risk. The LISS focused on environmental problems that are Soundwide and require a bi-state remedial effort. The Management Conference has identified six problems that merit special attention: (1) low dissolved oxygen (hypoxia), (2) toxic contamination, (3) pathogen contamination, (4) floatable debris, (5) the impact of these water quality problems, and habitat degradation and loss, on the health of living resources, and (6) land use and development resulting in habitat loss and degradation of water quality. The Management Conference has focused its efforts and resources on the most pressing problem among these, low dissolved oxygen, which affects a substantial portion of Long Island Sound in late summer, but has addressed all priority problems.

ERRATA

Page 130, The last two sentences under the first **objective** listed on that page were edited imprecisely and should be replaced by the following:

> "Environmentally-sensitive land use regulations and careful site planning and design can effectively mitigate potential adverse impacts of new land uses to Long Island Sound. Accordingly, clustered development should be encouraged within the context of stringent state and municipal standards and regulations that ensure the protection of natural resources, proper siting of community septic systems in unsewered areas, and appropriate intensity of land use."

CTDEP also suggests that interested parties refer to:

> Yaro, R.D., R.G. Arendt, H.L. Dodson, and E.A. Brabec. 1988. Dealing with change in the Connecticut River Valley: A design manual for conservation and development. 2nd printing. Lincoln Institute of Land Policy and the Environmental Law Foundation, Cambridge, MA. 181 p.
>
> The publication is available from CTDEP, Map and Publication Sales, 79 Elm St., Store Level, Hartford, CT 06106-5127.

How to Use this Document

The Comprehensive Conservation and Management Plan for Long Island Sound characterizes the priority problems affecting the Sound and identifies specific commitments and recommendations developed by the Long Island Sound Study (LISS) Management Conference. The introductory chapters briefly describe Long Island Sound and its watershed and the purpose and organization of the Long Island Sound Study. The following chapters detail the cause and impact of the Sound's priority problems and identify specific commitments and recommendations to restore and protect the Sound. The commitments are actions for which enhanced program resources have already been made available or for which there are firm obligations. The recommendations are actions that require additional funding that is not currently available. An overview of the actions is presented in tables at the end of the chapter text. The final chapters describe the areas that are critical to supporting implementation, including continued coordination by the Long Island Sound Study Management Conference, public involvement and education, and funding.

A summary of the plan, highlighting all its major elements, is also available for those seeking a broad overview.

For More Details About the LISS

For those seeking detailed information on various aspects of the program, the Management Conference has produced support documents. The support documents contain a more detailed characterization of the priority water quality problems facing Long Island Sound, a discussion of the existing statutory and regulatory programs available to manage these problems, and numerous options for improving management, including enhancements to existing programs, and recommendations for new initiatives. The Management Conference integrated the information contained within the technical support documents to develop the plan. The following is a list of the technical support documents:

- Hypoxia and Nutrient Enrichment: Assessment of Conditions and Management Recommendations
- Toxic Substance Contamination: Assessment of Conditions and Management Recommendations
- Pathogen Contamination: Assessment of Conditions and Management Recommendations
- Floatable Debris: Assessment of Conditions and Management Recommendations
- Assessment of Living Marine Resources
- Public Involvement and Education
- Environmental Monitoring of Long Island Sound: Program Inventory
- Discussion of Existing Management Programs for Long Island Sound and its Resources
- Federal Consistency Review

The support documents were based largely on the numerous technical studies that were conducted and reports that were written over the course of the LISS. These studies and reports have been completed, submitted to peer review, and are available at the EPA Long Island Sound Office.

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EXECUTIVE SUMMARY

Long Island Sound is an estuary, a place where salt water from the ocean mixes with fresh water from rivers and the land. Like other estuaries, Long Island Sound (the Sound) abounds in fish, shellfish, and waterfowl. It provides feeding, breeding, nesting, and nursery areas for diverse animal and plant life. But the Sound is unique in the degree to which it provides recreational and commercial value to the region. Since it was formed more than 8,000 years ago with the retreat of glacial ice and a rise in sea level, the Sound has been an important resource for people living along its shores. Native Americans were sustained by its abundant resources. Its embayments were natural harbors for European Colonists seeking refuge after their long journeys across the Atlantic Ocean. Today, it lies in the midst of the most densely populated region of the United States. More than 8 million people live in the Long Island Sound watershed and millions more flock yearly to the Sound for recreation. About $5 billion is generated annually in the regional economy from boating, commercial and sport fishing, swimming, and beachgoing. The ability of the Sound to support these uses is dependent on the quality of its waters, living resources, and habitats. The regional economy also benefits from many other valuable uses of the Sound, such as cargo shipping, ferry transportation, and power generation. With the uses it serves and the recreational opportunities it provides, Long Island Sound is among the most important estuaries in the nation.

The current value and quality of the Sound are partly the result of the investments in water pollution control programs made in the two decades since the passage of the Clean Water Act. These programs have led to measurable improvements in pollution control and water quality, in spite of ever-increasing numbers of people and activities on the Sound and within its watershed. Obvious sources of pollution are now regulated and controlled through permit programs, tidal wetlands are protected, and major efforts in the states of Connecticut and New York to build sewage treatment plants and control industrial discharges have helped to restore degraded waters. More recently, with programs focusing on the ecosystem as a whole, the approach has become more comprehensive to include increased efforts in stormwater and nonpoint source pollution control.

In spite of these efforts, problems remain. The quality of Long Island Sound is still far from what it should or can be. Many of the uses or values of the Sound are still impaired from old abuses. Other uses or values face new threats. Residential, commercial, and recreational development have increased pollution, altered land surfaces, reduced open spaces, and restricted access to the Sound. Development has dramatically increased the use of the Sound as a place to dispose of human and other wastes. The *paving over* of the land has increased runoff and has reduced the filtration and processing functions of natural landscapes. Habitat destruction and alteration throughout the watershed have harmed native wildlife populations and reduced the breeding grounds and nursery areas for a variety of species.

In 1985, Congress directed the U.S. Environmental Protection Agency (EPA), in cooperation with the states of Connecticut and New York, to sponsor the Long Island Sound Study. A Management Conference, involving federal, state, interstate, and local agencies, universities, environmental groups, industry, and the public was established and was charged with developing a Comprehensive Conservation and Management Plan for protecting and improving the health of Long Island Sound. The Management Conference has identified six problems that merit special attention: (1) low dissolved oxygen (hypoxia), (2) toxic contamination, (3) pathogen contamination, (4) floatable debris, (5) the impact of these water quality problems, and habitat degradation and loss, on the health of living resources, and (6) land use and development resulting in habitat loss and degradation of water quality. The Management Conference has focused its efforts and resources on the most pressing problem among these, low dissolved oxygen, which affects a substantial portion of Long Island Sound in late summer, but has addressed all priority problems. The plan calls for a sustained and cooperative effort among the states of Connecticut and New York, the EPA and other federal agencies, local governments, and the private sector to maintain and enhance the uses and values of the Sound. But the fate of the Sound depends on more than just the commitments of government agencies and regulated entities; it depends on the will and desire of the people of the region.

Hypoxia

Low levels of dissolved oxygen cause significant, adverse ecological effects in the bottom water habitats of the Sound. The levels regularly observed in the Sound during late summer reduce the abundance and diversity of adult finfish; reduce the growth rate of

newly settled lobsters and perhaps juvenile winter flounder; can kill species that cannot move or move slowly, such as lobsters caught in pots and early life stages of species such as bay anchovy, menhaden, cunner, tautog, and sea robin; may reduce the resistance to disease of lobsters and other species; and diminish the habitat value of Long Island Sound.

Excessive discharges of nitrogen, a nutrient, are the primary cause of hypoxia. Nitrogen fuels the growth of planktonic algae. The algae die, settle to the bottom of the Sound and decay, using up oxygen in the process.

The total nitrogen load to Long Island Sound is 93,600 tons per year. Of this, 40,800 tons of nitrogen per year are a result of human activity coming from point and nonpoint source discharges in the Sound's drainage basin *and are the subject of the plan*. Point source discharges, primarily sewage treatment plants, result in 32,400 tons of nitrogen each year and nonpoint source discharges, such as agricultural and stormwater runoff, result in 8,400 tons of nitrogen each year.

To increase oxygen levels, it is necessary to reduce the discharge of nitrogen into the Sound. The Management Conference has established interim targets for improving dissolved oxygen levels and is implementing a phased approach to achieving them by reducing nitrogen loadings to the Sound from point and nonpoint source discharges within the Sound's drainage basin.

In summary, the interim dissolved oxygen targets for the bottom waters of the Sound are to maintain existing dissolved oxygen levels in waters that currently meet state standards; increase dissolved oxygen levels to meet standards in those areas below the state standards but above 3.5 mg/l; and increase short-term average dissolved oxygen levels to 3.5 mg/l in those areas currently below 3.5 mg/l, ensuring that dissolved oxygen never goes below 1.5 mg/l at any time. There are also interim targets for the surface waters of the Sound. The benefit of achieving the interim targets would be the elimination of *severe* hypoxia. Most lethal and sublethal effects of hypoxia would be prevented and most of the severely impacted habitat area would be restored.

Phase I was announced in December 1990. It called for a freeze on point and nonpoint nitrogen loadings to the Sound in critical areas at 1990 levels. It committed the states and local governments to specific actions to stop a 300-year trend of ever-increasing amounts of nitrogen entering the Sound. The states have moved aggressively to implement the freeze, seeking the full cooperation of local governments. Connecticut reacted quickly to obtain $15 million in state funds to ensure that the nitrogen freeze was implemented. Consent orders are in place to cap the nitrogen loads at the 15 affected facilities. In New York City, the New York State Department of Environmental Conservation (NYSDEC) and the city have reached full agreement on sewage treatment permit limits, freezing total nitrogen loadings at 1990 levels. The permits will be finalized shortly. In Westchester County, the NYSDEC has issued final permits to the four existing sewage treatment plants, freezing their aggregate load at the 1990 level. This was done with the full agreement of the county. On Long Island, the NYSDEC has proposed individual permits that freeze the loads from individual discharges at 1990 levels; in response, the dischargers have proposed establishment of an aggregate limit. This proposal is currently under review by the NYSDEC.

Phase I agreements to control nonpoint sources centered around three categories: use of existing nonpoint source and stormwater management programs to focus on nitrogen control with the objective of freezing the loads; assessing tributary loads to Long Island Sound to begin planning for their control; and assigning priorities for management to coastal subbasins where nitrogen loads were estimated to be the highest.

Phase II includes firm commitments to reduce the annual, human-caused nitrogen load of 40,800 tons from in-basin sources by approximately 7,600 tons (or 18.6 percent). New York state will reduce its aggregate annual nitrogen load from 11 sewage treatment plants in New York by 25 percent (approximately 6,700 tons) at a total capital cost of $103.1 million. Five of the actions will be achieved by the end of 1995; four will be achieved by the end of 1996. The load reduction associated with centrate treatment is to be achieved by the year 2000. The target date for achieving the load reduction associated with the upgrade of the Newtown Creek water pollution control plant in the East River is currently being negotiated by the New York City Department of Environmental Protection (NYCDEP), the NYSDEC, and the EPA. Funding for these actions is available through the State Revolving Fund. Connecticut will reduce its aggregate annual nitrogen load from the 15 affected treatment plants by 25

percent (approximately 900 tons) by 1995. Funding is in place for the $18.1 million expenditure with $14 million available as 100 percent grants and the balance as State Revolving Fund loans.

Phase II activities for nonpoint nitrogen control will continue to take advantage of existing programs by focusing additional attention on nitrogen in priority coastal subbasins. The states of Connecticut and New York are formulating their Coastal Nonpoint Pollution Control programs to address coastal nitrogen sources.

The benefits of Phase II nitrogen reductions will be substantial. The amount of estuarine habitat presently degraded will be reduced by about 10 percent. The area most severely affected by hypoxia will shrink by more than 30 percent.

However, these reductions alone will clearly not meet the interim dissolved oxygen targets for dissolved oxygen. Therefore, an additional level of nitrogen reduction will be necessary. Based on preliminary water quality modeling, it is estimated that of the 40,800 tons per year total, in-basin, human-caused nitrogen load, required reductions to meet the interim dissolved oxygen targets are expected to range from 17,000 to 24,000 tons per year (or 42 percent to 59 percent). Achievement of these reductions would require the implementation of the mid- to high-level management scenarios as described in the Management Conference's 1990 *Status Report and Interim Actions for Hypoxia Management.* Preliminary cost estimates of these two levels of control for point sources are from $5.1 to $6.4 billion for New York state and from $900 million to $1.7 billion for Connecticut. Cost estimates for the necessary level of control of nonpoint sources have not been developed but are expected to be substantial.

In order to proceed with such a costly enterprise in a way that obtains the greatest environmental benefits for each dollar spent, approximate Soundwide reductions must be translated into discharge- or zone-specific load reduction targets. Using the LIS 3.0 model, the Management Conference will identify the most beneficial and cost-effective nitrogen load reduction targets for geographic management zones established around the Sound. The states and local governments will then be given the opportunity to propose the most cost-effective mix of point and nonpoint source reduction actions to achieve these nitrogen load reduction targets within each zone.

The third phase of the plan, therefore, is to:

- Complete work on a more advanced computer model by June 1994.
- Establish dissolved oxygen targets, and nitrogen load reduction targets by zone, by December 1994.
- Encourage and support the development of innovative, cost-effective technologies to reduce point and nonpoint sources of nitrogen.
- Complete in 1995-1997 the zone-by-zone plans to achieve the load reduction targets.
- Establish a firm timetable for achieving the load reduction targets by zone within 20 years with progress measured in five year increments (this timetable can only be met if the State Revolving Funds are adequately capitalized).
- Continue long-term implementation to ensure steady increases in dissolved oxygen and reductions in the area impacted by hypoxia.

Eliminating the adverse impacts of hypoxia from human activities (not just eliminating *severe* hypoxia) will require additional actions beyond the scope of the Long Island Sound Study. The New York-New Jersey Harbor Estuary Program is currently considering the need for nitrogen control on a systemwide basis; nitrogen control in the Harbor could reduce the export of nitrogen and increase the export of oxygen from the Harbor to the Sound. Additionally, New York City has initiated studies to evaluate the efficacy of relocating discharges from the upper and lower East River, thereby reducing these inputs of nitrogen to Long Island Sound.

Toxic Substances

Toxic substances include both naturally occurring and man-made substances that can cause adverse ecosystem or human health risks when exceeding certain concentrations. Overall, problems due to toxic contaminants occur in limited areas and are primarily associated with sediment contaminant levels. However, additional data on toxic substances in water, biota, and sediments are essential to a full characterization of the nature and extent of the toxic substance problems in the Sound.

To protect and restore Long Island Sound from the adverse effects of toxic substances, the Management Conference recommends actions in four key areas:

- Continue and, where appropriate, enhance existing regulatory and pollution prevention programs to reduce toxic substance inputs to Long Island Sound;
- Further evaluate sediments where toxic contamination problems exist to determine the feasibility of remediation;
- Improve communication to the public of any legitimate health risks from consumption of seafood species from the Sound; and
- Coordinate and strengthen monitoring activities for toxic substances to improve understanding and management of toxic contamination problems.

The Management Conference's priority management recommendation for toxic substances is to continue the permit programs and enforcement activity for both direct and indirect discharges, including toxicity testing of those discharges, responsible for greatly reducing toxic substance loads over the past 25 years. For example, the states of Connecticut and New York are reviewing municipal and industrial discharge permits to surface waters to reduce the allowable concentrations of toxic pollutants from the previous, permitted values. This includes municipal discharges and, therefore, affects pretreated industrial discharges as well. The net result will be a substantial reduction in the discharge of toxic materials over the next few years to meet adopted criteria for toxic substances in the states' waters.

The Management Conference also recommends continued support for existing pollution prevention site visit programs targeting industrial dischargers to Long Island Sound and its tributaries. The Connecticut Technical Assistance Program solicits requests from manufacturing facilities for voluntary pollution prevention audits and has conducted more than 40 audits in the past two years. The NYSDEC, as a part of its compliance inspection program, performs multimedia pollution prevention field assessments at sites where permitted activities are taking place. Other programs that are designed to prevent pollution, reduce pollutant loads, or clean up existing problems and spills must also be supported as part of a comprehensive program to manage toxic contamination in Long Island Sound.

Activities planned under the auspices of the New York-New Jersey Harbor Estuary Program will enhance toxic substance management in Long Island Sound. Total Maximum Daily Loads, Waste Load Allocations for point sources, and Load Allocations for nonpoint sources are being developed to ensure that water quality standards for mercury are met in the Harbor, the East River, and western Long Island Sound. The Waste Load Allocations and Load Allocations will be completed in 1994. Initially, permits will limit point source discharges of mercury to existing effluent limits. Work will continue to fully account for nonpoint sources of mercury, since the work to date has revealed the presence of a major, unidentified nonpoint source of mercury.

To further evaluate sediment contamination problems, the Management Conference will review the data on sediment contamination on a site-by-site basis. State and federal experts will evaluate the problem at each site and recommend additional assessments needed to fully characterize the problem, ascertain the need for and feasibility of remediation, and prepare a remediation plan. Additional assessments should be conducted and site plans addressing the feasibility, technical approach, cost, and value of conducting sediment remediation projects should be developed for Black Rock Harbor and Glen Cove Creek, where data may be sufficient to construct case study analyses. The cost of conducting characterization and feasibility studies is approximately $250,000 per harbor. This translates to $500,000 per year to address the problem at a rate of two harbors per year. Recently, the City of Glen Cove was awarded $250,000 from the New York State Legislature to evaluate the contamination of Glen Cove Creek. Funds for additional evaluations are presently not available.

The Management Conference will evaluate the research and management programs and activities in the Great Lakes and New York-New Jersey Harbor as part of developing an approach to remediate sediments. This will ensure cost-effective transfer of appropriate technology to Long Island Sound contamination problems.

To improve the communication of health risks to the public, the states of Connecticut and New York will coordinate health risk assessment and advisory recommendations. This will help minimize confusion about the safety of Long Island Sound fish, shellfish, and waterfowl, thus minimizing human exposure to contaminated species.

The Management Conference recommends that a comprehensive, coordinated monitoring program be implemented to fully evaluate toxic contamination

problems and their causes and trends in the Sound. Elements of the program include the:

- National Oceanic and Atmospheric Administration's Mussel Watch and Benthic Surveillance components of their Status and Trends Program;
- The EPA's Environmental Monitoring and Assessment Program, which has stations throughout Long Island Sound, and its Regional Environmental Monitoring and Assessment Program (R-EMAP), which is focusing on sediment contamination in western Long Island Sound as part of a regionwide program. The incremental cost to include Long Island Sound in the R-EMAP program was $200,000.
- Incorporation of the results of the National Oceanic and Atmospheric Administration's urban harbor sediment assessment, identifying the need for further assessment.
- Implementation of a comprehensive monitoring program for toxic substances in edible fish and shellfish to ensure compliance with the newly proposed Food and Drug Administration's fish safety initiative. The cost of implementing this recommendation is $300,000 per year.
- Implementing the recommendations of the Management Conference Monitoring Workshop to improve monitoring of toxic substances. The cost of implementing the recommendations is $15,000 per year.

In addition to these general monitoring recommendations, the New York-New Jersey Harbor Estuary Program has drafted a scope of work to develop comprehensive, systemwide models of PCBs, mercury, and other toxic pollutants. The Management Conference endorses these activities that will benefit Long Island Sound. As part of the effort, the U.S. Army Corps of Engineers has agreed to develop a work plan and budget to complete these models. The Corps and the other New York-New Jersey Harbor Estuary Program Management Conference participants have agreed to seek the funding necessary to complete these models. The systemwide models for PCBs and mercury would provide the technical foundation for comprehensive efforts to eliminate contamination problems in the Sound-Harbor-Bight system.

Pathogens

Human exposure to pathogens can cause illness and can occur either by direct contact with, or ingestion of, contaminated waters by bathers or by eating raw or partially cooked shellfish harvested from contaminated waters. Indications of pathogen contamination have resulted in closed beaches and shellfishing areas, hurting the economy of the region and damaging public perception of the quality of the Sound and its resources.

The Management Conference recommends that management actions be taken to control the major sources of pathogens and that site-specific management plans for each harbor, embayment, or discrete shellfish bed area be developed and implemented. This can be best accomplished by directing priority attention at four source control categories in the following order: combined sewer overflows, nonpoint source runoff, sewage treatment plant malfunctions, and vessel discharges. Those and other sources of pathogens should be identified by conducting site-specific surveys leading to better control of local sources of pathogens.

To control combined sewer overflows, New York City has begun to implement a combined sewer overflow abatement program to control the discharge of pathogens at a cost of $1.5 billion with enforceable completion dates for various aspects of the program during the period of 2001 to 2006. Connecticut will implement its long-term combined sewer overflow abatement program to manage combined sewer areas that affect Long Island Sound. The cities of Norwalk, Jewett City, Derby, Norwich, and Shelton have combined stormwater and sanitary systems that will be corrected by the year 2000 at a cost of approximately $27 million. Bridgeport and New Haven have large systems that will be corrected in phases. The first phases are underway with remaining phases scheduled over the next 20 years at costs of $91 million and $125 million, respectively.

To control nonpoint sources of pathogens, Connecticut and New York are implementing general statewide stormwater permit programs to manage stormwater from industrial and construction activities, in accordance with the EPA's national program regulations. These permits regulate construction activity at sites greater than five acres and from 11 industrial categories. New York state has initiated a pilot program using enforceable instruments (e.g.,

permits or consent agreements) to control and manage stormwater that causes closures of bathing beaches and shellfish beds. This pilot program has been funded at a cost of $100,000. Based on the program's effectiveness, more widespread implementation will be considered. Connecticut and New York also commit to using their statewide nonpoint source programs and to developing coastal nonpoint pollution control programs to control pathogen discharges to Long Island Sound. Successful implementation of these programs is contingent upon fully funding the nonpoint source control programs under Section 319 of the Clean Water Act and Section 6217 of the Coastal Zone Act Reauthorization Amendments.

To correct sewage treatment plant malfunctions, the EPA and the states of Connecticut and New York agree to take immediate enforcement seeking corrective actions and penalties in cases where sewage treatment plant malfunctions result in closures of bathing beaches or shellfish beds. Connecticut and New York commit to taking timely enforcement to eliminate dry weather overflows, eliminate illegal hookups to storm sewers, and to control wet weather overflows from sewers caused by excessive infiltration and inflow, especially in areas near bathing beaches and shellfish growing waters.

To protect against vessel sewage discharges, the states of Connecticut and New York will identify specific embayments warranting protection from vessel sewage discharge beyond the protection offered through the federal marine sanitation device standards and, to the extent feasible, will designate these embayments as no discharge zones after the EPA has determined that there are adequate pumpout and treatment facilities. New York state has identified Huntington and Lloyd Harbors as areas requiring additional protection and the EPA has issued an official public notice of its tentative determination that adequate pumpout or treatment facilities exist in the areas. Assuming a final affirmative determination, the NYSDEC will designate Huntington and Lloyd Harbors as the first no discharge zones in Long Island Sound. Connecticut and New York have received $120,000 and $1 million respectively in Clean Vessel Act grants to install vessel sewage pumpout facilities in Long Island Sound and other coastal waters. Both states will apply for additional funds in fiscal years 1995-97 to meet the need for pumpout facilities in harbors and embayments identified as potential no discharge areas.

To identify site-specific sources of pathogens, the states of Connecticut and New York will continue to perform bacterial surveys of harbors and embayments to identify contaminated shellfish areas and potential sources of pathogens. The states will continue to use seasonal or conditional certification of shellfish harvest areas and will act to open or close shellfish beds or bathing beaches, as may be warranted by water quality conditions. The Management Conference recommends that each state perform surveys to assess the impacts of point and nonpoint sources of pathogens and to identify management options. Management actions should be identified based on viability of the resource and feasibility and cost-effectiveness of management. New funding of $300,000 per year is needed to implement this recommendation at the rate of two harbors per state per year.

Floatable Debris

Trash floating in coastal waters and bays or washed up on the beach is called floatable debris. Floatable debris reduces the enjoyment of the Sound, can be a nuisance or hazard for boaters, and can harm wildlife. As a visual symbol of environmental degradation, floatable debris can also have serious economic consequences. The ultimate source of floatable debris is people who litter and improperly dispose of their waste. Litter anywhere in the Sound's drainage basin can ultimately enter the Sound. Litter is carried to the Sound primarily from stormwater discharges and combined sewer overflows, New York Harbor and tributaries to the Sound, and shoreline visitors and boaters.

There are two ways to deal with floatable debris: reduce the flow of litter from its major sources, and collect and pick it up once it is in the Sound. Ultimately, the most effective strategy is to combat the root cause of the problem -- littering and improper disposal. To reduce the flow of floatable debris into the Sound, the Management Conference has proposed management actions centered around two areas: combined sewer overflow abatement and stormwater management, and education. The combined sewer overflow abatement and stormwater management actions described previously in the discussion of actions to control pathogens also will substantially reduce the amount of floatable debris entering Long Island Sound.

Additional actions are directed at cleaning up floatable debris once it has entered the Sound. Existing floatable debris education and cleanup efforts should be continued and enhanced, particularly in municipalities that have combined sewer overflows or storm sewers discharging into Long Island Sound or its tributaries. Examples include:

- The New York-New Jersey Harbor Estuary Program has developed detailed short- and long-term floatable debris action plans for the Harbor. The implementation of these action plans will significantly reduce the amount of floatable debris entering the Sound from the Harbor.
- *Clean Streets/Clean Beaches* is an anti-litter campaign launched in April 1992 by a coalition of public and private groups in New York and New Jersey. The intent of this public education campaign is to make people aware that street debris ultimately turns up on beaches, and that this is one reason not to litter. This anti-litter program has been funded at a cost of $100,000.
- The New York Sea Grant Extension Program, Connecticut Sea Grant Marine Advisory Program, and Long Island Sound Study have organized volunteers from civic associations, schools, and environmental and youth groups who borrow pre-made stencils and use them to paint messages on storm drains, such as *Don't Dump--Drains to Long Island Sound.* This activity is estimated to cost $500 per coordinated event or $5,000 per year for ten events.
- As part of the National Beach Cleanup Program, annual cleanups of Long Island Sound shorelines have taken place since 1988. Each autumn volunteers physically pick up trash from shorelines adjacent to the Sound. As presently constituted, this program costs $10,000 per state per year to coordinate and support volunteer efforts. The Management Conference recommends that this program be enhanced to include a second beach cleanup in the spring, prior to the beach season, at an additional cost of $10,000 per state per year.

Living Resources and Habitat Management

The coastal environs of Long Island Sound represent a unique and highly productive ecosystem with a diverse array of living resources, ranging from microscopic plants and animals that drift with the currents to seaweeds and economically important finfish, shellfish, and crustaceans. In addition, many other types of wildlife, such as birds, sea turtles, and marine mammals, spend all or part of their lives in the Sound, on its shores, or in its watershed. While there are still abundant living resources in the Sound and in its watershed, there is little doubt that their overall abundance and diversity have been diminished by indifferent human uses of Long Island Sound and its resources.

A principal human cause of harm to the Sound's living resources is water pollution. There are two more negative human influences on living resources -- destruction and degradation of habitat and overharvesting from fishing and hunting.

The Management Conference recognizes the importance of existing habitat management programs in meeting its goals for the living resources of Long Island Sound, and urges the states and federal agencies to maintain them. The Management Conference also recommends enhancing ongoing habitat management programs.

A Soundwide system of reserves, consisting of the most significant and essential habitats, should be established. This should include designation of existing reserves and the acquisition of fee title or easement of additional habitats as they are needed to complete the reserve system. Acquisition of identified priority sites would cost an estimated $30 million. The states of Connecticut and New York need to develop or enhance and fully fund long-term land conservation funds for acquisitions and as a match for the federal Land and Water Conservation Fund. In New York state, the Environmental Protection Fund enacted in 1993 can meet that need, provided that additional revenues are dedicated to the fund, and the Open Space Conservation Plan associated with the fund can guide acquisition activities. The Management Conference advocates a major revitalization of the federal Land and Water Conservation Fund, including enhancement of grants to states and acquisition of federal refuges. Local land trusts also need to be developed or enhanced to supplement a Soundwide reserve system.

Existing state and federal programs to restore and enhance tidal wetlands and other habitats need to be enhanced. Intermodal Surface Transportation Efficiency Act funds and proposed Long Island Sound Challenge Grant funds, among others, should be used for this purpose. Each state's fish and wildlife and coastal management programs need to develop a

coordinated strategy to inventory and prioritize habitat restoration and enhancement needs, and to cooperatively implement restoration programs using all available state and federal resources. Development of a strategy will require $700,000 per year in additional funding. The estimated cost of implementing habitat restoration and enhancement projects is $1.7 million.

Existing state and federal programs to manage and restore populations of harvestable and endangered and threatened species need to be enhanced. Related management activities might include shellfish projects such as oyster cultch placement and shellfish seed stocking, artificial reef development in New York state, and reestablishing migratory finfish passage in Connecticut. Enhancement of species management programs will require $1.76 million per year of additional funding. Implementation of projects benefitting species will cost approximately $1.4 million. Funding from sources such as the Sport Fish Restoration Act (The Dingell-Johnson and Wallop-Breaux Acts), the 1993 federal Atlantic Coast Interjurisdictional Fisheries Act, the Pittman-Robertson Aid in Wildlife Restoration Act, the Endangered Species Act, and the Marine Mammal Protection Act should be used for these activities.

Land Use and Development

As a result of the cumulative effects of human activity, the natural values of the Sound have been diminished. In many parts of the Sound's watershed, intensive development has significantly altered the land and degraded the quality of waters flowing through it. Other areas are threatened by continuing development. Because the Sound is the *sink* for a 16,000 square mile watershed, its water quality is closely tied to the ways in which the land is used and developed. Urban and suburban development has also resulted in the loss of natural habitats and has limited public access to the coast.

In recognition of the importance of the relationship between land use and water quality, the Management Conference established a Land Use Work Group in February 1992 to identify the ways land use and development affect Long Island Sound water quality and habitat, and to present recommendations to improve land use planning and management throughout the Sound's watershed.

Five areas were identified as critical to enhancing land planning and use to improve water quality, habitat protection, and public access throughout watershed. Recommendations were developed in each area.

- The impacts from existing development are significant, particularly in urbanized areas, and must be reduced to improve coastal water quality. These areas should be targeted for nonpoint source management, including public education, infrastructure upgrades, spill prevention and response, and flood and erosion control. Also, abandoned or under-used sites should be a high priority for remediation and reuse.
- The impacts from new development are also significant and must be minimized to prevent further degradation of water quality. Progressive planning and management should ensure the application of best management practices, protect wetlands, minimize land disturbances, improve access, and maintain appropriate water-dependent uses.
- To improve land use decision-making that incorporates effective water quality and habitat protection, better information, training, and technical assistance must be available. Training, technical assistance, and financing should be made available to local governments, as well as education for the public, professionals, and trade organizations. This will help develop consistent land use and natural resource information and management practices in the region.
- Conservation of natural resources and open space is vital to the long-term protection of Long Island Sound. Open space preservation and conservation practices must be aggressively pursued. This might be accomplished through a watershed-based planning approach that integrates protection of surface waters with programs and plans that guide growth and development.
- Public access is essential to public use and enjoyment of Long Island Sound, especially since improvements to water quality involve public costs. Public access improvements should be aggressively pursued throughout the watershed using a combination of traditional techniques, such as fee-simple acquisition, and innovative techniques, such as transfer of development rights and tax credits.

Water quality and resource-based planning and management measures must be put into place

throughout the watershed in a consistent and coordinated manner. Through the Management Conference, efforts will continue. Specific actions and potential means to fund them will be identified, built upon the general recommendations presented above.

The New York State Department of State has recently prepared a Long Island Sound Coastal Management Plan that sets out specific recommendations for guiding land use and development, ensuring public access to the shore, and protecting important habitats. The plan is consistent with the Long Island Sound Study plan and should be adopted by New York state.

Connecticut's Coastal Management Program, adopted in 1980, contains many of the same provisions that are in the New York plan, including mandatory requirements for public access at waterfront parcels. Implemented at the local level as a mandatory component of planning and zoning reviews, the Connecticut program has afforded fragile coastal natural resources greater protection from development and has added in excess of ten miles of public access since 1980. The Connecticut program should be maintained at current levels.

Land use and development as it affects Long Island Sound is an unfinished agenda. Significant additional effort is required to determine the most appropriate means to effect change as well as to provide the funds needed to implement even the general recommendations presented in the plan. Additional analysis, new initiatives, and their costs must be underwritten by the federal government, the states of Connecticut and New York, local governments, and the private sector.

Supporting Implementation

Continuing the Management Conference

As a key component of plan development, the Management Conference was also directed to identify the means by which its implementation would be coordinated. The Management Conference has identified three areas that are critical to implementing the plan:

- The Management Conference must be continued to maintain and improve communication and coordination among different units of government, research and educational institutions, and concerned groups and individuals.
- Public education about Long Island Sound must continue along with mechanisms to involve the public in continuing management efforts.
- Adequate funding for the new and expanded efforts must be available and funding for existing programs that have been successful must be continued.

The states of Connecticut and New York, local governments, and the EPA have primary responsibility for implementing the plan. However, protection of the Sound is the responsibility of all sectors of government, the private sector, and individual citizens. A framework is needed for coordinating and redirecting efforts.

Extending the Long Island Sound Study Management Conference to continue this cooperative effort will provide the long-term commitment necessary to oversee implementation. Therefore, the Long Island Sound Study Policy Committee has formally requested that the EPA Administrator extend the Management Conference. To accommodate this need, the Congress has passed the Long Island Sound Improvement Act of 1990, which gave the EPA authority to extend the Management Conference upon plan completion. The EPA should, upon plan approval, extend the Management Conference for a minimum of five years to oversee implementation of the plan.

With adoption of the plan, the role of the Management Conference will shift from plan development to program implementation. Specifically, continuation of the Management Conference will provide a management framework to track, monitor, and report on program implementation; incorporate new information to enhance implementation; seek and advocate adequate funding; and continue public involvement.

These efforts will be summarized in a report every two years. The report will identify progress in implementing the plan, as well as any delays or obstacles to implementation; describe water quality conditions in the Sound and the effectiveness of management efforts to improve them; and recommend the redirection of efforts to meet the goals of the program. The Management Conference will continue to prepare fact sheets, articles, and newsletters to report on different aspects of the program.

As part of the Long Island Sound Improvement Act, the EPA established a Long Island Sound Office. To serve the bi-state community, the office has two facilities, one located in Stamford, Connecticut and the other in Stony Brook, New York. The basic activities of the Long Island Sound Office are to:

- Provide administrative support to the Management Conference and coordinate the EPA with other federal agency involvement in Long Island Sound issues;
- Support state program coordination and involvement in the Management Conference; and
- Maintain public education and involvement efforts with an added focus on local government involvement.

The cost associated with this base level of effort for the Management Conference is approximately $475,000 per year, of which $175,000 is for maintaining the Long Island Sound Office and providing support to the Management Conference, $150,000 is for state program coordination of implementation, and $150,000 is for public involvement and education. Funding is available for these programs in fiscal year 1994 but will be required in future years.

The Management Conference recommends that part of the funding be provided through Section 320 of the Clean Water Act. These funds can be used for activities such as monitoring and reporting on plan implementation. The Management Conference further recommends that additional funding be provided through the Long Island Sound Improvement Act. These funds can be used for all the activities cited above and any additional activities that would be instrumental in enhancing implementation of the plan.

Public Involvement and Education

Public involvement and education are essential to restoring and protecting Long Island Sound and will be fundamental to the successful implementation of virtually every part of the plan. Public involvement and education also help the public understand, appreciate, and enjoy the Sound's resources and the benefits derived from them. An informed and educated public can help develop a united and organized constituency to galvanize support for the cleanup and protection of the Sound and its resources.

Highlights of the actions for achieving the public involvement and education goal include:

- The Management Conference Public Involvement and Education Program and the state public outreach programs will be continued. Collectively, these programs will provide consistency of information going to the public and ensure that the public receives current information on the implementation of the Management Conference actions and recommendations.
- The EPA and the states of Connecticut and New York will provide information to municipalities regarding the importance of Long Island Sound protection and restoration. Special attention will be given to coastal municipalities with briefings by state officials to explain how implementation of the plan will affect their cities or towns and to foster cooperation and partnership. Briefings will also be held for specific user groups, local officials, and elected representatives.
- The Citizens Advisory Committee will continue to provide guidance to the Management and Policy Committees and to serve as a link between the public and the Management Conference.
- The Management Conference will continue to encourage public participation in activities relating to the cleanup and protection of the Sound and provide support for activities including storm drain stenciling, beach grass planting, and beach cleanups.
- The Management Conference will establish a public outreach work group to develop recommendations for implementing the public involvement and education strategy. The work group will work closely with, and serve to complement, the ongoing public outreach and education efforts of the Citizens Advisory Committee. The group will also be charged with determining funding sources for implementation of its recommendations, consulting with staff on tactics, working to provide coordination of public outreach efforts from both an internal and external basis, and assessing program effectiveness.
- The states of Connecticut and New York will continue to work with appropriate school districts in their states to develop Long Island Sound education materials and outreach programs for primary and secondary schools. These resources also will be made available for integration into other environmental education programs.

- The Management Conference will seek to create a public involvement and education (PIE) fund that could be supported by a variety of funding sources. Potential federal appropriations through the Long Island Sound Improvement Act could be used to create an endowment fund. The PIE fund would be administered by the Management Conference. A PIE fund, and interest generated from its endowment, would provide support for both non-governmental and governmental organizations for projects fulfilling the recommendations for education and involvement.

Since current state and private Long Island Sound public education programs are underfunded, the Management Conference recommends that additional state and private funding sources be directed toward meeting the needs of existing programs before being sought for a PIE fund.

Approximately $450,000 dollars would be needed to fund the priority enhancements to current involvement and education programs and recommendations for new programs as stated in the plan. This includes support of enhanced Management Conference and state public outreach programs that will now focus on implementation of the management plan ($200,000 per year); the development and facilitation of public participation in Long Island Sound cleanup and monitoring activities ($100,000 per year); and the integration of Long Island Sound educational materials and curriculum into the New York state and Connecticut school systems ages K-12 ($150,000 per year). Furthermore, the Management Conference also recommends that seed money be made available for the establishment of a PIE fund.

Summary of Plan Costs and Funding

The costs of cleanup efforts are significant. They include the costs of continuing existing programs, the costs of enhancing these programs, and the costs of project implementation such as upgrading sewage treatment plants or initiating practices to control nonpoint sources of pollution.

Funding to cover these costs must be provided by the federal, state, and local governments and by the private sector, in partnership, with each paying its fair share. The prospects for achieving the Management Conference's goals and objectives, and the pace with which progress is made, will be directly related to the availability of adequate funding.

Existing Program Funding

The plan includes numerous commitments on the part of the NYSDEC, the Connecticut Department of Environmental Protection (CTDEP), the EPA, local governments, and other federal, state, and local agencies to continue the implementation of ongoing programs. At a minimum, these commitments require that existing program activities continue to be funded at existing levels by the states of Connecticut and New York and from federal grants. These funds that support statewide programs are the base upon which Long Island Sound protection efforts must build.

The total statewide appropriation in New York state for water quality protection, natural resource management, and coastal zone management is $39.8 million. Federal grants to New York state for these activities provide an additional $29.4 million statewide. The total statewide appropriation in Connecticut for water quality protection, natural resource management, and coastal zone management is $8.7 million. Federal grants to Connecticut for these activities provide an additional $6.5 million statewide.

Enhanced Program Funding

The plan also includes commitments and recommendations for actions requiring additional program resources. The commitments are actions for which enhanced program resources have already been made available or for which there are firm obligations. The recommendations are actions that require additional funding that is not currently available. The total cost of the plan's priority commitments is $3.25 million. The total cost of the plan's priority recommendations is $5.99 million per year. The total cost of implementing all of the Management Conference's commitments is $11.74 million and the total cost of implementing all of the recommendations is $10.42 million per year.

Project Implementation Funding

The project implementation costs associated with the plan are large and are dominated by the potential cost of upgrading sewage treatment plants to remove nitrogen, the cost of remediating combined sewer overflows, and the cost of property acquisition. The capital costs of Phase II nitrogen reduction actions are $103.1 million in New York state and $18.1 million in Connecticut. The potential long-term costs are

much higher. Based on preliminary estimates, the costs of the additional nitrogen control for point sources ranges from $5.1 to $6.4 billion in New York state and from $900 million to $1.7 billion in Connecticut. These costs would be in addition to the $243 million in Connecticut and $1.5 billion in New York state needed to implement the currently planned combined sewer overflow abatement programs critical to reducing pathogens and floatable debris in the Sound.

Using these cost estimates, the total capital need for the wastewater program in New York state for the next 20 years has been estimated to be $25 billion; this includes $7 billion for the needs within the Long Island Sound drainage basin. The total capital need for the wastewater program in Connecticut for the next 20 years has been estimated to be $3.5 billion, almost all of which is for needs within the Long Island Sound drainage basin.

The two states have concluded that the existing State Revolving Funds are the preferred vehicles for funding major capital projects for wastewater programs; substantial funds have already been issued by the programs for project implementation. Based on the preliminary, high-cost hypoxia management scenario in this plan, the Connecticut State Revolving Fund needs an infusion of $70 million per year in federal funds and $47 million per year in state funds over 20 years to meet statewide needs, including Long Island Sound nutrient control needs. The New York State Revolving Fund needs an infusion of $623 million per year in federal funds and $128 million per year in state funds over 20 years to meet statewide needs, including Long Island Sound nutrient control needs.

Cost estimates for the necessary level of control for nonpoint sources of nitrogen have not been developed but are expected to be substantial.

Significant project implementation costs are also associated with the habitat-related commitments and recommendations. The total project costs for restoring habitat, creating reserves, and improving species management are $1.7 million, $30 million, and $1.4 million, respectively.

Sources of Funding

A number of funding sources must be targeted to help meet the need for enhanced program and project implementation funding.

The Management Conference recommends that the Clean Water Act be reauthorized and that grants to the states to help capitalize their State Revolving Fund programs be continued. Following reauthorization of the Act, the Management Conference will formulate a detailed financial plan, consistent with authorized federal funding levels, to meet the total cost for plan implementation. The financial plan will include a specific focus on the ability of local governments to pay for required improvements. The states are committed to providing technical assistance to local governments in complying with the plan.

To ensure that implementation of the management plan gets off to a good start, the Management Conference recommends that the Congress appropriate $50 million to fund a Long Island Sound Challenge Grant program.

- A significant portion of the funds would be used for point and nonpoint source nitrogen control actions that do not involve major capital improvements.
  - Funds would be obligated for use within the individual nitrogen management zones in proportion to the load reduction targets.
  - The entities responsible for achieving the nitrogen load reduction targets would submit applications for the funds to the states. The states would obligate funds for the most cost-effective projects.
- The remaining portion of the funds would be used to support actions in other areas, such as habitat restoration and acquisition, stormwater abatement, and public access. Of this remaining portion, $10 million would be allocated to habitat restoration and acquisition.
- Funds would be awarded on a competitive basis, with eligibility limited to projects that support implementation of the plan and go beyond the current legal or regulatory obligations of the recipients.

While the primary focus of the Management Conference has been on programs resulting from the Clean Water Act, there are other legislative initiatives and programs that affect the quality of Long Island Sound. This is particularly true for programs to protect living resources and habitat. Continued support for and improvements in these programs will

have direct benefits for the Sound. Programs that acquire land or easements include the Land and Water Conservation Fund, New York state's Environmental Protection Fund, and Section 318 of the Coastal Zone Management Act; programs that restore habitat include the federal Intermodal Surface Transportation and Efficiency Act; and programs that manage species include the Sport Fish Restoration Act (the Dingell-Johnson and Wallop-Breaux Acts), the 1993 federal Atlantic Coast Interjurisdictional Fisheries Act, the Pittman-Robertson Aid in Wildlife Restoration Act, the Endangered Species Act, and the Marine Mammal Protection Act.

I. Long Island Sound in Perspective

A. Geography

Long Island Sound lies in the midst of the highly urbanized and suburbanized northeast seaboard, one of the most densely populated regions in the nation. It is characterized by a nearly unbroken chain of urban centers, including the country's largest city, New York City.

The watershed of the Sound drains an area of more than 16,000 square miles. It encompasses virtually the entire state of Connecticut, portions of Massachusetts, New Hampshire, and Vermont, a small area in Canada at the source of the Connecticut River, and portions of New York City, and Westchester, Nassau, and Suffolk Counties in New York state. With such an extensive drainage basin, management actions must begin in those areas most directly impacting water quality in the Sound. As a result, the specific area included in the Long Island Sound Study is much smaller than the total drainage basin, focusing on the watershed within the states of Connecticut and New York. The water boundaries of the Sound have been established at the Battery on Manhattan Island to the west and The Race to the east (Figure 1).

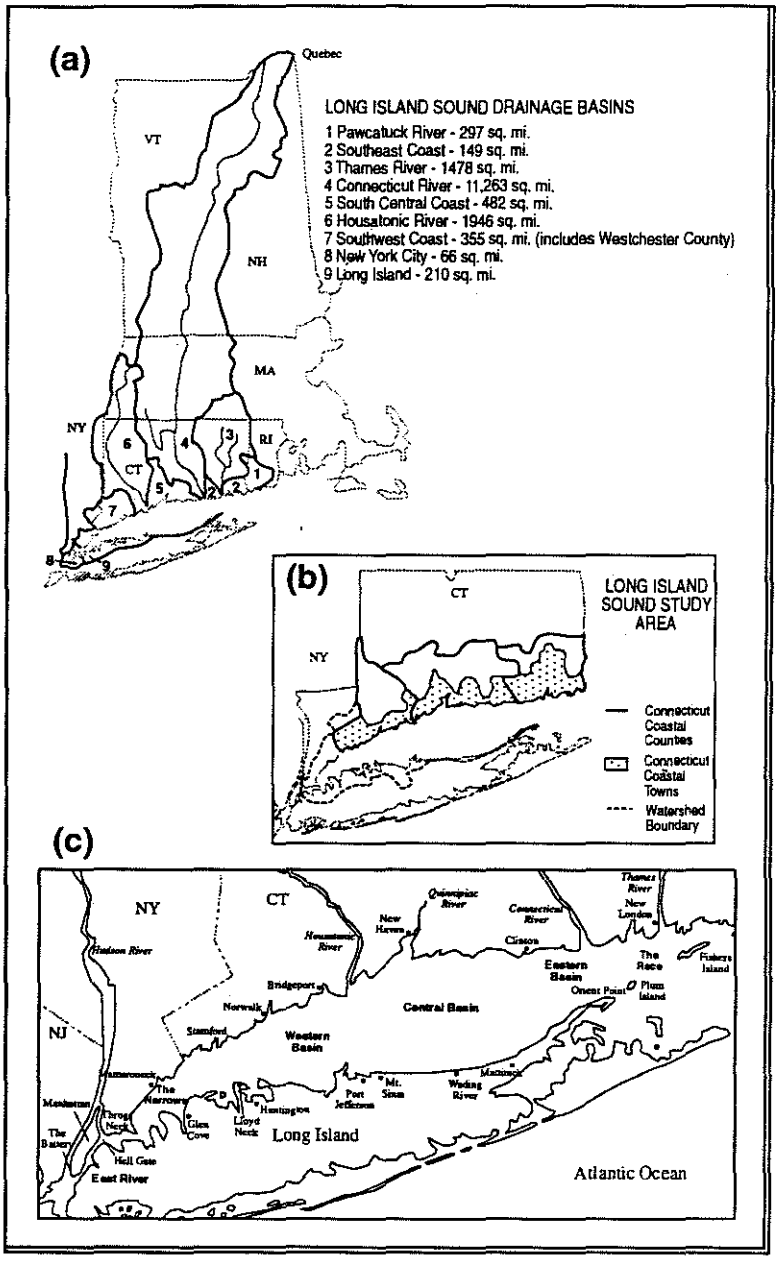


Figure 1 (a) Major drainage basins and tributaries of Long Island Sound. (b) The LISS study area. (c) Basins within Long Island Sound.

Unlike a typical estuary, the Sound has no major direct source of fresh water at its head. Instead, lower salinity waters enter the western Sound from the Upper Bay of New York Harbor through the East River and Harlem River tidal straits. Higher salinity waters of the Atlantic Ocean enter at its eastern end, through Block Island Sound. The largest source of freshwater is the Connecticut River, discharging into the eastern Sound. These unusual characteristics contribute to the Sound's complex circulation and mixing patterns. Furthermore, waters from outside the Sound's drainage basin that enter the Sound through its boundaries are significant sources of pollutants, underscoring the need for comprehensive, regional management.

B. Ecological Importance

Estuaries are highly productive ecosystems. While the Sound has problems, it is important to note that it remains highly productive, with a great abundance and diversity of aquatic organisms and wildlife inhabiting it for part or all of their lives. Improving and maintaining water quality is critical to their continued presence and health. In addition, Long Island Sound is not an ecologically isolated estuary; it is part of the East Coast migration route, providing nesting or resting habitat for waterfowl. Fisheries of the Sound, other estuaries and the open ocean are also linked together. As such, the Sound serves as vital habitat for fish passage and as spawning grounds and nurseries. Pollution, physical or chemical obstacles, or loss of viable habitat in this waterbody can affect not only the Sound, but also the productivity of the entire system.

Important ecological components of the Sound are its diverse and distinctive habitats including tidal wetlands and flats, beaches, dunes, bluffs, rocky intertidal areas, submerged aquatic vegetation (particularly eelgrass and kelp), natural and artificial reefs, the water itself and the sediment floor of the Sound. These habitats provide feeding, nesting, and nursery areas and shelter for finfish, shellfish, plankton, birds, and other organisms inhabiting or visiting its waters. Each habitat not only supports its own community of plants and animals but contributes to the productivity of the whole Sound. All of the habitats that make up the Sound are interconnected through the food web and are integral parts of the whole.

C. Economic Importance

Long Island Sound strengthens the region's economy through the many valuable uses that it supports. Some of the uses, such as shipping, ferry transportation, electric power generation, industrial use, and waste disposal, are indirectly dependent on water quality. Others, such as tourism, fishing, boating, and beach-going clearly depend on good water quality. A few of the resources that are economically important in terms of commercial or recreational fisheries are oysters, clams, bluefish, flounder, fluke, striped bass, weakfish, and lobster.

While no one would want to assess the value of the Sound in purely economic terms, it is instructive to estimate the value for some of the significant activities that depend on good water quality. The total annual use value of commercial and recreational fishing, beach swimming, and boating for the year 1990 was estimated to exceed $5 billion. This figure does not include the intrinsic value of the Sound as a natural resource worth protecting and preserving for future generations. Nor does it include other values that are more difficult to estimate but also contribute to the economic vitality and overall quality of the area, such as the importance of natural habitats and good water quality to nearshore residential property values.

D. Population and Land Use

The rich estuarine and woodland resources of the Long Island Sound coastal areas once supported some of the largest concentrations of Native Americans found in North America. The abundant natural resources of the area made it attractive to European settlers as well. Though both Connecticut and New York state (including Long Island) were almost entirely forested at the time of the explorer Giovanni Verrazano's arrival in the 16th century, growth in agriculture resulted in widespread deforestation of the basin by the late 1700s. By 1774, Connecticut was one of the most densely settled of any of the American colonies, with much of its population living in the shore communities and relying on agriculture and coastal trade.

During the Industrial Revolution, the regional economy shifted from agriculture to small manufacturing and maritime trades. Factory towns sprouted along the shorelines of Connecticut and New York, reflecting the reliance on water for transportation and commerce. The mid-19th and early-20th centuries saw southwestern Connecticut coastal communities and Long Island increasingly oriented towards New York City as the center of commerce. The arrival of railroads, first on Long Island and then along the Connecticut coast, enhanced the ability of many Long Island and Connecticut cities to flourish as industrial centers. The railroads also changed many of the communities into suburbs of New York City.

The railroads both encouraged, and were encouraged by, the growth of tourism. As coastal towns and villages became accessible to residents of New York City, extensive resorts were developed along both the Connecticut and Long Island shores of the Sound. The desire to enjoy the natural beauty and recreational assets of the Sound spurred the development of summer estates for the wealthy, particularly on the northern shore of Long Island, and summer cottages and vacation houses for the middle class.

The post-World War II era brought dramatic changes to the region. The decades immediately following the war were characterized by rapid increases in population and in suburbanization. The urgent need for inexpensive land, suitable for development, resulted in the conversion of agricultural lands and the filling of wetlands for suburban housing. As agriculture diminished, forest regrowth occurred, particularly in Connecticut.

The present distribution of human population within the Long Island Sound basin is very uneven, reflecting the distribution of manufacturing centers as they developed in the 1800s and early 1900s. Of the approximately 8.4 million people living in the basin, New York City, which makes up only about 0.4 percent of the land area, has about 42 percent of the population. Westchester, Nassau, and Suffolk Counties, with 2.1 percent of the land area, contribute 8.3 percent of the population and Connecticut, with 33 percent of the basin, has 37 percent of the population. Vermont, New Hampshire, and Massachusetts comprise the remaining 12.7 percent of the population in the drainage basin.

The population growth rate in the Connecticut and New York state portions of the Long Island Sound basin has declined significantly in recent decades. After rapidly expanding by 78 percent between 1940 and 1970, population growth has slowed to an increase of 1 percent between 1970 and 1990. Future population growth is expected to be about 4.1 percent (300,000 people) between 1990 and 2010 and 6.4 percent (500,000 people) over the period from 1990 to 2030.

E. Water Quality

In the two decades since the passage of the Clean Water Act, water pollution control programs have resulted in measurable improvements in water quality. The current value and quality of the Sound are partly the result of the investments in water pollution control programs since the passage of the Clean quality, in spite of ever-increasing numbers of people and activities on the Sound and within its watershed. Obvious sources of pollution are now regulated and controlled through permit programs, tidal wetlands are protected, and major efforts in the states of Connecticut and New York to build sewage treatment plants and control industrial discharges have helped to restore degraded waters.

These efforts have taken place because of increased awareness and concern among citizens and the responsiveness of public officials. Without the substantial investment already made in environmental protection, the value of the Sound would be far less than it is today.

Despite the significant progress made in solving many water quality problems, much work remains before the goals of the Clean Water Act to *restore and maintain the chemical, physical, and biological integrity of the nation's waters,* so they are *fishable* and *swimmable* are met in all of the Sound. The quality of Long Island Sound is still far from what it should or can be. Many of the uses or values of the Sound are still impaired from old abuses. Other uses or values face new threats. Residential, commercial, and recreational development have altered land surfaces, reduced open spaces, and restricted access to the Sound. The density of people living within the Sound's watershed increases with proximity to the coastline. This development has dramatically increased the use of the Sound as a place to dispose of human and other wastes. More than 60 public wastewater treatment plants discharge more than one billion gallons of treated effluent into the Sound each day. The paving over of the land has increased runoff and reduced the filtration and processing functions of natural landscapes. Habitat destruction and alteration throughout the watershed have harmed native wildlife populations and reduced the breeding grounds and nursery areas for a variety of species.

These and other problems require new approaches to protect and preserve Long Island Sound and to provide access for the public use and enjoyment.

II. The Long Island Sound Study

A. Background

In recognition of the threats facing the nation's estuaries, Congress appropriated funds in 1985 for the U.S. Environmental Protection Agency (EPA) to research, monitor, and assess the water quality of Long Island Sound. With the Clean Water Act Amendments of 1987, Section 320 of the act officially established a *National Estuary Program*. Long Island Sound was designated an *Estuary of National Significance* upon the request of the states of Connecticut and New York, and a Management Conference for the Long Island Sound Study (LISS) was convened in March 1988.

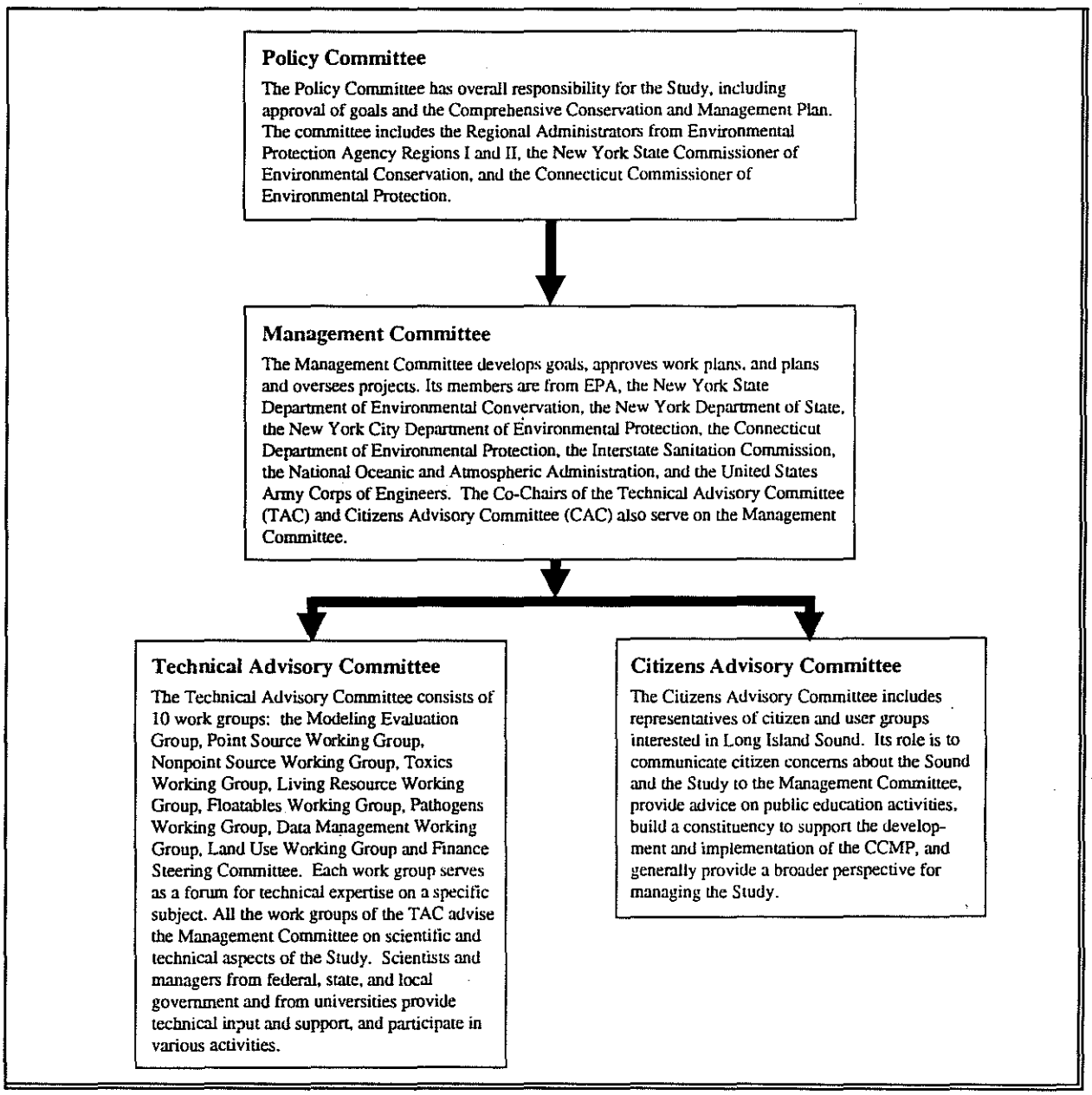


Figure 2 Committee functions and relationships.

The Management Conference is a cooperative effort involving federal, state, interstate, and local agencies, universities, environmental groups, industry, and the public. The conference consists of

several committees, including a Policy Committee, Management Committee, Citizens Advisory Committee, and Technical Advisory Committee (Figure 2). The Policy Committee approves any action that represents a new policy initiative, such as managing nitrogen loadings to Long Island Sound. The Management Committee gives the study overall direction and annually determines how LISS funds will be spent.

Day-to-day management of the LISS planning and research activities is carried out cooperatively by staff coordinators from the EPA, the Connecticut Department of Environmental Protection (CTDEP) and the New York State Department of Environmental Conservation (NYSDEC). Much of the research, assessment work and public outreach activities have been conducted by university and state staff and private contractors funded by federal and state LISS funds. Between 1985 and 1993, the LISS received approximately $11 million from the EPA, $2 million from the states of Connecticut and New York and $3 million from the National Oceanic and Atmospheric Administration (NOAA).

B. Goals for Long Island Sound

When the LISS was initiated, a strategy was developed to identify and investigate the most significant water quality problems affecting Long Island Sound; to identify feasible solutions to remedy these problems, incorporate them into a management plan and identify unfinished management actions for follow-up as funding becomes available. Based on this strategy, the goals of the LISS are:

1) Protect and improve the water quality of Long Island Sound and its coves and embayments to ensure that a healthy and diverse living resource community is maintained.

2) Ensure that health risks associated with human consumption of shellfish and finfish are minimized.

3) Ensure that opportunities for water-dependent recreational activities are maximized without conflict with ecosystem management.

4) Ensure that social and economic benefits associated with the use of the Sound are realized to the fullest extent possible, consistent with social and economic costs.

5) Preserve and enhance the physical, chemical, and biological integrity of the Sound and the interdependence of its ecosystems.

6) Establish a water quality policy that supports both the health and habitats of the living resources of the Sound and the active and passive recreational and commercial activities of people.

Achieving these goals will require difficult social, institutional, and political choices. Thus, it is necessary to move beyond technology-based controls (e.g., permit actions) and manage the Sound and its watershed as an ecosystem through the active participation of government and non-government agencies, and local and regional citizens.

C. Priority Areas of Concern

In its initial planning phase, the LISS identified three priority water quality and habitat protection problems in the Sound:

- Low dissolved oxygen (hypoxia);
- Toxic substance contamination; and
- The impact of water quality problems and habitat degradation and loss on the health of living resources.

Early in the study, the LISS recognized the need for and initiated a strong program of public involvement and education and this has also been identified as a priority area of concern.

During the summer of 1988, beach closings resulted from microbial contamination and wash-ups of medically related floatable debris. The high level of public concern and the large economic loss resulting from these wash-ups led the LISS to adopt two additional water quality issues:

- Pathogenic contamination and
- Floatable debris.

In 1991, the LISS added another priority issue — the need to examine the relationship between land use and water quality.

The LISS has focused on hypoxia as its highest priority, concentrating staff and financial resources to understand and address this critical, costly and complex issue. By 1990, enough progress had been made to proceed with early implementation, as described in the Long Island Sound Study's Status Report and Interim Actions for Hypoxia Management. The next step in managing hypoxia is presented in this plan along with a long-term management strategy.

The plan proposes significant actions to address other complex issues, such as contamination from toxic substances and pathogens. Additional work and future actions to address these issues will be included in revisions to this plan.

D. Commitment to Act

As part of the formal designation ceremony of Long Island Sound into the National Estuary Program, a pledge was signed by elected officials and representatives of the EPA, the CTDEP, and the NYSDEC that declared:

> ***Long Island Sound is an important natural resource that provides incomparable beauty and significant recreational and commercial benefits;***
>
> ***The Sound's living resources, water quality, and aesthetic character have suffered from rapid development and other human uses; and***
>
> ***Restoration and protection of the Sound's environmental quality require focused management by a partnership of federal, state, and local governments, affected industries, academia, and the public.***
>
> ***We therefore pledge to support the goals of the Long Island Sound Management Conference and we commit to restore and protect the environmental quality of Long Island Sound through the implementation of the Comprehensive Conservation and Management Plan.***

Reflecting that pledge, the plan commits government agencies, wherever possible, to take action. In some cases, where current staffing and funding are inadequate, recommendations for future action are presented. As a result, the plan presents what can be done now and what the priorities are for the future.

PRIORITY PROBLEMS

In the following chapters, the nature and cause of each priority problem identified by the Management Conference is characterized and an action plan to deal with each is identified. Chapters III - VI focus on the impairments to water quality. Chapter VII describes how degraded water quality and other stresses affect living resources. Each of these chapters identify the existing programs that must continue to be implemented and identify commitments and recommendations for actions to enhance these programs or create new ones. Chapter VIII provides a broader perspective on how land use and development affect water quality and habitat protection and presents general recommendations in five areas.

III. Hypoxia

A. What is Hypoxia?

The fish that live in the waters of Long Island Sound share with humans the need to breathe oxygen. While humans live in a relatively oxygen-rich environment, aquatic life in the Sound relies on oxygen dissolved in the water. Even under ideal conditions, the amount of oxygen that can be dissolved in water is limited. Often, during late summer, dissolved oxygen levels in the bottom water of the Sound fall well below normal, resulting in a condition known as hypoxia. The LISS has defined hypoxia as dissolved oxygen concentrations below 3 milligrams of oxygen in each liter of water (mg/l). Below that level, the supply of oxygen in the water is inadequate to support healthy populations of estuarine organisms. Even at oxygen levels above 3 mg/l, prolonged exposure can harm aquatic life in the Sound.

Hypoxia occurs during the mid-July through September period in the deep water of the western and central portions of the Sound and in some of its shallow embayments (Figure 3). These areas are characterized by high nutrient inputs, marked stratification of the water column, and, in some areas, stagnant conditions. While hypoxia is less common in the easternmost portions of the Sound, during some years hypoxic conditions have been recorded as far east as Mattituck, NY and New Haven, CT. Dissolved oxygen levels in the surface waters, above the pycnocline (a sharp density differential separating surface and deep waters), are generally not as low as those in bottom waters. Typical surface dissolved oxygen values range between 5 and 9 mg/l during July and August although they do get as low as 3 to 4 mg/l in the western narrows and the East River.

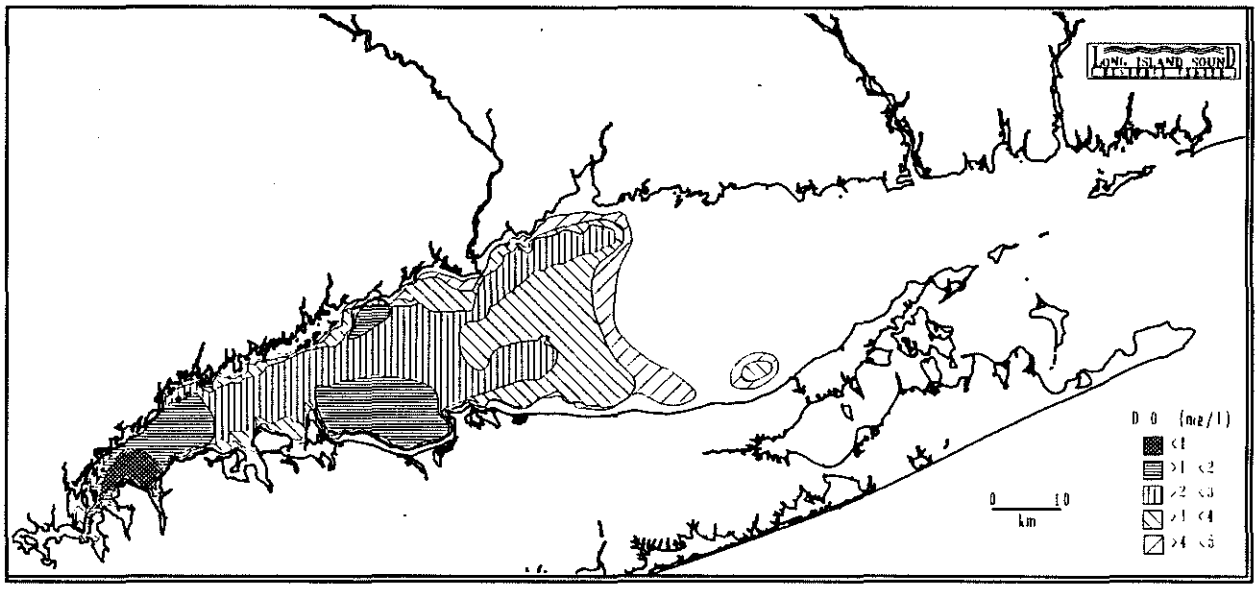


Figure 3 Minimum dissolved oxygen levels in the bottom waters of Long Island Sound observed in 1989.

Hypoxia in the Sound is not a new occurrence, but evidence suggests that it is becoming more severe and more common. The city of New York monitoring data, which have been collected since 1909, have shown periods of reduced dissolved oxygen in the East River and the western Sound. A study of central Long Island Sound in the 1950s identified mild hypoxic conditions in western portions of the study area.

It was not until intensive monitoring by LISS investigators was implemented from 1986 through 1993 that widespread and severe hypoxia was documented in the Sound. In 1989, about 40 percent of the Sound's bottom (more than 500 square miles) experienced dissolved oxygen concentrations less than 3 mg/l in the late summer (Figure 3). The lowest oxygen readings occurred in 1987 in the area near Hempstead Harbor when anoxic (no free oxygen) conditions were observed. These represent the most severe spatial and minimum concentration observations, respectively, during the monitoring period and are much worse than any conditions reported in earlier studies.

B. Why is Hypoxia a Problem?

The LISS is concerned about hypoxia because of the many ways it affects the living resources of Long Island Sound. Each late summer in the bottom waters of the Sound, the measured dissolved oxygen conditions are low enough to affect estuarine organisms in several ways (Table 1). Typical responses range from reduced abundance and growth to physiological stress and mortality. The severity of the effect depends on a variety of factors, including how low the dissolved oxygen concentrations get and the duration and spatial extent of hypoxia, as well as other factors such as the water temperature and the distribution and behavioral patterns of resident species. Therefore, resource effects attributable to hypoxia are significant but variable, even on an annual basis.

How hypoxia affects a particular species depends on a variety of factors, including the sensitivity of the species and the seasonal and areal distribution of its life stages. Laboratory work has demonstrated that, in general, early life stages (eggs and larvae) are more acutely sensitive than later ones (juveniles and adults). In addition, the diverse species and their life stages are often transient residents among different habitats of the Sound. This natural distribution determines whether a species or life stage of a species is at risk from hypoxia. For example, individuals found only in the surface waters of the Sound during the summer will not be affected by hypoxia because the surface waters generally do not become hypoxic. Other species, particularly while in their sensitive early life stages, present below the pycnocline in late summer are clearly at risk. Juvenile winter flounder, for example, are present in bottom waters during late summer low dissolved oxygen conditions and may experience mortalities and reduced growth. Similarly, the eggs, larvae, or juvenile stages of species such as bay anchovy, Atlantic menhaden, cunner, tautog, and sea robin are expected to be present in bottom waters of the Sound during hypoxic periods because of the timing of their spawning periods.

The sensitive stages of other species may simply miss the period of hypoxia or live above the pycnocline where oxygen levels are higher. For example, winter flounder embryos are one of the most low-oxygen sensitive life stages of this species but they are only present in the Sound during spring when dissolved oxygen concentrations are high. Similarly, the most sensitive life stage of the American lobster are the larvae, but they swim from the benthic habitat to the surface soon after hatching. Therefore, it is unlikely that they are exposed to low dissolved oxygen conditions long enough to succumb.

Organisms may alter their behavior in response to low dissolved oxygen concentrations. Some animals will emerge from their burrows in the sediment under stressful dissolved oxygen conditions to try to obtain more oxygen. Other organisms may increase their swimming activity to cover more area in an attempt to come into contact with more oxygen. However, at near-lethal dissolved oxygen concentrations, most organisms decrease non-respiratory activity. These behaviors may increase vulnerability to predation. For example, a species that comes out of its burrow is more visible and, therefore, more susceptible to predation. In addition, if finfish are concentrated in unaffected areas during a hypoxic event, they may be exposed to greater fishing pressure, predation, incidence of

disease, and food depletion. Thus, hypoxia can indirectly affect organisms because it alters their behavior.

Table 1 Dissolved oxygen concentrations (mg/l[1]) and their corresponding effects on some of the living resources of Long Island Sound.

DISSOLVED OXYGEN CONCENTRATIONS ABOVE THE PYCNOCLINE	
4 - 5 mg/l	Suitable for many species and life stages, but may result in limited biological consequences (e.g., American lobster larval mortality > 0% and < 25%) [2]
3 - 4 mg/l	25 - 50% mortality of larval American lobsters [3,4]
2 - 3 mg/l	50 - 95% mortality of larval American lobsters [4]
DISSOLVED OXYGEN CONCENTRATIONS BELOW THE PYCNOCLINE	
4 - 5 mg/l	Protective from most biological consequences
3 - 4 mg/l	Protective from many known biological consequences, but threshold for reduced growth of juvenile American lobsters, grass shrimp,summer flounder, also larval grass shrimp and mud crabs [5]
2 - 3 mg/l	Impaired finfish habitat (reduced abundance) and greater than 10% reduction in growth of newly settled American lobsters, delayed hatch of squid embryos, mortality of larval grass shrimp and mud crabs [5]
1 - 2 mg/l	Impaired American lobster and finfish habitat (reduced abundance), 10 - 90% mortality of some non-larval lab-tested species [6]
0 - 1 mg/l	Many severe consequences, even at short exposures, including > 95% decline in finfish abundance, nearly 90% decline in finfish diversity, and partial or complete mortality of all lab-tested species. Mortalities can occur in less than one hour [7]

1 mg/l = milligrams of dissolved oxygen per liter of water.

2 Highest effect concentrations observed with stage I American lobster larvae, which is the most sensitive stage for this species, were 4.2 and 4.4 mg/l for 10% mortality in 96 hour exposures (e.g., the concentrations at which 10% of test organisms died after 96 hour exposure to water of varying levels of dissolved oxygen). A 15 day exposure of stage I through IV resulted in 10% mortality at 5.1 mg/l.

3 Ninety-six hour LC25s (concentration at which 25% of the test organisms die) for stage I American lobster larvae in three tests: 3.7, 3.7, 3.8 mg/l; in two tests with stage II American lobster larvae: 4.2, 3.1 mg/l. The 15 day exposure of stages I through IV resulted in 25% and 50% mortality at 4.0 and 3.3 mg/l, respectively.

4 Ninety-six hour LC50s (concentration at which 50% of the test organisms die) for stage I American lobster larvae in three tests: 3.2, 3.2, 3.0 mg/l; in three tests with stage II American lobster larvae: 3.1, 3.0, 2.8 mg/l. The mean LC90 from these tests is 2.1 mg/l.

5 Highest effect concentration observed in lab tests with subpycnocline organisms is 3.5 mg/l. This effect was a statistically significant reduction in dry weight relative to controls of newly settled (juvenile) Long Island Sound American lobsters exposed from stage V through the molt to stage VI (12 - 20 days). Growth reduction effects were greater than 10% at lower concentrations.

6 10% mortality observed in 96 hour exposures of: juvenile-adult sand shrimp at 1.4 mg/l; winter flounder young-of-the-year at 1.6 mg/l; juvenile-adult grass shrimp at 1.4 mg/l. LC50s for young-of-the-year winter flounder at 1.3 mg/l; sand shrimp and grass shrimp juvenile-adults at 1.0 mg/l; juvenile Atlantic menhaden (literature value) at 1.0 mg/l. Long Island Sound field trawl data analysis shows statistically significant reduction in finfish abundance for three species in waters below 3.0 mg/l. Squid embryos were exposed for 16 and 20 days in two tests; 40% delay in hatch occurred at 2.3 and 2.7 mg/l respectively. LC50s for mud crab larvae range from 2.3 - 2.7 mg/l; LC25 for grass shrimp larvae is 2.5 mg/l (96-hour results).

7 Long Island Sound field trawl data analysis show major impacts on 15 of 18 species typically caught during survey period. Ninety-six hour lab LC50s: Long Island Sound tautog and scup juveniles at 0.8 mg/l; spot at 0.7 mg/l.

Motile organisms that might normally range in hypoxic areas appear able to move into more oxygenated waters. Trawl surveys conducted by the CTDEP yielded far fewer fish and fewer species during hypoxia, particularly when oxygen concentrations fell below 2 mg/l. The mean catch per tow of all species combined decreased from over 300 fish per tow at sites with dissolved oxygen above 2 mg/l to 38 fish per tow at sites with dissolved oxygen in the range from 1 to 2 mg/l. Only three fish per tow were collected at sites with dissolved oxygen less than 1 mg/l. Similarly, the number of species per tow declined from an average of 11 to an average of 1.6 at sites with oxygen levels above 3 mg/l and below 1 mg/l, respectively. In recent years, up to 300 square miles, nearly one third of the Sound, fell below 4 mg/l at any one time during the summer, reducing relative finfish abundance in the affected area by 40 percent. Preliminary results from recent studies suggest that the relative biomass (kg/tow) of demersal (bottom-dwelling) species (e.g., flounders, sea robins, and skates) may be reduced by more than 50 percent in hypoxic areas.

These effects have been consistently observed when hypoxia occurs in the Sound. From 1987 to 1991, summer catches in the Hempstead area, where dissolved oxygen concentrations are chronically lower than the areas to the east, were consistently lower than in areas to the east where oxygen was higher (Figure 4). Both the total catch and number of species caught were strongly correlated to dissolved oxygen concentration with average catches over the five years in the Hempstead area about half of those in the central Sound. Trawl catches in areas that were not affected by hypoxia were higher than usual, suggesting that many individuals moved out of hypoxic areas into areas of better water quality. Fish catch in the western Sound generally rebounded during the fall after the hypoxic events were over.

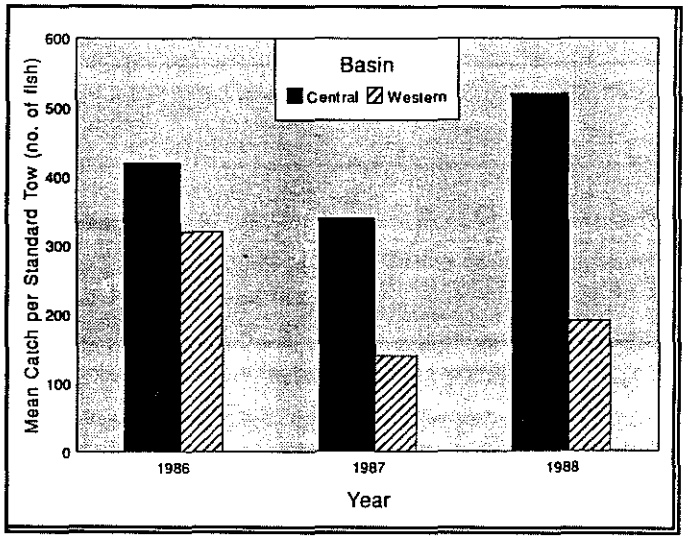


Figure 4 The mean catch per standard trawl for all species of fish collected during hypoxic periods when oxygen levels were lower in the western basin.

In contrast, benthic organisms that live on or in the sediments are generally not as motile. They cannot escape hypoxia and either must adapt to harsh environmental conditions or perish. Consequently, these organisms tend to have higher tolerances to hypoxia in terms of both concentration and length of exposure. Nevertheless, under severe hypoxic conditions, even tolerant benthic organisms may be affected. Some researchers have speculated that a *crash* (a severe decrease in numbers) in the benthic community observed in western Long Island Sound between the summer of 1972 and the spring of 1973 may have been a result of hypoxia.

Physiological responses to low dissolved oxygen concentrations are usually related to energetics. Energetic responses include increased ventilation, decreased aerobic metabolism and metabolic rate, and reduced growth and reproduction. Increased ventilation rates pass more water, and hence more oxygen, over the gills. Many species are able to reduce their oxygen requirement when concentrations decline. Some species, particularly worms and some bivalves, are more tolerant of hypoxia because they are able to switch from aerobic respiration (i.e., in the presence of oxygen) to obtaining oxygen through the breakdown of its own tissues, a process that cannot be sustained over a long period of time.

Preliminary analysis of a three year NYSDEC Lobster Disease Project suggests that environmental stress, which could be induced by hypoxia, is reducing lobster resistance to gaffkemia, a bacterial lobster disease, in western Long Island Sound. Stress may also result in reduced growth, which may be a symptom of decreased feeding, the ability to convert food to energy, or expenditure of excessive energy to increase ventilation or alter other physiological processes. Laboratory experiments have demonstrated these types of responses in juvenile lobsters as well as delayed molting in severely oxygen-stressed lobsters. Early life stages of most species are generally more susceptible to mortality due to low dissolved oxygen than are adults, further reducing recruitment potential.

Organisms have limits to their tolerance of low dissolved oxygen and severe hypoxia can result in mortality. Fish kills caused by low dissolved oxygen concentrations (or perhaps due to the release of toxic byproducts of anaerobic respiration) are not uncommon in some Long Island Sound bays and harbors. Fish kills, occasionally involving winter flounder, Atlantic menhaden, and Atlantic silversides, have occurred in Greenwich, Stamford, Norwalk, Bridgeport, New Haven, Hempstead, and Cold Spring Harbors, Manhassett and Oyster Bays, and some East River tributaries. Kills have also been observed in the Sound proper and have involved invertebrates. In western Long Island Sound, during a severe hypoxic event in 1987, dead invertebrates, including crabs and starfish, were collected during trawl surveys. American lobsters in traps have also been found dead in hypoxic waters of the western Sound.

The length of exposure to low oxygen conditions also affects organism response and the number of organisms that die. In laboratory experiments, deaths of test organisms (with the exception of molting crustaceans and late stage embryos of fishes) exposed to the LC50 (LC50 or *lethal concentration* is the concentration at which 50 percent of the organisms die in a prescribed amount of time) occurred within the first 24 to 48 hours of the 96 hour tests. LT50s (the lethal time to 50 percent mortality) provide a measure of the tolerance over time of organisms to hypoxia and/or anoxia. For example, larval grass shrimp LT50s decreased from 21.6 to 1.4 hours as dissolved oxygen concentrations decreased from 1.6 to 0.8 mg/l, indicating that small changes in oxygen levels can markedly affect survival.

The combination of mortality and behavioral and physiological effects of hypoxia on populations and communities is not well understood. Considerably more research needs to be conducted to determine the effects of low dissolved oxygen concentrations on biological systems as a whole. However, some effects can be predicted from the present understanding of trophic relationships and community structure.

In extreme cases, such as fish kills, hypoxic events certainly alter community structure. The entire population of a species can be wiped out while other species survive. This results in shifts in the dominant organisms from less hypoxia-tolerant to more hypoxia-tolerant species. These events have important implications for succession within the community and can affect community trophic relationships.

Changes in the community structure may reflect the physiological tolerances of the species to low dissolved oxygen. In the benthos, molluscs are generally less sensitive to low dissolved oxygen than worms, which are in turn more tolerant than crustacea and echinoderms. This may explain why bivalve molluscs were the most abundant form of benthos in the western Sound where hypoxia is more severe, while worms and then crustaceans were relatively more abundant in central and eastern regions. These observations suggest that low dissolved oxygen may influence the distribution and abundance of benthic organisms, although other factors are definitely involved.

Low dissolved oxygen may also have important effects on community structure through changes in trophic relationships. The eggs and larvae of finfishes that are vulnerable to hypoxic conditions may be important food of organisms higher in the food web. If polychaetes and bivalves experience mortality due to hypoxia, for example, they are no longer available as prey, except to scavengers. If mobile, forage-base species are excluded from low oxygen areas, they are unavailable to predators higher in the food web. These predators would have to move to other areas to find food where they would compete with predators that already inhabit the area. Also, the concentration of those species into a smaller area may result in higher susceptibility to overfishing.

Because many species cannot survive in low dissolved oxygen conditions, hypoxia in the waters of the Sound represents a loss of valuable habitat. The reproductive success of some species may be severely impaired because of breeding habitat limitations. Even those that are not directly affected by hypoxia may experience a loss of feeding habitat. Hence, Long Island Sound estuarine life is threatened during periods of hypoxia and is likely to decline as habitat is diminished. Because of its scope and severity, the LISS has identified hypoxia as the major water quality problem in the Sound.

C. How Does Hypoxia Occur?

During the late summer, the surface water of Long Island Sound is generally warmer and has a slightly lower salinity than deeper water. These factors result in the surface water being less dense than the deeper water. The lower density water forms a layer that *floats* on the cooler, more saline bottom water. This stratification creates a sharp density differential between the two layers, called a pycnocline, which restricts their mixing. Because the two layers do not mix, dissolved oxygen, which enters the surface layer from the atmosphere and as a byproduct of photosynthesis, does not easily pass into the deep water. While oxygen may be abundant in the surface layer, once the Sound stratifies, available

NUTRIENTS

Nutrients are natural substances required to sustain life. For phytoplankton, the unicellular algae which dominate plant life in Long Island Sound, the major nutrients include nitrogen (N), phosphorus (P), and carbon (C). Some species also require silica (Si) for growth.

Nitrogen: N is present as organic N or in the inorganic forms of ammonia, nitrite, and nitrate. The inorganic forms are preferentially used by phytoplankton to support their growth. Organic N is bound within organic material and is not available for plant growth until released in a usable, inorganic form by decay processes. N enters Long Island Sound from natural sources such as import from the Atlantic Ocean, transport with rivers, and atmospheric deposition. Levels of N are much enriched today from sewage treatment plants, industrial discharges, land runoff, and atmospheric pollution. N is also cycled within Long Island Sound, through the food chain, and from the sediments. The elemental form of N is the dominant gas in our atmosphere. Although some plants called nitrogen fixers can use N gas directly, those plants are uncommon in saline systems.

Phosphorus: P is also required by plants to maintain growth, but in a lesser amount than N (16 parts N to 1 part P). P is present in inorganic and organic forms in the Sound, and its natural and enriched sources are similar to those described for N.

Carbon: Large amounts of C are incorporated into all living matter. Aquatic plants derived most of their C from dissolved carbon dioxide in the water, created by respiration of estuarine organisms and diffusion from the atmosphere. C is also used to describe the organic material being discharged to Long Island Sound by sewage treatment plants or from runoff. This is usually referred to as "carbonaceous BOD" (biochemical oxygen demand) for the amount of oxygen consumed during its decay. Bacterial decay of organic matter creates carbon dioxide, but plants do not use the organic C directly.

Silica: Si is important to the growth of some forms of phytoplankton, called diatoms, which use it to build a shell. Most Si is derived from natural sources.

Sidebar 1 Nutrients.

oxygen in the deeper water is depleted by respiring organisms and the decomposition of organic material and is not replenished.

The amount of oxygen depletion in the bottom layer of the Sound depends on the degree of respiration and decomposition. Nutrients, especially nitrogen, are a key to how much organic material is available for decay in the bottom layer. Nitrogen is a necessary nutrient in a productive ecosystem — a building block for plant and animal tissues found everywhere on Earth (Sidebar 1). But too much nitrogen causes excessive growth of phytoplankton, called a *bloom*. Whereas phytoplankton growth was *limited* by the amount of nitrogen under natural conditions, there is currently an abundance of nitrogen. As such, plankton growth may not be limited until the excess nitrogen is converted into plant tissue (Sidebar 2). Several blooms may occur during the course of a year as conditions provide the necessary nutrient and light ingredients that promote the growth of phytoplankton. These blooms create a large amount of organic matter, much more than would be produced under natural conditions.

The bloom organisms eventually die and sink to the bottom, contributing a large organic matter load to the bottom waters of the Sound (Figure 5). Some of the organic matter decays as bacteria act upon it while it is sinking. Much of it settles into the sediments. During decomposition, oxygen is consumed, reducing its availability to other estuarine organisms. The sediment, because of the large amount of organic material that settles into it, is an important site of oxygen removal. The oxygen available in the bottom waters during the summer under stratified conditions becomes depleted during the decomposition of the overabundance of organic matter falling through the water column and in the sediments. Hence, the bottom waters of the Sound become hypoxic, much more so than ever would be expected under natural conditions. The problem is particularly acute in areas with a low degree of mixing or flushing, such as embayments and bottom waters of the Sound. In sum, when too much organic matter or phytoplankton is produced in the Sound, larger and more durable hypoxic areas are created.

NITROGEN AS THE LIMITING NUTRIENT

Nutrients are substances necessary to the growth and survival of plant material, including marine algae, in aquatic environments. If a key nutrient is absent, growth will be halted. The missing nutrient is said to be "limiting" the growth of algae.

The natural termination of algal blooms in Long Island Sound is linked to the consumption of dissolved inorganic nitrogen (ammonium, nitrite, and nitrate). This response is shown in both the monitoring data and model results. All the available nitrogen is taken up by the growth of plants, thus depleting the pool of nitrogen necessary for continued growth. The model forecasts that reducing loads of nitrogen to the Sound will reduce algal production by accelerating nitrogen limitation. As a result of earlier limitation, dissolved oxygen levels increase both spatially and temporally, thereby lessening hypoxia and also reducing the probability of hypoxia.

The LISS investigated other key nutrients, such as phosphorus and silica, to determine whether they could become the limiting nutrients if their loads to Long Island Sound were reduced. For phosphorus, model evaluations determined that even if all human-derived sources of phosphorus were removed, the natural sources would still be high enough that algal growth would not be limited. Therefore, phosphorus control does not appear to be an effective management option to reduce hypoxia in Long Island Sound. Silica, an essential nutrient for the production of diatoms, a group of algae that build a silicious shell, appears to limit growth of that group, but potential for management of silica is limited because its sources are primarily natural.

The LISS also considered the effects of carbon on dissolved oxygen levels in the Sound. The major sources of carbon are sewage treatment plants and the major tributaries, as well as transport into the Sound through The Race and the East River. Present levels of treatment at sewage plants already remove up to 90% of the biochemical oxygen demand from organic carbon. Although the remaining carbon in the discharges does affect dissolved oxygen levels in the Sound, and additional removal of organic carbon does result in increased dissolved oxygen levels, the overall impact of organic carbon removal is far less than results from nitrogen control.

Sidebar 2 Nitrogen as the limiting nutrient.

When the surface waters cool in early fall, the density gradient is reduced and the pycnocline is broken down. This, along with stronger winds, allows well-oxygenated surface water to mix throughout the water column, returning oxygen to the bottom waters.

D. What Are The Nitrogen Sources to the Sound?

Many sources of nitrogen have been categorized for planning and management purposes by the LISS. Understanding the components of the nitrogen load is fundamental to the understanding of this plan.

Today, about 93,600 tons of nitrogen are estimated to be delivered to the Sound each year (Figure 6). Of this, only about 43 percent (39,900 tons) of the nitrogen delivered to the Sound appears to originate from natural sources.

The amount of nitrogen identified as originating from natural sources approximates the amount believed to have been delivered to the Sound in pre-Colonial days, before the natural cycling and delivery system was significantly altered. Today, human activities account for about 57 percent (53,700 tons) of the Sound's annual nitrogen load. Because human activities are most amenable to management, the LISS has targeted them for priority attention.

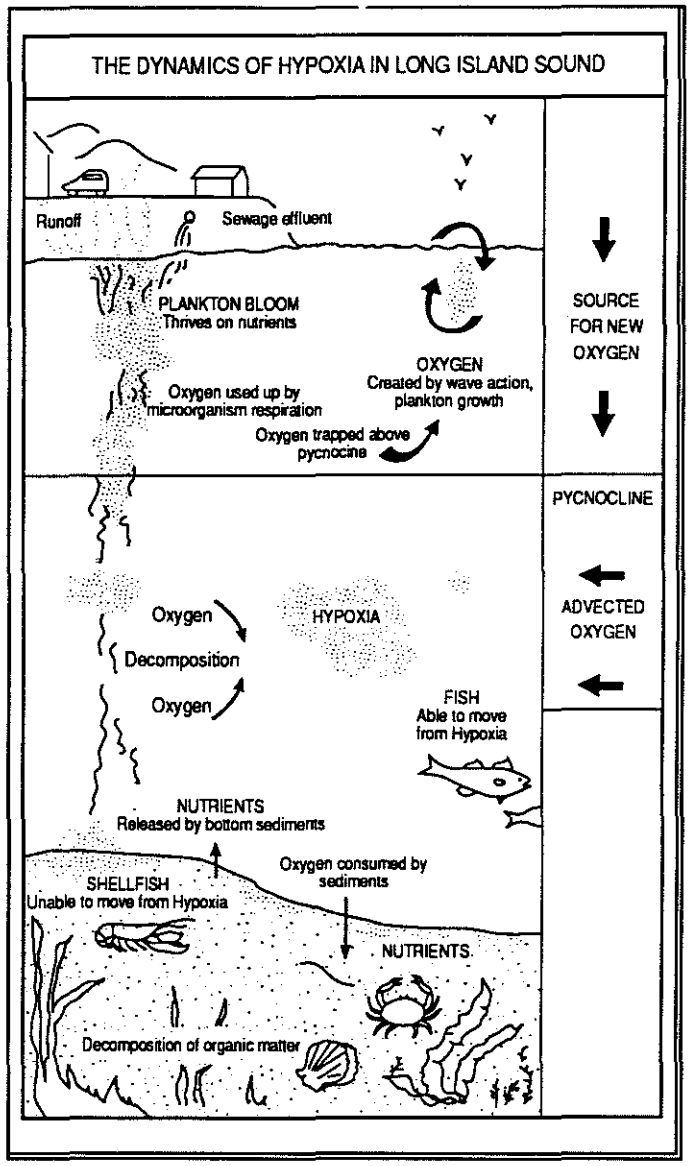


Figure 5 Dynamics of hypoxia in Long Island Sound.

1. Natural Sources

Nitrogen is abundant in the Earth's environment, comprising nearly 80 percent of the atmosphere in its elemental, gaseous form. However, nitrogen gas is not directly used as a nutrient by most life forms. It must be transformed into compounds that are usable by plants and animals. Bacteria play a key role in this transformation, often in association with certain plants. Once converted to a form usable by plants, it is incorporated into the tissue as a necessary building block for growth. Plants are consumed by animals, which produce wastes and both the plants and animals eventually die. The organic wastes and dead plant and animal tissues provide a medium for bacteria that break down the tissues, releasing nitrogen to the soil or, in aquatic habitats, to the water column and bottom sediment, thereby stimulating plant growth. Under certain conditions, other types of bacteria may use the nitrogen compounds and release the nitrogen to the atmosphere in its original, gaseous form, thus

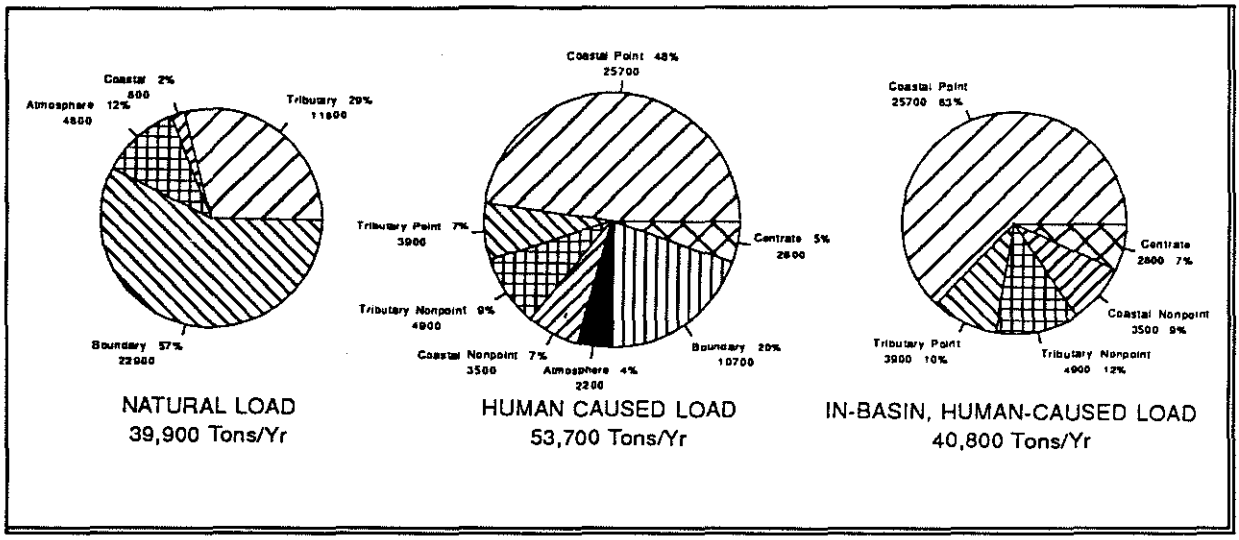


Figure 6 Distribution of nitrogen loads (tons per year) in three categories.

completing the nitrogen cycle (Figure 7).

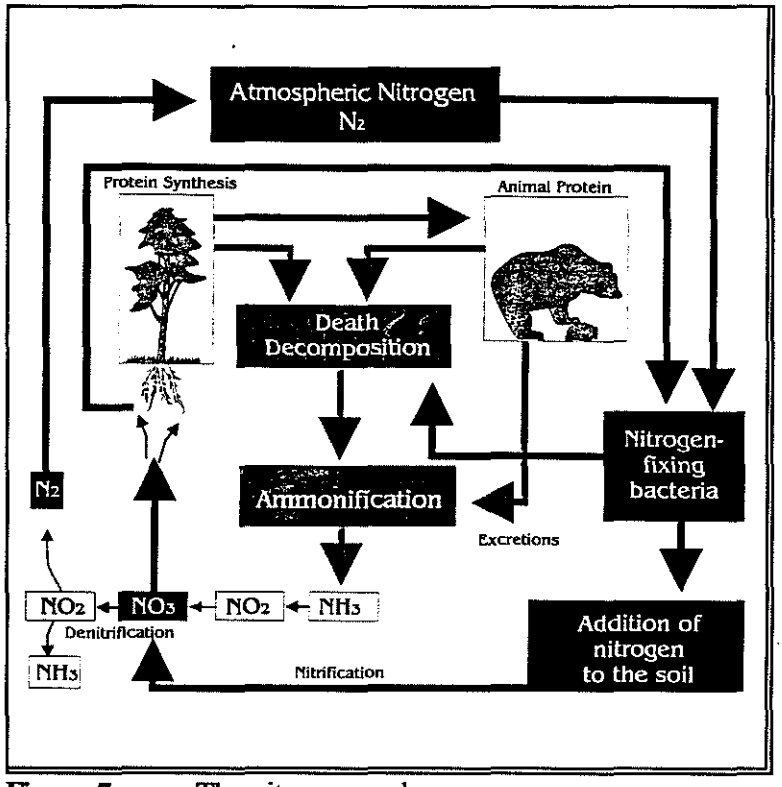


Figure 7 The nitrogen cycle.

Long Island Sound is an integral part of the nitrogen cycle, using the nutrients to generate plant life and providing a home for bacteria that recycle the nutrients. Much of the nutritionally useful nitrogen in the Sound is either delivered from the land or recycled in the Sound. Fixation of nitrogen gas from the atmosphere appears to be very limited in estuarine environments. Key delivery routes of nitrogen from natural sources to the Sound include rivers, direct stormwater runoff from coastal lands, groundwater transport, and atmospheric deposition directly on the Sound's surface. Forms of nitrogen delivered to the Sound include: organic nitrogen incorporated in dead or living plant and animal tissues that washes into the Sound or its tributary rivers; ammonia, primarily a byproduct of bacterial decay of plant and animal tissues or wastes, which may be dissolved in water and delivered by rivers, runoff, or groundwater or evaporated in the atmosphere and deposited via that route; and nitrite and nitrate, both byproducts of bacterial decay, although combustion produces these forms as well. Delivery routes of nitrite and nitrate are similar to those of ammonia.

This natural component of the nitrogen *budget* of the Sound is, of course, still active today and annually delivers an estimated 39,900 tons of nitrogen to the Sound, or about 43 percent of the total load of nitrogen (Figure 6). The LISS has categorized the natural sources into useful groups: coastal

runoff (2% of the natural load), delivery by the large tributaries (29%), atmospheric deposition (12%), and transport into the Sound across its boundaries — the East River and The Race (57%).

2. Human Sources

Human activity has greatly increased the amount of nitrogen delivered to Long Island Sound. Although the delivery routes, i.e., coastal runoff, tributaries, atmospheric deposition, and transport across the boundaries, remain the same as for natural sources, the amount of nitrogen carried along those routes has greatly increased. The activities most responsible for the increase are sewage treatment plants that discharge both directly into the Sound and into the tributaries leading to the Sound and alteration of land cover by development and agriculture leading to changes in runoff quantity and quality throughout the basin. Although less significant, the load from atmospheric deposition directly on the Sound is also a factor. Most of the human portion of the atmospheric load of nitrogen originates from vehicle exhausts and stack emissions.

A. Sewage Treatment Plants

Treatment plants, broadly identified as point sources, effectively remove many damaging pollutants and meet standards once believed to be stringent enough to solve most surface water quality problems, but they do not remove much nitrogen (unless specifically designed to do so). Worse still, conventional sewage treatment plants convert nitrogen from human and other organic waste into forms most readily usable by estuarine plant life — ammonia and nitrate — the same nutrients applied to lawns and agricultural crops to stimulate growth. More than half of the nitrogen delivered to the Sound attributable to human sources comes from these point sources and most of that in areas very close to the Sound rather than far up the tributary rivers. In 1992, the load from this source increased by 2,800 tons over 1990 levels. This increase was anticipated as a consequence of the termination of ocean disposal of sewage sludge from New York City and the need to treat some of the sludge at New York City sewage treatment plants discharging to the East River. Treatment involves dewatering the sludge prior to landside disposal. The water removed from the sludge, called *centrate*, is rich in nitrogen and contributes to the New York City sewage treatment plant loads of nitrogen.

B. Other Human Activity

Nitrogen also comes from other human activities, such as fertilization of lawns and crops, car emissions spewed into the air, and septic systems. It is carried by rain directly from the atmosphere and along with stormwater runoff after being picked up from agricultural, residential, and urban lands. These sources are referred to as nonpoint sources because they are not discharged from a sewage treatment plant or industrial discharge pipe (Sidebar 3). About 20 percent of the human nitrogen contributions come from these nonpoint sources. Although urban stormwater is often discharged from sewer pipes, it is also considered by the LISS to be a type of nonpoint source because of its diffuse origin prior to being channeled into a storm sewer system.

C. Boundary Load

The large input of nitrogen across the Sound's boundaries, i.e., through the East River and The Race, is generated by the same sources identified above: point, nonpoint, and atmospheric deposition. However, the delivery to estuarine and marine waters occurs outside of the Sound's geographic borders. Nevertheless, it is transported into the Sound and contributes to hypoxia and is, therefore, of managerial interest. The boundary contribution is roughly equivalent to the nonpoint and

atmospheric load, accounting for about 20 percent of the human-related nitrogen load.

All these human-generated sources provide 53,700 tons of nitrogen to the Sound each year, more than doubling the estimated load of pre-Colonial times. These human sources are believed to have the highest potential for management and are the initial focus of management planning activity. Of the annual load of 53,700 tons of nitrogen, the 10,700 tons that enter through the boundary and the 2,200 tons from atmospheric deposition are not directly managed by LISS efforts. However, efforts to reduce the substantial western load that passes through the East River will come under the auspices of the New York-New Jersey Harbor Estuary Program. Similarly, the LISS anticipates the atmospheric load to be reduced to about 1,540 tons of nitrogen per year through implementation of the new Clean Air Act.

The remaining 40,800 tons per year, broadly categorized as in-basin, human-induced sources, come from point and nonpoint sources that can be more directly managed by LISS participants. Of the 40,800 tons per year, 32,400 tons of nitrogen come from point source discharges, primarily sewage treatment plants (Figure 6). It includes both coastal and tributary point sources and the centrate load. An estimated 8,400 of the 40,800 tons of human-induced nitrogen each year are from nonpoint sources, such as agricultural and urban runoff.

E. Can Hypoxia Be Managed?

1. Understanding the Problem

Long Island Sound is too complex to understand using direct observations alone. Natural variations in weather and other physical factors affect the extent and severity of hypoxia. In order to understand the relationship among natural variations, human-induced pollutant loadings to the Sound, and hypoxia in the Sound, the LISS has developed mathematical models that describe these relationships (Sidebar 4). The modeling effort has been designed to assist in

NONPOINT SOURCE POLLUTION

Pollutants entering the Sound can be divided into two categories: **POINT** and **NONPOINT** sources of pollution. In the case of point sources, we can see the pollutants coming from a discharge pipe, sewage treatment plant, or industrial facility. Nonpoint source pollution is much more difficult to identify and regulate because its origins are so diffuse. Nonpoint source pollution enters Long Island Sound from sources throughout its drainage basin or watershed.

Two key components of nonpoint pollution are: 1) the volume of runoff and 2) the level of contaminants in the runoff. Land use activities impact both components and, as a result, the quantity and quality of runoff in the Long Island Sound basin are changed greatly from what existed when most of the basin was forested. From a quantity standpoint, it is not hard to visualize how a forested watershed tempers the runoff from a rainstorm. The tree canopy captures some of the rainfall and slows its progress to the forest floor. Water that does reach the floor is captured and slowed by the litter and humus there, which acts much like a sponge. Although the forest floor can and does become saturated and surface runoff to adjacent streams then begins, much of the water seeps into the soil and becomes part of the groundwater.

Our use of the land can greatly alter this process. Impervious materials used to pave streets and roof houses result in a very short transport time for stormwater runoff to nearby streams. Even grassy areas or agricultural fields provide more runoff than a forest because the tempering effects of the forest canopy, litter, and humus are lost. The end result is a faster, more intense delivery of rainwater to the surface waters. Stream levels oscillate much more rapidly in response to storm events as the natural "regulator" effect of forestation is lost.

The quantitative changes also impact the quality. Even without considering the added pollutants that we contribute in the form of lawn and crop fertilizers and atmospheric fallout, the slow passage of stormwater through the forest and the groundwater removes many of the associated contaminants. Adding the greatly increased load of pollutants to the quick delivery system we have engineered, it is no surprise that nonpoint sources of pollution are of great concern in the Long Island Sound basin.

Sidebar 3 Nonpoint sources of pollution.

developing answers to some fundamental questions:

- What causes low dissolved oxygen? What are the interactions between natural conditions and human influences?
- Will the problem worsen if nothing is done? If so, how severely and when?
- What can be done to manage the problem? How effective will different controls be?
- How long will it take to see improvements?
- How much will it cost?

Preliminary answers to these questions have been developed using a two-dimensional water quality model called LIS 2.0. The LIS 2.0 model, in combination with field measurements, provides the technical basis for the nitrogen management actions presented in this plan.

2. The Need to Manage Nitrogen

As introduced earlier, the growth of algal blooms in Long Island Sound is dependent upon the availability of dissolved inorganic nutrients. Both the field measurements conducted by the LISS and the LIS 2.0 model runs show that in the Sound these blooms end when the pool of nitrogen available for continued growth of these plants is depleted (Sidebar 2). As a result, reducing the loads of nitrogen to the Sound will reduce algal production. The LIS 2.0 model forecasts that reducing the load of nitrogen will increase dissolved oxygen levels, thereby lessening hypoxia and also reducing the probability of anoxia. The LIS 2.0 model also projects that increases in nitrogen delivered to the Sound could significantly worsen the hypoxia problem, causing larger areas to have lower dissolved oxygen levels for longer periods of time. The probability of events like the summer of 1987, when anoxia — the absence of dissolved oxygen — became a reality in parts of the Sound offshore of Hempstead Harbor, could also increase.

THE LONG ISLAND SOUND MODELS

The LISS has relied heavily on computer modeling of the Sound to sort out the complex interaction between natural conditions and human influences in causing hypoxia. Two models, a water quality model that approximates the biological and chemical processes of the Sound and a hydrodynamic model that describes physical processes, have been developed. An intensive field program in Long Island Sound to collect data for the computer models was undertaken from April 1988 to September 1989. These data were used to calibrate and verify the models to ensure that they reproduce the important features of the Sound.

The water quality model, called LIS 2.0, has provided needed insight into the causes of hypoxia and is the basis for the actions to begin to reduce nitrogen discharges to the Sound that are contained in this report. However, because it simulates the movement of the Sound's waters in only two dimensions (east-west and surface to bottom) and in a simplified manner, the LIS 2.0 model does not provide the best technical foundation for identifying the total level of reduction in nitrogen loads that should be attained or the most cost-effective means to achieve that target reduction.

The hydrodynamic model, developed by the National Oceanic and Atmospheric Administration and completed in July, 1993, uses tide and current measurements to simulate the water's circulation in three dimensions (east-west, north-south, surface to bottom). It is now being coupled to the water quality model, to create LIS 3.0. The LIS 3.0 model will provide a state-of-the-art tool to identify relate sources of nitrogen from specific geographic areas to the hypoxia problem in the western Sound. Because the impact of the nitrogen load from different management zones can be determined using LIS 3.0, the LISS can assign priorities for management to ensure the most the cost-effective options are pursued.

Sidebar 4 The Long Island Sound models.

Despite its limitations, the LIS 2.0 model has provided immediate insight for estimating future impacts to the Sound under current conditions. Using a conservative estimate of no more than a five percent increase in population, LIS 2.0 forecasted that, without nutrient controls, nitrogen loads will continue to increase, and with that increase:

- The minimum dissolved oxygen level (now defined as less than 3 mg/l) will fall even lower and the probability of episodes of anoxia will increase;
- Areas experiencing the lowest dissolved oxygen levels will expand and the periods of low dissolved oxygen will last longer;
- The 30 percent of bottom habitat now degraded by low dissolved oxygen will expand by more than 20 percent, even though population growth contributing the increasing nitrogen is projected at only five percent; and,
- The consequences to the Sound's ecosystems of losing an additional 20 percent of habitat are likely to be deleterious and potentially cumulative; dramatic ecosystem instabilities have been documented following incremental habitat loss.

The LISS considered other nutrients, such as phosphorus and silica, to determine whether they could be the limiting nutrient if their loads to the Sound were reduced. The LISS also considered the effects of carbon on dissolved oxygen levels in the Sound. Phosphorous was determined not to be significant to limit algal growth in the Sound. Silica, although necessary for the production of diatoms, is primarily naturally occurring, and does not lend itself to management actions. Sewage treatment plants already remove up to 90 percent of the biochemical oxygen demand from organic carbon, and thus, its management would result in a much less significant improvement than would nitrogen control (Sidebar 2).

3. The Effect of Reducing Nitrogen Loads

Using the LIS 2.0 model, the LISS identified a series of management options that could be accomplished and what they would ultimately mean for the health of the Sound. For example, the most ambitious management scenario examined using the best available technology to upgrade sewage treatment plants to remove nitrogen, coupled with aggressive reductions of nitrogen from nonpoint sources, could achieve perhaps a 55 percent reduction in the enriched load of nitrogen. This reduction would create oxygen conditions about halfway between levels presently found and those the model shows existed during pre-Colonial times (Figure 8, Figure 8).

The higher oxygen levels resulting from nitrogen reduction would make the Sound more hospitable to many more of the sensitive species and life stages. The areas of most severe impact would be greatly reduced. The duration of hypoxic events and the overall area affected by hypoxia be reduced substantially. The diversity and abundance of recreational and commercial species could increase during the summertime in the western portions of the Sound. The potential costs, however, would require a significant financial investment. The LISS has estimated total maximum costs for a high level of nitrogen removal from point sources to the Sound are $8.1 billion, $6.4 billion for New York and $1.7 billion for Connecticut. These costs are presented for perspective and do not reflect the costs of actions recommended in this plan. Additional detail on the LIS 2.0 model scenarios are contained in the *Status Report and Interim Actions for Hypoxia Management*.

Such an ambitious management program requiring reconstruction of sewage treatment plants would take decades to fully implement, leaving room for new technologies to be developed that may lead to additional improvements in water quality, perhaps more cost-effectively as well. And while it is unlikely that nitrogen loads can be reduced to pre-Colonial levels, there may be other options, in addition to nitrogen removal, to improve oxygen levels. These other alternative are being further evaluated by the LISS to assure that the direction management takes is the most productive one.

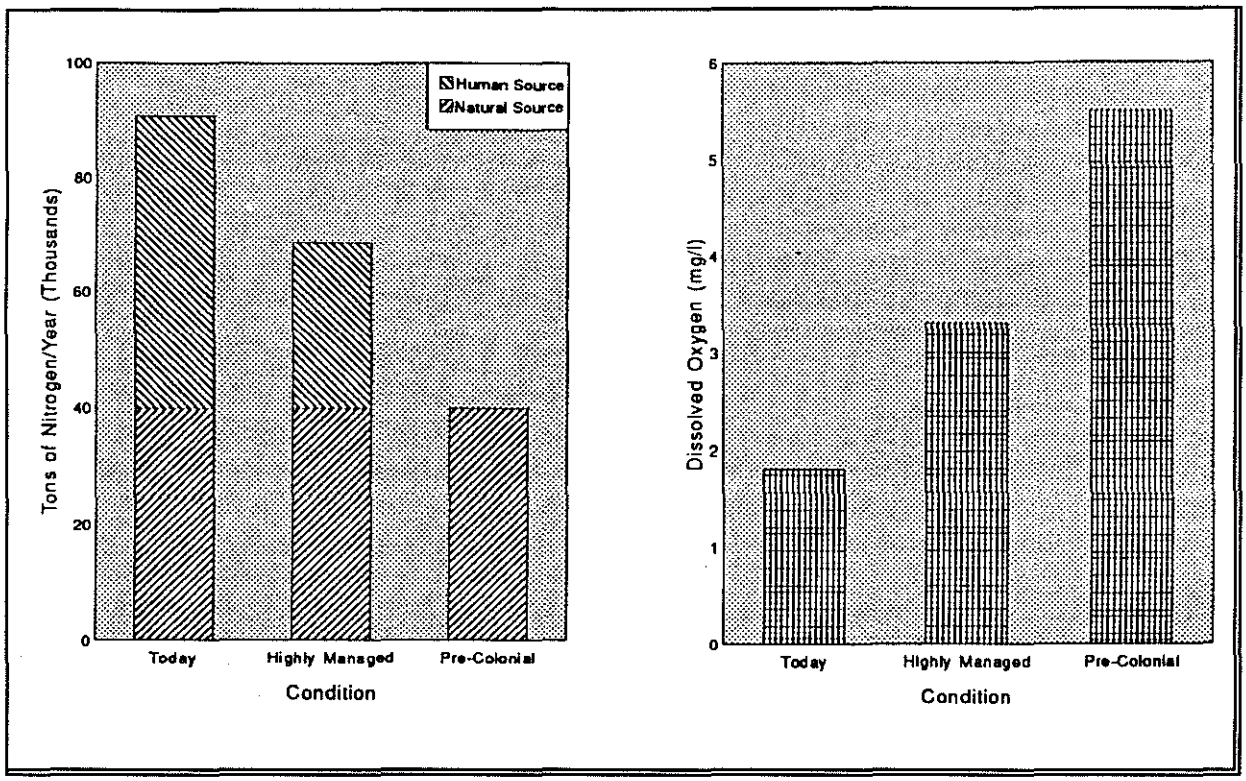


Figure 8 The relationship between nitrogen load reductions (left) and dissolved oxygen response (right) as predicted by the LIS 2.0 model.

F. How will Hypoxia be Managed?

1. Dealing with Uncertainty - The Phased Approach to Implementation

The base upon which decisions are made to manage and protect the environment is never complete. Ongoing research and technological development will alter our view on what is feasible or practical in managing the Sound, and changing social attitudes will alter our view of what is desirable. But in spite of the rapid technical advances that are possible, there will always be some level of uncertainty that citizens and policy makers will face. As a result, the LISS has adopted a program of phased implementation for hypoxia. Each phase must incorporate new information and apply the lessons gained from the previous one in a *learn-by-doing* process. Phased implementation stresses action, consistent with our current understanding, and flexibility, by reevaluating efforts as new scientific and technical information becomes available.

In accordance with this phased approach and the recognition of the immediate need to control nitrogen identified by LIS 2.0, the LISS passed a significant milestone in December of 1990, when the Policy Committee adopted a *no net increase* policy for nitrogen discharged from key sewage treatment plants and nonpoint sources. Implementation of those important early actions ensured that the hypoxia problem would not get worse (see Phase I, below). Today, *no net increase* is being implemented by Connecticut and New York.

Building upon this early implementation, the LISS has determined that the hypoxia management plan for the Sound must:

1) Set a goal for improving dissolved oxygen levels;
2) Develop a long-term strategy to achieve that goal; and
3) Maintain a program of monitoring and planning to continually reevaluate and refine management efforts and enhance implementation.

2. Setting a Goal for Hypoxia Management

The first step in the management plan for hypoxia is to establish a goal for improving dissolved oxygen levels. The LISS has established a goal to:

Increase dissolved oxygen levels in the Sound to eliminate adverse impacts of hypoxia resulting from human activities.

This goal will not be achieved in the short-term; rather it represents what management efforts should strive for. In the interim, however, steps can be taken to minimize adverse effects of hypoxia on the resources of the Sound. To help establish priorities for action, interim dissolved oxygen targets have been developed which represent the best scientific information available on oxygen levels believed to minimize adverse impacts on living resources of the Sound (Sidebar 5). While these interim targets are based upon scientifically defensible data available to date, continued study of the Sound's complex ecosystem and species response to dissolved oxygen levels will provide a better understanding of dissolved oxygen levels that fully protect aquatic life. To date, research shows that the most severe effects (mortality of most resident species) occur below a level of 1.5 mg/l at any time and below 3.5 mg/l in the short term, i.e., four days. Very sensitive organisms are affected when dissolved oxygen levels fall below 5 mg/l. As the information base grows, the interim targets will be reviewed and revised as appropriate.

These interim targets in no way compromise the LISS ultimate goal of *eliminating adverse impacts of hypoxia resulting from human activities*, but, rather, represent a significant step towards achieving this goal by providing a mechanism for measuring progress towards the goal. The interim targets will be used in conjunction with the LIS 3.0 model to evaluate management strategies for increasing dissolved oxygen levels. Through attainment of the interim targets, dissolved oxygen levels will be significantly increased, thereby increasing the total usable habitat available to aquatic life. Aquatic life will benefit from such increased dissolved oxygen levels. Based on the existing dissolved oxygen bioassay data, we now know that a number of species will directly benefit from attainment of these targets, including, but not limited to: lobster, winter flounder, oyster, tautog, and striped bass. Future research and bioassay work will define benefits to other species.

Over the long term, the goal must continue to be the *elimination* of adverse impacts resulting from human activities. To assist in defining dissolved oxygen levels that are fully protective of estuarine life in the Sound, the EPA is developing regional dissolved oxygen criteria for marine waters. Currently, the state standards are 5 mg/l in New York and 5 to 6 mg/l in Connecticut depending on water quality classifications.

3. A Long-Term Strategy to Achieve that Goal

The LISS needs to complete the LIS 3.0 model to have the technical and scientific basis for identifying the total level of nitrogen reduction that would be needed to achieve the interim targets. The LIS 3.0 model will also be used to test alternative nitrogen reduction scenarios that will help to identify where the investment of resources will result in the greatest environmental improvement.

Specific implementation actions presented in this plan are divided into three phases:

- Phase I, as announced in December of 1990, froze nitrogen loadings to the Sound in key geographic areas at 1990 levels to prevent hypoxia from worsening.

- Phase II, as detailed in this plan, includes significant, low-cost nitrogen reductions that begin the process of reducing the severity and extent of hypoxia in the Sound.

- Phase III will present nitrogen reduction targets to meet the interim targets for dissolved oxygen, which will prevent known lethal and sublethal effects of hypoxia on the Sound's estuarine life. Phase III will also lay out the approach for meeting these nitrogen load reduction targets.

The focus of all three phases of the plan is reducing the loading of nitrogen to the Sound from point and nonpoint source discharges within the Sound's drainage basin. In addition to traditional sewage treatment plant and nonpoint management options, the LISS is exploring alternative means of controlling nitrogen, including relocation of sewage treatment outfalls, tide gates on the East River to direct flow out of the Sound, construction of wetlands to augment nitrogen removal, water conservation to improve sewage treatment plant efficiency as well as a network of nonpoint source controls or best management practices. Management options will remain fluid and need to be continually revised to ensure that the best mix of options is implemented and movement toward the goal of eliminating the adverse impacts of hypoxia resulting from human activities is steady.

4. Making Reevaluation a Part of the Plan

A formal process must exist to incorporate new information and apply the lessons learned from implementation. Management efforts must be

INTERIM TARGETS FOR DISSOLVED OXYGEN

One of the goals of the LISS is to improve dissolved oxygen levels in Long Island Sound to eliminate adverse biological impacts of hypoxia that have resulted from human activities. These numerical targets identify levels to minimize most adverse impacts in the short term[1]. The targets are provided to assist the LISS in the development of an effective hypoxia management plan for the Sound. They are based on hypoxic-effects information available at present and are subject to revision. Some dissolved oxygen targets may not be readily achievable in portions of Long Island Sound. Specifically, the recommended interim targets for dissolved oxygen are:

- Below the pycnocline:
  1. For each area[2,3], with a dissolved oxygen minimum[4] of 5 mg/l and above (1988-1989 baseline) - maintain or enhance current levels.
  2. For each area with a dissolved oxygen minimum of 3.5 mg/l and above - achieve a four-day average[5] of 5 mg/l.
  3. For each area with a dissolved oxygen minimum below 3.5 mg/l - achieve at least a four-day average of 3.5 mg/l to minimize sublethal effects while also assuring that the dissolved oxygen concentration never falls below 1.5 mg/l to prevent lethal effects.
- Above the pycnocline or in non-stratified waters:
  1. For each area with a dissolved oxygen minimum of 5 mg/l and above - maintain or enhance current levels.
  2. For each area with a dissolved oxygen minimum of 5 mg/l or below - achieve at least a four-day average of 5 mg/l to protect from sublethal effects and a minimum at any time to protect eggs and larvae from acutely lethal conditions. These minima are:
     a. 4.0 mg/l in June and July to minimize effects on lobster larvae in the Sound
     b. 3.0 mg/l in August in the Sound and during all months in embayments to minimize effects on other crustacean larvae.

1 If other research demonstrates that higher average dissolved oxygen levels are required, these targets should be revised to reflect that possibility. The option of *doing more* must be reserved.
2 For interim targets, each of the above could be defined for areal extent (e.g., square miles of "x" dissolved oxygen value).
3 Area is defined as the spatial extent within a contour (at 0.5 mg/l increments).
4 Dissolved oxygen minimum is the lowest concentration of dissolved oxygen in an area at any time.
5 The average dissolved oxygen concentration should be calculated as moving averages, using true daily means derived from continuous records. Any dissolved oxygen observation exceeding the saturation concentration is to be recorded as the saturation concentration as there is no biological evidence of additional benefit of supersaturation. The LISS has decided to adopt an averaging period of four days. This is important to reduce the probability of prolonged exposures to near minimum dissolved oxygen conditions.

Sidebar 5 Interim targets for dissolved oxygen.

reevaluated, the condition of the Sound monitored, and public involvement maintained. The LISS recommends that these efforts be summarized and published in a biennial progress report (see *Chapter IX, Continuing the Management Conference* for details).

G. Overview of Hypoxia Management Actions

The three phases of implementation to manage hypoxia introduced above allow the LISS to adapt management actions to the prevailing level of understanding. This approach allows implementation to be phased in at appropriate intervals rather than delaying all actions until final plan preparation. It should be clear that although three implementation phases are identified, many of the specific actions have overlapping time frames for implementation. It is the intention of the LISS to implement all feasible actions as expeditiously as possible as long as the actions are consistent with identified management needs.

1. Phase I

This phase was announced in December of 1990 and was detailed in the *Status Report and Interim Actions for Hypoxia Management*. It called for a freeze on point and nonpoint nitrogen loadings to the Sound in key geographic areas at 1990 levels. It committed the states to specific actions to stop a 300 year trend of ever-increasing loadings.

Major accomplishments of Phase I include:

- Baseline 1990 loads from critical point source dischargers have been published and permits are being modified to cap loads at 1990 levels. In implementing this *no net increase* policy, the states of Connecticut and New York are committed to working with local governments to ensure planned economic development can continued while also protecting the Sound.

- Connecticut reacted quickly to obtain $15 million in state funds to ensure that the nitrogen freeze was implemented. Biological nutrient removal retrofitting was evaluated at 13 coastal treatment plants and consent orders are in place to cap the nitrogen loads at the 15 affected facilities, 11 of which are suitable for retrofitting.

- In New York, New York City and the NYSDEC have reached full agreement on sewage treatment plant limits, freezing the total loadings at 1990 levels and the NYSDEC is in the process of issuing these permits. In Westchester County, the NYSDEC has issued final permits to the four existing dischargers, freezing their aggregate loading at 1990 levels. This was done with the full agreement of the county. On Long Island, the NYSDEC has proposed individual permits, freezing the loadings from individual dischargers at 1990 levels. In response, the dischargers have organized to counter-propose aggregate limits, freezing the total loading from all the discharges at the 1990 level. This revised proposal is currently under review by the NYSDEC.

- Sewage treatment plants undergoing expansion or reconstruction have incorporated plans for nitrogen removal. Sewage treatment plants that are evaluating denitrification include Wards Island and Newtown Creek in New York City; all four treatment plants in Westchester County; and, in Connecticut, the Seymour, Norwalk, Greenwich, New Canaan, Ridgefield, Danbury, Montville, Naugatuck, Thomaston, Torrington, Waterbury, and Watertown sewage treatment plants.

- The LISS has prepared a *no net increase* strategy for controlling nitrogen from nonpoint sources. Many of the needs are being worked into state nonpoint pollution control initiatives including general stormwater permits in both states, a nonpoint pollutant load assessment and management program for Westchester County, state nonpoint source programs, state Coastal Nonpoint Pollution Control Programs, and demonstration and research projects funded by state and federal sources.

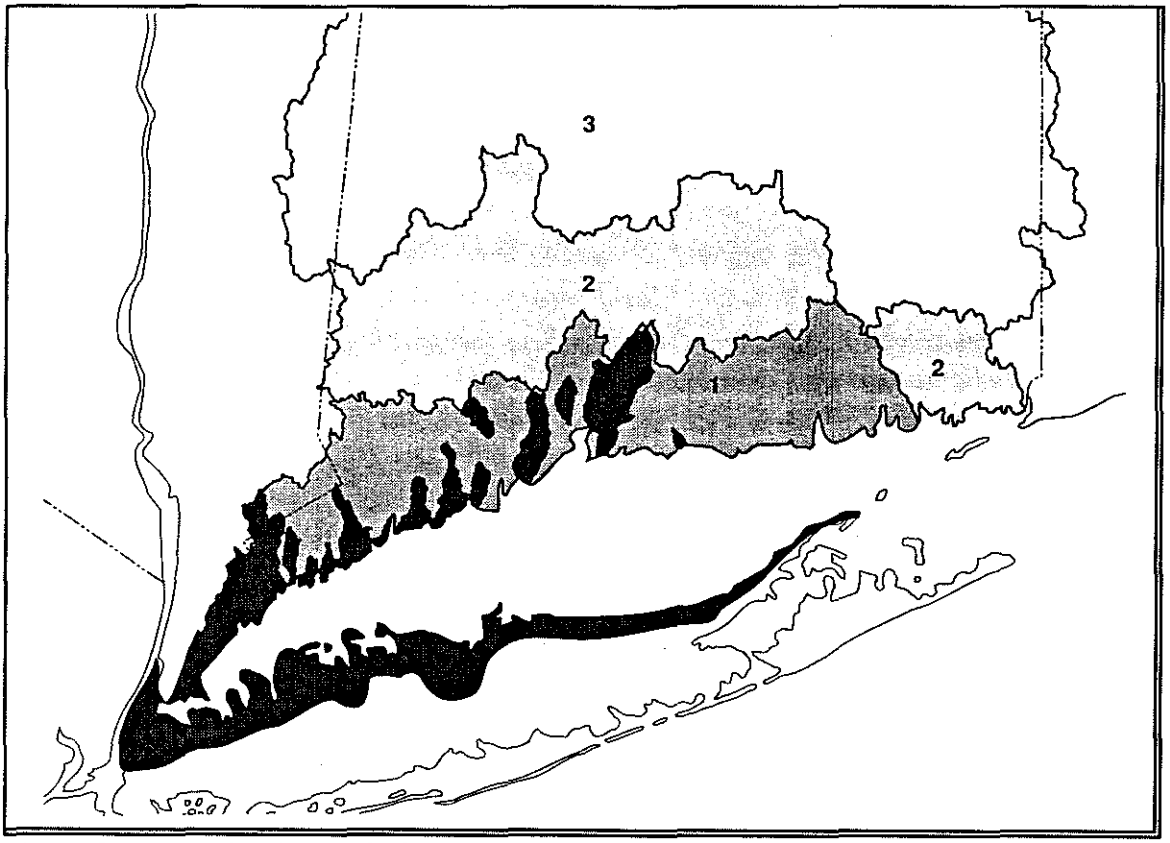


Figure 9 Three levels of priority for managing nonpoint sources of nitrogen. Within level 1, the highest priority subbasins are shaded.

- The LISS has identified high priority subregional basins where nitrogen loads from nonpoint sources are likely to be high. These high priority basins are recommended for initial planning attention to determine the need and approach for nitrogen control activities. High priority basins generally correlate to high levels of development. All of the portions of Westchester, Suffolk, and Nassau Counties and New York City that lie within the Long Island Sound drainage area, and densely populated portions of Fairfield and New Haven Counties are, therefore, identified as high priority basins for nonpoint management (Figure 9).

- An alternatives technologies workshop was held to explore alternative approaches to hypoxia management. Technologies identified as having the best potential for reducing hypoxia were: 1) relocation of outfalls from selected sewage treatment plants, 2) tide gates on the East River to alter hydrology, 3) construction of wetlands to remove nitrogen from wastewaters, 4) water conservation to improve sewage treatment. Other technologies that were examined include modifying the morphology of the Long Island Sound basin to influence circulation and mixing and aquaculture of seaweeds to remove excess nutrients. All evaluations included

recommendations for further evaluation or additional modeling to fully assess feasibility in the Sound.

- Monitoring of ambient nitrogen conditions and sources has continued including regular monitoring of the Sound and its tributaries, atmospheric deposition monitoring at two locations, and stepped-up monitoring of key point source discharges.

2. Phase II

A. Point Sources

While planning to maintain the 1990 baseline nitrogen loads under the Phase I agreements, the states and the LISS looked for ways to inexpensively reduce nitrogen loads. It was soon found that many of the sewage treatment plants could be retrofit to include varying levels of biological nitrogen removal without costly reconstruction of the entire plant (Sidebar 6). In fact, retrofitting proved to be such a viable option that relatively inexpensive reductions will result in an overall net reduction of nitrogen loads to the Sound, at least over the short run. This ensures steady progress towards improvements in the Sound until final nitrogen load reductions targets can be established using the LIS 3.0 model under Phase III. Some treatment plants will be able to reduce nitrogen loads to the degree that the retrofitting provide a longer term, or even a permanent, solution.

Therefore, as a central component of the Phase II management actions, the states have committed to begin low cost reductions of nitrogen, primarily through retrofitting coastal sewage treatment plants. Both states have built upon the *no net increase* policy and have plans and have identified funding to begin reductions of nitrogen at the sewage treatment plants of regional concern to the Sound (Table 2 & Table 3). This agreement to begin reducing nitrogen loads (specific actions summarized in Table 4) includes a commitment to achieve a secondary level of treatment at the Newtown Creek sewage treatment plant, the only remaining plant discharging to the Sound or its tributaries that has not done

BIOLOGICAL NUTRIENT REMOVAL

Conventional primary and secondary sewage treatment plants remove only small amounts of nitrogen and phosphorus from the wastewater. Biological nutrient removal (BNR) removes much greater amounts of nitrogen and phosphorus using natural breakdown processes. Relatively minor modifications (retrofitting) can be made to the equipment or operation of the sewage treatment plant to achieve nutrient removal, but only if the plant has excess capacity. Full BNR often requires reconstruction of the treatment plant at a high cost.

In BNR, biological organisms are used to remove the nutrients from the wastewater. The basic principal is to have alternating anaerobic (no or little oxygen) and aerobic (oxygenated) zones or tanks within the treatment process. In the aerobic zones, nitrification occurs while in the anaerobic zones denitrification occurs.

Nitrification is a process in which bacteria converts ammonia and organic nitrogen to nitrate. In sewage treatment plants, ammonia and organic nitrogen come from human wastes and dead plant and animal matter. The nitrifying bacteria is cultured for use at the plants to convert ammonia to nitrite and nitrate. Nitrification occurs naturally in ecosystems such as salt marshes and plays an important role in the cycling of nitrogen through the earth's environment. In sewage treatment plants and in nature, nitrification requires the presence of nitrifying bacteria and high concentrations of dissolved oxygen also referred to as "oxic" or "aerobic" conditions.

In the denitrification process, another type of bacteria extracts oxygen from nitrates, causing harmless nitrogen gas to be released into the atmosphere. Like nitrification, denitrification also occurs naturally in salt marshes and other ecosystems but under low oxygen conditions or "anoxic" conditions in the presence of denitrifying bacteria, nitrates, and organic carbon.

The two processes are linked through the recycling of the wastewater in the anoxic and oxic zones of the tanks. Typically, bacteria and nitrates generated in the nitrification stage are cycled along with sewage from the secondary settling tanks to the anoxic denitrification zone to fuel the denitrification process just described.

Sidebar 6 Biological nutrient removal.

so, and implement feasible nitrogen removal options at several key plants to begin to reduce the load of nitrogen.

Table 2 Nitrogen reductions from retrofits at Connecticut sewage treatment plants to be installed by 1995, unless otherwise noted.[1]

Town	Action	Proposed Total Nitrogen Removed (tons per year)	Percent of 1990 Baseline to Be Removed	Cost
Greenwich	Synthetic media	25	10	$325,000.
Stamford	Aeration/mixers	94	28	3,000,000.
West Haven	Anoxic zones	122	60	750,000.
Stratford	Anoxic zones	83	42	750,000.
Milford Housatonic	Aeration/mixers	71	43	800,000.
Norwalk	Aeration/mixers	36	13	1,200,000.
Norwalk (1998)	Full Denitrification	114	43	—
Fairfield	Aeration/synthetic media	97	42	4,000,000.
New Haven	Aeration/baffles	113	17	6,000,000.
Milford Beaver Br.	Aeration/pumps/mixer	25	53	650,000.
Westport	Cyclic/pumps	20	73	400,000.
Seymour	Full Denitrification	37	60	—
Ridgefield	Cyclic/pumps	13	70	210,000.
Total		901	27	$18,085,000.

1 The load of nitrogen removed is a target figure based on the studies submitted by the municipalities. The projected load reductions will be accomplished using existing sewage treatment plants, recognizing that as flows increase over time, the benefits of retrofitting will gradually be offset. However, at no time will the aggregate load of the 16 sewage treatment plants included in the *no net increase* policy exceed the 1990 baseline.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The municipalities in the states of Connecticut and New York will implement biological nutrient removal retrofits to reduce the load of nitrogen to the Sound on an interim basis.	CTDEP	Complete by 1995	$18.1 million
	NYSDEC	1995 for 5 plants 1996 for 4 plants 2000 for centrate	$103.1 million
Conduct feasibility studies and pilot demonstrations for nitrogen removal at 13 of its 14 sewage treatment plants, with actual design for Newtown Creek	NYCDEP	1994-1998	$5 million
Westchester County will investigate sludge rehandling at their four facilities to determine if opportunities exist for nitrogen load reduction	Westchester County	1993-1994	$500,000
The state of New York will continue to seek to reach agreement with Belgrave, Great Neck, Great Neck East Shore, Huntington, Oyster Bay, Port Washington, and Kings Park on permit modifications for implementing the *no net increase* in nitrogen policy	NYSDEC	1994	Redirection of base program

B. NONPOINT SOURCES

Although nonpoint sources contribute a much smaller percentage of the human-derived nitrogen delivered to Long Island Sound than point sources, if the goal of eliminating hypoxia is to be achieved, nonpoint source loads must be reduced. The nature of nonpoint source pollution also limits the ability to quantify benefits in terms of nitrogen load reductions as has been done for point source management activities. Therefore, reductions in nonpoint nitrogen loads are assumed since no practical means of widespread monitoring exists.

Phase II activities for nonpoint nitrogen control will continue to take advantage of existing programs by focusing additional attention on priority coastal subbasins. Recent emphasis on nonpoint management through federal and state initiatives has identified management practices and begun activities that are common to management needs for the Sound. Using information from the LISS that identifies priority areas for nonpoint source management of nitrogen, these initiatives provide a ready vehicle to speed implementation. Under this approach, there is agreement to implement strategies and actions aimed toward achieving *no net increase* of nitrogen loads from nonpoint sources and begin reducing them.

The specific nonpoint actions summarized in Table 5 generally take advantage of existing programs to focus management efforts on nitrogen. This does not involve radical changes in those programs; instead it enhances the utility of those programs designed to meet broader pollution control objectives with little or no additional cost. Some adjustments in priority will take place as a result of the LISS findings. The study has identified several priority areas, for example, where nitrogen loading is expected to be high because of the level of urbanization (Figure 9). Because urban areas produce a wide range of pollutants, targeting these areas for priority treatment is likely to be consistent with sound management approaches for other pollutants. Also, many of the best management practices that control nitrogen are at least as effective for a wide range of pollutants as those that might otherwise be selected.

Table 5 Reducing nitrogen loads from nonpoint sources.

ONGOING PROGRAMS	Responsible Parties/Status
The states of Connecticut and New York will continue to use their existing authority to manage nonpoint source pollution and appropriate federal grants such as Clean Water Act Section 319, 604(b), and 104(b) to carry out projects that will help prevent increases and, to the extent possible, achieve reductions in the nonpoint source nitrogen loads from high priority drainages identified in the Connecticut and New York portions of the Long Island Sound watershed.	Both the CTDEP and the NYSDEC will use these programs to continue to manage nonpoint sources of nitrogen. Nonpoint source management annual program costs, statewide, are $2.5 million in Connecticut.
The states of Connecticut and New York are developing their coastal nonpoint source control programs, as required by Section 6217 of the Coastal Zone Management Act.	These efforts were initiated in 1992 by the CTDEP and the NYDOS to implement requirements of Section 6217. The effort is funded at about $250,000 per year for both states combined. It is expected that the programs will be approved by the EPA and the NOAA in 1995. The states are using their programs to address nonpoint nitrogen control.
The states of Connecticut and New York will continue to implement general stormwater permit programs to control the discharge of stormwater from industrial, construction, and municipal activities, in accordance with the EPA's national program regulations. These permits will regulate discharges from construction activity greater than five acres and from eleven industrial categories.	These base programs run by the CTDEP and the NYSDEC, at a staff commitment cost of about $300,000 per year, provide a mechanism for controlling nonpoint sources of nitrogen from key urban sources.
The states of Connecticut and New York will continue to implement their existing permitting programs, such as the inland and tidal wetlands programs, to address nonpoint nutrient control with respect to Long Island Sound management needs, as appropriate.	General permitting programs for tidal and inland wetlands, run by the CTDEP and the NYSDEC, protect vital natural functions of nitrogen and other pollutant removal that wetlands afford. The CTDEP spends about $7 million per year on nonpoint source and wetland management.
The states of Connecticut and New York will implement the requirements of the reauthorized Clean Air Act to achieve additional nitrogen emission controls. Major actions include reduction of nitrous oxide emissions through adoption of statewide enhanced vehicle inspection and maintenance programs and stricter emission controls for stationary sources such as power plants.	Both the CTDEP and the NYSDEC are implementing aggressive emission control programs as part of the federal Clean Air Act that will reduce atmospheric loadings of nitrogen to the Sound. The cost of these new initiatives specific to nitrogen control has not been estimated.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The EPA will make nonpoint source management of nitrogen and other pollutants identified by the LISS, through wetlands and riparian zone protection as well as best management practices implementation, high priorities for fiscal year 1994 funding under Sections 319, 104(b), and 604(b) of the Clean Water Act.	EPA	1993 - 1994	Redirection of base program
Investigate expansion of stormwater permitting programs to regulate communities with populations fewer than 100,000 that border Long Island Sound within high priority management zones.	CTDEP NYSDEC	1994	Redirection of base program

Table 3 Nitrogen reductions from retrofits and other actions at New York sewage treatment plants.[1]

Facility	Action	Proposed Total Nitrogen Removed (tons per year)	Percent of 1990 Baseline to Be Removed	Cost
Hunts Point	BNR/Sludge Age	1,330	47	$2,245,000
Tallman Island	BNR/Sludge Age	1,005	58	4,600,000
Bowery Bay	Sludge Age	400	10	Operational
Wards Island	Sludge Age	255	6	Operational
Red Hook	BNR/Sludge Age	180	n/a [2]	1,600,000
Newtown Creek	Step Denitrification	1,715	n/a	—[3]
Hunts Point or Wards Island	Centrate Treatment	1,660[5]	n/a	94,000,000
Mamaroneck (1993)	Secondary Treatment	77	20	—[4]
Blind Brook	BNR	16	26	200,000
Glen Cove	BNR	60	37	400,000
King's Park	BNR	10	41	100,000
Total		6,708	n/a	$103,145,000

1 All retrofits will be completed by 1995. Installation of step denitrification at Newtown Creek and centrate treatment will not be implemented until after 1995.
2 Not applicable because these facilities are not included in the 1990 baseline load report.
3 Designed into a $1.5 billion upgrade and expansion of existing facility.
4 Part of the secondary treatment upgrade.
5 This nitrogen removal may be accomplished by means other than centrate treatment.

The point source actions agreed to under Phase II of this nitrogen control plan are significant despite their relatively low cost. Annual nitrogen loadings from eleven sewage treatment plants in New York will be reduced by 6,700 tons at a cost of $103.1 million. Nine of the plants will achieve their reductions by 1996. The load reductions associated with centrate treatment, or equivalent, are to be achieved by 2000. Secondary treatment has been achieved at all but one New York sewage treatment plant, Newtown Creek. The target date associated with the load reductions expected from the Newtown Creek sewage treatment plant upgrade is currently being negotiated by the NYCDEP, the NYSDEC, and the EPA. Funding for these actions is available through the New York State Revolving Fund.

In Connecticut, approximately $18.1 million is being spent, $14 million as 100 percent grants, to remove nearly 900 tons of nitrogen from the 1990 baseline load with all 11 retrofit projects expected to be completed by 1995. Seven of the projects (Stamford, New Haven, Milford Beaver Brook, Fairfield, Norwalk, Ridgefield, and Seymour) are either planned, or effective enough retrofit projects to be considered, permanent denitrifying facilities.

These point source reductions represent significant steps to improve dissolved oxygen levels in the Sound, removing an estimated 18.6 percent of the total in-basin, human-induced 1992 nitrogen point and nonpoint source load of 40,800 tons. This includes complete compensation for the 2,800 tons of

nitrogen per year increase associated with the end of ocean dumping and a 4,800 ton reduction from the 1990 freeze baseline (Figure 10).

The total cost of the actions agreed to under this objective is about $18 million in Connecticut and $98 million in New York with funding in place. Implementation of all actions within this agreement will continue beyond 1995, with more than half the expected reductions to be accomplished by the end of 1995.

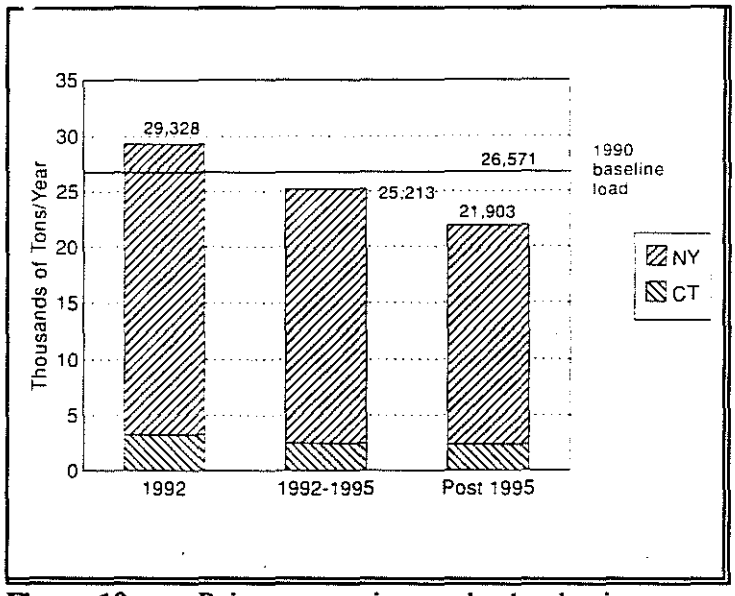


Figure 10 Point source nitrogen load reductions agreed to under Phase II of the nitrogen control plan.

The nitrogen load reduction from sewage treatment plants could achieve two kinds of benefits for the living resources of the Sound based upon a LIS 2.0 simulation for low level nitrogen management scenario. Summertime minimum dissolved oxygen concentrations in the bottom waters of the western Sound will be raised on average from 1.5 mg/l to about 2.4 mg/l. The amount of estuarine habitat presently degraded will be reduced by about 10 percent. The area most severely affected by hypoxia would be reduced by more than 30 percent.

Table 4 Reducing nitrogen loads from sewage treatment plants and other point sources.

ONGOING PROGRAMS	Responsible Parties/Status
The states of Connecticut and New York will continue their point source permitting and enforcement programs as a primary mechanism of pollutant load reduction. Fundamental to the direction of these programs are the states' water quality standards and classifications that provide the basis for management policies and decisions.	The CTDEP and NYSDEC administer the point source permitting and enforcement programs in their respective states. Using state water quality standards and criteria to drive regulatory actions, the states operate by regulating wastewater discharges through the issuance of discharge permits that include effluent limits and monitoring requirements, conducting inspections, ordering the abatement of pollution, and assisting in the financing of necessary municipal sewage treatment plants. These programs have resulted in significant reductions in pollutant loads from both industrial and municipal treatment plants and will be the key to implementing nitrogen removal actions. Statewide, annual costs are $5 million in Connecticut.
The state of New York will ensure compliance with the consent order to upgrade the Newtown Creek plant to provide secondary treatment with biological nutrient removal retrofit modifications.	The NYSDEC and the NYCDEP, during the $1.5 billion upgrade of the plant, will incorporate opportunities for nitrogen removal as part of the reconstruction project.
The state of Connecticut will freeze nitrogen discharges and, if appropriate, explore opportunities to reduce nitrogen discharges at three industrial facilities with significant nitrogen discharges.	The CTDEP, as a component of its permitting and enforcement program, will review the permits of the three industrial dischargers during renewal to ensure nitrogen loads do not increase and to try to reduce loads, if feasible.

In cooperation with the state of New York, Westchester County is developing a nonpoint source management plan that will include implementing best management practices for nonpoint source nitrogen control, monitoring their effectiveness and establishing a Westchester County management zone (or bubble) for assessing compliance with the nitrogen load freeze. The LISS will explore extending the bubble concept to other management zones throughout Connecticut and New York state portions of the Long Island Sound drainage.	NYSDEC Westchester County	1993 - 1996	$500,000 one time cost
Westchester County will implement the recommendations of the County Executive's Citizen Committee on Nonpoint Source Pollution in Long Island Sound.	Westchester County, Local Government	1993 initiation and continuing	$500,000 per year $200,000 per year for the first 3 years $600,000 for implementation
Point and nonpoint nitrogen load estimates will be made in the City of Stamford to assess feasibility of a point/nonpoint source *trading* program. A cost-effective mix of management options will be proposed that may be used to help decide how nitrogen reduction targets can be met once they are established.	CTDEP City of Stamford	1992 - 1994	$87,000 one time planning effort
New York state will pursue the expansion of the State Building Code to include provisions for erosion and sediment control and stormwater practices for all construction activities in order to prevent increases in nonpoint nitrogen runoff.	NYSDEC NYSDOS	1993 - 1994	Redirection of base program
Provide technical assistance to coastal municipalities to address impacts of hypoxia in their municipal regulations and plans of development, as required by state law.	CTDEP	1993 and continuing	Redirection of base program
Advocate the use of the June nitrate test on agricultural lands to ensure that fertilizer applications to crops do not exceed crop needs.	CTDEP NYSDEC	1993 and continuing	Redirection of base program

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
In addition to continuing general stormwater permitting programs, the state of New York should determine if the general permit adequately regulates nitrogen from activities subject to national stormwater regulations.	NYSDEC	—	$50,000
Explore the expansion of current requirements for federally licensed or permitted projects to obtain a water quality certification in New York to protect water quality from sources of pollution to include all projects adjacent to wetlands and other sensitive areas (e.g., adjacent to wetlands) or those that exceed a minimum size (e.g., greater than one acre).	NYSDEC	1994-1995	$50,000
The states of Connecticut and New York should develop a habitat restoration plan that includes a list of potential project sites and priorities. Wetland projects that are in close proximity to priority nitrogen management areas should be highlighted.	CTDEP NYSDEC NYSDOS	—	See *Chapter VII, Management and Conservation of Living Resources and Their Habitats.*
Evaluate Maryland's *Critical Areas* regulations and the reported nutrient reduction benefits and make recommendations of the potential value of a similar program for Long Island Sound.	LISS	1993 - 1995	$50,000

The management activity that is likely to yield significant benefits, but needs expansion, is education of the millions of people who live in the Long Island Sound basin. Regulatory programs can only take nitrogen control so far; an enlightened public that, in reality, *manages* much of the land by their everyday activities provides the human resource necessary to ensure land management is in keeping with clean water objectives. Educational outreach funds and staff must be made available to all basin residents and should receive the same emphasis as regulatory programs. The benefits of individual actions can far outweigh the regulatory gains if educational programs are effective.

Finally, land use management helps ensure that future growth does not negate the benefits derived from today's management practices. The LISS has begun formulating recommendations that are designed to foster responsible land use in keeping with the goal of restoring the Sound. Land use management activity focuses on the preservation of natural nitrogen removal functions that certain land types such as wetlands afford (Sidebar 7). Land use activities are detailed later in this plan.

3. Phase III

The actions agreed to in Phase II of this plan will result in significant reductions in the load of nitrogen. As stated earlier, the benefits of these reductions, as forecast by the LIS 2.0 model, will be substantial. Summertime minimum dissolved oxygen concentrations in the bottom waters of the western Sound will be raised, on average, from 1.5 mg/l to about 2.4 mg/l. The amount of estuarine habitat presently degraded will be reduced by about 10 percent and the area most severely affected would shrink by more than 30 percent.

However, the Phase II reductions alone will clearly not meet the interim dissolved oxygen targets nor achieve the goal for dissolved oxygen. Additional steps must be taken, not only to meet the interim targets, but also to progress toward the long-term goal of eliminating adverse impacts of hypoxia caused by human

HOW NITROGEN IS REMOVED BY NATURAL SYSTEMS

Once deposited on the land in the form of fertilizer or animal waste, or flushed underground into a septic tank in the form of human sewage or small food scraps, bacterial and chemical action makes nitrogen available to be taken up to varying degrees by living plants. When it rains, nearly all the remaining nitrogen infiltrates through the soil to groundwater, though a small amount may be transported into nearby streams via subsurface or overland flow.

Nitrogen which infiltrates into the groundwater will eventually discharge into wetland environments including riparian wetlands, near or adjacent to flowing water. Measurements of nitrogen concentrations in groundwater may be high, suggesting that much nitrogen is entering the groundwater. However, measurements of nitrogen concentrations in streams will often be lower, indicating that uptake and nitrogen loss is occurring where groundwater and subsurface flows discharge into surface waters.

What is happening to the nitrogen? When groundwater and subsurface flow pass through riparian wetlands, nitrogen is taken up by vegetation, particularly woody shrubs and trees. Significantly, riparian wetlands also convert dissolved nitrogen into nitrogen gas by means of bacterial denitrification. Similar nitrogen removal functions exist in coastal marshes and tidal wetlands. This is the same biological nutrient removal (BNR) process recreated at sewage treatment plants where bacteria convert nitrates to harmless nitrogen gas (**see Sidebar 6 - Biological Nutrient Removal**). Similarly, denitrification depends on low oxygen concentrations often found in saturated soils, and the presence of denitrifying bacteria, nitrates and organic carbon, all present in riparian wetlands. Laboratory studies show high rates of nitrogen loss from flooded soils, especially soils that undergo periodic flooding and drying, as in floodplain wetlands. For example, a 1980 U.S. Department of Agriculture study of nitrogen and phosphorus inputs and outputs of a riparian wetland ecosystem in a 3,873 acre drainage of the Little River in Georgia showed that denitrification and storage in woody vegetation accounted for more than six times as much nitrogen removal as nitrogen output to streamflow. Clearly these habitats are worth protecting for their valuable role in nitrogen removal and as part of the management of hypoxia.

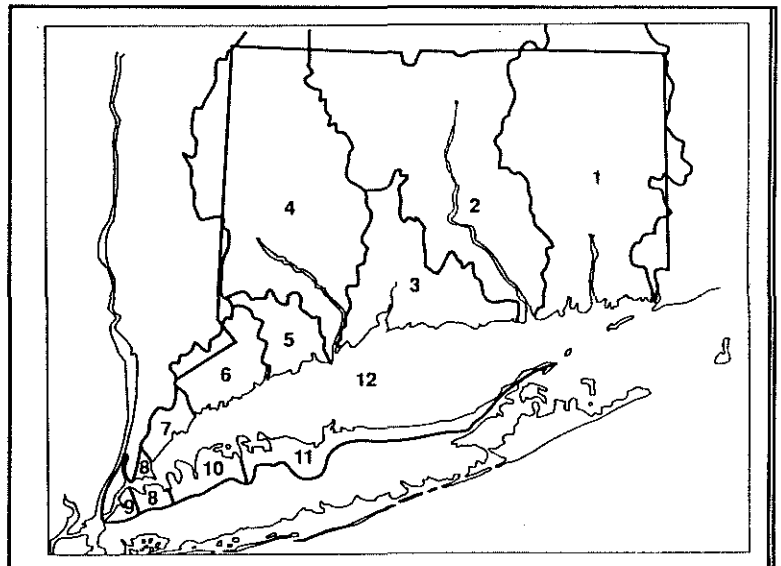
Sidebar 7 How nitrogen is removed by natural systems.

activity. The states and the EPA are committed to implement additional nitrogen controls or undertake other appropriate actions aimed at achieving the long-term goal.

The LISS is nearing completion on a more sophisticated computer model, the LIS 3.0, that will be able to clearly link the wide range of nitrogen sources from the entire geographic region to the hypoxia problem. Although the LIS 2.0 has been a valuable analytical tool in the initial LISS examination of hypoxia, it cannot precisely identify how efficiently nitrogen originating from the eastern extreme of the Sound is delivered to the western end where hypoxia is most severe.

With the new LIS 3.0 model, the LISS will be able to assign management priorities with more certainty and will be able to develop realistic nitrogen targets based on the interim dissolved oxygen targets for specific, geographic *management zones.*

The LISS has identified 12 management zones to partition nitrogen loading data among areas where management activities are likely to be interrelated (Figure 11). The management zones were delineated primarily by using natural drainage basin boundaries. This aggregates nitrogen from common geographic origins within each zone, allowing a basin or watershed approach to managing water quality. For example, within a zone, all point and nonpoint sources are identified, a goal or target for nutrient load established, and a plan developed that identified the mix of reductions among all sources that meet that goal. Eleven management zones have been created around the Sound plus a twelfth management zone comprised of Long Island Sound's surface.



Zone - Name	Drainage Area (acres x 1000)	Zone - Name	Drainage Area (acres x 1000)
1 - Thames	1044.2	7 - Westchester	69.4
2 - Connecticut	7211.6	8 - Bronx/Queens	55.6
3 - Quinnipiac	327.9	9 - Manhattan/Queens	42.0
4 - Housatonic	1242.9	10 - Nassau	55.8
5 - Saugatuck	138.4	11 - Suffolk	107.2
6 - Norwalk	158.9	12 - Long Island Sound	832.0

Figure 11 Geographic management zones established for nitrogen planning.

Using the management zones, the model will define a base condition and a pre-Colonial condition. These simulations will be used to confirm and refine the preliminary findings of the LIS 2.0 modeling results. The LIS 3.0 model will be used to test alternative nitrogen reduction scenarios for each management zone (Figure 11) and to select the final nitrogen control plan.

Nitrogen controls within the nonpoint source priority areas (Figure 9) will be an essential part of the overall nitrogen control strategy within each of the management zones. On the New York side, these priority areas totally coincide with the area of the management zone. On the Connecticut side, these priority areas are subsets within each of the management zones.

Until the LIS 3.0 model is completed, LIS 2.0 can be used to begin to estimate nitrogen reductions required to meet the interim dissolved oxygen targets. Of the 40,800 tons of nitrogen per year that comprise the total in-basin, human-induced load, required in-basin nitrogen load reductions that meet the targets are expected to range from 17,000 to 24,000 tons, or about 42 percent to 59 percent reductions, respectively. These reductions would continue beyond those implemented in Phases I and II (Figure 12). Achievement of these reductions would require the implementation of the mid- to high-level management scenarios as described in the 1990 *Status Report and Interim Actions for Hypoxia Management.*

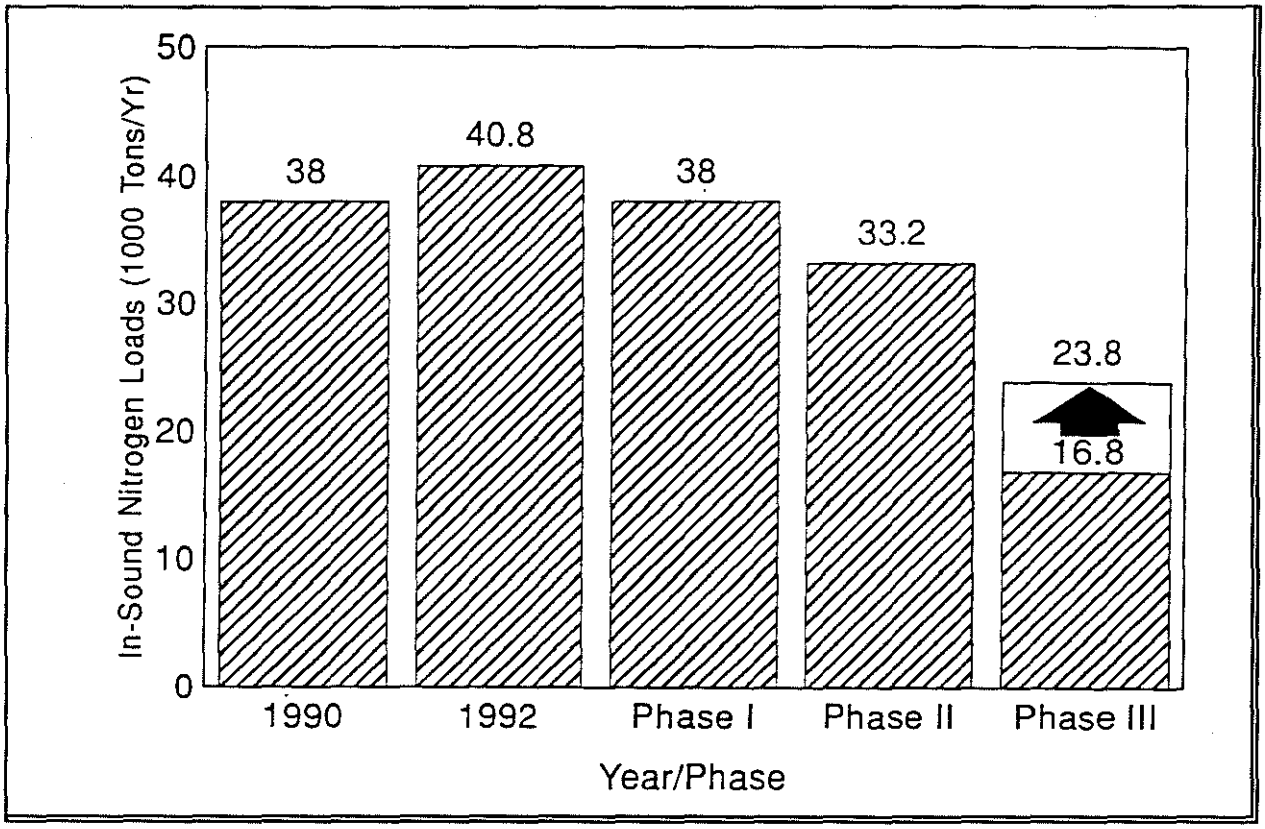


Figure 12 Phased plan to reduce the annual load of human-caused point and nonpoint source discharges in the Sound's drainage basin.

The benefit of achieving the interim targets would be the elimination of severe hypoxia and prevention of most lethal and sublethal effects. Most of the severely impacted habitat area of the Sound would be restored. However, in order to proceed with such a costly enterprise in a way that obtains the greatest environmental benefits for each dollar spent, approximate Sound wide reductions must be translated into discharge- or zone-specific nitrogen load reduction targets. Briefly, two important steps must be taken in Phase III:

- Using the LIS 3.0 model, the LISS will identify the most beneficial and cost-effective nitrogen load reduction targets for geographic management zones established around the Sound (Figure 11).

- The states and local governments will then be given the opportunity to propose the most cost effective mix of point and nonpoint source reduction actions to achieve these nitrogen load reduction targets within each zone.

The LIS 3.0 model provides managers with a solid foundation for forming effective nitrogen control plans with confidence that the desired water quality improvements will result. It is clearly the tool to guide implementation. However, the LIS 3.0 model is geographically limited to the Sound and cannot be used to predict effects of actions that may be implemented in neighboring estuaries such as New York-New Jersey Harbor. A regional or systemwide model is needed to quantify those relationships and to test some of the more far-reaching alternative approaches, including tide gates on the East River and relocation of certain sewer outfalls.

New York City is developing a harbor eutrophication model, which is technologically equivalent to LIS 3.0 but covers an area from the New York Bight apex to Oyster Bay in Long Island Sound. This model is expected to be completed by December 1994. The harbor eutrophication model will allow evaluation of management approaches not tested with the LIS 3.0 model such as the feasibility of employing alternative technologies. Implementation of management actions supported by the LIS 3.0 model will not be delayed while this model is being tested. Instead, when completed, the model will be used to supplement LISS management and identify possible changes in management direction, which will be considered and acted upon, if appropriate.

Table 6 Continuing management of hypoxia.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The LISS will complete work on the LIS 3.0 model and the necessary management scenario projection runs.	LISS	Complete by June, 1994	LISS Funded
Develop LIS 3.0-based dissolved oxygen targets and nitrogen load reductions targets for each management zone.	LISS	By December, 1994	Redirection of base program
Establish a firm timetable for achieving, within 20 years, the load reduction targets by zone, with progress measured in five year increments.	CTDEP NYSDEC	—	Redirection of base program
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Develop zone-by-zone plans to achieve the nitrogen load reduction targets.	CTDEP NYSDEC Local and County Governments	1995-1997	$1 million committed for three New York zones; $700,000 per year for three years needed
Encourage and support development of innovative, cost-effective technologies to reduce point and nonpoint sources of nitrogen.	LISS	—	LISO Base Program
Periodically recalibrate LIS 3.0 to reflect the changing conditions of the Sound and use it to explain these changing conditions and to evaluate proposals to modify the management plan, as necessary.	LISS	—	$300,000 per recalibration

In summary, the LISS agrees to the commitments in Table 6 that will:

1) Complete the LIS 3.0 Model. It is anticipated that the LIS 3.0 model will be available for developing dissolved oxygen targets, nitrogen reduction targets, and management plans during the summer of 1994. The schedule for completing the model is:

   February 1994 — Completion of LIS 3.0 calibration report.
   April 1994 — Completion of regional runs for 11 management zones.
   May 1994 — The LISS reviews regional runs and develops management scenarios.
   June 1994 — Management scenario projection runs completed.

2) For each management zone, develop nitrogen reduction targets required to achieve dissolved oxygen targets using the LIS 3.0 model.

3) Evaluate the options for reducing the nitrogen load within each zone through a wasteload allocation process. Reductions are likely to be achieved through a combination of point and nonpoint source actions. The mix of actions within each management zone will vary, depending on the basin characteristics and management opportunities. In these evaluations, growth will be accounted for and options for management will be consistent with LISS land use recommendations.

4) Select the most cost-effective mix of options that achieves the necessary reduction.

5) Based on the wasteload allocation analysis, develop preliminary management plans, including a schedule to begin facilities planning at appropriate sewage treatment plants, and implementation of nonpoint source reductions.

6) Further evaluate the innovative, alternative technologies identified as feasible by the LISS, using the harbor eutrophication model being developed by New York City, and incorporate findings and recommendations of historic hypoxia trend analysis studies funded by the LISS.

7) Develop and implement final nitrogen control plans that represent feasible, cost-effective actions as identified by the research and modeling efforts sponsored by the LISS.

8) Monitor and evaluate effectiveness of applied strategies.

9) Reassess management plans and make modifications as deemed necessary. The LISS recommends periodic reuse of the LIS 3.0 model to explain changing conditions in the Sound and evaluate proposals to modify the management plan.

10) Achieve the long-term goal through additional nitrogen reductions from discharges to the Sound and from sources outside the Sound, or through alternatives to nitrogen management that improve dissolved oxygen levels.

4. Funding

Until the options for control within each management zone are specified, cost estimates will be general. But there is no question that the financial investment to manage hypoxia in the Sound will be high. Based on the preliminary estimates, if the high-level of nitrogen control were selected, the Connecticut State Revolving Fund would need an infusion of $70 million per year in federal Clean

Water Act funds and $47 million per year in state funds over 20 years to meet all statewide wastewater control needs (including Long Island Sound nitrogen control needs). The New York State Revolving Fund would need an infusion of $623 million per year in federal Clean Water Act funds and $128 million per year in state wastewater control funds over 20 years to meet statewide needs (including Long Island Sound nitrogen control needs). These funds would be for sewage treatment plant construction only.

The costs of controlling nonpoint sources of nitrogen has not been estimated and, in fact, probably cannot be realistically estimated with existing information. However, nonpoint management costs would be likely to be substantial because of the widespread and diffuse nature of nonpoint sources. It is important that existing nonpoint source control programs receive full funding to continue the very necessary activity of controlling nonpoint sources of nitrogen.

The LISS is recommending that Congress appropriate $50 million to fund a *Long Island Sound Challenge Grant program,* a significant portion of which would be used to ensure that the Phase III nitrogen control efforts get off to a fast start with full local government cooperation. The portion of these funds allocated for nitrogen control would be used to fund cost-effective point and nonpoint source control actions, not involving major capital improvements while encouraging innovation.

The funding recommendations presented in (Table 7) are critical to the improvement of water quality and the living resources of the Sound. These actions are expected to substantially increase the amount of viable habitat in the Sound. The end result will be more productive fisheries in the Sound and improved ecological integrity.

Table 7 Funding to implement hypoxia management plans.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Increase funding of the Connecticut and New York State Revolving Fund Programs to meet statewide wastewater control needs, including Long Island Sound nitrogen control needs.	Congress Connecticut New York state	20 years	Federal cost of $700 million per year. Cost to states of $175 million per year.
Appropriate $50 million to fund a *Long Island Sound Challenge Grant Program,* a significant portion of which would be used to ensure that the Phase III nitrogen control efforts get off to a fast start with full local government cooperation.	Congress	Over five years	$50 million
Fully fund the nonpoint source control programs under Section 319 of the Clean Water Act and Section 6217 of the Coastal Zone Act Reauthorization Amendments to support additional nonpoint source management activities.	Congress	—	319 - $130 million nationwide 6217 - $12 million nationwide

5. Monitoring and Assessment

Actions summarized in Table 8 provide specifics on the continuing need to monitor and evaluate conditions in Long Island Sound — to ensure efficacy of management actions and to better understand the dynamics of pollution problems. Without monitoring or means for estimating nitrogen loads from

key sources within each management zone, control options cannot be detailed and measures of success cannot be quantified. It is essential that load assessments continue to provide site-specific information on nitrogen sources and how they can be managed to meet the nitrogen reduction targets. Key monitoring categories include sewage treatment plants, tributaries, nonpoint source estimates through land cover evaluations and atmospheric deposition.

Table 8 Monitoring and assessment of hypoxia.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The states of Connecticut and New York, New York City, and the Interstate Sanitation Commission will monitor dissolved oxygen and nutrients in Long Island Sound, its major tributaries, and key sewage treatment plants.	CTDEP NYSDEC NYCDEP ISC	1994	$340,000
A monitoring workshop was held in 1993. The workshop integrated findings of the LISS to develop a comprehensive, Soundwide monitoring plan and determine point and nonpoint source baseline nitrogen loads.	LISS	Completed in early 1994	See *Chapter IX, Continuing the Management Conference*
As part of a combined National Estuary Program Action Plan Demonstration Project and a CTDEP Long Island Sound Research Fund project, the EPA and the state of Connecticut will complete a demonstration project designed to evaluate and quantify the benefits of a riparian zone in the denitrification process.	CTDEP	1992 - 1994	$100,000 for Phase I
The state of Connecticut, through its Long Island Sound Research Program, has solicited proposals to identify the role of riverine transport in attenuating the load of nitrogen delivered to the Sound in the Housatonic or Naugatuck Rivers. If an acceptable proposal is identified, it will be a priority for funding in 1994.	CTDEP	1993 - 1995	$150,000
The state of Connecticut, through its Long Island Sound Research Program, will continue to fund atmospheric deposition monitoring of nitrogen at two coastal locations through May, 1994.	CTDEP	1991 - 1994	$50,000 per year
The EPA Office of Research and Development will continue to develop regional dissolved oxygen criteria for marine and estuarine waters.	EPA	Complete 1994	Redirection of base program
The NYSDEC will complete its initial study on the effects of hypoxia and disease on Long Island Sound lobsters.	NYSDEC	1994	LISS Funded
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Continue long-term dissolved oxygen and nutrient monitoring of the Sound, its major tributaries, and key sewage treatment plants.	CTDEP NYSDEC ISC EPA NYCDEP	Continuing	$300,000 per year
Continue to monitor finfish and crustaceans of the Sound with emphasis on determining population response to low dissolved oxygen.	CTDEP	Continuing	See *Chapter VII, Management and Conservation of Living Resources and Their Habitats* for details.

Continue to monitor the effects of hypoxia on disease of lobsters.	NYSDEC	Continuing	See *Chapter VII, Management and Conservation of Living Resources and Their Habitats* for details.

Monitoring for dissolved oxygen and nutrients has developed to the point that the monitoring objectives are being met as funding allows. Detailed monitoring plans for the other priority water quality issues await the deliberations of the monitoring workshop participants. Those plans will not be finalized until early 1994. The details of the present hypoxia and nutrient monitoring presented here are likely to be altered based on the monitoring workshop, but the general components should remain the same. A certain amount of restructuring of any monitoring plan will always be necessary and is a positive aspect of continued attention to the LISS monitoring program.

The hypoxia monitoring program addresses three objectives that assess: 1) the physical and chemical conditions of the Sound, 2) the sources of relevant pollutants, and 3) the biological effects of hypoxia.

A. PHYSICAL AND CHEMICAL CONDITIONS

Monthly cruises are conducted to monitor oxygen, nutrients and physical conditions of Long Island Sound along an axial (east-west) transect. Ten stations were established for this low-level, long-term monitoring, seven of which are sampled by the CTDEP and three, the westernmost, are sampled by the NYCDEP. These stations are continuations of master stations set up for model development and, therefore, have data recorded since 1987. During critical summer periods, sampling is supplemented by the Interstate Sanitation Commission and the CTDEP Marine Fisheries surveys to better define temporal and spatial aspects of hypoxia. This monitoring answers fundamental questions related to dissolved oxygen and nutrients such as:

- What are the trends of nutrient enrichment?
- What is the spatial distribution of dissolved oxygen levels in the Sound?
- What is the temporal duration of dissolved oxygen levels in the Sound?
- What is the severity of reduced dissolved oxygen levels in the Sound?

Monitoring also provides the foundation for changes that will result from management activity to answer the question:

Do management actions to reduce nitrogen loading in the Sound improve the dissolved oxygen levels in the open water of the Sound?

Monitoring has been effective in answering the premanagement questions about the nature of hypoxia. Each year the data have identified the onset of hypoxia, its spatial extent, its severity, how long it nlasts, the relationship between stratification and dissolved oxygen, and the general dynamics of nutrients and phytoplankton. The monitoring has been conducted with the EPA-approved quality control and assurance plans and methods have been selected drawing upon the considerable expertise of local researchers and managers as well as from other estuary programs. In round table discussions participants review data and assure that monitoring design and analytical techniques are appropriate for the system. Data have been analyzed through 1992 and maps of conditions generated that show the spatial extent of hypoxia and the temporal changes.

At the monitoring workshop, the physical and chemical monitoring of the Sound will be reviewed and the general questions identified previously will be revisited. As management activity intensifies, the general questions will be reformed into hypotheses to identify changes from implementation of management. Sampling schemes such as addition or relocation of stations and sampling frequency may require modification. The present monitoring program, however, provides the information critical to making wise decisions about how future monitoring should be conducted.

B. SOURCES OF NUTRIENTS

Without an understanding of the sources from which nutrients originate, it is not possible to assign priorities to management actions. Modeling and monitoring activity must define the cause-effect link. Although identifying target reductions in nitrogen loading await completion of the LIS 3.0 model, monitoring through the last several years has greatly improved our understanding of key sources. When the targets are established, a database will exist to guide management decisions.

Sampling has been designed to answer the questions:

- What regions in the Sound contribute to nutrient enrichment?
- What are the major sources of nutrients within each geographic region among the categories of point sources, nonpoint runoff, upstream or tributary contributions and atmospheric deposition?
- What is the temporal distribution of loads from those sources?
- What are the chemical forms of the nutrients delivered to the Sound?
- How does land use relate to nonpoint sources?
- What are the natural attenuation capacities of the land and rivers?
- How effective are management activities within each source category?

These questions can best be addressed through quantitative monitoring of point sources, nonpoint runoff, tributaries and atmospheric deposition. The LISS, through its Status Report agreements in 1990, formalized monitoring of relevant point sources in the Long Island Sound basin. Sewage treatment plants and industries with substantial nitrogen loads are regularly monitored in both states. Monitoring has been conducted for three years and has been sensitive enough to identify changes in nitrogen loads caused by plant modifications and was also used to calculate a baseline nitrogen load for a subset of sewage treatment plants that are part of the *no net increase* agreement.

Nonpoint runoff cannot be monitored by establishing stations and periodically taking water samples and discharge information because it is too diffuse. In addition, the geographic extent of the area to be monitored would result in costs well beyond any available funding sources. Instead, land cover is used as a surrogate for field monitoring and loadings are calculated based on export coefficients. The LISS has developed a satisfactory land cover database that may be periodically updated to identify trends. Also, tributary monitoring in test basins was used to verify the accuracy of the export coefficients, which were derived in watersheds in Connecticut as well.

Tributary monitoring has been conducted in Connecticut for decades through a CTDEP cooperative agreement with the U.S. Geological Survey. Those data were invaluable for calculating nitrogen loads to the Sound, testing the validity of export coefficients for general categories of land cover and identifying attenuation of nitrogen during riverine transport. Those stations will continue to be supported. Additional stations may be funded to document loading and transport estimates in test watersheds.

Atmospheric deposition of nutrients had not been monitored in the area of the Sound. Techniques for evaluating dry and wet deposition have evolved significantly in recent years, enforcing the need for more timely information. To meet the need, the CTDEP has supported research-grade monitoring at two stations along the Sound for the last two years. Those data have supplemented general atmospheric loading estimates derived from the literature.

These source monitoring components provide the data necessary to quantify the nitrogen loads from the 12 management zones identified previously. The LISS has also researched the potential for load reductions from each of the source categories, particularly from point and nonpoint sources. That information will be used to develop preliminary plans for each management zone to reduce nutrient loadings to target levels. As with the Long Island Sound monitoring, considerable attention has been paid to employ proper field and analytical techniques in all these programs. However, as the questions are reconfigured into testable hypotheses in the implementation phase of the study, some adjustments in source monitoring is anticipated. The activities of the monitoring workshop will impact the present monitoring programs.

C. BIOLOGICAL EFFECTS

The LISS participants, particularly the CTDEP, the NYSDEC, and the EPA Environmental Research Lab in Narragansett, Rhode Island have been active in researching and monitoring biological effects of hypoxia in Long Island Sound. The EPA Lab has been instrumental in identifying low dissolved oxygen effects on typical Long Island Sound species at various life stages. The lab intends that the research will develop dissolved oxygen criteria useful in establishing dissolved oxygen targets for the Sound. The NYSDEC examined the relationship between gaffkemia incidence in lobster and levels of oxygen in western Long Island Sound, which is fully discussed in the Living Resources section of this plan. The EPA and the NYSDEC studies provide the solid research foundation necessary to establish biological effects relationships to hypoxia.

Without a mechanism to accurately measure and refine nitrogen load estimates and conditions in the Sound, the effectiveness of management actions or the need to adjust management approaches cannot be evaluated. Quantitative monitoring approaches will assure that progress toward the goals of the LISS is continuous as well as provide the scientific understanding of the system that will help guide management activities in the future.

IV. Toxic Substances

A. What are Toxic Substances?

Toxic substances are chemicals, both naturally occurring and those derived from human sources, that cause adverse biological effects or human health risks when their concentrations exceed a certain level in the environment. In Long Island Sound, toxic substances are found in the water, attached to sediment particles, and within the living tissues of plants and animals. Because many chemicals tend to attach to particles, the heaviest concentrations are found in the sediments.

Table 9 The LISS list of toxic substances of concern.

METALS		
Cadmium	Copper	Mercury
Chromium	Lead	Zinc
CHLORINATED HYDROCARBONS		
Chlordane	Heptachlor	Polychlorinated biphenyls
DDT, DDD, DDE	Lindane	Trans-nonachlor
Dieldrin	Pesticides	
POLYNUCLEAR AROMATIC HYDROCARBONS		

The EPA identifies 129 substances nationwide as priority pollutants. The LISS list of toxic substances of concern is shorter, focusing on those substances of most relevance in the area (Table 9). Human activity has resulted in high enough concentrations of some of these chemicals to be of concern in the Sound. The LISS has reviewed all available data on the levels of these toxic substances in the water, sediments and biota of Long Island Sound. These levels were compared to applicable standards, criteria, and guidelines to provide an indication of environmental problems.

B. What Problems Do Toxic Substances Cause In Long Island Sound?

Many toxic substances resist degradation and persist for a long time in the environment. From the time of their release into the environment to the time when they are no longer environmentally available, toxic substances may exert a negative impact on living organisms, including humans.

There is no doubt that human activity has increased the concentrations of some toxic substances in the Sound. The crucial question is whether concentrations of toxic substances in the Sound are high enough to cause biological and ecosystem effects. Based on available information, the LISS has identified a number of impacts from toxic substances in the Sound. However, it must also be noted that our base of information is incomplete. There are gaps in the information available on the geographic distribution and the relative concentrations of organic contaminants and dissolved metals in water, sediment, and fish tissue. Additional monitoring is needed to identify pollutant sources and develop site-specific strategies.

1. Water Column

Very few reliable data on water column toxic contaminant levels exist. Data on organic contaminants, such as polychlorinated biphenyls (PCBs), were too sparse to allow the LISS to draw any clear conclusions about contamination problems. However, estimates of dissolved heavy metals concentrations in the Sound calculated (Table 10) from levels in plankton indicate that, with the exception of lead, probable metal concentrations outside of harbors and tributaries are generally comparable with cleaner, open ocean samples.

Table 10 Concentrations of metals (μg/l) in the dissolved phase.[1]

Metal	Mean	Maximum	Mean Ocean [2]
Silver	0.0038	0.0044	0.0027
Cadmium	0.074	0.120	0.078
Chromium	0.290	0.380	0.208
Copper [3]	0.072	0.440	0.256
Nickel	0.520	2.000	0.472
Lead	0.056	0.160	0.0021
Zinc [3]	0.315	1.000	0.390

1 Concentrations were calculated using mean and maximum plankton levels (Source: Brownawell, Fisher, and Naeher, 1992).
2 Bruland (1983)
3 Note: These mean and maximum values appear to be underestimates. Direct dissolved copper and zinc measurements (Battelle, 1991) found mean concentrations of 1.867 and 5.967 μg/l, respectively.

The most useful and accurate study of water column contamination was conducted in the East River and western Sound in 1991 as part of the New York-New Jersey Harbor Estuary Program. Water column analyses revealed metal concentrations similar to those estimated using phytoplankton (Table 11), except for copper and zinc. Because copper and zinc tend to associate with organic carbon, they may be less available in dissolved form for uptake by phytoplankton, leading to underestimates for those two metals. Average metals concentrations in the East River and western Long Island Sound did not exceed the New York state or Connecticut standards, except for mercury which exceeded standards occasionally in the East River. Therefore, the only documented exceedance of either state's standards in the open waters of the Sound is for mercury in the East River.

Evidence of toxicity associated with contaminants in the water column has not generally been observed in the Sound (Table 12). Indications of some aquatic life impairments have been observed in the Upper East River. Toxicity is determined by level of mortality. However, sublethal effects, such as tumors and reduced reproductive success, have been recorded at several locations. For example, the embryos of winter flounder exposed to New Haven Harbor water consistently exhibited signs of stress and abnormality. Lesser indications of abnormality were observed in samples from Hempstead Harbor and Shoreham. In parallel studies, winter flounder in New Haven Harbor consistently suffered from reduced reproductive success and a high incidence of biochemical and pathological abnormalities.

Table 11 Concentrations of heavy metals (μg/l, dissolved metal basis) with New York standards for SA[1] waters and Connecticut standards.

Metal	WLIS Concentration (Battelle, 1991)			New York Standard[2]	Connecticut Standard[3]
	Dissolved	Total	Acid Sol.		
Silver	0.016	0.047	0.042	2.3[4]	2.3
Cadmium	0.096	0.084	0.114	2.7	9.3
Copper	2.150	3.633	3.367	2.9[5]	2.9
Lead	0.167	1.217	1.178	8.6	8.5
Mercury	0.0037	0.0070	0.0054	0.1[6]	0.025 (methyl)
Nickel	1.417	1.700	2.017	7.1	8.3
Zinc	6.550	7.750	7.883	58	86

1 SA waters in New York meet all designated uses
2 Acid-soluble form, unless otherwise noted
3 Dissolved form, with the more restrictive of the saltwater aquatic toxicity or human health criterion listed.
4 In SD waters of New York only
5 Dissolved fraction
6 Total metal basis

Table 12 Comparison of average calculated dissolved metal concentrations (μg/l) with levels causing effects in sensitive species.[1]

Metal	Calculated Concentration	Effect Level		
		Phytoplankton	Bivalve Larvae	Adult Bivalves
Silver	0.0038	—	14	33
Cadmium	0.074	1.0	20	10
Chromium	—	—	4,469	100
Copper	0.072	0.3	5.0	3.0
Nickel	0.520	>60	349	1200
Lead	0.056	20	476	100
Zinc	0.315	20	125	10

1 Source: Brownawell, Fisher, and Naeher, 1992; toxic metal concentrations are as reported by Bryan (1984) and Langston (1990).

While the impacts were not as severe as those recorded at some of the most contaminated East Coast sites, the New Haven Harbor contaminant levels were high enough to exceed effects thresholds. These effects were related to the presence of organic compounds, particularly polynuclear aromatic hydrocarbons (PAH).

A NOAA hard clam reproductive success study in five southwestern Connecticut harbors also identified a relationship between reproductive success and contaminant levels in the water column. Bridgeport Harbor clam embryos exhibited more chromosomal irregularity and larval abnormality

related to higher contaminant levels. Norwalk clams also exhibited lower percentages of normal fertilization and development success than were observed at the other sites. While these sublethal effects cannot be extrapolated to Sound-wide condition or population effects, they do identify local problems in some urban harbors that merit additional study. They also suggest that sublethal effects studies may identify contaminant problems not exhibited through more traditional quantitative measurements of contaminant levels or even general mortality bioassays.

In summary, the quality of Long Island Sound's waters is good with respect to toxic substances. The only documented exceedance of either state's water quality standards in the open waters of the Sound is for mercury in the East River. However, data on organic contaminants were too sparse to allow the LISS to draw any clear conclusions about contamination problems. While few tests of water column toxicity have been conducted, indications of some aquatic life impairments have been observed in the Upper East River.

Table 13 Average total metal levels in sediments[1] compared to criteria and defined *high* concentrations.

Metal	Area			NYSDEC Guidelines		CTDEP Guidelines[2]	High Levels	
	WLIS	CLIS	ELIS	Low Effect Level	Severe Effect Level	Levels	NOAA[3]	HARBORS[4]
Arsenic	9.0	5.6	6.2	6	33	20	—	50-60
Silver	3.0	0.6	0.39	—	—	-	0.74	—
Cadmium	1.4	0.4	0.16	0.6	10	7	0.72	24-35
Chromium	138	79	37	26	110	300	135	510-570
Copper	121	57	9.5	16	110	400	55	2000-7700
Mercury	0.7	0.21	0.1	0.2	2	1.5	0.30	7-17
Nickel	25	16	8	16	75	100	—	90-665
Lead	89	31	13	31	250	200	52	1150-1960
Zinc	198	99	35	120	820	400	172	1000-4800

1 In mg/kg, dry basis, from three areas of the Sound (see Figure 13 for areas).
2 Bioeffects testing has shown that at concentrations greater than these, acute toxicity usually occurs.
3 NOAA Status & Trends nationally high sites (O'Connor, 1990).
4 Highest levels observed in the Army Corps of Engineers data (Brownawell, Fisher, and Naeher, 1992).

2. Sediments

The database for sediments, particularly for heavy metals, is the most comprehensive of all the toxic contaminant data reviewed. Higher concentrations of metals are found in the western Sound, where finer-grained sediment enriched with organic carbon are more prevalent. Because heavy metal concentrations are so closely correlated with organic carbon levels, the values were adjusted or *normalized* by dividing the metal concentration by the amount of organic carbon in the sample. When this analysis was performed with the two data sets for which total organic carbon determinations were made, the east-west trends were reduced or eliminated (Figure 13). This suggests that besides close proximity to a source, sediment properties are significant in heavy metal distributions.

The NOAA Status and Trends program also identified *high* (roughly, the top 17 percent of the nationwide observations for each substance) concentrations of metals in sediments based on their national survey. Western Long Island Sound average concentrations exceeded the NOAA *high* values for all metals (Table 13).

Table 14 Long Island Sound harbors with elevated contaminant levels in sediments.[1]

	Contaminant							
Harbor or River	Pb	Cd	Cu	Ni	Hg	Zn	Cr	PCB
Bridgeport Harbor	X							X
Milford Harbor	X			X				X
Stamford Harbor	X	X				X		X
Connecticut R.		X			X			
Housatonic R.			X	X			X	
New Haven Harbor			X	X		X		X
New Rochelle Cr.			X	X		X		
New London Harbor				X		X		
Norwalk Harbor				X	X			
Northport Harbor					X			
Hutchinson R.						X		
Branford Harbor						X		

1 For contaminants that were at least locally elevated, normalized for carbon (Source: Brownawell, Fisher, and Naeher, 1992).

Based on all the available data, toxic contamination problems do persist in the sediments of some areas of the Sound. This may be due, in large part, to historical discharges that occurred prior to implementation of state and federal Clean Water Act requirements. Despite great strides in reducing the load of toxic substances to the Sound, field studies have not documented decreases in the amount of toxic substances in sediments in contaminated areas over time.

Heavy metal concentrations in surface sediments have not changed noticeably since 1972. This is a result of continuous mixing of the surface layer by both physical processes and burrowing organisms, coupled with the very slow sedimentation rate (0.92 millimeters per year) of the Sound. However, surface sediment metal concentrations for copper, lead, and zinc appear to be enriched from three to ten times above levels in deeper sediments presumed to predate the Industrial Revolution.

Urbanized harbors often have elevated concentrations of both metals and some organic compounds. Several harbors stand out as having locally highly contaminated sediments (Table 14) possibly comparable to the western Long Island Sound. Areas of potential concern include Five Mile River (Cu, Ni, Zn, Cr), the West River which discharges to New Haven Harbor (Pb, Hg, Cr), the Quinnipiac River (Pb, Cu, Ni, Zn, Cr), and Glen Cove Creek (Cu, Pb, Ag, Zn, Ni, As, Hg, Cd). In addition, extensive studies of Black Rock Harbor have identified very high concentrations of many toxic contaminants.

Information on organic contaminants is sparse compared to that on heavy metals, except for PCBs, which are found in higher concentrations in the western Sound and in some Connecticut harbors. Mean PCB concentrations reported did not exceed one part per million in Long Island Sound sediments although higher levels were found in Norwalk, Bridgeport, and New Haven Harbors. Data from the Corps of Engineers data also reported individual analyses above one part per million on a dry weight basis for those harbors, as well as New Rochelle Creek, Milford Harbor, and Stamford Harbor.

The most internally consistent data for organic contaminants was from NOAA's Status and Trends Program. On that basis, some organic compounds are found in Long Island Sound sediments at higher than nationally *high* concentrations (Table 15). Locations which exceeded NOAA's nationally *high* values for total DDT, chlordane, PCB or PAH are primarily in the western Sound or its embayments (Table 16). However, NOAA sampled relatively few stations.

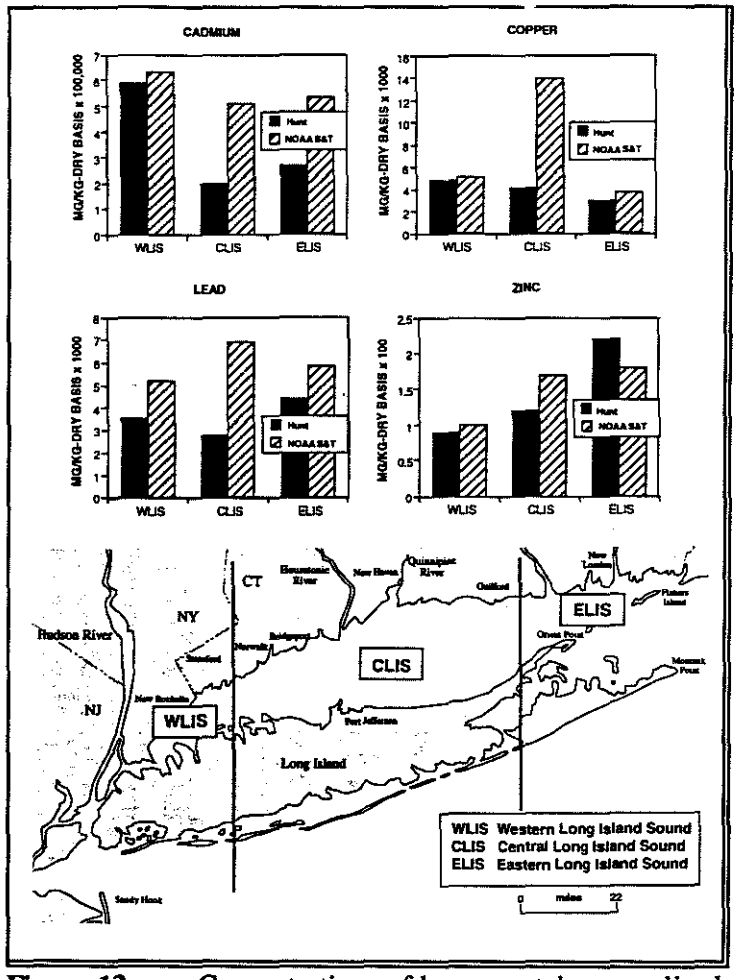


Figure 13 Concentrations of heavy metals normalized to organic carbon in sediments from three areas (Source: Brownawell, Fisher, and Naeher, 1992).

Table 15 Concentrations of organic compounds in LIS sediments compared to nationally *high* sites.[1]

Substance	LIS Average (µg/kg, dry basis)	NOAA *high* (µg/kg, dry basis)
tPCB[2]	249	200
tDDT	36	40
tPAH	7814	3900
tChlordane	7.7	5.5

1 Samples from the fine-grained fraction of sediments (Source: NOAA, 1991).
2 t = total of all forms.

Table 16 NOAA Status & Trends locations which exceeded nationally high levels of contamination in fine-grained sediments.

Location*	tPCB	tDDT	tPAH
Connecticut River	X		X
Sheffield Island			X
Western LIS	X		X
Huntington			
Mamaroneck			X
Hempstead	X	X	X
Throgs Neck	X	X	X

* Samples were also taken in Eastern Long Island Sound, New Haven Harbor, Housatonic River and Port Jefferson but were too low in fine sediments to be evaluated. No other sites were sampled.

Sources: NOAA, 1988, 1990.

Several approaches are used to identify potential problems from sediment contamination. One approach is to use established guidelines to extrapolate biological effects from observed contaminant levels in sediments or in tissues of living organisms. Another approach directly measures the toxicity of contaminated sediment to test organisms. In the most widely applied toxicity test, an amphipod (a shrimp-like crustacean) is exposed for ten days in the laboratory to sediments taken from the Sound. Toxicity is determined by the level of mortality.

When sediment toxic levels were compared to the NYSDEC *lowest effect level* screening guidelines, average western Long Island Sound metals concentrations exceeded the guidelines for all metals evaluated (Table 13). Central Long Island Sound average concentrations equaled or exceeded these guidelines for chromium, copper, mercury, lead, and nickel. Average eastern Long Island Sound metal concentrations exceeded these guidelines for arsenic and chromium. *Severe effect level* guidelines were exceeded for average concentrations of copper and chromium in localized areas of the western Long Island Sound. Concentrations of sediment contaminants in nearshore areas, such as harbors, were often well above the average levels observed from the offshore data. Based on available information, several of the heavy metals may be at toxic levels in offshore sediments in western Long Island Sound, with few likely to be at toxic levels in offshore, central and eastern portions of the Sound.

This does not mean that extensive sediment contamination exists in the sampled areas that exceeded guidelines. Contaminant distribution is often random and spotty, depending on sediment character and distribution dynamics. While NYSDEC guidelines suggest some toxicity problems may exist, the CTDEP uses relative concentrations of metals found throughout the Sound to identify, site-specifically, potential toxicity problems. The CTDEP guidelines are supported by bioeffects testing procedures and test data results specific to the Sound. Metals concentrations in Long Island Sound sediments do not exceed the Connecticut guidelines (Table 13). For that reason, it must be emphasized that these guidelines provide only a first indication that a sediment contamination problem might exist.

There is always a need to conduct follow up studies that determine whether or not the contaminants are biologically *available* to impact living organisms. This is usually done through toxicity testing or biological sampling. For example, in cases where problematic levels of toxic substances are suspected, New York, Connecticut and the U.S. Army Corps of Engineers require toxicity testing for dredging projects to identify whether a biological impact exists for the mix of contaminants that are present in the sediments, and therefore, confirm environmental risk. National sediment criteria are being developed to augment the present interim standards for assessing the effects of contaminants on organisms in sediments.

Sediment toxicity tests at Long Island Sound sites conducted as part of NOAA's Status and Trends Program did not reveal toxicity, in spite of high toxic contaminant levels found at those sites. However, sample sediment toxicity tests conducted as part of the EPA Environmental Monitoring and Assessment Program showed significant toxicity to amphipods near Throgs Neck, in the Housatonic River near Devon, in Black Rock Harbor, and in Eastern Long Island Sound near Mattituck. The Black Rock Harbor Study also identified toxicity associated with the sediments, particularly in the inner harbor area (Sidebar 8). Local harbors with highly contaminated sediments may be toxic to resident organisms as was shown in the Black Rock Harbor studies. NOAA's screening of 20 embayments around the Sound, when complete, will help further define the distribution of toxic sediments. Because of concerns with the potential effects of contaminated sediments, the disposal of material from dredging projects is often controversial. State and federal coastal dredging permitting programs have established procedures and criteria for safely managing contaminated material being disposed of as part of a dredging project (Sidebar 9).

BLACK ROCK HARBOR ACTION PLAN DEMONSTRATION PROJECT

Black Rock Harbor has a small but highly urbanized drainage basin. Point source discharges entering the harbor include one sewage treatment plant, two industrial discharges, and eight combined sewer overflows. Other sources of contamination include the contaminated harbor sediments, and possible groundwater contamination from landfill leachate. During 1988 and 1989, samples from the treatment plant, combined sewers, industries, landfill groundwater wells, harbor waters, and harbor and marina sediments were collected for chemical analysis and toxicity testing.

Toxicity tests determine the degree of toxicity of a sample, based on the response of the test organisms. Marine fish, invertebrates, and algae were used to test the samples from Black Rock Harbor. The test results showed that the bottom sediments are the most significant source of contaminants to the harbor. The sediments, particularly in the inner harbor were found to be toxic to marine organisms.

The various effluents collected showed no or low levels of toxicity. However, high concentrations of PCBs, PAHs, and heavy metals were identified in groundwater below an inactive landfill. Analyses of effluent from the Bridgeport-West treatment plant and of combined sewer overflows (CSOs) discharging to the harbor detected PCBs (0.012 ug/l) in the plant effluent on one of three sampling occasions but, since the sewer system is combined, the origin of the PCB may well have been urban runoff. In the Bridgeport CSOs, PCBs averaged 0.260 ug/l for eight samples analyzed. These are high concentrations for an active source; however additional monitoring is needed to better characterize the loads and sources of the PCBs. Chlordane and DDT and its metabolites were found in very low concentrations in the Black Rock Harbor CSOs. CSOs were also active sources of PAHs, as is typical of an urban environment. The PAHs were probably associated with urban stormwater as the STP effluent had only comparatively low levels of PAHs. Notable were the higher levels of PAHs in the winter STP samples compared to summer values which may be related to higher fossil fuel usage in the winter heating period.

The Black Rock Harbor Action Plan Demonstration Project was designed as the first phase of an ecological risk assessment approach. The study clearly identified sediment-associated toxicity and characterized active sources of toxic contaminants for which management actions need to be planned. It also demonstrated an approach that appears useful for contamination evaluations in other areas.

Sidebar 8 Black Rock Harbor APDP.

In summary, while most of the Sound's sediments do not exhibit contamination levels of concern, problems have been documented in some areas of the western Sound and in several, mostly urbanized, harbors, rivers, and embayments. In these areas, the levels of metals in the sediment could be affecting benthic biota. The LISS has

concluded that problems due to toxic contaminants occur in limited areas and are primarily associated with sediment contaminant levels. Further characterization of the nature and extent of this problem is warranted.

3. Tissues

Tissue analyses of resident organisms from the Sound for toxic contaminants can help identify potential contamination problems. Living organisms can serve as *sentinels* in that they are continually exposed to ambient conditions and may, through analysis of their tissues, identify an impact from a sporadic or low-level contamination problem that might not be observed by water or sediment monitoring. Some species can accumulate contaminants in their tissues which may affect the health of those species. Unfortunately, the relationship between organism body burden and toxicity (or organism health) is not well defined but should become a research priority as a potential mechanism of toxicity in Long Island Sound biota. Tissue analyses also help identify and manage risks to seafood consumers from toxic contaminants present in commercial and recreational species.

Based on national surveys, there are minor east-west trends in the concentrations of metals and organic contaminants in oysters and blue mussels. While few hot spots were noted, there appear to be some elevated levels of some metals in the Bridgeport-Housatonic River area, in Connecticut and around Throgs Neck, Mamaroneck, and Hempstead Harbor, in New York. Based on NOAA's Mussel Watch Program, some Long Island Sound sites are consistently among the most contaminated sites observed nationally for some heavy metals, particularly copper (Table 17), and organic compounds (Table 18). While the levels of contamination may affect the health of those species, there are no human health risk/consumption advisories due to the levels of these toxic substances in these organisms.

DREDGING

Dredging of harbors in Connecticut and New York is necessary to provide safe navigation for commerce and access for commercial fishing and recreational boating activities. Four sites have been designated in Long Island Sound for the disposal of sediments dredged from Long Island Sound harbors. These sites were selected after a detailed environmental analysis identified sites where disposal would have minimal environmental impacts. Materials other than dredged sediments, such as garbage and construction debris, may not be disposed at these sites.

Anyone proposing to dredge and dispose of estuarine sediments at one of the designated sites must first receive permits from the CTDEP, since all four disposal sites are located in Connecticut waters, and the U.S. Army Corps of Engineers. Since many divisions within the NYSDEC are involved in dredging and contaminated sediment management, the Department formed a Task Force on Contaminated Sediments in 1992 to develop an action plan for handling contaminated sediments and dredging issues.

As part of any dredging project, sediment testing is required to determine the level of contamination and the acceptability of open water disposal. Most sediments identified for disposal do not have levels of contamination which are likely to cause adverse biological effects. In those cases, open water disposal may occur without additional detailed biological testing or special management practices. When contaminant levels are at concentrations which may or are expected to cause adverse biological effects, biological testing is required to identify toxicity. If toxicity is high or at levels of concern, the material must be covered with a cap of clean material upon disposal. This cap is sufficiently deep to isolate the contaminated sediments from burrowing organisms.

Since 1980, a Disposal Area Monitoring System (DAMOS) has been in place to monitor the environmental impacts at the disposal sites. To date, these investigations show that Connecticut and the Corps of Engineers are conservatively managing dredged sediments and that no adverse impacts have been identified.

Sidebar 9 Dredging.

Table 17 Ranking of NOAA Mussel Watch sites in the Sound for tissue contamination by heavy metals (1986-1989).[1]

Site	CD	CR	CU	PB	HG	NI	ZN
Connecticut River		16t*	12t				
New Haven Harbor							
Housatonic River		7	5t				
Sheffield Island							
Mamaroneck			8t	20t			
Throgs Neck			5t	8			
Hempstead Harbor			10t				
Huntington Harbor							
Port Jefferson							

* t=tied with other sites.
1 Only the top 20 ranks were considered.

Source: NOAA, 1989

Table 18 Ranking of NOAA Mussel Watch sites in the Sound for tissue contamination by organic compounds (1986-1988).[1]

Site	tPCB[2]	tDDT	Chlordane	Dieldrin	Lindane	HMW* PAH
Connecticut River				18t[3]		
New Haven Harbor				20t		
Housatonic River	15t					
Sheffield Island					17t	
Mamaroneck			14		5	
Throgs Neck	13	17	10		14t	4
Hempstead Harbor	17		7	15	7	
Huntington Harbor				20t		
Port Jefferson						

* High Molecular Weight PAH
1 Only the top 20 ranks were considered
2 t=total of all forms
3 t=tie with other sites

Source: NOAA, 1989.

With regards to metals in fish, enriched levels of copper and cadmium have been recorded in lobster hepatopancreas (tomalley, green, or digestive gland) and higher levels of copper and zinc in winter flounder taken from the vicinity of the Housatonic River. However, winter flounder and blackfish

tissue from throughout the Sound had lower concentrations of heavy metals than has been reported in regional surveys of the North Atlantic.

PCBs were the most frequently surveyed contaminants in finfish and lobsters and have been identified as substances of concern. While levels in striped bass, bluefish, and American eel approached the 2.0 ppm Food and Drug Administration (FDA) tolerance level and have elicited consumption advisories in Connecticut and New York, PCBs in winter flounder, summer flounder, blackfish, and lobster tail and claw were low. In the lobster hepatopancreas, variable PCB levels have been observed, often in excess of 2.0 ppm. In terms of human health risk the significance is likely to be less than for striped bass and bluefish because the hepatopancreas is small in weight relative to the tail and claw. PCB levels in lobster hepatopancreas are probably high because of high lipid levels in the hepatopancreas, which PCBs tend to associate with, but the reason for the wide variability in concentrations is not clear.

Human health risk from seafood consumption is usually expressed as a criterion or *action level* for an individual contaminant. The FDA establishes tolerance levels for seafood in interstate commerce based on human health effects of toxicity considering seafood consumption rates and the economic impact of restrictions. State health departments review data on contaminant concentrations in seafood and may issue consumption advisories to protect public health. The states of Connecticut and New York have issued consumption advisories for Long Island Sound fish (Sidebar 10). These advisories identify the recommended maximum consumption level for different segments of the population based on known contaminant concentrations to ensure that an individual's exposure does not exceed acceptable risk levels. The substance of greatest concern in these advisories are PCBs, which have been found in high concentrations in some fish tissues, bottom

CONSUMPTION ADVISORIES

Consumption advisories issued by New York and Connecticut for fish and seafood products taken from Long Island Sound.

NEW YORK:

To minimize potential adverse health impacts, the New York State Department of Health recommends:

- Eat no more than one meal (1/2 pound) per week of fish from the East River to the Throgs Neck Bridge.
- Eat no more than one meal per week of bluefish and American eel.
- Do not eat American eels from the East River.
- Eat no more than one meal per month of striped bass taken from the marine waters of Western Long Island Sound, which includes that portion of the island west of a line between Wading River and the terminus of Route 46 near Mastic Beach.
- Eat no more than one meal (1/2 pound) per week of striped bass taken from Eastern Long Island marine waters.
- Women of childbearing age, infants and children under 15 should not eat striped bass taken from Long Island marine waters.
- It is recommended that the hepatopancreas (tomalley) of crabs and lobsters not be eaten because this organ has high contaminant levels.
- The health implications of eating deformed or cancerous fish are unknown. Any grossly diseased fish should be discarded. Levels of PCB, mirex, and possibly other contaminants of concern (except mercury) can be reduced by removing the skin and fatty portions along the back, sides and belly of striped bass and bluefish.

CONNECTICUT:

- Sensitive groups (pregnant women, nursing mothers, children under 15 and women who plan to become pregnant soon) should not eat bluefish larger than 25 inches. If consumers in this group choose to eat bluefish larger than 25 inches, consumption should be limited to no more than a few meals per year.
- Sensitive groups should not eat any striped bass from Long Island Sound and nearby waters. If consumers in this group choose to eat striped bass, consumption should be limited to no more that a few meals per year.
- The general population is advised to eat only a moderate number of striped bass and bluefish meals (18 per year or fewer), eat smaller fish when possible, remove fatty portions of the fish when cleaning them and broil them so that fat drips away.
- It is suggested that the hepatopancreas (tomalley) of lobster should be eaten only in moderation.

Sidebar 10 Consumption advisories.

sediments, and some active sources such as combined sewer overflows (CSOs) in the Black Rock Harbor area.

To further complicate management of this issue, fish with elevated concentrations of PCBs that are caught in the Sound may not necessarily have accumulated their total body burden in local waters. Striped bass and bluefish, which have wide migration ranges, can accumulate PCBs and other contaminants through diet and direct exposure throughout their geographic extent. It is difficult to specify the geographic source of body contaminant burdens for species that have a wide geographic distribution.

There are also some concerns about contaminant levels in waterfowl tissues. New York state has issued an advisory on consumption of mergansers and other waterfowl. The relationship of these contamination problems and Long Island Sound management needs is unclear, because waterfowl occupy diverse habitats and have wide migration patterns. This is similar to concern raised about finfish above. Connecticut has funded research into contamination of scup that may provide additional insight into this type of problem and management needs for the Sound. Scup have been found to have elevated levels of PCBs, lead, and cadmium which may affect the health of these birds.

In summary, the analysis of fish and shellfish tissue data indicate that very few contamination problems exist that could affect the health of seafood consumers. The only documented substances of concern are PCBs, which were discharged into the environment before the complete ban on their manufacture and severe restrictions on their use. PCB action levels are exceeded in the flesh of a few fish from the Sound and the states have issued consumption advisories for those species. Because PCBs are globally distributed and most fish and forage species migrate widely, it is not clear if the problem observed in the Sound is caused by in-Sound sources. This same concern may be also true for waterfowl. With respect to shellfish, even though there are no human health risks or consumption advisories due to levels of toxic substances in these organisms, there are some *hot spots* of contamination which may affect the health of the Sound oysters and blue mussels.

C. What are the Sources of Toxic Contaminants?

Industries, sewage treatment plants, land use, and the manufacturing, use, and disposal of everyday products contribute contaminants to the Sound. There are many pathways by which the contaminants find their way into the Sound (Figure 14). Metals are deposited from the atmosphere, particularly in densely-populated, industrialized areas that surround the Sound. Pesticides used in agricultural, residential, and urban areas wash into the Sound through streams, storm sewers or with sewage. Sewage contains many metals, particularly copper, and lead has been associated with urban runoff.

Toxic substances may cycle from sediments through the food chain and back into the sediments several times before finally becoming buried. Therefore, resuspension of contaminated sediments can be a continuing source of toxic substances.

Because many chemicals are resistant to degradation, contamination from past activities or practices in the watershed can persist for a long time. For example, Connecticut has been historically a world leader in the brass, silver, and metal finishing industries. Heavy metals from these industries such as copper, zinc, cadmium, and chromium remain a concern in the Sound. PCBs are another example. The use of PCBs in the United States as coolants and lubricants in transformers, capacitors, and other electrical equipment has been banned since 1976. However, PCBs still exist in the environment

because it is resistant to degradation and because PCB-containing devices, manufactured prior to 1976, are still in use.

Much of the specific information on pollutant loads to the Sound is from the National Coastal Pollutant Discharge Inventory (NCPDI) conducted in 1985 by the National Oceanic and Atmospheric Administration (NOAA) in cooperation with the LISS (Figure 15). The LISS conducted and reviewed other studies to supplement this information and identify several relevant sources of toxic contaminants to the Sound. Currently, no single source category of toxic contaminants appears to be the primary determinant of conditions in the Sound.

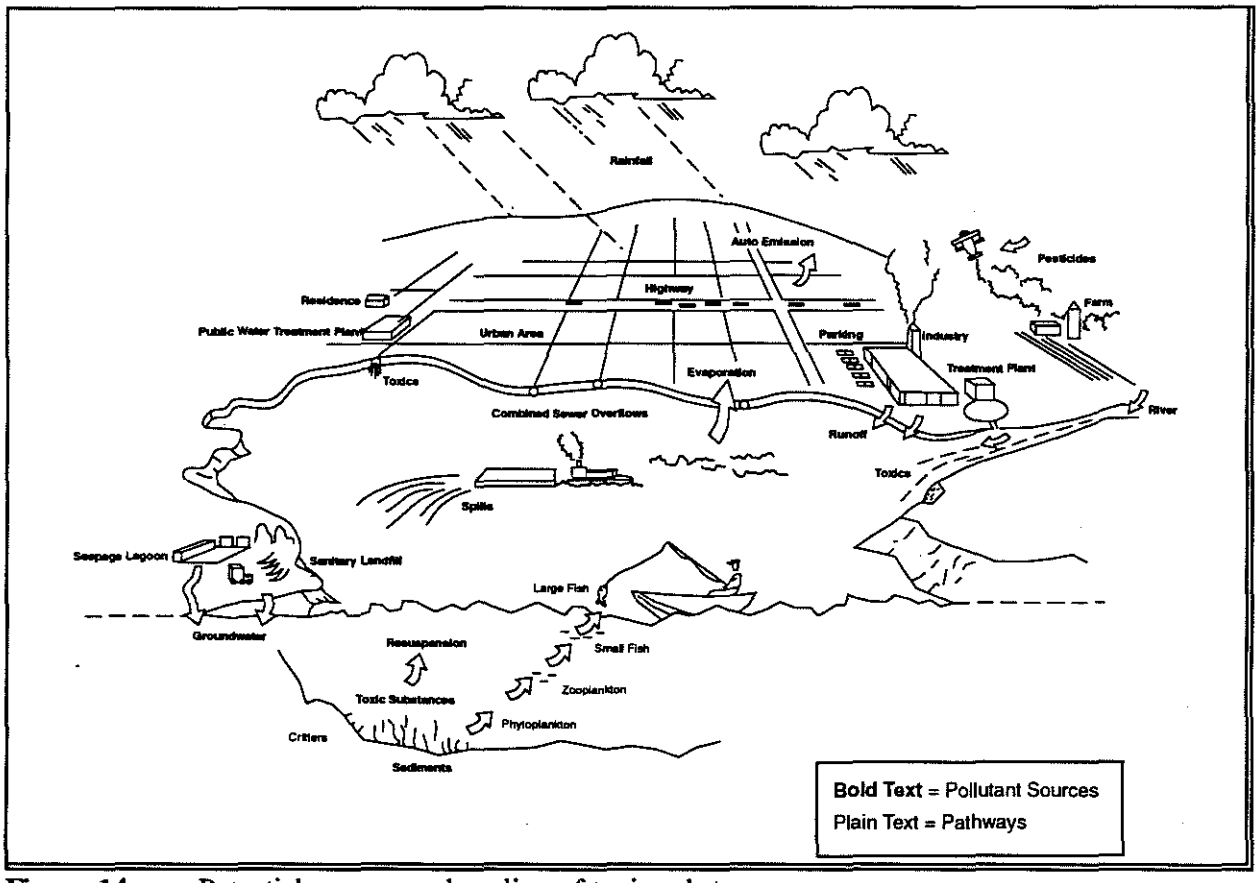


Figure 14 Potential sources and cycling of toxic substances.

1. Upstream Sources

Upstream sources are the greatest contributor of most heavy metals to the Sound. Of the upstream sources, the Connecticut River is the most significant source on a mass loading scale because of its large discharge volume. This does not necessarily indicate a water quality problem in the Connecticut River because ambient concentrations of most pollutants do not exceed state criteria for surface waters. Also, a portion of the upstream loads originates from natural sources; for example heavy metals are found in bedrock and soils being eroded and delivered to the rivers where they become part of the monitored load. Other significant upstream sources include the Naugatuck, Quinnipiac, and Thames Rivers in Connecticut.

2. Sewage Treatment Plants

Sewage treatment plants (STPs) are the second most significant source of most pollutants. STP loads are dominated by the large New York City plants. Although Bronx and Queens comprise less than 5 percent of the coastal surface area bordering the Sound, the STPs located there contribute a large portion of the heavy metals load discharged by STPs.

Quarterly STP effluent monitoring for metals was initiated in Connecticut since the NCPDI was completed. The monitoring data for southwestern Connecticut STPs from 1988 through 1990 showed some metals concentrations below NCPDI estimates and more similar to the monitoring data available for the New York City Treatment Plants (Table 19). If the monitored data are typical for most STPs in the central and eastern portions of the Sound, loads of chromium, lead, and zinc are substantially lower than the NCPDI data suggest.

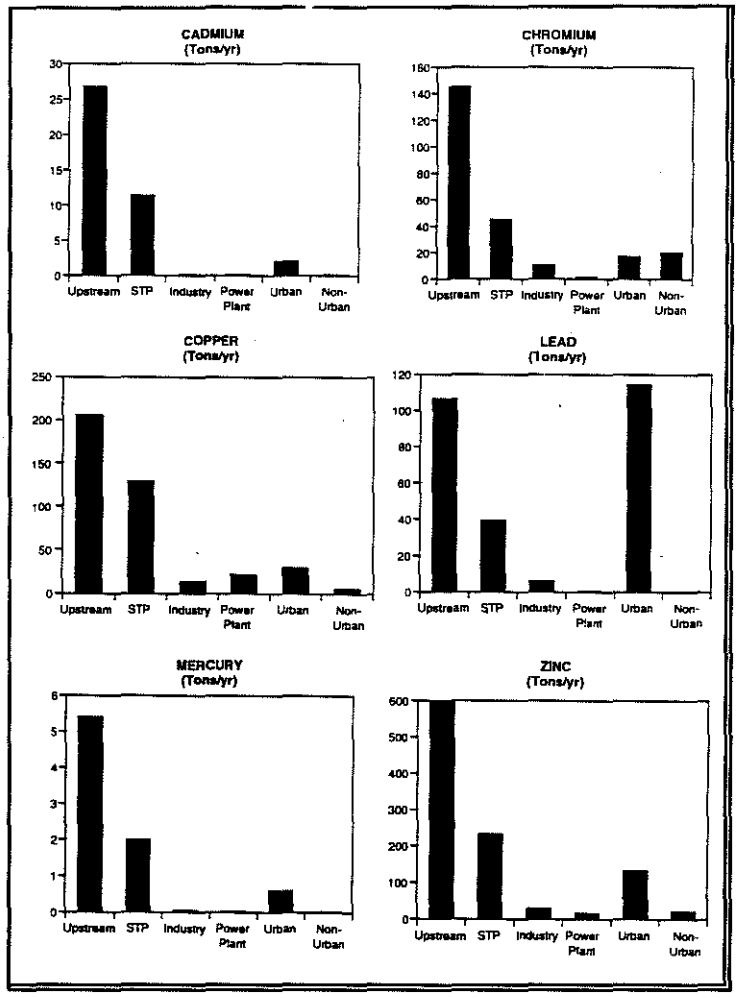


Figure 15 Contribution of heavy metals to Long Island Sound from different sources.

Table 19 Monitored concentrations of heavy metals (mg/l) at Connecticut coastal sewage treatment plants compared to NOAA estimated concentrations[1] and New York City monitoring data.

Metal	Connecticut Monitored*	NCPDI Estimated	New York City in NCPDI**
Cadmium	<0.01	0.011	0.005-0.0018
Chromium	0.011	0.043	0.0098-0.0363
Copper	0.04	0.037	0.0658-0.1773
Lead	<0.002	0.045	0.0068-0.0191
Mercury	<0.2 µg/l	0.30 µg/l	0.2-8.1 µg/l
Zinc	0.081	0.165	0.0895-0.195

* Mean of 12 plant means (1988-1990 data).
** Range of 4 plant means (1984 data).

3. Urban Runoff

Urban runoff and stormwater are the third most significant source of contaminants Soundwide and can be particularly important locally. The data reflect the urbanization in the western portion of the Sound with 80 percent of the annual urban runoff originating from a band extending from western Suffolk County through New Haven County. It is the largest source of lead and contributes PCBs and PAHs which may locally affect Long Island Sound's waters and biota. Both stormwater and other nonpoint sources of toxic contaminants need better documentation.

4. Other Sources

There are many minor sources of toxic contaminants which may affect limited areas of the Sound. Industrial dischargers, excluding power plants, are a relatively small contributor to the total loads to the Sound . However, a large number of the 24 major and 231 minor facilities identified in the NCPDI were clustered along the Quinnipiac and Housatonic Rivers and could be of local significance or contribute to *upstream* loadings. Power plants, despite the large discharge flow, contribute very small loads of toxic pollutants to the Sound. The load from power plants is dominated by copper and zinc, as might be expected from corrosion of plumbing, but contributed only 5.5 percent and 1.6 percent of the total Long Island Sound load, respectively. Non-urban runoff contributes only relatively small amounts of metals to the Sound.

Other sources of contaminants associated with urbanized areas are likely to exist. Older, inactive landfills may have the potential to leach contaminants into the Sound, although their contributions have not been quantified. Petroleum product spills and boating operations contribute PAHs and other contaminants associated with petroleum products to the Sound. This may occur during offloading operations or from improperly maintained boat engines.

Atmospheric deposition is also likely to be contributing substantial amounts of heavy metals such as copper, lead, and zinc (Table 20) as well as organic compounds to the Sound, but additional evaluation is warranted.

Table 20 Estimated atmospheric load of selected toxic substances (wet and dry) directly to the surface of the Sound and relative to total contaminant loading.

Substance	Tons per year on LIS Surface	Percent of Total Load Derived from Atmosphere
Cadmium	3.5	8
Chromium	20.9	8
Copper	168	29
Lead	309	54
Zinc	419	29
Total PAH	11-110	No estimate
Total PCB	0.4-4	No estimate

D. Overview of Toxic Substance Management Actions

Action in a number of specific areas is needed to address problem areas or initiate further reductions in toxic inputs. The goal of the LISS Toxic Substance Management Plan is to protect and restore the Sound from the adverse effects of toxic substance contamination by reducing toxic inputs, cleaning up contaminated sites, and effectively managing risk to human users. The LISS recommendations center around four priority areas of management:

1) Continuing and, where appropriate, enhancing existing regulatory and pollution prevention programs, which have already greatly reduced toxic substance inputs to the Sound;
2) Further evaluating sediments where toxic contamination problems exist to determine the feasibility of remediation;
3) Improving communication to the public of any legitimate health risks from consumption of seafood species from the Sound; and
4) Coordinating and strengthening monitoring activity for toxic substances to improve understanding and management of toxic contamination problems.

Although many other recommendations were considered, priority attention is directed towards these key areas of documented impact or characterization/problem identification needs as discussed in earlier sections. It is anticipated that as the information base grows, it will be necessary to periodically reassess management activities to address newly identified problems and to direct management towards those identified needs.

1. Existing Regulatory and Pollution Prevention Programs

Contamination by toxic substances has long been recognized as a major issue since passage of the Clean Water Act over 25 years ago. As a result, there are many existing programs and authorities (both regulatory and voluntary) that have been successful in reducing and minimizing the load of toxic substances to the Sound. A few examples are:

- The development of standards and criteria for toxic discharges;
- Pollution prevention, pretreatment and waste reduction programs;
- Water quality-based effluent limits for point sources;
- Toxic substance bans or use limitations, such as those imposed on PCBs, DDT, and leaded gasoline:
- Remediation of inactive hazardous waste sites;
- domestic waste management, including recycling programs and hazardous waste collection days, developed by state and local agencies;
- Oil and chemical spill response programs;
- LIS Research Fund studies on toxic source, fate, and ecological impact;
- Agricultural management practices, such as integrated pest management and runoff controls;
- State and federal coastal dredging permitting programs; and
- Seafood consumption advisories.

Significant progress in the control of toxic contaminant sources by ongoing state and federal permit programs and enforcement activities has been made and is reflected in the quality of the Sound. Efforts to control municipal and industrial sources will continue through programs such as the Pollution Discharge Elimination Systems delegated by the EPA to Connecticut and New York. Implementation of environmental regulations have substantially reduced loadings of toxic metals and

organics through secondary treatment of municipal wastes, the pretreatment and treatment of industrial wastes, as well as other environmental controls such as the ban on PCBs and lead in gasoline.

Nonpoint sources, including stormwater, atmospheric deposition, spills, landfill leachate, and boating operations may contribute a wide range of contaminants, but they are not well-quantified at this time. Amendments to the Federal Clean Water Act in 1987 required state water quality assessments of nonpoint source pollution and management plans to address nonpoint problems. Both Connecticut and New York have completed Section 319 assessments and are in the process of implementing their management plans. Because the programs are relatively new, special grants to test best management practices and develop guidance have been sought by both states and the LISS. Projects to test general nonpoint control technologies and develop stormwater management guidance including control of toxic substances have been sponsored by both states and the EPA through 319 demonstration grants. New requirements of Section 6217 of the Coastal Zone Management Act will also consolidate nonpoint activities into a cohesive nonpoint source management program.

The Pollution Prevention Act of 1990 established pollution prevention as the public policy of the United States. Both Connecticut and New York have established policies to prevent pollution in all media. In New York state, an objective of the NYSDEC is to reduce the generation and release of hazardous substances into all environmental media consistent with sound facility management and economic practices. One of the NYSDEC's goals is to achieve a 50 percent reduction of hazardous substances released into air, land, and water by the year 2000. These policies should be applied to the extent possible in all regulatory and compliance programs. The NYSDEC, as part of its compliance inspection program, performs multi-media pollution prevention field assessments at sites where permitted activities are taking place. In Connecticut, it is a priority of the CTDEP to expand and accentuate the use of pollution prevention in all agency programs. Consistent with this policy, the CTDEP has begun a program to institutionalize multi-media pollution prevention in regulatory programs, eliminate barriers to pollution-prevention initiatives, and identify targets for an outreach program. The Connecticut Technical Assistance Program (ConnTAP) solicits requests from manufacturing facilities for voluntary pollution prevention audits, and has conducted over 40 audits in the past two years.

Many additional members of the regulated community would be interested in pollution prevention, with proper education and technical assistance. Pollution prevention has many advantages besides reducing emissions, including savings from reduced or avoided costs due to fewer raw materials, less waste treatment and/or disposal, lower compliance fees and reduced liability insurance, etc. Workshops are an excellent forum for the exchange of technical information to facilitate changes toward prevention. New York City and Suffolk County already have pollution prevention programs that could be expanded to meet specific goals of the management plan.

At the federal level, the EPA has a number of voluntary pollution prevention programs that are currently in progress, including:

- 33/50 Program - a voluntary program to reduce the release and transfer of seventeen targeted chemicals by 33 percent in 1992 and 50 percent in 1995, using 1988 Toxics Release Inventory data as a baseline;
- Design for the Environment - facilitates information exchange and research in order to design products and processes in ways that eliminate or minimize the creation of pollution;

- Green Lights - encourages major corporations, state, and local governments and other organizations to install energy-efficient lighting as a method to reduce energy consumption, and thereby prevent pollution; and,
- Energy Star Computers - prevents pollution by lowering power consumption through intelligent design.

Facility planning is essential in controlling sources of toxic contaminants reaching the Sound. In August 1993, the NYSDEC released draft regulations (Part 378) to require facilities that generate hazardous waste or release toxic chemicals to reduce or eliminate such generation or discharges to the extent technically feasible and economically practicable. If these regulations are adopted, such facilities would be required to develop and implement toxic chemical reduction plans. In doing this, the hierarchy or order of preferred management practices are:

- Reduce or eliminate;
- Recover, reuse, recycle on-site;
- Recover, reuse, recycle off-site;
- Detoxify, treat, destroy;
- Dispose of in a landfill (least preferable).

A similar program has been implemented in Connecticut since 1988, when permit regulations were revised to establish permit limits on both the toxicity of discharges (whole effluent) and specific substances (numeric criteria). The toxic substances control program addresses both the protection of aquatic live and human health. Upon permit renewal cycles, discharge permits are modified to limit toxic pollutants to the degree that provides that protection. The permittees are required to conduct detailed toxicity evaluations to determine the source of any toxicity found in their effluents. Toxicity is generally reduced through pollution prevention, process modification, or effluent treatment upgrades. By the end of fiscal year 1993, 43 of 56 targeted major industrial NPDES permits have been modified to require compliance with limits on whole effluent toxicity. Since 1989, the number of municipal sewage treatment plants reporting no *end-of-pipe* toxicity has increased steadily from 36 to 66 (84% of the total 79 plants), indicating substantial improvement of effluent quality in Connecticut.

Planned activities under the auspices of the New York-New Jersey Harbor Estuary Program (HEP) will also enhance toxic substance management in the Sound. Under Section 304(l) of the Clean Water Act, the Harbor is listed as impaired by copper and mercury, while the Sound is not listed. Since the Harbor is listed, control strategies must be developed to correct this impairment. At present, the HEP is developing Total Maximum Daily Loads (TMDLs), Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint sources to ensure that water quality standards for mercury are met in the Harbor, the East River, and western Long Island Sound. Additional work will be required to fully account for nonpoint sources of mercury, since the work to date has revealed the presence of a major unidentified source of mercury. The NYSDEC will also assure that permits limiting New York City sewage treatment plant discharges of a broad range of toxic metals to existing effluent limits. By controlling sources to the East River, water quality in western Long Island Sound will benefit. The CTDEP is using a wasteload allocation approach to regulate dischargers along the Quinnipiac and Naugatuck Rivers. Reductions of heavy metals discharged to those rivers will benefit water quality in the Sound as well.

Preventing toxic contaminants from entering the Sound is the most effective method of preventing future degradation and, in many instances, may be the most economical means of managing toxic contaminants. The CTDEP and the NYSDEC have primary responsibility for program

implementation along with EPA authorities. However, widespread pollution prevention activities must include all private enterprises and the public. Specific actions relevant to source control and pollution prevention that begin to meet the objective of preventing toxic contaminants from being released into the environment by improving source controls where necessary or by implementing pollution prevention actions are summarized in Table 21.

Table 21 Toxic contaminant source controls and pollution prevention.

ONGOING PROGRAMS	Responsible Parties/Status
The states of Connecticut and New York, and the Army Corps of Engineers will continue to regulate dredging and the disposal of dredged sediments through existing permit programs.	CTDEP, NYSDEC, NYSDOS, EPA, USACOE. (See Table 41 of *Chapter VII, Management and Conservation of Living Resources and Their Habitats* for further detail.)
The states of Connecticut and New York and the EPA will continue their pretreatment programs to ensure that toxic discharges to sewage treatment plants are controlled. The states of Connecticut and New York, through their Pollution Discharge Elimination System Programs, will continue to ensure that facilities comply with their permit limits.	CTDEP, NYSDEC. (See Table 4 of *Chapter III, Hypoxia* for further detail.)
The states of Connecticut and New York and the EPA will apply pollution-prevention techniques, as appropriate, to both direct and indirect discharges of toxic substances by emphasizing wastewater minimization, recycling of wastewater, and alternative processes and chemicals to reduce toxicity and toxic loads and to minimize effects on all environmental media.	CTDEP, NYSDEC, EPA. Both states and the EPA have established policies on pollution prevention to highlight the importance and benefits of controlling pollution before it enters the wastestream and potentially impacts the environment. Connecticut has established pollution prevention as a public policy by statute and has begun a program to institutionalize multi-media pollution prevention in regulatory programs, eliminate barriers to pollution-prevention initiatives, and identify targets for an outreach program. New York's policy is to reduce the generation and discharge of pollutants to all environmental media consistent with sound facility management and economic practices.
The states of Connecticut and New York will review municipal and industrial discharge permits to surface waters to reduce the allowable concentrations of toxic pollutants from the previous permitted values.	CTDEP, NYSDEC. The net result will be a substantial reduction in the discharge of toxic materials over the next few years to meet adopted criteria for toxic substances in the states' waters.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The LISS will encourage adequate funding to continue and expand pollution prevention site visit programs targeting industrial dischargers to the Sound and its tributaries.	LISS	Initiated 1993/ Continuing	Minimal staff time
As part of the NY-NJ Harbor Estuary Program, total maximum daily loads, wasteload allocations for point sources, and load allocations for nonpoint sources will be developed to ensure that water quality standards for mercury are met in the Harbor, the East River, and Long Island Sound.	HEP NJDEPE NYSDEC EPA	1994	Redirection of base program

As part of the New York-New Jersey Harbor Estuary Program, the states of New York and New Jersey will establish water quality-based effluent limits for copper, mercury, and six other toxic metals, as necessary. Permits will be subsequently modified.	NJDEPE NYSDEC	Completed by December 1994	Redirection of base program
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Support education on the environmental impact of using home, garden, and commercial hazardous chemicals and pesticides and will continue to provide guidance on how to minimize use of these chemicals and properly dispose of them through household hazardous waste collection.	LISS	Initiated 1993/ Continuing	$20,000; See *Chapter X, Public Involvement and Education*, for details
Evaluate mass loadings of toxic contaminants and determine their relationship to ambient water and sediment quality.	LISS CTDEP NYSDEC	—	$200,000 per year
Identify and assign priorities to toxic substances which should be banned from use and for which *virtual elimination of discharge* should be the goal.	LISS CTDEP NYSDEC	—	$200,000 per year

2. Sediment Contamination

The most comprehensive database on toxic substances in the Sound exists for concentrations in sediment. In some areas of the western portion of the Sound and in several urbanized harbors, rivers, and embayments, sediment levels of both metals and organic compounds are elevated. Although there is clear evidence that toxic contaminants are a problem in the sediments of some areas of the Sound, assessments of areas suspected of having highly contaminated sediments is incomplete. Because of natural sediment character and processes, for example, seemingly high levels of contaminants may be of little environmental relevance because they are unavailable to living organisms. Many areas in the Sound, especially the harbors and embayments are not well documented as to the level of contamination and should be further characterized for both toxic contaminant levels and ambient toxicity to estuarine organisms. To begin the process of remediating sediments, the LISS will conduct further assessments of toxic contaminant distribution in sediments of western Long Island Sound and embayments identified as having elevated toxic contaminant burdens. Based on these assessments, determine the feasibility, value, and cost of remediating contaminated sediments, where remediation may be necessary.

Improving the sediment substrate will be beneficial not only to benthic habitats, but also to higher level organisms that feed on lower trophic level organisms. These actions would significantly improve and expand habitat for shellfish, finfish, and other estuarine life, reduce threats to human health, and restore human uses of some of the more highly contaminated harbors. The CTDEP and the NYSDEC, in cooperation with the LISS, hold primary responsibility for ensuring this objective is met. State water pollution control and hazardous waste programs have the authority to require both control of active sources leading to sediment contamination as well as remediation of contaminated sites. The U.S. Army Corps of Engineers and the EPA have relevant technical and managerial expertise for the evaluation and planning. Unfortunately, technical feasibility and cost hamper cleanup efforts. The LISS has investigated some evaluation and remediation approaches and must continue to explore approaches that are being newly developed in the Great Lakes and New York-New Jersey Harbor.

To initiate the necessary evaluations and to begin to assign locations where sediment remediation may be feasible, the actions listed in Table 22 will be taken.

Table 22 Addressing sediment contamination.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The LISS will review the National Oceanic and Atmospheric Administration (NOAA) 1991 sediment chemistry and toxicity survey results of harbors and embayments, when available in the Spring 1994. This will supplement the available data.	LISS NOAA	Completed 1994	Existing staff to be used.
The LISS will provide a preliminary review of the data on sediment contamination on a site-by-site basis. State and Federal experts will evaluate the problem at each site and recommend additional assessments needed to fully characterize the problem, ascertain the need for and feasibility of remediation and prepare a remediation plan.	LISS	Ongoing	Existing staff to be used.
The City of Glen Cove plus their Review Committee will evaluate the contamination of Glen Cove Creek.	NYSDEC City of Glen Cove	1994/1995	$250,000
The LISS will review and evaluate sediment remediation approaches developed in the Great Lakes ARCS Program and HEP.	LISS	1994/1995	Existing staff to be used.
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Conduct further assessments and develop site plans addressing the feasibility, technical approach, cost and value of conducting remediation activities for Black Rock Harbor and Glen Cove Creek, where data may be sufficient to conduct case study analyses. Recommend other harbors for characterization and feasibility studies to be conducted at a rate of two harbors per year.	LISS	Ongoing	$250,000 per harbor or $500,000 per year

3. Risk Communication

The states of Connecticut and New York have issued advisories on consumption for selected fish taken from the Sound. The toxic substances of greatest concern in these advisories are the PCBs, which are toxic compounds found in the insulating oils of transformers, capacitors, and other electrical equipment. Continuing health risk advisories, most often related to PCB contamination of seafood products, preclude full utilization of Long Island Sound's resources. While it is expected that full implementation of programs to minimize toxic discharges will result in lower health risks, it is important to minimize human exposure to toxic substances through effective risk communication in the interim. A uniform health risk management approach would enhance communication and facilitate risk assessments. Actions are summarized in Table 23 that emphasize PCB impacts as a primary cause of seafood advisories in the Sound. These actions are aimed towards the objective of developing a mechanism to promote common approaches to releasing and publicizing advisories for Long Island Sound seafood species.

Table 23 Improving human health risk management.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The LISS will advocate the coordination between the states of Connecticut and New York to review health risk and advisory recommendations and formulate plans to ensure consistency.	LISS CTDEP CTDOHS NYSDEC NYSDOH	Initiated 1994/ Continuing	No Cost
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Develop strategies for controlling loadings of contaminants for which seafood consumption advisories have been issued.	LISS CTDEP NYSDEC	—	$150,000 per year.
Develop a strategy for identifying toxic substances of human health risk concern in Long Island Sound seafood species and tolerance levels for those substances.	LISS	—	$150,000 per year.

The Connecticut Department of Environmental Protection, the Connecticut Department of Health Services, the Connecticut Department of Agriculture, Aquaculture Division, the New York State Department of Environmental Conservation, and the New York State Department of Health are responsible for implementing these actions and for protecting seafood consumers from toxic contaminants. It is anticipated that improved communication of consumer advisories will reduce public health risk.

4. Monitoring

Comprehensive characterization of toxic contamination problems in the Sound is difficult at this time due to an inadequate database. Similarly, although strict regulatory programs for point source dischargers in both states have greatly reduced the load of toxic contaminants reaching the Sound, the lack of comprehensive, coordinated monitoring prevents conclusive trend analysis. There is a need to establish monitoring goals and approaches and implement a monitoring plan that will allow managers to identify toxic contamination problems, causes, and trends. That information is needed to develop management plans to identify and control sources, identify and clean up priority sites, and minimize risks to both the living organisms of the Sound and to human consumers of seafood products from the Sound.

The proposed LISS toxic contaminant monitoring program will focus on water, sediment and tissue media. The data collected from the monitoring program will be used to answer questions about resource and human health risks and sources of toxic contaminants. The elements of this program are as follows:

A. Contaminants in Tissues of Key Species

Consistent monitoring of fish and shellfish tissues to determine levels and distribution of toxic contaminants, to identify contamination problems, and to evaluate potential health risks must be implemented in the Sound. Questions to be answered through tissue monitoring include:

- What are the status and trends of toxic contaminants in tissues?
- Where (geographically) are the problem areas?
- Are there potential resource impacts from the observed levels?
- Are there human health risks from consumption of seafood species?

Tissues, if regularly and systematically monitored, can be an excellent sentinel for toxic contaminants, integrating exposure from several sources over time. State tissue monitoring efforts typically focus on potential human health risks rather than identifying toxic contaminant trends over time and space. Surveys have been used to reconnoiter potential toxic contamination problems. If the survey indicated a human health risk, more intensive surveys were conducted to provide sufficient data to develop a human health risk evaluation. If an advisory was warranted, periodic surveys were conducted to determine status over time and, if conditions changed, the advisory would be expanded or withdrawn.

Presently there are two federal programs that systematically monitor tissues to identify spatial and temporal characteristics of toxic contamination in the Sound. Both programs are part of a national contamination evaluation and raise cautions about use of the data for drawing conclusions about local conditions. NOAA's Status and Trends program looks at mussel tissues and finfish organs from the Sound. EPA's Environmental Monitoring and Assessment Program analyzes finfish tissues if an external and histopathological examination of the finfish indicates a potential contamination problem. At the LISS Monitoring Workshop, participants recommended that these programs be continued and periodically expanded to address long-term tissue monitoring needs for the Sound. It is likely that they will provide the foundation for expanded efforts conducted by the states or the federal agencies.

B. CONTAMINANTS IN SEDIMENTS

Sediments were identified as the medium that most warranted additional survey, monitoring, and management attention. Presently there are no state programs that systematically monitor sediments around the Sound. Monitoring must be designed to answer the questions:

- Where are problem concentrations of toxic contaminants found in sediments?
- What are the impacts on the resources of the Sound?
- What are the trends of those problem substances?

Federal agencies are the only groups that regularly and systematically measure contaminant levels in sediments. State efforts are largely directed towards evaluating potential problems identified during reconnaissance surveys, special studies, or from regulatory analyses of sediments conducted as part of a proposed dredging project or permit application. NOAA's Status and Trends Program and EPA's Environmental Monitoring and Assessment Program annually sample sediments in several locations of the Sound for toxic contaminant analysis. Use of sediment toxicity testing approaches are prominent in both the federal monitoring programs and the regulatory approach to evaluating potentially harmful sediments subject to dredging. The two-year Regional Environmental Monitoring and Assessment Program will assess sediment quality and will enable a generalization of information on toxic contaminants in sediments over the entire Harbor, Bight Apex and western portion of the Sound, as well as a comparison with toxicity test results and other biological effects indicators (i.e., benthic community gradients). Toxicity testing will be an important part of a comprehensive monitoring program for the Sound. The LISS Monitoring Workshop participants reviewed the ongoing programs and the regulatory programs that could be used to supplement the database and found them to be sufficient for a *first-cut* assessment of sediment contamination. If contamination is identified then follow-up surveys and source trackdowns must be conducted.

C. WATER COLUMN

Questions to be addressed for water column monitoring parallel those asked for sediment evaluations. Monitoring of water for toxic contamination can be costly because of the large number of samples that must be taken to quantify variability in an extremely variable medium as well as the fact that very few laboratories can accurately analyze toxic substances in seawater. Water column analyses might be limited to special studies and emphasize the use of toxicity testing to identify problems. Specific chemical analyses could be conducted to determine specific problematic substances, and their sources and dynamics. Routine monitoring of the water is unlikely to meet that need even if it was more affordable.

Presently, the states conduct few water column evaluations in the Sound. Those that are conducted are used to generate wasteload allocations or to identify nearfield toxicity problems in the vicinity of effluent discharges. Neither use can be considered a long-term monitoring program.
Neither NOAA nor EPA monitoring includes analyses of water samples for toxic contaminants. While both the NOAA and the EPA have occasionally conducted water toxicity testing as part of their evaluations of Long Island Sound water quality, they have not incorporated such testing into their continuing program and rely on sediment and tissue analyses to identify contamination problems because they are cost-effective and the media concentrations are less variable.

D. LOADS AND FATE

Through state and federal permitting requirements, most of the point source dischargers in the Long Island Sound basin are monitored for relevant chemical parameters. In recent years, end-of-the-pipe toxicity testing has been added to the repertoire of permitting requirements to ensure environmental safety of wastewater discharges. Toxicity testing helps identify combined effects of chemical contaminants in an effluent that might not be recognized through chemical analyses alone. Other sources are not so well documented or monitored. Those include nonpoint source contributions, atmospheric deposition, and redistribution of chemical contaminants from ambient conditions such as contaminated sediments. Basic questions to be answered about sources and fate include:

- How much chemical contamination is contributed to the Sound from human sources?
- What are the major sources of toxic contaminants (e.g., point, nonpoint, atmospheric, redistribution, etc.)?
- How do these sources relate to contamination problems found in tissues, sediments and the water column?
- What are the management options for controlling those sources and how should priority be determined?

To effectively understand the quantitative relationship between toxic loads and the concentration of toxic chemicals which are present in the water, sediment, and biota, a mass balance mathematical model could be developed to provide insight into this relationship. The New York-New Jersey Harbor Estuary Program plans on doing such for PCBs, mercury and other toxic pollutants. Development of comprehensive, systemwide models will help prioritize remedial actions, indicate the level of reduction necessary in order to satisfy standards and criteria and forecast how quickly the system could respond to load reductions. The systemwide models for PCBs and mercury would provide the technical foundation for comprehensive efforts to eliminate problems in the Sound-Harbor-Bight system.

Based on the results of the LISS Monitoring Workshop, staff will develop a detailed monitoring and assessment plan to better identify toxic contamination problems, their causes, and trends. Specific information needs include:

1) Use of appropriate analytical techniques to assure data comparability among sites and time.
2) Analysis of organic compound distribution and ecosystem impact.
3) Expansion of tissue monitoring to complete spatial coverage for key plant and animal species.
4) Bioeffects testing.
5) Identification and quantification of atmospheric depositional loads.

Management decisions should be based on the best technical information available because source control and remedial actions are very costly and must be well-targeted. Developing a monitoring and assessment program that has diagnostic value, is affordable and can be sustained, and produces data that are transformed into usable information will provide the level of detail needed for management and policy options.

To begin to address this need, the LISS has initiated actions summarized in Table 24.

Table 24 Monitoring and assessment of toxic contaminants.

ONGOING PROGRAM	Responsible Parties/Status
The mussel watch and benthic surveillance components of NOAA's Status and Trends Program and the EPA's Environmental Monitoring and Assessment Program provide regular and systematic sampling of contaminant levels in the Sound.	EPA, NOAA. NOAA's Mussel Watch and Benthic Surveillance components of the National Status and Trends Program have been ongoing since 1984 in Long Island Sound. Annual samples of mussels, sediments, and fish tissues are taken and analyzed for several toxic substances, providing a continuing monitoring base to identify trends in Long Island Sound water quality. Similarly, EPA's Environmental Monitoring and Assessment Program has looked at toxic impacts and toxic substance levels in tissue samples from the Sound since 1990.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
A monitoring workshop was held to integrate findings of the LISS and develop a comprehensive, Soundwide monitoring plan for toxic substances.	LISS	Initiated 1993/ Completed 1994	See *Chapter IX, Continuing the Management Conference.*

Under the auspices of the New York-New Jersey Harbor Estuary Program (HEP), the U.S. Army Corps of Engineers has agreed to develop a work plan and budget to develop systemwide models for PCBs, mercury, and other toxic pollutants that will provide the technical foundation for comprehensive efforts to eliminate these contamination problems in the Sound-Harbor-Bight system. The Corps of Engineers and other participants have agreed to seek the funding necessary to complete these models. Special attention will be directed to fully account for nonpoint sources of mercury.	HEP USACOE	1994	Existing staff to be used
Monitoring initiatives will be coordinated with the EPA Regional - Environmental Monitoring Assessment Program (R-EMAP) to further the understanding of sediment toxicity and benthic community structure gradients in western Long Island Sound.	CTDEP NYSDEC EPA	Initiated1993/ Completed 1994	$200,000

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Conduct site-specific characterization surveys of water, sediment and biota in harbors where active sources of toxic substances are believed to persist at a rate of two harbors per year.	CTDEP NYSDEC	—	$200,000 per harbor; or $400,000 per year
Identify sources and sites of PCB loadings to the Sound ecosystem from in-Sound and NY-NJ Harbor Estuary sources. Focus on reducing and eliminating PCB loadings on a priority basis, concentrating on areas of known contamination such as Black Rock Harbor.	CTDEP NYSDEC EPA	—	$200,000 per year
Monitor contaminant levels in selected estuarine organisms to ascertain their effects on the biology of the species and their effects on the edibility of the species.	LISS CTDEP NYSDEC EPA NMFS USFWS	—	$300,000 per year
Implement the recommendations from the LISS Monitoring Plan to improve contaminant monitoring.	LISS	—	$15,000

5. Research

Environmental contamination by toxic contaminants presents extremely complex biogeochemical, physical, and kinetic interactions among different contaminants and media (sediment, water, and biota). The factors must be understood if effective management is to be accomplished. These needs are identified as recommendations at this time, though continuation of work begun by the LISS through the EPA Long Island Sound Office should recognize these recommendations as priority research topics (Table 25).

Table 25 Research to investigate toxic contamination in Long Island Sound.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
The relationship between organism body burdens and their toxic response needs to be investigated as an important mechanism of toxic impact.	University Research	—	$250,000 per year
Trophic level transfer and bioaccumulation effects of contaminants up the food chain need to be quantified to better manage both the aquatic community and human health risks.	University Research - State Health Risk Agency Guidance	—	$500,000 per year
While toxicity testing of sediments and waters is an efficient means of identifying toxicity problems, the relationship between toxicity and specific causative agents needs to be determined.	University Research/ Research Lab	—	$500,000 per year
Evaluate the use of an ecological risk assessment approach, demonstrated in the LISS Black Rock Harbor Action Plan Demonstration Project, for more widespread application to identify toxicity and its sources in embayments and harbors of the Sound.	LISS CTDEP NYSDEC EPA	—	$100,000

In summary, the benefits of implementing this plan will be significant:

- Preventing toxic contaminants from entering the Sound by continuing the successful regulatory and pollution prevention programs is the most effective method of preventing future degradation and, in many instances, may be the most economical means of managing toxic substances.
- Reducing contaminant loads and remediating sediments will be beneficial not only to organisms that live on or in the sediments, but also to organisms that feed on them.
- These actions will significantly improve and expand habitat for shellfish, finfish, and other estuarine life.
- Risk to seafood consumers will be further reduced.
- An improved toxic substance monitoring base will allow faster response to emerging problems and a greater ability to plan remediation activities.

V. Pathogen Contamination

A. What Are Pathogens?

Pathogens are disease-causing microorganisms, such as bacteria or viruses. Sources of pathogens in Long Island Sound include inadequately treated human sewage and wild or domestic animal wastes. Human exposure to pathogens can occur either by direct contact with or ingestion of contaminated waters by bathers, or by eating raw or partially cooked shellfish harvested from contaminated waters.

The potential presence of human pathogens has historically been monitored by measuring bacterial *indicator* organisms. Indicator organisms are not harmful to humans but are easy to measure and have similar origins as do pathogenic microorganisms. While there is considerable debate over their use to identify public health risk, bacterial indicators are widely used to manage bathing and shellfishing waters. National efforts to develop new methods that better define pathogenic contamination are promising, but require further development.

Total coliform bacteria were the first indicator widely used to monitor surface waters. However, this group contains organisms of non-fecal origin and, therefore, was replaced or supplemented by monitoring a subset of the group, fecal coliforms. Fecal coliforms are usually associated with fecal material and are thus more likely to identify the presence of pathogens. The EPA has recently recommended use of *Enterococcus* bacteria as another indicator for use in regulating bathing beach closures.

B. What Are The Problems Associated With Pathogens?

Human exposure to pathogens in Long Island Sound can cause illness, most often gastroenteritis, but also potentially more serious diseases such as salmonellosis and hepatitis A. Exposure to pathogens can occur either by direct contact and ingestion of contaminated waters by bathers or by eating raw or partially cooked shellfish harvested from contaminated waters. Because there is limited flushing and tidal action in inshore coves, bays, and harbors, these areas are often more heavily impacted than the open or offshore waters.

Pathogens affect the use of Long Island Sound. For example, the Sound's bathing beaches and shellfish grounds may be closed temporarily or over the long-term when monitoring indicates the presence of pathogens. While these closures protect human health, they can have a severe impact on businesses that depend on recreation and tourism and on the viability of the shellfishing industry. To protect public health, to avoid negative impacts to the local economy, and to allow for fuller resource utilization, exposure to pathogens must be reduced by eliminating the causes of the problem.

1. Bathing Beaches

Pathogen contamination causes a number of beach closures around the Sound. Every beach closure is a loss in recreational opportunity and results in a financial loss to localities. From the period 1986 to 1990, a total of 1,440 beach days were lost at Long Island Sound beaches, 406 of which were reported during 1990. (Each beach has 106 beach days per year, which corresponds to the beach season from Memorial Day to Labor Day.) Almost all closures occurred at beaches in enclosed embayments, rather than at beaches directly on the Sound (Figure 16; refer to Table 26 for drainage area designations). Beaches where standards (the states set water quality standards for human contact) were exceeded were usually near heavily populated areas of western Long Island Sound.

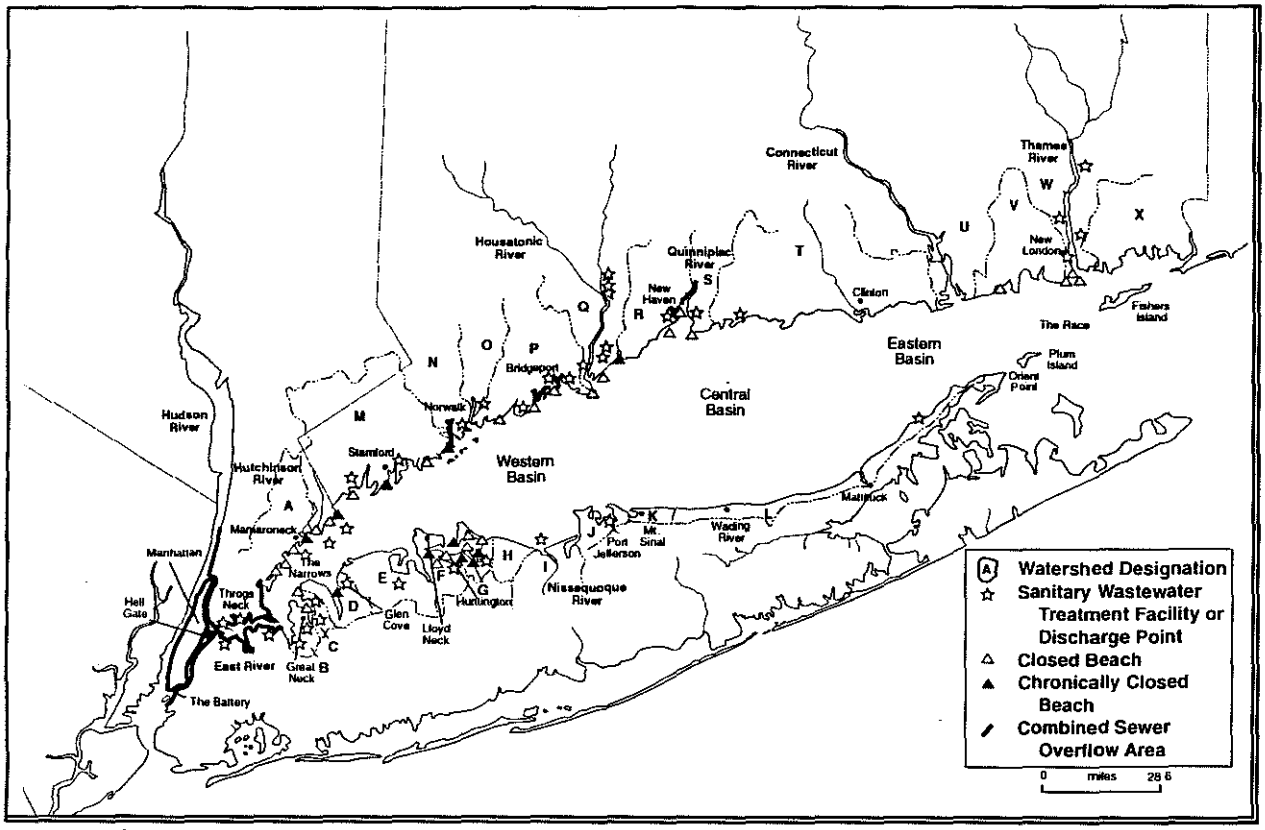


Figure 16 1990 status of Long Island Sound beaches.

Table 26 Long Island Sound drainage area designations.

Designation and Basin Title			
A-Hudson Major	G-Northport Bay	M-Southwest Western	S-Quinnipiac
B-Little Neck	H-Fort Salonga	N-Norwalk	T-South Central Eastern
C-Manhasset Bay	I-Nissequogue, Stony Brook Harbor	O-Saugatuck	U-Connecticut Main Stem
D-Hempstead Harbor	J-Port Jefferson Harbor	P-Southwest Eastern	V-Southeast Western Main Stem
E-Oyster Bay	K-Mount Sinai Harbor	Q-Housatonic Main Stem	W-Thames Main Stem
F-Huntington Bay	L-Eastern Long Island	R-South Central Western	X-Southeast Eastern
			Y-Pawcatuck Main Stem

During the 1986 to 1990 period, beaches were closed because of elevated coliform levels observed during routine sampling, elevated levels expected from rainfall, or problems at sewage treatment plants resulting in the release of inadequately treated sewage. In New York state, rainfall-associated events were the primary cause of beach closures, resulting in 451 lost beach days. In Connecticut, sewage treatment plant malfunctions were the primary cause, resulting in 196 lost beach days.

Also during that time, 10 beaches were chronically closed (i.e., closed for at least three days per year for at least three of the five years). The 10 beaches were closed from 5 to 31 percent of their total

beach days (Table 27). The chronically closed beaches, in order of severity, were Scudder Park, Gold Star Battalion, Mamaroneck Area, Huntington Beach Community, Hempstead Harbor Area, Centerport Yacht Club, Mamaroneck Beach Cabana and Yacht Club in New York, and the beaches in the Norwalk and Milford areas of Connecticut.

Table 27 Chronically closed beaches in Long Island Sound (1986 to 1990).

BEACH NAME	LOCATION	# LOST DAYS	% OF TOTAL BEACH DAYS[1]
Westchester CCBC	Westchester Co., NY	25	5
Mamaroneck Area	Westchester Co., NY	86	16
Hempstead Harbor Area	Nassau Co., NY	42	8
Gold Star Battalion	Suffolk Co., NY	155	29
Fleets Cove	Suffolk Co., NY	27	5
Huntington Beach Comm.	Suffolk Co., NY	82	15
Centerport Yacht Club	Suffolk Co., NY	44	8
Scudder Park	Suffolk Co., NY	166	31
Norwalk Area	Norwalk, CT	126	24
Milford Area	Milford, CT	26	5

1 Percent of total beach days was calculated as number of lost days/530 days. There are 530 beach days in five years.

Source: Tetra-Tech, Inc., 1992

2. Shellfish Growing Waters

In theory, virtually the entire bottom of Long Island Sound is capable of supporting some species of shellfish. Potentially, the whole of Long Island Sound could be a shellfish bed. For purposes of this plan, however, this discussion is limited to recognized, productive shellfish beds.

Of the 66,000 acres of productive shellfish beds in New York, 73 percent were classified restricted/prohibited (Table 28). In Connecticut, of the 52,500 acres of productive shellfish beds, 35 percent were classified restricted/prohibited. That the impact on the shellfish harvest is greater than the amount of impacted acreage alone suggests because the restricted areas are among the most productive and accessible beds and occur close to shore or in embayments (Figure 17; refer to Table 26 for drainage area designations). The loss rate of productive shellfish acreage has slowed considerably throughout the Sound in recent years. This is due in part to shellfish relay programs that have permitted limited harvesting in areas that are subject to episodic pathogen contamination, such as embayments. A relay program permits moving shellfish from restricted areas to certified areas for depuration and subsequent harvest.

Table 28 Shellfish growing waters classification definitions.

Approved or Certified Area

Shellfish can be harvested for direct human consumption in areas where the median or geometric mean total coliform most probable numbers (MPN) do not exceed 70 coliforms per 100 milliliters (70/100 ml) of water with not more than 10 percent of the samples exceeding an MPN value of 230/100 ml (5-tube decimal dilution test) or MPN of 330/100 ml (3-tube decimal test), or the median or geometric mean MPN does not exceed 14/100 ml fecal coliform, with not more than 10 percent exceeding an MPN of 43/100 ml (5-tube dilution test) or 49/100 ml (3-tube dilution test). This determination is based on a minimum of 15 samples at each station in the growing area over a three year evaluation period. Samples are collected during adverse pollution defined in the National Shellfish Sanitation Program Manual as conditions determined by changes in meteorological, hydrographic, seasonal, and point source that have been historically demonstrated to unfavorably impact a particular growing area.

Conditionally Approved or Certified Area

These areas are predictably influenced by occasional intermittent contamination. Shellfish can be directly harvested only under specified conditions (i.e., when water quality meets the above certified area criteria under identified situations of reduced pollutant inputs). The area is temporarily closed (restricted) when contamination conditions have occurred. Runoff from rainfall is the major factor that affects conditional closures in New York state and Connecticut.

Restricted Area

Shellfish growing areas that have been classified by the state shellfish control agency as areas from which shellfish may be harvested only by special permit and the shellfish must be subjected to a suitable and effective purification process (such as relay or transplant). New York state does not classify areas as restricted but restricts access to uncertified areas for transplanting or depuration harvest by issuing special permits that identify the specific special harvest area to be used in any relay or transplant harvest project.

Conditionally Restricted Area

These areas are predictably influenced by pathogenic contamination, as with conditionally certified areas, but in this case even in dry weather the areas do not meet the approved (certified) area criteria. Harvesting for depuration may occur when water quality is meeting the depuration harvest area criteria, usually this would be in dry weather.

Prohibited Area

No harvesting is permitted from an area that is grossly contaminated or for which no current shoreline survey and water quality assessment is available.

(Definitions provided by the New York State Department of Environmental Conservation and the Connecticut Department of Agriculture, Aquaculture Division and are adapted from the National Shellfish Sanitation Program Manual Guidelines.)

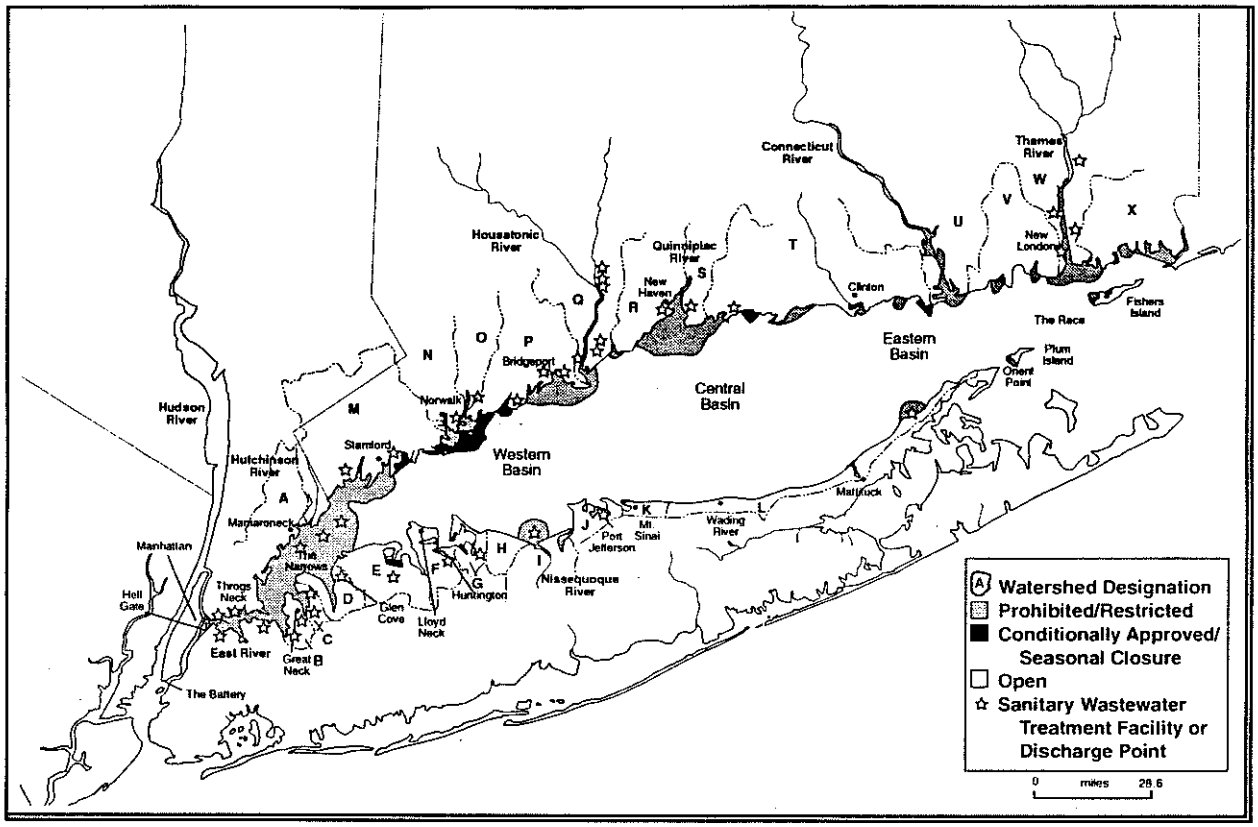


Figure 17 1990 status of Long Island Sound shellfish areas.

Table 29 Connecticut shellfish harvests (1972 to 1990).

YEAR	OYSTERS				HARD CLAMS	
	MARKET HARVEST BUSHELS	TRANSPLANT BUSHELS	SEED HARVEST BUSHELS	TOTAL DOLLARS (millions)	POUNDS	DOLLARS (millions)
1990	380,000	2,000	71,900	22.6	1,126,128	3.5
1989	250,885	2,300	42,188	15.3	710,400	2.8
1988	141,565	3,000	56,890	9.0	311,500	0.9
1987	69,721	3,000	142,857	5.0	596,020	1.5
1986	115,800	3,000	35,000	6.6	759,000	2.1
1985	112,259	60,000	31,500	6.8	844,900	1.2
1984	243,883	100,000	56,600	12.8	771,600	2.7
1983	128,500	100,000	40,000	8.6	461,600	1.5
1982	129,815	150,000	32,468	10.8	419,784	1.4
1972	32,468	100,000	10,000	3.2	250,000	0.5

Source: Connecticut Department of Agriculture, Aquaculture Division.

A relay or transplant program reduces the economic loss of productive shellfish beds. In Connecticut, approximately 85 to 90 percent of the harvest from approved waters was relayed or transplanted from restricted and prohibited areas by the shellfish industry. These programs and other programs designed to rejuvenate formerly productive areas led to an increase from 36,368 acres under cultivation in 1972 to 44,493 acres in 1990 (Table 29). Over the same period, the harvest value of oysters and hard clams increased from $3.7 to $26.1 million. Harvest values have not been adjusted for inflation.

Table 30 New York hard clam harvests for Long Island Sound (1972 to 1991).

YEAR	NUMBER OF BUSHELS HARVESTED BY TOWN				TOTAL VALUE (DOLLARS)	% OF TOTAL NY HARVEST
	BROOKHAVEN	SMITHTOWN	HUNTINGTON	OYSTER BAY		
1972	1,450	-	9,511	13,013	283,097	4
1973	1,449	-	4,122	1,599	133,307	1
1974	1,039	-	3,425	18,659	470,263	4
1975	1,074	-	22,375	14,414	754,555	5
1976	880	251	14,799	9,199	605,691	3
1977	769	-	6,688	10,745	470,289	3
1978	454	-	9,841	12,216	644,801	4
1979	1,435	-	15,306	4,579	797,183	5
1980	4,705	-	14,106	6,092	1,074,005	6
1981	6,906	-	-	1,842	411,415	2
1982	7,849	-	22,919	5,199	1,890,810	13
1983	2,692	1,432	31,704	11,266	1,816,672	17
1984	3,074	513	33,519	4,781	1,744,121	19
1985	1,607	712	325,787	5,661	2,141,440	22
1986	2,444	705	44,699	17,302	3,357,574	24
1987	2,160	128	67,082	27,740	7,289,549	42
1988	2,639	562	66,442	24,330	7,375,022	41
1989	2,405	348	65,685	22,135	7,987,726	38
1990	2,765	600	43,333	20,739	5,102,786	33
1991	3,990	164	34,885	27,932	4,776,313	36

Source: NYSDEC, Division of Marine Resources, Bureau of Shellfisheries.

In New York, the primary harvested shellfish is hard clams. Hard clam harvests increased from 23,974 bushels in 1972, with a value of $283,097, to 97,110 bushels in 1987, with a value of $7,289,097. The harvest has since decreased to 66,971 bushels in 1991, with a value of $4,776,313 (Table 30). However, the importance of Long Island Sound hard clams relative to the total harvest from New York waters has gone from 3 percent in 1972 to 42 percent in 1987. In 1991, the Sound accounted for 36 percent of the New York harvest. This increase was due to increased shellfish

production in Long Island Sound and reduced hard clam harvests in the southern bays of Long Island (e.g., Great South Bay and Moriches Bay). Two townships, Huntington and Oyster Bay, provide exceptional hard clam harvests and merit special efforts to protect against degradation and improve conditions where possible.

3. Effects of Pathogens on Living Resources

Very few disease organisms are shared by humans, lower animals, and plants. Pathogens are usually specific to a species or class. While pathogens are all of natural origin, quite often human activity promotes their transport and spread among affected species. Because of its human origin, poorly treated sewage is a carrier of human pathogens and, depending on the severity of the problem, can distribute pathogens widely in aquatic environments. Exposure by swimming in contaminated waters or eating contaminated shellfish reintroduces the pathogen into humans. Human activity can also promote plant and lower animal diseases. Stormwater systems, for example, may transport domestic pet and wildlife wastes to other areas, spreading diseases affecting those animals. Disposal of plant wastes may even spread plant diseases to uninfected areas. Promotion of disease in non-human organisms will also occur if human activity stresses plant and animal life, leaving them more susceptible to the pathogens that naturally affect them. Thus, pollution and habitat damage can play a role in plant and lower animal disease outbreaks.

Severe outbreaks of finfish and shellfish diseases can reduce their numbers to the extent that commercial and sport fishing are impacted. Even if an animal infected by a pathogenic organism does not die, it may become weak and more susceptible to predators, or stresses. Pathogens may also be responsible for the development of scars or lesions, making the animal unappealing for human consumption. An example of a fatal pathogen is *Gaffkemia,* which kills lobsters. *Gaffkemia,* although it is a naturally occurring pathogen that does not harm people, has been observed most frequently in lobsters and crabs in the Sound during periods of stressful environmental conditions, such as hypoxia.

Even though few outbreaks of human disease due to consumption of Long Island Sound seafood have been documented, both human and animal pathogens impact resource utilization by rendering the resource unhealthy or unappealing for human consumption, or contributing to the population decline of a harvested species.

C. What Are The Sources of Pathogens?

Typical sources of pathogens to Long Island Sound are inadequately treated human sewage and wild and domestic animal wastes. Inadequately treated sewage is discharged from sewage treatment plants with capacity limitations, plant design flaws, inadequate maintenance or system operation, combined sewer systems, or unrepaired sewage conduits. Other human pathogen sources include failing septic systems and illegal connections to storm drain systems. Illegal connections to sanitary sewers, such as connections of roof drains and sumps, can cause sewer system pipes to overflow at pump stations or manholes during rainfall or electrical failures. Older sewer systems, such as those in New York City and the Connecticut cities of New Haven, Norwalk, Jewett City, Derby, Norwich, Shelton, and Bridgeport, have combined stormwater and sanitary systems. These systems overflow (combined sewer overflows) during rainfalls, discharging untreated sewage with stormwater. (Figure 18.)

Large populations of coastal wildlife, especially waterfowl, may be contributing substantial loads of indicator organisms in some areas, particularly in low density residential neighborhoods. The

primary non-human origin of indicator organisms in nonpoint source runoff is fecal waste from waterfowl, wildlife, and domestic animals. The concentrations of pathogens and indicator organisms in runoff depend on the amount and intensity of rainfall, the time between storms, and land use.

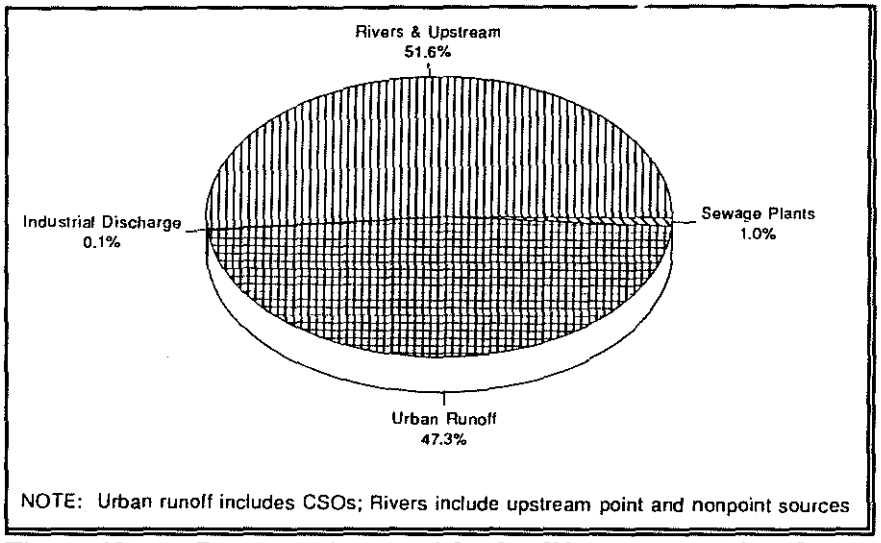


Figure 18 Percent estimates of fecal coliform loadings into Long Island Sound.

D. How Will Pathogens Be Managed?

The sources of pathogens vary from site to site. Therefore, management actions must: (1) control major sources of pathogens, such as combined sewer overflows and stormwater discharges and (2) develop and implement site-specific management plans for each harbor, embayment or discrete shellfish bed area.

The goals for managing pathogen contamination are to:

Increase the amount of area certified/approved for shellfish harvesting while adequately protecting the public health; and

Eliminate public bathing beach closures while adequately protecting the public health.

Consistent with that approach, strategies to meet the goals for controlling pathogen contamination were developed. Other management needs and actions were identified to address vessel discharges, monitoring, research, assessment, and education.

E. Overview of Specific Management Actions

1. Combined Sewer Overflows

Combined sewer overflows (CSOs) are a particular problem in the western portion of Long Island Sound, in and around New York City, and around some large Connecticut cities (New Haven, Norwalk, Jewett City, Norwich, Derby, Shelton, and Bridgeport). Abatement of CSOs is a long-term, costly solution to a major contributor of pathogens to Long Island Sound. CSO abatement in the above-cited cities will directly benefit water quality conditions in the Sound. Abatement programs are currently underway in Connecticut and New York.

New York City has begun to implement a combined sewer overflow abatement program to control the discharge of pathogens at a cost of $1.5 billion with enforceable completion dates for various aspects of the program during the period of 2001 to 2006.

Connecticut will implement its long-term combined sewer overflow abatement program to manage combined sewer areas that affect Long Island Sound. The cities of Norwalk, Jewett City, Derby, Norwich, and Shelton have combined stormwater and sanitary systems that will be corrected by the year 2000 at a cost of approximately $27 million. Bridgeport and New Haven have large systems that will be corrected in phases. The first phases are underway with remaining phases scheduled over the next 20 years at costs of $91 million and $125 million, respectively.

The actions summarized in Table 31 are directed towards managing this source, and are likely to yield significant benefits in terms of reducing bathing beach and shellfish area closures.

Table 31 Controlling pathogen contamination from combined sewer overflows.

ONGOING PROGRAMS	Responsible Parties/Status
Continue CSO implementation programs and update overall management plans to assure implementation addresses bathing beach and shellfish closures and is consistent with water quality standards.	The CTDEP and municipalities are implementing a long-term CSO abatement strategy to manage or eliminate all CSO areas remaining in the Long Island Sound region. This activity is expected to be completed over a 20-year period at a cost of $243 Million. Consistent with the terms of a June 26, 1992 consent agreement with the NYSDEC, the NYCDEP will implement a comprehensive CSO abatement program, including facilities that affect water quality on the Sound. Various aspects of the program are to be completed during the period of 2001 to 2006 at a cost of $1.5 Billion.

2. Nonpoint Sources

Nonpoint sources, including urban stormwater runoff, are major contributors of pathogens to Long Island Sound. Nonpoint sources of pathogen contamination present a challenge to managers because of their diffuse nature and uncertainty about the relationship between indicator organisms and the presence of human pathogens. The Clean Water Act Section 319, Nonpoint Sources Management Program, forms the basis for most of the extensive programs currently established in Connecticut and New York. When implemented, the Coastal Nonpoint Source Control Program, established by Section 6217 of the Coastal Zone Act Reauthorization Amendments will further address nonpoint sources. Primary implementation tools for nonpoint source control include: best management practices, both structural and nonstructural permits; changes in building codes; consent agreements; and education. Stormwater discharges are a major cause of shellfish bed and bathing beach closures, particularly in urban embayments. Reducing inputs from this source, being accomplished through the state general stormwater permitting process, will maintain existing uses and remediate areas for potential use.

The actions summarized in Table 32 are directed towards evaluating the tools and best management practices available for controlling nonpoint sources of pathogens and beginning implementation through existing management programs.

Table 32 Controlling pathogen contamination from nonpoint sources.

ONGOING PROGRAMS	Responsible Parties/Status
Implement the state nonpoint source management initiatives supported with funding from Section 319 of the Clean Water Act.	The CTDEP and the NYSDEC administer programs to reduce loadings from nonpoint sources of pathogens, with federal financing at 50 percent of authorized levels.
Develop state coastal nonpoint source control programs, as per Section 6217 of the Coastal Zone Management Act to address nonpoint source pathogen load from the Long Island Sound coastal zone.	The CTDEP, the NYSDEC, and the NYSDOS are responsible for developing the program at the state level, while the EPA and the NOAA have oversight responsibilities at the federal level.
Implement general stormwater permit programs to control the discharge of stormwater from industrial, construction and municipal activities, as per EPA regulations.	The CTDEP and the NYSDEC are responsible for implementing and managing their permit programs. New York State has initiated its statewide stormwater permitting efforts by focusing on the Long Island Sound watershed, while Connecticut's stormwater permitting program considers regional benefits for Long Island Sound. Both states have issued two General Permits each, one for construction activities and one for all industrial activities, as per definitions in federal stormwater regulations. This requires applicants to develop and implement comprehensive stormwater pollution prevention plans and controls.
Provide technical assistance to coastal municipalities to address impacts of pathogens in their municipal regulations and plans of development, as required by state law.	The CTDEP assists local municipal managers to reduce inputs, using existing staff.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Pursue changes of the State Building Code to include provisions for stormwater management.	NYSDEC NYSDOS	1994/1995	Redirection of base program
Initiate a pilot program to control stormwater discharges using enforceable instruments (i.e., permits or consent agreements). Connecticut and New York will evaluate the effectiveness of the pilot program for more widespread implementation	NYSDEC	Ongoing/ Continuous	$100,000

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Expand current requirements for federally licensed or permitted projects to obtain a water quality certification to include all projects in sensitive areas or where a contaminant or parameter is found to exist at or exceeding threshold value.	NYSDEC	1994/1995	See Table 5 of *Chapter III, Hypoxia* for details.

3. Point Sources

When they are operating properly, sewage treatment plants (STPs) contribute a relatively small percentage of the total pathogens entering Long Island Sound. However, it is necessary to minimize the incidence of malfunctions at the plants that interfere or bypass disinfection processes. Problems like illegal sewer hookups must be corrected and wet weather overflows must be prevented, to protect the public from the effects of accidental pathogen discharge. When problems do occur, prompt

notification, response, and, if necessary, enforcement action must be taken as a priority when sewage treatment plants malfunction. These actions will serve to minimize emergency closing of shellfish beds and bathing beaches located near sewage treatment plants.

Although pathogen concentrations in STP effluent are generally low, the large volumes discharged from many STPs may contribute enough pathogens to locally affect the Sound. Overall, STPs contribute 1 percent of fecal coliform loadings into Long Island Sound.

The actions summarized in Table 33 are directed towards minimizing malfunctions of STPs and preventing dry weather overflows and reducing illegal hook-ups to storm sewers through aggressive management programs. Furthermore, these actions will ensure prompt notification, response, and, if necessary, enforcement action, in cases of raw sanitary waste discharge.

Table 33 Controlling pathogen contamination from sewage treatment plants.

ONGOING PROGRAMS	Responsible Parties/Status		
Minimize malfunctions of treatment systems and eliminate dry weather overflows and illegal hookups to storm sewers through aggressive management programs. Ensure prompt notification and response and take quick enforcement action.	The CTDEP and the NYSDEC, using existing enforcement programs, will take administrative actions in cases where the closure of beaches or shellfish beds could have been prevented by proper operation and maintenance of STPs.		
Identify and take priority enforcement actions to control wet weather overflows from sewers caused by excessive infiltration and inflow.	The CTDEP and the NYSDEC, in coordination with local municipalities, administer programs to detect and correct illegal sewer hookups and control dry weather overflows from sanitary sewers.		
COMMITMENT	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Implement a beach and shellfish closure action plan to take immediate corrective and priority enforcement actions addressing improperly treated municipal discharges. Preventable incidents involving beaches and shellfish areas will be emphasized.	CTDEP NYSDEC EPA	Ongoing/ Continuous	Redirection of base program

4. Vessel Discharges

Vessel discharges do not contribute a major percentage of pathogens to Long Island Sound, but can cause localized water problems, particularly if the discharges occur in the vicinity of shellfish beds or swimming beaches. Creation of vessel *No Discharge* zones, development and implementation of *best management practices* at marinas, and increasing the number of marine pump-out facilities on the Sound and its tributaries are key elements of managing vessel discharges. In addition, during the permitting process, the proximity of proposed docks and marinas to shellfish waters, bathing beaches, wetlands, and other important habitat areas will be emphasized. The actions summarized in Table 34 are directed towards controlling waste from vessel discharges.

Table 34 Controlling pathogen contamination from vessel discharges.

ONGOING PROGRAMS	Responsible Parties/Status
During the permitting process, minimize the impacts of boat dockage facilities and temporary live-aboard anchorages by considering their proximity to productive and certified shellfish waters, existing boat channels, wetlands, and critical habitat areas, and tidal flushing in the waterway.	The CTDEP, the NYSDEC, and the NYSDOS, through existing regulations such as the Tidal Wetland Act, Protection of Waters, Water Quality Certification, and the Coastal Nonpoint Source Program.
Consider the impacts of vessel discharges through appropriate resource management and recovery programs and will limit or condition the siting or operation of boating facilities as necessary to minimize such impacts.	The CTDEP and the NYSDEC administer these existing programs. Siting of facilities is already considered in the permitting process.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
New York state and Connecticut will apply to the EPA to create vessel *No Discharge* areas in specific embayments and harbors after ensuring the sufficient availability of pump-out stations and treatment facilities.	CTDEP NYSDEC EPA Local Municipalities	Ongoing/ Continuous	Redirection of base program
New York state has identified Huntington and Lloyd Harbors as areas requiring additional protection and the EPA has Public Noticed its tentative determination that there are adequate pump-out facilities in these areas.	NYSDEC EPA	1993/1994	Redirection of base program
Connecticut, through a 319 grant, will ensure completion of a marina and mooring area water quality assessment guidance document. Connecticut has also completed a marinas *best management practices* project report for nonpoint sources of pollution, which may be used to develop requirements for use of certain best management practices at marinas. New York state will review these documents for potential incorporation into state management programs.	CTDEP NYSDEC	Ongoing/ Continuous	Redirection of base program
Complete regulations to require pump-out facilities as required by, and in accordance with, state law.	CTDEP	Ongoing/ Continuous	Redirection of base program
The states of Connecticut and New York have received funding from the Federal Clean Vessel Act to conduct a pump-out needs survey, determine the effectiveness of existing facilities, develop and implement plans for construction of additional pump-out stations by marinas and prepare education/information plans.	CTDEP NYSDEC	Initiated 1993/ Completion 1995	$1 million for NY. $120,000 for CT.
Collect information on sewage discharge controls in Long Island Sound, disinfection chemicals used, boater education and sewage treatment plant acceptance of pump-out wastes. Evaluate availability of treatment capacity for pump-out wastes and secure commitments from municipalities to accept these wastes.	NYSDEC Municipalities	Initiated 1994/ Completion 1994	$42,000

5. On-site Systems

Nearly half of the homes and businesses in the Long Island Sound watershed have septic tank waste disposal systems. When located appropriately and functioning properly, septic systems should not be

a source of pathogens to Long Island Sound. When properly sited and maintained, septic systems are an excellent waste management alternative. However, when not properly sited or maintained, they can be a source of pathogens. It is important for both states to coordinate management actions with local governments to determine when and if septic systems are failing and impacting shellfish areas and bathing beaches.

The actions summarized in Table 35 are directed towards controlling contamination from on-site systems, where they have been identified as a source of pathogens contributing to water quality problems.

Table 35 Controlling pathogen contamination from individual on-site systems/discharges.

ONGOING PROGRAMS	Responsible Parties/Status		
Connecticut and New York state are coordinating management actions with local governments when on-site septic systems are found to be failing and impacting shellfish growing areas and bathing beaches.	CTDEP NYSDEC Local municipalities and health agencies.		
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Continue and enhance management actions with local governments when on-site septic systems are found to be failing and impacting shellfish growing areas and bathing beaches.	CTDEP NYSDEC Local municipalities and health agencies to administer the program. Repairing or upgrading the systems will be at property owner expense.	Ongoing/ Continuous	Redirection of base program. Enhancement costs: $100,000 to increase staff; $60,000 for administrative costs per year per state
Evaluate existing septic system controls (including system monitoring, required maintenance and repair and replacement of failing systems) to determine if they are sufficient to protect coastal ecosystems and recommend changes to local governments.	NYSDEC	Continuous based upon availability of funding	$120,000 to increase staff; $200,000 for field and laboratory expenses; $30,000 for administrative costs

6. Public Education

Some of the sources of pathogen contamination in Long Island Sound can be reduced or eliminated by relatively simple lifestyle changes on the part of the general public. For this reason, the LISS has developed a public education plan. It will target specific audiences, and will be coordinated with efforts by federal, state, and local public outreach experts. Education of the general public, local municipal officials, boaters, and other groups about pathogen issues will help ensure that risk of contamination and exposure are reduced and will facilitate management actions. The action summarized in Table 36 is directed towards providing education opportunities for the above-mentioned groups to learn about sources of pathogenic contamination and best management practices effective in controlling pathogens.

Table 36 Controlling pathogen contamination through public education.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Develop and implement a public education plan, targeting specific audiences, in cooperation with federal, state and local public outreach experts and environmental education	LISS Management Conference	Upon available funding.	$20,000; See *Chapter X, Public Involvement and Education* for details.

7. Monitoring and Assessment

Even with the implementation of these actions, it will be necessary to monitor Long Island Sound, particularly bathing beaches and shellfish areas, for pathogen contamination. Data from monitoring must be assessed to determine the success of pathogen abatement actions, as well as to determine an areas fitness for recreational activities and harvesting of shellfish.

Monitoring and assessment are essential to improved understanding of pathogen contamination in the Sound. Site-specific management plans for harbors and embayments with shellfish growing areas and bathing beaches need to be developed. The actions summarized in Table 37 are directed towards enhancement of monitoring, assessment, and research of pathogen contamination to ensure proper management of bathing areas and shellfish harvesting areas.

The monitoring objectives for pathogens (Table 37) focus on bathing beaches and shellfish harvesting. Monitoring approaches for pathogens, or pathogen indicators as is usually the case, have not been developed by the LISS. A monitoring approach needs to be structured to answer the questions:

- What is the geographical extent, temporal duration and frequency of pathogenic contamination affecting use of bathing beaches and shellfish beds?
- What are the sources of pathogens affecting the uses of Long Island Sound and its resources?

To protect beachgoers and shellfish consumers, both states have programs that are implemented at various governmental levels to monitor presence of pathogen indicators. In New York, primary responsibility for bathing beaches falls to county governments and shellfish sanitation is monitored by the NYSDEC. In Connecticut, state beaches are monitored by the CTDEP, town beaches are monitored by local health officials, and shellfish beds are monitored and regulated by the Connecticut Department of Agriculture, Aquaculture Division. These programs are successful at protecting beachgoers and shellfish consumers, but they do not document sources of the pathogen indicators. Some sources, such as sewage treatment plants, are required to monitor pathogen indicators to check disinfection effectiveness, as specified in their permits. Occasionally, nonpoint and riverine sources of pathogen indicators are sampled to determine sources of pathogens, including natural sources, that do not appear to be originating from a point source but are impacting water quality. Connecticut Department of Agriculture, Aquaculture Division also has a monitoring program for paralytic shellfish toxins, which are produced by microscopic organisms that inhabit the water column. The Monitoring Workshop reviewed the existing programs and identified ways that monitoring can help us understand the sources of and the relationship between pathogen indicators and actual human risk from swimming and consuming shellfish.

Table 37 Monitoring and assessment of pathogens.

ONGOING PROGRAMS	Responsible Parties/Status
Review existing data and reports and the recommendations of the Monitoring Workshop to identify shellfishing or bathing areas in need of further assessment.	The LISS is responsible for coordinating the workshop. Monitoring responsibility lies with many local, state, federal, and private entities. The workshop was conducted in 1993, and implementation can begin, pending funding.
Perform bacterial surveys of harbors and embayments to identify contaminated shellfish areas and potential sources of pathogens as required by the National Shellfish Sanitation Program.	The CTDEP, the CT Dept. of Agriculture/Aquaculture Division and the NYSDEC administer these ongoing programs, as per the National Shellfish Sanitation Program, which requires pollution source inventories for all Approved/Certified shellfish areas.
Use seasonal or conditional certification of shellfish harvest areas, as may be warranted by water quality variations, under guidelines provided by the National Shellfish Sanitation Program.	The CTDEP, the CT Dept. of Agriculture/Aquaculture Division, and the NYSDEC administer these programs.
Meet annually with health directors of coastal municipalities to refine monitoring and bathing beach closure protocols and share information.	The CTDEP and local authorities will hold a one-day meeting annually.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Evaluate existing monitoring programs and, as necessary, make recommendations for enhancement.	LISS CTDEP NYSDEC	Initiated 1993/ Completion 1994	Base program redirection

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Conduct a workshop to determine appropriate and consistent methods for bathing beach monitoring and laboratory analysis and work to adopt, if feasible, common methods.	LISS Management Conference	Upon availability of funding	$5,000
Implement the recommendations of the LISS Monitoring Plan to enhance pathogen monitoring.	CTDEP NYSDEC	Upon availability of funding	$10,000
Develop and conduct a dry and wet weather sampling program for specific drainage basins. Both states will evaluate this pilot program for possible expansion.	CTDEP NYSDEC	Upon availability of funding	$250,000
Assess the impacts of identified point and nonpoint sources and assign priorities to areas where management actions are most likely to be beneficial. Priority criteria will include viability of the resource, feasibility and cost-effectiveness of management. Enhance state bacterial surveys of harbors and embayments to identify contaminated shellfish areas and potential sources of pathogens.	CTDEP CT Dept. of Agriculture/ Aquaculture Division NYSDEC	Upon availability of funding	$150,000 per year for each state

Support the efforts to develop a better understanding of the relationship between pathogen indicators and the risk to public health such as the National Indicator Study.	LISS Management Conference	—	Not Estimated.
Along with supporting the National Indicator Study, investigate funding for a regional epidemiological survey to determine the relationship between waters of varying indicator quality and public health.	CTDEP NYSDEC EPA State and local health departments	Upon availability of funding	$500,000

VI. Floatable Debris

A. What is Floatable Debris and Why Is it a Problem?

Trash found floating in coastal waters and bays, or washed up on the beach is called floatable debris. Floatable debris is a unique form of water pollution because it is readily visible to even the untrained eye.

Most floatable debris consists of waste material and litter from the products we use on a daily basis — cigarette filters, plastic juice containers, paper, plastic wrapping, styrofoam cups — products that are used and then discarded carelessly or improperly. Whether such reckless disposal occurs at the beach or waterfront area or far inland, the litter can be transported by stormwater runoff or wind to the Sound.

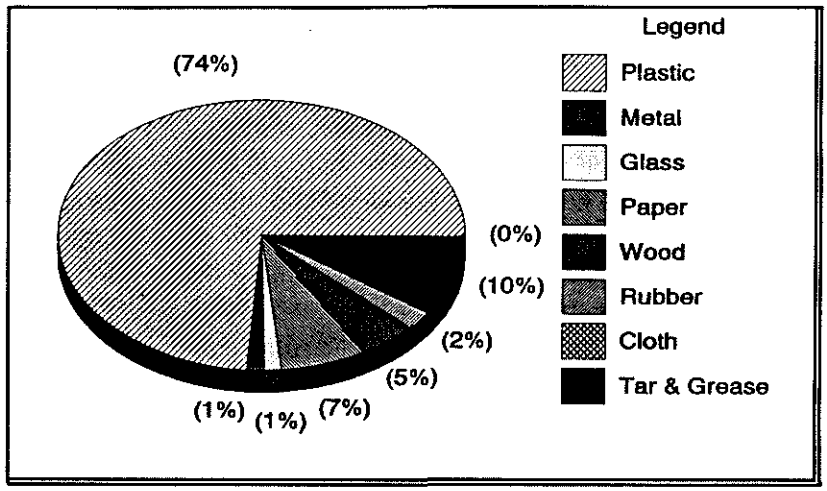


Figure 19 Percent composition of debris collected during survey of Long Island Sound based on number of items collected.

Figure 19 shows the composition of debris collected along the shores of Long Island Sound during the 1990 National Beach Cleanup, by percentage, based on the number of items in each general category. Clearly, plastic was the single largest component of debris found on beaches during that year, comprising 74 percent of the total. This is similar to the national totals, where plastic comprised 64 percent of the debris collected. During the 1990 National Beach Cleanup, the most abundant items collected were: cigarette filters (12.6%), plastic pieces (6.8%), foamed plastic pieces (5.9%), paper pieces (4.7%), glass pieces (4.6%), plastic food bags and wrappers (4.2%), glass beverage bottles (4.0%), metal beverage cans (4.0%), plastic caps and lids (3.9%), plastic straws (3.3%), foamed plastic cups (2.8%), and plastic eating utensils (2.4%). These twelve types of items made up over 59% (by number) of the materials collected that year.

Debris floating on Long Island Sound or stranded on beaches and shorelines is not just aesthetically repugnant, it is symptomatic of more basic problems in infrastructure and in personal behavior. There have been severe economic consequences for tourism, fishing, boating, and other recreational businesses that depend on the public's appreciation of Long Island Sound's waters and beaches and their trust in its environmental quality.

Floatable debris, when not combined with sewage (as can happen through combined sewer overflows), is not particularly dangerous to humans. While unsightly and sometimes offensive, most of this material is common trash. However, following numerous sightings of floatable debris in the Sound in 1988, justifiable public concerns over water pollution escalated as irrational fears overwhelmed common sense. The floatable debris included a small number of syringes which alarmed people into believing that the Sound was awash with dangerous medical waste. In reality, approximately two shopping bags full of medically related waste were removed. Most of this was believed to have washed into the Sound from city streets or combined sewers. No evidence of illegal

dumping was found. Nevertheless, attendance at beaches on Long Island's South Shore plummeted 5.6 million from 1987 to 1988. Seafood retailers and restaurateurs throughout the northeast saw business plummet as public concern over beach safety expanded into worries about the health effects of seafood consumption. The loss to the Long Island economy alone for the summer of 1988 was estimated to be as high as $1-2 billion. Drastic social and economic consequences resulted from this particular floatable debris problem.

Floatable debris is also a nuisance and hazard for boaters. Floating lines can foul a boat's propellers. Sheets of plastic and plastic bags can block an engine's cooling water intake, resulting in the engine overheating. Larger, heavier floatable debris can cause hull or propeller damage to boats that inadvertently run into it.

Floatable debris can have serious impacts on the estuarine life of Long Island Sound, primarily when it is ingested or when organisms become entangled in it. Ingestion can cause suffocation or starvation. For example, plastic packing pellets, a common component of floatable debris, resemble food items such as fish eggs — a diet staple of many birds and finfish. Since the pellets are undigestible, they remain whole in the stomachs of these animals, leaving very little or no space for real food. If the pellets are not expelled, the animals may starve to death. Entanglement occurs when an animal becomes trapped and immobilized in debris. The animal cannot move to obtain food, escape from predators, or breathe properly. It could lose limbs due to strangulation or infection, or die by starvation, predation, or drowning. Types of floatable debris commonly responsible for entanglement include six-pack holders, ropes, cargo strapping bands, and fishing gear such as nets and fishing line. While endangered and threatened species are no more vulnerable than others to floatable debris, there is a special concern. Since there are very few individuals of these species that remain, death of even one can be detrimental to the sizes of their populations.

B. What Is the Extent of the Floatable Debris Problem in Long Island Sound?

The LISS has concluded that floatable debris in Long Island Sound, although much less concentrated than in New York Harbor, is present in great enough quantities to be of concern. The presence of floatable debris is greatest in the areas of highest population, usually in the western Sound. Debris in the Sound is characterized by relatively small sized plastic and paper materials, such as food wrappers, plastic bags, straws, coffee stirrers, styrofoam pieces, and plastic beverage containers. Sewage-related items are less common but still significant. Medically related wastes such as syringes and needle caps are present but in very small quantities not indicative of hospital or health facility illegal dumping. Medically related wastes are probably flushed down toilets or discarded as litter by individual users of insulin and other, often illegal, drugs.

Due to the effects of winds and currents, floatable debris has a tendency to accumulate into *surface slicks*, rather than dispersing. Debris slicks are concentrations of naturally occurring material, such as detached seaweed and marsh grass, along with common trash. These surface slicks may accumulate in large enough quantities that the slick can cover big areas of aquatic vegetation or other organisms, preventing photosynthesis, respiration, or movement. Large debris slicks may cause localized problems when they wash ashore. Once ashore, floatable debris mars beaches, thus diminishing public enjoyment of them.

While floatable debris can be a real threat to the estuarine life of the Sound, documentation of its effects is scarce. This may be because animals that die from entanglement or ingestion do so offshore

and unobserved. In other areas near the Sound, such as the South Shore of Long Island, there have been many cases of whales and turtles, animals listed as endangered or threatened, dying because of floatable debris.

C. Where Does Floatable Debris Come From?

Although frequently mentioned together in the press, beach debris is unrelated to either sewage sludge or dredged sediments disposal. In addition, no municipal garbage has been legally disposed of in area waters for more than 50 years. Illegal disposal is not common enough to account for much of the problem. The sources of floatable debris are more pervasive and complex than illegal dumping. Most of this debris started out on our streets as common litter or in our homes as household waste.

COMBINED SEWER OVERFLOWS

In older urban areas, the storm and sanitary sewers are combined in underground pipelines. In a combined system, the flood of water from any substantial rainfall (as little as 0.04 inch per hour in New York City) overloads the capacity of the sewage treatment plant. Everything in the system, including sewage and floatable debris, is allowed to pass unscreened and untreated into the nearest body of water. This "raw" discharge is called a combined sewer overflow (CSO). CSOs discharge floatable wastes, as well as bacteria, nutrients, and other contaminants from the sewer system and roadways directly into the local waterways and the Sound.

Sidebar 11 Combined sewer overflows.

Floatable debris enters the Sound three ways:

- Through litter delivered by stormwater discharges and combined sewer overflows;
- From New York Harbor and tributaries to the Sound; and
- By being deposited by shoreline visitors and boaters.

The relative contribution of each source is difficult to quantify, but storm sewers and CSOs are probably the most significant. This conclusion is based on the observation that the debris consists of items found in common street litter. This is further documented by an extensive floatable debris study conducted by the NYCDEP. Their findings indicate that more than 82 percent of the floatable debris found in the waters of New York Harbor originates from CSOs and stormwater sewers. Common street litter comprises most of the debris delivered via the storm sewers or from CSOs. A much smaller but often offensive fraction of the debris is material improperly flushed down the toilet. It is then washed into coastal waters during CSO events.

D. How Will Floatable Debris Be Managed?

There are two main ways to manage floatable debris: reduce the flow of litter from its major sources (including CSOs, stormwater sewers, and tributaries to the Sound) and collect and pick it up once it is in the Sound. Ultimately, the most effective strategy is to combat the root cause of the problem -- littering and improper disposal. To reduce the flow of floatable debris into the Sound, the LISS has proposed management actions centered around two areas: 1) combined sewer overflow abatement and stormwater management, and 2) education. Additional actions address cleaning up floatable debris once it has entered the Sound.

The underground infrastructure systems in towns and cities must be changed to abate or eliminate the CSO contribution to the problems of floatable debris, as well as nonpoint sources. The redesign and restructuring of these systems are major public works projects, involving large amounts of money, long periods of time, and inconvenient disruption of services. Nonetheless, the states of Connecticut

and New York and individual cities are undertaking projects to separate storm sewers from municipal lines and re-channel or retain storm runoff. Unless stormwater is retained, the same problem persists.

The floatable debris problem is where the two major environmental concerns of water pollution and solid waste disposal meet. Stopping floatable debris at its sources — households, businesses, institutions and streets — must be tied to public awareness, litter control, recycling, and enforcement of existing laws.

More immediate attempts at controlling floatable debris involve debris collection, either in the water or after it has washed up on beaches. Although they do not deal with floatable debris at their sources, programs to remove debris from beaches may restore public confidence which was lost during recent summers and increase public stewardship of Long Island Sound.

E. Overview of Specific Management Actions

1. Combined Sewer Overflows and Stormwater

One important component of the plan to manage floatable debris in Long Island Sound is to ensure regional coordination to implement the floatable debris recommendations of the LISS. This would benefit the Sound because technical and management transfer is the first step in developing an integrated regionwide control strategy. A forum to discuss (regionally and nationally) tried or implemented management approaches as well as current technological innovations will help managers determine the most efficient and cost-effective plans of action for floatable debris abatement. To begin this process, a representative from the CTDEP will be appointed as a member of the New York-New Jersey Harbor Estuary Program/New York Bight Restoration Plan Floatable Debris Work Group to integrate regional floatable debris control programs to share floatable abatement technology.

Surveys of floatable debris in Long Island Sound found that the majority of items were typical of common street litter. CSOs and stormwater discharges are major sources of street litter to the Sound. New York City has the only combined system in New York that discharges to Long Island Sound. In Connecticut, all of the state's CSOs are in the Sound watershed.

To address its CSO problem, New York City is implementing a comprehensive CSO abatement program. The program includes plans for the areas of Newtown Creek, the East River and Flushing Bay in the western Sound. CSO abatement was the subject of a consent order between the New York State Department of Environmental Conservation and the New York City Department of Environmental Protection that was signed on June 26, 1992. This agreement sets an implementation schedule for CSO abatement in New York City, including areas adjacent to Long Island Sound.

As a part of the CSO program, the city government will implement a citywide planning program to control the discharge of floatable debris from CSOs. They will also evaluate abatement alternatives such as street cleaning, catch basin maintenance and replacement, booming and skimming, and public education. The city is also planning to construct multi-million gallon retention basins underground to capture CSO discharges.

The plan is intended to benefit the Sound by removing floatable debris from the waste stream, before they have a chance to enter the Sound. To accomplish this, the plan includes short-term measures to abate floatable debris discharges from more than 50 percent of the city's CSO drainage area by early 1994. Also included are enforceable end dates (ranging from the year 2001 to 2006) for completing

construction of retention tanks. This will ensure that water quality standards for dissolved oxygen and coliform are met. For CSOs not covered by the 1994 abatement deadline, the plan establishes enforceable dates for initiation of construction of floatable debris capture facilities.

In Connecticut, the CTDEP will continue to implement its long-term CSO abatement strategy to manage or eliminate all combined sewer areas remaining in the Long Island Sound region. Connecticut's strategy includes developing and implementing measures to reduce pollutant loadings as well as engineering designs to minimize floatable debris released from CSOs. Enforceable administrative orders exist with Norwalk, New Haven, Bridgeport, and municipalities with CSOs along major tributaries (Norwich, Jewett City, Derby, and Shelton) addressing separation of sewerage and stormwater drainage systems. Each municipality in the state has submitted an individual plan and has committed to milestone dates.

Floatable debris also enters the Sound through stormwater discharges. In 1987, Congress, recognizing that stormwater represents a significant source of pollutants, amended the National Pollutant Discharge Elimination System (NPDES) to require permits for certain stormwater discharges. The EPA developed regulations to implement the new stormwater NPDES program, which is administered by the EPA and those states authorized by the EPA, which include Connecticut and New York.

New York and Connecticut are implementing general statewide stormwater permit programs to manage stormwater from industrial and construction activities, in accordance with the EPA's national program regulations. The permits regulate construction activity at sites greater than five acres and from 11 industrial categories. Regulations also apply to cities with a population of more than 100,000. In the Long Island Sound area, this includes New York City and the City of Stamford. The states of Connecticut and New York will continue to work with their respective cities to control their discharge of stormwater in order to meet the EPA's national stormwater management regulations. Other cities can be asked to voluntarily improve their street cleaning efforts to reduce the amount of debris washed from the streets into the storm drain system, and from there into the Sound.

Connecticut and New York have issued two general permits each for construction and industrial activities identified by federal stormwater regulations. In order to receive a permit for industrial activities, applicants will be required to develop and implement comprehensive stormwater pollution prevention plans and controls that minimize the potential for polluted runoff from storms and monitor runoff according to the type of activity and the type of pollutants that might be discharged. Permits for discharges from new construction areas greater than five acres will require the applicant to develop and submit a plan addressing pollution that would occur during as well as after construction.

The largest contributors of wastewater to the Sound are sewage treatment plants. When sewage treatment plants become disabled by power outages or equipment failures, untreated wastewater carrying both sewage and floatable debris can be discharged directly into the Sound. More than 1.2 billion gallons of wastewater from homes and businesses are discharged daily by the 45 sewage treatment plants adjacent to the Sound. Plants are outfitted with mechanisms such as screens that filter out floatable debris and remove it from the waste stream. However, continual maintenance is necessary to ensure that the plants are operating properly, otherwise they become sources of debris.

The Long Island Sound Study recommends maintenance of sewage treatment plant equipment to continually pull floatable debris out of the waste stream. This would benefit the Sound by preventing

solid pollution from entering tributaries or the Sound itself. Municipal authorities operating the plants should schedule regular maintenance. A Metcalf and Eddy study gives estimated capital costs for minor modification retrofit option at all plants to be almost $3,000,000.

These actions will benefit the Sound by preventing floatable debris from entering the Sound and its tributaries. The LISS agrees to actions summarized in Table 38 that will control floatable debris from CSOs and stormwater sewers.

Table 38 Controlling floatable debris from CSOs and stormwater sewers.

ONGOING PROGRAMS	Responsible Parties/Status
Continue implementation of long-term CSO abatement programs to manage or eliminate all CSO areas remaining in the Long Island Sound region.	CTDEP, NYSDEC, NYCDEP, and local municipalities. See Table 31 of *Chapter V, Pathogen Contamination* for further detail.
Control discharge of stormwater from industrial, construction, and municipal activities in accordance with the EPA's national program regulations.	The NYCDEP began control of stormwater discharges in 1993. The City of Stamford will begin control in May 1994.

2. Education and Cleanup

The LISS recommends that existing floatable debris education and cleanup efforts be continued and enhanced, particularly in municipalities that have combined sewer overflows or storm sewers discharging into Long Island Sound or its tributaries.

A. New York-New Jersey Harbor Estuary Program Floatable Debris Cleanup

The New York-New Jersey Harbor Estuary Program has developed detailed short- and long-term floatable debris action plans for the Harbor. The implementation of these action plans will significantly reduce the amount of floatable debris entering the Sound from the harbor.

B. Storm Drain Stencilling

In addition to actions by the federal, state, and municipal governments, there are many things that citizens can do to prevent floatable debris from ending up in the Sound. One public activity to assist with floatable debris control is storm drain stencilling. The New York Sea Grant Extension Program, Connecticut Sea Grant Marine Advisory Program and Long Island Sound Study have organized volunteers from civic associations, schools, environmental and youth groups who use pre-made stencils to paint messages such as *Don't dump — drains to Long Island Sound* onto storm drains in their community. Many people are not aware that litter, motor oil, antifreeze and paint must not be put into storm drains. The painted messages discourage the dumping of litter and pollutants in and around storm drains, effectively increasing public awareness. Messages including *Don't Dump, Drains to Bay (River, Ocean, Harbor, Our Drinking Water)* have also been made into stencils. Administrative costs for these activities are approximately $500 (per event). This covers publicity, paint, etc. This program can be enhanced by expanding it into different townships. Enhancement costs would be $100,000.

C. *CLEAN STREETS/CLEAN BEACHES*

Stencils carrying the message *Clean Streets/Clean Beaches* have also been developed and painted on storm drains. *Clean Streets/Clean Beaches* is a new anti-litter campaign that was launched in April 1992 by a coalition of public and private groups in New York and New Jersey. The main thrust of the campaign is public education.

The program's purpose is to bring the link between street debris and its impact on beaches to the public's attention. The theme emphasizes that litter thrown in the street washes into storm sewers during heavy rainfalls. The litter then enters our waters through CSOs and stormwater sewer outfalls and ultimately washes up on local shorelines. The campaign is intended to make people aware that street debris ultimately turns up on beaches, and because of this new awareness, change their behavior to prevent littering. Some public education tools being used include an educational video with teacher's guide and a children's newspaper. A poster in English and Spanish has been distributed. The *Clean Streets/Clean Beaches* storm drain stencil was developed by the New York Sea Grant and is available for distribution. Annual publicity events featuring celebrities have been sponsored to drum up local support.

The EPA awarded $100,000 in grants for the anti-litter campaign, the education video and materials, and the stencil program. The program will be enhanced, specifically to include outreach to individual schools and small businesses. Enhancement costs will be $100,000.

D. *PACK IT IN/PACK IT OUT*

For the small cost of making and hanging signs, Connecticut has implemented a limited Pack It In/Pack It Out policy for solid waste management at some parks and other public areas. In many areas that typically generate a low volume of trash, the state removed trash receptacles and put up signs asking people to take their garbage with them. Many of these receptacle-free sites are reported to remain cleaner than those with containers. This program prevents litter from being washed into the Sound, or in to tributaries of the Sound. In addition, the absence of trash receptacles, which often contain food waste, reduces the presence of species such as rats, gulls and raccoons, which can cause harm by displacing and preying upon more sensitive species, such as piping plovers and terns.

E. NATIONAL BEACH CLEANUP

Once litter is carried into the Sound by tributaries, CSOs, or storm drain sewer outfalls, it washes up onto local beaches. The Long Island Sound Study will expand its efforts to clean up local beaches by supporting the National Beach Cleanup Program. As a part of the National Beach Cleanup effort, annual cleanups of Long Island Sound shorelines have taken place since 1988. Each year volunteers pick up trash from shorelines adjacent to the Sound. Removing debris from beaches improves the aesthetic enjoyment of this natural resource. Conducted by volunteers as part of the national *Coastweeks* program, the cleanup is coordinated in New York by the Department of Environmental Conservation and in Connecticut by the Connecticut Sea Grant Program. The EPA will expand its involvement in the project through the Long Island Sound Office. The National Beach Cleanup Program costs $10,000 per state per year. The money is mainly for administration, including publicity, garbage bags, etc. A second beach cleanup in the Spring, prior to the beach season, is a possible enhancement of this program, and would cost an additional $10,000.

F. Routine Beach Cleanups

The introduction of floatable debris to the Sound will be reduced with the implementation of CSO and stormwater controls. However, cleanup activities play an important role in reducing the street litter from those sources and minimizing the overall impact of floatable debris that has entered the Sound.

Routine beach cleanups are conducted twice per day at New York state beaches and once per day at Connecticut beaches during the summer season. Neither state has provisions for regular beach cleaning during the off season.

Recommendations for maintaining clean beaches and minimizing resuspension of debris back into Long Island Sound waters include:

- Clean beaches in the evening to prevent resuspension overnight.
- Use solid waste receptacles with lids instead of the open mesh type.
- Provide recycling containers in convenient locations.
- Use environmentally responsible containers for food and beverages at concession stands.

G. Directory

A recent survey by the EPA identified more than 100 volunteer groups in the New York metropolitan area who work on projects and activities to reduce marine debris. Projects include recycling at marinas, litter reduction and beach cleanup programs. Compiling and distributing a directory of these groups could attract new volunteers and help new groups that plan to implement similar projects.

H. Reduce and Recycle

Less packaging and more recycling limit the total amount of litter available to end up in the Sound. An effective floatable debris management program must encourage the public and manufacturers to promote recycling, use less packaging and substitute products made from degradable material whenever possible.

I. Boat Waste

Solid waste generated aboard commercial and recreational vessels also contributes to floatable debris found within Long Island Sound. The Sound is heavily used by recreational boaters. On a high-use day, such as during a holiday weekend, there may be as many as 25,000 boats on the water. Even small quantities of shipboard wastes thrown overboard can add up quickly into a substantial source of floatable debris.

A federal law requires all ports and docking facilities with more than 10 slips to provide adequate trash receptacles for wastes generated while at sea. The EPA awarded a $71,000 grant to the NYSDEC to conduct a demonstration project encouraging proper solid waste handling and recycling at five Marinas in New York, four of which are located adjacent to the Sound. The project is intended to educate boaters by example. The boaters would see, learn, and then use demonstrated methods for handling on-board wastes and methods for recycling. This program will be expanded and implemented at all marinas on the Sound. Expanding the program will cost $10,000 per location.

J. BOAT USE

Marina operators should be encouraged to accept responsibility for litter control and recycling. For example, more bait and tackle shops and marinas should collect used monofilament fishing line for recycling and publicize the reason for careful disposal of fishing gear.

Floats and floating docks are usually made of styrofoam and polystyrene. They decompose into fragments and disperse into coastal waters. If organisms burrow into the material, they can cause additional fragmentation. Agencies that issue permits to construct piers and docks should require floatation materials that are resistant to decomposition and fragmentation. This would result in a substantial reduction in floating debris generated by boat owners at marinas.

The Long Island Sound Study agrees to actions summarized in Table 39 that will increase cleanup efforts, particularly prior to and during the beach season, along the Sound and in municipalities that have CSOs or storm sewers discharging into Long Island Sound or its tributaries.

Table 39 Increasing floatable debris cleanup efforts.

ONGOING PROGRAMS	Responsible Parties/Status
Continue to implement *Pack It In/Pack It Out* anti-litter campaign.	CTDEP and the public.
The New York-New Jersey Harbor Estuary Program has developed detailed short- and long-term floatable debris actions plans for the New York-New Jersey Harbor.	The plans are being implemented by the U.S. Army Corps of Engineers, USEPA, NYSDEC, NYCDEP, NJDEPE, and municipalities. The program was initiated during the summer of 1989 and is ongoing at a cost of $1,000,000 per year.
National Beach Cleanup Program. As part of this program, annual cleanups of Long Island Sound shorelines have taken place since 1988. As presently constituted, this program costs $10,000 per year per state to coordinate and support volunteer efforts.	NYSDEC, Connecticut Sea Grant Program, Volunteers

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Continue to implement *Clean Streets/Clean Beaches* anti-litter campaign.	Coalition of public and private groups in New York and New Jersey	This action was initiated in 1992 and is ongoing.	$100,000 grant from the EPA
Conduct a demonstration project to encourage proper solid waste handling and recycling at 5 marinas.	NYSDEC	1991	$71,000 grant from the EPA

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Expand involvement in *Coastweeks* program to include a second beach cleanup in the spring, prior to the beach season.	LISS Management Conference	----	$20,000 per year
Continue to coordinate volunteers to paint stencilled messages on storm drains, such as *Don't Dump—Drains To Long Island Sound*.	New York Sea Grant Extension Program, Connecticut Sea Grant Marine Advisory Program, Long Island Sound Study, Volunteers	Ongoing	$5,000; See *Chapter X, Public Involvement and Education* for details.
Maintain clean beaches and minimize resuspension of debris back into Long Island Sound waters by: - Cleaning beaches in the evening to prevent resuspension overnight. - Using solid waste receptacles with lids instead of the open mesh type. - Providing recycling containers in convenient locations. - Using environmentally responsible containers for food and beverages at concessions stands.	State and local governments.	—	—
Compile and distribute a directory of volunteer groups in the Long Island Sound watershed that work on projects and activities to reduce marine debris.	LISS	—	See *Chapter X, Public Involvement and Education* for details.
Encourage the public and manufacturers to promote recycling, use less packaging, and substitute products made from degradable material whenever possible.	—	—	—
Encourage marina operators to accept responsibility for litter control and recycling.	—	—	—
Require floatation materials that are resistant to decomposition and fragmentation.	—	—	—

3. Monitoring and Assessment.

Little monitoring of floatable debris is presently conducted in Long Island Sound. However, citizens' activities such as beach cleanup days provide invaluable information on the distribution of floatable debris washups and their severity. While floatable debris monitoring would provide a useful function in any waterbody and within its drainage basin, floatable debris has been shown to be a relatively minor problem in the Sound. For that reason, the LISS Management Conference will pay attention to floatable debris problems as they arise, conduct surveys, if necessary, and review citizens' data and reports to continually re-evaluate the severity of the problem and the need to monitor.

VII. Management and Conservation of Living Resources and Their Habitats

A. What are the Living Resources of Long Island Sound and the Habitats They Occupy?

In **The Great Gatsby**, F. Scott Fitzgerald wrote, *"The most domesticated body of salt water in the Western Hemisphere, the great wet barnyard of Long Island Sound."* When he penned this description of Long Island Sound, it had suffered from decades of abuse during the industrialization of the region. However, in many respects, environmental quality has improved since the early part of this century. Long Island Sound is now the greatest producer of oysters on the east coast;, some of its islands are essential breeding habitat for endangered birds; it contains critical feeding and spawning habitat for marine fishery resources that occur along the entire Atlantic seaboard; and it serves as a major pathway for migration of many important anadromous fish species. The Connecticut River estuary complex has been designated by the U.S. Department of Interior as one of 15 priority ecosystems in the United States and the Nature Conservancy has identified it as one of its *40 Last Great Places*.

The coastal environs of Long Island Sound represent a unique and highly productive ecosystem with a diverse array of living resources, ranging from microscopic plants and animals that drift with the currents to seaweeds and economically important finfish, shellfish, and crustaceans. In addition, many other types of wildlife, such as birds, sea turtles and marine mammals, spend all or part of their lives in Long Island Sound, on its shores, or in its extensive watershed.

Many of the Sound's resources are harvested for human consumption. These include oysters, clams, bluefish, flounder, fluke, striped bass, scup, lobsters, various waterfowl, and many others. Commercial and recreational fishing contributed more than $1.2 billion to the regional economy in 1990. Other plants and animals — wetland plants, ospreys, marine mammals — may not provide a direct economic benefit, but are important because they are part of the food web, contribute to biodiversity and ecosystem stability, can be barometers of the health of the Sound, and have an aesthetic value. Some species are rare and have been designated as endangered, threatened or of special concern, such as Kemp's Ridley turtle, piping plover, least and roseate terns, osprey, and harbor seals.

Although some plants and animals seem to have little direct economic or aesthetic value, they are integral components of the Sound's ecosystem and are interconnected with all other organisms through the food web. Tiny plants and animals known as plankton, as well as seaweeds, are the base of much of the food web. Fish such as Atlantic silversides and bay anchovy are important food sources for many of the harvested species. Disruption of the ecological balance among the plants and animals of the Sound is detrimental to the entire ecosystem.

A wide diversity of plants and animals occur in the many land and aquatic habitats of Long Island Sound and its extensive watershed. The organisms that inhabit the Sound rely on specific habitat requirements for survival (e.g., food, shelter, nest sites, breeding and nursery areas, and clean water). The many different types of habitats found in the Long Island Sound watershed include tidal wetlands, sand and mud flats, rocky intertidal and subtidal areas, beaches, dunes, bluffs, submerged aquatic vegetation such as eelgrass and kelp, reefs, coastal shorelands, the water itself, and the sediment floor of the Sound. Different habitats dominate the north and south shores of the Sound. The Long Island coast is dominated by beaches composed of sand and pebbles and bluffs, with only a

few harbors and tributaries. The Connecticut and Westchester county coast is dominated by rocky shores, islands, and wetlands and has many coves and embayments.

Tidal wetlands are important feeding, breeding, and nesting areas for many types of invertebrates and birds. Birds feed on the small animals exposed on sand and mud flats when the tide is out; and other animals such as crabs and finfish, feed on them when the tide is in. Many species attach to rocks on reefs and in rocky intertidal areas where there are strong waves. Beaches and dunes are home to a specialized group of plants and animals adapted to the harsh conditions of salt spray, wave action, and burial by sand, and some of the wildlife that breed in these habitats are endangered or threatened. Eelgrass meadows, kelp beds, and other underwater plants are called submerged aquatic vegetation. They provide shelter, refuge, and food for many species. They are also important breeding and nursery areas (for example, eelgrass is critical habitat for juvenile bay scallops). Because many animals move about, and activities in one habitat affect the health of others, the habitats of Long Island Sound are not isolated, but interconnected and integral to the quality of the Sound.

B. What are the Goals for the Living Resources of Long Island Sound and Their Habitats?

The LISS has developed general goals to help guide specific living resource and habitat management activities. Specifically, these goals are to:

Assure a healthy ecosystem with balanced and diverse populations of indigenous plants and animals by:

- Achieving environmental conditions that allow effective reproduction, growth, movement and feeding of all organisms;
- Maintaining a wide diversity of habitat types, consistent with historic conditions, throughout the region; and
- Increasing the abundance of species listed by the states and/or federal government as endangered, threatened or of other special concern.

Increase the abundance and distribution of harvestable species by:

- Assuring that environmental conditions do not impede the reproductive success (i.e., through juvenile life stages) of species that reproduce in Long Island Sound;
- Identifying and maintaining existing breeding and nursery habitats for species in the Sound and increasing the availability and productivity of such areas in the future;
- Attaining environmental conditions that support full use of the Sound as a migratory passageway and a feeding, growing and resting area for resident resource species; and
- Encouraging management practices intended to conserve harvested resources.

Assure that edible species are suitable for unrestricted human consumption by:

- Assuring that toxic contaminants from sources in Long Island Sound or its drainage basin are not the cause of health risks resulting in consumption advisories or commercial or recreational fisheries restrictions; and
- Preventing further closures of shellfish harvest areas due to pathogen contamination and reducing the duration of closures.

C. What Are the Major Problems Affecting the Living Resources?

Many problems affect the living resources of Long Island Sound, and these may be divided into three basic management elements that address the problems of the Sound's coastal and estuarine life: water quality management, habitat management, and species management. The LISS has concentrated on water quality impairments as they relate to the health of living resources, because these were central to the original water quality improvement mission of the LISS.

1. Water Quality Management

Overall, the biological communities within Long Island Sound may function properly, but there are specific sites or regions where water quality degradation is affecting the health, diversity, and distribution of plants and animals or their habitats. Some of these impacts are related to the priority water quality problems — hypoxia, toxic contaminants, pathogens, and floatable debris - affecting the Sound. The consequences of these water quality problems on the health of the Sound's plants and animals can be severe. While these priority problems are not directly related to the physical loss or destruction of Long Island Sound habitats, they impair habitat quality. Therefore, they must be reversed if the condition of the Sound's plants and animals is to improve. These priority problems and their impacts on living resources have been described in detail in previous chapters; they are summarized below.

— Hypoxia is the most serious consequence of nitrogen enrichment in coastal waters. Since hypoxia can occur in more than 40 percent of the bottom water in late summer, it has been identified as the most important water quality problem affecting living resources in Long Island Sound. Impacts of hypoxia on estuarine organisms range from reduced abundance and growth to physiological stress and mortality. Laboratory tests conducted for the LISS show that the most severe effects occur when dissolved oxygen falls below 1.5 mg/l in the short term and 3.5 mg/l over a longer period, but that there are probably mild effects of hypoxia when dissolved oxygen falls below 5 mg/l. Surveys have shown that the diversity and number of fish caught decrease in late summer during periods of low dissolved oxygen. During anoxic (no oxygen) events in 1987, numerous fish kills were reported in western and central Long Island Sound. Hypoxia may indirectly increase mortality because animals affected by it may be more vulnerable to predators or more susceptible to disease. The overall result of hypoxia in Long Island Sound is the loss of valuable habitat because it is no longer usable by many animals. This may significantly reduce the productivity of the plant and animal communities in Long Island Sound. Other results of nitrogen enrichment which will require the attention of water quality managers include effects on phytoplankton at the base of the marine food web, declines in eelgrass production, and changes in abundance and diversity of other macrophytes (formation of blooms of macroalgae, e.g., Ulva).

— Toxic contaminants in high concentrations can be lethal to plants and animals. However, bioassay testing of Long Island Sound sediments and water to date has demonstrated such lethal effects in only limited locations. At lower concentrations, contaminants may disrupt growth, reproduction and other physiological processes. Bottom-feeding and bottom-dwelling organisms are most likely to be affected because the levels of toxic contaminants in the sediments are often higher than in the water. This may be especially true in the western Sound and embayments, where levels of toxic substances in the sediments are higher than in eastern areas. One example of a species which feeds on bottom-dwelling organisms and which has elevated levels of some contaminants is the greater scaup, a diving duck that breeds in other parts of North America and

overwinters on Long Island Sound. The extent to which the Sound is the source of these contaminants is unknown. When consumed, toxic contaminants can pass through the food web and concentrate or bioaccumulate, thereby severely impacting animals that consume many small, contaminated prey. For example, elevated levels of PCBs have been measured in bluefish, striped bass and harbor seals. Consumption of bluefish and striped bass can result in an accumulation of contaminants by humans. Thus, toxic contamination represents a human health issue, as well as a habitat issue. As a result of potential health risks, Connecticut and New York have issued advisories to moderate, or in some cases, prevent consumption of some types of fish from Long Island Sound (e.g., striped bass and eels, among others).

- There are many pathogens (disease-producing organisms) in Long Island Sound. Some cause diseases in resident plants and animals, while others cause human illnesses. Many pathogens are present naturally, but others, including many that cause human illness, are more prevalent because improperly treated human wastes are sometimes discharged into coastal waters. One example of a naturally occurring pathogen that can kill lobsters, but is not harmful to humans, is *Gaffkemia*. Preliminary results of a lobster mortality study conducted by New York state indicate that this disease may occur more frequently under stressful conditions, such as hypoxia. In addition to affecting the condition of natural resource populations, human and nonhuman pathogens affect the human consumption of the Sound's resources. For example, infected animals may be unappealing to eat because of naturally occurring pathogens; in other cases, shellfishers may be prohibited from harvesting shellfish for direct consumption in certain areas where indicators of human pathogens are present.

- Floatable debris can affect estuarine life in Long Island Sound either through entanglement or ingestion. In the Sound, only a few deaths caused by floatable debris have been documented. However, floatable debris in the Sound is a legitimate concern, particularly to large estuarine animals. Certain endangered species, especially marine mammals and sea turtles, are susceptible to mortality from ingestion of balloons and plastic bags or entanglement caused by six-pack rings or other nondegradable materials.

Water quality management is critical to the plants and animals of Long Island Sound. Actions specific to hypoxia, toxic contamination, pathogens, and floatable debris have been detailed in prior sections of this plan and will not be repeated here.

2. Habitat Management

The destruction of coastal habitats has had a major impact on the diversity and abundance of plants and animals in the Sound. In addition, the loss of certain habitats has reduced their critical water quality functions (e.g., sediment filtration and nutrient removal). Many of these problems are site-specific.

While some habitat loss is of natural origin (e.g., storm damage), it appears that much of the decline of the coastal habitats of the Sound has been caused by human activities. For example, approximately 25 to 35 percent of the Sound's tidal wetlands, which are critical breeding areas for marine biota and wildlife and help filter land runoff including nutrients, have been destroyed during the last century by filling, dredging and development. Virtually all of the tidal wetlands in the Sound were ditched for mosquito control purposes in the first half of the twentieth century. While ditching did not destroy tidal wetlands, certain functions and values were altered or diminished. These include elimination of natural pools and pannes and an attendant decline in wildlife use. As one example of habitat

degradation in tidal areas, the common reed is displacing the native fresh and brackish tidal wetland plants at an alarming rate in the Connecticut River estuary and certain other tidal rivers.

Laws that regulate activities in tidal wetlands in both states have virtually arrested the loss of this habitat type. However, regulatory programs are not designed to correct habitat degradation caused by historic activities such as construction of tidegates, undersized culverts and dams. Stormwater discharges, which have increased because of human activity, dilute the salt content of coastal waters and cause deposition of sediment, resulting in degradation of tidal wetlands. Intertidal sand and mud flats have undergone similar losses caused by human activities like dredging and filling, as well as natural erosion and sedimentation, resulting in the loss of critical feeding, spawning and nursery areas for finfish and crustaceans, and feeding areas for shorebirds.

Overall in the Sound there has been a significant decrease in the quantity and distribution of submerged aquatic vegetation (especially eelgrass). The decline in submerged aquatic vegetation is believed to be linked to increased nitrogen loadings. Excessive blooms of phytoplankton and increased growth of algae on plant blades, the result of nutrient enrichment in the water, reduce the light available for these submerged plants, and cause a reduction of the area suitable for seaweed and eelgrass growth. Recent studies in other east coast estuaries suggest that excessive nitrogen is toxic to eelgrass. Thus, these elevated nitrogen levels may cause shifts in vegetation from eelgrass, which has high habitat value but is not tolerant of high levels of nitrogen, to species that are of less value for food and shelter, such as sea lettuce, but are more tolerant of high levels of nitrogen.

Construction of breakwaters, groins, jetties, seawalls, and inlets interrupts the transport of sediments that naturally replenish beaches and dunes. This results in accelerated erosion of these habitats as well as bluffs in proximity to these erosion control structures. This is usually a local problem. Similarly, building construction and foot and vehicular traffic can degrade beaches and dunes. Even small losses of the fragile vegetation that traps and retains sediments can make a dune considerably more vulnerable to erosion. Loss of natural dune habitat is one of the primary reasons that plants such as sickle-leaved golden aster, sea beach panic grass and prickly pear cactus have become rare. Endangered and threatened species such as piping plover and least tern have declined because of the destruction of their nesting habitat on beaches and dunes.

Many of the habitats around the Sound that have been destroyed or degraded are critical to the survival of plants and animals, including some of economic importance and those that are endangered or threatened. Thus, restoration and enhancement of these areas will provide additional habitat, and may help to increase the abundance and distribution of Long Island Sound living resources.

A. How Will We Manage Habitat Problems?

Connecticut, New York, and the federal government have long managed and protected the coastal lands and aquatic habitats of Long Island Sound. Some of these programs date back to early parts of this century, while others are more recent. They provide the primary framework to protect, manage, and enhance coastal habitats. These ongoing programs have been funded previous to and are administered separately from the LISS. However, the LISS supports them and may be able to assist with their enhancement. The objectives, commitments, and recommendations that follow support and encourage continuation of these programs and identify new activities to enhance the programs and attain the goals for the living resources of the Sound and their habitats. Current activities recommended for continuation will be continued subject to the decisions of, and support provided by, the agencies that fund them.

Long Island Sound is an area that has undergone rapid industrialization and rapid diminution of areas remaining in their natural condition. It is desirable to identify areas of land and water of outstanding or exemplary scientific, educational, or biological value to reflect the regional differentiation and variety of ecosystems and address all the significant natural habitats found in Long Island Sound. These sites would be combined to form a *Long Island Sound Reserve System*. Many of these sites are already in public ownership or held for conservation purposes. Therefore, acquisition priorities should emphasize sites not currently held for conservation purposes. The purpose of developing such a reserve system is to ensure that as much outstanding or exemplary coastal habitat as possible is left undeveloped for the benefit of living resources that depend on them. Linking existing protected areas with new ones in a *system* is intended to elevate the importance of such areas in the public consciousness and to enhance the sense of interconnectedness between the habitats of the region and their living resources. It is intended that current public uses of existing areas be continued. For any newly designated areas, the broadest range of public access should be encouraged, consistent with the environmental requirements of indigenous plant and animal populations.

Both Connecticut and New York have coastal permit programs that regulate activities such as dredging, filling and construction of docks and piers, proposed to be located in the tidal waters of the Sound. These include the tidal wetlands regulatory programs in both states, the Structures, Dredging and Filling and Inland Wetlands and Watercourses regulatory programs in Connecticut, and the Protection of Waters and Freshwater Wetlands Programs in New York. On the federal level, the U.S. Army Corps of Engineers (USACOE) administers Section 10 of the Rivers and Harbors Act, which regulates activities in the navigable waters of the U.S., Section 404 of the Clean Water Act, which regulates placement of fill and disposal of dredged sediments into the waters of the U.S. and Section 103 of the Marine Protection, Research and Sanctuaries Act, which regulates transportation and disposal of dredged sediments in territorial seas. The adoption of comprehensive coastal management programs by both states in the late 1970s and early 1980s have strengthened regulatory programs, providing further protection for coastal land and aquatic habitats.

There are also a number of other federal and state programs that target management and restoration of Long Island Sound habitats. For example, wildlife programs have habitat management and restoration components. Both states have tidal wetland restoration programs. The Coves and Embayments Program in Connecticut targets restoration of degraded water and habitat quality in embayments and tidal rivers. Numerous land management programs exist to protect lands through acquisition (purchase) or easement (i.e., control or use of land by a designated agency or entity without ownership).

B. ONGOING AND PROPOSED PROGRAMS

The following tables describe the principal ongoing habitat management programs of the departments and organizations responsible for habitat management in the Long Island Sound region. Each table then identifies the commitments and recommendations of the LISS to enhance these programs. These actions will help to achieve the habitat management objectives of the LISS and are an important step towards addressing the habitat management problems identified in this section. The overall objective of managing habitat is to implement habitat protection, conservation, and restoration programs that will include land acquisition, easements, land use regulations, habitat restoration efforts, and pollution abatement.

The actions summarized in Table 40 focus on the restoration and enhancement of habitat.

Table 40 Restoration and enhancement of aquatic and terrestrial habitats.

ONGOING PROGRAMS	Responsible Parties/Status
Connecticut, New York, and federal agencies will continue to pursue the restoration of degraded tidal wetlands.	These programs are administered by the NYSDEC, the NYSDOS, the CTDEP, the CTDOT, the U.S. Fish and Wildlife Service, the USACOE, and the EPA. Since 1980, the CTDEP has, in cooperation with many partners, restored over 1000 acres of degraded tidal wetlands. The CTDEP uses the Long Island Sound Cleanup Account to fund the restoration of degraded tidal wetlands. The CTDEP has created a tidal wetland restoration program with staff and specialized equipment with annual operating costs of $350,000. The CTDEP receives commitments of approximately $800,000 per year from the CTDOT's Intermodal Surface Transportation Efficiency Act (ISTEA) program to fund wetland restoration projects associated with transportation facilities. The USFWS provides, on average, $45,000 of Partners in Wildlife Funds to Connecticut to conduct wetland restoration and also provides staff and equipment to assist in tidal wetland restoration. It also provides challenge grant monies to conduct tidal pool and panne restoration activities in its Connecticut refuges.
Through Connecticut's coastal permit programs and consistency with the Connecticut Coastal Management Act, applicants may be required to protect, restore or enhance aquatic resources.	These programs are managed by the CTDEP. Retrofits or removal of tide gates have been required to increase tidal flows to tidal wetlands and embayments and offsetting of unavoidable wetland losses for public benefit projects such as bridge replacements through wetland restoration has been required.
Connecticut is preparing a tidal wetland management plan that includes an identification of potential wetland restoration sites.	The responsible party is the CTDEP. This project has been funded by NOAA's Office of Ocean & Coastal Resources Management and is expected to be completed by fall of 1994.
Connecticut will continue the Coves & Embayment Restoration program to restore degraded tidal and coastal embayments and coves.	Since 1982, the CTDEP has sponsored, in cooperation with coastal municipalities, the restoration of 20 sites. In 1989, the Connecticut legislature amended the Clean Water Fund to create the Long Island Sound Cleanup Account, which has provided increased funding to this program. Annual restoration costs average $500,000 per year. The Department will continue to request appropriations for this account as needed.
Connecticut, New York, and federal agencies currently administer programs for the restoration of habitats other than tidal wetlands such as dunes, submerged aquatic vegetation beds, and coastal woodlands.	The NYSDEC, the CTDEP, and the USFWS are the responsible parties. The CTDEP continues to conduct dune restoration activities on state lands and assists municipalities and private citizens with their restoration projects. The CTDEP created the Long Island Sound License Plate Fund, which provides funding for restoration projects. In 1993, $25,000 was specifically set aside for municipal dune restoration projects. Management of coastal upland habitats is conducted chiefly on Connecticut Wildlife Management Areas. The USFWS has begun to manage coastal uplands in the McKinney National Wildlife Refuge units.

New York is phasing out, and Connecticut prohibits, maintenance ditching of mosquito ditches in favor of selective use of open marsh water management techniques to control mosquitos and restore pools and ponds on tidal wetlands.	The responsible parties are the CTDEP and the NYSDEC in cooperation with mosquito control agencies and federal agencies. The CTDEP, the USACOE, the USFWS, NOAA's National Marine Fisheries Service (NMFS), and the EPA agreed to discontinue maintenance of mosquito ditches in Connecticut's tidal wetlands since 1985 and to allow the selective use of the open marsh water management as a mechanism to restore the natural character and habitat diversity of tidal wetlands.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Coastal America, a cooperative effort of several federal agencies, is conducting a study in Connecticut to evaluate the impacts of transportation facilities upon ten tidal wetland sites. This study is being sponsored by the CTDEP and undertaken by the USACOE. When the study is completed, restoration plans will be developed for those sites where a transportation facility is shown to be the cause of the degradation. Restoration is expected to be implemented through a combination of ISTEA, Water Resources Development Act, Long Island Sound Cleanup Account funds, New York's Environmental Protection Fund, and, where appropriate, natural resource damages recovered under CERCLA or OPA90.	CTDEP CTDOT Coastal America Partners	Study will be completed in 1994; restoration projects will proceed as funding is approved.	$100,000 for the initial study; restoration costs will vary for each project site.
Connecticut's Coves & Embayments Program will complete nine restoration projects in progress and commitments to begin three new projects.	CTDEP in cooperation with the municipality sponsor	Varies depending on project	$263,625 for projects in progress and $123,475 for projects to commence.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Connecticut and New York should continue to pursue the use of funds from the following programs, and explore additional funding sources, to support restoration and enhancement activities described in the previous recommendation: The Land and Water Conservation Fund, the Intermodal Surface Transportation Efficiency Act (ISTEA) Enhancement Program, the Partners in Wildlife Program, Section 319 of the Clean Water Act, Army Corps of Engineers Section 22 Planning Funds, the Water Resources Development Act, National Coastal Wetlands Conservation Grants, the North American Waterfowl Management Plan, Connecticut's Long Island Sound Cleanup Funds, and the Coastal Zone Management Act.	CTDEP CTDOT NYDOT NYSDEC NYSDOS EPA USACOE USFWS	Ongoing	Existing staff will be used; project costs vary from site to site.
The rapid displacement of native brackish and fresh tidal plant communities on the Connecticut River has been identified as the single most significant habitat problem in this estuary. A specific restoration program for the control of common reed in these tidal wetlands needs to be implemented to check and reverse the spread of common reed and develop the most efficient means of effecting this restoration. Control techniques need to be evaluated for the full range of wetland habitat types on the river. Baseline surveys will be established and post-control monitoring over multiple years will be conducted.	CTDEP USFWS	3 years	$130,000 for amphibious mulching machine and $100,000 for staff, supplies and monitoring.

New York should continue to phase out maintenance ditching for mosquito control. These programs should receive additional support for selective use of open marsh water management techniques to control mosquitos and restore pools and ponds on tidal wetlands.	NYSDEC in cooperation with mosquito control agencies	—	$1,000 per acre for open marsh water management
Obtain long-term funding for Connecticut wetland restoration staff.	CTDEP	Upon approval of funding	$250,000 per year for staff
Connecticut and New York should develop a restoration plan for the full range of coastal terrestrial and estuarine aquatic habitats adjacent to and in Long Island Sound. The restoration plan will include a list of potential restoration projects and a priority listing of projects to be implemented. Preliminary sites identified for future restoration in New York include: City Island ($300,000); Pelham Bay Park ($400,000); Wading River ($50,000); Sunken Meadow Creek ($50,000); Crab Meadow ($50,000); and Mattituck Creek ($100,000). Other sites in New York where costs have not been estimated include Pugsley Creek, Udall's Cove, Oak Neck Creek, Frost Creek, and East Creek. Connecticut has estimated that ten priority sites could be restored for $750,000, or approximately $75,000 per site.	CTDEP NYSDEC NYSDOS EPA NOAA USACOE USFWS	3 years	$50,000 per year for each state for three years; Restoration costs will vary depending upon project type.
New York should strengthen their capabilities for implementing programs that restore degraded habitats. This should be undertaken in cooperation with the implementation of the Long Island Sound Regional Coastal Management Plan.	NYSDEC NYSDOS	—	$250,000 per year

Despite the many laws and regulations that govern uses of habitat in the Sound, not every habitat receives equal protection. Even though there is considerable public ownership of coastal upland habitats and lands held for conservation purposes by private organizations, the uses allowed in these areas do not always protect critical coastal habitats. Often, the reason for this is that the significant habitat components of these lands are not recognized and therefore, no appropriate management measures have been adopted. The latter problem applies particularly to submerged lands that are in the public trust and for which the states have a trustee responsibility. Also, not all of the significant or exemplary coastal lands are publicly owned, so additional protection can only be assured through direct acquisition or use of less than fee simple approaches such as easements.

Types of exemplary and significant coastal habitats to be protected through acquisitions and less than fee simple approaches include colonial waterbird nesting sites, critical habitats for rare species, coastal barriers, and tidal wetlands. Examples of specific sites targeted for acquisition include Great Meadows Salt Marsh in Stratford, CT, Porpoise Channel in Brookhaven, NY, and Plum Point in North Hempstead, NY. Also, critical shoreland wetland sites on the Connecticut River estuary need to be identified and protected as necessary to support ongoing programs such as the Conte Fish and Wildlife Refuge and the *Last Great Places Campaign*.

Any consideration of the living resources of Long Island Sound must consider the entire watershed. Many species in the Sound, whether directly or indirectly, are affected by activities upstream in the watershed. Anadromous fish migrate through rivers and streams, migratory waterfowl utilize river corridors as flyways, and greenways must be maintained to facilitate the movement of migratory and resident animals. Upland habitats in the Long Island Sound watershed are being rapidly lost to commercial, industrial and residential development. Unlike wetlands and coastal waters, there are limited state or federal mechanisms to protect, preserve and conserve upland habitats. Protection of upland habitats is still largely left to local decision-makers who may be unaware of the importance of habitat within their jurisdiction or who may be influenced by competing needs of society for use of the land.

The actions summarized in Table 41 focus on the protection and acquisition of habitat.

Table 41 Habitat protection and acquisition.

ONGOING PROGRAMS	Responsible Parties/Status
The states of Connecticut and New York and the USACOE will continue to implement their permit programs and coastal consistency provisions of states' Coastal Management Programs to regulate use and development of aquatic resources and critical habitats such as tidal and freshwater wetlands, intertidal flats, submerged aquatic vegetation beds, beaches, and dunes. These programs also regulate dredging and the disposal of dredged sediments at designated sites in Long Island Sound. Open water disposal is only permitted at the designated open water sites and may only occur if the disposal will not cause adverse impacts to estuarine organisms.	Programs are managed by the NYSDEC, the CTDEP, the USACOE, the EPA, and the NYSDOS that are essential to habitat preservation and conservation. Key permit programs include Tidal Wetlands, Structures and Dredging and Filling, and Coastal Management and Inland Wetlands and Watercourses Programs in Connecticut; Protection of Waters and Freshwater Wetlands program, and Coastal Erosion Hazard Protection in New York; Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbors Act, and Section 103 of the Marine Protection, Research and Sanctuaries Act. These are the primary programs that regulate activities in coastal waters and freshwater wetlands to protect and minimize adverse impacts to aquatic habitats. The states and federal agencies routinely update dredged sediment disposal plans and procedures as new testing and management protocols are developed. Annual program costs are $1.15 million in Connecticut.
Connecticut will continue to reduce habitat degradation caused by stormwater runoff projects (e.g., chronic dilution effects and sedimentation) through the goal of retaining the first one-inch of runoff.	The CTDEP and local governments are implementing stormwater management actions in accordance with stormwater general permitting guidelines and the standards in the Coastal Management Act to avoid or minimize habitat degradation caused by stormwater runoff. This is accomplished through the goal or requirement of retention of the first one-inch of runoff.
Connecticut and New York have programs to acquire by easement, fee simple acquisition, or other means habitats important for populations of plants and animals. These programs include the development of priority listings for acquisition and protection. Connecticut and New York have land acquisition & management programs that use state funds and federal fund programs such as the Land & Water Conservation Fund, the National Coastal Wetland Conservation Program, and the North American Waterfowl Management Plan to protect and acquire coastal lands and wetlands.	Both states have had a long history of acquiring lands and wetlands along the shoreline and in the Long Island Sound watershed. In Connecticut, the CTDEP is responsible for land acquisition programs for and the management of parks, forests and wildlife management areas. The CTDEP is responsible for the management of over 114 different management areas, totaling over 11,700 acres of land and wetland, located along its tidal shorelines. The NYSDEC and the CTDEP are the primary parties responsible for initiating acquisition projects. In Connecticut, the Recreation and Natural Heritage Trust Program is the principal state funding program for land acquisition. Examples of coastal habitats that have been acquired with this fund include Cedar Island in Clinton, Davis Farm at Barn Island in Stonington, Beacon Hill in Branford, and Selden Island in Haddam. In 1992, Connecticut established a Migratory Bird Conservation Stamp Program containing a dedicated fund, a portion of which will be used for acquisition related to migratory bird protection and enhancement. In 1992, Connecticut's statewide program costs were $17,000,000.

The USFWS maintains a national system of refuges, which includes the Stewart B. McKinney National Wildlife Refuge in Connecticut (i.e., Salt Meadow, Chimon Island, Sheffield Island, Goose Island, Milford Point and Falkner Island Units) and Long Island National Wildlife Refuge Complex in New York (i.e., Oyster Bay and Target Rock units).	These units in Long Island Sound are owned and managed by the USFWS. Congress has authorized the expansion of the McKinney National Wildlife Refuge and the Service is currently pursuing acquisition of a portion of the Great Meadows complex in Stratford, Menunketesuck Island, and wetlands in Westbrook. Three million dollars have been appropriated for these sites to date, and the remaining acquisition costs are projected at $11 million.
Congress has authorized the creation of the Silvio Conte Connecticut River National Fish & Wildlife Refuge within the Connecticut River watershed for the purpose of conserving, protecting and enhancing the Connecticut River Valley populations of plants, fish, and wildlife; preserving natural diversity and water quality; fulfilling international treaty obligations relating to fish and wildlife; and providing opportunities for scientific research and education.	The USFWS is responsible for the development of recommendations with respect to defining and designating refuge boundaries, developing a management strategy for the river and identifying lands for acquisition. The Service is working cooperatively with the states and heritage programs to collect information for *Species of Special Emphasis* and significant concentration areas for these species. As part of this analysis, the Service has identified the lower tidal section of the Connecticut River as a nationally significant fish and wildlife habitat complex.
Connecticut has established a Migratory Bird Conservation Stamp Program, the proceeds of which can be used for acquisition and management. The newly created state income tax form check off for endangered species, natural areas preserves, and watchable wildlife creates a fund that can be used for the identification, protection, conservation, management, and education activities related to the above listed wildlife and habitats.	These programs are statewide programs administered by the CTDEP and a portion of the proceeds are expected to be directed to projects associated with Long Island Sound. Connecticut has completed its first issue duck stamp and prints, and the sale of art products will be an ongoing program. Projects are soon to begin under this program and will include restoration and wildlife conservation. An artist has been selected for the second stamp and these will be issued in the spring of 1994. This is the first year for the check off program.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Create a Long Island Sound Reserve System consisting of areas of land and water of outstanding or exemplary scientific, educational, or biological value to reflect regional differentiation and variety of ecosystems and to include representatives of all of the significant natural habitats found in the Sound. Where appropriate, sites will be selected from existing lands and wetlands held for conservation purposes so that acquisition funds will be directed towards those lands in private ownership that are needed to complete the reserve system. The primary activities in the recommendation include site identification (2 years) and site protection through the development of management plans, acquisition where necessary, and site management.	CTDEP NYSDEC New York State Office of Parks and Recreation and Historic Preservation USFWS Long Island Sound Bi-state Committee	—	$50,000 per year for each state for staff to identify sites, develop acquisition strategies and manage the reserve complex. Acquisition costs will depend upon areas identified for protection through purchase.
Connecticut and New York should continue to acquire or protect through less than fee simple means, significant coastal habitats through funding sources such as the Land and Water Conservation fund, the National Coastal Wetland Conservation Program, the North American Waterfowl Management Plan, Connecticut's Recreation and Natural Heritage Trust Program, Connecticut's Migratory Bird Conservation Stamp Program, New York's Environmental Protection Fund, and, where appropriate, natural resource damages recovered under CERCLA or OPA90.	CTDEP NYSDEC Assistance of local governments, environmental groups and federal granting agencies	—	$50,000 per year for each state for staff

Acquire and protect those sites that are considered priorities for acquisition in the New York State Open Space Conservation Plan. Sites include Oyster Bay Harbor ($5 million); Porpoise Channel ($2 million); Plum Point ($1 million); Udall's Cove ($8 million). Other sites on Long Island Sound that are among the state's highest priority acquisition sites include: Bronx River Trailway, Udall's Ravine, Alley Creek ($750,000); Long Creek and Mattituck Creek ($340,000); Premium River ($750,000); and Cedar Beach Creek ($186,000).	NYSDEC New York State Office of Parks and Recreation and Historic Preservation	—	Priority sites for acquisition total $16 million
Acquire and protect those sites that are considered priorities for acquisition in Connecticut. The Great Meadows site is the highest priority. (See also Ongoing Programs, previous page.)	CTDEP USFWS	—	$14 million
Encourage activities of existing Long Island Sound-specific land trusts and encourage formation of new trusts, to seek donations and easements of localized habitat areas for the plants and animals of Long Island Sound.	NYSDEC EPA-LIS Office	—	Redirect base program

Inventories and management strategies for Long Island Sound habitats can be important and effective management tools. The LISS recommends that habitat management strategies for specific complexes or regions be developed. Commitments and recommendations summarized in Table 42 highlight specific locations and priorities for protection, restoration and acquisition, and provide useful information for permit decisions.

Table 42 Inventories and management strategies for aquatic and terrestrial habitats.

ONGOING PROGRAMS	Responsible Parties/Status
Connecticut, New York, and The Nature Conservancy will continue the Natural Diversity Database in Connecticut and the Natural Heritage Program in New York. These programs collect, maintain, and update information pertaining to significant terrestrial and aquatic habitats.	The Natural Diversity Database is managed by the CTDEP and has been collecting significant habitat information since 1983. The Department continues to conduct statewide surveys and is preparing, in cooperation with The Nature Conservancy, a plant community classification for Connecticut. Detailed biological inventories and management recommendations have been prepared for several coastal sites. All applications to the CTDEP for permits are compared against information in the database to assure that impacts to significant habitats are considered in the regulatory process. (See description of Connecticut's Endangered Species Program for annual operating costs.)
The USFWS will continue the Southern New England-New York Bight Coastal and Estuary Project. The project focuses on assessing and monitoring the regional geographic distribution and population status of a large number of key species called *Species of Special Emphasis* and their habitats including evaluating the threats to the physical integrity of these habitats and the viability of species populations. Primary objectives are to determine and delineate those regionally important habitats and species populations requiring both immediate and long term protection, conservation, enhancement, and restoration.	The USFWS administers this program. Fifteen regionally significant habitat complexes have been identified and mapped in Long Island Sound.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The NYSDEC will, on a pilot basis, develop a site-specific habitat management strategy for the Oyster Bay/Cold spring Harbor complex. Phase II will entail implementation of the identified strategy.	LISS NYSDEC	Initiated in fall 1992, strategy to be completed in winter 1994	$50,000 of LISS funds for the development of the strategy. Implementation costs to be determined.
Connecticut is identifying wetland complexes of statewide significance and general wetland protection strategies for areas located in Long Island Sound and the Connecticut River. This project has been funded by the EPA under Section 104(b) of the Clean Water Act.	CTDEP	Fall 1994	$62,500
Develop a nomination document to recommend the designation of the Connecticut River estuary as a *Wetland of International Importance* for the purpose of establishing a formal designation of this area to recognize the ecological significance of this ecosystem and to foster increased protection of its significant habitat complex and living resources.	CTDEP	Fall 1994	$25,000
Develop a strategic plan for the estuarine portion of the Connecticut River that will identify habitat and species issues/problems, monitoring, and research needs and recommendations to foster increased protection of this nationally significant ecosystem.	CTDEP	2 years	$50,000 per year for two years
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Develop and periodically update a list of significant habitats, habitat complexes, and sensitive areas for protection and management. When completed, habitat management plans will be developed for these areas. In New York this should be undertaken in cooperation with the implementation of the NYSDOS Long Island Sound Regional Coastal Management Plan.	CTDEP NYSDEC NYSDOS	—	$50,000 per year for each state
Expand the Southern New England-New York Bight Coastal and Estuary Project to: 1) include the watersheds of Long Island Sound; and 2) reexamine the habitat complexes previously identified in Long Island Sound based upon the most current listing of Species of Special Emphasis. Examine the complexes more carefully to fine tune the management recommendations and implement these recommendations through state, county and municipal agencies.	USFWS	Ongoing	—
Federal habitat programs should develop a watershed approach to protection of the living resources of Long Island Sound and their habitats, such as development of a Connecticut River/Long Island Sound Management Unit by the USFWS.	USFWS	—	—
Designate portions of the Connecticut River Estuary as a National Estuarine Research Reserve. A Reserve designation will result in promoting research that is directed towards resource management issues and provide facilities and programs for public education and interpretation.	CTDEP NOAA	3 years for selection of sites and development/ approval of management plan.	$150,000

3. Species Management

Throughout Long Island Sound, the populations of many species have declined or are declining. Some of these species require management to maintain or improve current levels of harvest, while others have declined so much that they are listed as endangered or threatened. In the latter case, restoration is required. There are many reasons for declines in living resource populations. They include natural fluctuations in population size, habitat loss and degradation, overharvesting and competition or predation by exotic species or native species whose populations have increased to the extent that they adversely impact other species.

Overharvesting Long Island Sound's estuarine life is a problem that dates to colonial times. To protect species such as winter flounder, lobster, bluefish and diamond-backed terrapins, among many others, it is essential to manage harvests. Management measures regulating the taking of fish and wildlife resources have been imposed when necessary since the late 1800s in response to problems associated with overharvesting. Since many of the Sound's living resources are migratory, management requires implementation of interstate management programs. For example, interstate regulations on the taking of striped bass since 1984 have resulted in a significant increase in that species in Long Island Sound and along the East Coast. Management of fishery and wildlife harvests will continue to evolve as resource needs and problems arise.

Dams built on Connecticut rivers and streams have restricted the upstream movements of migrating finfish, such as alewives, smelt, blueback herring, American shad and Atlantic salmon. These fish migrate from the ocean, through Long Island Sound, and into freshwater streams to spawn. When these migrations are blocked by dams, the fish cannot reach the habitats they require for successful spawning, limiting the possibilities of a population sustaining itself.

Historically, three marine mammals (harbor seal, harbor porpoise and bottle-nosed dolphin) were common in the Sound. The causes of their decline in the Sound are unknown but may include Atlantic coast declines in population size, increased boating activities, a stock collapse of a major food source in the 1970s (sea herring), or degraded water quality. Harbor seal populations are increasing and they occur chiefly in the eastern Sound. Bottle-nosed dolphins and porpoise are less abundant today and occur in small schools. Dolphins occur in the eastern and central Sound and porpoises are seen most frequently between Plum Gut and the mouth of the Thames River. The Sound is seasonally inhabited by sea turtles, some of which are listed as endangered species (e.g., Kemp's Ridley turtles). Marine mammal and endangered sea turtle populations are protected by the NMFS under the auspices of the Marine Mammal Protection Act and the Endangered Species Act, respectively.

Water intake pipes at power plants and other industrial facilities can kill small organisms, including the eggs and larvae of estuarine animals, by drawing them into the plant and subjecting them to physical damage and large changes in pressure and temperature. In addition, larger animals can become caught on screens that cover the intake. This can be a serious problem if the intake pipe is located near nursery grounds.

Thermal discharges from power plants can affect estuarine plants and animals in two ways. When very warm water is discharged, it may exceed tolerance levels for sensitive species or life stages that cannot move from the area. This is usually only a very localized problem. Additionally, heated effluent from power plants can enable migratory estuarine species to inhabit an area during a time of year when surrounding waters would not be warm enough to support them. Subsequently, interruption of the heated discharge can cause severe impacts to the migratory animals in the area, by exposing them to water significantly colder than they can tolerate.

Dredging, an activity necessary to maintain navigable waterways for human uses, can kill or remove bottom-dwelling organisms from the affected area. However, recolonization ordinarily occurs quickly. While colonizing organisms can be an important source of food for other species, the characteristics, hydrology or topography of the bottom sediments may be altered; in such instances, the habitat has changed. At times, these changes may expose cleaner sediments or improve flushing. However, sediment suspended in the water by dredging can bury organisms adjacent to the dredge site, reduce spawning success in oysters and interfere with migration of finfish. These suspended sediments are especially damaging if they are contaminated with toxic substances or laden with nutrients (e.g., nitrogen). Water that remains in dredge holes may be depleted of dissolved oxygen, resulting in hypoxia and reduced productivity of the benthic community.

A number of non-native plants and animals have been introduced into Long Island Sound, and they can adversely compete with native species, reducing their numbers. Similarly, if populations of native species get too large they can cause damage when they prey upon or compete with other species. Examples of such species include the common reed, bittersweet, Norway rats, raccoons, gulls, mute swans and non-migratory Canada geese. Even house pets such as cats and dogs that are free to roam can cause significant losses of native and especially rare species. Many of these animals will eat the eggs and young of rare animals such as piping plover and terns, jeopardizing the survival of small populations. It is believed that populations of black-backed and herring gulls have increased due to easily acquired food from landfills and food left on beaches. As a result, these birds can displace and prey upon beach nesting birds.

A. How Will We Manage Species?

Connecticut, New York, and the federal government have long managed and protected the aquatic resources of Long Island Sound. Some of these management programs date back to early parts of this century, while others are more recent. They provide the framework to protect, manage and enhance individual species. These ongoing programs have been funded previous to and administered separately from the LISS. However, as with habitat programs, the LISS supports their activities and may be able to assist with their enhancement. The objectives, commitments, and recommendations that follow support and encourage continuation of these programs and identify new activities to enhance the programs and attain the goals for the living resources of the Sound and their habitats. Current activities recommended for continuation will be continued subject to the decisions of, and support provided by, the agencies that fund them.

Both Connecticut and New York have shellfish and marine and freshwater finfish management programs. Staff from these programs work closely together and coordinate activities with federal agencies such as the NMFS and USFWS and interjurisdictional bodies such as the Atlantic States Marine Fisheries Commission and the Regional Fishery Management Councils. These programs manage and maintain harvestable fishery resources for species such as striped bass, bluefish, winter flounder, scup, summer flounder, tautog, weakfish, shad, and lobster through development of management plans and implementing regulations. In addition, both states and the federal government have programs to manage and enhance wildlife populations, including activities conducted under the auspices of the North American Waterfowl Management Plan. There are federal and state endangered and threatened species programs that survey and research these species and develop and carry out management plans to identify and increase numbers of rare species, and the Natural Diversity Data Base in Connecticut and the Natural Heritage Program in New York, which act as the repository for locational information about rare species and their habitats. There are also programs to help protect, restore and enhance populations of specific types of species, such as activities conducted under the Marine Mammal Protection Act. In addition, coastal management programs provide protection and

conservation of resources by evaluating potentially detrimental activities that have been proposed (e.g., dredging and filling). Finally, permit programs such as the National Pollution Discharge Elimination System regulate point source discharges in a manner that avoids adverse biological effects from contaminants contained in discharge waters.

B. ONGOING AND PROPOSED PROGRAMS

The following tables describe the principal ongoing programs of the departments and organizations responsible for living resource management in the Long Island Sound region. Each table then identifies the commitments and recommendations of the LISS to enhance these programs. These actions will help to achieve the species management objectives and are an important step towards addressing the species management problems identified in this section. The overall objective of managing species is to encourage the development of species or species group management plans for the living resources of Long Island Sound. These plans should incorporate strategies developed by state as well as interjurisdictional management institutions.

Endangered and threatened species are important ecological components of Long Island Sound. Management of endangered and threatened species will help to protect existing populations and restore them as appropriate. Commitments and recommendations are summarized in Table 43.

Table 43 Managing endangered and threatened species.

ONGOING PROGRAMS	Responsible Parties/Status
Connecticut, New York, and federal agencies will continue to implement their Endangered Species Programs in order to protect endangered and threatened species that live in and adjacent to Long Island Sound.	CTDEP, NYSDEC, NMFS, USFWS. The CTDEP is responsible for managing Connecticut's Endangered Species Program and implementing the requirements of the Endangered Species Act. Since 1975, Connecticut has conducted systematic surveys to locate populations of threatened, endangered, rare and declining species. Locational information is now maintained and updated in the Natural Diversity Database. Lists of such species are periodically revised and published. To date, most of the emphasis has been placed upon plants and vertebrates. Little or no information has been generated with respect to invertebrates, algae, mosses, and lichens. Monitoring is conducted approximately every five years to confirm the status of previously identified populations. Coincidentally, critical habitat information is compiled and digitized. The Department has begun to implement the requirements of the Endangered Species Act but one of the critical elements yet to be undertaken is identification of essential habitats and development of associated management strategies/recovery plans. All permit applications submitted to the CTDEP are reviewed by the database staff to assure that no adverse impacts to these species will occur. The annual budget for this program on a statewide basis is $350,000. The federal Endangered Species Act is administered by the USFWS for all species expect marine species which are administered by the NMFS.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Develop a list of endangered and threatened invertebrates. Maintain and update the diversity database. Periodically revise the list of threatened and endangered species. Expand the monitoring program, identify essential habitats, and develop recovery plans.	CTDEP	—	$150,000 per year for staff; $200,000 per year for least tern and piping plover nest site restoration
Develop legislation or regulations in New York state that will minimize disturbance to the essential habitats of rare plants and animals.	NYSDEC	—	Redirect Base Program
Revise and publish a list of rare and sensitive species associated with the coastal lands and waters of Long Island Sound.	NYSDEC	Every 5 years	$50,000

Many of the Sound's resources are harvested for human consumption, including oysters, clams, lobsters, blue crabs, bluefish, winter flounder, fluke, striped bass, scup, tautog, and black duck. In order to prevent overharvesting, these resources must be managed. Table 44 summarizes the actions to effectively manage these species so they are available for the enjoyment and employment of current and future generations.

Table 44 Managing harvested species.

ONGOING PROGRAMS	Responsible Parties/Status
Development and implementation of fishery management plans, including research, monitoring ,and conservation law enforcement activities.	The CTDEP, the NYSDEC, the NMFS, and the USFWS cooperate under the auspices of the Atlantic States Marine Fisheries Commission and the New England and Mid-Atlantic Fishery Management Councils to develop plans that reduce fishing mortality, prevent overfishing, and increase stock size and yield from Long Island Sound (and all Atlantic coast) fisheries. Research, monitoring, and conservation law enforcement activities are integral components of such activities, costing Connecticut in excess of $1,000,000 per year in state and federal funds.
Management of shellfish aquaculture activities including resource monitoring.	In state-managed waters, the Connecticut Dept. of Agriculture's Aquaculture Division, the NYSDEC, and private shellfish companies engage in practices intended to enhance production of oysters and hard clams, as well as manage other available resources (e.g., surf clams) as needed. In waters under municipal jurisdiction, a number of towns have shellfish commissions that manage town shellfish beds for recreational and sometimes joint recreational/commercial harvests. In Connecticut, the state program costs approximately $1,250,000 for staff, base programs, and cultch (shell) acquisition. Municipal programs are often conducted for $5,000 or less.

Improvement of anadromous fish passage opportunities including associated research and monitoring activities.	The CTDEP, with involvement of private conservation organizations and municipalities, bypasses dams that serve as barriers to fish migration. This includes planning and development of fishways to improve runs of anadromous herrings and management of existing fishways on the Farmington and Salmon Rivers intended principally to aid in Atlantic salmon restoration and, secondarily, to enhance runs of other anadromous species (e.g., alewives, river herring, American shad). In Connecticut, these activities are funded at approximately $500,000 of state and federal funds, which cover operation and maintenance of fish holding and passage facilities and resource monitoring associated with American shad management.
Wildlife management, including research and monitoring activities in support of management programs.	The NYSDEC, the CTDEP, The Atlantic Flyway Council, and private conservation organizations establish harvest limits and develop programs to control nuisance species or those that are detrimental to important living resources and their habitats. The state and federal agencies also develop programs that restore diminished species. In Connecticut, these activities are funded at approximately $150,000 of state and federal funds (specific to Long Island Sound).
Activities that minimize mortality due to entrainment and impingement of eggs, larvae, and juvenile and adult aquatic organisms at industrial facilities.	The CTDEP, the NYSDEC, the EPA, the NMFS, the USFWS, power plant staff, and staff of other industrial facilities review facility activities to achieve *best available technology* through permit conditions and Clean Water Act 316(a) and (b) demonstrations. In Connecticut, these activities cost CTDEP approximately $150,000, exclusive of permit process administrative costs.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Define, revise, and coordinate the establishment of seasonal restrictions for dredging that minimize adverse effects on aquatic organisms, especially finfish and shellfish and their habitats.	LISS CTDEP NYSDEC NYSDOS EPA NOAA USACOE USFWS Marine Sciences Research Center at the State University of New York at Stony Brook (MSRC/SUNY)	1994	Redirection of base program

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Enhance implementation of interstate fishery management plans for Long Island Sound fishery resources.	CTDEP NYSDEC NMFS USFWS	To be initiated upon approval of funding.	$250,000 per year per state will be used to fund fishery management staff and, in Connecticut, law enforcement officers.

Expand efforts to bypass obstructions to anadromous finfish migrations on Connecticut tributaries to Long Island Sound and the Connecticut River by constructing or installing fishways or fishlifts.	CTDEP Municipal governments and environmental organizations USFWS NMFS	To be initiated with enhanced funding.	$100,000 per year for CTDEP staff to administer activities and construct small tributary fishways. Costs to be determined as project opportunities arise.
Enhance municipal shellfish restoration programs.	Municipal governments	Upon funding	$100,000 per state per year for a number of small grants to municipalities to enhance oyster, clam and bay scallop restoration efforts.
Enhance the Connecticut Oyster Restoration Program on public beds in state waters by stocking settling habitat (cultch) and conducting related activities (e.g., resource sampling).	Connecticut Dept. of Agriculture Aquaculture Division	To be initiated with enhanced funding	$100,000 per year for staff and $400,000 per year for purchase of cultch for maintenance of restored beds.
Develop a marine biotoxin assessment program for shellfish.	Connecticut Dept. of Agriculture Aquaculture Division NYSDEC	To be initiated upon approval of funding	$300,000 per year in Connecticut and $150,000 per year in New York for staff and laboratory costs.
Develop artificial reefs in appropriate areas of New York waters to increase fishing opportunities, consistent with the New York State Artificial Reef Development Plan. Plans have been developed to construct reefs in New York waters of Long Island Sound off Matinecock Point, Eatons Neck, Miller Place/Mt. Sinai, and Mattituck Inlet.	NYSDEC and cooperators	To be initiated upon approval of funding	Approximately $100,000 for each of four reefs planned for Long Island Sound.
Develop methods to reduce the incidental take of nontarget species and undersized individuals in fishing activities.	CTDEP NYSDEC NMFS USFWS Atlantic States Marine Fisheries Council New England and Mid-Atlantic Fishery Management Councils Commercial and recreational fishing organizations	To be initiated upon approval of funding	$50,000 per year per state for staff and approximately $10,000-20,000 per year for test materials and equipment.

Prohibiting introductions of known or potentially undesirable exotic species will minimize threats such as predation on or competition with native plants and animals. The actions in Table 45 to control

species that at times cause damage will help to restore the ecological balance of the Sound. Exotic species and those species that cause damage can be especially damaging to populations of endangered or threatened species in and around the Sound.

Table 45 Managing exotic and nuisance species.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Develop measures to prohibit or prevent the introduction or release to Long Island Sound and its watershed of known or potentially undesirable species.	CTDEP NYSDEC USFWS U.S. Coast Guard Shipping companies	To be initiated as soon as possible	$50,000 per year per state for staff to develop and manage program.
Implement a management program to reduce abundance of mute swans that are causing losses of certain aquatic habitat types such as submerged aquatic vegetation and certain types of emergent tidal wetland vegetation.	CTDEP	To be initiated as soon as possible	To be included within costs of above item.

4. Education

Informing and educating the public about the plants and animals of Long Island Sound is fundamental to fostering a sense of responsibility for these valuable resources. It is a first step towards involving the public in cleaning up and caring for the Sound. The actions in Table 46 will help to inform and educate the public about the Sound's living resources and involve them in implementing this plan.

Table 46 Educating the public about the plants and animals of Long Island Sound.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Develop an outreach program to inform and educate the public about the plants and animals in Long Island Sound.	Federal, state, and local governments, educational systems, organizations, and environmental organizations	—	See Public Involvement and Education Section of this Management Plan.
Develop a citizens monitoring program specific to the plants and animals of Long Island Sound sufficient to aid managers in identifying problems and assessing the effects of management efforts.	Federal, state and local governments, educational and environmental organizations and private citizens.	—	See Public Involvement and Education Section of this Management Plan.

5. Monitoring, Assessment, and Research

Monitoring plants and animals helps to determine if there are trends in resource condition or environmental quality that we should be aware of. For example, the status of species at the top of the aquatic food chain (e.g., osprey) can serve as an environmental indicator of the overall health of the ecosystem. Only through monitoring can we determine if valuable habitat is being destroyed or if we are overharvesting fish and wildlife resources. Once these trends are apparent, research will identify the causes and assess their importance. Despite the knowledge gained through the LISS, many questions about the plants and animals of Long Island Sound remain. Research will help to answer some of these questions. Research can also point us to alternative, less detrimental ways of living. Once we have made lifestyle changes intended to improve the Sound, we must determine their effectiveness through additional monitoring. Thus, monitoring, assessment, and research are all critical to the future of the Sound.

One of the best measures of the health of the Sound and the efficacy of remedial measures proposed by the LISS are living resources. Species and biological communities are the ultimate integrators of all environmental factors, variables, and parameters in the Long Island Sound ecosystem and are best overall indicators of the health and water quality of the Sound. Therefore, any monitoring program for the Sound should identify key organisms and communities as long term monitoring tools.

The states of Connecticut and New York, the Interstate Sanitation Commission, and a number of federal agencies have monitored the condition of Long Island Sound resources and their environment in past years, to the best of their abilities. With the information derived, resource and environmental assessments have been prepared to guide managers in their decision-making. The CTDEP's Long Island Sound Resource Center at Avery Point was created in 1988 to develop the full potential of estuarine-related Geographic Information System applications, to computerize pertinent literature and data for rapid access through standard library search protocols, and to complete a description of the geology of Long Island Sound. Regrettably, however, a consistent, stable source of funding for all of these important activities has never been established.

The results of the LISS together with many problems occurring in other estuaries have led to the identification of a number of critical research needs in the Sound, many of which are intended to evaluate the effects of water quality degradation, especially that associated with nitrogen enrichment. In 1989, the Connecticut legislature created the Long Island Sound Research Fund for the purpose of addressing priority research as it relates to the management of Long Island Sound. Annually, the CTDEP releases a request for proposals to instate academic institutions to solicit research proposals addressing high priority management issues.

The commitments and recommendations in Table 47 and Table 48 are intended to improve the information available for management of Long Island Sound by developing a data base that incorporates resource and habitat information and sources of impacts for the purpose of management and monitoring.

Table 47 Developing an informational database about living resources and their habitats.

ONGOING PROGRAMS	Responsible Parties/Status
Connecticut will continue its statewide Geographic Information System (GIS) Program to digitize spatial information and data for resource management purposes.	The CTDEP is responsible for the development and management of Connecticut's GIS program. A variety of data layers have been or are being completed including detailed hydrography, drainage basins, surficial materials , state property, water quality classifications, land use-land cover, contour information, water supply information, and sewer service areas. Digitizing of soils and orthophotography is soon to commence. Present funding for GIS operations is $400,000 per year statewide.
Connecticut has created a Long Island Sound Resources Center for the purposes of: 1) developing the full potential of estuarine related GIS applications; 2) computerizing pertinent literature and data for rapid access through standard word search and spatial basis; and 3) completion of the estuarine geology of Long Island Sound. Additionally, this Center is taking a leadership role in the development of side scan sonar mapping of Long Island Sound that is now being overlaid with benthic community information. This will become the foundation of future living species and habitat management programs.	This program is administered by the CTDEP. The computerization of pertinent literature has been completed and resource data is in progress. At the moment, funding is only available for the continuation of the estuarine geology mapping which has an annual program costs of $50,000 per year. In order for the Center to maintain and enhance the literature-GIS capabilities, develop CD ROM capabilities for rapid retrieval of published literature, data and imagery, and to assist resource managers in developing new GIS based programs, funding levels needs to be increased by $150,000.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Identify spatial data for living resources and habitat on a soundwide basis and digitize priority data sets for incorporating into a Soundwide Geographic Information System.	LISS	Initiated in winter of 1993-1994; completion date is winter 1994-1995	$57,000 LISS Funds

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Expand the data layers for living resources and their habitats on a soundwide basis.	EPA-LIS Office	5 years	$75,000 per year
Develop and maintain state databases and an integrated Long Island Sound database describing the living resources of Long Island Sound and their habitats.	CTDEP NYSDEC	—	$50,000 per year for each state for staff and $100,000 one-time only for data processing hardware/software
Expand the side scan sonar/benthic habitat mapping program in order to create baseline information for management and conservation purposes.	CTDEP	—	$100,000 per year for 5 years
Maintain and enhance the Long Island Sound literature, indexing and GIS capabilities of the Marine Sciences Research Center at SUNY, Stony Brook.	MSRC/SUNY	—	$75,000 per year

Table 48 Soundwide and site-specific research and monitoring.

ONGOING PROGRAMS	Responsible Parties/Status
Connecticut conducts a Soundwide open water fishery survey that has become an integral component of the LISS monitoring and management programs. In addition, Connecticut conducts a nearshore finfish survey, and surveys of lobster, shad, anadromous herrings, Atlantic sturgeon, and shortnose sturgeon (the latter is listed by the federal government as an endangered species). Other marine surveys include a survey of oyster recruitment (Connecticut Department of Agriculture, Aquaculture Division) and recreational and commercial fishery statistics activities.	The CTDEP Fisheries Division and the Department of Agriculture, Aquaculture Division conduct these surveys at an annual cost of $500,000-800,000 of state and federal funds. (These costs are included in the total costs of Ongoing Programs in the Harvested Species section). Critical EPA funding for Long Island Sound-specific living resource monitoring and research activities is only secured through 1994 and other sources of support for the open water survey will be reduced. If these LISS-specific activities are to be continued, an alternate source of funding must be developed.
Connecticut conducts nesting surveys of colonial waterbirds, Least Tern and Piping Plover, Osprey, waterfowl, a mid-winter eagle survey, and surveys of diamond-backed terrapin, threatened and endangered terrestrial species, and other species of special concern.	The CTDEP Wildlife Division conducts these surveys at a cost less than $100,000. (These costs are included in the total costs of the Ongoing Programs in the Harvested Species section).
New York conducts an American lobster mortality project funded by the LISS. In addition, New York conducts the NMFS's Recreational Fishery Statistics Survey, surveys of commercial fishery landings, seabird surveys (e.g., ospreys, piping plovers, least terns), surveys of threatened and endangered species and species of special concern, and other surveys as needed.	NYSDEC

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Connecticut should pursue the construction and staffing of a marine science technology center at Avery Point with a research focus on Long Island Sound.	CTDED CTDEP CTDOA University of Connecticut	—	$33 million in capital costs; $4 million per year in operating costs.
Enhance wildlife monitoring activities (e.g., seabirds, waterfowl, and marine turtles.	CTDEP	—	$50,000 per year for staff, interns and contract work
Monitor the status and trends of eelgrass in the Sound and all species of submerged aquatic vegetation in the Connecticut River using remote sensing and ground surveys.	CTDEP EPA	To be initiated upon funding	$100,000 per year for photography, field surveys, and boundary delineations
New York should initiate a nearshore fishery independent survey of Long Island Sound.	NYSDEC	To be initiated upon funding	$150,000 per year
Continue the lobster mortality and disease monitoring project in Long Island Sound.	NYSDEC	Annually	$65,000 per year

Additional research is needed to fill in the gaps in our current understanding of how Long Island Sound functions as an ecosystem. Table 49 summarizes actions to develop a research agenda that identifies information gaps and outlines priorities for research on living resources.

Table 49 Living resources and habitat research.

ONGOING PROGRAMS	Responsible Parties/Status
Connecticut will continue the Long Island Sound Research Fund. This fund is used to foster research that addresses priority management issues in Long Island Sound including living species and their habitats.	The CTDEP administers this program and identifies priority research topics on an annual basis. A request for proposals is then made available to eligible research institutions in Connecticut. Annually the Department holds a Long Island Sound Research Conference through which researchers present the results of their studies to managers, researchers, students and the general public. Annual funding is $1,000,000 and funding requests are submitted on an annual basis.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Connecticut has funded the following living resources and habitat research: evaluation of the causes of declines of eelgrass; assessment of contaminant levels in the greater scaup; changes in the phytoplankton community resulting from nitrogen enrichment; effects of hypoxia on bottom feeding fish; vegetation changes in a restoring tidal wetland; and mapping of benthic communities.	CTDEP and various Connecticut researchers	Each research topic has a different completion date ranging from spring of 1994 to 1996.	$870,000

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Identify priorities for management-oriented research about the living resources of Long Island Sound and their habitats.	CTDEP NYSDEC EPA EPA-LIS Office NMFS USFWS Academic Institutions	—	$5,000 workshop

VIII. Land Use and Development

A. Why is Land Use and Development a Concern?

Long Island Sound is the *sink* for a 16,000 square mile watershed, and, therefore, its water quality is closely tied to the ways in which we use and develop the land. However, concern for water quality protection has often been neglected in land use policies, especially cumulative or downstream impacts of land use that are difficult to predict. As population and development increased, the local land use planning and regulatory processes fostered uses that have cumulatively degraded the Sound. With approximately 8.4 million people living within its drainage basin at some of the highest densities found in the country, Long Island Sound is particularly vulnerable to the *tragedy of the commons* -- the collective impact of individual choices made by government, landowners, industry, and consumers.

Even where environmental impacts have been identified, engineered solutions have sometimes generated secondary water quality problems. For example, to replicate natural drainage efficiencies in urbanized areas, storm water systems have been designed to discharge runoff as quickly as possible. As a result, contaminants in stormwater are rapidly discharged to the Sound and its upstream waters.

Urban and suburban development has also resulted in the loss of natural habitats and has limited public access to the coast. In the past, ignorance of the value of natural habitats resulted in their despoliation. For example, wetlands were considered unproductive wastelands, a nuisance to be filled for more *constructive* uses. While existing habitat management and regulatory programs have substantially improved the situation since the 1970s, particularly for tidal wetlands, some habitats are still vulnerable to development pressures. Also, despite a significant increase in the number of public waterfront areas, additional public access sites are needed.

B. How are Land Use and Development Managed?

Our system of federalism divides land and water management among federal, state, county, and local governments. Land use and zoning decisions have typically been, and still are, the purview of local government. Given our strong tradition of home rule, it is likely to stay that way. While some may call for a single regional entity with overall authority, there are good reasons for land use and zoning decisions to be locally based, especially for water quality because impacts are often site-specific. The extent to which water quality will be affected depends significantly on the hydrological regime of the site, the nature of the land use, the design and construction of the use, the management of the use, measures taken to mitigate adverse impacts, and the impacts of neighboring uses. Local officials are most familiar with site-specific conditions, and as a result, are best positioned to make decisions that will work for a particular development and to enforce land use and zoning controls, provided they are properly trained.

The land use statutes in Connecticut and New York generally have authorized, but have not required, consideration of water quality or habitat impacts. Many land use decision-makers, however, choose not to consider them. Without a clearer mandate, many decision-makers may be reluctant to consider the effects of land use on water quality and habitats. Where revisions to statutes have been made, such as a 1991 amendment requiring Long Island Sound shoreline towns in Connecticut to consider water quality impacts, additional guidance often is needed. When officials must or do consider water quality impacts in project reviews, the lack of clear standards and guidance promotes inconsistent decisions both within and among jurisdictions.

Local decision-makers serving on boards and commissions are often volunteers. Even the most responsive regulatory programs are not going to be successful if the decision-makers are untrained and lack necessary technical assistance. The high turnover rate on many volunteer commissions makes training a continuing need, but due to cost considerations, training programs for local officials have not been a governmental priority. Extension services, associations of local officials, and bar associations have had to fill in the training gap. Even the most interested lay board member will not receive adequate instruction in a few brief training sessions to be a skilled water quality technician, particularly in the application of best management practices. Even the strongest programs on paper may, therefore, fail to address water quality adequately in practice. It is a major policy challenge to formally incorporate water quality and habitat protection issues into existing public land use decision-making and to ensure that adequate training and technical assistance are provided.

C. What Needs to be Done?

Managing the impact of development is complex and often controversial because the Sound has a large and highly populated drainage area; there are many layers of authority for land use management, and the basin contains varied and dispersed nonpoint sources of pollution such as urban runoff. Growth and development create opposing visions of economic vitality versus environmental degradation which often polarizes the land use issue.

In recognition of the importance and complexity of this issue, the Management Conference established a land use work group in February 1992. The group's purpose was to identify the ways that land use and development affect water quality, habitat protection, and public access and to present recommendations to improve land use planning and management throughout the Sound's watershed.

The work group concluded that:

1) The impacts from existing development must be reduced to improve water quality;
2) The impacts from new development must be minimized to prevent further degradation of water quality;
3) For land use decisions to effectively incorporate water quality and habitat protection, information, training, and education must be expanded;
4) Conservation of natural resources and open space is vital to the protection of the Sound; and
5) Public access is essential so that the public can use and enjoy Long Island Sound, especially since improvements to Long Island Sound water quality involve public costs.

Programs to meet these goals must be conducted on a watershed basis and in a coordinated and comprehensive fashion.

Each of these five findings is discussed in more detail in the following sections. General objectives for each of the findings are identified. The role of existing programs in meeting these objectives is discussed and specific enhancements to the present efforts are recommended.

1. Reduce Impacts of Existing Development

The New England River Basins Commission, in a 1975 report, summarized its plan for Long Island Sound in two words - *guide growth.* It is instructive to compare that prescription for management of the Sound with the current reality of a developed watershed that experienced diminished population growth in the 1970s and 1980s and for which limited growth is projected in the 1990s. Guiding or

even restricting future growth will not alleviate current water quality problems caused by existing, often poorly planned, land uses. While guiding and managing future development will remain important, especially in the preservation of open space and significant habitats, managing existing uses, and redevelopment are critical to reducing land use impacts on Long Island Sound water quality.

Objective: Implement the programs identified in this plan to control polluted stormwater runoff using structural and operational best management practices.

Programs to control stormwater runoff through structural and operational best management practices have been identified throughout this plan. Their implementation will directly address significant sources of nitrogen, toxic substances, pathogens, and floatable debris. Prominent programs include NPDES stormwater permitting, the Coastal Nonpoint Pollution Control Program under the Coastal Zone Management Program, nonpoint source control under Section 319 of the Clean Water Act, and combined sewer overflows (CSO) abatement programs. Support for these programs must continue. Improved land planning and use is needed to support their implementation and coordinate activities at the state, local, and federal levels and with the private sector.

To enhance these efforts the CTDEP, the NYSDEC, and the NYSDOS should examine the ramifications of exemption from Section 6217 of the Coastal Zone Management Act Reauthorization Amendments of municipalities with CSOs or general stormwater permits. The implementation of the Section 6217 Coastal Nonpoint Pollution Control Program and CSO and stormwater abatement programs should be required in a consistent and equitable manner.

Objective: Upgrade infrastructure capability and operation for existing development.

To restore degraded waters and preserve clean waters in the Sound and its tributaries, federal, state, and local policies should encourage urban and suburban redevelopment. Specifically, public and private investment in urban environmental infrastructure, such as sewage treatment plants and the reclamation of derelict waterfront properties on the Sound and its tributaries, should take priority over developing undisturbed lands. This will reduce pollutant loads from the most significant sources to the Sound and reduce obstacles to growth in developed areas. State and municipal governments should carefully plan redevelopment to ensure that adequate sewage treatment capacity exists to meet additional demands.

There are many programs related to infrastructure construction and maintenance. One example of particular importance is maintenance and operation of sewage treatment plants including maintaining sufficient treatment capacity, providing incentives for retrofitting sewage treatment plants, and upgrading for nitrogen removal. See Appendix A *Connecticut and New York State Initial Infrastructure Project List* for examples of the potential costs of sewage treatment plant upgrades and abatement of CSOs.

State and local governments should also take advantage of making *improvements* to existing structures (e.g., highways, and flood and erosion control structures) to improve stormwater management infrastructure.

Objective: Remediate abandoned or underutilized sites that can be significant sources of pollutants to Long Island Sound such as abandoned industrial sites, hazardous waste sites, and sites containing underground storage tanks.

Urban waterfront sites may be contaminated with toxic substances resulting from historic land uses. As a result, developers and investors shy away from those sites because of the potentially high costs of remediation and liability. This has a secondary effect of encouraging new *sprawl* development in suburban and rural areas on *safe* undeveloped lands. Setting cleanup standards, subsidizing some cleanups, and limiting open-ended liability are important incentives for urban redevelopment and for enhancing water quality. For example, the state of Connecticut is implementing a pilot Urban Sites Remediation Program to identify and evaluate contaminated urban industrial sites deemed vital to the economic development needs of the state and to provide funding for cleanup of sites. This program is designed to expedite the cleanup and subsequent redevelopment of urban sites where infrastructure exists, rather than developing remaining parcels of land. The cleanup of such sites can reduce impediments to redevelopment as well as reduce potential pollutant sources to the Sound.

To enhance these efforts the CTDEP, the NYSDEC, and the EPA should set cleanup standards and provide incentives such as subsidizing some cleanups, and limiting open-ended liability. Programs like the Connecticut pilot Urban Sites Remediation program should be supported and expanded.

Objective: Maintain and improve oil and spill prevention and responsiveness plans and their coordination at the federal, state, and local levels.

Spill preparedness has been a priority in both states for many years. In Connecticut, the Long Island Sound Oil Spill Prevention and Protection Program is an ongoing responsibility of the CTDEP's Oil and Chemical Spill Response Division. Since 1972, the main emphasis of this program has been protection of estuaries, rivers, and coastal areas of the state, complementing the coastal zone and open water oil spill objectives of the federal government. The combined resources of the CTDEP, municipal and industrial cooperatives, spill contractors, and the United States Coast Guard give the state extensive spill protection capability. Coordination among spill response participants is fundamental to successful management and is enhanced by the production and updating of local, state, and federal contingency plans and maintained communications among appropriate agencies.

In New York, the Spill Response Program is administered by the NYSDEC, headquartered in Albany, with trained response personnel assigned to regional offices throughout New York state. The program operates a 24-hour Spill Hotline for receiving notification of petroleum and chemical spills. The program staff responds to known and suspected spills, and ensures that containment, cleanup, and disposal are completed to minimize environmental damage. This program is part of a network that responds to emergencies caused by spills. Besides the NYSDEC, the network includes local health, fire, and police departments, the State Department of Health, the EPA, and the Coast Guard.

Considering the number of spills and potential environmental damage which might result without prompt and effective action, spills management should remain a top priority in the control of toxic contaminants of relevance to Long Island Sound.

2. Minimize Impacts of New Development

The cumulative impact of development can be significant, even if the impact from individual activities appears minor. Adequate consideration of the cumulative impact of individual actions on pollutant loadings and habitat loss is needed to adequately protect the Sound.

Of particular importance are government policies that strongly discourage the development of environmentally sensitive and significant areas such as wetlands and river or stream banks (also called riparian zones). Existing state and federal wetland regulations consider a variety of wetland values,

including their potential nutrient and pollution removal functions. They do not, however, effectively regulate by these functions. This is particularly relevant considering some of these areas are privately held and can be developed. The public benefits of preserving wetlands and riparian zones for protecting water quality must be considered as well as other documented benefits such as flood protection, habitat for wildlife, and scenic preservation.

Furthermore, the concept that the state holds some lands in sovereign trust for the public good must be asserted consistently throughout the watershed. For example, the Public Trust Doctrine provides that lands subject to the ebb and flow of the tides, including tidal wetlands, are held by the state in trust for the public good. Adjacent upland owners have the right of access to intertidal areas (consistent with the character of the area) but not development or ownership rights. Public ownership of intertidal areas provides additional rationale for controlling the use and impacts upon wetlands, rivers, and stream banks.

Objective: Protect and enhance remaining tidal and freshwater wetlands and protect riparian zones and wetland buffers both inland and in the coastal areas.

Specific programs to protect and enhance wetlands, wetland buffers, and riparian zones are described in the Living Resource Management and Habitat Protection section of this plan.

Of primary importance is the strict application and enforcement of tidal and freshwater wetlands protection laws in Connecticut and New York to prevent the loss of wetlands and encourage a net gain in quality and function. The value of protecting wetlands and watercourse buffers should be affirmed through education efforts. Also, sufficiently wide upland buffers should be mandatory and based on consistent, justifiable criteria such as soil, slopes, intensity of proposed use, vegetation and wildlife, and watershed needs.

Objective: Explore how resource trading (i.e., mitigation) policies affect Long Island Sound.

Created wetlands and other habitats are frequently less valuable than the established areas whose loss they are intended to mitigate. For example, the nature and value of created wetlands vary widely, often related to ecological succession (the changes in species inhabiting an area over time). Created wetlands do have immediate benefits, such as: soil stabilization, especially in the intertidal zone; adsorption of nutrients, pathogens, and contaminants from runoff; and food and refuge for wildlife. As a result, case-by-case analyses are required to determine whether created wetlands and habitats will adequately replace the functions and values lost from the destruction of natural systems.

The CTDEP and the NYSDEC should review existing programs, analyzing the success rate of mitigation, identifying how they are linked to benefits for the Sound, and develop a Sound-wide inventory of degraded resources and potential restoration activities.

Objective: Guide development to suitable areas with existing infrastructure and encourage compact growth patterns.

The further development, or redevelopment, of previously developed areas is, often, more environmentally sound than development in natural areas and has other socially desirable benefits.

Government should expand public transportation, provide incentives for its use, and discourage private automobile use. Through appropriate state and local programs, growth should be guided to areas with existing transportation and infrastructure. Incentives should be provided for redevelopment

of areas (e.g., enterprise zones, density bonuses). Contaminated sites should be cleaned up to encourage redevelopment. Efforts such as the state of Connecticut Urban Sites Remediation Program that identifies and remediates contaminated urban industrial sites deemed vital to the economic development needs of the state should be supported.

Long Island Sound water quality issues should be emphasized in state and local plans of development and in the review of federal and state projects and programs.

Objective: Advocate cluster development to protect sensitive areas and preserve open spaces without encouraging development densities that result in negative social and environmental impacts.

Clustering can result in a net environmental benefit, especially in developed and sewered areas, as long as it is does not result in densities greater than the natural capacity of the land. However, cluster development should not be encouraged in non-sewered areas that would result in community septic systems.

Objective: Recognize potential impact of expanded or changing land uses on the capacity of water delivery and treatment infrastructure.

New residential and institutional uses on old commercial and industrial sites are desirable as long as the infrastructure has the capability or is upgraded to handle potential increases in water consumption and treatment. Planning and regulatory agencies should consider development and institutional use trends and what effect they will have upon the consumption and treatment of water.

Objective: Give priority to appropriate water-dependent uses at coastal zone locations.

Uses requiring a location at the water's edge or in coastal waters should not have to compete with other land uses that can be accommodated elsewhere in the watershed. Planning and regulatory agencies should adopt local land use ordinances and regulations throughout the watershed giving priority to water-dependent uses in the coastal zone. Land adjacent to deep water areas should be reserved for maritime uses requiring deep water access, such as loading and unloading of cargo ships.

Objective: Develop and implement programs requiring use of Best Management Practices (BMPs) for <u>both</u> the construction and operation of new development.

Programs to control stormwater using structural and operational BMPs must be implemented. These include permitting of stormwater discharges established under the Clean Water Act amendments of 1987, the Coastal Nonpoint Pollution Control management programs required by Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990, and the nonpoint source management plans supported under Section 319 of the Clean Water Act. Other sections of the management plan detail recommendations in this area.

Objective: Develop policies for package plants, including provisions for their maintenance.

Package plants (e.g., small sewage treatment plants) can be positive in abatement of failing septic systems. However, experience has shown high failure rate of package plants, resulting in their default and takeover by municipalities. As a result, package plants have provided only a short-term solution to waste treatment. Long-term deficiencies are created by allowing additional hook ups in areas presently inadequately serviced, increasing intensity of use in inappropriate areas.

To begin to correct these problems, the CTDEP, the NYSDEC, and the EPA should analyze the effectiveness, longevity, and appropriate application of package plants.

Objective: Examine septic system use and siting policies.

Proper use and siting of septic systems will help minimize nitrogen and pathogens impacts on the Sound or its tributaries. The CTDEP, the NYSDEC, and local health departments should review programs and guidance on siting, operation, and maintenance of septic systems and examine the appropriateness of sewer avoidance practices in sensitive areas.

Objective: Reexamine flood and erosion control programs and policies.

Discouraging construction in areas especially prone to floods will help protect coastal resources and habitats, public safety, and land and water under the public trust. Recommendations for structural erosion and flooding control measures should be consistent with water quality, habitat protection, and public access objectives.

Congress and the Federal Emergency Management Administration (FEMA) should restructure the National Flood Insurance Program, through reauthorization, to ensure that it does not encourage construction in flood prone coastal areas. One example would be to eliminate subsidies in velocity zones (the coastal area at greatest risk of flood damage). State and local guidelines and requirements should then be modified and be consistent with the national program. Through the reauthorization of the National Flood Insurance Program, a funded buy out program should be created for areas susceptible to chronic flooding hazards.

3. Improve Information Management, Training, and Education

At present, myriad local, state, and federal agencies make land use related decisions that directly and indirectly affect Long Island Sound water quality. Because their responsibilities developed over time, these agencies often do not apply consistent water quality management guidelines, if they consider water quality at all, nor do they all have access to expert technical assistance when developing plans and reviewing projects. Coordinated guidance should be provided to ensure that Long Island Sound water quality priorities are addressed and duplication of effort and conflicts are minimized.

An approach worth considering is one used under the federal Coastal Zone Management Act. The Act provided the impetus for Connecticut and New York to develop programs to manage and protect coastal resources. Water quality and resource use and protection policies have been developed as guidelines for the evaluation of activities affecting the coastal zone. Decision-makers at all levels of government are legally bound to ensure their decisions are consistent with these policies. The coastal management program conducted in Connecticut provides training and technical assistance to local officials on a project by project basis, thereby providing for consistent analysis of impacts from proposed projects. Expanding this management approach for water quality throughout the watershed would begin to address the problems identified above. The success of this approach would depend on providing assistance to a municipality, conservation commission, or other appropriate agency to implement regulations, conduct site plan reviews, or receive and evaluate technical information.

Objective: Develop consistent information on a regional scale.

Consistent and readily available information will support watershed planning efforts. Information may be used by regulatory agencies to assist with the decision-making process on the acceptability of

potential projects. Developers can use the information to assist in the design of projects that will meet standards for permit issuance. Information should also be available to the public in an easy to read and understandable format.

Regional databases should be supported on a number of topics including land use and land cover, water use, the value of water quality-dependent uses, wastewater generation, and critical habitats and resources. Geographic Information Systems should be expanded and improved to help organize and present data.

Objective: Provide training, technical assistance, and financing for local government.

Adequate and standardized training will facilitate consistency by decision-makers at all levels of government.

The states should develop proposals to establish and institutionalize water quality training programs for local land use regulatory officials, the legal community, etc. The proposals should identify potential funding sources.

Objective: Educate the general public and groups such as contractors, architects, and engineers on the impact of actions throughout the watershed on water quality of the Sound.

Educating groups in the development field (e.g., architects, engineers, and contractors) will encourage proposals for environmentally compatible projects and discourage project proposals that would clearly fail standards for permit issuance.

Federal, state, and local agencies should conduct workshops throughout the watershed to describe why regulations are in effect, what their benefits are, and what regulatory agencies are trying to achieve in the permit review process.

4. Conserve and Enhance Natural Resources and Open Spaces

The Sound's ability to cleanse itself and support indigenous populations has been reduced. The ability of the remaining areas to carry out these functions must be permanently protected.

Regulatory protection for environmentally significant areas alone will not ensure long term preservation of these sites. Land acquisition, or purchase or transfer of development rights may be necessary to maintain the remaining natural areas and their important water quality and habitat values.

Objective: Advocate a watershed approach to integrate protection of surface waters with programs and plans for guiding growth and development.

The broad range of impacts of land use and development are best addressed through a comprehensive watershed planning process. Reauthorization of the Clean Water Act should integrate watershed protection of surface waters with coastal protection efforts like the state Coastal Zone Management Programs.

Objective: Preserve open space and natural areas.

Preserving environmentally sensitive habitats, such as forests, and maintaining open space minimizes runoff pollution and provides wildlife habitat.

Existing federal, state, and local open space or other land acquisition programs should support Long Island Sound water quality and habitat objectives. Opportunities for private groups to buy land for the purpose of water quality and habitat protection should be identified. Open space preservation actions are detailed in the Living Resource Management and Habitat Protection section of this plan.

Objective: Adopt practices that conserve water and energy and reduce solid waste disposal needs through waste minimization, reuse, and recycling.

Reductions in the generation of solid waste and hazardous waste will reduce disposal costs, and land fill needs. Water conservation can result in improved treatment and maintain capacity at sewage treatment plants.

Federal, state, and local agencies should encourage conservation activities through government procurement practices, incentive programs, and regulation. The utilization of gray water for non-consumptive uses (e.g., watering plants) to conserve potable water and to potentially create natural habitat should be explored. Local recycling programs, including hazardous household collection programs should be supported. Other potential tools include: the use of construction standards for efficient energy and water use; requiring publicly funded (or publicly guaranteed) projects to practice water conservation in building and landscaping as a condition of funding; and imposing disincentives on excessive waste generation, including excess consumer packaging.

5. Increase Public Access

Increased public access to Long Island Sound will provide the public with greater opportunities for use and enjoyment, especially since the Sound's water quality improvements require substantial public costs. Promoting physical and visual access to the coast increases the use, value, and appreciation of the Sound.

Objective: Preserve and enhance public access and view corridors to coastal waters.

Public access improvements should be aggressively pursued throughout the watershed using a combination of traditional techniques, such as fee-simple acquisition, application of coastal management standards, and other innovative techniques, such as transfer of development rights and tax credits.

State and local agencies should put public access signs at all appropriate locations to identify both full public access, and limited access when necessary to protect sensitive resource areas.

New York state should incorporate data on access and acquisition sites into a NYSDEC Geographic Information System and implement the NYSDEC's report on *Recommendations for Improving Marine Recreational Fishing Access in New York State's Marine and Coastal District.*

D. What Are the Next Steps?

Environmental legislation has established and expanded resource protection programs at the federal, state, and local levels. Private conservation and education organizations have also proliferated. As a

result, existing agencies and organizations have the basic authorities and tools in place to protect and preserve the Sound. However, in our current system, water quality concerns are incorporated into the land use decision-making process in a fragmented and inconsistent manner. Watersheds often defy political borders -- a key reason why improved coordination is needed among all levels of government. Watershed level planning must tie together the efforts of local governments to meet both local and regional needs. Federal, state, and regional agencies each have a role in producing clear guidance, technical and financial assistance, and training to make programs effective.

The New York State Department of State has recently prepared a Long Island Sound Coastal Management Program that sets out specific recommendations for guiding land use and development, ensuring public access to the shore, and protecting important habitats. The program is consistent with the Long Island Sound Study plan and should be adopted by New York state.

Connecticut's Coastal Management Program, adopted in 1980, contains many provisions similar to the New York program, including mandatory requirements for public access at waterfront parcels. Implemented at the local level as a mandatory component of planning and zoning reviews, the Connecticut program has afforded fragile coastal natural resources greater protection from development and has added in excess of ten miles of public access since 1980. The Connecticut program should be maintained at current levels.

Continued implementation of Connecticut's Coastal Zone Management Program and that of New York's newly developed Long Island Sound Coastal Management Program will greatly assist in improving land use management in the coastal zone.

However, much still needs to be done to implement all aspects of these plans. Land use and development as it affects Long Island Sound is an unfinished agenda. Significant additional effort is required to determine the most appropriate means to effect change as well as to provide the funds needed to implement even the general recommendations presented in the plan. Additional analysis, new initiatives, and their costs must be underwritten by the federal government, the states of Connecticut and New York, local governments, and the private sector.

SUPPORTING IMPLEMENTATION

As a key component of plan development, the Management Conference was directed to identify the means by which its implementation would be coordinated. The Management Conference has identified three areas that are critical to implementing the plan:

- The Management Conference must be continued to maintain and improve communication and coordination among different units of government, research and educational institutions, and concerned groups and individuals.

- Public involvement and education about Long Island Sound must continue along with mechanisms to involve the public in continuing management efforts.

- Adequate funding for the new and expanded efforts must be available and funding for existing programs that have been successful must be continued.

The following three chapters detail the activities needed in each area to successfully support implementation.

IX. Continuing the Management Conference

A. Who will Implement the Plan?

The states of Connecticut and New York, local governments, and the EPA have primary responsibility for implementing the plan. However, protection of the Sound is the responsibility of all sectors of government, the private sector, and individual citizens. A framework is needed for coordinating and redirecting efforts. Extending the Long Island Sound Study Management Conference to continue this cooperative effort will provide the long-term commitment necessary to oversee implementation.

Continuing the Management Conference recognizes the fact that, for an ecosystem as large and complex as Long Island Sound, a framework is needed to coordinate action among the many government agencies and private organizations with distinct authority and jurisdiction over activities effecting the Sound. It also recognizes the fact that over the past 20 years, environmental legislation has established and expanded the environmental protection programs on the federal, state, and local level. Private conservation and education organizations have also proliferated. As a result, in almost all cases, existing agencies and organizations have the authority and tools to protect and preserve the Sound. Many programs are very successful in managing and improving environmental conditions. A framework for coordinating and redirecting these efforts is needed to address specific Long Island Sound issues rather than creating a new layer of bureaucracy.

The Management Conference has served as the institutional framework for coordinating development of the management plan. The Management Conference can also provide an effective framework for coordinating and enhancing implementation of the plan. Such a long-term commitment is absolutely necessary. The failure of a 1975 plan for Long Island Sound prepared by the New England River Basins Commission was not in its content or recommendations. It languished because the program ended with the plan. Extending the Management Conference into implementation reflects the reality that a cooperative long-term commitment is necessary to protect and improve the quality of Long Island Sound. It also provides for continuing direct public involvement in managing the Sound.

Therefore, the Long Island Sound Study Policy Committee has formally requested that the EPA Administrator extend the Management Conference. To accommodate this need, the Congress passed the Long Island Sound Improvement Act of 1990, which gave the EPA authority to extend the Management Conference upon plan completion and directed the EPA to establish an office to provide continued support to an extended Management Conference. The EPA should, upon plan approval, extend the Management Conference for a minimum of five years to oversee implementation of the plan.

B. What is the New Role of the Management Conference?

With adoption of the plan, the role of the Management Conference will shift from plan development to program implementation. Specifically, continuation of the Management Conference will provide a management framework to:

- Track, monitor, and report on program implementation;
- Incorporate new information to enhance implementation of actions;
- Develop additional commitments for implementation from participating agencies;
- Seek and advocate adequate funding; and
- Continue public involvement.

These efforts will be summarized in a report every two years. The report will: identify progress in implementing the plan, as well as any delays or obstacles to implementation; describe water quality conditions in the Sound and the effectiveness of management efforts to improve them; and recommend the redirection of efforts to meet the goals of the program. The Management Conference will continue to prepare fact sheets, articles, and newsletters to report on different aspects of the program.

Throughout the plan, a number of high priority activities to enhance implementation have been identified. These activities, rather than forestalling cleanup actions, are intrinsic to improving the effectiveness of those actions over the long term. By applying the knowledge gained from restoration efforts, the Management Conference will ultimately improve the effectiveness of actions in achieving environmental results.

In this vision, the plan becomes more of a fluid document, incorporating the lessons learned from implementation. The pace of government action is monitored, potential delays are identified, and new approaches developed in response. The involvement of citizen groups and local government is maintained and expanded. The health of the Sound is monitored to assess the effectiveness of actions. And new information is synthesized to update and redirect the action plan on a regular basis.

Meeting this vision is a challenge. Regional coordination and planning is time consuming, often longer than the attention span of the public and government. The focus of citizens and government too often moves from crisis to crisis. Long-term and complex issues, such as protecting Long Island Sound, often get pushed aside.

C. What are the Core Needs to Coordinate Implementation and Report on Progress?

As part of the Long Island Sound Improvement Act, Congress directed the EPA to establish an office to provide continuing support for an extended Management Conference. To serve the bi-state community, the EPA established a Long Island Sound Office with two facilities, one located in Stamford, Connecticut and the other in Stony Brook, New York. The basic activities of the Long Island Sound Office are to:

- Provide administrative support to the Management Conference and coordinate the EPA with other federal agency involvement in Long Island Sound issues.
- Support state program coordination and involvement in the Management Conference; and
- Maintain public education and involvement efforts with an added focus on local government involvement.

Space and basic services are being provided for the office, at no extra charge to the federal government, by the City of Stamford and by the State University of New York at Stony Brook. Using existing program resources, the EPA is staffing the office with a director and technical staff person and providing for associated travel and support expenses. The operational costs of the office, such as secretarial support, office supplies, equipment, telephone service, equipment maintenance, and production of publications have been supported in the past by direct federal appropriation for the office.

Each year, the Management Conference has funded program coordinator positions within the NYSDEC and the CTDEP. Each coordinator provides full-time staff support to the Management

Conference and is the primary conduit for broader state program information and involvement in the Management Conference. The cost of continuing this basic coordination function is $150,000.

Since 1992, the Management Conference has funded a public outreach coordinator stationed within each Long Island Sound Office facility to support the educational and outreach activities of the Management Conference. The program can be maintained at a cost of $150,000 per year. The outreach coordinators develop scientifically based information on issues related to the Sound and provide support to the Citizens Advisory Committee.

In summary, the cost associated with this base level of effort for the Management Conference is approximately $475,000 per year. This includes $175,000 for maintaining the Long Island Sound Office and for providing administrative and technical support to the Management Conference, $150,000 for state program coordination of implementation, and $150,000 is for public involvement and education. Funding is available for these programs in fiscal year 1994, but will be required in future years.

D. How Will Information from Existing and Future Monitoring Activity be Managed?

The Management Conference must develop a continuining monitoring program to assess the effectiveness of implemented management actions. While the Management Conference has already implemented a number of monitoring enhancements, a series of workshops were held to identify the components of a comprehensive plan for monitoring the Sound. The workshop focused on developing a monitoring program that maximizes the value of ongoing monitoring programs and identifies critical enhancements. The components of the monitoring plan have been presented in the action tables within Chapter's III-VII.

Management of monitoring data and information is an integral component of the long-term monitoring strategy. Because the New York-New Jersey Harbor and Long Island Sound are interconnected systems, management of monitoring data from both systems must be coordinated. As a result, both programs have adopted the EPA's Ocean Data Evaluation System (ODES) as a common repository for monitoring data. Both programs have also combined resources to hire a data manager to ensure that data are organized and stored in ODES. However, because electronic data management is a quickly evolving field, the Management Conference must remain flexible in the type of system or process that is used to manage data.

The two programs have identified the following data management needs to guide efforts:

- Provide for storage, retrieval, editing, and Quality Assurance/Quality Control (QA/QC) of Long Island Sound and New York-New Jersey Harbor data, including physical, chemical, and biological components;
- Fully integrate LISS and HEP data relevant to systemwide analysis;
- Provide access to these data to the EPA, the states, other agencies, and investigators;
- Provide full description of data sets including QA/QC documentation;
- Provide appropriate tools to users including data entry package, statistical package, Geographic Information System (GIS) interface, and STORET interface; and
- Provide real-time data access and analysis.

E. How Will the Management Conference be Funded Now That the Plan is Done?

The Management Conference recommends that part of the funding be provided through Section 320 of the Clean Water Act. The Management Conference is expected to receive approximately $300,000 per year from the EPA for four years for activities such as monitoring and reporting on plan implementation. The Management Conference further recommends that additional funding be provided through Section 119 of the Clean Water Act, created by the Long Island Sound Improvement Act. These funds can be used for all the activities cited above and any additional activities that would be instrumental in enhancing implementation of the plan. Section 320 of the Clean Water Act requires a non-federai match of 25 percent on all funds and Section 119 of the Clean Water Act requires a non-federal match of 50 percent. The states of Connecticut and New York should, at a minimum, ensure the availability of matching funds for all available federal grants.

Throughout the Management Conference, the states of Connecticut and New York have provided support by making program staff available to assist in developing and implementing the plan. this support is expected to continue.

During the past three years, the state of Connecticut has also funded Long Island Sound-related research and education in Connecticut secondary schools, colleges, and universities through general obligation bonds. This program has committed approximately $1 million per year on research topics ranging from water quality and sediment transport to living resource population dynamics. In 1992, Connecticut established a Long Island Sound motor vehicle registration plate with funds dedicated to public access improvements, estuarine and aquatic habitat restoration and preservation, education, public outreach, and research for Long Island Sound. Both programs are guided by advisory committees. In future years, Connecticut will continue to evaluate and recommend, as appropriate, the planning and research needs identified in the Management conference for inclusion in calls for proposals and in funding future research. The NYSDEC will seek to identify a source of New York state funding to support a portion of the continuing planning needs of the Management Conference.

There are also continuing planning process actions funded by municipalities such as the monitoring of the East River and western Sound conducted by the City of New York as part of its New York Harbor Monitoring Program. This monitoring contributes valuable data on Long Island Sound. Other local governments have also contributed data useful in assessing the Long Island Sound ecosystem.

F. How Will the Management Conference Ensure That Other Federal Programs are Consistent With the Management Plan?

1. Federal Consistency Review Requirements

One of the basic requirements of the Long Island Sound Study is to review all federal programs for consistency with its management plan. The purpose of this requirement, which is outlined in Section 320(b)(7) of the Clean Water Act, is to ensure that federally sponsored activities do not work at cross purposes with the objectives of the Management Conference. The *federal consistency review* requirement recognizes the need to coordinate government programs and program goals that can affect the success of coastal resource protection.

The Coastal Zone Management Act also recognizes the significance of federal actions on the coast. It also requires that a federal consistency review be performed to ensure that federal programs affecting the coastal zone be consistent with a state's approved Coastal Zone Management Plan. These reviews have been conducted effectively for more than a decade by the New York State Department of State and the Connecticut Department of Environmental Protection, as part of the state coastal zone management programs. Both agencies sit on the Management Conference Management Committee.

In 1988, the EPA and the NOAA entered into an agreement designed to avoid conflicts and duplication of effort between the National Estuary Program and the Coastal Zone Management Program. The agreement provides an opportunity to build upon the strengths of the individual programs by integrating their federal consistency review requirements.

2. The LISS Federal Consistency Process

The ongoing review programs in the states of Connecticut and New York have the staff, experience, and facilities necessary to perform consistency reviews. By incorporating relevant parts of the LISS management plan into the state coastal zone management plan, the Clean Water Act requirements can be met on an ongoing basis. Building upon the federal consistency review conducted under the state coastal zone management program offers a number of advantages:

- The duplication and redundancy of multiple reviews are avoided.
- Activities requiring a federal permit or license are included in the reviews.
- Responses to comments are mandatory and the states have veto power over federal actions.
- The state programs have demonstrated the capacity to perform the consistency reviews for over a decade and will provide for long-term consistency and coordination of efforts.
- Coordination of coastal resource protection efforts between the Management Conference and the state coastal zone management programs are enhanced.

Therefore, the Management Conference will build upon the existing federal consistency reviews conducted by the state coastal zone management programs. The states will incorporate relevant actions of the Management Conference into the coastal zone management programs.

G. Overview of Specific Management Actions

The Management Conference should be extended to coordinate implementation. The actions summarized in Table 50 focus on maintaining an effective program.

Table 50 Supporting implementation.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Formally extend the Management Conference for a minimum of five years to continue coordination and oversee implementation of the management plan. The Citizens Advisory Committee will remain part of the Management Conference structure.	EPA Administrator	Initiated upon approval of the plan. Completion date July 1, 1994.	Redirection of base program

Continue and expand the role of the EPA Long Island Sound Office, consistent with the requirements of the LIS Improvement Act of 1990. Funding is available in FY 1994, but will be required in future years.	EPA Regions I and II.	Ongoing. The office has facilities in Stamford, CT and Stony Brook, NY.	Operational costs approximately $175,000 per year.
Continue state program coordination and involvement in the Management Conference. Funding is available in FY 1994, but will be required in future years.	EPA-LIS Office	Ongoing starting in FY 1994.	$150,000 per year
Maintain public involvement and education efforts with an added focus on local government involvement. Funding is available in FY 1994, but will be required in future years.	EPA-LIS Office	Ongoing starting in FY 1994.	$150,00 per year
Establish delegation of authority to allow the EPA Long Island Sound Office to support projects of studies as authorized by the Long Island Sound Improvement Act.	EPA-Headquarters	Upon approval of the plan.	Redirection of base program
Advocate modification to Clean Water Act Section 320(g)(2) to allow the EPA to provide base funding through cooperative agreements to National Estuary Programs that complete their management plans.	CTDEP NYSDEC	Ongoing.	Redirection of base program
Develop a coordinated monitoring plan to assess the effectiveness of implementation, considering innovative approaches and building upon existing programs.	LISS	Completed in early 1994.	$25,000
Coordinate data management efforts between Long Island Sound and New York-New Jersey Harbor Estuary Program (HEP), including support for a systemwide data manager.	LISS and HEP Management Conferences	Funded for 1994.	$25,000 per year from each program
Modify the current structure of the LISS as needed to oversee implementation of the plan.	LISS Management Committee	Complete by the end of 1994.	Redirection of base program
Ensure that the LISS is consistent with existing state coastal zone management (CZM) policies.	EPA	Concurrent with the submittal of the plan to the Governors of New York state and Connecticut.	Redirection of base program
Incorporate relevant elements of the plan into the state CZM program for federal consistency reviews.	CTDEP NYSDOS	Complete by the end of 1994.	Redirection of base program

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Continue to support and enhance data management, analysis, and reporting.	LISS Management Conference	Ongoing	$200,000 per year
Prepare an annual progress report on implementation including recommendations to redirect efforts.	LISS Management Conference	Annually, starting one year after the plan is approved.	$35,000 per issue; included under operational costs of LIS Office.

X. Public Involvement and Education

A. Why Are Public Involvement and Education Important?

Public involvement, education, and support are essential components of the effort to restore and protect the Sound and will be key to the successful implementation of virtually every part of this plan. Increased involvement and education also help the public understand, appreciate, and enjoy the Sound's resources and the benefits derived from them.

The public must understand what the Sound's water quality and resource problems are and how they can be involved in the solutions. An informed and educated public can help develop a united and organized constituency to galvanize support for the cleanup and protection of the Sound and its resources.

The goal of public involvement and education, therefore, is to promote an understanding and appreciation of the Sound as a regional ecosystem and a national treasure and help people in all parts of the community feel connected to the Sound. Ultimately, a citizenry that values the Sound and its resources will take responsibility for its restoration and protection.

B. What Has Been Done To Involve and Educate the Public?

The Long Island Sound Study Management Conference understood the importance of citizen support and dedicated substantial resources to keeping the public informed about and involved in the progress of the study. A program was established to support public involvement and education by:

THE CITIZENS ADVISORY COMMITTEE

Membership in the Citizens Advisory Committee (CAC) includes representatives from industry, municipalities, civic organizations, and environmental groups from around the Sound. The CAC provides a two-way informational conduit between the study managers and the public. The CAC keeps the public informed about LISS issues and progress and makes study managers aware of public concerns. The CAC has and will continue to play a valuable role in helping public review of LISS reports. With more than 120,000 constituents and organizations represented, the CAC has a strong voice when acting together to shape policy decisions.

Sidebar 12 The Citizens Advisory Committee.

- ✓ Helping to coordinate the Citizens Advisory Committee (CAC) by arranging for meeting facilities, distributing meeting materials and minutes, maintaining the CAC database, notifying members of upcoming meetings, and developing meeting agendas.
- ✓ Keeping the public informed about LISS issues and activities through presentations, press releases, new publications, and public service announcements.
- ✓ Preparing and issuing LISS fact sheets. The fact sheets summarize LISS research results and provide information on Sound issues such as septic systems, nonpoint source pollution, and consumption of seafood. More than 130,000 copies are in circulation among libraries, educational institutions, nonprofit groups, and the public.
- ✓ Producing and distributing publications — 90,000 copies of *Earth Guide: 88 Tips for Cleaner Water, Plants and Animals of Long Island Sound,* and more than 40 *Sound Tips* to local newspapers.

- ✓ Writing and issuing *Update*, the program newsletter, to more than 6,000 interested parties. Program staff also write articles about LISS for other publications such as *On the Water, Connecticut Currents, Nor'easter, The Seaport Sun,* and the *Port Chester-Westmore News.*

- ✓ Distributing two posters — one showing the interrelated uses of the estuary and the other demonstrating the link between people's everyday activities and water pollution.

- ✓ Making more than 100 presentations about the Sound to a wide range of groups and organizations, senate and congressional subcommittees, and university and high school classes.

- ✓ Setting up and staffing displays at trade shows and conferences.

The states of Connecticut and New York supported public involvement and education through activities including:

- ✓ CTDEP providing $2 million over the past two years to universities, high schools and non-profit organizations for Long Island Sound research and education programs;

- ✓ CTDEP and NYSDEC providing numerous speakers on Long Island Sound for a variety of public interest and environmental organizations, colleges and high schools;

- ✓ CTDEP facilitation of Project Learning Tree, Project Wild, and Project Wild Aquatic, which give teachers the tools to set up curricula for students to teach them about water quality and Long Island Sound;

- ✓ NYSDEC incorporation of a Public Information and Education Plan into its overall workplan for the Division of Marine Resources;

- ✓ CTDEP facilitation of the Search Program, which introduces students in grades 9-12 to environmental quality monitoring and assessment;

- ✓ NYSDEC and New York Power Authority (NYPA) sponsorship of a year-long education grants program with funds provided through NYPA's Sound Cable Grant Program. Seven organizations received grants totalling $100,000 for storm drain stencilling, videos, a water quality monitoring manual, a marine education directory, student educational cruises, a nitrogen budget computer program, and assistance for the Listen to the Sound Campaign.

- ✓ CTDEP providing grants of over $250,000 from the Long Island Sound License Plate Program Long Island Sound Fund to support Long Island Sound education and outreach projects.

C. What Kind of Public Involvement and Education Program Do We Need for Today?

A public involvement and education program should inform and educate citizens about Long Island Sound and the commitments and recommendations of this plan. The program should also identify opportunities for the public to help update the plan and carry out recommended activities to clean up and restore the Sound.

With the release of this plan, an expansion of ongoing state, federal, and nongovernmental public involvement and education activities will be required with a focus on communicating the management plan findings and promoting recommended actions. To assist this effort, the LISS Public Involvement and Education Program has been continued and is now housed within the EPA Long Island Sound Office. In addition, Connecticut and New York state will conduct educational outreach programs to complement regulatory programs and policies established to implement this plan. The states will also provide specific information and training on the plan and Long Island Sound to the regulated community (e.g., municipalities, businesses, and industries).

An essential part of the public involvement and education strategy is to use the ongoing efforts and experience of the numerous nongovernmental organizations dedicated to the protection of the Sound. These organizations will continue to play a vital role in distributing Long Island Sound information and increasing public awareness of the plan. Building upon these efforts is an efficient way to maximize the use of scarce resources.

D. Overview of Specific Management Actions

1. Build Community Awareness and Appreciation

The public involvement and education program will build community awareness and appreciation of Long Island Sound — its ecosystem, history, and intrinsic and economic value to the region. The program will provide opportunities for adults and children to personally discover the Sound, to get involved, to experience their unique connection to the estuarine environment, and to instill in them a desire to restore and protect the complex ecosystem of the Sound. A sincere appreciation of the Sound and its resources will bridge the gap from knowledge (of issues and potential solutions) to involvement in protecting a vital part of people's quality of life.

The EPA and the states of Connecticut and New York have committed to building upon the current outreach and education activities performed by the LISS Public Involvement and Education Program and state programs and providing a new focus on interpretation and implementation of this plan. To achieve this, the Management Conference proposes to:

- Continue the LISS Public Involvement and Education Program and the state public outreach programs. Collectively, these programs will provide consistency in information going to the public and ensure that the public receives current information on the implementation of the LISS actions and recommendations. These programs will continue to develop printed and other educational materials for specific audiences, exhibit Long Island Sound materials at regional and local fairs and events, encourage education and disseminate information on the Sound for urban populations, promote the importance of the Sound's resources to children in the region and highlight their responsibility as stewards of those resources and use public educational materials from nonprofit organizations; and,

- Urge the states of Connecticut and New York to continue support for research conferences and public events on the Sound. Research conferences and public events keep the public informed about current issues and are a constant reminder of the states' commitment to the Sound. Examples of these activities include the CTDEP conference highlighting the results of the Long Island Sound Research Grant Program, the Long Island Sound Watershed Alliance *Citizens' Summit* annual conference and the bi-state Long Island Sound research conference sponsored by local universities, Sea Grant programs, and the states. *Coastweeks*, an annual three-week

celebration of marine and coastal environments, held nationally, should be strengthened by the states of Connecticut and New York to promote the protection of the Sound and to emphasize the plan's actions and recommendations. These actions are summarized in Table 51.

Table 51 Building community awareness and stewardship.

ONGOING PROGRAMS	Responsible Parties/Status
The LISS and state public involvement and education programs are: - Developing printed and other educational materials for specific audiences; - Exhibiting Long Island Sound materials at regional and local fairs and events; - Encouraging education and information on the Sound for urban populations; - Promoting the importance of the Sound's resources to children in the region; and, - Using public educational material of non-profit organizations.	The state environmental protection agencies will continue ongoing programs designed to build community awareness of the Sound. Connecticut's current public outreach efforts cost approximately $100,000 per year. In addition, during calendar year 1993, Connecticut's Long Island Sound License Plate Program spent $250,000 from the Long Island Sound Fund on education projects. The Management Conference has budgeted approximately $150,000 per year to support the LISS public participation program.
Support research conferences such as: - The CTDEP conference to highlight its Long Island Sound Research Grant Program; - The Long Island Sound Watershed Alliance *Citizens' Summit* annual conference on the Sound; - The bi-state Long Island Sound research conference sponsored by local universities, Sea Grant programs, and the states;	Connecticut and New York and the Long Island Sound Watershed Alliance are responsible for continuing their support and/or sponsorship of Long Island Sound-related conferences at an annual cost of approximately $5,000 per conference.
Coastweeks, an annual three week celebration of marine and coastal environments is supported by both states.	Connecticut and New York will continue to support Coastweeks in their respective states for an annual cost of $10,000 per state for organization of National Beach Cleanup Day and development of a listing of Coastweeks events.

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Enhance the LISS and state public involvement and education programs to provide additional funding to build upon the current outreach and education activities with a new focus on interpretation and implementation of the management plan.	CTDEP NYSDEC EPA	When funding is available	$200,000 per year

2. Promote Understanding

The proposed public involvement and education program must tell citizens about the issues facing the Sound, demonstrate why they are important, and show people that, with their help, the issues can be resolved. The public must be kept informed of the ways in which the management plan's actions and recommendations are being carried out and how these actions will result in a cleaner Sound.

In order to facilitate public understanding of Long Island Sound issues, the states of Connecticut and New York will incorporate Long Island Sound information into all related programs conducted by state staff wherever possible. In addition, the states have committed to providing information to all municipalities about the Sound and the importance of protecting and restoring it. Special attention will be given to coastal municipalities with briefings by state officials to explain how implementation

of the management plan will affect their cities or towns. Briefings will also be held for specific user groups, local officials, and elected representatives.

The states will also assess opportunities for training and educating the environmental decision-making communities and provide technical assistance on management plan implementation to the regulated communities. By arming local decision-makers with the most recent information about the Sound and the LISS, the states will provide them with the ability to make informed decisions relating to the Sound's preservation and protection.

The Bi-state Marine Resources Committee should be used to ensure Long Island Sound related legislation moves on a parallel track in both Connecticut and New York. In addition, the Committee should help educate local governments and the public about the importance of the Sound and the successful implementation of the LISS commitments and recommendations.

Long Island Sound information must be made readily available to the public, researchers, government officials, and interested groups. The EPA and the states of Connecticut and New York will pursue further development of resource centers to serve as clearinghouses and depositories for information about the Sound and will investigate ways to improve funding for these centers. These actions are summarized in Table 52.

Table 52 Promoting understanding.

ONGOING PROGRAMS	Responsible Parties/Status
Incorporate Long Island Sound information into all related programs conducted by state staff wherever possible.	Connecticut and New York environmental protection agency's have been incorporating Long Island Sound information into their programs since the onset of the LISS. During implementation, new and additional information will be added and provided to staff as appropriate. The cost of such efforts is considered a redirection of the base program.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Provide information to all municipalities on the LISS and the importance of protecting and restoring the Sound. Special attention will be given to coastal municipalities in the form of briefings by state officials to explain exactly how implementation of the plan will affect that particular city or town and how to work cooperatively together to implement the management plan. Briefings will also be held for specific user groups, local officials, and elected representatives.	CTDEP NYSDEC	Initiated upon signature of the plan by the state Governors and the EPA Administrator	Redirection of base program
Assess opportunities for training and educating the environmental decision-making community and provide technical information and assistance on implementation of the plan to the regulated community.	CTDEP NYSDEC	Ongoing	Redirection of base program
Utilize the Bi-state Marine Resources Committee to ensure Long Island Sound related legislation moves on a parallel track in both Connecticut and New York and to help educate local governments and the public about the importance of the Sound and the successful implementation of the LISS recommendations.	CTDEP NYSDEC NYSDOS	Ongoing	Redirection of base program

RECOMMENDATIONS	Responsible Parties	Time Frame	Estimated Cost
Pursue reestablishment of funding for the Long Island Sound Resource Center at Avery Point and further development of a similar resource center in New York to serve as clearinghouses and depositories for information about the Sound and investigate ways to improve funding for these centers. (See *Chapter VII, Management and Conservation of Living Resources and Their Habitats* Table 47.)	CTDEP NYSDEC EPA	Ongoing	$150,000 per year for Connecticut Long Island Sound Resource Center; $60,000 per year for a New York facility

3. Facilitate Public Policy and Hands-on Activities

The public must be involved in setting policy for the Sound and its current and future protection as well as participating in the cleanup of the Sound through hands-on activities. Such involvement will help foster a sense of stewardship for the Sound and instill a desire to make a clean, healthy Sound a reality.

During the course of the LISS, the Citizens Advisory Committee played a key role in providing public input at the policy level for all aspects of the LISS, as well as serving as a vital link between the public and LISS management agencies. Through their continued involvement in the LISS during its implementation phase as advisors to the Management and Policy Committees, the CAC will act as a catalyst for public involvement from a policy perspective and provide essential communication between the Management Conference and the public.

To ensure continued hands-on public participation in the Sound cleanup, the EPA and the states of Connecticut and New York will continue to encourage, promote, and support public activities, including storm drain stencilling, beach grass planting, and beach cleanups.

To further facilitate public participation, the EPA and the states of Connecticut and New York will promote citizen involvement in educational and monitoring activities in and around the Sound and consider providing technical guidance to citizen monitoring groups. These actions are summarized in Table 53.

Table 53 Facilitating public participation.

ONGOING PROGRAMS	Responsible Parties/Status
Encourage public participation in activities relating to the cleanup and protection of the Sound and provide support for activities including storm drain stencilling, beach grass planting, and beach cleanups.	Connecticut will consider funding hands-on activities that meet the statutory criteria of the Long Island Sound License Plate Program provided there are adequate funds in the Long Island Sound Fund. For example, during fiscal year 1993 $30,000 was made available for beach grass planting and storm drain stencilling. Other efforts supported by the CTDEP, the NYSDEC, the EPA and Sea Grant will continue as funding allows. The Connecticut and New York Sea Grant programs are providing storm drain stencils and informational brochures to the public.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
The LISS Citizens Advisory Committee will continue to provide guidance to the Management and Policy Committees and serve as a link between the public and LISS management agencies. The CAC has been instrumental in providing guidance to the Study and serving as a conduit between the Management Conference and the public.	The CAC will continue this role as part of the extension of the Management Conference.	Immediately	Costs are $4,000 per year for expenses and travel and would be covered under the basic cost of maintaining the Management Conference
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Enhance funding for hands-on activities such as storm drain stencilling, beach grass planting and beach cleanups to allow the public to actively participate in the cleanup and restoration of the Sound and learn more about its ecosystem.	CTDEP NYSDEC EPA Sea Grant	When funding becomes available	$25,000 per year
Promote citizen involvement in educational and monitoring activities in and around the Sound and consider: - Providing technical assistance to citizen monitoring groups; - Developing a reward system for citizens participating in Long Island Sound protection and restoration programs; - Developing environmental habitat kits and guide maps; - Production and distribution of videos of Long Island Sound research cruises.	CTDEP NYSDEC EPA	When funding becomes available	$75,000 per year

4. Increase Communication and Cooperation

The Management Conference will establish a public outreach work group to guide implementation of the commitments and recommendations presented in this chapter. The work group will work closely with the CAC and complement the CAC's ongoing outreach efforts. The work group will also be charged with identifying funding sources for carrying out public education commitments and recommendations, consulting with staff on tactics, providing coordination among all the Sound's public outreach groups, and assessing program effectiveness.

Members of the work group will be solicited and approved by the Management Committee. Membership will include representation from the CAC, school teachers, marine educators, media and communications industry, environmental groups, interpretive centers, municipalities, marine trades industry, business, Sea Grant, and government agencies.

In combination with the establishment of the work group, the EPA and the states of Connecticut and New York will help coordinate ongoing governmental and nongovernmental public outreach efforts, and will encourage private and nonprofit groups to continue to develop and implement Long Island Sound educational and outreach programs. These actions are summarized in Table 54.

Table 54 Increasing communication and cooperation among groups.

COMMITMENTS	Responsible Parties	Time Frame	Estimated Cost
Increase efforts to coordinate ongoing governmental and nongovernmental public outreach efforts as the plan becomes implemented and encourage private and nonprofit groups to continue to develop and implement Long Island Sound educational and outreach programs.	CTDEP NYSDEC EPA	Ongoing	Redirection of base program
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Establish a public outreach work group to guide the implementation of the public involvement and education commitments and recommendations. The work group will work closely with and serve to complement the ongoing public outreach and education efforts of the Citizens Advisory Committee. The group will also be charged with determining funding sources for implementation of public involvement and education recommendations, consulting with staff on tactics, working to provide coordination of public outreach efforts from both an internal and external basis, and assessing program effectiveness.	CAC CTDEP NYSDEC EPA	Upon signature of the plan by the state Governors and the EPA Administrator	Redirection of base program

5. Develop Educational Opportunities

Any public involvement and education program must provide ways to educate young people about the environment. A key objective for the Long Island Sound involvement and education program is to develop a long-term sense of environmental appreciation for and understanding of the Sound by enhancing educational opportunities at all age levels.

There are several ways to achieve this goal. The states of Connecticut and New York will continue to work with appropriate school districts in their respective states to develop Long Island Sound educational materials and outreach programs for primary and secondary schools. These resources will also be made available for integration into other environmental education programs and general curriculum as appropriate.

Current actions designed to assist teachers in their efforts to integrate Long Island Sound issues into their existing curricula will be continued such as:

- Providing educational materials prepared by the states, Sea Grant Programs and non-profit organizations to teachers for incorporation into their school programs;

- Teacher conferences held by the Connecticut and New York Sea Grant Programs to exchange existing curriculum ideas, and to provide materials and ideas for teachers to use to teach about the Sound.

In addition, the state of Connecticut's Long Island Sound High School Research Grant Program, initiated in 1990, should be continued. A similar program will be considered by the state of New York to provide resources to allow a variety of high schools to conduct science classroom studies on the Sound and its watershed.

Finally, the LISS will encourage natural history museums and nature centers to promote Long Island Sound issues within their programs. These actions are summarized in Table 55.

Table 55 Enhancing Long Island Sound education at all educational levels.

ONGOING PROGRAMS	Responsible Parties/Status		
Support ongoing actions that assist teachers in their efforts to integrate Long Island Sound issues into their existing curricula.	Connecticut, New York, the EPA, and Sea Grant will continue to work with teachers to assist them with efforts to integrate Long Island Sound materials and information into their curricula. Approximate annual staff costs equal $50,000.		
COMMITMENTS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Continue Connecticut's Long Island Sound High School Research Grant Program, initiated in 1990. This program provides funding for students to conduct research on the Sound and its watershed.	CTDEP	Ongoing	$30,000 per year
Encourage natural history museums and nature centers to promote Long Island Sound issues within their programs.	CTDEP NYSDEC EPA	Ongoing	Redirection of base program
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Work with school districts and, where appropriate, the Department of Education, in Connecticut and New York to develop Long Island Sound educational materials and outreach programs for primary and secondary schools. Help teachers integrate Long Island Sound information into their curricula and provide materials wherever possible. This should include hiring a Long Island Sound education coordinator.	CTDEP NYSDEC	When funding becomes available	$75,000 per year
Enhance ongoing actions to assist teachers in their efforts to integrate Long Island Sound issues into their existing curricula including the development and support of teacher workshops.	CTDEP NYSDEC EPA	When funding becomes available	$75,000 per year
Consider a Long Island Sound High School Research Grant Program to provide resources to allow a variety of high schools to conduct research on the Sound and its watershed.	NYSDEC	When funding becomes available	$30,000 per year

6. Secure Funding

The one aspect of a successful public involvement and education program that must be achieved is a secure funding source or sources. Certainly, a strong private, federal and state partnership will be required to provide the financing necessary to implement these public involvement and education efforts and federal and state funds should be allocated when and where possible.

It will also be important for all organizations associated with the public involvement and education effort, both governmental and nongovernmental, to take advantage of the various grant programs available which provide funding for education activities. These include Connecticut's Long Island Sound Fund and Long Island Sound High School Research Grant Program, and EPA's Education Grants. Private sector funding should also be sought when and where possible and other private grant programs identified. These actions are summarized in Table 56.

Table 56 Securing funding for public involvement and education activities.

ONGOING PROGRAMS	Responsible Parties/Status		
The LISS will continue to encourage all organizations involved in the public involvement and education effort, both governmental and nongovernmental, to take advantage of the various grant programs for which they are eligible, that provide funding for educational activities. These include Connecticut's Long Island Sound Fund, Long Island Sound High School Research Grant Program and EPA's Education Grants. Private sector funding should also be sought when and where possible and other private grant programs identified.	The EPA and the states will publicize grant opportunities whenever possible.		
RECOMMENDATIONS	**Responsible Parties**	**Time Frame**	**Estimated Cost**
Seek to create a public involvement and education (PIE) fund that could be supported by a variety of funding sources, including federal appropriations through the Long Island Sound Improvement Act. The PIE fund would be administered by the LISS Management Conference. A PIE fund and interest generated from its endowment would provide support for projects fulfilling plan involvement and education actions and recommendations as proposed by both nongovernmental and governmental organizations. Current state and private Long Island Sound public education programs are underfunded. State and private funding sources must be directed toward meeting the needs of existing programs before being sought for a PIE fund.	CTDEP NYSDEC EPA	Upon signature of the plan by the state Governors and the EPA Administrator	Seed money should be made available for the establishment of a PIE Fund.

E. How Can Individuals Help?

— Voice your concerns about the Sound directly to elected officials. Find out who your local, state and federal government representatives are and let them know that the Sound is important to you. Because many of the decisions that affect the Sound are made on the local level, you can personally make an impact by interacting with municipal commissions. Your input really does make a difference!

— During fishing and hunting trips, encourage other anglers, hunters and commercial fishermen to harvest consistent with applicable management measures and regulations and to minimize non-harvest mortality (hook and release, discards).

— Boaters should avoid discharging marine sanitation devices into coastal waters. Pump-out facilities should be used whenever possible to prevent release of pathogens directly into coastal waters, and can help prevent localized water quality problems.

— Do not release into, or transport to Long Island Sound, living organisms from other water bodies.

— Avoid adding unnecessary grease and solids to septic systems. Inspect septic tanks annually, and pump out every three to five years.This will minimize malfunctioning of septic systems.

An improperly working septic system can contaminate groundwater, which can reach Long Island Sound.

— Avoid jogging or walking through beaches during the relatively brief periods when migrating birds are nesting or feeding.

— Use as few hazardous products as possible. When you must, use those labelled CAUTION, as these are less toxic than products labelled DANGER or WARNING. Buy only as much of the product as you need; you will then eventually throw out only the container, not the toxic substance it contained. Remember that substances poured down drains, storm sewers or on the land are likely to be transported to the Sound.

— Properly dispose of the toxic products that you use. Many counties and municipalities have hazardous waste collection days.

— Never pour motor oil or other auto fluids down a drain or sewer or discard them with the trash (in Connecticut and New York, it is against the law). New York state requires most service stations to accept motor oil for recycling. In Connecticut, municipal recycling stations accept motor oil for recycling. Some service stations will accept brake and transmission fluids and antifreeze; if not, save these in separate containers for local hazardous waste pickups.

— Individuals should pick up after their pets with a newspaper or scooper and dispose of wastes in a toilet. This will reduce animal wastes, which contain bacteria and viruses that can contaminate shellfish and cause health officials to close beaches.

— Place all trash securely in trash cans. Trash cans with holes, cracks, rusted-out spots and lids that do not fit allow trash to blow onto streets, or allow wildlife to enter and spread the trash. Rainfall carries the trash into the sewers where it eventually travels into the Sound.

— Don't be a litterbug in your towns, cities, or at the beach! Never throw litter into the street, down storm drains, or onto the beach, especially plastic. Recycle as much as possible. When at the beach, gather your garbage and dispose of it properly.

— Be sure that you gather all six-pack rings and other plastic items for proper disposal. If allowed to wash into the Sound, marine animals may eat these items or become entangled in them.

— Be a protector. If you live near a nesting beach, you can help by posting signs or patrolling the nesting area. Contact your state wildlife department or the National Audubon Society for more information.

— Work with your community, city or state to protect the wetlands that remain, and support wetland conservation initiatives.

— Landscape in ways not harmful to the plants and animals of Long Island Sound. When planting, use native vegetation, which will provide habitat for other species.

— Participate in Connecticut and New York Cooperative Anglers Programs.

— Stay informed by following media stories concerning the Sound. By becoming more knowledgeable, you will be a more convincing advocate for the Sound in your conversations with friends and neighbors.

— Join marine user and citizens' groups. If you use the Sound to swim, fish, scuba dive or boat, there is a group in your area that represents people who share your interest in the Sound. Citizens' groups are for those who would like to take an active role in issues that affect the Sound on a local, regional or national level.

— However you choose to get involved, it's important to make your voice heard! The future of the Sound depends on people like you getting involved in the process.

XI. Costs and Funding

A. Introduction

The costs of cleanup efforts are significant. They include the costs of continuing existing programs, the costs of enhancing these programs, and the costs of project implementation, such as upgrading sewage treatment plants or initiating practices to control nonpoint sources of pollution. The following sections will summarize the costs associated with plan implementation in each of these categories. Funding to cover these costs must be provided by the federal, state, and local governments and by the private sector, in partnership, with each paying its fair share. Specific recommendations are made for funding the plan after considering other identified wastewater treatment needs in the states of Connecticut and New York and the ability of local and state governments to pay for additional requirements. The prospects for achieving the Management Conference's goals and objectives, and the pace with which progress is made, will be directly related to the availability of adequate funding.

B. Existing Program Funding

This plan includes numerous commitments on the part of the NYSDEC, the CTDEP, the EPA, local governments, and other federal, state, and local agencies to continue the implementation of ongoing programs or to redirect ongoing program resources. At a minimum, these commitments require that existing program activities continue to be funded at existing levels by the states of Connecticut and New York and from federal grants. These funds that support statewide programs are the base upon which Long Island Sound protection efforts must build.

As presented in Table 57, the total statewide appropriation in New York state for water quality protection, natural resource management, and coastal zone management is $39.8 million. Federal grants to New York state for these activities provide an additional $29.4 million statewide. As shown in Table 58, the total statewide appropriation in Connecticut for water quality protection, natural resource management, and coastal zone management is $8.7 million. Federal grants to Connecticut for these activities provide an additional $6.5 million statewide.

Table 57 Existing program funding statewide[1] in New York (in millions of dollars).

Program Element	State	Federal
Water Quality Management	8.72	12.20
Natural Resources Management	28.97	14.63
Coastal Zone Management	2.12	2.55
TOTAL	39.81	29.38

1 Funds are for programs statewide. Long Island Sound is one of 17 drainage basins in New York state encompassing less than one percent of the area and approximately 23 percent of the population of the state.

Table 58 Existing program funding statewide[1] in Connecticut (in millions of dollars).

Program Element	State	Federal
Water Quality Management		
- Permitting and enforcement	1.82	1.76
- Water quality planning, standards, and monitoring	0.80	0.59
- Nonpoint source management	1.00	1.42
- LIS monitoring	0.05[2]	0.29
Natural Resources Management		
- Coastal structures, dredging permits	0.50	0.00
- Aquaculture	0.45	0.00
- Coastal zone management	1.00	1.00
- Coastal fish and wildlife management	0.25	0.65
- LIS research	1.37	0.00
- Tidal wetlands restoration	0.60	0.80
- Coves and embayments restoration	0.50	0.00
- LIS education and outreach	0.38[3]	0.00
TOTAL	8.72	6.51

1 Almost all of the state is included in the Long Island Sound drainage basin.
2 Does not include $500,000 capital investment in research vessel and depreciation.
3 Includes $250,000 from the LIS License Plate Fund.

C. Enhanced Program Funding

The previous chapters identified commitments and recommendations for actions to enhance ongoing programs through the redirection of existing resources or the allocation of new resources. The commitments are actions for which enhanced program resources have already been made available or for which there are firm obligations. The recommendations are actions that require additional funding that is not currently available. The plan's priority commitments and recommendations and their cost are identified in Table 59. These costs are for administering and staffing the programs, not the capital costs of implementing specific projects, which are discussed in the next section.

The total cost of the plan's priority commitments is $3.25 million. The total cost of the plan's priority recommendations is $5.99 million per year. The total cost of implementing all of the commitments listed in the plan is $11.74 million and the cost of implementing all of the recommendations in the plan is $10.42 million per year.

Table 59 Enhancements to existing program funding (in dollars).

Program Element	Commitments	Recommendations
	One Time	Annual
Hypoxia		
- Complete LIS 3.0	Funded by the LISS	-
- Establish N-reduction targets	Existing Program Redirection	-
- Develop zone-by-zone plans	1,000,000	700,000[1]
- Monitoring/Modeling	-	400,000[2]
- Other	6,727,000	150,000[3]
Toxic Substances		
- Monitoring	200,000	315,000
- Sediment remediation assessment	250,000	500,000
- Other	-	2,550,000[4]
Pathogens		
- Enforceable instruments	100,000	-
- Vessel discharges	1,120,000	-
- Site-specific surveys	-	300,000
- Monitoring	-	10,000
- Other	42,000	510,000[5]
Floatable Debris		
- Clean Streets/Clean Beaches	100,000	-
- Enhance beach cleanups	-	20,000
- Storm drain stenciling	-	5,000
- Other	71,000	-
Living Resources and Habitat		
- Habitat restoration strategy	-	700,000
- Species management	-	1,760,000
- Monitoring	-	150,000
- Other	1,652,000	985,000[6]
Management Conference		
- Coordination of Management Conference by the LIS Office	175,000	175,000
- State coordination of implementation	150,000	150,000
- Public involvement and education	150,000	150,000
Data Management and Reporting	-	200,000

Education		
- Outreach on plan implementation	-	200,000
- Public involvement in cleanup and monitoring	-	100,000
- Integration of curriculum	-	150,000
- Other	-	240,000
PRIORITY TOTAL	3,245,000	5,985,000
TOTAL	11,737,000	10,420,000

1 To develop zone-by-zone plans.
2 Includes the annualized cost of recalibrating the LIS 3.0 model for new conditions every three years.
3 One-time cost.
4 Does not include one-time cost of $100,000.
5 Does not include one-time cost of $755,000.
6 Does not include one-time cost of $685,000.

D. Project Implementation Funding

1. Long Island Sound Needs

The project implementation costs associated with the plan are large and are dominated by the potential cost of upgrading sewage treatment plants to remove nitrogen, the cost of remediating combined sewer overflows, and the cost of property acquisition (Table 60).

The capital costs of Phase II nitrogen reduction actions are $103.1 million in New York state and $18.1 million in Connecticut. The potential long-term implementation costs of nitrogen removal are much higher. Based on preliminary estimates, the costs of the additional nitrogen control for point sources ranges from $5.1 to $6.4 billion in New York state and from $900 million to $1.7 billion in Connecticut. These costs would be in addition to the $243 million in Connecticut and $1.5 billion in New York state needed to implement the currently planned combined sewer overflow abatement programs critical to reducing pathogens and floatable debris in the Sound.

Cost estimates for the necessary level of control for nonpoint sources of nitrogen have not been developed but are expected to be substantial.

Significant project implementation costs are also associated with the habitat-related commitments and recommendations. The total project costs for restoring habitat, creating reserves, and improving species management are $1.7 million, $30 million, and $1.4 million, respectively.

There are various other environmental infrastructure projects related to Long Island Sound which are ready to proceed should funding be made available. The states of Connecticut and New York developed project lists that would provide economic stimulation should that become a priority for new administrations (Appendix A).

Table 60 Project implementation funding estimates (in millions of dollars).

Program Element	New York	Connecticut	Total
Hypoxia			
- Phase II: point sources	103.10	18.10	121.20
- Phase II: nonpoint sources	N/E[1]	N/E[1]	N/E[1]
- Phase III: point sources	5,100.00 to 6,400.00	900.00 to 1,700.00	6,000.00 to 8,100.00
- Phase III: nonpoint sources	N/E[1]	N/E[1]	N/E[1]
Toxic Substances	N/E[2]	N/E[2]	N/E[2]
Pathogens and Floatable Debris			
- Stormwater/nonpoint sources	N/E[1]	N/E[1]	N/E[1]
- Combined sewer overflows	1,500.00	243.00	1,743.00
Living Resources and Habitat			
- Restoration	0.95	0.75	1.70
- Reserves	16.00	14.00	30.00
- Species Management	0.40	1.00	1.40

1 Not Estimated -- The potential costs of implementing stormwater and nonpoint source control actions will depend on the site-specific assessments of conditions and the applicability of management controls.
2 Not Estimated -- The cost of remediating sediments would be developed as part of the proposed harbor-specific characterization and feasibility studies.

2. State Water Quality Needs

Prior to the LISS, both states had identified significant municipal water pollution control needs. In 1989, New York's State Revolving Fund (SRF) was developed to finance, by the year 2000 approximately $4 billion of the $11.7 billion of the statewide categorical need. It did not include any additional LISS needs. In Connecticut, the Governor presented a water pollution control needs assessment study to the state legislature in 1986. The study documented the need to fund projects in four major categories to comply with federal mandates. The four categories were: 1) combined sewer overflow projects, 2) treatment plant projects, 3) small community projects, and 4) interceptor projects. The total program estimates at the time were $1.1 billion. These needs were the basis for the states' SRF capitalization requirements and annual funding programs. Substantial funds have been obligated to the programs for project implementation.

Table 61 Average annual obligations to the State Revolving Fund Program for wastewater treatment statewide in New York and Connecticut (in millions of dollars).

Program Element	New York		Connecticut	
	State	Federal	State	Federal
Total	35.00	173.00	60.69	18.53
- Wastewater Treatment	-	-	53.10	15.94
- Combined Sewer Overflows	-	-	7.59	2.59

Since New York's SRF enactment, new requirements and eligibilities in the area of stormwater control, control of sludge use and disposal, nonpoint source pollution control, and groundwater protection have raised the funding requirement to $18.1 billion. In Connecticut, inflation, new unmet needs, and revised cost estimates have added $700 million to the original cost estimates, exclusive of any additional LISS needs. While these state-identified, base needs are not Long Island Sound specific, many of the projects will benefit the Sound. For example, CSO abatement efforts in New York City and in Connecticut and secondary treatment at New York City's Newtown Creek sewage treatment plant are included in the base needs. These facilities and improvements are part of the states ongoing effort to resolve water pollution control problems.

The costs of nitrogen control in Long Island Sound must be evaluated with other needed wastewater pollution control measures to develop a comprehensive financing plan for wastewater pollution abatement in the states. Using these cost estimates, the total capital need for the wastewater program in New York state for the next 20 years has been estimated to be $25 billion; this includes $7 billion for the needs within the Long Island Sound drainage basin. The total capital need for the wastewater program in Connecticut for the next 20 years has been estimated to be $3.5 billion, almost all of which is for needs within the Long Island Sound drainage basin.

E. Current Financing Mechanism - State Revolving Fund

The 1987 Amendments to the Clean Water Act phased out grant financing for construction of sewerage projects and replaced them with a revolving loan mechanism dedicated to wastewater facility construction. Under this new revolving fund, the capitalization grants contributed by the federal government are matched by a 20 percent contribution from the states. These capitalization grants allow the states of Connecticut and New York to subsidize a percentage of the interest cost. All of the principal and the remainder of the interest expenses must be financed by the municipalities to pay for the identified needs. In order to qualify for federal capitalization funds, Connecticut and New York state enacted highly leveraged SRF programs.

New York state established its SRF in the custody of the Environmental Facilities Corporation (EFC). This public corporation benefits local governments in New York state by offering below-market interest rate loans to municipalities to finance wastewater improvements. Currently, the interest rate is set at up to one-half of the market rate to be repaid in twenty years. Lower rates of interest, including zero interest loans, are available for communities that can demonstrate an inability to pay the standard subsidized rate. The state of Connecticut operates its SRF directly through the CTDEP. Two percent loans in combination with grants ranging from 20 percent to 50 percent provide financing of 100 percent of total eligible project costs.

Both Connecticut and New York state leverage the federal and state capitalization funds in the bond market to increase the pace and number of projects which can be funded. This is essential because the states' needs are so large that it is crucial to build as many projects as quickly as possible to maximize value of the equity in the SRF. In addition, the leveraging protects the basic capitalization of the fund through investments on behalf of participating municipalities. This insures a continuous dedicated fund for environmental protection through sewage treatment plant investment.

The magnitude of ever increasing capital needs has limited the ability of the states and local governments to respond in a timely way to critical environmental priorities. The additional needs identified by the Management Conference compound an already difficult financing problem. Some needs may have to be forestalled for lack of funds. Additionally, regular federal capitalization grants are uncertain because of the national budgetary process, hurting regular program planning that is critical to the pace of investment.

New York state is currently on a course to finance and build $4.0 billion dollars of environmental improvements through the NYSRF by the year 2000. This was over a third of the wastewater improvements at the time the NYSRF was established. It is not enough because current needs have more than doubled and are now estimated to be $25 billion. In Connecticut, original funding projections called for an annual state commitment of $40 million for 20 years, as a complement to the estimated annual federal contribution of up to $25 million that was to be phased out by 1994. This investment pace would have met the total program costs of $1.077 billion as identified by the Governor at the time the CTSRF was enacted. At original funding levels and no new resources, full program funding of the now required $3.5 billion need in Connecticut is not possible within a reasonable timeframe.

The states need to ascertain the capitalization requirements that would be required if their environmental protection goals are to be fulfilled over the next 20 years. The evaluation assumed that there would be a 5 percent inflation rate over the 20-year period. In addition, the states' existing SRF programs as currently operating were used as the basis for financial modeling. The capital program in New York state is intended to resolve an identified $25 billion need. In Connecticut the need is $3.5 billion. The additional Long Island Sound needs are included in these overall estimates. If these capital plans are financed through the SRFs and the existing federal statutory cost-sharing formulas remain in effect, the federal contribution to the annual SRF capitalization funding in New York should be approximately $623 million and New York state's share should be approximately $128 million.

In Connecticut, based upon the state's current grant/loan program, the state's share of the capitalization requirement should approximately be $47 million and the federal share approximately $70 million. These funding requirements cannot be satisfied with the current budget appropriation to the EPA for SRF capitalization using the existing allocation formula to the states.

Under these circumstances, approximately $1.5 billion (leveraged dollars) annually in new construction financing will be required in New York state in addition to the funds that are released each year because of the revolving nature of the SRF. This means that at the beginning of the 20 year period a $1.5 billion dollar program will need to be financed and will grow to $3.5 billion by the end of the 20-year period, a result of 5 percent inflation. In Connecticut, the capital outlays start at approximately $170 million annually and grow to nearly $280 million at the end of the 20-year period.

Even with the fund adequately capitalized, there is a question of local affordability. This is a function of a municipality's willingness and ability to pay for a proposed wastewater facility improvement. Technically, a municipality's current economic position can be measured by evaluating historical, current, and projected expenditures and revenues. Business and residential economic positions, as measured by such things as income and full value assessments and by comparing these attributes with other similar communities, can help objectively determine ability to pay. Willingness to pay for improvements is a more subjective task. However, it is an area where state governments can help local municipalities through technical assistance. Organizing historical financial information, establishing clear state priorities, assisting localities in developing their own capital plans, and gaining access to bond markets is critical to overcoming the willingness to pay for capital improvements. This task is made more daunting because the wastewater projects overlap municipal jurisdictional boundaries. Nonetheless, it can be accomplished if adequate resources were made available.

F. Alternative Revenue Sources

While the SRF programs are currently the main source of federal and state funding for wastewater treatment capital improvement projects, various alternative approaches to raise revenue at the state and local level have been studied. A report prepared by Apogee Research, Inc. for the Management Conference presented information on a wide array of alternative financing mechanisms that could provide revenue streams for continued research, management and implementation activities as well as the construction of various projects to abate Long Island Sound water pollution. Certain of the types of taxes or fees arrayed in the Apogee Report and discussed below may be best imposed at the state level with others imposed at the local level.

- Water Use Fee: A fee for water use, in each state as a whole or limited to the Long Island Sound watersheds, could be levied on all residential, commercial and industrial users. The Apogee Report estimated that at a flat rate of 10 cents per 1,000 gallons of water an annual revenue of almost $90 million could be generated in the New York City area alone. If imposed on a statewide basis this fee is estimated to generate an annual revenue of $15 million in Connecticut and $150 million in New York. Such a fee would be easy to collect through existing water purveyors, and if imposed at the state level would ensure a continuing and reliable source of revenue for not only Long Island Sound activities but also state wide water pollution abatement efforts.

- Fertilizer Tax: While both states currently assess fees to support their fertilizer regulatory programs, an additional tax, on either all fertilizer or just nitrogen containing fertilizer, could be imposed and the revenue used for water quality activities. The Apogee Report estimates that a $2.00 rate per short ton could raise an annual revenue of almost $63,000 in Connecticut and slightly $1.0 million in New York.

- Livestock and Poultry Head Charge: The Apogee Report collected data on livestock and poultry inventories, and based on charges that ranged from $2.00 per head of cattle to 1 cent per chicken estimated that a head charge could raise an annual revenue of approximately $231,000 in Connecticut and over $3.3 million in New York.

- Product Fees or Taxes: The idea of product fees or taxes to support water pollution abatement efforts stems from the rationale that chemical constituents of various products impair water quality and are frequently detected in surface and ground water. The Apogee Report focused on cleaning products and using a one percent surcharge on state sales tax estimated an annual

revenue of slightly over $1.0 million for New York. No estimate was prepared for Connecticut. The product fee or tax could be extended to personal care products, disposable diapers, tampons, paints, motor oil, herbicides and pesticides.

- Toilet Paper Tax: A tax on toilet paper, even at a low rate, offers a potentially significant revenue stream given the large population around Long Island Sound. The Apogee Report estimates that a 5 percent tax rate on toilet paper could raise an annual revenue of over $3.0 million in Connecticut and $11.5 million in New York City and Nassau, Suffolk and Westchester Counties.

- Boat Registration Fee: In addition to the state boat registration fee, the Apogee Report estimated that a *local option* registration fee imposed by local government could raise an annual revenue of up to $4.1 million in Connecticut and $620,000 in New York (based on Nassau, Suffolk and Westchester Counties, excluded New York City).

- Marine Fuel Tax: An additional marine fuel sales tax of 5 cents per gallon was estimated by the Apogee Report to raise an annual revenue of almost $1.0 million in Connecticut and slightly over $1.0 million in New York (based on Nassau, Suffolk and Westchester Counties, excluded New York City).

- Marine Slip Fee: Another revenue stream based upon boating, would be to charge a fee on slips in commercial and public marinas around Long Island Sound. The Apogee Report estimates, at a rate of $100 per slip, an annual revenue of $2.8 million in Connecticut and $832,800 in New York could be raised.

- Other Revenue Sources: While acknowledged as potential sources of revenue, the Apogee Report eliminated property, shellfish/fish, real estate transfer, new plumbing fixture, lodging, road fuel, effluent permit, septic tank and check-off taxes or fees due to issues of equity, feasibility, and impacts. However, innovative ways to generate funds have been demonstrated in Connecticut by their Long Island Sound motor vehicle license plates, and now in New York with their recently enacted Environmental Protection Fund which will obtain revenue from regional conservation license plates, leases on underwater lands, the sale of surplus state lands and the real property transfer tax.

The estimates provided by the Apogee Report should be taken as illustrative of revenue stream potentialities. The value of the estimates lies in their order of magnitude to raise annual revenue of up to $27 million in Connecticut and $170 million in New York. A decision to access any, all or other alternative revenue sources resides in the respective state public policy decision-making arena. However, accessing such revenue sources would provide needed funds for the continuing research, management, and implementation activities associated with the restoration of the Long Island Sound.

G. Conclusions and Recommendations

Long Island Sound is a national resource; its cleanup, therefore, must reflect a partnership effort among federal, state, and local governments if it is to be equitable and successful.

1. Long Island Sound Challenge Grant Fund

To ensure that implementation of the management plan gets off to a good start, the Management Conference recommends that the Congress authorize a total of $50 million under Section 119(d) of the Clean Water Act. This section of the Clean Water Act, created by the Long Island Sound Improvement Act of 1990, authorizes grants for projects that will help implement the plan. Appropriations could be spread over a period of five years. The Management Conference would use the $50 million to fund a Long Island Sound Challenge Grant program.

A significant portion of appropriated funds would be used to ensure that the Phase III nitrogen control actions that do not involve major capital improvements get off to a fast start with full local government cooperation. Innovative projects would be encouraged.

- The states Connecticut and New York would create separate Long Island Sound accounts to accept funds.

- The EPA would allocate a significant portion of the funds to the states for use within the individual nitrogen management zones in proportion to the LIS 3.0-based load reduction targets for nitrogen.

- These funds would then be allocated by the states to the individual zones based on the load reduction targets.

- The entities responsible for achieving the nitrogen load reduction targets, such as sewerage authorities, municipal governments, and individual farmers, would submit applications for the funds to the states. The point source applications would need to meet minimum criteria for pounds per year nitrogen reduction per dollar expended. The results of the Connecticut point source retrofit program indicate a minimum of 365 pounds per year of nitrogen removed for every $3,700 invested. Nonpoint source applications would need to meet a competitive criteria.

- The states would obligate funds for the most cost-effective projects.

The remaining portion of the funds would be used to support actions in other areas, such as habitat restoration and acquisition, stormwater abatement, and public access. Of this remaining portion, $10 million would be allocated to habitat restoration and acquisition. Funds would be awarded on a competitive basis, with eligibility limited to projects that support implementation of the plan and go beyond the current legal or regulatory obligations of the recipients.

2. State Revolving Fund Programs

The Management Conference has concluded that SRFs are the preferred method to finance the clean up of Long Island Sound. Both states have used the federal SRF capitalization grants to enact sophisticated, publicly accepted financing vehicles that are institutionally capable of addressing the needs of Long Island Sound. Any funding proposal that includes wastewater investment should be provided through these institutions. The Clean Water Act should be reauthorized and grants to the states to help capitalize their State Revolving Fund programs should be continued. Following reauthorization of the Act, the Management Conference will formulate a detailed financial plan, consistent with authorized federal funding levels, to meet the total cost for plan implementation. The financial plan will include a specific focus on the ability of local governments to pay for required

improvements. The states are committed to providing technical assistance to local governments in complying with the plan.

The SRFs in Connecticut and New York state are now generally understood by the municipal borrowers and highly regarded by the investment markets. The strong market grade for the funds is testimony to the sound structure and the leadership of the SRFs. Through November of 1992, New York state has issued $1.2 billion in loans to New York communities. In Connecticut, visibility of the SRF is evident in funding levels authorized above planned levels, as well as the high level of acceptance by state legislators and municipalities alike. The program is flexible in the sense that, given the legislative will and support, it could integrate the concepts of affordability, user impact, and financial hardship to minimize financial impact.

However, Long Island Sound financing has been made more complicated by the need to finance the additional water pollution control needs identified in this plan. These needs have increased the size of the states' wastewater programs to levels never envisioned in 1986 and will increase the cost to the states beyond their ability to pay for them. Even if the states dramatically increase their commitment to pay for a higher proportion of these improvements, the capital needs cannot be met by the states alone.

To address the funding problem, a broad-based funding option is needed. Special fees and taxes at the levels discussed in the Apogee Report will be insufficient to meet the total potential capital needs. Furthermore, to maintain and avail continued local support, additional technical help is required to assess the ability and willingness of local government to pay for environmental protection improvements. However, innovative and alternative financing approaches should be considered given the magnitude of the capital needs. While not directly linked to discussions of the Clean Water Act reauthorization, interest has been shown in alternative revenue sources and funding mechanisms.

To continue the clean up efforts, the LISS has concluded that the Clean Water Act needs to be reauthorized and that capitalization grants must continue.

- New York state will need approximately $623 and $128 million of federal and state funds, respectively, per year for twenty years to meet its anticipated needs.

- Connecticut will need approximately $70 and $47 million of federal and state funds, respectively, per year for twenty years to meet its anticipated needs.

- Based upon the results of reauthorization of the Clean Water Act and agreement on Long Island Sound clean up, the LISS will formulate a detailed financial plan which will address the total costs for implementation with a specific focus upon local governmental units and their ability to pay for the required improvements.

- The states agree that they must work with and provide technical assistance to help local governments develop capital plans.

- The EPA and the states of Connecticut and New York will seek to identify opportunities to support projects remediating adverse environmental consequences of violations.

3. Other Programs

While the primary focus of the Management Conference has been on programs resulting from the Clean Water Act, there are other legislative initiatives and programs that affect the quality of Long Island Sound. This is particularly true for programs to protect living resources and habitat. Continued support for and improvements in these programs will have direct benefits for the Sound.

Programs that acquire land or easements include the Land and Water Conservation Fund, New York state's Environmental Protection Fund, and Section 318 of the Coastal Zone Management Act. The successful acquisition of lands and easements necessary to complete the proposed Long Island Sound reserve system and to meet public access needs will require a substantial investment by state and local governments and by private land trust organizations. This effort needs significant federal assistance in the form of 50 percent matching grants from the Land and Water Conservation Fund. Federal legislation to restructure the fund and revitalize its provisions for matching grants to states has been advocated by many organizations, including the President's Commission on American Outdoors (1987), and the 75th Anniversary Symposium of the National Park Service. Such a restructuring and revitalization of the Fund should bring annual state grants back at least to the levels that existed in 1979. The Management Conference specifically recommends that the Land and Water Conservation Fund's provisions for grants to the states be revitalized at annual appropriations of $400 million to $450 million.

In addition, funding for direct land aquisition by the Department of Interior must be established to support land aquisitions for the U.S. Fish and Wildlife Service's National Wildlife Refuge System. The Management Conference recommends reforming the Land and Water Conservation Fund to be at the same level as is proposed above for the states.

To meet the Management Conference's goals for the living resources of Long Island Sound, certain programs will require critical federal funding:

- Continued authorizations and appropriations is needed for the Sport Fish Restoration Act (the Dingell-Johnson and Wallop-Breaux Acts). In the next reauthorization, Congress should restore revenues from the 1993 federal fuel tax increase, which was specifically withheld from the Aquatic Resources Trust Fund created by the act. This would assist both states in maintaining projects supported by this federal aid program in the face of declining annual appropriations. Such projects presently occurring in the Sound include: fisheries monitoring and management, fishing and boating access, artificial reef planning and development, tidal wetlands management, and installation of boat pumpout stations.

- The federal Intermodal Surface Transportation and Efficiency Act makes federal matching grants available for restoration of wetlands and other habitats adversely affected by transportation projects, the acquisition and development of open space conservation projects associated with transportation projects, and the remediation of transportation-induced water quality impacts. Regional Transportation Planning Boards should give high priority to applications for enhancement grants for actions identified in this plan.

- In 1993, the federal Atlantic Coast Interjurisdictional Fisheries Act was enacted. This law provides needed teeth to ensure uniform state adoption of fisheries harvest regulations agreed upon by the Atlantic States Marine Fisheries Commission. Additional funding will be needed to administer the act and to monitor the fisheries under cooperative management. Congress should appropriate the full amounts authorized by the act.

- Appropriations under Section 318 of the Coastal Zone Management Act, which provides funding for the National Estuarine Research Reserve System, need to be increased to permit an expansion of the system to include new reserves, including a proposed reserve on the Connecticut River. To met the unmet needs of existing research reserves and to allow designation and funding of additional reserves, an authorization and annual appropriation increase to $10 million to $12 million per year is needed.

- Authorizations and appropriations under federal wildlife programs, including the Pittman-Robertson Aid in Wildlife Restoration Act, the Endangered Species Act, and the Marine Mammal Protection Act should be continued.

Appendix A. Initial Infrastructure Projects for Connecticut and New York

CONNECTICUT		
Connecticut Potential Needs:		
Ansonia	Denitrification	$13,602,000
Branford	Denitrification	$16,908,000
Bridgeport East	Denitrification	$63,590,000
Bridgeport West	Denitrification	$152,778,000
Derby	Denitrification	$12,292,000
Fairfield	Denitrification	$27,633,000
Greenwich	Denitrification	$45,000,000
Groton City	Denitrification	$12,489,000
Groton Town	Denitrification	$17,615,000
Milford Beaver	Denitrification	$12,400,000
Milford Housatonic	Denitrification	$25,200,000
Montville	Denitrification	$11,314,000
New Canaan	Denitrification	$11,485,000
New Haven	Denitrification	$109,414,000
New London	Denitrification	$31,048,000
North Haven	Denitrification	$3,600,000
Norwalk	Denitrification	$66,817,000
Norwich	Denitrification	$26,415,000
Seymour	Denitrification	$12,800,000
Shelton	Denitrification	$21,966,000
Stanford	Denitrification	$83,000,000
Stratford	Denitrification	$44,200,000
West Haven	Denitrification	$67,750,000
Westport	Denitrification	$17,100,000
Cheshire	Denitrification	$27,200,000
Danbury	Denitrification	$82,700,000
Meriden	Denitrification	$33,682,000
Naugatuck	Denitrification	$32,200,000
New Milford	Denitrification	$6,000,000
Southington	Denitrification	$24,697,000
Thomaston	Denitrification	$10,350,000
Torrington	Denitrification	$23,000,000
Wallingford	Denitrification	$27,147,000
Waterbury	Denitrification	$46,000,000
Watertown	Denitrification	$5,750,000
East Hampton	Denitrification	$14,694,000

East Hartford	Denitrification	$46,246,000
East Windsor	Denitrification	$8,285,000
Enfield	Denitrification	$30,040,000
Glastonbury	Denitrification	$12,826,000
Hartford	Denitrification	$140,574,000
Mattabassett	Denitrification	$53,258,000
Middletown	Denitrification	$22,086,000
Portland	Denitrification	$6,703,000
Rocky Hill	Denitrification	$29,955,000
South Windsor	Denitrification	$14,287,000
Suffield	Denitrification	$7,704,000
Windsor	Denitrification	$6,873,000
Windsor Locks	Denitrification	$9,642,000
Connecticut Existing Needs:		
Jewett City	CSO Correction	$750,000
Middletown	CSO Correction	$2,452,000
Middletown	CSO Correction	$5,030,000
Middletown	CSO Correction	$22,575,000
Waterbury	CSO Correction	$203,000
W. Hartford-MDC	CSO Correction	$22,282,000
Norwich	CSO Correction	$450,000
Norwich	CSO Correction	$89,864,000
Hartford-MDC	CSO Correction	$91,000,000
Bridgeport	CSO Correction	$2,855,000
Bridgeport	CSO Correction	$34,650,000
Bridgeport	CSO Correction	$66,150,000
New Haven	CSO Correction	$15,628,000
New Haven	CSO Correction	$122,000,000
New Haven	CSO Correction	$2,094,000
Norwalk	CSO Correction	$1,000,000
Middletown	CSO Correction	$9,000,000
Middletown	CSO Correction	$12,000,000
New Haven-MDC	CSO Correction	$12,750,000
Hartford-MDC	CSO Correction	$23,000,000
Hartford -MDC	CSO Correction	$25,000,000
Connecticut Total Estimated Need		**$ 2,189,048,000**

NEW YORK STATE		
New York State Existing & Potential Needs:		
New York City		
Hunts Point	BNR Retrofit Denitrification	$2,000,000 $1,421,000,000
Tallmans Island	BNR Retrofit Denitrification	$2,000,000 $505,000,000
Wards Island	Centrate Treatment STP Improvements Denitrification	$94,000,000 $640,000,000 $1,058,000,000
Bowery Bay	Denitrification	$805,000,000
Newtown Creek	Secondary Treatment and BNR Retrofit	$1,700,000,000
Citywide	CSO Abatement	$1,500,000,000
Westchester County		
New Rochelle S.D.	STP Expansion Denitrification	$16,500,000 $87,000,000
Mamaroneck S.D.	Denitrification	$89,000,000
Port Chester S.D.	Denitrification	$36,100,000
Blind Brook S.D.	BNR Retrofit Denitrification	$200,000 $21,750,000
Nassau County		
Glen Cove	Denitrification	$14,000,000
Belgrave WPCD	STP Improvements Denitrification	$2,000,000 $8,180,000
Great Neck S.D.	Denitrification	$12,300,000
Village of Great Neck S.D.	S.S. Rehab. STP Improvements Denitrification	$2,000,000 $440,000 $6,400,000
Port Washington	Denitrification	$16,400,000
Oyster Bay S.D.	Denitrification	$5,000,000
Suffolk County		
Port Jefferson (v)	STP Improvements Denitrification	$5,026,000 $3,270,000
Northport (v)	STP Upgrade	$1,150,000
Suffolk Co. S.D. #21	Nitrogen Removal	$5,000,000
Suffolk Co. S.D. # 6	Denitrification STP Rehabilitation	$8,180,000 $800,000
Huntington S.D.	Denitrification	$8,180,000
Suffolk Co. S.D. #6	STP Rehabilitation	$800,000
New York Total Estimated Need		**$ 7,304,330,000**
CT & NY Total Estimated Need		**$ 9,493,378,000**

Appendix B. Glossary of Terms

AEROBIC: Presence of free oxygen (oxygen gas).

ALGAE: Simple rootless plants that grow in sunlit waters in relative proportion to the amounts of nutrients available. Most forms can provide food and habitat. They can affect water quality adversely, however, by lowering the dissolved oxygen in the water when they decompose.

ALGAL BLOOMS: Sudden spurts of algal growth, which can affect water quality adversely. Often, excessive blooms indicate nutrient enrichment. Some species cause potentially hazardous changes in local water chemistry.

ALTERNATIVE TECHNOLOGIES: Technological improvements utilizing physical or biochemical means of increasing dissolved oxygen in addition or in lieu of nitrogen source controls.

AMBIENT: Referring to average concentrations of substances in the surrounding media (water, air, or sediment).

ANADROMOUS: Fish that spend their adult life in the sea but swim upriver to freshwater spawning grounds to reproduce.

ANAEROBIC: Absence of free oxygen (oxygen gas).

ANOXIA: An environment with very little or no free oxygen. Oxygen may be available in association with other elements, e.g., nitrate.

AQUIFER: An underground geological formation, or group of formations, containing usable amounts of groundwater that can supply wells and springs.

ATMOSPHERIC DEPOSITION: Emissions of sulfur and nitrogen compounds and other substances including heavy metals and toxic organic compounds that are sometimes transformed by complex chemical processes in the atmosphere, and deposited often far from the original sources, and then deposited on earth in either a wet or dry form. The wet forms, popularly called *acid rain*, can fall as rain, snow, or fog. The dry forms are acidic gases or particulates.

BACTERIA: (Singular: bacterium) Microscopic organisms that are an important, natural component of the environment. many forms are instrumental in the breakdown of organic matter, releasing nutrients to the environment where they can be used by primary producers. They can also aid in pollution control by consuming or breaking down organic matter in sewage or by similarly acting on oil spills or other water or soil pollutants. Disease-causing bacteria in soil, water, or air can also cause health problems for humans, animals, and plants.

BENTHIC ORGANISM: A form of aquatic plant or animal life that is found on or near the bottom of a stream, lake, or ocean.

BENTHIC COMMUNITY STRUCTURE GRADIENT: The relative presence or absence of benthic organisms found in bottom habitats in response to different concentrations of contaminants or variable substrates.

BENTHOS: All marine organisms (plant and animal) living on or in the bottom of the sea.

BEST MANAGEMENT PRACTICE (BMP): A method of preventing or reducing the pollution resulting from an activity. The term originated from rule and regulation in Section 208 of the federal Clean Water Act.

BIOACCUMULATION: The uptake of substances (e.g., metals) leading to elevated concentrations of those substances within plant or animal tissue.

BIOACCUMULATIVE: Substances that increase in concentration in living organisms (that are very slowly metabolized or excreted) as they breathe contaminated air, drink contaminated water, or eat contaminated food. (See: Biological Magnification.)

BIOASSAY: Using living organisms to measure the effect of a substance, factor, or condition by comparing before-and-after data. Often used to test toxicity of sediments and water that may be contaminated with toxic substances.

BIOCONCENTRATION: Concentration of contaminants by an aquatic organism through its digestive tract or gill tissues.

BIOEFFECTS TESTING: A test that measures the response or effect of contaminants in water or sediment upon a living organism.

BIOLOGICAL NUTRIENT REMOVAL (BNR): A wastewater treatment process in which biological organisms, primarily bacteria, are used to remove nutrients such as nitrogen and phosphorus from wastewater. The basic principle of BNR is to have alternating anoxic (no or little oxygen) and aerobic (oxygenated) zones or tanks within the treatment process. Nitrification occurs in the aerobic zones, and denitrification occurs in the anoxic zones. Nitrogen is removed in the denitrification process where it is released to the atmosphere as a harmless gas.

BNR RETROFIT: Institution of minor mechanical and operational changes at a wastewater treatment plan for the purpose of removing nitrogen.

BIOMONITORING: (1) The use of living organisms to test ambient environmental conditions, often to check the impact of effluents on receiving waters. (2) Analysis of blood, urine, tissues, etc., to measure chemical exposure in humans.

BIOTA: Plants and animals inhabiting a given region.

BIOTIC COMMUNITY: A naturally occurring assemblage of plants and animals that live in the same environment and are mutually sustaining and interdependent.

BIVALVE: A mollusc with two shells hinged together (e.g., clam, oyster).

BLOOM: A proliferation of algae and/or higher aquatic plants in a body of water; often related to nutrient pollution. (See: Algal Bloom.)

BOUNDARIES: The eastern and western outlets of Long Island Sound: specifically, The Race where Long Island Sound meets Block Island Sound and the Atlantic Ocean in the east and the Battery at the interface between the East River and New York Harbor in the west.

BRACKISH: A mixture of fresh and salt water. Specifically, estuarine waters where the ocean-derived salt content ranges from 0.5 ppt to 30 ppt.

CADMIUM: A heavy metal that may be toxic in the environment at or above certain concentrations. Cadmium is used in a number of ways; among them, the most important use being for anti-corrosion protective electroplating of iron and steel. Today, the only continued use of cadmium is in batteries. Cadmium exhibits several toxic effects. Classified as a teratogen, carcinogen, and a probable mutagen, it has been implicated as the cause of severe deleterious effects on fish and wildlife.

CARCINOGEN: Any substance that can cause or contribute to the development of cancer.

CENTRATE: Liquid, nitrogen-rich product of sludge dewatering.

CHOLERA: An infection of the small intestine caused by the bacterium *Vibrio cholera*. Cholera results in profuse diarrhea that in severe untreated cases can lead to rapid dehydration and death. Infection is always a result of swallowing food or water that has been contaminated with the vibrio.

CHLORDANE: A chlorinated organic insecticide having both stomach poison and fumigant properties. Like DDT, it has a high degree of persistence in the environment and a tendency to be concentrated in the food chain. The EPA completely banned the use of chlordane in 1988.

CHLORINATED HYDROCARBONS: These include a class of persistent, broad-spectrum insecticides that linger in the environment and accumulate in the food chain. Among them are DDT, aldrin, dieldrin, heptachlor, chlordane, lindane, endrin, mirex, hexachloride, and toxaphene. Other examples include TCE, used as an industrial solvent.

CHLORINATION: The application of chlorine to drinking water, sewage, or industrial waste to disinfect or to oxidize undesirable compounds.

CHROMIUM: A trace element essential to humans; at high levels of exposure it is known to be toxic to humans. Chromium produces inflammation of the skin and, if inhaled, damages the nose. People exposed to chromium fumes have a greater risk of developing lung cancer.

CHRONIC EFFECTS: Lethal response or debilitating damage to an organism(s) resulting from prolonged exposure to a toxicant(s). Exposure time may be several days, weeks, months, or even years.

COASTAL RUNOFF: Stormwater and the materials it carries contributed to the Sound from coastal lands surrounding the Sound.

COASTAL ZONE: Lands and waters adjacent to the coast that exert an influence on the uses of the sea and its ecology, or, inversely, whose uses and ecology are affected by the sea. Legally the definition varies from state to state.

COLIFORM BACTERIA: Widely distributed microorganisms found in the intestinal tract of humans and other animals and in soils. Their presence in water indicates fecal pollution and potentially dangerous contamination by disease-causing microorganisms.

COMBINED SEWERS OVERFLOWS: Discharges from a sewer system that carries both sewage and stormwater runoff. Normally, its entire flow goes to a wastewater treatment plant but, during a heavy storm, the storm water volume may be so great as to cause overflows. When this happens, untreated mixtures of stormwater and sewage may flow into receiving waters. Stormwater runoff may also carry toxic chemicals from industrial areas or streets into the sewer system.

CT PUBLIC ACT 91-170: An act requiring that coastal towns in Connecticut address priority problems identified by LISS through zoning changes and other local actions. The state of Connecticut will provide technical assistance to these communities.

CONTAMINANT: Any physical, chemical, biological, or radiological substance or matter that has an adverse affect on habitats or organisms.

CONVENTIONAL POLLUTANTS: Statutorily listed pollutants which are understood well by scientists. These may be in the form of organic waste, sediment, acid, bacteria and viruses, nutrients, oil and grease, or heat.

COPPER: A metal that has many industrial uses. Uses include plumbing, electrical products, metal plating, brass, pesticides, fungicides, paint and wood preservatives. Sewage sludge is enriched in copper.

CRITERIA: Acceptable limits in various media (e.g., water, sediments) for pollutants derived by the EPA. When issued by the EPA, the criteria provide guidance to the states on how to establish their standards.

CRUSTACEA: A class of arthropods with jointed appendages and segmented exoskeletons of chitin. This class includes barnacles, crabs, shrimps, and lobsters.

CUMULATIVE IMPACTS: Combined effects resulting from more than one action.

DDT: The first chlorinated hydrocarbon insecticide (chemical name: dichloro-diphenyl-trichloroethane). It has a half-life of 15 years and can collect in fatty tissues of certain animals. EPA banned registration and interstate sale of DDT for virtually all but emergency uses

in the United States in 1972 because of its persistence in the environment and accumulation in the food chain.

DECOMPOSITION: The breakdown of matter by bacteria and fungi. It changes the chemical makeup and physical appearance of materials being broken down and may cause changes in the environment as well.

DENITRIFICATION: A biochemical process in which specific bacteria extract oxygen bound up in molecules of nitrate, resulting in the release of harmless nitrogen gas into the atmosphere. This process occurs naturally in salt marshes and wetlands and can be established in wastewater treatment plants to remove nitrogen from wastewater.

DESIGNATED USES: Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act. Uses can include cold water fisheries, public water supply, agriculture, etc.

DIRECT DISCHARGER: A municipal or industrial facility that introduces pollution through a defined conveyance or system; a point source.

DISSOLVED OXYGEN (DO): The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to protect DO in waste-receiving waters.

DIVERSITY (SPECIES): A measurement that generally combines a measure of the total number of species in a given environment with the number of individuals of each species. Species diversity is high when there are many species with a similar number of individuals; low when there are fewer species and when one or two species dominate.

DOMINANT SPECIES: A species or group of species that, because of their abundance, size, or control, strongly affect a community.

DRAINAGE BASIN: The land area drained by a river or stream and its tributaries.

DREDGING: Mechanical removal of sediment from the bottom of waterbodies. This disturbs the ecosystem and causes silting that can have adverse impacts on aquatic life.

DREDGED MATERIAL: (See: Dredged Sediments.)

DREDGED SEDIMENTS: Bottom sediments associated with the estuarine water of the Sound which removed, usually for navigational purposes, by mechanical means such as a bucket or hydraulic dredge. The disposal of dredged sediments may occur either upland or in the water of the Sound. State and federal permit programs only allow sediments to be disposed in the Sound at designated sites and only in a manner that will not cause adverse effects on organisms. Materials that are not classified as sediment such as medical waste, hazardous material, and construction debris are not allowed to be disposed at these sites.

DREDGING WINDOW: (See: Seasonal Restriction.)

DRY WEATHER OVERFLOWS: Illegal discharges of untreated wastewater from combined sewer overflows and storm drains unrelated to rainfall events. During rainstorms such discharges are referred to as *wet weather flows*.

DUNES: Windblown (aeolian) deposits of sand generally located landward of the beach. In Long Island Sound, dunes are typically narrow ridges of low elevation (less than 10 feet in height).

ECOLOGICAL IMPACT: The effect that a human or natural activity has on living organisms and their non-living (abiotic) environment.

ECOSYSTEM: The interacting system of a biological community and its non-living environmental surroundings.

EFFLUENT: Wastewater -- treated or untreated -- that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

EFFLUENT LIMITATION: Restrictions established by a state or the EPA on quantities, rates, and concentrations of pollutants in wastewater discharges.

EMISSION: Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

ENFORCEMENT: EPA, state, or local legal actions to obtain compliance with environmental laws, rules, regulations, or agreements and/or obtain penalties or criminal sanctions for violations. Enforcement procedures may vary, depending on the specific requirements of different environmental laws and related implementing regulatory requirements.

ENRICHMENT: The addition of nutrients (e.g., nitrogen, phosphorus, carbon compounds) from sewage effluent, runoff, or atmospheric deposition to surface water. This process greatly increases the growth potential for algae and aquatic plants.

ENVIRONMENTAL: The sum of all external conditions affecting the life, development, and survival of an organism.

EPA: The U.S. Environmental Protection Agency, established in 1970 by Presidential Executive Order, bringing together parts of various government agencies involved with the control of pollution.

EPA OCEAN DATA EVALUATION SYSTEM (ODES): A data management and retrieval system developed, used and supported by EPA. Environmental data collected by the National Estuary Programs and the 301(h) ocean discharge program are required to be submitted in ODES format.

EPIDEMIOLOGY: The branch of medicine that studies epidemics and epidemic diseases.

ESTUARY: A semi-enclosed coastal body of water where freshwater and saltwater mix. These areas may include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife. (See: Wetlands)

FACILITIES PLAN: The conceptual design of a treatment system (e.g., for a wastewater treatment plant).

FECAL COLIFORM BACTERIA: Specific coliform bacteria associated with the digestive track of warm-blooded animals. (Also, see Coliform)

FERTILIZER: Materials such as nitrogen and phosphorous that provide nutrients for cultured plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

FINFISH: Term used to distinguish fish (with fins) from shellfish.

FOOD CHAIN: Chain of organisms, existing in any natural community, through which energy is transferred. each link in the chain feeds on and obtains energy from the one preceding it and in turn is eaten by and provides energy for, the one following it. At the beginning of the chain are green plant. (See: Food Web.)

FOOD WEB: The interrelated food relationships in an ecosystem including its production, consumption, and decomposition, and the energy relationships among the organisms involved in the cycle. (See: Food Chain.)

FRESHWATER: A term applied to water with salinity less than 0.5 parts per thousand (National Wetlands Definition).

GASTROENTERITIS: Inflammation of the mucous membrane of the stomach and intestine caused by any of a variety of viruses, bacteria, and other small organisms that have contaminated food or water supplies.

GENERAL PERMIT: A permit applicable to a class or category of regulated activities.

GEOGRAPHIC INFORMATION SYSTEM (GIS): A computerized database of land use, land cover and many other types of information that can be statistically analyzed and graphically displayed using maps.

GROUNDWATER: The supply of freshwater found beneath the Earth's surface (usually in aquifers) which is often used for supplying wells and springs. Because groundwater is a major source of drinking water, there is growing concern over areas where leaching agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating groundwater.

HABITAT: The place where a population (e.g., human, animal, plant, microorganism) lives and its surroundings, both living and non-living.

HEAVY METALS: (See: Metals.)

HEPATITIS A: A type of chronic hepatitis in which there is intense and progressive inflammation and destruction of cells surrounding certain structures within the liver.

HEPATOPANCREAS: Lobster liver, commonly referred to as *tomalley*.

HYDROCARBONS (HC): Chemical compounds that consist of carbon and hydrogen.

HYDRODYNAMIC: Concerning the forces, energy and pressure of water in motion.

HYPOXIA: Low concentrations (e.g., less than 3 ppm) of dissolved oxygen in water.

INDICATOR: In biology, an organism, species, or community whose characteristics define the presence of specific environmental conditions.

INDIGENOUS: Having originated in or living naturally in a particular region or environment; native.

INDIRECT DISCHARGE: Introduction of pollutants from commercial and industrial facilities into a sewage treatment plant.

INFLUENT: Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant.

INTEGRATED PEST MANAGEMENT (IPM): Application of biological pest (and physical) controls; an alternative to synthetic chemical pesticides.

INTRINSIC: Inherent; of or relating to the fundamental nature of a thing.

LAND USE: Refers to the ways in which a community or area makes use of its natural resources.

LARVAE: The newly hatched, earliest stage of any species, such as lobsters, that undergoes metamorphosis, differing noticeably in form and appearance from the adult.

LEACHATE: A liquid containing the soluble constituents of materials which have been *leached* by water or other liquids percolating through the soil where the materials are located.

LEAD: A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasolines, paints, and plumbing compounds have been sharply restricted or eliminated by federal laws and regulations

LIMITING NUTRIENT: A nutrient (e.g., nitrogen, phosphorus) that limits the growth of a population (e.g., plants) or determines the carrying capacity of the environment by its scarcity.

MANAGEMENT CONFERENCE: The membership of the committees established to run and advise the Long Island Sound Study. See Appendix C for a description of the committees and their functions.

MARINE SANITATION DEVICE (MSD): Any equipment installed on board a vessel to receive, retain, treat, or discharge sewage and any process to treat such sewage

METALS: Metallic elements that can cause harm to living organisms and can accumulate in the food chain. Often divided into common metals (e.g., zinc, iron, copper) and trace metals (e.g., chromium, cadmium, arsenic). Elements of primary concern in the environment are the heavy metals.

MERCURY: A heavy metal that can accumulate in the environment and is highly toxic if breathed or swallowed. Industrial uses of mercury include manufacture of thermometers, mirrors, pharmaceutical, mercury vacuum pumps, agricultural fungicides and germicides. Mercury can enter the environment via combustion of fossil fuels since mercury is a trace element in both coal and tar. Mercury is a significant element in terms of its potential toxicity.

MILLION GALLONS PER DAY (MGD): A measure of water flow, usually at a wastewater treatment plant.

MICROORGANISM: Unicellular living organisms so small that individually they can usually only be seen through a microscope, some of which cause diseases (e.g., bacteria, viruses).

MITIGATE: To make less serious or severe.

MODELING: An investigative technique using a mathematical or physical representation of a system or theory, usually on a computer, that accounts for all or some of its known properties. Models are often used to test the effect of changes of system components on the overall performance of the system.

MONITORING: Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things.

MOTILE: Moving or capable of moving spontaneously.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES): A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by EPA, a state, or (where delegated) a tribal government on an Indian reservation.

NATIONAL STATUS AND TRENDS PROGRAM (NS&T): NOAA's NS&T Program involves a series of activities undertaken to quantify the current status and long-term, temporal and spatial trends of key contaminant concentrations and biological indicators of effects in the nation's coastal and estuarine environments.

NICKEL: An element that is considered relatively non-toxic to man. The concentrations tolerated by most marine organisms appear to be high. The sources of nickel include stainless steel, nickel-plating, storage batteries, spark plugs, and electrical contacts.

NITRATE: A compound containing nitrogen and oxygen (NO_3) that can exist in the atmosphere or as a dissolved gas in water and that can have harmful effects on humans and animals. For example, high concentrations of nitrates in drinking water can cause severe illness in infants.

NITRIFICATION: The biochemical process in which specific bacteria convert ammonia and organic nitrogen to nitrate. In wastewater treatment plants, ammonia and organic nitrogen come from human wastes and dead plant and animal matter. The nitrifying bacteria are cultured for use at the plants to convert ammonia to nitrite and nitrate. Nitrification occurs naturally in ecosystems such as salt marsh and wetlands and can be established in wastewater

treatment plants to remove ammonia and nitrogen from wastewater.

NITROGEN: Nitrogen is an element that is present as organic nitrogen or in inorganic forms of ammonia, nitrite, and nitrate. The inorganic forms are preferentially used by phytoplankton to support their growth. Organic nitrogen is bound with organic material and is not available for plant growth until released in a usable inorganic form by decay processes.

NONPOINT SOURCE: Pollution sources that are diffuse or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by stormwater runoff. Commonly used categories for non-point sources are: agriculture, forestry, urban, mining, construction, dams and channels and land disposal.

NUTRIENT: Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus, but is also applied to other essential and trace elements including carbon and silica.

OIL SPILL: An accidental or intentional discharge of oil that reaches bodies of water; can be controlled by chemical dispersion, combustion, mechanical containment, and/or adsorption.

ORGANIC: (1) Referring to or derived from living organisms. (2) In chemistry, any compound containing carbon.

ORGANIC CHEMICALS/COMPOUNDS: Animal or plant-produced substances containing mainly carbon, hydrogen, and oxygen.

ORGANIC MATTER: Carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.

ORGANISM: Any living thing.

OUTFALL: The place where an effluent is discharged into receiving waters.

OXYGEN DEMAND: Consumption of oxygen by bacteria to oxidize organic matter.

PAHS: Polynuclear aromatic hydrocarbons (PAHs) comprise a group of petroleum derived hydrocarbon compounds that are found in the water and fish tissue of aquatic organisms in Long Island Sound and elsewhere. PAHs have a tendency to bioaccumulate and many are known or suspected carcinogens. Loadings to the Sound result from oil spills and other uncontrolled discharges of petroleum products.

PATHOGENIC: Capable of causing disease.

PATHOGENS: Microorganisms that can cause disease in humans, animals, or plants. They may be bacteria, viruses, or parasites and are found in sewage, in runoff from animal farms or rural areas populated with domestic and/or wild animals, and in water used for swimming. Fish and shellfish contaminated by pathogens, or the contaminated water itself, can cause serious illnesses.

PCBS: A group of toxic, persistent chemicals (polychlorinated biphenyls) used in transformers and capacitors for insulating purposes and in gas pipeline systems as a lubricant. Further sale or new use was banned by law in 1979.

PERMIT: An authorization, license, or equivalent control document issued by EPA or an approved state agency to implement the requirements of an environmental regulation, e.g., a permit to discharge from a wastewater treatment plant or to operate a facility that may generate harmful emissions.

PERSISTENCE: Refers to the length of time a compound, once introduced into the environment, stays there. A compound may persist for less than a second or indefinitely.

PHYTOPLANKTON: That portion of the plankton community comprised of tiny unicellular plants, (e.g., algae, diatoms, dinoflagellates).

POINT SOURCE: A stationary location or fixed facility from which pollutants are discharged or

emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack.

POLLUTANT: Generally, any substance introduced into the environment that adversely affects the health of plants and animals, or the usefulness of a resource.

POLLUTION: Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, and radiological integrity of water.

PRETREATMENT: Processes used to reduce, eliminate, or alter the nature of wastewater pollutants from non-domestic sources before they are discharged into publicly owned treatment works.

PRIMARY WASTE TREATMENT: First steps in wastewater treatment; screens and sedimentation tanks are used to remove most materials that float or will settle. Primary treatment results in the removal of about 30 percent of carbonaceous biochemical oxygen demand from domestic sewage.

PRIORITY POLLUTANT: A pollutant that is listed by the EPA as a pollutant of concern.

PRODUCTIVITY: Process by which plants remove dissolved carbon dioxide and micronutrients from the water and, using solar energy, convert them to complex organic compounds of high potential energy.

PUBLICLY OWNED TREATMENT WORKS (POTW): A waste-treatment works owned by a state, unit of local government, or Indian tribe, usually designed to treat sewage and other domestic wastewaters.

QUALITATIVE: Pertaining to the non-numerical assessment of a parameter.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC): A system of procedures, checks, audits, and corrective actions to ensure that research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

QUANTITATIVE: Pertaining to the numerical assessment of a parameter.

RECEIVING WATERS: A river, lake, ocean, stream, or other watercourse into which wastewater or treated effluent is discharged.

RESIDUAL: Amount of a pollutant remaining in the environment after a natural or technological process has taken place, e.g., the sludge remaining after initial wastewater treatment, or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

RESTORATION: The act of returning something such as habitat or water quality to its condition prior to human disturbance. Measures taken to return a site to natural conditions.

RESUSPENSION: Lifting of in-place bottom sediments into the water column by waves, bottom currents, or other mechanical disturbance.

RIPARIAN ZONE: Areas adjacent to rivers and streams.

RUNOFF: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into the receiving waters.

SALINITY: The amount of solid material contained in seawater once the organic matter has been completely oxidized; reported in grams of material to kilogram of seawater (i.e., part per thousand or ppt). The salt or chlorine content of the water can be used to determine the salinity. More simply, the amount of salt in water.

SANITARY SEWERS: Underground pipes that carry only domestic or industrial waste, not stormwater.

SECONDARY TREATMENT: The second step in most sewage treatment plants in which bacteria consume the organic parts of the waste. It is accomplished by bringing together waste, bacteria, and oxygen in trickling filters or in the activated sludge process. This treatment removes floating and settleable solids and about 90 percent of the oxygen-demanding substances and suspended solids. Disinfection is the final stage of secondary treatment. (See: Primary, Tertiary Treatment.)

SEDIMENTS: Particulate organic and inorganic matter that accumulates in a loose unconsolidated form. It may be chemically precipitated from solution, secreted by organisms, or transported by air, ice, wind or water and deposited. Resuspension of sediments may destroy fish-breeding areas and other habitats and cloud the water so that needed sunlight might not reach aquatic plants. Careless farming, mining, and building activities will expose soils, allowing them to be washed off the land after rainfalls and contribute to sediments.

SEPTIC TANK: An underground storage and treatment tank for wastes from homes having no sewer line to a treatment plant. The waste goes directly from the home to the tank, where the organic waste is decomposed by bacteria and the sludge settles to the bottom. The effluent flows out of the tank into the ground through drains; the sludge is pumped out periodically.

SEWAGE: The waste and wastewater produced by residential and commercial establishments and discharged into sewers.

SEWAGE SLUDGE: Sludge produced at a sewage treatment plant, the disposal of which is regulated under the Clean Water Act.

SEWER: A channel or conduit that carries wastewater and stormwater runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers are used for both purposes.

SHELLFISH: An invertebrate having a rigid outer covering, such as a shell or exoskeleton; includes clams and lobsters; term is the counterpart of finfish.

SIDE TREATMENT: Treatment of wastewater or its by-products physically separate from secondary treatment plant processes.

SLUDGE: A semi-solid residue from any of a number of air or water treatment processes. Sludge can be a hazardous waste.

SPECIES: A reproductively isolated aggregate of interbreeding populations of organisms.

SPRAWL: Unplanned or poorly planned development of open land.

STANDARDS: Prescriptive norms that govern action and actual limits on the amount of pollutants or emissions produced. The EPA, under most of its responsibilities, establishes minimum standards. States can issue stricter standards if they choose.

STORM SEWER: A system of pipes (separate from sanitary sewers) that carry only water runoff from building and land surfaces.

STORMWATER: Runoff caused by rain or snow storms.

STREAM: A body of water, including brooks and creeks, that moves in a definite channel in the ground driven by hydraulic gradient.

SUBMERGED AQUATIC VEGETATION (SAV): Vascular plants that live and grow completely underwater or just up to the water surface. Includes eelgrass, widgeon grass, tapegrass or wild celery and pondweeds.

SURFACE WATER: All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.);

also refers to springs, wells, or other collectors that are directly influenced by surface water.

SYSTEMWIDE EUTROPHICATION MODEL (SWEM): A coarse grid hydrodynamic water quality model proposed for the NY-NJ Harbor - Long Island Sound - NY Bight complexes.

TECHNOLOGY-BASED STANDARDS: Effluent limitations applicable to direct and indirect sources that are developed on a category-by-category basis using statutory factors, not including water-quality effects.

THRESHOLD: A point or level beyond which certain effects would occur.

TOTAL MAXIMUM DAILY LOAD: The maximum amount of a substance, such as metals or nutrients, that can be discharged in a day by a permitted wastewater treatment plant or industry.

TOXIC: Harmful to living organisms.

TOXICANT: A poisonous agent that kills or injures animal or plant life.

TOXICITY: The degree of danger posed by a substance to animal or plant life.

TOXIC SUBSTANCES: Materials contaminating the environment that cause death, disease, and/or birth defects in organisms that ingest or absorb them. The quantities and length of exposure necessary to cause these effects can vary widely.

TRASH HOODS: Apparatus inside a catch basin of a storm sewer which traps large objects (i.e. floatable debris).

TRAWLING: Commercial fishing method that utilizes a net towed behind a boat.

TRIBUTARY: A stream, creek, or river that flows into a larger stream, creek, or river.

TROPHIC LEVEL: A successive stage of nourishment as represented by links in the food chain. Primary producers (phytoplankton) constitutes the first trophic level, herbivorous zooplankton the second trophic level, and carnivorous organisms the third and higher trophic levels.

VIRUS: The smallest form of microorganisms capable of causing disease.

WASTELOAD ALLOCATION (WLA): The maximum load of pollutants each discharger of waste is allowed to release into a particular waterway. Discharge limits are usually required for each specific water quality criterion being, or expected to be, violated.

WASTEWATER TREATMENT PLANT: A facility containing a series of tanks, screens, filters, and other processes by which pollutants are removed from water.

WASTEWATER: The spent or used water that contains dissolved or suspended matter from individual homes, a community, a farm, or an industry.

WATER COLUMN: The water located vertically over a specific location on the sea floor.

WATER QUALITY CRITERIA: (See: Criteria.)

WATER QUALITY STANDARDS: State-adopted and EPA-approved ambient standards for water bodies. The standards cover the use of the water body and the water quality criteria which must be met to protect the designated use or uses (e.g., drinking, swimming, fishing).

WATERSHED: The land area that drains into a stream, river, estuary, or other waterbody.

WETLANDS: An area that is regularly saturated by surface or groundwater and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions. Examples include: swamps, bogs, fens, and marshes. Often defined based on soil characteristics.

ZINC: An essential trace element to living organisms. It is toxic when present in high

concentrations and can act synergistically to increase the toxicity of other metals and contaminants. Uses of zinc-based chemicals include wood preservatives, pigments, metallurgical operations, dry cell batteries, and its most important use as a catalyst in vulcanizing rubbers. Major point sources of atmospheric zinc are smelters, galvanizing operations, and waste incinerators.