

LIVING MARINE RESOURCES

Introduction

One of the best measures of the health of the Sound and of 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 ecosystem and are the best overall indicators of the health and water quality of the Sound. The Living Marine Resource (LMR) component of the proposed Long Island Sound Monitoring Program (LISMP) has two primary goals: (1) to assess the general health of LMR communities in the Sound, (2) to help determine the impact on LMRs of specific anthropogenic stresses such as hypoxia and the presence of various contaminants in the Sound. To be successful, the LMR component, as well as the entire proposed LISMP, must be cost-effective and take full advantage of existing monitoring programs.

LMR communities exist in a complex web of natural biological, physical, and chemical interactions and associations that constitutes the ecosystem of the Sound. These relationships are influenced by the presence and activity of a variety of contaminants and other anthropogenic stresses. Moreover, many finfish and shellfish species are subject to direct fishing pressure. Assessing the ecological health and condition of LMRs, and their temporal and spatial trends are daunting, but tractable tasks. Determining the causes of such conditions and trends are more difficult.

The LMR monitoring program is designed to assess the general ecological condition of LMR communities in the Sound, but it also

includes components that identify species to serve as indicators of the influence of hypoxia and chemical contamination in the Sound. The elements of the base program describe the minimum necessary to address these goals. Most of the base elements focus on describing the condition of one of the principal components (plankton, benthos, finfish) of the Sound's LMR community. Documenting overall trends in the abundance and health of LMRs is a necessary precursor to more specific examination of the possible natural or anthropogenic causes of whatever trends are detected. A number of the recommended program enhancements address this latter goal.

Following the description of the base and program enhancement elements, the quality control and quality assurance concerns and needs of the LMR monitoring program are presented. Next, three types of standard informational products are described that could be used to disseminate the data and information developed through LMR monitoring. The section concludes with recommendations for research that would refine or improve the LMR monitoring program, particularly studies that would advance our understanding of how LMRs, at the species and community levels, respond to changes in water quality and other environmental parameters.

The LMR component of the LIS Monitoring Program is designed to answer the following questions.

- What is the general health of LMR communities in Long Island Sound (i.e. finfish, benthic invertebrates, plankton)?

- What fraction of Long Island Sound exhibits the effects of anthropogenic stress, as evidenced by impacts on LMRs?

Minimalist Program

The following elements constitute the minimalist LMR monitoring program. As noted above, the base program is designed to paint a picture of the overall health and condition of LMR communities in the Sound. Not all communities are covered in the minimalist program. Choices were necessary in terms of the components of the LMRs in the Sound and its watershed that were of greatest concern and which were most likely to be impacted by water quality and other changes stemming from implementation of LISS management recommendations.

Programmatic Monitoring

The ultimate measure of program success is an improvement in the health of the ecosystem. Monitoring of living resources provides indicators of ecosystem health that will be used to assess the effectiveness of programmatic actions to reduce pollutant loadings. However, as shown in Figure 2, there are also programmatic measures particular to the living resources track, important examples of which are:

- The number of habitat protection and restoration plans developed.
- The number of habitats acquired.
- The amount of wetland acres restored.

Environmental Monitoring

Open Water Finfish Survey

Where: 40-45 stations in main stem LIS, stratified by water depth
(<20 m, >20 m)

When: Twice annually, in Spring & Fall

How: Bottom trawl

Data: Species abundance and composition, length, growth, mortality

Why: (1). finfish are high in the trophic web and serve to integrate the effects of perturbations on other levels of the ecosystem; (2). many finfish species are important in commercial and/or recreational fisheries or as forage for resource species

Who: Currently being done by CTDEP; no significant alteration to their program is required

Benthic Macrofauna Survey

Where: 10-15 stations in main stem of LIS, concentrated in western & central sections

When: Annually in summer

How: Surficial (10-15 cm) sediment grab, multiple replicates/station

Data: Species abundance/composition, number/abundance of sensitive taxa

Why: (1). Benthic macrofauna are useful indicators of environmental stress; (2). Benthic macrofauna are important trophically in LIS, forming an important component of diet of finfish resource species

Who: Currently being done by U.S. EPA EMAP-E program; no significant alteration to their program is needed. *If the EMAP-E program is not conducted on an annual basis, the LIS Monitoring Program will have to add this.*

Plankton Community Survey

Where: Axial water quality stations in main stem LIS

When: Biweekly in spring bloom (February & March); monthly at other times

How: Surface plankton tows; water sampler

Data: Relative abundance of dominant (top 5-10) species of phytoplankton & zooplankton; bacterioplankton; size-fractionated chlorophyll.a (<10 micron,>10 micron)

Why: (1). Plankton are foundation of LIS pelagic food web; (2). role of phytoplankton in hypoxia; (3). some phytoplankters are sensitive to common chemical toxicants; e.g. metals

Who: Partly covered by NYCDEP water quality survey (extreme WLIS) and CTDEP LIS ambient monitoring survey in remainder of Sound (chlorophyll.a only); *requires expansion of latter survey to include plankton sampling & increased sampling frequency in bloom period.*

Survey of Lobster Abundance/Distribution/Condition

Where: Western/central LIS

When: Monthly for 12 months, every third year

How: Larvae-neuston nets; juveniles-small mesh pots; adults-commercial pot. Sampling data: abundance of larvae, juveniles, adults; size composition, sex ratio, moult state of commercial catch; incidence of carapace damage and any associated diseases; catch percent effort.

Why: (1). Lobsters (all life stages) are present in hypoxic regions of LIS; (2). larval lobsters are very sensitive to hypoxia

compared to other crustacea and finfish endemic to LIS;
(3). documented outbreaks of disease (gaffkemia) two to four times each year in LIS lobster population.

Who: NYS DEC ongoing commercial pot sampling program; CTDEP larval/juvenile lobster assessment program; *suggest coalescing programs into a single design; some enhancement of these two programs is necessary.*

LMR Habitat Survey and Inventory

Where: Throughout LISS study area, including tributaries

When: In year one of LISMP; then once every three years

How: Aerial photography, photogrammetry, field surveys; all data entered onto LIS GIS

Data: Areal extent of major LMR habitats in LIS & tributaries; various quantitative measures of health or quality of habitats (e.g. density of SAV)

Why: LIS LMRs require access to adequate amounts of high quality habitat; the amount/quality of some habitat types is threatened by human activities

Who: The LISS should to create an updated LIS GIS database, including habitat elements. This, in concert with federal &

state habitat inventorying programs (e.g. USFWS National Wetlands Inventory and state tidal/freshwater wetlands programs and existing efforts directed at rare or endangered species) should form the core of this element. *Additional resources are required to refine the initial database and for subsequent periodic updates to it.*

Nearshore Fishery Survey

Where: Embayments

When: Fall

How: Seine Nets

Data: Identify larval and juvenile fish species sex, length, and abundance.

Why: To assess recruitment success.

Who: This program can build on work that has been conducted by the CTDEP. NYSDEC would need to develop a complementary program.

Desirable Additions

The following components -- program enhancements -- would complement the minimalist LMR monitoring program and improve our

understanding of the dynamics of LMR communities in Long Island Sound. They are presented as recommended additions to the minimalist program, to be undertaken if resources are available beyond those necessary to support the base program. While it would be desirable to include all components in the minimalist program, this is impractical in light of the limited, new funds that will be available to conduct LMR monitoring in the Sound.

The minimalist program enhancements are presented in ranked order. The first two elements (molluscan shellfish and avian resource assessments) are viewed as necessary to complete the coverage of major LMR community components begun in the minimalist program. The survey of pathologic abnormalities in winter flounder would provide insight into the possible effects of toxic organic compounds on the LMRs of Long Island Sound. Several forage fish important as prey for piscivorous fish and birds will not be effectively sampled in the open water finfish survey base program element.

Understanding the reasons behind trends in the abundance of resource species in the Sound would be significantly aided by knowledge of abundance trends and population parameters of selected forage species. The periodic, intensive summer finfish survey in the hypoxia-critical area of western LIS would provide a direct and focused assessment of the response of the fish community to dissolved oxygen improvements attributable to nutrient load reductions. Assessing the abundance of larval and juvenile fish in the waters of the Sound can indicate the relative spawning success of important resource species and, in parallel with

expanded research on the early life history dynamics, help resource managers forecast recruitment success in these species.

- *Molluscan Shellfish Resource Survey*

Where: Public shellfishing areas of the Sound [not privately-owned or leased areas (mariculture)]

When: Recruitment in these species is during spring and summer; surveys should be conducted in fall

How: Mechanical dredge (clam-shell for hard clam and oysters; scallop/surf clam dredges for those species)

Data: Abundance, age structure, density

Why: (1). LIS supports economically important public molluscan shellfisheries; (2). molluscan shellfish concentrate and can be affected by some contaminants (e.g. metals and organic compounds)

Who: No current shellfish resource assessment work exists on public grounds in LIS; new fiscal resources will be required

- *Avian Community Census and Assessment*

Where: Throughout LIS watershed, in habitats used by water-dependent birds; these will include fresh and salt marshes, rocky islets and beaches.

When: Year-round; specific times and frequencies will depend on the individual species or species group of concern (e.g. roseate terns, colonial nesting birds, waterfowl, etc.)

How: A variety of techniques, such as aerial counts, feeder surveys, banding, breeding ground nest counts.

Data: General population indices (abundances, hatching success ratios) and, for a few select, sentinel species, more detailed information on contaminant body burdens & physiological condition

Why: (1). Birds sit high in the LIS food web and the overall health of bird communities can be an integrative measure of ecosystem health and functioning; (2). birds and bird populations are a valuable resource to people living in the LIS watershed, providing both consumptive and non-consumptive use and value

Who: Immediate need for a fuller and more complete integration of ongoing public and private efforts to document and assess the health of avian populations in the LIS region. Among the existing programs are the National Audubon Society Christmas Bird Count, various U.S. Fish and Wildlife Service programs, and the Nature Conservancy.

- *Survey of Pathological Abnormalities in Winter Flounder*

Where: Open Water Finfish Survey and EMAP-E stations in western & central basins of LIS

When: Summer (EMAP-E); spring & fall (finfish survey)

How: Bottom trawl: gross external inspection; sub-sample for histopathological examination

Data: Incidence of gross external abnormalities (e.g. skin lesions) and splenic macrophage aggregates (MAs) in winter flounder

Why: (1). Winter flounder is an abundant, sediment-associated finfish in LIS; (2). incidence of external lesions and splenic MAs in marine finfish appear to be useful indicators of stress posed by organic chemical contaminants

Who: EMAP-E conducts visible pathology assessment of finfish at base sampling sites; additional resources required to establish this program as part of the annual spring/fall open water finfish survey

- *Assessment of LIS Forage Species*

Where: Location of sampling effort will depend on the particular species of concern (e.g. Fundulus and Menidia are in the

nearshore areas; bay anchovy is in the open, surface waters of LIS); these key forage species are not effectively sampled in the open water finfish survey in the base program

When: Depends on species

How: Depends on species (mid-water trawl for anchovy; seines for Fundulus and Menidia)

Data: Same as for open water survey in base program

Why: (1). The health of resource species depends, in part, on the health of the forage base that supports them; (2). these species serve as an intermediary between lower production levels of the Sound (plankton) and production at higher trophic levels

Who: No ongoing programs assess the forage base in LIS; NMFS data from Mid-Atlantic coastal waters may be sufficient for some species, such as sand lance, but information about other forage species in LIS must come from surveys within the Sound itself. For this, new program resources are required.

•*Intensive Finfish Survey*

Where: 20 stations in western & central main stem LIS

When: Biweekly from June-August; once every 3 years

How: Bottom trawl

Data: Same as spring/fall open water trawl survey

Why: Assess effect of changes in spatial & temporal distribution or severity of hypoxia on finfish community of LIS

Who: CTDEP has terminated its summer trawl survey; this would repeat it every three years

• *Ichthyoplankton Survey*

Where: Main stem hydrographic stations as an add-on to plankton survey in base program; additional lateral stations would be highly desirable; samples at surface and mid-water

When: Same as plankton survey

How: Multiple closing small-mesh net

Data: Abundance/distribution

Why: (1). The relative abundance of larval and juvenile fish can be indicative of pending year class strength in some resource species.

Who: No current program in place and new resources would be required; presumably same organization conducting plankton & hydrographic surveys

(QA/QC)

Ensuring that all LISMP program components, including that pertaining to LMRs, have standardized, scientifically sound protocols for quality control and quality assurance is a high priority. This is particularly true given that the recommended LISMP involves relying heavily upon the efforts of a number of public and private organizations. The proposed LISMP's is a composite of existing activities and a minimalist set of newly-created monitoring activities. A discrete QA/QC plan must be developed for each base program element and base program enhancement element in the LMR component. For some of these, e.g. the open water finfish survey (CTDEP) and the benthic macrofauna survey (EMAP-E), these QA/QC plans are already in place. For other elements, they will need to be established by the agencies and organization involved.

Informational Products

The LMR component of the LIS Monitoring Program will accumulate a large amount of data on the living marine resources of the Sound. These data are of interest to a wide variety of organizations and individuals for use in a myriad of ways. The agencies involved in collecting the data should be prepared to produce the following informational products, which will satisfy the requirements of all prospective users of LIS LMR

monitoring data. The products are listed in ascending order of data aggregation, synthesis, and interpretation.

Data Tables/Disks

Data that have been subject to the standard quality assurance and quality control procedures developed for the LMR Monitoring Program should be made available on disk and in tabular/hard copy form. Some analysis of the data may be appropriate for particular users, but the primary emphasis at this level is providing high quality, reliable data and known accuracy which carry with them complete documentation of methods used in sample collection and analysis. The principal expected user group for this type of product are scientists.

Aggregated and Summarized Data

These products would depict and describe trends in aggregated LMR data. The interrelationships among data would be highlighted and the significance of the trends and interrelationships in the data would be assessed in terms of their significance in management. Produced in the form of technical memoranda and reports, this level of output would be directed mainly at senior level environmental managers and policy makers.

General Public Outreach

General public outreach efforts would focus on printed materials, but also might include use of mass media (print and electronic) as well as verbal presentations. The emphasis would be on LMR information placed in the full management context of the Long Island Sound Study, including

relationships with non-LMR data. These efforts would highlight the major results of the LISS, with particular attention to the condition of LMRs and the determinants of those conditions, both natural and anthropogenic. These efforts would also describe the opportunities for citizen involvement in LMR management in Long Island Sound, e.g. becoming part of an LMR or other citizen monitoring program. The purpose of informational products at this level is both educational and promotional of the overall LIS management effort.

Recommended Companion Research

Research dealing with the dynamics of LMR communities constituted only a small portion of the overall research activities supported through the Long Island Sound Study. There are still many deficiencies in our understanding of these communities and the biotic and abiotic factors that influence them. The following research needs were identified as having direct relevance to one or more of the base program and enhancement elements in the LMR monitoring component. They represent a virtual tip of the iceberg. The monitoring program will describe what the LMR communities of Long Island Sound look like, at present, and over time. A fuller understanding of the dynamics of these communities is necessary if we are to determine the reasons why they look as they do and the possible role of environmental and fishery management strategies and practices in affecting the picture.

Development of Biomarkers

The external lesions and splenic microphage aggregates used in the program enhancement on assessment of winter flounder condition represent only one option in the use of biomarkers to signal the physiological condition of LMRs in the Sound. High priority is attached to research on the identification, assessment, and verification of additional biomarkers for fish, shellfish, and other LMR groups. Such markers should be clearly linked to organismic health.

Determination of Critical Habitat Requirements: Selected Species or Species Assemblages

Natural resource managers have long recognized the need of wild populations for adequate, high quality habitat for such functions as breeding, nursery, and feeding. The habitat requirements and preferences of many species change with life history stage. For some species, our knowledge of these changing habitat requirement is very limited. Research is needed to determine in more useful terms the habitat requirements of key resource or forage species.

Development of Habitat Evaluation and Assessment Techniques

Once concerned primarily with maintaining or restoring the quantity of "critical" habitat, LMR managers are now equally concerned about the quality of habitat. Does it perform its LMR support function well? What physical, chemical, and other aspects of the habitat contribute to this "performance?" Research is needed and would aid in answering these questions for the common LMR habitats of Long Island Sound and its watershed. More specifically, low-cost assessment techniques are

required that are capable of evaluating not only the size of a habitat, but can also assess its functionality as a habitat.

Determination of Nutrient-Trophic Linkages in LIS

The overenrichment-phytoplankton-stratification-hypoxia chain of events and causalities has been the principal focus of the LISS. We are now wrestling with the question of what this sequence of events may mean in the larger ecosystem dynamics of Long Island Sound. Understanding its ecosystem relevance would be aided by research on fundamental changes in that ecosystem, e.g. lower trophic level disruptions caused by persistent over enrichment. What does the establishment of a “microbial loop” augur for the flow of energy through the system? How are perturbations at lower levels transmitted through to higher trophic levels, the levels at which the health of LIS is gauged by the general public?

