Long Island Sound Symposium: A Study of Benthic Habitats

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A Report By

The Connecticut Academy of Science and Engineering

For

The Connecticut Energy Advisory Board

Connecticut Academy of Science and Engineering

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Connecticut Academy of Science and Engineering
179 Allyn Street, Suite 512, Hartford, CT 06103
Phone or Fax: 860-527-2161
e-mail: acad@ctcase.org
web: www.ctcase.org

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This study was initiated at the request of the Connecticut Energy Advisory Board on April 1, 2004. The project was conducted by an Academy Study Committee with the support of Tom Filburn, Ph.D., Project Study Manager. The content of this report lies within the province of the Academy's Energy, Production, Use and Management Technical Board and Environment Technical Board. The report has been reviewed by Academy Members Peter G. Cable and Alan C. Eckbreth. The report is hereby released with the approval of the Academy Council.

Richard H. Strauss
Executive Director

MEMBERS OF THE STUDY COMMITTEE ON LONG ISLAND SOUND SYMPOSIUM: A STUDY OF BENTHIC HABITATS

Gale Hoffnagle, CCM, QEP (Academy Member)
Chairman, Academy Study Committee
Senior Vice President and Technical Director
TRC Companies, Inc.

Roger D. Flood, PhD
Associate Professor, Marine Sciences Research Center
State University of New York at Stony Brook

John W. Ladd, PhD
Benthic Mapping Coordinator
Hudson River National Estuarine Research Reserve, Hudson River Estuarine Program
New York State Department of Environmental Conservation

Ralph S. Lewis
Associate Professor in Residence of Marine Sciences, University of Connecticut
Connecticut Department of Environmental Protection (ret.)

Matthew S. Mashikian, PhD (Academy Member)
Professor of Electrical Engineering, University of Connecticut (ret.)
President & CEO, IMCORP

Edward C. Monahan, PhD (Academy Member)
Director, Connecticut Sea Grant College Program &
Professor of Marine Sciences & Resource Economics
University of Connecticut

Linda C. Schaffner, PhD
Associate Professor of Marine Science, Virginia Institute of Marine Science
College of William and Mary
Also, 2003-2005 President, Estuarine Research Federation

STUDY MANAGER

Tom Filburn
Assistant Professor of Mechanical Engineering
University of Hartford

EXECUTIVE SUMMARY

STUDY OBJECTIVES

The Connecticut Academy of Science and Engineering (CASE) convened the "Long Island Sound Symposium: A Study of Benthic Habitats" on July 28-29, 2004 on behalf of the Connecticut Energy Advisory Board (CEAB). An agenda (see Appendix E: Agenda) was developed as a framework for discussions at the symposium. The symposium assembled national and local experts to provide guidance for understanding, analyzing and evaluating data about Long Island Sound (LIS), and to enhance the capability of the CEAB and state agencies in planning, managing and evaluating proposed energy-related uses of LIS and its benthic habitats.

The symposium provided information that was utilized by a CASE Study Committee to develop its findings and suggestions for the consideration of the CEAB.

SUMMARY OF FINDINGS

The CEAB intends to create an efficient mechanism by which the state and its subdivisions periodically proactively identify future energy-related needs and/or problems. They plan to evaluate proposals based on established criteria; preferential standards in the areas of energy reliability, environmental and natural resource protection; cost effectiveness and other impacts; and how well such proposals solve the problem or address the state's needs. A final, approved proposal is expected to embody the highest level of benefit with the lowest potential impact.

The LIS Symposium provided information in selected areas of interest and was divided into two sections with several sessions comprising each section, as follows:

- Long Island Sound Data and Information: Benthic Habitat Classification and Mapping; Endangered and Threatened Species; and Mollusks;
- Impact Analyses: EMF; Temperature Impacts; Safety Issues and Impacts; and Installation and Maintenance Impacts.

The findings and suggestions included in this report can be used as a tool in the development of the preferential standards, and for next steps in an effort to learn more about the environment of LIS for a variety of purposes, including the consideration of energy-related projects. Most importantly, the symposium identified a need to focus attention on the general issue of the overall management of LIS for the purpose of gaining a better understanding of a variety of LIS issues and needs in an effort to balance the need for installation of energy-related projects with protection of the Sound's sensitive environmental areas and ecosystems. Organizational structures such as the Chesapeake Bay Program, the Gulf of Maine Council on the Marine Environment and the Gulf of Maine Mapping Initiative, and the LIS Study (LISS) can serve as useful models for creating a mechanism to address Sound-wide environmental matters.

Consideration should be given to creating an organizational structure such as a Long Island Sound Center for the Marine Environment (LISCME) as a joint initiative of state (Connecticut and New York) and federal agencies, academic institutions, and scientists to coordinate and oversee a collaborative effort for the purpose of developing a better understanding of, and improving decision making with regard to, the environment and ecology of LIS. This type of regional collaborative effort could help ensure that LIS is viewed as a regional resource and that future research and studies will meet the needs of all agencies and regulators. This center would require funding and staff support at levels to assure it is sustainable and effective in meeting its goals and objectives. A strategy for securing adequate funding for operations and projects would need to be developed.

It is recognized that it may not be feasible or possible to create such a center, in which case it is suggested that the state consider implementing the suggestions and developing the concepts envisioned for the center within the various Connecticut state agencies and organizations that could assume such responsibilities.

Understanding the characteristics of the seabed is an essential tool for managing the marine environment for a variety of purposes including: installation and maintenance of energy infrastructure such as cables, pipelines, and renewable energy structures; development and management of marine sanctuaries; commercial and recreational fishing, including shellfishing; aquaculture; and shipping. The purpose for which information about the marine environment will be used is a critical factor in determining the level of detail necessary for mapping all or portions of LIS.

Physical environment (non-living resource) mapping provides a foundation of information that can then be used to create habitat (living resource) maps of a variety of benthic organisms and species of interest. The ability to translate physical environment maps into habitat maps requires a better understanding of the relationships among species of interest and their physical, chemical, and biological environments. More detailed physical mapping of LIS may be necessary to develop habitat maps in areas of interest and on a Sound-wide basis. It is suggested that progress in understanding infrastructure impacts on LIS's benthic communities, and the broader but essential task of better understanding the overall structure and importance of benthic communities in LIS, should be included in this effort.

Regardless of the organizational structure of such an entity, the following concepts should be considered:

- ➢ Develop the purpose and scope of an environmental evaluation program for LIS. This plan should take into consideration:
    - The need for a focused evaluation program for those regions of LIS most likely to be considered for energy infrastructure crossings. Possible mapping projects would include:
        - Mapping regions surrounding existing cables and pipelines, as well as integrating any data and information available from existing underwater infrastructure projects.
        - Selection of additional targeted areas that can be projected for use as future infrastructure crossings based upon the location of land-based support

infrastructure and known sedimentary environments of LIS.

- LIS-wide environmental management initiatives to identify resources for the purpose of creating marine sanctuaries or reserves, and for other purposes that may require additional detailed data, as well as mapping all or portions of LIS.

➢ Formulate goals and objectives for a LIS environmental evaluation program, such as:

- Conducting an assessment of what is known, including the collection and analysis of existing data and maps, for adequacy to support program goals and objectives.
    - Certain areas may need to be mapped by securing additional data in finer detail based upon the characteristics of the sedimentary environment. For example, heterogeneous areas may need to be mapped in greater detail, while existing data and maps may be adequate in homogeneous areas. Determination and analysis of discriminators such as these will provide a foundation for decision making and a more focused mapping effort.
- Developing technical projects to secure data and information, including additional mapping initiatives, where necessary, in support of the overall goals and objectives of the evaluation program.
- Reviewing and assessing whether a standard habitat classification system for LIS should be adopted, and if so, facilitating a process for this purpose.
- Identifying a risk assessment protocol for future infrastructure encroachments into LIS.

➢ Create a centralized data repository that is recognized and financially supported to inventory, archive, and disseminate all LIS technical information. This repository would develop a system to assure that various data and information and resultant products will be compatible with each other, with the needs of the environmental evaluation program, and in compliance with federal standards. This system should include requirements, standards and protocols for data collection, navigation, and architecture for a GIS-based data and information system including appropriate metadata. This would enable data and information collected from publicly-funded research projects, and, as may be required, from owners of infrastructure projects installed in LIS, to be preserved and available for developing a comprehensive understanding of LIS. Additionally it is suggested that the repository:

- Be non-regulatory.
- Require agencies, contractors and academics who work in LIS to report results and raw data, where appropriate. Protocols can be established to keep certain kinds or aspects of data confidential for some appropriate time period, so that contributing data to the repository does not compromise academic or business enterprises.
- Consider development of a policy to provide free access to data and information to all researchers, agencies, companies, and possibly the public in an effort to promote the best studies, analyses, and infrastructure proposals.

➢ The mapping initiative for LIS would include:

- Creating non-living resource maps that identify the geology of the bottom and sub-bottom of LIS. These maps provide a foundation of information that can be used to create living resource maps. The characteristics of the bottom provide clues as to the type of living resources that may populate certain areas of the seabed. These types of maps include:
    - Sedimentary environment and textures maps created from sidescan or multibeam sonar or other technologies. Ground-truthing is used to verify the data that are collected electronically by using grab sampling, video and photo surveys and other methods. Figures 1A, 1B, and 1C represent examples of these types of maps.
    - Bathymetric maps to identify elevations of the seafloor and in conjunction with sedimentary environment mapping, provide a three-dimensional picture of the bottom.
- Creating living resource maps to identify benthic habitats, mobile fauna habitats and endangered and threatened species. These maps would be created by using non-living resource maps and information to identify and prioritize areas for study, with sampling being done to identify specific habitats. A process to determine targeted species of concern for further study should be created. Additional research and study is necessary for scientists to develop methods to be able to produce habitat maps.
- Prioritizing the importance of nearshore, coastal and deep water mapping regions, and identifying the best and most cost effective methods and technologies for various types of mapping projects.

It should be expected that a complete mapping of the physical environment and living resources of LIS would involve significant cost and time. However, a suggested starting point for an initial pilot mapping project could be based on the state's interest in comparing the environmental impacts of various alternative routes for the purpose of siting future energy infrastructure crossings of LIS. The project would include selecting regions of the Sound to be mapped based on the location of relevant existing land based energy infrastructure. The process to determine the specific mapping activities would include a review of existing physical environment maps with sampling to determine if additional mapping is necessary. These maps would then be used to identify various habitats and to create habitat maps. Initial physical environment mapping of the nearshore areas within the targeted mapping region should be expected since very little physical environment information is currently available for nearshore areas of LIS.

Long Island Sound Data and Information

Any attempt to minimize the impacts of infrastructure development on the Sound's ecosystem requires a better understanding of key aquatic resources, habitats, species and ecological service functions. The CEAB's "Draft Preferential Criteria" provides a preliminary list of sensitive coastal resources and habitats and recognizes that other sensitive habitats may exist. Also, these criteria identify a need to avoid, minimize or mitigate effects of infrastructure development on these resources and habitats.

The LIS Symposium provided useful insights regarding some of the key habitats, species and processes, and identified a need for a process to facilitate the development of an overview of LIS as an ecosystem. However, although the need for additional data about LIS is important, it is suggested that the initial focus should be placed on developing a process that ensures adaptive management of LIS and the development of science-informed policy based on the best available science, while recognizing that the future will bring more and, hopefully better, scientific information.

Options for establishing the LISCME to address Sound-wide environmental matters include expanding the mission of the Long Island Sound Study (LISS), creating a new bi-state organizational entity specifically designed for this purpose, or creating an initiative comprised of various Connecticut state agencies and organizations to assume such responsibilities. The LISS is a cooperative effort that was created to protect and improve the health of the LIS by implementing the Sound's Comprehensive Conservation and Management Plan (1994). The LISS website states: *"the Plan identifies the 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. Using the Plan as a blueprint, the Long Island Sound Study has continued to refine and add detail to commitments and priorities, including the 1996 Long Island Sound Agreement and the 2003 Long Island Sound Agreement."* Although other factors may be considered in the decision to develop the LISCME, an advantage to utilizing the LISS is that they have already begun to develop a framework for bringing scientists and managers together.

Other programs previously mentioned, including the Chesapeake Bay Program and the Gulf of Maine Council/Gulf of Maine Mapping Initiative can provide insight and guidance for the development of a Connecticut LIS initiative or the LISCME.

There are data relevant to LIS, including bathymetric maps, molluscan fisheries areas and habitat classification information that have been gathered over the last 50 years. However, these data do not provide a level of detail sufficient to allow informed decision making for future encroachments into LIS. It is suggested that this information be archived in any future LIS centralized data repository.

Benthic Habitat Classification and Mapping

Non-living resource mapping initiatives have been completed for the Hudson River and are on-going for the Gulf of Maine. Benthic habitat mapping is being considered for both of these areas. A very rough estimate of the cost of a detailed, Sound-wide, non-living resource mapping initiative could exceed $10 million, and could be significantly higher based upon the scope of the mapping initiative. This estimate is based only on information available from non-living resource mapping initiatives in the Gulf of Maine and Hudson River. Relatively detailed non-living resource maps exist for LIS, but more detail is needed in correlating bottom types with habitat classifications. In addition, the shallow regions of LIS (< 5 m) have not received sufficient attention due to the difficulty and cost of using standard acoustic techniques to secure bathymetric data and bottom type information. New spectral imaging systems should be pursued for accurate and reduced-cost mapping efforts in the shallow nearshore regions of LIS, although the timeline for using such systems is not yet known. Acoustical mapping techniques, such as multibeam technology, can map most areas of the bottom without the projected development time associated with optical techniques. More accessible survey vessels may also provide greater access to certain shallow water areas.

Overall, there is currently insufficient information to determine the relative merits of comparing different cable or pipeline routes for planning and siting decision purposes. Also, there is a need to develop methods for generating habitat maps from acoustic and/or optical images and bottom samples. Separate habitat maps must be generated for each species of interest, which requires an understanding of how a particular species uses the physical, chemical, and biological environment. Consideration should be given to supporting targeted habitat mapping pilot projects to test methods and apply lessons learned in order to develop habitat mapping protocols that could be used on a wider scale.

Endangered and Threatened Species

While both the state of Connecticut and the federal government have adopted an endangered and threatened species program, very little information is available on species that rely on LIS. Some information is available on large species, especially mammals, but no information has been systematically gathered on benthic species in LIS. Consideration should be given to developing a program within the LISCME to identify and list the benthic species, including species that are endangered and threatened species as well as of special concern. However, it should be noted that although there have been efforts in other estuaries to identify and list benthic species, there do not appear to be any known efforts to identify or list benthic species that may be endangered, threatened, or of special concern.

Mollusks

The review of mollusks in this study focuses on oysters and clams, due to their inability to move in response to anthropogenic disturbances on the seafloor. Information regarding the location of leased oyster and clam shellfish beds that are utilized for growing, cultivating and harvesting activities is known and available. However, it is suggested that more detailed maps identifying the level of productivity of these regions should be produced to provide more accurate information; such information could then be used to assess the impacts of energy infrastructure installation and maintenance activities on this habitat. It seems possible that a cooperative effort of academics, personnel from the Connecticut Department of Agriculture, and individuals employed in shellfish harvesting could produce the information necessary to create accurate maps that could be used for planning purposes.

Long-term impacts of encroachment activities can be severe, altering both the bottom topography and sediment density to such a degree that it would impact the productivity of the impacted shellfish beds for future mollusk growth and harvesting. This long-term impact can last for years, even after mitigation. Reportedly, following the installation of cables and pipelines, impacted shellfish beds in LIS have not been restored to pre-construction levels of productivity. As a minimum, mitigation efforts should include: detailed mapping of the pre-installation conditions using high-resolution techniques; harvesting of all shellfish prior to project initiation; restoration of the bottom after the disturbance, matching sediment, morphology and especially planting shell where appropriate, and assessing financial penalties if restoration is not possible; and replacing lost shellfish with seed or market size, as appropriate. Although the technology and methods for shellfish bed restoration are known — including matching sediment layers and the pre-construction elevation profile — a variety of factors affect the ability to successfully accomplish this task. Successful restoration of a disturbed swath through a shellfish bed as a result of construction activity may be more difficult to achieve than creating a new shellfish bed. Pilot projects can test methods to construct new shellfish beds in LIS. If successful, creating new shellfish beds should be considered as an alternative for mitigating an encroachment into an existing shellfish bed.

Impact Analyses

EMF

No electric field is produced outside the shielded conductors of submerged cable installations. Additionally, the magnetic field produced in the operation of a cable is weak and at a level similar to that produced by the earth's magnetic field. Therefore, it is not expected that EMF generated by the operation of a submerged cable will have any impact on flora and fauna communities. If desired, existing measurement methods can be used to detect EMF from existing cables to confirm the values predicted in project planning.

Temperature

The low rate of steady-state energy dissipation from installed electric cables cannot have a significant impact on LIS given its large mass of water and rapid circulation. Therefore, the concern regarding temperature is more with the location of this energy transfer into the sediment layer and bottom boundary. In general, cables are designed so that during their operation, sediments located near a cable do not dry out. Under these conditions, little temperature rise is expected at the sediment-water interface. The thermal conductivity of the sediment layer, coupled with the known energy losses from the electric cables, will allow for accurate predictions of temperatures throughout the sediment layer — predictions that can be confirmed by careful measurements. Biologists will be able to evaluate these temperatures and predict if there will be any negative impacts on flora or fauna from these temperature changes. It is expected that, although there will be some change in temperature in the sediment immediately surrounding a cable, the depth of the cable's burial and insulating factors of the cable will minimize the impacts, if any, on the benthic habitats located in its immediate vicinity.

Since pipelines operate at near-ambient temperatures, it is not expected that their operation will cause any negative impacts due to temperature.

Safety Issues and Impacts

An anchor striking a submerged object was the main safety issue addressed during the symposium. Some of the older electric cables are fluid-filled, contributing to the potential environmental impacts of a broken cable. However, more recent cables don't have a fluid component, which eliminates one of the potential environmental consequences of a severed cable. Safety systems installed on existing electric cables in LIS are equipped with high speed circuit breakers that very quickly de-energize a cable in case of an anchor strike of other equipment snag. These systems eliminate any hazard to the public from the release of energy caused by a break in a cable.

Several panelists were involved in projects that used engineered materials to provide protection for cables and pipelines. Most recently, this method was used to protect a section of the Hubline, a submerged natural gas pipeline located in Boston Harbor. These same materials can also be

applied to submerged electric or telecommunication cables. The effects on benthic habitat of materials used to armor cables and pipelines need to be better understood. It is suggested that the planning phase of a project should include a risk assessment to determine the degree to which areas along a project's proposed route are susceptible to anchors strikes and thus worthy of protection. Additionally, it is suggested that a risk assessment for a pipeline project include an analysis of any impacts or hazards caused by a sudden release of compressed natural gas between the pipeline's isolation valves.

Installation and Maintenance Impacts

Initial installation and subsequent maintenance activities can be expected to produce repeated sea bottom disturbances from virtually any encroachment into LIS. Given that any infrastructure project will require occasional maintenance, and possibly removal at the end of its design life, it is suggested that cumulative impacts of infrastructure projects should be considered. It is generally understood that initial impacts can be expected to last for months, with long-term effects possibly lasting for years. For example, there may be a rapid return of biomass, though not necessarily recovery, to a disturbed area, but it may take longer for a more typical bottom benthic community to be rebuilt. However, the precise nature of the impacts, as well as the sedimentary conditions, both in shallow and deep water, that are needed to minimize impacts on the various benthic habitats, need to be better understood. Additionally, habitat restoration efforts, such as valuable shellfish beds, need to be completed in a manner so as to restore such areas to pre-construction productivity, or provide compensation for the loss of productivity of these impacted areas.

It appears that the industry is continuing to seek methods to minimize the impacts of the installation and maintenance of cables and pipelines. Certain methods, such as horizontal drilling, can currently transit areas up to 7,200 feet with little or no impact to the surface over which the cable or pipeline is installed. Also, the timing of construction activity should be planned to minimize its effects on the benthic community and life within the water column.

Aesthetics

The question of the aesthetics of LIS was not included in the scope of this project, but was added to this report in order to identify it as an issue that may need to be considered in the future. It is suggested that the value of LIS cannot be measured simply in the value of fish produced or other economic criteria. Consideration should be given to identifying a value that can be applied to the aesthetic enjoyment of the Sound's open surface and long vistas with regard to the evaluation of projects that may be considered for placement on the surface of or above LIS.

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I. INTRODUCTION

BACKGROUND

Long Island Sound (LIS) occupies approximately 1,200 square statute miles of estuary between the Connecticut coast and Long Island. Numerous marine organisms, including many of the commercially valuable fish and shellfish species, depend on the LIS estuary at some point in their development. LIS is also economically important to the Connecticut-New York region for a variety of commercial and recreational purposes (Diaz, R.J., G.R. Cutter, Jr., K.W. Able, 2003).

A variety of electric, gas and telecommunication utility infrastructure has been placed in LIS. At present, two operational electric transmission cables (one AC, one DC), one natural gas pipeline, and two telecommunications lines have been installed on or beneath the seafloor between Connecticut and Long Island (New York). In addition, various cables, pipelines, and telecommunication lines operate within Connecticut and New York, and between Long Island and Europe.

Connecticut Energy Advisory Board

Pursuant to an "Act Concerning Long-Term Planning for Energy Facilities (Public Act No. 03-140)" the Connecticut Energy Advisory Board (CEAB) was reconstituted with a revised mission in 2003. It includes representatives from state agencies engaged in planning, energy, transportation and environmental programs. The CEAB will use existing data resources to determine the state's energy needs and make recommendations on how to meet those needs in a manner that is environmentally responsible, reliable, and cost effective. In response to energy demand, the CEAB will seek to encourage the continued development of competitive energy markets through the promotion of a diverse array of strategies such as renewable energy, energy efficiency, and the development of a modern, adequate and secure generation and transmission infrastructure.

The CEAB is charged with revising the evaluation process for energy-related siting decisions to inspire the development of proposals that best or most responsibly meet energy needs in Connecticut. The current siting process of addressing energy capacity needs and siting transmission facilities, for instance, is influenced significantly by the economic market. The regulatory agencies — primarily the Siting Council, but also state agencies that regulate these activities ranging from the Department of Public Utility Control to the Department of Environmental Protection — are constrained in their ability to consider and evaluate competing strategies once a proposal that meets the minimum statutory and regulatory standards enters the review process.

Pursuant to PA03-140 Sections 18 and 19, the CEAB intends to create an efficient mechanism by which the state and its subdivisions periodically proactively identify future energy-related needs and/or problems. This process will be followed by an open solicitation on behalf of the state for "solutions" to the identified problem or need that will provide an opportunity for the market to respond. The CEAB will evaluate the proposals based on established criteria; preferential standards, in the areas of energy reliability, environmental and natural resource protection; cost effectiveness and other impacts; and how well they solve the problem or address the state's needs. The final approved proposal would be expected to embody the highest level of benefit with the lowest potential impact, either by an individual response standing alone or by combining the most desirable aspects of multiple proposals. The regulatory structure would have to continue to accept "free market" proposals but, by adopting a system of identification and solicitation, would be freed from the solely reactive process now in place.

Purpose of Long Island Sound Symposium: A Study of Benthic Habitats

The Connecticut Academy of Science and Engineering (CASE) convened the "Long Island Sound Symposium: A Study of Benthic Habitats" on July 28-29, 2004, on behalf of the CEAB, to have national and local experts assist Connecticut in understanding the most accurate yet cost-effective means to analyze and evaluate available data about LIS. Guidance from 33 symposium panelists and rapporteurs (see Appendix F: Long Island Sound Symposium/Study Panelists; and Appendix G: Panelists and Rapporteurs – Biographical Sketches) was solicited to identify additional habitat/ecosystem information that would enhance the capability of state agencies in planning, managing and evaluating proposed energy-related uses of LIS and its benthic habitats. Additionally, CASE formed a Study Committee (see Appendix H: Study Committee Biographical Sketches) to oversee the project and provide guidance for determining suggestions for consideration of the CEAB. An agenda (see Appendix E: Agenda) was developed as a framework for discussions at the symposium and by the Study Committee in its effort to formulate suggestions for consideration. The LIS Symposium was divided into two sections with several sessions comprising each section, as follows:

- Long Island Sound Data and Information: Benthic Habitat Classification and Mapping, Endangered and Threatened Species, and Mollusks;
- Impact Analyses: EMF, Temperature Impacts, Safety Issues and Impacts, and Installation and Maintenance Impacts.

The goal of this study is to identify an appropriate level of data necessary for broad, long-term marine infrastructure planning purposes that can be used in the formulation of preferential standards. This effort may require something less than a comprehensive resource mapping of all LIS estuarine and seabottom lands, but should provide adequate information for long-term planning. In addition, decision making for individual projects requiring state and federal permits will be supplemented by site-specific data and analysis supplied by the applicants. As such, the types of data that should be required to be supplied by applicants seeking state and federal permits should also be identified.

The contents of this report are based on the proceedings of the symposium and information provided by its panelists, rapporteurs and other researchers. The findings of the study reflect the collective decisions of the CASE Study Committee and do not represent the views, positions or policies of the CEAB or its members.

II. LONG ISLAND SOUND DATA AND INFORMATION

A LIS-wide organization with a mission to develop a better understanding of, and to improve decision making with regard to, the environment and ecology of LIS does not exist. Additionally, a centralized data repository that is recognized and financially supported for collecting and archiving all LIS data and information, such as physical and chemical characteristics of the benthos, water quality, and biological activity for both the water column and the benthic community, has not been developed. This is due, in part, to the regional nature of LIS, which borders two states (Connecticut and New York) and in fact has two different US Environmental Protection Agency offices and two different US Army Corps of Engineers (USACE) districts responsible for monitoring its water quality and end-use (EPA Region 1: New England, EPA Region 2: New York, New Jersey; USACE - District 1 and USACE - District 2). The Connecticut Department of Environmental Protection (DEP) and the University of Connecticut, working together, created and support the Long Island Sound Resource Center (LISRC) with a charter to serve as Connecticut's repository for the collection and dissemination of information about LIS. The LISRC is also partially supported by the LIS Foundation.

The Chesapeake Bay and the Gulf of Maine have been identified for comparison purposes, although both are ecologically different from LIS. The Chesapeake Bay is the largest estuary in the United States; LIS has approximately one-sixth its wetted area. It is an estuary shared by three states, while LIS is directly shared by two: Connecticut and New York, and bordered by Rhode Island. The Gulf of Maine is shared by Massachusetts, Maine, and New Hampshire as well as Canada's Nova Scotia and New Brunswick Provinces. The Gulf of Maine Council was created in 1989 to maintain and enhance environmental quality of the Gulf of Maine and to allow for sustainable resources use by existing and future generations. The Gulf of Maine Mapping Initiative (GOMMI) is an international partnership of government and others to map the seafloor of the Gulf of Maine. Therefore, using the Chesapeake Bay Program (CBP) (http://www.chesapeakebay.net/) and the Gulf of Maine Council (http://www.gulfofmaine.org/knowledgebase/gomc_member_links.asp) and GOMMI as models for assessing the methods of collecting, housing and accessing information on LIS may provide useful lessons and guidance in considering the development of a multi-state organization, including a centralized repository for information, for addressing the environmental issues of LIS.

While there is no central LIS program equivalent to GOMC/GOMMI and CBP, a number of LIS studies have provided important background data on the nature and distribution of the benthic environment (Poppe and Pollini, 1998; Poppe et al., 2000; Zajac et al., 2000). Data mining could offer large paybacks for a small investment. An initial attempt at data mining by the Task Force on Long Island Sound (LIS Task Force) is described under the "Environmental Resource Maps" section of the "Comprehensive Assessment and Report – Part II: Environmental Resources and Energy Infrastructure of Long Island Sound" dated June 3, 2003 that was prepared pursuant to Public Act No. 02-95 and Executive Order No. 26. Data mining could be used to summarize the various reports that have been completed over the decades and to help begin to identify data gaps. Data mining should extend beyond a simple literature search by bringing together experts from various fields, such as remote sensing, marine geology, marine ecology, etc.

The development of a useful database for future investigation into LIS will require:

- Creation of a centralized data repository for all LIS information through a joint bi-state effort of Connecticut and New York, as well as federal agencies as conservators of LIS.
- Establishment of protocols for data collection, storage and dissemination, and a review system of some type to assess protocols for specific projects.
- Academic researchers have indicated that this office will be more actively used if it is not directly affiliated with any regulatory agency (e.g. DEP, EPA)

BENTHIC HABITAT CLASSIFICATION AND MAPPING

Mapping of the terrestrial features adjacent to LIS has been conducted since the 1600s. Sea floor mapping in LIS and its application to ecological assessment has been a much more recent endeavor. The need for seafloor mapping arises from an effort to balance the desire to maintain an ecologically vital LIS with the historic increase in energy use and its required infrastructure, as well as other uses of the sound. Understanding aquatic landscape features and habitats and the effects of man-made changes would greatly benefit society.

Sanders' work during the early 1950s represents the starting point for attempts to correlate bottom type with quantification of infaunal abundance and type. Despite the fact that this data set is nearly 50 years old, many researchers have used Sanders' report as a framework for interpreting the results of subsequent studies. More recent work occurred during the 1970s and 1980s, including several Sound-wide surveys and more detailed work in the central basin of LIS. There have been other surveys that examined Fisher's Island Sound (eastern end). These surveys employed standard techniques that included collecting seabed samples with a grab sampler and analyzing those samples for benthic fauna. Samples were then correlated to sediment type, and bathymetric map information. This detailed information can be used to understand the factors that control faunal distribution patterns and the importance of different faunal communities; however, in general, the kind of information that is needed to transform maps of the physical environment (non-living resource maps) into actual habitat maps (living resource maps) has not been collected. It is still necessary for researchers to identify what kinds of observations are necessary to create habitat maps.

Habitat mapping is much more complex than just grain size and erosion vs. deposition. However, some maps created in the 1990s are detailed enough for certain types of analyses and assessments. Also, recent experience suggests that the data that go into such maps need to be carefully evaluated: researchers working for the EPA Environmental Monitoring and Assessment Program found that sediment type in over 50% of selected monitoring sites along the East Coast of the United States was not correctly classified.

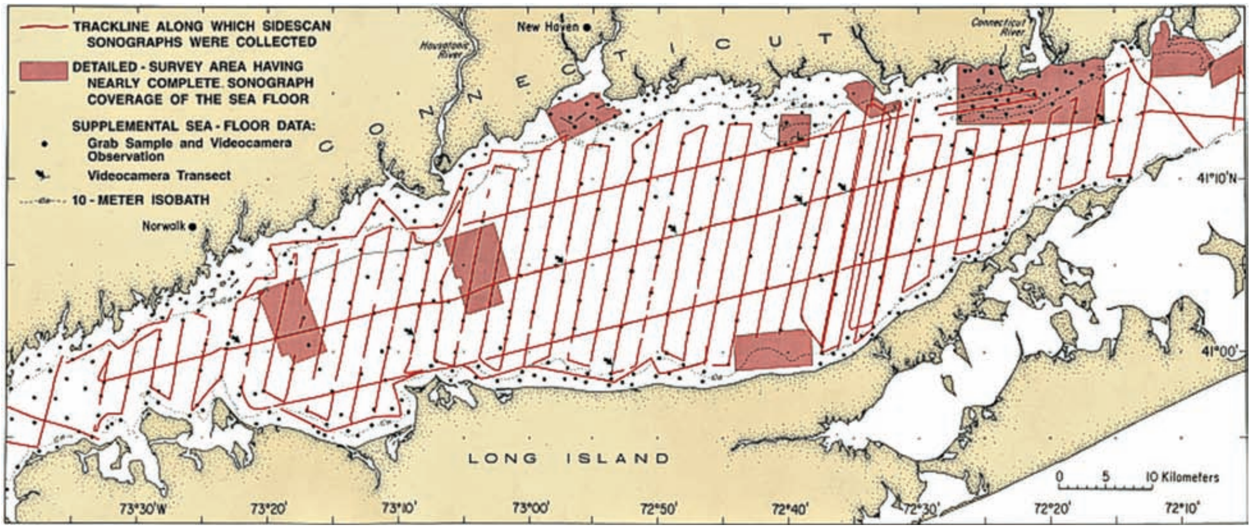


Figure 1A: Tracklines and Sonograph Coverage of the Seafloor; Seafloor Environments Within Long Island Sound: A Regional Overview; Journal of Coastal Research, Vol. 16, No. 3, Summer 2000, pages 533-550, Knebel & Poppe

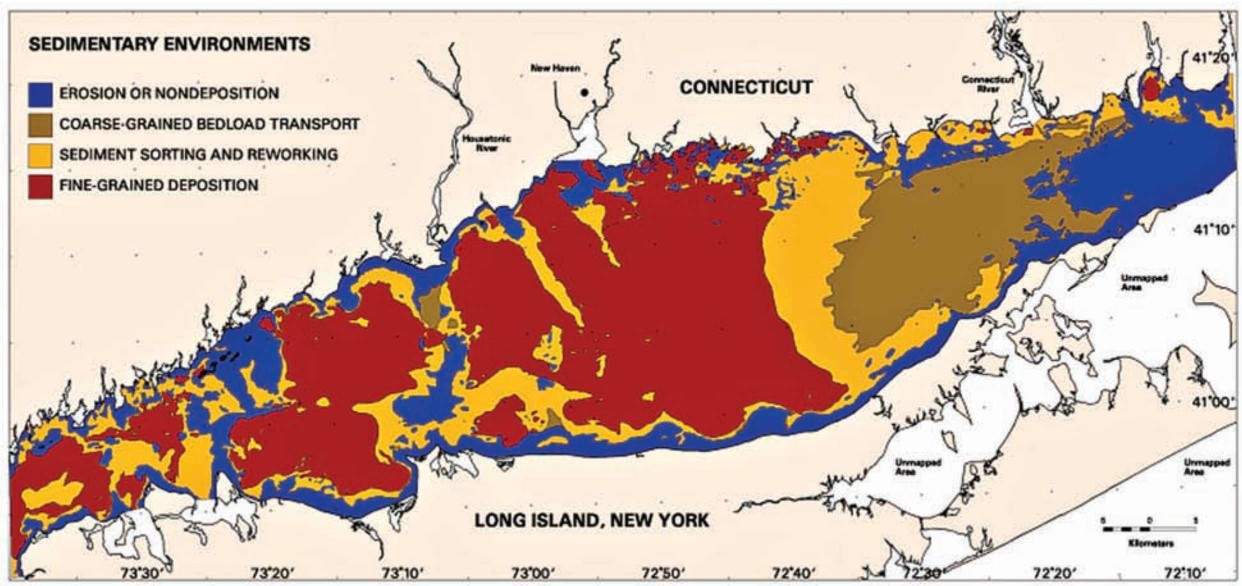


Figure 1B: Sedimentary Environments; Seafloor Environments Within Long Island Sound: A Regional Overview; Journal of Coastal Research, Vol. 16, No. 3, Summer 2000, pages 533-550, Knebel & Poppe

Sedimentary Environments and Surficial Sediment Distribution Patterns

The surface sediment distribution in LIS (see Figure 1B. Note that Figure 1A provides information for creating Figure 1B) can be patchy, but does display certain general trends. These trends are related to geology, bathymetry, and the effects of currents and tides. Tidal currents are relatively strong throughout LIS (over 100cm/sec in the eastern portion of LIS, decreasing to 20-30 cm/sec in the western portion of LIS; additional information is available on the USGS website at http://smig.usgs.gov/SMIG/features_0900/li_sound_inline.html#tide_driven). The eastern portion of LIS consists of coarser sediments. This is because of the stronger currents and faster tidal movement (incoming water rushes faster in the eastern portion of LIS, sweeping away the finer sediments). The tidal movements are slower in the western portion of LIS, where the total affected volume of water is smaller. A much larger volume of water is affected in the eastern portion of LIS because the majority of tidal interchange water enters from the more open area at the eastern end of the Sound. However, there are few long-term current meter measurements in LIS to document the vertical structure of currents or the importance of strong flows during storms.

LIS fluid circulation is controlled by an east-to-west weakening of tidal current speeds coupled with the westward-directed estuarine bottom drift. This produces an erosion environment at the narrow eastern entrance to LIS, which transitions to a coarse-grained bedload transport area in the east-central Sound, then passes into a contiguous band of sediment sorting, and ends with broad areas of fine-grain deposition on the central and western portions of the Sound (see Figure 1C. Note that Figure 1A provides information for creating Figure 1C). The distribution of these environments is a guide to the future utilization of the seafloor.

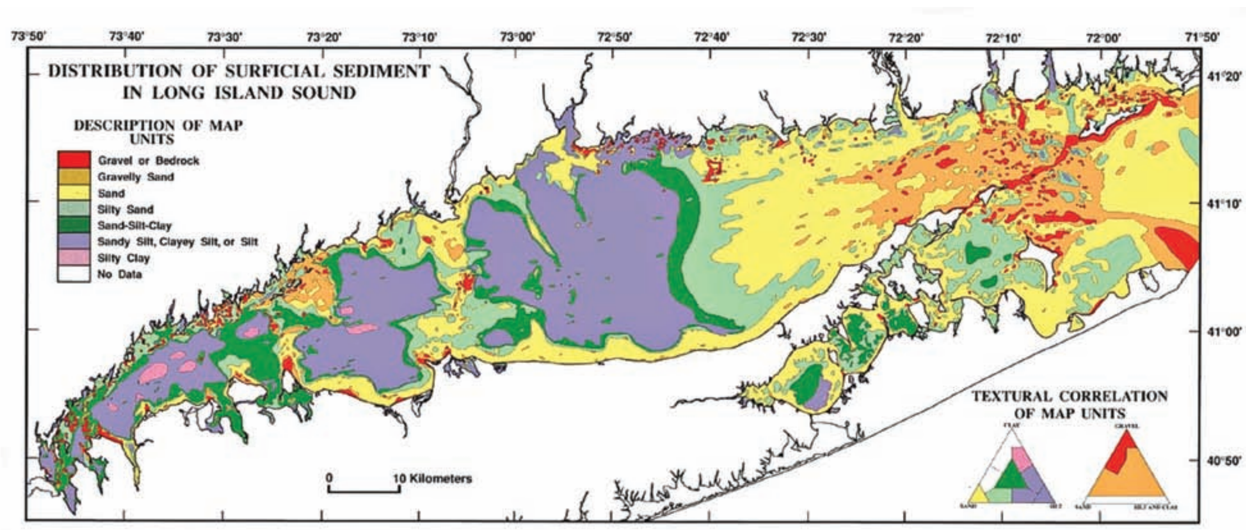


Figure 1C: Distribution of Surficial Sediment in Long Island Sound and Adjacent Waters: Texture and Total Organic Carbon, Journal of Coastal Research, Vol. 16, No. 3, Summer 2000, pages 567-574, Pope, Knebel, Mlodzinska, Hastings & Seekins.

The eastern-central and most nearshore margins of the Sound comprise mostly sand. Silty sand and sand/silt/clay mark the transition between high- and low-energy environments. Clayey silt and silty clay are the main constituents in low energy environments like the central and western basins. Finer, soft sediments accumulate in areas that are not eroded by storms (this is the basis for selection of dredging disposal sites). Coarse sediments are often shaped into sand waves which migrate across the sea floor. These migrating waves can possibly expose buried cables, making them more susceptible to damage. This information may be useful for determining potential depths for burying cables and pipelines, but it is not sufficient to determine the choice of a specific route that will minimize environmental impact. Coring data within LIS is plentiful and studies are still being conducted. High-resolution remote sensing can produce images of the seafloor that will provide the ability to interpolate sediment bed type between existing samples; this will provide a better understanding of sediment (and faunal) distribution patterns at a finer scale than is now possible. Such information will be important for understanding the potential environmental impacts of proposed routes of cables/pipelines.

Acoustic Mapping Techniques

The US Geological Survey (USGS), DEP, EPA, and the National Ocean Survey (NOS) have collected sidescan sonographs, subbottom profiles and high-resolution bathymetric data to characterize the seafloor within the LIS basin. Acoustic records have been ground-truthed using sediment samples and video observation, as well as modeled using current and wave data. These mapping surveys provide a regional picture of the seafloor and underlying geology; however, modern high-resolution images of the floor of LIS exist for only a few local areas (see Figure 1A). For an overview of habitat data collection technologies that form a basis for habitat assessment, see Appendix C.

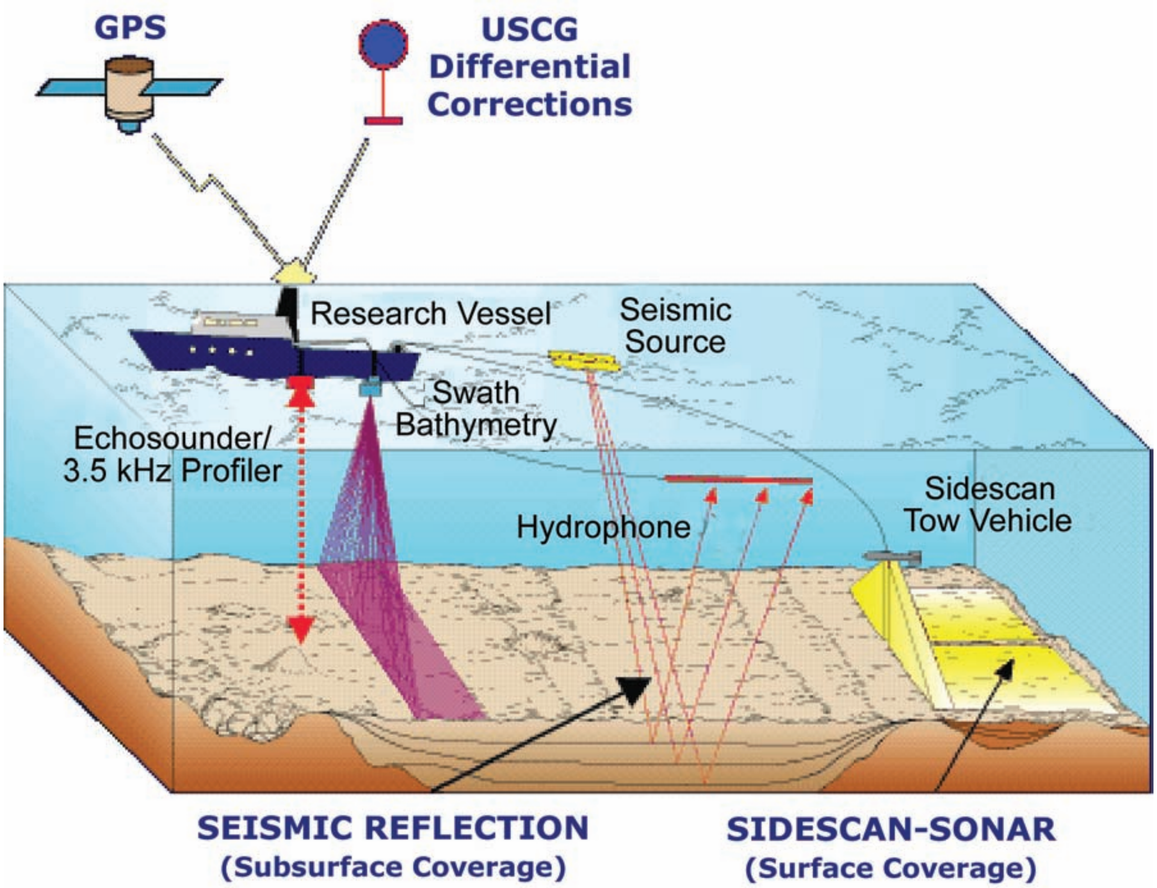


Figure 2: Acoustic Mapping Technologies

Optical Mapping Technologies

Shallow, nearshore areas tend to be highly productive for shellfish and other species of importance, thus making knowledge of nearshore areas an important component of a comprehensive LIS mapping program. However, mapping bathymetry and identifying bottom types in shallow water (~5 m) is currently very expensive, although new and developing technologies offer opportunities to reduce such costs. Optical mapping techniques can be utilized in certain shallow water areas in which traditional towed sonar arrays and their associated survey vessels have difficulty operating safely and effectively. More mobile survey vessels have recently been introduced to the market and may in the future offer opportunities for accessing areas that are difficult to navigate with traditional survey vessels. In addition, the shallow water prevents sonar methods from mapping wide scans, which is a factor that increases the cost of sonic imaging in shallow water. Multibeam mapping, which is a newer version of sonar mapping technology, is being used effectively in both deep and shallow water environments. However, shallow water mapping using this method is still very costly.

Figure 3 depicts the technique of analyzing reflected sunlight to determine water depth and bottom composition.

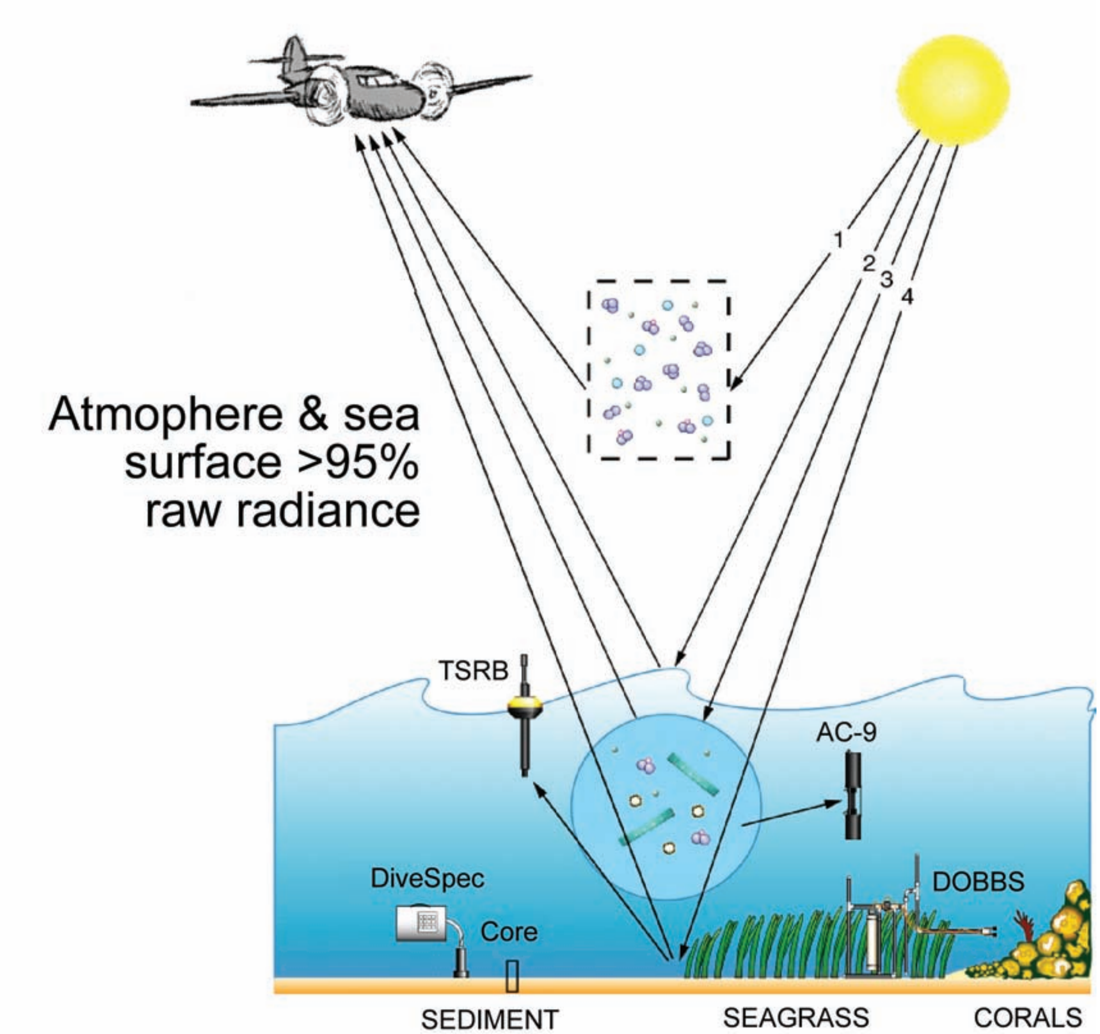


Figure 3: Spectral Imaging to determine water column and bottom composition

Some shallow-water mapping can probably be done with the high spatial resolution 4-m channels of the IKONOS satellite. However, the limited spectral data (three visible channels) and quality issues in the blue channel, where the signal is lowest, would provide only approximate values for mapping and bathymetry.

Currently, the best optical techniques (most accurate, highest resolution) involve aircraft remote sensing using a hyperspectral imager. Researchers at UCONN at Avery Point are currently in the process of securing a cost estimate for mapping the shallow regions of LIS from the manufacturer of the Portable Hyperspectral Imager for Low Light Spectroscopy (PHILLS), which is designed specifically for this task. The spatial resolution for this technique can be as small as one meter. Additional work will be necessary to apply the algorithms and correlate fieldwork in order to validate the results. As presently applied, this technique requires that an aircraft fitted with the imaging device fly over the area to be mapped. Its advantages come from the rapid coverage provided by aircraft imaging, and instrument safety in the shallow water regime (it never touches the water). The disadvantages of this technique are the relatively high cost of aircraft, the need for cloudless sky, and the need for minimum turbidity within the water column to maximize the penetration depth of hyperspectral imaging. Other variations in the application of optical hyperspectral imaging are being investigated. Researchers at UCONN at Avery Point are involved in developing techniques that would be more portable (helikite, autocopter) and cost-effective, more independent of cloud cover, and that would allow for time series analysis. These techniques are still in the concept stage, but could make an important contribution to shallow water mapping as an additional tool for decision making and analysis. Appendix A contains a comparison of different spectral mapping techniques with some estimate of cost and resolution. It is suggested that the UCONN investigators be encouraged to collaborate with federal agencies, such as the USACE and NASA, that are developing optical survey systems for shallow water.

Environmental Resource Maps

Appendix C of the LIS Task Force report contains a host of environmental resource maps. The LIS Task Force assembled available information from a variety of sources, and data layers differed in the accuracy with which they depicted information. Also, none of the data layers were based on comprehensive, high-resolution surveys. Additionally, they are of varying quality and do not contain digital links to the original observational data. These maps are shown at low resolution, and need to be verified and reviewed by experts in the various fields if they are to be used as part of any planning project. Also, information from the New York portion of LIS is missing on many maps, reinforcing the need for bi-state cooperative planning for LIS. The LIS Task Force report noted that “substantially more detailed and timely information may be required for comprehensive resources planning.”

It is suggested that a much higher-resolution mapping initiative is needed in order to determine the detailed distribution and significance of the seabed resources. This mapping effort will be useful as a planning level resource for energy-related infrastructure projects in LIS.

The Environmental Resource Maps show many marine environment characteristics, including lobster pot density, sediment types, and endangered species. While the lobster pot and fish density maps may have been accurate for the survey time, temporal changes will occur. There is no definitive, comprehensive marine environment map that will be representative for all times of the year in LIS, as different species populate different areas at different times. Due to these temporal changes, mapping can only generate a general understanding for the year-round marine environment. The sedimentary environment provides a strong determinant for the species found in different habitats, but can potentially be altered by storm events. Also, different species roam different areas at different times. In addition, the transition zones represented on the Environmental Resource Maps are only a line between environments. Biologists recognize that transition zones can be much wider than this representation. It is expected that actual transition zones throughout LIS will vary greatly in width depending on the interaction of several physical factors, including wave and current energy.

It is expected that transition zones may be very important to the health and productivity of some benthic communities, but very little is known about these areas in terms of their ecological importance. While some information suggests that transition areas are ecologically important, this remains a potentially critical unknown with respect to assessing dynamics and potential impacts.

Shellfish population information is important since existing electric cables, the natural gas pipeline and future LIS projects may be installed through areas that contain high shellfish density or are exceptionally productive shellfish growth areas. While the lobster population is not addressed specifically in this report, it has seen a severe decline in the last few years, probably from both parasitic (paramoeba) attack and a variety of environmental stressors. The oyster and clam populations are generally found at water depths of 10 meters or less. They represent a multi-million dollar industry in Connecticut and therefore should be considered both when mapping LIS and planning for the installation of cables, pipelines or other energy infrastructure. General locations of shellfish areas are not adequate for site-specific determination. It is suggested that more detailed investigations will need to be performed prior to the installation of any cable/pipeline or other energy-related project to discern the magnitude of the expected disturbance and its impact on the local benthic community, including the shellfish population. Most cultivated shellfish beds experience wide fluctuations in shellfish densities due to natural processes (setting patterns, temperature, and food availability from year to year). One way to quantify the productivity of various shellfish grounds will be to conduct surveys of the active shellfishermen.

The oyster population has been deeply affected by the parasite MSX in the past few years; this can be seen by the dramatic drop in the number of bushels landed. (For additional information, see Mollusks, p. 15.) MSX is not passed from oyster to oyster; it jumps from an undetermined host mollusk. The Connecticut Department of Agriculture, Bureau of Aquaculture noted that another disease called Dermo is widespread throughout LIS oysters and adds an additional stress to this community. Both Dermo and MSX appear to be cyclic in nature, but it is not known what environmental factors make populations more or less susceptible to their effects.

Benthic Habitat Mapping Needs

The objective of the benthic habitat classification and mapping session of the LIS Symposium was to determine and identify habitat classification needs for the estuarine and benthic habitat within LIS for use in planning for and management of encroachments into LIS and their impact on benthic habitats. Shallow water mapping nearshore (water depths to ~5 meters) will likely include optical techniques and possibly acoustic techniques, especially in turbid waters where optical techniques will not penetrate. Deeper water mapping (to depths as shallow as 5 meters) is expected to be accomplished using acoustic mapping methods. Overlap in mapping techniques may be used where needed.

Symposium panelists discussed other habitat mapping efforts, including the Gulf of Maine Mapping Initiative (http://www.gulfofmaine.org/gommi/), the Chesapeake Bay Program (http://www.chesapeakebay.net/) and the Hudson River Estuary Program (Ladd et al., 2002; Nitsche et al., 2004; http://benthic.info).

- The Gulf of Maine Mapping Initiative (GOMMI) was created in 2001 as a result of a mapping workshop that was sponsored by the Gulf of Maine Council and NOAA. It is a multi-year project, with the first phase focusing on non-living resource mapping. Phase 2 of the initiative will produce habitat maps of the seabed. As of 2002, approximately 15% of the Gulf of Maine was mapped in a level of detail necessary for the management of undersea resources. Mapping efforts, using multibeam technology, in the Gulf of Maine have been ongoing since 1994. Currently (Fall 2004), GOMMI is in the process of completing a user needs assessment project to determine options to implement and fund a strategic plan and to define user needs and priorities. Part of this project included a user needs assessment survey (September 2004), that indicated:

  "An essential principle underpinning GOMMI is to address the interests of Gulf of Maine stakeholders. Mapping cannot occur in a vacuum, but instead needs to be comprehensive, to provide a useful tool to help manage the sustainable human use of Gulf of Maine resources, and to highlight sensitive habitats for conservation planning.

  People use the waters of the Gulf of Maine for fishing, transportation and shipping, aquaculture, pipeline and cable construction, seabed mining, offshore oil and gas exploration and development, military operations, whale-watching, pleasure boating – the list is nearly endless. Only by consultation with users can the GOMMI Steering Committee appropriately prioritize the areas to be mapped, discover what types of maps stakeholders need, and justify the Initiative's requests for support. User needs will continue to drive the development of GOMMI, so it is essential to involve stakeholders from the beginning."

- The Chesapeake Bay program has not focused on a bay-wide mapping and habitat classification program.

- The New York State Department of Environmental Conservation (NYSDEC) Hudson River Estuary Program completed a baseline mapping project for the benthos of the Hudson River Estuary for water depths greater than 5 meters (200 sq km) and is in the process of determining next steps to translate these maps of the physical environment into habitat maps useful for wildlife management. This project included multibeam bathymetry, sidescan sonar, seismic profiles with grab sampling and cores for ground truthing, and limited benthic faunal analysis. This mapping initiative was developed by NYSDEC to gain a greater understanding of wildlife habitat environments in the river for the purpose of fisheries management. NYSDEC is interested in learning about where fish spawn, where they find food, and changes that occur on a seasonal basis. The project envisions a process that develops links and relationships between maps of the physical environment, invertebrate benthic communities, and species of interest.

The GOMMI and the Hudson River Estuary Program can be used to estimate upper and lower bounds for the cost to complete similar, non-living resource mapping tasks within LIS. Table 1 provides a comparison of the survey days, area involved and cost for these projects, as well as projected upper and lower cost estimates to complete similar work within LIS. This cost summary was based on a quick, informal review of projects without consideration of the most appropriate approach for undertaking a mapping initiative of LIS. Better cost estimates can be determined as the overall scope and resolution of the mapping initiative is better defined, including identification of mapping methods and the collection and analysis of ground-truthing studies.

Location	Survey Days	Survey Area km^2/day	Area km^2	Cost	Cost/area
Hudson River (completed)	120	1.7	200	$2M	$10k/km^2 (actual)
Gulf of Maine (proposed)	400	412	165,000	$30M ($3M/year for 10 years)	$180/km^2 (estimate)
LIS High Cost	?		3,400	$34M	$10k/km^2
LIS Low Cost	?		3,400	$612k	$180/km^2

Table 1: Sedimentary and Bathymetric Mapping (excluding habitat mapping) Cost Estimates (Note: Gulf of Maine figures are from the Gulf of Maine Mapping Initiative: A Framework for Ocean Management, http://www.gulfofmaine.org/gommi/)

Although decisions regarding development of a comprehensive mapping program, including the specific goals for such a program, for LIS need to be developed, the following information provides some general mapping cost guidelines for a mapping project that would include the entire LIS area. It should be noted that ongoing mapping efforts by NOAA may be used to reduce the cost of such a program.

Experts within the mapping field do not expect a mapping project that would include all of LIS to achieve the low cost estimate in Table 1. The Gulf of Maine project has large expanses of deep water which allow for wide coverage with acoustic mapping techniques, resulting in a lower unit mapping cost ($180/ km2). The $34 million LIS estimate ($10k/km2 unit mapping cost) is probably too high as well, since LIS has deeper water than that found in much of the Hudson River, allowing for a more rapid survey than required in the Hudson.

While mapping techniques and surficial sediment composition dominated this session's discussion, the implicit assumption is that it is possible to determine and understand habitats based on these mapping techniques. Scientists are still attempting to convert physical environment data into true habitat maps. To date, maps have only been made of the physical environment of the seafloor of some estuaries, but these physical environment maps have not been transformed into true habitat maps in any estuary because the links between the physical environment and the biota have not been defined. Zajac et al. (2000), Diaz, et al. (2003), Strayer and Malcolm (2004), and Maher and Cerrato (2004) have recommended approaches to resolve this issue.

Another challenge to producing habitat maps from maps of the physical environment is the question of temporal change: how does the use of the physical environment change for a given species with the seasons? How does the physical environment itself change with time? The necessary information or even the conceptual constructs are not presently known to address these questions.

The adoption of a habitat classification system is a basic requirement and foundation for the collection of data and information about LIS. NOAA developed a draft habitat classification system that includes a continental shoreline habitat (Appendix B contains sections of the NOAA draft continental shoreline classification system along with the levels available for review and consideration within the NOAA draft). Other habitat classification systems are available, including one from the European Union, UK and Ireland and others. The identification and selection of a preferred habitat classification scheme was beyond the scope of this study. It is suggested that the development of a habitat classification system be considered for LIS.

Initial mapping efforts of the physical environment and living resources should be considered as base or reference maps. Once completed, these maps will provide a foundation from which changes can be measured and identified over time to help determine if and when additional mapping of certain regions may be necessary. For example, a review of baseline physical environment maps with targeted additional mapping or sampling may indicate little change and that complete re-mapping of the physical environment would therefore not be necessary. Also, findings identifying the degree of change from the sampling of known habitat areas may be an indicator that additional detailed habitat mapping is, or is not, necessary at a given point in time. It is suggested that it might be sufficient to review mapping requirements at intervals of five to ten years and more frequently in areas where there is significant human activity. Decisions to update existing base/reference maps can then be made based on the goals of the mapping initiative at that time, the need for more up to date information, and the amount of change expected based on preliminary findings. It is known that different areas have different uses during different times of the year (e.g., spawning, feeding, etc.). Therefore, it is suggested that such mapping efforts may need to be undertaken periodically during the year in which the mapping project occurs, to more fully understand the year-round activity in such areas. Baseline or reference maps also provide a context for higher resolution site-specific surveys that may be needed for a specific infrastructure project.

It is suggested that a comprehensive plan for mapping LIS be developed with clear objectives. Future mapping projects that are undertaken should have a detailed purpose consistent with the overall plan. It is expected that habitat mapping will be a multi-million dollar project, but one that is necessary in order to fully understand the impacts of disturbances to the seabed on benthic habitats.

There presently is not enough information for a comparative assessment of the environmental impact of any particular pipeline or cable route, in part because the distribution or relative value of ecologically important species or habitats is not known in general or in detail. A mapping initiative of LIS that quantifies the distribution and importance of various habitats and species is an essential step for the comparative assessment of the impacts of proposed projects.

ENDANGERED AND THREATENED SPECIES

Both the federal government and the state of Connecticut have programs that are designed to preserve species in danger of extinction. The federal effort began in earnest with the 1973 Endangered Species Act. The Connecticut legislature passed its own Endangered Species Act in 1989. This legislation seeks to conserve the state's natural heritage for the enjoyment and benefit of current and future generations. Both acts use the terminology of Endangered (E) or Threatened (T), while the Connecticut act also includes a designation of Special Concern (SC). "Species of Special Concern" means any native plant species or any native non-harvested wildlife species documented by scientific research and inventory to have a naturally restricted range or habitat in the state, to be at a low population level, to be in such high demand by man that its unregulated taking would be detrimental to the conservation of its population, or that has been extirpated from (become extinct in) the state.

The federal list of threatened and endangered species has to this point been mostly tied to the terrestrial environment, and has considered mostly the large mega fauna that are associated with the marine environment and generally known, such as the whales, sea turtles and some marine nesting birds. The Marine Mammal Protection Act protects mammals not considered endangered presently. A partial list of endangered and threatened species for LIS, besides the marine turtles and the occasional whales, includes:

- Birds that rely on LIS for food, including the Roseate Tern (E), Peregrine Falcon (E), Bald Eagle (T) and Piping Plover (T), with both the tern and plover nesting on shore.
- Fish: Shortnose Sturgeon (E) and the Atlantic Salmon (E) (In the Connecticut River watershed, Atlantic Salmon has been extirpated and is a species being re-established under a restoration program.)
- Plants in the nearshore environment (beach) include: Sandplain Gerardia (E), and Seabeach Amaranth (T).

It was agreed by the panelists — both researchers and government regulatory personnel — that much more information needs to be gathered in this area in order to know exactly how endangered or threatened species utilize habitats in LIS and to understand which benthic species may be endangered, threatened, or species of concern.

There is no modern accounting of the benthic species of protists, invertebrates, fish, and seaweeds of Long Island Sound that would permit assessing which marine or estuarine organisms -- during any or all of their life stages -- are endangered, threatened, or of special concern, or how they may be affected by future encroachments into LIS. The same dearth of information makes even listing ecologically important benthic species problematic. Hundreds to thousands of benthic species have been recorded from Long Island Sound since the first lists appeared in the 1810s. Periodic partial surveys have been conducted for selected groups of organisms in LIS throughout the 19th and 20th centuries. As a result, there are many hundreds of papers and reports scattered over 200 years which, while a rich data source, remain unsynthesized. No evidence has been found of any modern-day surveys that would provide reliable assessments of the current status of the biodiversity and distribution of many key species in LIS. In other major American estuaries, such as San Francisco Bay, the Chesapeake Bay, and the Puget Sound there have been consistent on-going monitoring surveys for several decades of benthic communities. The purpose of these surveys is to establish the condition of these bays, identify and evaluate trends, and identify areas that may need restoration. Therefore, since no effort is currently being made to understand both the history and the current status of the benthic organisms of LIS, and since knowledge of the existence of endangered and threatened species is desirable to the state and others in the planning and evaluation of potential infrastructure projects, it is suggested that as a first step the state, or other organization with a broad mandate and bi-state support, develop a program with adequate support to identify and list the benthic species of LIS. Once the benthic species are known, it may then be possible to identify those species that are endangered, threatened, or of special concern. It should be noted that although an exhaustive search has not been completed, it does not appear that the estuaries involved in listing benthic species have been involved in efforts to identify and list those benthic species that may be endangered, threatened, or of special concern, nor is the Center for Biological Diversity (http://www.sw-center.org/swcbd/) knowledgeable of any such efforts.

MOLLUSKS

The Connecticut shellfish industry comprises three different types of shellfish that require different harvesting techniques and different habitats. Adult lobsters feed and live on the sea bottom, but, because of their mobility, it is assumed that they are relatively unaffected by utility encroachments into LIS. Also, lobsters often live in fairly dense "communities" where either hard substrates (rock, shell, etc.) offer protection, or in substrates that enable them to form burrows. However, it is suggested that any possible links between future encroachments and important environmental factors affecting lobsters, such as their habitats, oxygen values in the water or high seasonal temperatures, may be worthy of examination. Oysters, after a free-swimming larval phase, live attached to hard surfaces such as shell and rock on the sea bottom, and therefore are completely sessile. Clams also have a free-swimming larval phase and then live within the top few inches of the sediment layer, capable of only very limited lateral movement. This report will concentrate on post-larval oysters and clams because of their inability to move in response to an anthropogenic encroachment to their habitat.

The installation and maintenance of infrastructure in the vicinity of shellfish beds is of interest not only for environmental but also for economic reasons. It should be noted that various industries associated with LIS contribute to Connecticut's economy in varying degrees. In 2002, the combined shellfish industry represented about $13 million in sales ($10 million for hard clams, $2 million for oysters and $1 million for lobsters). Total economic impact by the components of Connecticut's Maritime Cluster, as documented by a 1997 report entitled "Connecticut's Ports: Transportation Centers for People and Goods," produced by Parsons Brinckerhoff with the assistance of the Connecticut Economic Resource Center, is over $3 billion (1997 - payroll and sales data. This figure includes: Recreation $332 million; Commercial Fishing, including shellfishing $60 million; and other sectors including Transportation and Manufacturing & Services - $1.26 billion).

Currently, the state of Connecticut leases 57,000 acres of submerged bottom for the cultivation of clams and oysters. Also, a total of 15,000 acres of shellfish/natural beds are leased or managed by Connecticut towns, and there are many undesignated potential shellfish growing areas in LIS. Due to the parasite MSX, oyster production has dropped precipitously, while clam harvesting has increased. In the five-year period from 1996-2000, oyster harvesting dropped from ~600,000 bushels/year to less than 100,000 bushels/year. During that same period, clam harvesting grew from 150,000 bushels/year to over 250,000 bushels/year. As previously noted, the lobster catch has plummeted from what is theorized to be a variety of stressors.

To understand the impact of anthropogenic activity on oyster and clam beds, an understanding of the processes used to culture them is important. For most commercial oyster growers, the first step is to plant clean shells on some of their leased grounds where the shells serve as an ideal substrate on which the larval oysters settle, and become "seed." Putting shell down is completed each year by mid-July, in advance of oyster spawning. The newly-settled oysters are allowed to grow on the seed beds for at least one year, and then are typically removed by dredge and transferred to growing beds or they can be left on the seed bed to grow to market

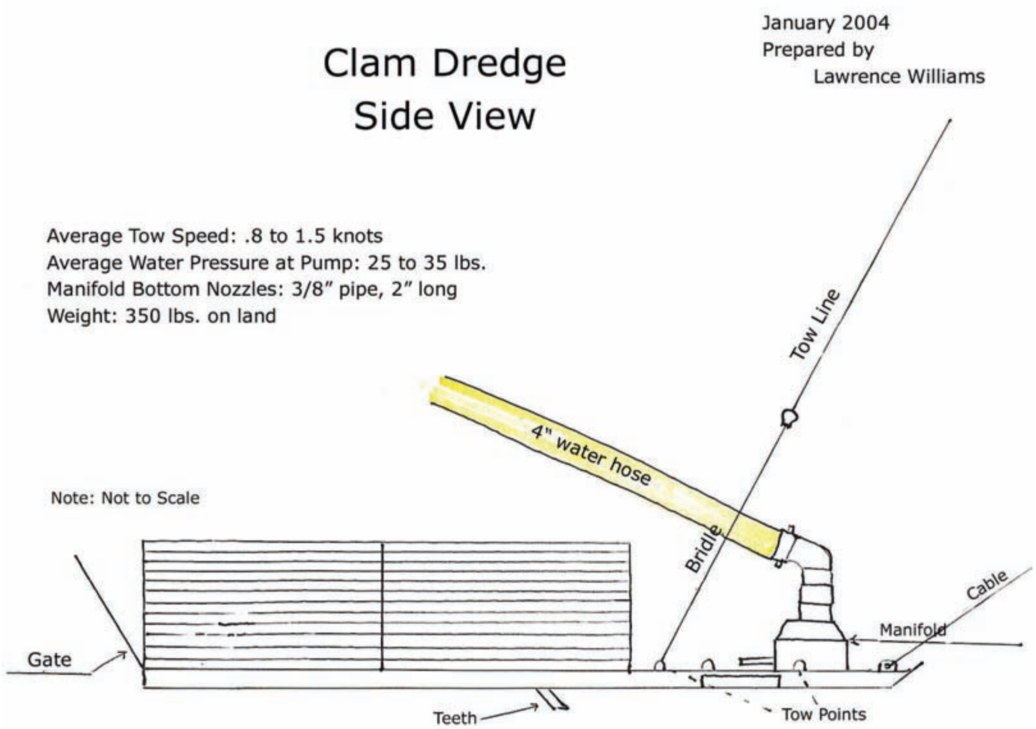


Figure 4: Side view of Clam Harvesting Dredge

size. Three to four years after setting, the oysters reach market size and are harvested by dredge. The shellfish beds leased by the state to commercial shell fishermen include both natural oyster seed beds and growing beds. Additionally, the state owns and maintains 5,000 acres of public natural oyster seed beds and allows the public to harvest seed oysters from these beds annually. The state's effort to maintain the public seed beds, which includes cleaning and planting clean shell is limited to approximately 100 acres per year due to available funding and is completed during the month of June. The seed beds are open for harvesting seed oysters from September 21 – July 19 annually annually. Seed oysters from the public natural oyster seed beds are harvested using methods specified by the state and then transferred to commercial growing beds. These natural seed beds have been designated and used for such purpose for 100 years and remain the primary source of oyster seed for the commercial shellfish industry.

Hard clam larvae settle naturally on the bottom throughout LIS, including leased areas, in shallow waters generally within three miles of the shore. The clams reach market size three to five years after settlement. The clams grow a short distance (1-2 inches) below the water-sediment interface with little mobility in this environment. Shell fishermen use hydraulic clam dredges to harvest clams from the sediment layer and rotate among the leased bottom areas to allow clams to grow to market size. Figure 4 shows a typical clam dredge used for harvesting clams from this top layer of sediment. This kind of dredge is vastly different than that used in the plowing operations typical of cable installation.

Both oyster and clam beds have seabeds that have been manipulated for relatively long periods of time (years or decades) in order to produce the best environment for oyster and clam production. Past cable and pipeline projects that have been installed through these areas have apparently

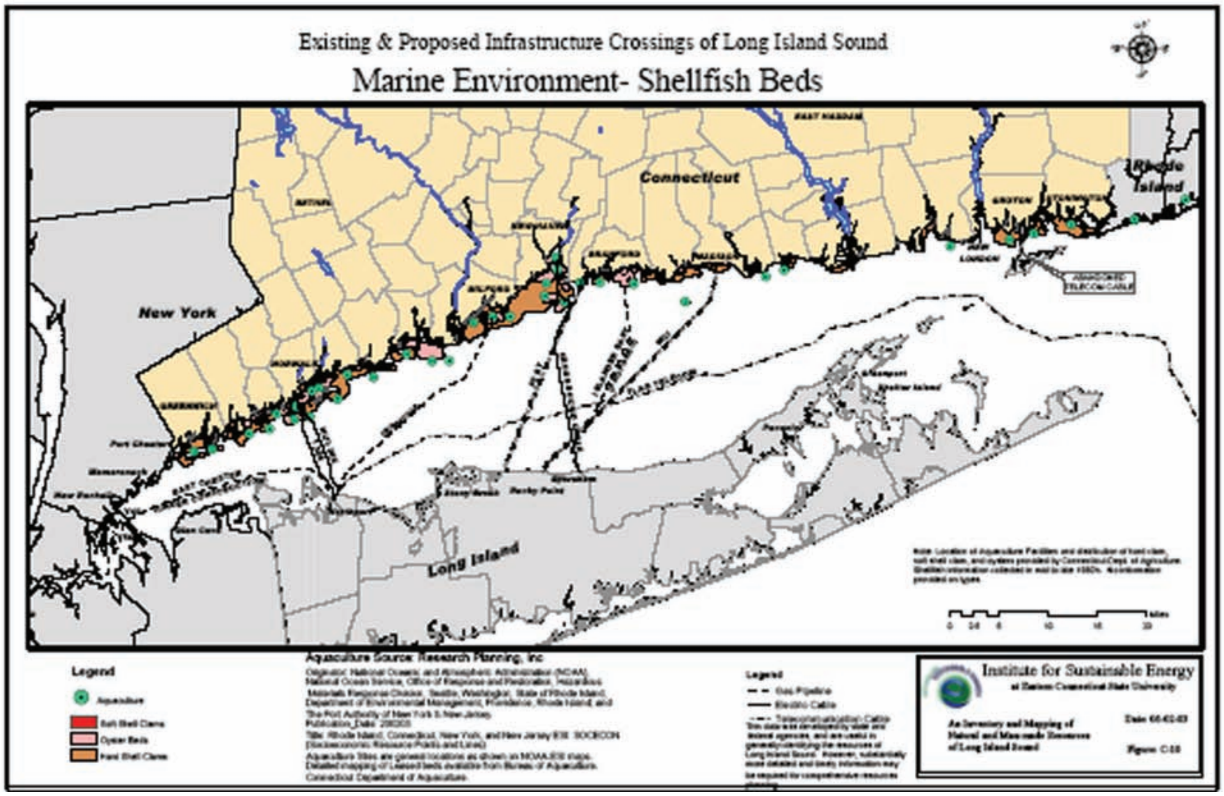


Figure 5: Shellfish bed locations along the CT shoreline; Marine Environment – Shellfish Beds: Environmental Resource Maps, Comprehensive Assessment and Report – Part II: Environmental Resources and Energy Infrastructure of Long Island Sound, Appendix C; dated June 3, 2003

significantly changed the characteristics of the seabed and in some cases, a decline in shellfish production has resulted. The inability to use traditional cultivation techniques due to the change in the bottom profile of these areas has been identified as a cause for this loss of production.

Reportedly, following the installation of cables and pipelines, impacted shellfish beds in LIS have not been restored to pre-construction levels of productivity. Although the technology and methods for shellfish bed restoration are known — including matching sediment layers and the pre-construction elevation profile — a variety of factors affect the ability to successfully accomplish this task. Successful restoration of a disturbed swath through a shellfish bed as a result of construction activity may be more difficult to achieve than creating a new shellfish bed. Pilot projects can test methods to construct new shellfish beds in LIS. If successful, creating new shellfish beds should be considered as an alternative for mitigating an encroachment into an existing shellfish bed.

Figure 5 shows a rough approximation of the locations for cultivation of various mollusk types; however, it is not detailed enough to be used for project planning. Therefore, it is suggested that additional detailed mapping of shellfish production areas should be developed to be used as a tool in infrastructure project planning under the assumption that more detailed maps of shellfish production locations do not exist.

The LIS Symposium panelists identified a concern regarding possible impacts on mollusk habitats when infrastructure projects encroach on shellfish beds, especially when there is some manipulation of the seabed. Any dredging, backfilling, jetting or plowing operation (along with associated propwash or anchoring impacts) has the potential to impact the shallow sea bottom required for mollusk growth (< 10 meters), including smothering clams already buried in the sediment. These same operations can cover oysters living on the hard bottom due to the re-suspension of silt from the bottom into the water column, and can limit the feeding ability of oysters or clams. For both clams and oysters, seabed manipulations like those described here may cause mortality.

Both the sediment type and its morphology are important features for mollusk growth. Generally flat bottoms with a narrow range of density (differing for clams and oysters) are required for their growth. Long-term impacts of encroachment activities can be severe, altering the bottom topography and sediment density to such a degree that it affects the productivity of the impacted shellfish beds for future mollusk growth and harvesting. These long-term impacts can last for years, even after mitigation. At a minimum, mitigation efforts should include:

- Detailed mapping of the pre-installation conditions using high-resolution techniques;
- Harvesting of all shellfish prior to project initiation;
- Restoring the bottom after the disturbance, matching sediment and morphology, planting shell when appropriate, and assessing financial penalties if restoration is not possible; and
- Replacing lost shellfish with seed or market size as appropriate.

The use of designated corridors for cables and pipelines across contained bodies of water has been suggested as a method for confining the impact of these encroachments on mollusks to limited areas. No examples of this practice were documented during the symposium, and no easily discernable benefit was noted. For terrestrial installations, although not a common practice, electric cables and natural gas pipelines occasionally share a designated right-of-way. Also, within these corridors, the cable and pipeline installations are located as far apart as possible within the right-of-way. In addition, new developments such as horizontal drilling can potentially make it possible to run utilities, especially cables and perhaps pipelines, beneath shellfish beds. At present this technique is limited to about 7,200 feet, but future increases in this distance are likely.

It is further suggested that an effort should be undertaken to help identify mollusk set, growth and harvesting areas. These measures should include surveys with the participation of the Department of Agriculture's Bureau of Aquaculture, active shellfishermen, and academic researchers. This community should be able to identify those sea bottom areas that have historically had higher productivity, as well as areas that have the potential to be leased for shellfish production and therefore should receive special attention in the consideration of future projects. Other coastal regions have been involved in shellfish mapping programs such as the North Carolina. The North Carolina Department of the Environment and Natural Resources (contact information: http://www.ncdmf.net/habitat/chpp30.html) has been engaged in a long-term shellfish bed mapping initiative for the past 15 years. Their goal is to map shellfish beds along the entire North Carolina coast through sampling and analysis to determine shellfish densities. This mapping program is part of North Carolina's Coastal Habitat Protection Plan.

III. IMPACT ANALYSES

EMF

Electromagnetic Fields (EMF at static Extremely Low Frequency (ELF) ranges) surround us everyday. These sources include the static geomagnetic field of the earth and 60-Hz fields generated from the electric power system. At these frequencies, the term EMF refers to electric and magnetic fields. Electric fields are caused by voltage and magnetic fields are caused by current flow. This study only addresses the type of cables utilized in underwater crossings (undersea conductors). These cables are shielded and no electric field is generated outside of such cables, which is not the case for overhead transmission lines. Therefore, the term EMF in this report refers only to the magnetic field created outside an undersea power cable by virtue of the current traveling in the conductors of a cable. This field is only created when electric current is passed through a conductor. The strength of the field at locations around the cable depends on the amount of current traveling through the cable. Since the underwater electric transmission lines will be carrying current and will stretch across the entire LIS, the question has been raised as to whether or not the EMF from these lines will be harmful in any way to aquatic or human life in a cable's proximity. The magnetic field intensity, H, of an EMF is dependent on the distance between the object being affected and the EMF source. The intensity of the magnetic field is inversely proportional to the distance from the center of the conductor. The easiest method to determine this magnetic field intensity, H, for a conductor, is to apply Ampere's circuital law, seen below in equation (1).

$$H = I/2\pi r \text{ A.} \qquad (1)$$

In the MKS system, advocated by the Institute of Electrical and Electronic Engineers (IEEE), the magnetic field intensity, H, is measured in Amperes per meter (A). For purposes of biological studies, however, the magnetic field is usually referenced as the magnetic field flux density, B, measured in Webers per square meter, or Tesla. However, most literature referencing the impact of magnetic fields on various organisms report using the unit Gauss (G) or milliGauss (mG). Tesla is related to Gauss as follows: 1 T = 10,000 G. The equation relating B (flux density) to H (field intensity) is: $B = \mu_0 H$, where μ_0 is the permeability of free space, or $4\pi \times 10^{-7}$. In the United States, magnetic flux density is commonly expressed in units of milligauss (mG), where 1 mG = 0.1 T.

The frequency of the EMF from a Direct Current (DC) cable is 0 Hertz (Hz, or cycles per second); the frequency of an Alternating Current (AC) cable is 60 Hz (in North America; Europe uses a 50 Hz system). As stated above, the strength of the EMF field at any location is a function of the distance from the cable. The fundamental principles of electromagnetic theory allow for an accurate prediction of the strength and properties of an EMF field, as long as technical details of cable construction and current flow are known. This detailed technical information includes the dimensions and the amount of current flowing through the cable. Various instruments are available to measure the intensity of the EMF field while a cable is in use. Measurements obtained after the installation of a cable can be used to verify the validity of assumptions on which pre-installation calculated EMF values are based. For cables buried beneath the sediment of LIS, these measurements can be obtained from a magnetometer towed behind a boat as it passes over the buried electric cable. Current instrumentation and methods used for field strength measurement are sufficiently accurate that they do not need to be updated or replaced.

AC and DC EMFs differ in the following ways: DC is a static field like the earth's geomagnetic field, and it operates at 0 Hz or as a very slow changing field; AC EMF fields operate at 60 Hz, which means they oscillate in direction at the given frequency, or 60 Hz for the North American electric system. Table 2 shows the calculated values of magnetic field strength surrounding both the DC Cross-Sound Cable and the AC 1385 Cable when operating at their normal rated capacity (300 MW Cross-Sound). Note that these values are specific to the individual cable designs and projected current flow. Other designs and current flows may vary from this level. As a reference for the DC cable, all forms of life experience continuous exposure to the earth's magnetic field of around 500 mG.

Distance above Cable (ft)	Cross-Sound DC cable Field strength (mG)	1385 AC Cable field Strength (mG)
3	355	
6	160	20
16	23	
56		0.3

Table 2: Electric Cable Magnetic Field Strengths

Given the calculations in Table 2, the depth of burial for the DC cables should be great enough so that the EMF created in the water column at and above the sediment-water interface will be less than that of the earth's own magnetic field. This means that unless a person is swimming next to the cable, the EMF level will be less than twice that of the magnetic field created by the earth. As far as aquatic life is concerned, there have been no studies of a direct link between EMF and an increase in cancers among marine animals. The EMF session panelists agreed that the low levels of magnetic field found above shielded undersea cables would not be at levels sufficient to cause harm to humans or aquatic life.

Some studies have reported that certain sea and land organisms have sensors that can detect DC magnetic fields like those naturally occurring within the earth. These sensors are not a primary sense for these organisms and at the levels produced by submarine cables, should not have an effect on migratory patterns, feeding, or day-to-day habitation. Even if there were such an effect, it would exist only in the immediate vicinity of the cable, and an organism's sensors would operate properly once the organism left the area of the cable. Also, it is expected that migratory species are not likely to remain near a cable for a long period of time. Therefore, no adverse effects from the EMF of any submarine cables are projected. Additionally, incidental exposure of organisms to EMF should not result in any residue that would be harmful to humans if they consume species found near a cable.

While calculations have been performed on the low levels of EMF expected from both AC and DC cables under LIS, measurements of EMF on actual, operating cables are only available for the Cross-Sound Cable at depths just below the surface of the water. These measurements were reported as part of the "Eighteen-Month Post-Installation Benthic Monitoring Survey for the Cross Sound Cable Project" by Ocean Surveys, Inc (OSI report #02ES020.4; March 8, 2004). The measurements were taken by using a magnetometer that was towed just below the surface of the water along the route of the cable, during its operation, to study the effects of magnetic field variations on surface vessel operations. The reported magnetic field measurements were essentially at background magnetic field levels, from ~529-535 mG. No data was available for measurements of the magnetic field at depths close to the seabed. Also, it is expected that magnetometer surveys of the 1385 Cable will be performed when this line is placed in service. In addition, these field strength measurements should be correlated with the power/current passing through both cables to allow extrapolation of the data to other operating conditions.

TEMPERATURE IMPACTS

The temperature of LIS fluctuates seasonally from -1°C to +22°C. This strong intra-annual variation in the temperature of the water suggests that the organisms living there must be able to adapt to such wide fluctuations in temperature. However, there is some evidence that some organisms, including lobsters, are near their warm-water limit (LIS is the southern extreme of the lobster habitat range) and have become more susceptible to disease or infection at recent maximum summer temperatures in LIS. Also, maximum LIS bottom temperatures are expected to continue to increase in response to global warming, making areas such as LIS less suitable for lobsters. Much of the aquatic life in LIS cannot regulate its own body temperature and is therefore strongly affected by the surrounding water temperature. The general trend with regard to temperature change for these types of organisms shows that an increase in temperature, below lethal limits, usually means an increase in energy used and food consumed. A standard rule of thumb states that metabolic activity will double with every 10°C increase in the environment. Thus, a change in the temperature of the environment can have a dramatic effect on the species living in the area. For instance, it has been found that seasonal fluctuations in temperature already seen in LIS affect reproductive rates and growth rates in aquatic populations.

It has been suggested that the small amount of heat generated by a buried electric cable may in fact produce larger organisms with higher population counts. The most recent electric cable installation was buried far below the biota (plants and animals), and it is expected future cable installations will be as well. The amount of heat created by these cables will probably not raise sediment surface temperatures high enough to harm the biota living in areas near buried cables. Calculations for the Cross-Sound Cable suggest that sediment temperature about 1-5 cm below the sediment-water interface will increase less than 6°C when the cable is operating at full capacity (see Appendix D). Another possible effect from a cable's operation may be a local (within several feet on either side of the cable) alteration of the distribution of certain types of species. This could occur because of the fact that LIS lies in the overlap between two marine boundaries: the southernmost range of the boreal province species and the northernmost range of the southern species.

The total amount of heat released by an electric cable is relatively small compared to the total energy balance of LIS. A typical electric cable loses a few percent of the total energy carried as heat — less than 10 MW for either the Cross-Sound Cable or the 1385 cable when operating at full load. This is very small compared to other sources of heat input into LIS. For example, Millstone Point Unit #2 (a nuclear power plant in Waterford that uses LIS for cooling) operates at approximately 890 Megawatts (MW) of gross electric production with a gross thermal production of 2700 MW of energy. It therefore has a thermal efficiency of ~33%. This means that it regularly rejects ~1800 MW of energy (2700-890) to LIS as part of its everyday operating cycle. This level of heat rejection easily dwarfs (by two orders of magnitude) the <10 MW energy release found in the Cross-Sound Cable and 1385 cable. In addition, both of these cables release this energy uniformly across their 26-mile and 11-mile length, respectively. Both cables release energy at approximately 25 W per linear foot of cable. The thermal effects from these cables could not be discerned once you enter the water column due to the large mass and circulation of water.

Additionally, the thermal effects of telecommunication cables are expected to be much lower than electric cables as they are not designed to carry large currents, and therefore will not have resistive heating. The potential thermal effect from underwater pipelines is also likely to be small, since pipelines often operate at ambient temperatures.

The greatest impact of heat is not to the surrounding aquatic life but to the cable itself. As a result, the maximum current of a cable is sometimes limited by the ability of the sediment to conduct heat away from the cable. Future electric cable designs may incorporate the use of a cooling fluid within the cable which will allow for higher current capacities. Neither the Cross-Sound Cable nor the 1385 Cable rely on internal cooling fluids. A cable needs to be designed so that its maximum operating temperature does not dry out the surrounding sediment, which would in turn decrease the already poor thermal conductivity of the sediment and potentially damage the cable's insulation, reducing its ability to carry its rated current/power. If this type of damage were to occur, the cable would need to be repaired, requiring maintenance that would impact surrounding areas.

SAFETY ISSUES AND IMPACTS

It is suggested that safety standards be implemented in order to ensure that future marine infrastructure crossings are constructed in a manner that will prevent accidental anchor or other equipment snags or strikes. The presently installed 1385 AC Cable rests on the seafloor and has been severed several times by anchor strikes. This and other damage resulted in the leakage of electrical insulating fluids into LIS and subsequent cable repairs resulted in disturbance to the seabed. Therefore, it is suggested that it would be inadvisable to authorize the construction of fluid-filled cable systems that are placed on the seabed. More recent cable installations have relied on burial, with depths of 3-6 feet being the commonly used criteria for cable placement. However, no data for LIS are available as to whether installation beneath the seabed totally eliminates damage to a cable from anchor strikes, and no information was gleaned from the symposium on the safety effects of burying pipelines. Conversely, it is understood that burial of the much larger pipeline systems will have a larger impact on the benthic community, due to the wider swath of affected area, than burial of cables.

Safety systems have been implemented in both the DC Cross-Sound Cable and the AC 1385 Cable. These safety systems include high speed "circuit breakers" that will de-energize the cable in the case of an anchor strike or other equipment snag. The DC Cross-Sound Cable has not yet had to rely on its safety systems. However, the 1385 Cable has successfully used its safety system after several anchor strikes. It seems reasonable to assume that the Cross-Sound Cable and other future electrical cable systems will be able to rely on these safety systems to protect the public in case of inadvertent equipment strikes. Unfortunately, inadvertent anchor strikes or other events that damage electric cables will require repairs. Further information regarding repairs is provided in the Installation and Maintenance section of this report.

Natural gas pipeline systems have different safety criteria. While electrical cables can be de-energized within milliseconds, pipeline systems rely on valves to isolate problem areas. The difficulty associated with this safety system comes from the large volume of high-pressure gas still contained within the pipeline between the isolation valves. This high pressure gas can be a safety hazard in the event of a rupture of a pipeline system.

Other safety concerns associated with natural gas pipelines located beneath LIS can be loss of surface vessel buoyancy as a result of a rupture of the pipeline. The large volume of gas located between the isolation valves of the Iroquois Pipeline or other future pipeline system that relies on isolation valves at either end of the sub-sea system could present a hazard to shipping in case of a large-scale rupture of the pipeline in proximity to boating traffic. This is especially true in shallow water, where the gas plume would not dissipate on the way to the surface.

It would seem impractical to address the issue of cable/pipeline safety simply by increasing the burial depth of the cable and pipeline. The impact to the benthic community would be greatly exacerbated by burial depths that reach 10-20 feet, due to the much greater volume of sediment that is disturbed in order to reach these depths. Additionally, only a marginal increase in safety would be achieved with this type of design, as large sea anchors can routinely penetrate sea floor sediments to depths of 10 feet or greater.

It is suggested that a more reasonable approach to anchor strike safety for both cable and pipeline systems would be to selectively armor areas of the cable and pipeline. This approach seeks to create an environment that will prevent anchors from grabbing the utility infrastructure by having them simply pass over the system without inflicting damage. This system has been implemented on sections of the Hubline, a 30-inch natural gas pipeline that crosses Boston Harbor. The Hubline and other systems (for instance, natural gas lines in the Gulf of Mexico) have relied on engineered materials (mats, gravel back-fill and other materials) to create an environment that will not allow penetration of the typical marine anchor. In addition, the Mineral Management Services within the US Department of the Interior has been monitoring the numerous natural gas pipelines that cross the Gulf of Mexico from many production platforms. They have already codified some of the requirements for installing these pipelines into the Code of Federal Regulations (e.g., 49CFR192, 30CFR).

However, it is not known how adding armoring materials, especially hard substrates such as rock or mats, to the generally fine-grained LIS seabed will impact the benthic community. The effect of such substrate changes may depend upon the shape of the deposit. A long, linear deposit that transits a large range of water depths might have a noticeable impact on benthic fauna.

It is suggested that the project planning/approval process should require applicants to identify high-risk areas — those that are most prone to anchor strikes, such as known shipping channels, and those most sensitive to habitat modification. This information can then be used to determine what sections, if any, of a cable or pipeline system should be armored.

The safety impacts of other energy infrastructures on or under LIS such as wind farm structures, tidal or current energy turbines, or other structures have not been addressed and are beyond the scope of this project. However, it is likely that the proposed increase in understanding of the value of various LIS organisms and habitats will contribute to the evaluation of any infrastructure proposed for LIS.

In summary, it is suggested that future cable/pipeline system projects should have risk assessments performed during the project's planning process to identify the higher risk areas susceptible to anchor strikes. Consideration should be given to armoring these regions to prevent anchor strikes, especially in the case of pipelines where such systems cannot currently be de-energized in milliseconds. The risk assessment phase of the project should also evaluate the dangers posed by pipelines containing compressed natural gas between isolation valves, and the optimum spacing for these isolation valves to minimize hazards to shipping and the general public.

INSTALLATION AND MAINTENANCE IMPACTS

This session's objective was to determine the short- and long-term effects of marine infrastructure construction activity on benthic habitats and the recovery of those habitats, including:

- Length of time for recovery of benthic habitats (and underlying sediment) after construction activity;
- Identification and understanding of the critical factors associated with habitat recovery;
- Investigation of recovery times of benthic habitats and an attempt to compare that recovery time to standard storm events;
- Comparison of the disturbances caused by construction activity versus molluscan aquaculture and harvesting activity.

Anthropogenic activities that affect benthic habitats in LIS include: navigational dredging, pipeline laying and embedment, electric cable removal and embedment, horizontal drilling, beach renourishment, and fishing and aquaculture activities. The impacts from all of these activities include modification of the bottom topography through alteration of the sediment-water interface, alteration of the sediment column and its erodibility (including the addition of new materials), and introduction of suspended sediment into the water column. Figure 1C shows a large-scale general disbursement of sediment types throughout LIS.

Navigational dredging has been conducted for many decades in many areas throughout LIS utilizing traditional clam-shell bucket dredging equipment (see Figure 6, below). This process consists of grabbing large bucketfuls of bottom sediment and placing them on a barge for disposal at one of the four active disposal sites within LIS. Navigational dredging occurs in limited areas (generally in areas which have been dredged previously), and is necessary to maintain the coastal infrastructure. Naturally this technique produces a large bottom disturbance and is accompanied by large increases in suspended sediment in the water column as depicted by the brown plume in Figure 6 (lower left side of the photo). However, there are appropriate controls on the amount of sediment that can be released in the water column, the timing of dredging and the disposal of material to minimize environmental damage. This kind of dredging uses techniques similar to those used in burying cables and pipelines in shallow water, although the areas dredged for cables generally haven't undergone previous dredging and aren't routinely exposed to the stresses of dredging.

Figure 6: Traditional Clam-Shell Bucket Navigational Dredging

It is anticipated that this type of dredging activity will cause suspended solid levels to reach the gram/liter (g/l) level within a few yards of the clam-shell, and would drop to a range of 100-900 mg/l out to several hundred yards. At a distance of 1000 yards or more from the dredge bucket, the suspended solid levels will drop to background values. However, dredging is not the only event which can produce large increases in suspended solids. Figure 7, below, shows the concentration of suspended sediment in New Haven harbor during a storm event that lasted for several days in 1993. Questions arise as to the differences in material suspended by a storm event versus dredging. The composition of the dredge material is probably dissimilar to that of the storm material in aerial extent and physical characteristics including floc/grain size and density, settling rate, and organic matter concentration. Also, the surface sediments in dredged mollusk areas may be altered in terms of grain size, composition or roughness, resulting in different suspended-sediment characteristics.

The installation of gas pipelines can also be expected to disturb the bottom of LIS. For instance, the installation of the Iroquois Pipeline relied on dredging for shallow regions (<30 feet) and post-jetting using air and water jets in depths from 30-58 feet. At depths below 58 feet, the pipeline was jetted in order to bury at least the lower half of the pipe below the sediment-water interface. However, the contractor was unable to restore the seabed to its original condition after the pipeline was installed (in part because of a severe winter storm), resulting in topographic variation that may have made the area less favorable for mollusks. In deeper water, this burial technique allows for lobster migration over the pipeline.

Other construction techniques are available for installing these and other energy infrastructure in LIS. Directional, or horizontal, drilling can be used to achieve a very low level of disturbance to the benthic community, at least if no off-normal conditions arise (e.g., drilling mud loss

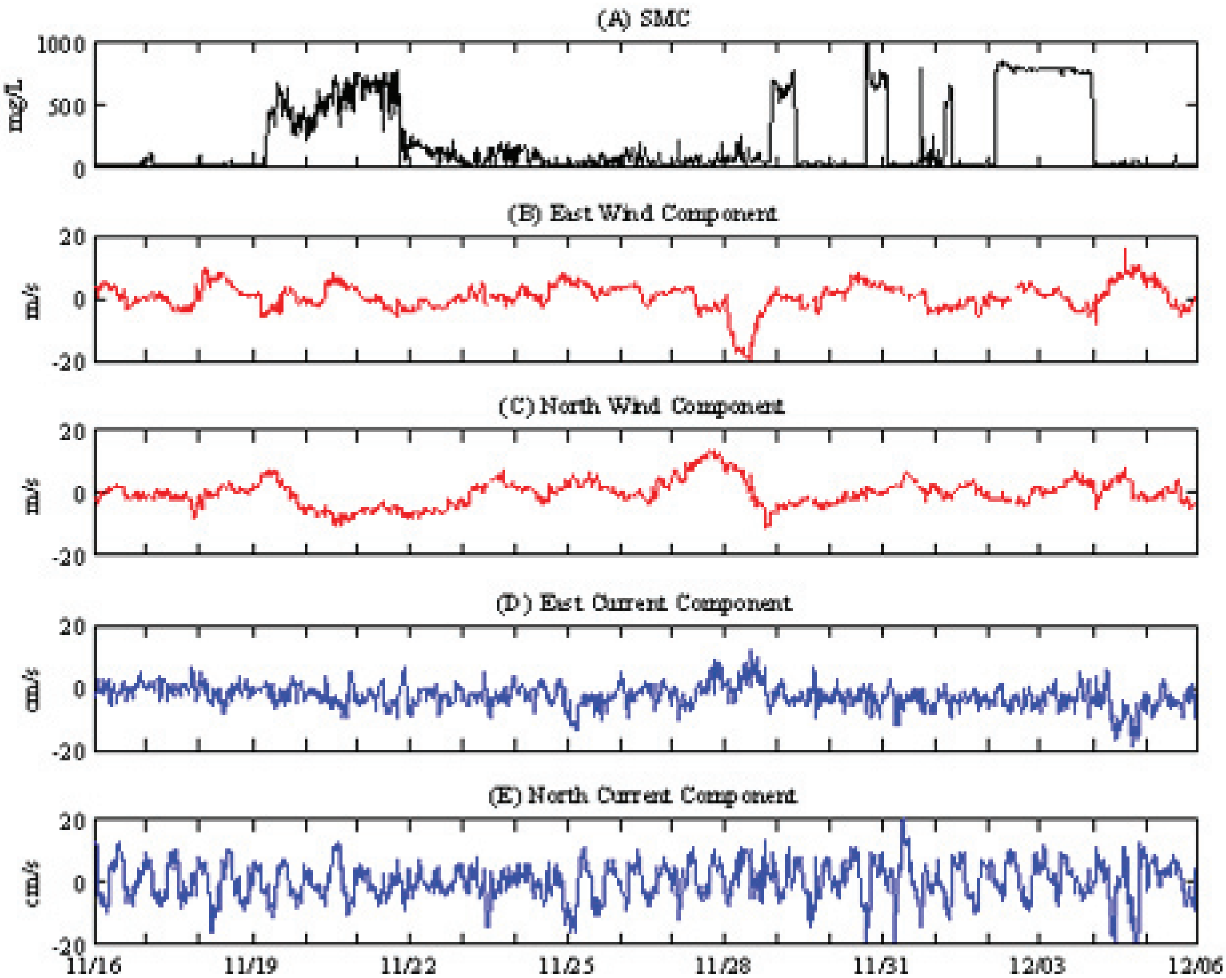


Figure 7: Suspended Sediment Levels and Current Values, New Haven Harbor Storm Event 1993

through fissure). The major concern with directional drilling is the potential loss of drill "mud," a clay-like substance not indigenous to LIS. However, in salt water this drill "mud" material can be readily identified and removed if necessary. Unfortunately, directional drilling is limited in its application and can only be used for distances under ~ 7,200 feet, although companies active in the field are advancing this limit. The most recent cable installation in LIS used a smart jet (plow), a sled that moved along the sea bottom and used hydraulic jets to temporarily suspend the sediment while the cable was placed several feet below the sediment/water interface. Table 3 shows various installation techniques with their expected impact area.

Technique	**Impact Distance/Side (ft)**	**Note**
Directional Drilling	0	Limited to 1-2 mile distances
Plow	~ 75	Not demonstrated for pipelines
Hydraulic Jetting	100-300	
Mechanical Dredging	100-150	Limited to near shore (shallow)

Table 3: Installation Technique Impact Area

The recovery time for anthropogenic activity can vary depending on the time of year, and the location and degree of impact. In general, it is expected that rapid responses, if not necessarily recovery, of the community (certain fauna) that was present before a disturbance will occur within the first three months, with recovery continuing for periods ranging from three to ten years, and possibly longer where there are sedimentological or topographic disturbances to the seabed, such as the creation of high and low areas on otherwise flat terrain. Anecdotal evidence was presented indicating that it is possible to identify the sediment surface where cables were installed at least three years ago, and the track of the Iroquois pipeline, installed in 1991, is still clearly defined as a bathymetric feature.

Data were presented during the symposium displaying suspended sediment levels possible from storm events (~ 500 mg/l). However, reportedly, no studies have been performed on understanding the response of benthic habitats to storm events or to dredging disturbances. Additionally, it is suggested that a determination should be made as to whether the criteria to be used in recovery analysis should include only community structure or also population characteristics of key species.

There was no discussion during the symposium that addressed what should be done with cables and pipelines at the end of their useful life. Consideration should be given to the impacts related to the abandonment in place or the removal of such infrastructure, as there would be little economic incentive to do so at the time removal may be required.

AESTHETICS

This study and the LIS Symposium focused on issues that did not take into consideration the many recreational uses of LIS. While utility infrastructure proposals received to date have focused discussion on the bottomland (e.g., cable/pipelines on the sea floor), consideration should be given to:

- the potential for installations that either permanently or temporarily occupy a large area or extend a considerable distance above the surface; or
- the potential for installations that extend a considerable distance along LIS's shoreline.

It is suggested that some measure of the potential impacts of this type of infrastructure on the aesthetics of LIS should be developed.

Exploration of this issue may warrant further consideration, including the formation of standards for energy structures that would be placed on and/or above the surface of LIS. These standards may take into consideration the many recreational uses of LIS including: sport fishing; boating (motor and sail) and other pleasure craft; and the relationship between regularly scheduled commercial ferry services and the location of such infrastructure.

IV. SUMMARY OF FINDINGS AND CONCLUDING REMARKS

The LIS Symposium provided information that can be used to inform the CEAB of next steps in its effort to create preferential criteria/standards that will be used in the consideration of energy-related projects in LIS. Most importantly, the symposium identified a need to focus attention on the general issue of the overall management of LIS for the purpose of gaining a better understanding of a variety of LIS issues and needs. Such a focus will serve the public interest by helping to balance the need for installation of energy-related projects with protection of the Sound's sensitive environmental areas and ecosystems. Organizational structures such as the Chesapeake Bay Program,the Gulf of Maine Council on the Marine Environment and the Gulf of Maine Mapping Initiative, and the LIS Study can serve as useful models for creating a mechanism to address Sound-wide environmental matters.

Consideration should be given to creating an organizational structure such as a Long Island Sound Center for the Marine Environment (LISCME) as a joint initiative of state (Connecticut and New York) and federal agencies, academic institutions and scientists to coordinate and oversee a collaborative effort for the purpose of developing a better understanding of, and to improve decision making with regard to, the environment and ecology of LIS. This type of regional collaborative effort could help ensure that LIS is viewed as a regional resource and that future research and studies will meet the needs of all agencies and regulators. This center would require funding and staff support at levels to assure it is sustainable and effective in meeting its goals and objectives. A strategy for securing adequate funding for operations and projects would need to be developed.

It is recognized that it may not be feasible or possible to create such a center, in which case it is suggested that the state consider implementing the suggestions and developing the concepts envisioned for the center within the various Connecticut state agencies and organizations that could assume such responsibilities.

Understanding the characteristics of the seabed is an essential tool for managing the marine environment for a variety of purposes, including: installation and maintenance of energy infrastructure, such as cables, pipelines, and renewable energy structures; the development and management of marine sanctuaries; commercial and recreational fishing, including shellfishing; aquaculture; and shipping. The purpose for which information about the marine environment will be used is a critical factor in determining the level of detail necessary for mapping all or portions of LIS.

Physical environment (non-living resource) mapping provides a foundation of information that can then be used to create habitat (living resource) maps of a variety of benthic organisms and species of interest. The ability to translate physical environment maps into habitat maps requires a better understanding of the relationships among species of interest and their physical, chemical, and biological environments. More detailed physical mapping of LIS may be necessary to develop habitat maps in areas of interest and on a Sound-wide basis. It is suggested that progress on understanding infrastructure impacts on LIS's benthic communities, and the broader but essential task of better understanding the overall structure and importance of benthic communities in LIS should be included in this effort.

Regardless of the organizational structure of such an entity, the following concepts should be considered:

- ➢ Develop the purpose and scope of an environmental evaluation program for LIS. This plan should take into consideration:
    - The need for a focused evaluation program for those regions of LIS most likely to be considered for energy infrastructure crossings. Possible mapping projects would include:
        - Mapping regions surrounding existing cables and pipelines, as well as integrating any data and information available from existing underwater infrastructure projects.
        - Selection of additional targeted areas that can be projected for use as future infrastructure crossings based upon the location of land-based support infrastructure and known sedimentary environments of LIS.
    - LIS-wide environmental management initiatives to identify resources for the purpose of creating marine sanctuaries or reserves, and for other purposes that may require additional detailed data, as well as mapping all or portions of LIS.
- ➢ Formulate goals and objectives for a LIS environmental evaluation program, such as:
    - Conducting an assessment of what is known, including the collection and analysis of existing data and maps, for adequacy to support program goals and objectives.
        - Certain areas may need to be mapped by securing additional data in finer detail based upon the characteristics of the sedimentary environment. For example, heterogeneous areas may need to be mapped in greater detail, while existing data and maps may be adequate in homogeneous areas. Determination and analysis of discriminators such as these will provide a foundation for decision making and a more focused mapping effort.
    - Developing technical projects to secure data and information, including additional mapping initiatives, where necessary, in support of the overall goals and objectives of the evaluation program.
    - Reviewing and assessing whether a standard habitat classification system for LIS should be adopted, and if so, facilitating a process for this purpose.
    - Identifying a risk assessment protocol for future infrastructure encroachments into LIS.
- ➢ Create a centralized data repository that is recognized and financially supported to inventory, archive, and disseminate all LIS technical information. This repository would develop a system to assure that various data and information and resultant products will be compatible with each other, with the needs of the environmental evaluation program,

and in compliance with federal standards. This system should include requirements, standards and protocols for data collection, navigation, and architecture for a GIS-based data and information system including appropriate metadata. This would enable data and information collected from publicly-funded research projects, and, as may be required, from owners of infrastructure projects installed in LIS, to be preserved and available for developing a comprehensive understanding of LIS. Additionally it is suggested that the repository:

- Be non-regulatory.
- Require agencies, contractors and academics who work in LIS to report results and raw data, where appropriate. Protocols can be established to keep certain kinds or aspects of data confidential for some appropriate time period, so that contributing data to the repository does not compromise academic or business enterprises.
- Consider development of a policy to provide free access to data and information to all researchers, agencies, companies, and possibly the public in an effort to promote the best studies, analyses, and infrastructure proposals.

➢ The mapping initiative for LIS would include:

- Creating non-living resource maps that identify the geology of the bottom and sub-bottom of LIS. These maps provide a foundation of information that can be used to create living resource maps. The characteristics of the bottom provide clues as to the type of living resources that may populate certain areas of the seabed. These types of maps include:
  - Sedimentary environment and textures maps created from sidescan or multibeam sonar or other technologies. Ground-truthing is used to verify the data that are collected electronically by using grab sampling, video and photo surveys and other methods. Figures 1A, 1B, and 1C represent examples of these types of maps.
  - Bathymetric maps to identify elevations of the seafloor and in conjunction with sedimentary environment mapping, provide a three-dimensional picture of the bottom.
  - Geotechnical mapping to determine the ability of the sediment to support certain types of structures; this type of map does not currently exist for LIS.
- Creating living resource maps to identify benthic habitats, mobile fauna habitats and endangered and threatened species. These maps would be created by using non-living resource maps and information to identify and prioritize areas for study, with sampling being done to identify specific habitats. A process to determine targeted species of concern for further study should be created. Additional research and study is necessary for scientists to develop methods to be able to produce habitat maps.
- Prioritizing the importance of nearshore, coastal and deep water mapping regions, and identifying the best and most cost effective methods and technologies for various types of mapping projects.

It should be expected that a complete mapping of the physical environment and living resources of LIS would involve significant cost and time. However, a suggested starting point for an initial pilot mapping project could be based on the state's interest in comparing the environmental impacts of various alternative routes for the purpose of siting future energy infrastructure crossings of LIS. The project would include selecting regions of the Sound to be mapped based on the location of relevant existing land based energy infrastructure. The process to determine the specific mapping activities would include a review of existing physical environment maps with sampling to determine if additional mapping is necessary. These maps would then be used to identify various habitats and to create habitat maps. Initial physical environment mapping of the nearshore areas within the targeted mapping region should be expected since very little physical environment information is currently available for nearshore areas of LIS.

Long Island Sound Data and Information

Any attempt to minimize the impacts of infrastructure development on the Sound's ecosystem will require a priori identification of key aquatic resources, habitats, species and ecological service functions. The CEAB's "Draft Preferential Criteria" provides a preliminary list of sensitive coastal resources and habitats and recognizes that other sensitive habitats may exist. Also, these criteria identify a need to avoid, minimize or mitigate effects of infrastructure development on these resources and habitats.

The LIS Symposium provided useful insights regarding some of the key habitats, species and processes, and identified a need for a process to facilitate the development of an overview of LIS as an ecosystem. However, although the need for additional data about LIS is important, it is suggested that the initial focus should be placed on developing a process that ensures adaptive management of LIS and the development of science-informed policy based on the best available science, while recognizing that the future will bring more and, hopefully better, scientific information.

Options for establishing the LICME to address Sound-wide environmental matters include expanding the mission of the LISS, creating a new bi-state organizational entity specifically designed for this purpose, or creating an initiative comprised of various Connecticut state agencies and organizations to assume such responsibilities. The LISS is a cooperative effort that was created to protect and improve the health of the LIS by implementing the Sound's Comprehensive Conservation and Management Plan (1994). The partners of the program include state and federal agencies, scientists from the region, and other stakeholders. The LISS website states: "the Plan identifies the 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. Using the Plan as a blueprint, the Long Island Sound Study has continued to refine and add detail to commitments and priorities, including the 1996 Long Island Sound Agreement and the 2003 Long Island Sound Agreement." Although other factors may be considered in the decision to develop LISCME, an advantage to utilizing the LISS is that they have already begun to develop a framework for bringing scientists and managers together.

Other programs previously mentioned, including the Chesapeake Bay Program and the Gulf of Maine Council/Gulf of Maine Mapping Initiative, provide an opportunity to learn from their experiences and can provide insight and guidance for the development of a Connecticut LIS initiative or the LISCME.

There are data relevant to LIS, including bathymetric maps, molluscan fisheries areas and habitat classification information that have been gathered over the last 50 years. However, these data do not provide a level of detail sufficient to allow informed decision making for future encroachments into LIS. It is suggested that this information be archived in any future data repository that is developed to house LIS data and information.

Benthic Habitat Classification and Mapping

Non-Living resource mapping initiatives have been completed for the Hudson River and are on-going for the Gulf of Maine. Benthic habitat mapping is being considered for both of these areas. A very rough estimate for the cost of a Sound-wide detailed non-living resource mapping initiative could exceed $10 million, and could be significantly higher based upon the scope of the mapping initiative. This estimate is based only on information available from non-living resource mapping initiatives in the Gulf of Maine and Hudson River. Relatively detailed non-living resource maps exist for LIS, but more detail is needed in correlating bottom types with habitat classifications. In addition, the shallow regions of LIS (< 5 m) have not received sufficient attention due to the difficulty and cost of using standard acoustic techniques to secure bathymetric data and bottom type information. New spectral imaging systems should be pursued for accurate and reduced cost mapping efforts in this nearshore region, although the timeline for using such systems is not yet known. Acoustical mapping techniques, such as multibeam technology, can map most areas of the bottom without the projected development time associated with optical techniques. More accessible survey vessels may also provide greater access to certain shallow water areas. Overall, there is currently insufficient information to determine the relative merits of comparing different cable or pipeline routes. Also, there is a need to develop an understanding of and methods for generating habitat maps from acoustic and/or optical images and bottom samples. Separate habitat maps must be generated for each species of interest, which requires an understanding of how a particular species uses the physical, chemical, and biological environment. Consideration should be given to supporting targeted habitat mapping pilot projects to test methods and use lessons learned to develop mapping protocols and techniques that could be used on a wider scale.

Endangered and Threatened Species

While both the state of Connecticut and the federal government have adopted an endangered and threatened species program, very little information is available on species that rely on LIS. Some information is available on large species, especially mammals, but no information has been systematically gathered on benthic species in LIS. Consideration should be given to developing a program within the LISCME to identify and list the benthic species including species that are endangered and threatened or of special concern. However, it should be noted that although there have been efforts in other estuaries to identify and list benthic species, there do not appear to be any known efforts to identify or list benthic species that may be endangered, threatened, or of special concern.

Mollusks

The review of mollusks in this study focuses on oysters and clams due to their inability to move in response to anthropogenic disturbances on the sea floor. Information regarding the location of leased oyster and clam shellfish beds that are utilized for growing, cultivating, and harvesting activities is known and available However, it is suggested that more detailed maps identifying the level of productivity of these regions should be produced in order to provide more accurate information that could then be used to assess the impacts of energy infrastructure installation and maintenance activities on this habitat. It seems possible that a cooperative effort of academics, personnel from the Connecticut Department of Agriculture and individuals employed in shellfish harvesting could produce the information necessary to create accurate maps that could be used for planning purposes.

Long term impacts of encroachment activities can be severe, altering both the bottom topography and the sediment density to such a degree that it would impact the productivity of the impacted shellfish beds for future mollusk growth and harvesting. This long term impact can last for years, even after mitigation. Reportedly, following the installation of cables and pipelines, impacted shellfish beds in LIS have not been restored to pre-construction levels of productivity. As a minimum, mitigation efforts should include: detailed mapping of the pre-installation conditions using high-resolution techniques; harvesting all shellfish prior to project initiation; restoring the bottom after the disturbance, matching sediment, morphology and especially planting shell where appropriate, and assessing financial penalties if restoration is not possible; and replacing lost shellfish with seed or market size, as appropriate. Although the technology and methods for shellfish bed restoration are known — including matching sediment layers and the preconstruction elevation profile — a variety of factors affect the ability to successfully accomplish this task. Successful restoration of a disturbed swath through a shellfish bed as a result of construction activity may be more difficult to achieve than creating a new shellfish bed. Pilot projects can test methods to construct new shellfish beds in LIS. If successful, creating new shellfish beds should be considered as an alternative for mitigating an encroachment into an existing shellfish bed.

EMF

No electric field is produced outside the shielded conductors of submerged cable installations. Additionally, the magnetic field produced in the operation of a cable is weak and at a level similar to that produced by the earth's magnetic field. Therefore, it is not expected that EMF generated by the operation of a submerged cable will have any impact on flora and fauna communities. If desired, existing measurement methods can be used to detect EMF from existing cables to confirm the values predicted in project planning.

Temperature Impacts

The low rate of steady-state energy dissipation from installed electric cables cannot have a significant impact on LIS given its large mass of water and rapid circulation. Therefore, the concern regarding temperature is more with the location of this energy transfer into the sediment layer and bottom boundary. In general, cables are designed so that during their operation, sediments located near a cable do not dry out. Under these conditions, little temperature rise is expected at the sediment-water interface. The thermal conductivity of the sediment layer, coupled with the known energy losses from the electric cables, will allow for accurate predictions of temperatures throughout the sediment layer — predictions that can be confirmed by careful measurements. Biologists will be able to evaluate these temperatures and predict if there will be any negative impacts on flora or fauna from these temperature changes.

Again, careful observation near both existing AC and DC cables and pipelines should be able to document the extent of any temperature anomaly and the degree to which the observed temperature distribution agrees with the predictions. It is expected that, although there will be some change in temperature in the sediment immediately surrounding a cable, the depth of its burial and insulating factors of the cable will minimize the impacts, if any, on the benthic habitats located in the immediate vicinity of a cable installation. Since pipelines operate at near-ambient temperatures, it is not expected that their operation will cause any negative impacts due to temperature.

Safety Issues and Impacts

An anchor striking a submerged object was the main safety issue addressed during the symposium. Representatives of Northeast Utilities indicated that the 135-kV AC cable between Norwalk and Long Island has been caught and severed on at least three occasions. Some of the older electric cables are fluid-filled, contributing to the potential environmental impacts of a broken cable. However, newer cables do not have a fluid component, which eliminates one of the potential environmental consequences of a severed cable. Several panelists were involved in projects that used engineered materials to provide protection for cables and pipelines. Most recently, this method was used to protect a section of the Hubline, a submerged natural gas pipeline located in Boston Harbor. These same materials can also be applied to submerged electric or telecommunication cables. The effects on benthic habitats of materials used to armor cables need to be better understood. It is suggested that the planning phase of a project should include a risk assessment to determine the degree to which areas along a project's proposed route are susceptible to anchors strikes and thus worthy of protection. Additionally, it is suggested that a risk assessment for a pipeline project include an analysis of impacts or hazards caused by a sudden release of compressed natural gas between a pipeline's isolation valves.

Installation and Maintenance Impacts

Initial installation and subsequent maintenance activities can be expected to produce repeated sea bottom disturbances from virtually any encroachment into LIS. Given that any infrastructure project will require occasional maintenance, and possibly removal at the end of its design life, it is suggested that cumulative impacts of infrastructure projects should be considered. It is generally understood that initial impacts can be expected to last for months, with long-term effects possibly lasting for years. However, the precise nature of the impacts needs to be better understood. For example, there may be a rapid return of biomass, not necessarily recovery, to a disturbed area, but it may take longer for a more typical bottom benthic community to be rebuilt. However, the precise nature of the impacts, and sedimentary conditions, both in shallow and deep water, that are needed to minimize impacts on the various benthic habitats needs to be better understood. Additionally, restoration efforts of habitats, such as valuable shellfish beds, need to be completed in a manner so as to restore such areas to pre-construction productivity, or provide compensation for the loss of productivity of these impacted areas.

It appears that the industry is engaged in ongoing efforts to seek methods to minimize the impacts of the installation and maintenance of cables and pipelines. Certain methods, such as horizontal drilling, can currently transit areas up to 7,200 feet with little or no impact to the surface over which it is installed. Also, the timing of construction activity should be planned to minimize its effects on the benthic community and life within the water column.

Aesthetics

The question of the aesthetics of LIS was not included in the scope of this project, but was added to this report in order to identify it as an issue that may need to be considered in the future. It is suggested that the value of LIS cannot be measured simply by the value of fish produced or other economic criteria. Consideration should be given to identifying a value that can be applied to the aesthetic enjoyment of the Sound's open surface and long vistas with regard to the evaluation of projects that may be considered for placement on the surface or above LIS.

Overview of Findings

I. Long Island Sound Data & Information

Issues

- No organization in place to address all LIS-wide environmental issues of concern & coordination of research activities.
- No centralized data repository recognized and financially supported for collecting & storing all LIS data.
- Data is scattered & non-uniform.

Findings

- **Create LIS-wide Organization**
  - Mission: Coordinate and oversee collaborative effort to develop a better understanding of and to improve decision making with regard to the environment and ecology of LIS.
  - Multi-state effort w/federal agencies; or through CT agencies, with others as appropriate.
  - Need process to establish community of experts to provide guidance and undertake research.
  - Create LIS centralized data repository.
  - Use existing models to guide development: LIS Study, LIS Research Center, Chesapeake Bay Program, Gulf of Maine Council and Gulf of Maine Mapping Initiative
  - Develop strategy to secure funding for sustainability.

LIS Center for the Marine Environment - Concept

- **Develop Purpose and Scope of LIS Environmental Evaluation Program**
  - Focused evaluation program for areas most likely to be considered for energy infrastructure crossings, including targeted mapping projects.
  - LIS-wide environmental management initiatives for creating marine sanctuaries/reserves and other purposes, including mapping all or portions of LIS.
- **Formulate Goals and Objectives for LIS Environmental Evaluation Program**
  - Facilitate process to review/assess/adopt habitat classification system.
  - Identify risk assessment protocol for future infrastructure encroachments in LIS.
  - Identify specific mapping, habitat & other knowledge gaps.
- **Create Centralized Data Repository**
  - Non-regulatory.
  - Establish guidelines/standards for data collection, storage & dissemination.
  - Protocols should insure future data are: compatible; useful; available; & archived.
  - Assemble existing LIS data.
  - Require publicly funded research results & data, and approved infrastructure project data to be reported.
- **LIS Mapping Initiative**
  - Prioritize mapping initiatives and identify the best and most cost effective methods and technologies for mapping projects.
  - Create non-living resource maps (sedimentary environment and texture maps; bathymetric maps; and geotechnical maps) as needed to supplement existing information in support of objectives of mapping initiative.
  - Create living resource maps to identify benthic habitats, mobile fauna habitats, and endangered and threatened species.
    - Non-living resource maps provide foundation for creating habitat maps.
    - Additional research and study necessary for scientists to develop methods to produce habitat maps.
    - Identify species of concern for further study and habitat mapping.

Overview of Findings (Continued)

A. Benthic Habitat Classification & Mapping

- Non-living resource mapping initiative completed for Hudson River and on-going for Gulf of Maine.
- Existing LIS information is insufficient for infrastructure planning and siting decision making.
- Non-living resource maps exist for LIS but more detail is needed to correlate seabottom types with habitat classifications.
- Shallow water regions of LIS are not adequately mapped.
  - Optical imaging technology is under development and offers opportunity for reduced cost shallow water mapping.
  - More accessible survey vessels with multibeam mapping technology may also provide greater access to nearshore shallow water regions of interest.
- Consider supporting targeted habitat mapping pilot projects to test methods and use lessons learned to develop habitat mapping protocols that could be used on a wider scale.

B. Endangered and Threatened Species

- Some coastal regions are involved in listing benthic species. However, no known efforts to identify or list benthic species that are endangered, threatened, or species of concern.
- For LIS, some information is known about large species, but no information has been gathered about benthic species.
- Consideration should be given to developing program (possibly in conjunction with benthic habitat mapping initiatives) to identify and list the benthic species of LIS including endangered and threatened species and species of special concern.

C. Mollusks

- Focus placed on oysters and clams due to their immobility in the event of installation and maintenance disturbances.
- Location of oyster and clam shellfish beds is known. State leases 57,000 acres of seabed for shellfishing and owns/maintains 5,000 acres of natural oyster seed beds. Towns lease 15,000 acres of shellfish beds.
- Consideration should be given to producing detailed maps identifying level of productivity of shellfish beds for purpose of assessing impacts of energy infrastructure installation and maintenance activities on shellfish habitats.
- Long-term effects of encroachment activities can last for years and result in loss of productivity of impacted shellfish beds.
- Mitigation efforts should include: detailed mapping of pre-installation conditions; harvesting all shellfish prior to start of project; restoring bottom after disturbance – matching sediment, morphology, and planting shell, where appropriate; assessing financial penalties if restoration is not successful; and replacing lost shellfish with seed or market size, as appropriate.
- Technology and methods for shellfish bed restoration are known. In LIS, there have been no known successful shellfish bed restorations as a result of a cable or pipeline installation.
- Successful restoration of a “swath” through a shellfish bed to pre-disturbance level of productivity may be more difficult to achieve as compared to creating new shellfish beds, as compensation for loss of productivity of the impacted shellfish bed.
- Pilot projects can test methods to construct new shellfish beds in LIS. If successful, creating new shellfish beds could be an alternative for mitigating an encroachment into an existing shellfish bed.

Overview of Findings (Continued)

II. Impact Analyses

A. EMF

- No electric field is produced outside shielded conductors of submerged cables.
- Magnetic field produced in cable operation is weak and at levels similar to that produced by earth's magnetic field.
- It is not expected the EMF generated by operation of a submerged cable will have any impact on flora and fauna communities.
- Existing measurement methods can be used to verify EMF levels predicted in project planning, if desired.

B. Temperature Impacts

- Low rate of steady-state energy dissipation (temperature increase of water), if any, in surrounding area, from operation of a submerged cable will not have significant impact on the large mass of water and rapid circulation of LIS.
- Cables are designed to minimize loss of energy, heat, into sediment layer surrounding submerged cable.
- Temperature change in area surrounding cables can be calculated during project planning and confirmed by careful measurement following installation.
- Some change in temperature is expected, although depth of cable burial will minimize any impact on benthic communities in vicinity of cable.
- Biologists will be able to evaluate impacts, if any, on benthic flora and fauna from temperature calculations and actual measurements, as appropriate.
- No impacts are expected from the operation of pipelines, since they operate at or near ambient temperatures.

C. Safety Issues and Impacts

- High-speed circuit breakers very quickly de-energize submerged cables in event of an anchor strike or other equipment snag eliminating any hazard to the public from release of energy caused by a break in a cable.
- Areas along a cable or pipeline route that are susceptible to anchor strikes, etc. should be protected with engineered materials. Cable and pipeline burial depths, alone, do not necessarily provide adequate protection to prevent damage to submerged infrastructure.
- Effects on benthic habitats of materials used to armor submerged infrastructure need to be better understood.
- Planning phase of a project should include risk assessment to determine which areas along cable/pipeline route should be armored.
- Risk assessment for a pipeline project should include analysis of any impacts/hazards that may be caused by a sudden release of compressed natural gas between a pipeline's isolation valves.

D. Installation and Maintenance Impacts

- Since installation and subsequent maintenance activities along a submerged cable/pipeline route can be expected to produce repeated disturbances to the sea bottom the cumulative impacts should be considered during the project review process.
- Initial impacts from an installation of a cable/pipeline can last for months and long-term impacts can possibly last for years.
- Disturbed areas may see rapid return of biomass, but it may take longer for typical bottom type benthic communities to be rebuilt. Conditions needed to minimize impacts on benthic communities need to be better understood.
- Shellfish bed restoration efforts need to be completed in a manner so as to restore such areas to pre-construction levels of productivity, or provide compensation for loss of productivity. *(See Mollusk Section for additional comments)*
- Consider impacts of de-commissioning cables & pipelines at end of their useful life – abandonment or careful removal.

Overview of Findings (Continued)

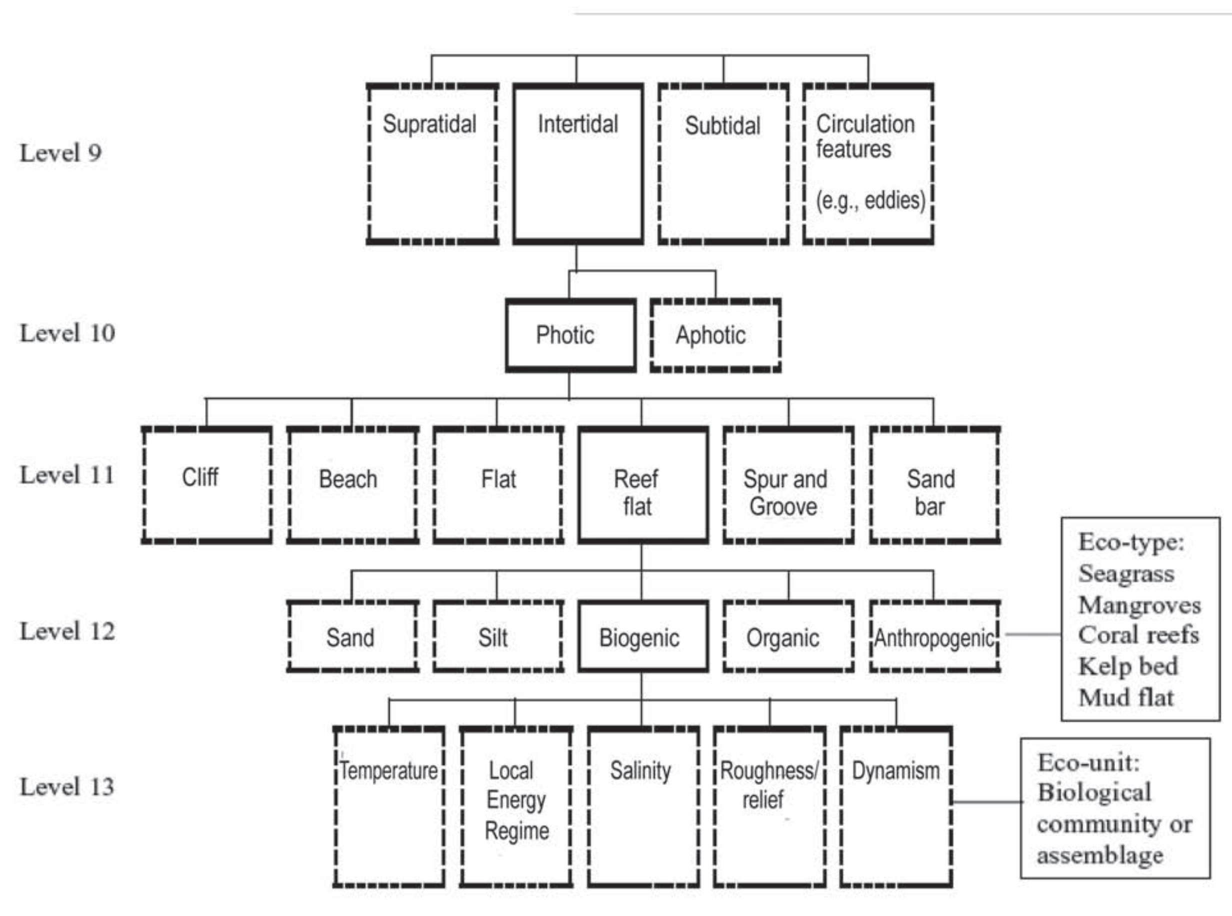
E. Aesthetics
• Aesthetics of LIS was not included in the scope of this project, but was added to the report for future consideration. • Consideration should be given to identifying a value that can be applied to the aesthetic enjoyment of the Sound's open surface and long vistas with regard to the evaluation of projects that may be considered for placement on the surface of or above LIS.

APPENDIX A

SPECTRAL IMAGING TECHNIQUES

Sensor	**Platform**	**Spectral Resolution**	**Spatial Resolution**	**Estimated Cost**
MODIS/SeaWiFS	satellite	6-7 bands	1 km (visible)	free
IKONOS	satellite	4 broad bands	1 - 4 m	$2625/scene
Hyperion	satellite	Hyperspectral (10 nm)	30 m	$1500/42 km $2500/185 km $2000 priority
ALI	satellite	4 broad bands	30 m	+$300/2 sensors
HyMap	aircraft	Hyperspectral (15-20 nm)	3.5-10 m	$40K/area of Monterey Bay
PHILLS (FERI)	aircraft	Hyperspectral (<5 nm)	4 m	$25K/day plus deployment fee
AVIRIS	aircraft	Hyperspectral (10 nm)	17 m	$70K non-NASA

APPENDIX B
NOAA HABITAT CLASSIFICATIONS



Appendix C

Overview of Technologies for Habitat Data Collection

Technology	Parameter(s)/Data Layers	Maximum Swath ($km^2.h^{-1}$)	Spatial Resolution (horizontal)	Ground truth method(s)	Strengths	Challenges
Side scan sonar (acoustic)	substrate, bedforms, relief, backscatter	3.5 (depends on swath width)	As fine as 0.01 m up to 5 m. Best for 0.1 m.	Diver survey, video, photography, grabs	The only technology capable of producing coverage imagery of the seafloor surface at all depths. Good for object detection.	Distortion from unintended sensor motion; Poor coverage directly below the sensor; navigational hazards in shallow water; sometimes difficult to distinguish substrate from slope changes; geo-hazards and kelp hazards
Single-beam echosounder (acoustic)	Bathymetry, large-scale substrate	1.5			Can interface with acoustic substrate classifiers	Narrow beam surface coverage; better for transects than for complete coverage
Multibeam swath mapping (acoustic)	Substrate, bathymetry, slope, bedforms, relief, backscatter	5 (depends on water depth)	As fine as 0.1 m up to 5 m. Best at 1 meter resolution.	Diver survey, video, photography, grabs	Less sensitive to motion; continuous coverage below the sensor; generate detailed, quantitative bathymetric data that is good for classification and image processing	swath width limited by water depth ; data from outer beams can be questionable

Appendix C

Overview of Technologies for Habitat Data Collection (cont.)

Technology	Parameter(s)/Data Layers	Swath ($km^2.h^{-1}$)	Spatial Resolution (horizontal)	Ground truth method(s)	Strengths	Challenges
Diver transects	Fish, substrate, mega-epibenthos, dominant biological species			Already ground-truthed		Intensive; visibility limitations
Diver video	Fish, substrate, mega-epibent hos, dominant biological species	.2	From .01 m to 1 m. Best at .1 m.	Already ground truthed	Allows mega-epibenthos identification	Intensive; visibility limitations
Drop or towed video	Fish, substrate, mega-epibenthos, dominant biological species	.2	From .01 m to 1 m. Best at .1 m.	Already ground-truthed		Navigational hazards in shallow water; visibility limitations; intensive; tows are difficult in complex areas
ROV video	Substrate, fish, mega epibenthos identification			diver		Difficult to operate in complex areas; kelp hazards; some vis. limits when operated near bottom
Aerial photography	Vegetation, substrate		.5-10 meters	Diver or towed video		Light penetration limits (15 – 20m depth); cloud interference; glare
Satellite imagery	Vegetation	>100	Spatial resolution varies depending on the sensor (60 cm to 1 km)		Can map a large area; good for shallow waters	Resolution is not as fine as some other methods; poor in deeper waters; cloud interference

Appendix C

Overview of Technologies for Habitat Data Collection (cont.)

Technology	Parameter(s)/Data Layers	Swath ($km^2.h^{-1}$)	Spatial Resolution (horizontal)	Ground truth method(s)	Strengths	Challenges
Diver transects	Fish, substrate, mega-epibenthos, dominant biological species			Already ground-truthed		Intensive; visibility limitations
Diver video	Fish, substrate, mega-epibent hos, dominant biological species	.2	From .01 m to 1 m. Best at .1 m.	Already ground truthed	Allows mega-epibenthos identification	Intensive; visibility limitations
Drop or towed video	Fish, substrate, mega-epibenthos, dominant biological species	.2	From .01 m to 1 m. Best at .1 m.	Already ground-truthed		Navigational hazards in shallow water; visibility limitations; intensive; tows are difficult in complex areas
ROV video	Substrate, fish, mega epibenthos identification			diver		Difficult to operate in complex areas; kelp hazards; some vis. limits when operated near bottom
Aerial photography	Vegetation, substrate		.5-10 meters	Diver or towed video		Light penetration limits (15 – 20m depth); cloud interference; glare
Satellite imagery	Vegetation	>100	Spatial resolution varies depending on the sensor (60 cm to 1 km)		Can map a large area; good for shallow waters	Resolution is not as fine as some other methods; poor in deeper waters; cloud interference

APPENDIX C (CONTINUED)

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APPENDIX D

Assume Free Convection (conservative, ignores bottom currents which will produce higher convective coefficients) at the Sediment-Water Interface

Average Free Convection Coefficient for Water $h = 100\ W/m^2*k$

Assume Conduction occurs directly above Electric Cable (No heat dispersion radially through sediment, very conservative)

From Siting Council Finding of Facts

Qdot = 25 W/ linear foot of cable

Therefore if cable is ~ 0.5 ft diameter
then,
Qdot =25 W / (1 foot length)*(0.5 foot width) = 50 W/ft^2

Qdot = 538 W/m^2

Qdot=h*ΔT

538 W/m^2 = 100 W/m^2 °C *ΔT

$\therefore\ \Delta T \cong 5.5$ °C

This conservative analysis indicates that sediment-water temperature should be no more than 5.5 °C above water column temperature

APPENDIX E

Agenda
Connecticut Energy Advisory Board
Long Island Sound Bottomlands Symposium:
A Study of Benthic Habitats
July 28-29, 2004

Introduction: This draft agenda for the Long Island Sound (LIS) Bottomlands Symposium has been developed by the Connecticut Academy of Science and Engineering on behalf of the Connecticut Energy Advisory Board (CEAB) as a result of discussions with the CEAB Preferential Standards Planning Committee. It is presented for review, comment and guidance in an effort to identify the appropriate topics and issues to be presented for discussion and debate at the Symposium.

Background:
Pursuant to Public Act 03-140 the Connecticut Energy Advisory Board is required to develop preferential standards that will be incorporated into a revised evaluation process for new energy projects in Connecticut.[1] The findings and recommendations of the symposium will provide valuable, necessary information for the development of preferential standards specifically related to Long Island Sound.

In developing the preferential standards for LIS, the CEAB shall take into account the recommendations and findings of the Task Force on Long Island Sound (hereinafter "Task Force report") prepared pursuant to Public Act 02-95 and Executive Order 26. One of the key recommendations of the Task Force that specifically addresses the availability and further need for data and information on Long Island Sound is the following:

> "Much of the data presented was developed by state and federal agencies, and is useful in generally identifying the resources of Long Island Sound. However, substantially more detailed and timely resource information is required for comprehensive planning, and for making project-specific assessments and site-specific determinations of resource delineation, environmental impact, and engineering constructability" http://www.sustainenergy.org/taskForceWorkingGroup/AssessmentReport2.pdf)

Purpose of LIS Symposium:
To convene national and local experts to assist Connecticut in understanding the most accurate yet cost-effective means to analyze and evaluate available data about Long Island Sound and to identify additional habitat / ecosystem information that would enhance the capability of state agencies in planning, managing and evaluating proposed energy related uses of Long Island Sound and its bottomlands.[3]

The goal of the above-referenced analysis is to identify an appropriate level of data needed for broad, long-term marine infrastructure[4] planning purposes that will assist in the formulation of preferential standards. This identification may require something less than a comprehensive resource mapping of all Long Island Sound estuarine and marine bottomlands but will provide adequate information for long-term planning. In addition, decision-making for individual projects requiring state and federal permits will be supplemented by site-specific data and analysis supplied by the applicants as well. As such, the types of data that should be required to be supplied by applicants seeking state and federal permits should also be identified.

APPENDIX E (CONTINUED)

I. Long Island Sound Data and Information

Objective: Identify the research, monitoring and analysis needed in the three areas: habitat classification/mapping; identification and mapping of rare and endangered species; and mapping of molluscan (i.e., shellfish beds) populations to identify an appropriate level of data and information needed to improve the understanding of the effects and management of proposed uses of, encroachments into, Long Island Sound bottomlands.

> ***For each symposium topic, the speakers will be asked to discuss the following topics relative to what is in Long Island Sound, either naturally or man-made, and where is it located for coastal, near shore and offshore regions:***

1. To effectively evaluate the impacts of the proposed uses and encroachments into LIS, what information or data do we need now and what will we need in the next five to ten years?
2. Do we have the required information or data to evaluate the impacts of the proposed uses and encroachments into LIS? Where are the shortfalls?
3. What is needed to complete the information or database in terms of cost and resources?
4. What are the recommended approaches for obtaining, housing and accessing information or databases?

Topic 1.1: Benthic Habitat Classification and Mapping

Background:
The Task Force report identified a suite of adequately and inadequately mapped habitat features such as benthic substrates, rocky reefs, and other critical habitats or living resources such as wildlife, finfish and shellfish. Whether the habitat features are adequately mapped needs to be verified and the areas where there are data gaps also need to be identified.

Attempts to relate benthic communities to sea floor environments in Long Island Sound began in the 1950's, with significant efforts in the1970's and early1980s (see http://pubs.usgs.gov/of/of98-502/chapt4/rz1cont.htm). In the 1990's with funding from Long Island Sound Research Fund grants and the USGS, Ralph Lewis (then at the CT DEP), Roman Zajac at the University of New Haven and researchers at the USGS (Larry Poppe, Harley Knebel, Dave Twichell) initiated a comprehensive benthic mapping program for Long Island Sound using technologies such as side scan sonar and video imaging. In addition to developing Sound-wide maps depicting sea floor environments, detailed studies were conducted in several project areas where benthic communities were related to sea floor habitats and 'habitat' maps were produced. A portion of these investigations are summarized in an article entitled, "Relationship among sea-floor structure and benthic communities in Long Island Sound at regional and benthoscape scales" by Zajac, et.al. (2000). More recently, NOAA developed a draft classification for marine and estuarine ecosystems. The US Fish & Wildlife Service has been meeting with scientists from LIS to develop a habitat classification for submerged lands. This ad-hoc team examined the NOAA classification and found it to be inadequate for the Sound. This project has no dedicated funds to support the development of this classification and no mandatory deadlines.

APPENDIX E (CONTINUED)

Objective: To determine and identify habitat classification needs for estuarine and marine bottomlands that will assist planning for and management of uses and encroachments into LIS bottomlands and to learn more about estuarine and marine habitat mapping and the associated costs to enhance bottomland mapping efforts in the Sound.

***To be addressed*:**

1. What approaches to classify aquatic habitat have been successfully used in other estuaries? Which of these efforts map habitats as opposed to surficial sediments or sedimentary environments?
2. Are there any habitat classifications other than the NOAA draft?
3. What mapping technologies for both offshore and near shore waters were most successful? What were their limitations?
4. Do we have a good start in mapping benthic habitats in LIS as described by Roman Zajac in the above-referenced article and what are the constraints to completing this project (e.g., funding, scientists, and taxonomists)?
5. Are the benthic habitats in LIS stable (persistent) or dynamic (subject to change)? If dynamic, how would that affect the reliability of habitat characterization and mapping data over time? How frequently would remapping need to be conducted? Are there definable areas of stable or dynamic habitat conditions?
6. Are the mapping approaches for the Gulf of Maine or elsewhere adequate for siting marine infrastructure?[5] What level of information or data was necessary to evaluate the environmental impacts on benthic environments?
7. To complete the mapping of the near shore sedimentary environments and surficial sediments of the near shore zone, is the constraint funding or technology (e.g., do we merely adapt the offshore techniques to shallow draft vessels?).
8. What level of mapping, habitat classification and benthic community characterizations should be required for new infrastructure projects?

Topic 1.2: Endangered and Threatened Species.

Background:
There is a federal and state Endangered Species Act that establishes a set of regulatory requirements distinct from state and federal permitting requirements for construction activities in tidal waters. The first list of 'rare' species in Connecticut was published in 1976. Since that time there has been no concerted effort to identify the rare species of Long or Fishers Island Sounds (e.g., invertebrates and macrophytes). One of the rarest sea turtles, for example, the Kemp's Ridley turtle is present in Long Island Sound but little or no information is known about its distribution or the habitats that it uses.

Objective: To identify the threatened and endangered species found in LIS and their relevant life stages that might be adversely affected by certain current and proposed uses of benthic environments in LIS.

To be addressed:

1. To what extent has the federal list investigated the rare and endangered invertebrates and macrophytes of estuarine waters?

APPENDIX E (CONTINUED)

2. Has any coastal state comprehensively listed bottomland species? If so, what methodologies were employed to develop the list?
3. Once a list is established, is the species distribution determined?
4. What are the endangered species in LIS?
5. When and where are they found and at what life stages?
6. How are they affected by certain proposed uses of and encroachments into LIS bottomlands?
7. What are the ecologically important species and their critical habitat?

Topic 1.3: Mollusks

Background:
There is a subgroup of mollusks, especially oysters and clams (bivalves) that are harvested commercially or recreationally. Concentrations of these bivalves are often referred to as shellfish beds, but the term shellfish also applies to lobsters. Here we make the distinction, as is done nationally (in the classification of wetlands and deep waters habitats) between shellfish and use the term mollusks.

From the standpoint of permitting marine activities and infrastructures, the Corps of Engineers and CT DEP evaluate the impacts of proposed activities upon mollusks, particularly hard clam, soft clam and oysters. Two maps have been produced for Long Island Sound that show concentrations of oysters, hard clams and soft clams but the problem with this information is that there is no distinction between the categories historic, existing and potential, nor how the map was created and what data was used. Additionally, the maps do not provide any information on the populations of bivalves that might be present in these areas. Consequently, these maps do not provide a level of scientific data that could be sustained as part of an administrative hearing or court proceeding. Instead, these maps have been used as a guide to decide when applicants should be required to conduct field surveys to determine shellfish productivity and potential adverse impacts.

Objective: To develop comprehensive molluscan maps that document the distribution of key commercial and recreational shellfish resources in LIS with appropriate differentiation between actual and potential presence.

To be addressed:
1. What methodology will best develop a database/maps of molluscan distribution and abundance? How often is mapping required?
2. What are the commercial or recreationally significant species of LIS?
3. What are the specific areas of LIS that are required for the well-being of those commercial and recreationally significant species and what food chains are necessary to allow them to thrive?
4. How do bottomland disturbance impacts from molluscan aquaculture and harvesting activity differ from cable installation techniques?
5. What should be required of applicants and harvesters to identify molluscan productivity and effects in areas of potential adverse impacts?

APPENDIX E (CONTINUED)

II. Impact Analyses

Objective: To evaluate the short-term and long-term environmental and ecological impacts of marine infrastructure and the measures available to avoid, minimize or mitigate such impacts.

For each symposium topic, the speaker will be asked to discuss the following topics:

1. What are the environmental and ecological impacts? Are they well known? How do they differ by geographic area, e.g. near shore, off shore, coastal?
2. How transferable are information, data and impact assessments from other areas?
3. What impacts observed in other areas are not transferable to Long Island Sound? Why aren't they? Would additional information or data about the Sound enhance transferability?
4. Where have corridors for cables and pipelines across contained bodies of water been instituted? What is known about the environmental impact of those corridors? How does the impact differ depending upon the geographic area? **(*See also topic 1.1)***
5. If environmental impacts are unknown or poorly defined, what data are needed to identify and understand those impacts? Consider: ***(See also topic 1.1)***
   - Exact specification of the data to be obtained.
   - Method(s) of collection of those data.
   - Funds estimated to be required to obtain the data.
   - Time needed to collect the data and analyze the results.
   - Probability that the analysis will answer the impact question.

Topic 2.1: EMF

Objective: To identify potential effects of EMF on aquatic and human life proximate to marine infrastructures.

To be addressed:
1. What are the electromagnetic frequency strengths at the seafloor from underground cables buried at specific depths below the seafloor? How have these measurements been made (towed magnetometer)? Are these instruments too insensitive – are new tools needed to measure EMF in the field?
2. What are the specific EMF strengths that affect various biotas, e. g. shellfish, bottom feeding fish, predator fish, seafloor plants, worms, eels etc?
3. Can EMF have any effect on humans and their uses of the Sound? If so, under what conditions? How can those affects be managed or mitigated?
4. What are the differences between DC versus AC cables with regards to magnetic fields and electro-magnetic fields
5. Can EMF have an impact on the food harvested from LIS?

Topic 2.2: Temperature Impacts

Objective: To identify potential effects of temperature change caused by marine infrastructure crossings on aquatic life and ecosystems of Long Island Sound.

APPENDIX E (CONTINUED)

To be addressed:

1. What temperature differences can be observed at the seafloor as a function of depth from buried cables?
2. Are these temperature differences of consequence (plus or minus) to any species of biota? (*See list above under Topic 2.1*)
3. Are these temperature differences of consequence to the overall temperature of the water in the Sound?

Topic 2.3: Safety Issues and Impacts

Objective: To ensure marine infrastructure crossings are constructed with due attention to standards that prevent accidental anchor or other equipment snagging or strikes.

To be addressed:

1. What is known about conflicts between cables/pipelines and bottomland activities such as dragging, trawling and anchor strikes? What are the public safety issues related to these conflicts?
2. How are siting and placement criteria or standards developed that ensure that a cable is buried to a suitable depth to avoid strikes from anchors or trawling (e.g., size and tonnage of ships, speed, anchor type, dragging types, sediment characterization [e.g., texture]). What model/methods are available to predict anchor strikes?

Topic 2.4: Installation and Maintenance Impacts

Objective: To determine short and long-term effects of marine infrastructure construction activity on benthic habitats and their recovery (includes impacts to benthic organisms and mobile macrofauna).

To be addressed:

1. What are the lengths of time for recovery of the benthic habitat and underlying sedimentary environment associated with the various construction or installation technologies or techniques (e.g., air lifting, jet plow, dredging, horizontal directional drilling, blasting)? What are the critical factors?
2. How do those bottomland disturbance impacts and recovery times referenced in question number 1 above associated with construction techniques compare or differ from activities such as standard storm events, molluscan aquaculture and harvesting and navigational dredging projects in terms of intensity, duration or impact?
3. How do state of the art technologies to bury cables and pipelines vary in their impact to the environment (e.g., turbidity plumes – distance from disturbance that turbidity can cause impacts)?
4. What studies are recommended for individual projects proposed in bottomlands to determine impacts (e.g., benthic diversity, & biomass)?

(Footnotes)

[1] The preferential standards or criteria will address the substantive areas of energy reliability, environmental and natural resource protection, societal impacts and cost effectiveness. Competing proposals for energy projects will be evaluated against the established criteria.

[2] The Task Force Report Part II, for instance, includes a summary of existing data/mapping types for Long Island Sound in Table 17 (page 154 – 156). Some of the datasets will be useful in the development of the performance standards.

APPENDIX E (CONTINUED)

[3] The analysis and evaluation of available data would take into account the documentation of the Task Force report.
[4] "Marine infrastructure" includes, but is not limited to, electric power line, gas pipeline, and telecommunication crossings.
[5] Seafloor mapping is a priority for the Gulf of Maine and it is a multi-year effort contingent upon available funds. It has been reported that available mapping was used to successfully site a fiber optic cable in a manner that minimizes adverse environmental impacts. See *Coastal Services*, Vol. 7, Issue 2, March/April 2004 article entitled, "Talking about a Revolution: The Gulf of Maine Mapping Initiative."

APPENDIX F

LONG ISLAND SOUND SYMPOSIUM/STUDY PANELISTS

Impact Analyses

JULY 28, 2004: 8:50 am – 12 Noon

Installation and Maintenance Impacts

W. Frank Bohlen, PhD *(Rapporteur)*
Professor of Marine Sciences, University of Connecticut

Focus on Short Term Impacts

Brian Dorwart, PE, PG
Vice President, Haley & Aldrich, Inc.

Thomas J. Fredette, PhD
DAMOS Program Manager, U.S. Army Corp of Engineers, New England District

Richard E. Kleiman
Vice President, ESS Group, Inc.

Michael Ludwig
Ecologist, NOAA, National Marine Fisheries Service

Larry Williams
President/Owner, Jessie D, Inc.

Focus on Long Term Impacts

Peter J. Auster, PhD
Science Director, National Undersea Research Center, University of Connecticut

Drew A. Carey, PhD
Principal Scientist, CoastalVision

Glenn Lanan
Senior Project Manager, INTEC Engineering

Vincent Malkoski
Senior Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries

Gus McLachlan
Environmental Project Manager, Duke Energy Gas Transmission

Roman Zajac, PhD
Professor of Biology and Environmental Sciences, University of New Haven

APPENDIX F: SYMPOSIUM PANELISTS (CONTINUED)

Impact Analyses

July 28, 2004: 1 pm - 2 pm

Safety Issues and Impacts:

Kenneth Bowes ***(Rapporteur)***
Director, Transmission Projects, Northeast Utilities

Brian Dorwart
Vice President, Haley & Aldrich, Inc.

Ed Gonzales
Director of Operations, AK Energy Services

Glenn Lanan
Senior Project Manager, INTEC Engineering

Robert J. Taylor, P.E. *(via conference call)*
Research Civil Engineer, Naval Civil Engineering Laboratory, U.S. Navy

Impact Analyses

July 28, 2004: 2:10 - 3:20 pm

Temperature Impacts

Robert B. Whitlatch, PhD (*Rapporteur*)
Professor of Marine Sciences
University of Connecticut

Rich Kleiman
Vice President, Ecological and Environmental Permitting, ESS Group, Inc.

Glenn Lanan
Senior Project Manager, INTEC Engineering

Impact Analyses

July 28, 2004: 3:30 pm - 4:30 pm

EMF (*Electromagnetic Field Effects*)

Gale F. Hoffnagle, *(Rapporteur)*
Chairman, Academy Study Committee

Robert Adair, PhD
Sterling Professor Emeritus of Physics, Yale University

APPENDIX F: SYMPOSIUM PANELISTS (CONTINUED)

William Bailey, PhD
Principal Scientist, Exponent Health

Long Island Sound Data and Information

July 29, 2004: 8:45 am – 12 Noon

Benthic Habitat Classification and Mapping

John W. Ladd, PhD – (*Rapporteur*)
Benthic Mapping Coordinator
Hudson River National Estuarine Research Reserve, Hudson River Estuarine Program
New York State Department of Environmental Conservation

Peter J. Auster, PhD
Science Director, National Undersea Research Center &
Adjunct Professor of Marine Sciences, University of Connecticut

Heidi M. Dierssen, PhD
Assistant Professor in Residence of Marine Sciences, University of Connecticut

Mark L. Kosakowski
Section Manager – Oceanography & Coastal Sciences, Ocean Surveys, Inc.

Pierre Legendre, PhD
Professor of Biological Sciences, Université de Montréal
Also, Elected Fellow, Royal Society of Canada (Academy of Science)

William Murphy, PhD
CEO, Earthworks, LLC

Thomas Noji, PhD
Chief, Ecosystems Processes Division
NOAA, National Marine Fisheries Service

Roman Zajac, PhD
Professor of Biology and Environmental Sciences, University of New Haven

Long Island Sound Data and Information

July 29, 2004: 1 pm – 2pm

Endangered and Threatened Species

Robert B. Whitlatch, PhD (*Rapporteur*)
Professor of Marine Sciences
University of Connecticut

APPENDIX F: SYMPOSIUM PANELISTS (CONTINUED)

Jim T. Carlton, PhD
Professor of Marine Science, Williams College
Director of Maritime Studies Program of Williams College & Mystic Seaport

Mary F. Conley
Coastal Planner, Maryland Department of Natural Resources

Michael F. Ludwig
NOAA, National Marine Fisheries Service

David Simpson
Supervising Fisheries Biologist, Marine Fisheries Division
Connecticut Department of Environmental Protection

Long Island Sound Data and Information

July 29, 2004: 2:10 pm – 4:30 pm

Mollusks

Ed Rhodes, (*Rapporteur*) *-tentative*
Executive Director, East Coast Shellfish Growers Association

Joseph DeAlteris, PhD
Professor of Fisheries and Aquaculture
University of Rhode Island

Christopher Judy
Shellfish Program Director
Maryland Department of Natural Resources

Michael F. Ludwig
NOAA, National Marine Fisheries Service (CT)

Clyde MacKenzie
NOAA, National Marine Fisheries Service (NJ)

Inke Sunila, PhD
Shellfish Pathologist
Bureau of Aquaculture, CT Department of Agriculture

Robert B. Whitlatch, PhD
Professor of Marine Sciences
University of Connecticut

Lawrence Williams
President/Owner, Jessie D, Inc.

APPENDIX G

PANELISTS AND RAPPORTEURS BIOGRAPHICAL SKETCHES

Robert Kemp Adair, PhD
Sterling Professor Emeritus of Physics, Yale University

Panelist: EMF

Sterling Professor Emeritus of Physics, Senior Research Scientist, Yale University, Dept. of Physics, Yale University, PO # 208121, New Haven, CT 06520-8121.

Ph.D., University of Wisconsin, 1947; M.Sc. (Physics) University of Wisconsin, 1948; Ph.D. (Physics) University of Wisconsin, 1951; D.Sc. (Hon) University of Wisconsin, 1994.

Instructor, Wisconsin, 1951-1953; Physicist, Brookhaven National Laboratory, 1953-59; Yale University: Associate Prof., 1959; Professor, 1961; Higgins Professor, 1972; Sterling Professor, 1988 -- 1994.Emeritus, 1994 --; Senior Research Physicist, 1994 ---; Department Chairman 1967-70; Director of the Division of Physical Sciences, 1977-80; Brookhaven National Laboratory, Associate Director for High Energy and Nuclear Physics, , 1987-88; Physicist to the National Baseball League 1987-1989.

Author: Strange Particles (with Earle Fowler), 1963; Concepts in Physics, 1969; The Great Design, 1987; The Physics of Baseball, 1990, 3rd Ed. 2002; Associate Editor Physical Review, 1963-1966; Associate Editor Physical Review Letters, 1974-1976; Editor, Physical Review Letters, 1978-1984

Guggenheim Fellow, 1954; Ford Foundation Fellow, 1962-1963; Sloane Foundation Fellow, 1962-1963; Fellow American Physical Society; Chairman, Division of Particles and Fields, 1972-1973; Member; National Academy of Sciences, 1976 -- ; Chairman, Physics Section, 1986-1989; Secretary, Class of Physical Sciences, 1988-91; Chairman, Class of Physical Sciences, 1991-1994; Fellow, American Academy of Arts and Sciences; Special Fields: Nuclear physics, Elementary particle physics, sports physics, biophysics.

Peter J. Auster, PhD
Science Director, National Undersea Research Center, University of Connecticut

Panelist: Installation and Maintenance Impacts
Benthic Habitat Classification and Mapping

Dr. Peter J. Auster is the Science Director for the National Undersea Research Center and an Assistant Professor-in-Residence of Marine Sciences at the University of Connecticut. His research focuses on the ecology and conservation of fishes. He has participated as a scientist or chief-scientist on 40 major research cruises and has conducted research in the northwest Atlantic, Gulf of Alaska, Bering Sea, Caribbean Sea, Indian Ocean, South and East China Seas, and the equatorial Pacific. He also participated in research expeditions to Lake Baikal in Russia and Lakes Victoria and Malawi in the Rift Lake Valley of East Africa.

For the past 15 years, he has conducted studies to define how seafloor landscapes mediate the distribution and abundance of fishes, understand the linkages between habitat level processes and population-community dynamics, and develop methods for monitoring habitat integrity. From an applied science perspective, he has focused his attention on the impacts of fishing gear on the environment and developing the scientific basis for using marine protected areas as a conservation tool.

His basic approach to fieldwork has been to use the same types of techniques underwater that wildlife biologists use on land. That is, making direct underwater observations to study how individual animals react to variations in nature. He has conducted over 1,400 scuba dives, 55 submersible dives, and 380 remotely operated vehicle dives.

APPENDIX G (CONTINUED)

Peter serves on a number of panels and committees that are focused on marine resource management and conservation. He is involved in several outreach initiatives that are targeted at informing the public about marine conservation issues. Most recently, he was awarded a Pew Marine Conservation Fellowship in 1999, the NOAA Environmental Hero Award in 2000, and was named an Ocean Hero by the American Oceans Campaign in 2001.

William H. Bailey, PhD
Principal Scientist, Exponent Health

Panelist: EMF

Dr. William H. Bailey is a Principal Scientist in the Health/Epidemiology and Toxicology/Health Risk Practices, and Director of Exponent's New York office. Before joining Exponent, Dr. Bailey was President of Bailey Research Associates, Inc., the oldest research and consulting firm with specialized expertise in electromagnetic fields and health.

Dr. Bailey specializes in the application of state-of-the-art risk assessment methods for environmental health issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey is particularly well known for his research on potential health effects of electromagnetic fields and has served as an advisor to numerous state, federal, and international agencies. He has investigated exposures to alternating current (ac) and direct current (dc) electromagnetic fields, 'stray voltage' and electrical shock, as well as exposures to a variety of chemical agents. He is also a member of a working group that advises a committee of the World Health Organization on risk assessment, perception, and communication. Dr. Bailey is a visiting scientist at the Cornell University Medical College and has lectured at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and National Institutes of Health postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

W. Frank Bohlen, PhD
Professor of Marine Sciences, University of Connecticut

Rapporteur: Installation and Maintenance Impacts

W. Frank Bohlen is a physical oceanographer and Professor in the Department of Marine Sciences at the University of Connecticut in Groton, Connecticut. He earned his B.S in Electrical Engineering from the University of Notre Dame in 1960 and his PhD in Physical Oceanography from the MIT/WHOI Joint Program in 1969. Dr. Bohlen's primary research interests include the dynamics of sediment transport in estuarine and coastal waters, numerical modeling of transport processes, and instrument system design for long-term time series observations. Over the past thirty-five years he has conducted a variety of field and laboratory investigations dealing with the processes governing sediment transport with particular emphasis on the effects of storms and similar high energy aperiodic events both natural and man-induced. These studies have included evaluations of fine grained sediment transport in coastal, estuarine, riverine and lacustrine waters, wetland sedimentation and viability, processes affecting the infilling of navigational channels, port designs to minimize sedimentation and the associated maintenance, resuspension induced by construction activities including mechanical dredging and dredged material disposal, the dispersion of drilling muds, and a variety of studies dealing with the transport of sediment associated contaminants. The results of these investigations have been used by Federal, State and private groups and organizations involved in the use and management of coastal resources.

Dr. Bohlen is a member of the American Geophysical Union, the Estuarine Research Federation, the Marine Technology Society, and The Oceanography Society. He has recently completed service on the NAS/NRC Committee on Remediation of PCB-Contaminated Sediments.

APPENDIX G (CONTINUED)

Kenneth Bowes
Director, Transmission Projects, Northeast Utilities

Rapporteur: Safety Issues and Impacts

Kenneth Bowes is currently the Director of Transmission Projects for Northeast Utilities (NU). He is primary responsible for the management of transmission substation and line projects throughout Connecticut, Western Massachusetts, and New Hampshire. Ken has more than 20 years of experience at NU where he has held a variety of engineering, environmental operations and management positions including the Director of Transmission Construction, Test & Maintenance, and Director of Transmission & Distribution Maintenance. He has had responsibility of the operation & maintenance of NU's 3000 miles of transmission. This includes the future replacement project for the 1385 Line (Long Island Cable System). Ken holds a B.S.E.E. degree from the University of New Hampshire and a M.S.E.E degree from Rensselaer Polytechnic Institute. Ken has written numerous conference and journal paper on power quality and power system harmonic issues.

Drew A. Carey, PhD
Principal Scientist, CoastalVision, LLC

Panelist: Installation and Maintenance Impacts

Dr. Carey is a marine environmental scientist with over twenty year's experience in benthic ecology, sedimentology, environmental monitoring, and marine policy. He is a recognized expert on impacts of dredging and disposal on marine ecosystems. In 1999, Dr. Carey formed an environmental consulting firm, CoastalVision, LLC to provide marine environmental technical support to government agencies, commercial firms and public interest groups. CoastalVision has established projects compiling data for coastal management in Narragansett Bay, Long Island Sound and Massachusetts waters. Dr. Carey is a senior technical lead for the Dredged Material Disposal Site Designation EIS in Long Island Sound, supporting the Corps of Engineers and EPA. He is the technical studies manager for the Disposal Area Monitoring System (DAMOS) as a subcontractor to ENSR. He has supported numerous projects associated with permitting and aquatic disposal site screening for Massachusetts Coastal Zone and the Coastal Resources Management Council in Rhode Island. Dr. Carey provided facilitation for the Narragansett Bay Summit and the Partnership for Narragansett Bay.

James T. Carlton, PhD
Professor of Marine Science, Williams College
Director of Maritime Studies Program of Williams College & Mystic Seaport

Panelist: Endangered and Threatened Species

Dr. James T. Carlton is Professor of Marine Sciences at Williams College (Williamstown, Massachusetts) and Director, Williams-Mystic,The Maritime Studies Program of Williams College and Mystic Seaport (Mystic, Connecticut). He was an undergraduate at the University of California, Berkeley, took his Ph.D. at UC Davis in Ecology, and was a postdoctoral scholar at the Woods Hole Oceanographic Institution. His research is on global marine bioinvasions (their ecosystem impacts, dispersal mechanisms, and management strategies) and on endangered species and extinctions in the marine environment in modern times. He is the founding Editor-in-Chief of the international journal "Biological Invasions". He is a 1996 Pew Fellow in the Environment and Conservation, a Fellow of the American Association for the Advancement of Science, and a Distinguished Research Fellow of the University of California. In 1999 he was the first scientist to receive the U.S. Government's interagency "Recognition Award for Significant and Sustained Contributions to the Prevention and Control of Nonindigenous Species in America's Aquatic Ecosystems". He was Co-Chair of the Marine Biodiversity Committee of the National Academy of Sciences, which produced *Understanding Marine Biodiversity: A Research Agenda for the Nation* (1995). He has testified seven times on invasive species issues before the United States Congress (Senate and House subcommittees). Jim's current research on marine bioinvasions focuses on the waters of the northwest Atlantic Ocean (Bay of Fundy to mid-Atlantic), the northeast Pacific (San Francisco Bay to British Columbia), and the Hawaiian Islands.

[publications on marine endangered and extinct species:]

APPENDIX G (CONTINUED)

1991. J. T. Carlton, Geerat J. Vermeij, David R. Lindberg, Debby A. Carlton, and Elizabeth C. Dudley. The first historical extinction of a marine invertebrate in an ocean basin: the demise of the eelgrass limpet *Lottia alveus*. Biological Bulletin 180: 72-80; 1993. J. T. Carlton. Neoextinctions of marine invertebrates. American Zoologist 33(6): 499-509; 1995. J. T. Carlton. Marine invasions and the preservation of coastal diversity. Endangered Species Update (School of Natural Resources, The University of Michigan), 12(4/5): 1-3; 1996. J. T. Carlton. Marine conservation ecology: recognizing the roles of invasions and extinctions in a long-term era of declining systematics and taxonomy. Supplement to the Bulletin of the Ecological Society of America, 77(3): 70; 1999. J. T. Carlton, Jonathan B. Geller, Marjorie L. Reaka-Kudla, and Elliott A. Norse. Historical extinction in the sea. Annual Review of Ecology and Systematics 30: 515 – 538; 2001. J. T. Carlton. Endangered marine invertebrates, pp. 455 - 464, in Encyclopedia of Biodiversity, Volume 2. Academic Press, San Diego, California; 2002. [Book review] “*Limulus* in the limelight: a species 350 million years in the making and in peril?”. Journal of Experimental Marine Biology and Ecology 271: 227-230.

Mary F. Conley
Coastal Planner, Maryland Department of Natural Resources

Panelist: Endangered and Threatened Species

Mary Conley has worked as a Coastal Planner with the Maryland Coastal Zone Management Program for the past five years. Her efforts with the Program have focused on aquatic sensitive areas planning, watershed planning, and stakeholder involvement in coastal issues. Prior to working with the Department of Natural Resources, she worked with the Chesapeake Bay Program, concentrating on atmospheric deposition to the Bay. She holds a Bachelor’s degree in marine biology and geology from the College of Charleston and a Master’s degree in Marine Science from the University of Texas at Austin. Her master’s work focused on benthic ecology, studying the influence of a brown tide event on the benthic macrofauna community.

Joseph DeAlteris, PhD
Professor of Fisheries and Aquaculture, University of Rhode Island

Panelist: Mollusks

Joseph DeAlteris is a Professor of Fisheries and Aquaculture at the University of Rhode Island since 1983. He is also President of DeAlteris Associates Inc, a coastal environmental consulting firm. Joe earned is MS and PhD degrees from the Virginia Institute of Marine Science, College of William and Mary. He has 30 years experience in the science and management of shellfish resources including the effects of anthropogenic activities on shellfish resources, and the restoration of those resources.

Heidi M. Dierssen, PhD
Assistant Professor in Residence of Marine Sciences, University of Connecticut

Panelist: Benthic Habitat Classification and Mapping

Education: 2000, Ph.D., Institute for Computational Earth System Science, University of California Santa Barbara, Santa Barbara, California; 1989, M.S., Biological Sciences, Stanford University, California; 1989, B.S., Biological Sciences, Stanford University, California, with honors.

Dr. Dierssen is an interdisciplinary research scientist who uses coastal optics and remote sensing to address questions related to biological and physical processes in the ocean. My research employs a broad variety of new observational tools for monitoring coastal ecosystems including remote sensing from both satellites and aircraft, autonomous underwater vehicles, and profiling moorings and my research has spanned the breadth of the world’s oceans, including polar, temperate, and tropical seas.

The products obtained from ocean color satellites are focused on unicellular phytoplankton in the world’s deep oceans and have yet to map seafloor habitats in shallow water. I am involved in several projects to exploit satellite ocean color imagery in shallow ecosystems.

APPENDIX G (CONTINUED)

She is currently funded to develop and test optical approaches for estimating seagrass in two very different carbonate shelf environments: 1) Oligotrophic waters of the Bahamas Banks with little anthropogenic influences; 2) Eutrophic waters of Florida Bay experiencing high degree of anthropogenic disturbance

The abundance and distribution of seagrass resources across these environments will be linked to managing and preserving coastal marine resources is a formidable challenge given the rapid pace of change affecting coastal environments. Fast, accurate and quantitative tools are needed for detecting change in coastal ecosystems. Traditional in situ surveys are time and labor-intensive, generally lack the spatial resolution and precision required to detect subtle changes before they become catastrophic, and can be difficult to maintain from year-to-year. I am involved in several instrument development proposals for using Unmanned Aerial Vehicles (UAVs) to obtain high resolution optical imagery of the nearshore coastal zone. UAVs can fly underneath cloud cover to provide unprecedented spatial and temporal imagery of the coastal zone.

Brian C. Dorwart, P.E, P.G.
Vice President, Haley & Aldrich, Inc.

Panelist: Installation and Maintenance Impacts
Safety Issues and Impacts

Education: University of Massachusetts, M.S. Civil Engineering, 1979; State University of New York at Buffalo, Graduate Studies toward MSCE, 1976-1978; University of Rochester, B.A. Geology, 1972; Babson College, Graduate Studies toward M.B.A.

Mr. Dorwart has more than 24 years of experience in the technical and project management of projects involving instrumentation, geotechnical engineering, and underground construction. Previous work as a contractor, exploration driller, construction technician, and laborer provide a unique perspective to his geology and geotechnical engineering approach to projects. Project work ranges from heavy construction of tunnels, dams, and highways, to light industrial building and machine foundations. Areas of specialization include directional drilling, instrumentation, and construction support services. He has managed construction activities, including developing strategies for bid preparation, design, and installation. He has developed design and construction approaches for complex geotechnical projects for contractors, owners, engineers, and public agencies.

For the past fourteen years, Mr. Dorwart has concentrated on directional drilling projects and has experience in design, construction monitoring, construction management, consulting, and construction in environmentally sensitive areas and under highways, rivers, ocean outfalls, and railroads. These projects have included installation of pipes up to 36 in. diameter and 6,500 ft long for gas, telecommunications, oil, electric power, water, and sewer. Projects are located nationally and examples include ocean outfalls passing under sensitive coral reefs and crossing the Intracoastal waterway in southern Florida; gas pipes passing under landslides and sensitive sea coast environments in Washington State; a crossing under Boston Harbor; a shipping channel crossing under the Hudson River at the Verrazano Narrows; multiple river taps for a water supply in North Dakota; and force mains crossing under sloughs and an interstate highway in Washington State. Mr. Dorwart has presented numerous technical presentations at professional conferences on the design and construction of directional bores.

Presently, Mr. Dorwart is the chair of the DCCA geotechnical practices committee and is actively developing a risk management approach for HDD projects for distribution by the DCCA. Additionally, he is a member of NASTT, ASCE, and AREMA.

Publications and Papers:"Risk-Based HDD Design and Construction" Trenchless Technology Magazine, June 2004; "Directionally Drilled Raw Water Intakes, Grand Forks, North Dakota", Paper No. 6.19; Brian C. Dorwart, P.E., P.G., Gregory R. Fischer, Ph.D., P.E., Wayne L. Gerszewski, P.E., Michael K. Yavarow, P.E., Proceedings 5th International Conference on Case Histories in Geotechnical Engineering, New York, New York, April 13-17 2004; Risk-Based Design Process For Directionally Drilled Raw Water Intakes, Grand Forks, North Dakota," Brian Dorwart, P.E., P.G., Gregory Fischer, Ph.D., P.E., Wayne Gerszewski, P.E., and Michael Yavarow, P.E., NASTT No-Dig 2004, New Orleans, LA, March 22-24, 2004; "WHITE PAPER-Risk Based Design Approach for Horizontal Directional Drilled Bores - A Pro-Active Project Approach to Facilitate Project Success" Brian Dorwart, PE, DCCA Conference Presentation, 20 March 2004; "Enough Subsurface Information?," *Tunnel*

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Business Magazine 1999. "Construction of Log Storage Facility Over Dredged Organic Soils," with G.R. Fischer, M.G. Vitale, D.R. Johnston, Proceedings, Geosynthetics '95, Nashville, 1995, p.377-390.

Thomas J. Fredette, PhD
DAMOS Program Manager, U.S. Army Corp of Engineers, New England District

Panelist: Installation and Maintenance Impacts

Employed from 1986 to the present as the Program Manager for DAMOS (Disposal Area Monitoring System) by the Regulatory Division, US Army Corps of Engineers, New England District, Concord, MA. DAMOS is a multidisciplinary environmental monitoring program which investigates impacts of sediments disposed at more than ten sites in the offshore waters of New England. Results of the program are published in a series of technical reports, various professional publications, and public information mediums. Further information on the program can be found at http://www.nae.usace.army.mil/environm/damos1.htm.

From 1983 to 1986 I was a Research Scientist at the U.S. Army Corps of Engineers Waterways Experiment Station, Coastal Ecology Group in Vicksburg, Mississippi working on environmental impact studies of coastal engineering activities. I received my B.S. degree in Marine Biology in 1977 from Southeastern Massachusetts University (now UMass Dartmouth), an M.A. in 1980 and Ph.D. in 1983 in Marine Science from the Virginia Institute of Marine Science at The College of William and Mary.

Edward D. Gonzales
Director of Operations, AK Energy Services

Panelist: Safety Issues and Impacts

Over twenty five (25) years of experience in virtually every aspect of pipeline construction and project management. Expertise include feasibility studies, route selection, public and government relations, right-of-way acquisition, contract solicitation, bid evaluation and negotiations, construction management, mapping and surveying, construction inspection, expert testimony, Horizontal Directional Drilling (HDD), marine construction and extensive involvement in local, state and federal permit filing process in various states as well as FERC applications and requirements.

Recent Experience: Responsible for all natural gas market expansion projects in the Northeast and Eastern Canada from inception through commissioning of facilities. Directed initial feasibility assessments, project estimates, all field work, environmental and right-of-way permitting and acquisition, engineering, material procurement, construction management, public/government relations and legal support for various projects. These projects included most recently the HubLine Project, Maritimes & Northeast Pipeline Phase III and various marketing expansion projects in Pennsylvania and New Jersey. The most recent project was the HubLine/Maritimes Phase III which included seven HDD's – two water to water and two land to water, along with 25 miles of onshore construction and 30 miles of offshore construction in Massachusetts Bay.

Gale F. Hoffnagle, CCM QEP
Senior Vice President & Technical Director, TRC Environmental Corporation
Chairman, Connecticut Academy of Science and Engineering Study Committee

Rapporteur: EMF
Note: See Connecticut Academy of Science and Engineering Study Committee for bio information.

Christopher Judy
Shellfish Program Director, Maryland Department of Natural Resources

Panelist: Mollusks

Chris Judy is the Shellfish Program Director for the Maryland Department of Natural Resources (DNR), a position held since 1998. He received a B.S. degree from the University of Maryland in 1979 in Resource Management

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with a focus on the Chesapeake Bay. He continued with graduate studies into the early 1980's in Marine Science, emphasizing Chesapeake Bay and shellfish topics, and then departed graduate school to accept a position with Maryland State Government. Job experience has included environmental education with the Chesapeake Bay Foundation, water quality sampling and stream surveys with the Maryland Department of the Environment, fish and shellfish surveys with DNR. He began his work in the DNR Shellfish Program in 1986 and has extensive experience with the aquaculture leasing program, shellfish population assessment, the clam and oyster industries, management of permits, and surveys for environmental impacts relative to permitted activity on shellfish beds. He lives near Annapolis, MD.

Richard E. Kleiman
Vice President, ESS Group, Inc.

Panelist: Installation and Maintenance Impacts
Temperature Impacts

Mr. Kleiman has more than 15 years of experience in energy facility siting, environmental project management, watershed management, wetlands science, water quality assessment, wildlife management, habitat assessment, site remediation, inter-governmental coordination, regulatory compliance, and print journalism. He has overseen the successful licensing of numerous coastal and offshore energy projects under the FERC and NEPA review processes as well as other local, state, and federal regulatory programs in the northeastern United States. His energy clients include Northeast Utilities, Keyspan, TransCanada, Yankee Gas, National Grid, New England Power, Massachusetts Electric, United Illuminating, Cape Wind Associates, and Long Island Power Authority. Prior to joining ESS, he served as the Boston Harbor Watershed Team Leader for the Massachusetts Executive Office of Environmental Affairs and led intergovernmental review processes for controversial projects subject to state environmental review. He founded the National Corporate Wetlands Restoration Partnership (CWRP), administered by the federal Coastal America Partnership in conjunction with the CEQ and other agencies, and chairs the Rhode Island CWRP Advisory Board.

Mark L. Kosakowski
Section Manager – Oceanography & Coastal Sciences, Ocean Surveys, Inc.

Panelist: Benthic Habitat Classification and Mapping

Education: B.S. Physical and Biological Oceanography, Magna Cum Laude, Boston Univ., 1985
Minor Studies: Geology and Coastal Zone Management; Attended Marine Program in Residence, Marine Biological Laboratories, Woods Hole, MA. Masters Studies: Public Health (MPH)

Professional History: Ocean Surveys, Inc.: Section Manager/Coastal Sciences, 2000 to Present; Ocean Surveys, Inc.: Program Manager/Oceanographic Section, 1996 to 2000; Ocean Surveys, Inc.: Project Manager/Oceanographer, 1988-1996; Town of East Lyme, CT: Registered Sanitarian/Environmental Engineer, 1986-1988; Town of Ridgefield, CT: Sanitarian, 1985-1986

Mr. Kosakowski has a broad base of experience in the environmental sciences. He has specialized in the areas of coastal/estuarine ecology and hydrodynamics, particularly in relation to discharge plume dynamics, sediment transport processes and water quality evaluations. Mr. Kosakowski has extensive experience in the acquisition, analysis, and interpretation of current velocity, wave, tide, sedimentation, meteorological and water quality data as well as benthic and neuritic biological sampling and the input of this data into engineering/environmental analyses. He has knowledge of industrial health and safety programs and laboratory experience in standard methods, USEPA and Army COE methodology for analysis of sludge, water, and wastewater.

A Senior Oceanographer at Ocean Surveys, Mr. Kosakowski has managed numerous field investigations conducted in support of NPDES permitting and design of power plant, industrial and wastewater outfalls, environmental impact assessment of port and harbor development, marine crossings (pipeline, cables and bridges) and marine resource development. These studies entailed a full spectrum of marine survey services including the deployment and servicing of current meter, wave and tide gauge arrays, dye tracer studies, drifting drogue tracking, water quality monitoring, satellite telemetry, limnological data collection and analysis, meteorological monitoring,

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and hydrographic surveys. Mr. Kosakowski is also an expert in benthic habitat mapping using remote sensing technologies, multibeam hydrography, side san sonar imaging, and underwater TV.

John W. Ladd, PhD
Benthic Mapping Coordinator
Hudson River National Estuarine Research Reserve, Hudson River Estuarine Program
New York State Department of Environmental Conservation

Member, Connecticut Academy of Science and Engineering Study Committee

Rapporteur: Benthic Habitat Classification and Mapping
Note: See Connecticut Academy of Science and Engineering Study Committee for bio information.

Glenn Lanan
Senior Project Manager, INTEC Engineering

Panelist: Installation and Maintenance Impacts
Safety Issues and Impacts
Temperature Impacts

Glenn Lanan is a Civil Engineer who specializes in the design and construction of offshore pipelines and related facilities. He received his Bachelor and Master of Civil Engineering degrees from the University of Delaware, where he focused on ocean and coastal engineering studies. Mr. Lanan has gained over 28 years of experience in all phases of marine pipeline design, construction and operations while worked for several major energy companies and consulting engineering firms.

Mr. Lanan is presently the Pipeline Engineering Discipline Manager for INTEC Engineering in Houston, Texas. He routinely manages offshore pipeline engineering projects in industry frontier areas such as deep water, the Arctic, environmentally sensitive areas, and pipeline system designs with unique engineering challenges such as very high or low operating temperatures. He recently completed an assignment as the pipeline engineering manager for the world's first offshore Arctic oil production pipeline and he is a registered Professional Engineer in the states of Texas and Alaska.

Pierre Legendre, PhD
Professor of Biological Sciences, Université de Montréal

Panelist : Benthic Habitat Classification and Mapping

Career Summary: M.Sc. (zoology), McGill University, 1969; Ph.D. (biology), University of Colorado, 1971. Postdoctoral fellow at the *Genetiska Institutionen*, Lunds Universitet, Sweden, in 1971-72. Research associate, then Research director at Université du Québec à Montréal, and finally Professor in the *Département de physique*. Moved to *Département de sciences biologiques*, Université de Montréal, in 1980. Recipient of the Michel-Jurdant prize for Environment Sciences, Association canadienne-française pour l'Avancement des Sciences (ACFAS), for 1986. Killam Research Fellow, Canada Council, in 1989-1991. Fellow of the *Royal Society of Canada* (Academy of Science) since May 1992. Recipient of the *Distinguished Statistical Ecologist Award* of the *International Congress of Ecology (INTECOL)* in 1994, and of the Romanowski Medal (environmental science) of the Royal Society of Canada in 1995. In April 1999, the Ninth Lukacs Symposium "*Frontiers of Environmental and Ecological Statistics for the 21st Century*" gives him the *Twentieth Century Distinguished Service Award* "for outstanding contribution to the synergistic development and direction of statistics, ecology, environment and society".

Education: B.A., Collège Saint-Viateur, Outremont, 1965 (College affiliated to Université de Montréal); M.Sc., McGill University, 1969 (Zoology); Ph.D., University of Colorado, 1971 (Biology).

NOAA's National Marine Fisheries Service (NMFS) has employed Michael Ludwig for more than twenty-five years in the Habitat Conservation Division. His principal responsibilities are related to evaluating the environmental

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impacts of development within Coastal and Exclusive Economic Zone waters of the United States. He is Biologist in-charge of the Milford, CT field Office and the NMFS, Northeast Region's Aquaculture Coordinator for the Division. His education includes degrees in Zoology and Marine Geology, Marine Science focusing on predator prey relationships and Physical Oceanography.

Michael Ludwig
Ecologist, NOAA, National Marine Fisheries Service

Panelist: Installation and Maintenance Impacts
Endangered and Threatened Species
Mollusks

Mr. Ludwig is involved in national and international resource management issues such as subaqueous utility installations, the use of transgenic species, water quality enhancement and dredging. Specific activities include dredged material management, use of explosives in aquatic settings, habitat enhancement, shellfish stock restoration, the evaluation and identification of managed fishery species essential habitat needs, endangered species management as well as the assessment of Navigation improvement projects for the principal Ports in CT, NY & RI.

Mike has written extensively on aquatic impacts. His work has appeared in both national and international publications. His most recent paper in the US is an assessment of the conflicts between marine transportation development and aquatic resources. He writes a column on international environmental issues for the Irish publication: Sherkin Comment, published by the Sherkin Island Marine Station in County Cork, Ireland.

Clyde L. MacKenzie
Shellfish Biologist, Northeast Fisheries Science Center, National Marine Fisheries Service, NOAA

Panelist: Mollusks

Clyde L. MacKenzie, Jr. is a long-time oyster and clam biologist with the National Mrine Fisheries Service. He began his career with the Milford, Connecticut Laboratory in 1958, where he worked on applied problems in the oyster industry. He spent a year, 1972-1972, on Prince Edward Island helping the province to turn around its falling oyster production. He has spent the last 30 years at the Sandy Hook Laboratory working on clams and environmental problems. During that time, he hastravelled in Central America, Mexico and northern South America surveying hitherto undescribed shellfisheries. He has published about 90 papers on the biology and management of shellfish and one book, The Fisheries of Raritan Bay.

He was called upon to testify as an expert witness on two suits placed by oyster companies against the Iroquois natural gas company, after it placed one of its pipelines across Long Island Sound from Milford to Port Jefferson. The first trial was in Milford and the second one was in Norwalk.

Vincent Malkoski
Senior Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries

Panelist: Installation and Maintenance Impacts

Project Leader, MDMF Environmental Review Program - Coordinate the Division's technical review and preparation of written comments regarding proposed and on-going coastal alteration projects within Massachusetts' coastal waters. Division representative on the ASMFC Habitat Committee, NEFMC Habitat Plan Development Team, MEMA Interagency Hazard Mitigation Committee, New Bedford Harbor Trustees Technical Advisory Team, MCZM Marine Habitat Working Group, MA Dredge Materials Management Plan Technical Team, RI Regional Long-Term Dredge Disposal Site Working Group, MA Ocean Management Task Force Date Trends and Use Characterization Working Groups.

Project Leader, MA Artificial Reef Program - Provide administrative oversight, support, and technical assistance for the location, development, monitoring, and maintenance of new and existing artificial reef sites in Massachusetts' coastal waters. Massachusetts' representative on the ASMFC Artificial Reef Technical Committee.

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Project Leader, Boating Infrastructure & Clean Vessel Act Grant Programs – Exercise administrative oversight, support, and technical assistance for the Boating Infrastructure & Clean Vessel Act Grant Programs. *MDMF Diving Safety Officer & Chief Diver*

George A. McLachlan (Gus)
Environmental Project Manager, Duke Energy Gas Transmission

Panelist: Installation and Maintenance Impacts

Gus has a BS in Natural Resources Conservation from the University of Connecticut and has over 18 years of engineering and environmental permitting and construction compliance management experience in the natural gas pipeline field. Gus's experience with the permitting and evaluation of natural gas pipeline projects covers a broad geographical area, from Pennsylvania to Maine. He is responsible for coordinating and managing all environmental permitting for DEGT for on and offshore pipeline projects and compressor stations. He has permitted over 700 miles of pipeline to date.

Most recently Gus managed the environmental permitting for the Maritimes & Northeast Pipeline Project. This 300 mile mainline pipeline extends from the Canadian border through Maine, New Hampshire and Massachusetts and provides a new Northeast delivery system for the natural gas reserves discovered off of the Canadian Maritimes. In addition, Gus managed the permitting for the HubLine Pipeline Project off the coast of Massachusetts. This Project consists of a 29-mile 30-inch diameter subsea pipeline that parallels the coast of Eastern Massachusetts. This Project is one of a kind in the Northeast and involved offshore pipeline construction through Boston Harbor, shipping lanes and the Massachsuetts South Essex Ocean Sanctuary. Other significant features of the project included four horizontal directional drills, with two of the drills consisting of water to water construction extending over 4,000 feet each in length. Gus continues to manage the post-construction environmental monitoring phases of the HubLine Project.

William Murphy, PhD
CEO, Earthworks, LLC

Panelist: Benthic Habitat Classification and Mapping

William Murphy is the principal and CEO of Earthworks LLC, a small business that he founded in 1998. Bill works closely with each client and supervises all tasks to ensure every product is exceptional. Dr. Murphy (PhD Geophysics, MS Fluid Mechanics, Stanford; BA Geology Williams) has over 24 years experience in geophysical and geological measurement services and interpretation. Sixteen of these years were with Schlumberger Ltd. He has conducted and managed subsurface surveys and logged boreholes on five continents and on water using advanced seismic, sonar, ultrasonic, electromagnetic, and drilling techniques. He has contributed to the theory of wave propagation in rocks and sediment in over 50 publications, resulting in 3 awards. He has made over 100 presentations on geophysical imaging and rock physics. He has performed, supervised and researched methods in geophysical processing and developed new geophysical tools, resulting in 2 US patents: 5,869,755; 5,335,542; and two UK issues. His work in applying computer graphics for interpreting geological, geophysical and remote-sensing data has resulted in 3 US patents: 6,070,125; 6,044,328; and 6,035,255.

Thomas T. Noji, Jr., PhD
Chief, Ecosystems Processes Division; Director, James J. Howard Marine Sciences Laboratory
National Marine Fisheries Service, NOAA

Panelist: Benthic Habitat Classification and Mapping

Dr. Noji was born and raised on Long Island. He conducted undergraduate studies at Earlham College in Indiana and received his Ph.D. in Biological Oceanography form the Institute of Oceanography, University of Kiel, Germany, in 1987. He conducted research at the University of Kiel from 1985-1989 and at the fisheries research facility, the federal Institute of Marine Research, in Bergen, Norway from 1990-2001.

In 2001 he began work with NOAA at the Northeast Fisheries Science Center (headquarters in Woods Hole) as

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the chief of the Ecosystems Processes. The Division consists of four Branches (Oceanography, Marine Chemistry, Behavioral Ecology and Coastal Ecology) with staff of about seventy scientists, technicians and support personnel from three marine research laboratories (located in Sandy Hook, NJ; Woods Hole, MA; Narragansett, RI) in the northeastern USA. He is also the Director of the James J. Howard Marine Sciences Laboratory in Sandy Hook, NJ. Dr. Noji is a visiting professor at Rutgers University and conducts a special topics seminar series on Marine Ecosystems Research.

During his career, research has focused on a variety of topics including oceanic plankton ecology and sedimentation; benthic-pelagic coupling; pelagic recycling; protistan ecology; image analysis center coordination; marine biogeochemical cycles; oceanic carbon pumps; photosynthesis in temperate and arctic protists; remote sensing in relation to forecasting of harmful algae blooms; benthic habitat characterization; marine contaminant transport; coastal zone management; fisheries management; essential fish habitat; and marine habitat mapping and classification.

Dr. Noji serves on several advisory boards including: CoML - Scientific Steering Committee for the Gulf of Maine project in the Census of Marine Life Program; EFH - EFH Steering Committee for New England Fishery Management Council; GOMMI - Steering Committee of Gulf of Maine Mapping Initiative; ICES ACE – U.S. Delegate to ICES Advisory Committee on Ecosystems; ICES MHC – U.S. Delegate to ICES Marine Habitat Committee; ICES WGMHM – member of ICES Working Group on Marine Habitat Mapping; NJMSC - Board of Trustees for New Jersey Marine Science Consortium; PSEG-Monitoring advisory committee of Public Services Enterprise Group.

Ed Rhodes
Executive Director, East Coast Shellfish Growers Association

Rapporteur: Mollusks

Ed Rhodes is a Connecticut native. He graduated from Rensselaer Polytechnic Institute and did graduate work at Southern Connecticut State University and the Marine Biological Laboratory.

Ed’s formative years were primarily in shellfish research, starting at the NMFS lab in Milford in 1959, with occasional stints in industry growing shrimp and pompano in Florida and oysters on Long Island.

He split for Chile in 1989 and spent 7 years there starting up and running a large scallop aquaculture company. On his return to the U.S. he became the national aquaculture coordinator for the National Marine Fisheries Service, and served in that position from 1997 until the end of 2001.

Ed returned to Connecticut 3 years ago, and has renewed his interest in Long Island Sound issues, especially those pertaining to shellfish.

Ed is the Executive Director of the East Coast Shellfish Growers Association, and is the owner of Aquatecnics, an aquaculture consulting business. He is also the aquarist at Soundwaters in Stamford and serves on a number of regional Boards including NRAC (Northeast Regional Aquaculture Center, USDA).

David G. Simpson
Supervising Fisheries Biologist, Marine Fisheries Division
Connecticut Department of Environmental Protection

Panelist: Endangered and Threatened Species

Education: Master of Science, Southern Connecticut State University, New Haven, CT, 1989 *(Thesis: Population Dynamics of Tautog, Tautoga onitis, in Long Island Sound)*; Bachelor of Arts, Biology, University of Rhode Island, Kingston, RI, 1980
Professional background: I have been employed by DEP in the Marine Fisheries Division for 23 years. As a Supervising Fisheries Biologist since 1989 my primary duties include: Overseeing the Division’s research and monitoring programs; Principal investigator: Lobster Assessment and Monitoring , LIS Trawl Survey and related

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programs; Supervising a staff of nine biologists, boat captains, technicians, and 13 seasonal employees; Assist in development of fishery regulations, develop compliance options; Represent the Division on several interstate fishery management committees including Atlantic States Marine Fisheries Commission (ASMFC) Species Technical Committees (TC) for summer flounder, scup, black sea bass complex, the Northeast Area Monitoring and Assessment Program (NEAMAP) Management Board, Management and Science Committee, and numerous subcommittees such as: Multispecies stock assessment, power plant entrainment impacts, fish age determination, and serve as the designee to the New England Fishery Management Council.
Research interests include hypoxia impacts on living resources, fishing gear selectivity and multi species resource monitoring surveys.

Inke Sunila, PhD
Shellfish Pathologist, Bureau of Aquaculture, Connecticut Department of Agriculture

Panelist: Mollusks

Education: (1987) Ph.D.,Department of Zoology, Division of Physiology, University of Helsinki. (Doctor's Thesis: "Histopathological effects of environmental pollutants on the common mussel, Mytilus edulis L. (Baltic Sea), and their application in marine monitoring."); (1988) Ph.lic. (Licentiate in Philosophy); (1980) M.S; (1974-1980) B.S.

Academic and professional positions:
1997- Shellfish Pathologist. State of Connecticut, Department of Agriculture, Bureau of Aquaculture.
2000 - Adjunct Assistant Professor, University of Connecticut, Department of Pathobiology and Veterinary Science.
1993-1996.Research Scientist. The George Washington University. Medical Center. Department of Pathology, Washington, D.C..
1987-1992. Research Scientist. Cooperative Oxford Laboratory, Oxford, MD.

Present work includes disease diagnosis and management of bivalve shellfish, stock assessments and development of disease resistant strains. Research interest has been directed to the effects of environmental factors on the health of bivalves, malignant neoplasia in bivalves and apoptosis. Publications (37, available upon request) include work concerning pathology of oysters, clams and mussels from the Long Island Sound, the Chesapeake Bay and the Baltic Sea.

Robert J. Taylor, P.E.
Research Civil Engineer, Naval Civil Engineering Laboratory, U.S. Navy

Panelist: Safety Issues and Impacts (via conference call)

Education: BSCE University of Rhode Island, 6/64; MSCE University of Rhode Island, 1/67.
Professional Positions: Date: November 1969 to present. Research Civil Engineer, Naval Civil Engineering Laboratory, Port Hueneme, CA. Team Lead: Waterborne Barrier Program; Date: June 1997 to December 2002. Office of Naval Research, Arlington, Va. Technical Director and Program Manager: Mobile Offshore Base Program; Date: 1975 to present. Mooring and anchoring consultant; Date: January 1968 to November 1969. U.S. Army, Civil Engineer, Army Waterways Experiment Station; Date: February 1967 to November 1967. Research Civil Engineer, Naval Civil Engineering Laboratory; Date: June 1964 to January 1967. Graduate Research Assistant, University of Rhode Island.

Professional Experience: Over 38 years research experience in ocean engineering. Developed drag and direct embedment anchors and anchor design, selection and rigging methods in use by the Navy and offshore industry. Conducted research to develop methods for determining the engineering properties of marine sediments; have extensive experience in the development and installation of suspended cable structures and buoy systems; and have developed an open-ocean floating breakwater system. Recent research efforts concern the development of high capacity pile-driven plate anchor systems for Navy moorings and soil- structure interaction studies to develop guidance on the design of bottom- founded structures. Served as the Technical Director and Program Manager for the Office of Naval Research Mobile Offshore Base Science and Technology Program. This program is focused on developing the technology to establish the feasibility and cost of this unprecedented offshore floating structure. Currently serving as the leader of the Waterborne Barrier Program responsible for developing, designing and installing barriers capable of protecting Navy Ships from attack by high speed, explosive-laden boats.

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Provided consulting services to the Navy and to the worldwide offshore industry for over 25 years. These activities have concerned the design of unique anchoring systems, the selection and sizing of anchors, pipeline protection from drag anchors, assessment of anchor performance, and the specification of seafloor soil properties. Example consulting services during 2000-2002 include: New Carissa anchoring assessment: U.S. Department of Justice; Triton Anchor Analysist: Kvaerner A/S and Masons Ltd.; New Carissa anchoring assessment: Department of Justice, State of Oregon; Hubline Pipeline Protection and anchor assessment: Duke Energy; Islander East Pipeline Protection and anchor assessment: Project Consulting Services; Barge Texas Anchoring analysis: Healy & Baille.

Written more than 100 unclassified Technical Reports, Journal Articles and Design Guides in the areas of anchors, breakwaters, soil testing and offshore installations and presented many at technical conferences. Provided anchor performance specifications for API RP-2P and RO-2FP1, the Navy Salvage Manual and Handbook, the Navy Underwater Construction and Repair Manual and the Navy Design Manual for Fleet Moorings.

Invited lecturer on anchoring systems at various government laboratories and Universities including, UC Berkeley, Oregon State, U. Hawaii, U. Rhode Island, Woods Hole Oceanographic Institute, Scripps Institute of Oceanography, Brigham Young University, UC Santa Barbara, UC San Diego, and the Naval Post Graduate School.

Patents and Patent Publications: Propellant-Actuated Deep Water Anchor, Patent No. 3,910,218, 7 October 1975; Propellant-Actuated Deep Water Anchor System (Improved Fluke), Navy Case 61,040, Tech. Cat. No. 3750, June 1977; Fuseless Explosive Propellant Cartridge, Patent No. 4,328,736, 11 May 1982; Anchor Holding Capacity Augmentation System, Patent No. 4,397,255, Navy Case 65,135, August 1983; High Efficiency Marine Anchor System, Patent No. H000250, April 1987; Anchor with Folding Self-Deploying Stabilizers, Patent No. 4,798,159, January 1989; Passive Anchor Latch, Navy Patent, May 1999; Port Security Barrier System, Navy Patent, Jan 2002; Nearshore Port Security Barrie System, Navy Patent in Process, April 2002

Robert Whitlatch, PhD
Professor of Marine Sciences, University of Connecticut

Rapporteur: Temperature Impacts
Endangered and Threatened Species

Panelist: Mollusks

Dr. Robert B. Whitlatch is Professor of Marine Sciences at the University of Connecticut. He received with Ph.D. degree (Evolutionary Biology) from the University of Chicago and was a post-doctoral scholar at the Woods Hole Oceanographic Institution. His research interests lie in the area of experimental marine benthic population and community ecology. Recent work has focused on benthic disturbance-recovery processes in soft-sediment systems, the ecology of marine invasive species, and the effects of climate change on facilitating the invasive process. He has served on numerous peer-review panels for the National Science Foundation, NOAA and EPA and recently was a member of the National Academy of Sciences' committee to assess potential environmental and ecological impacts of the proposed introduction of a non-native oyster into Chesapeake Bay. He serves on the editorial boards of Journal of Sea Research and the Journal of Experimental Marine Biology and Ecology.

Representative Recent Publications:
Whitlatch, R.B., A.M. Lohrer and S.F. Thrush. 2001. Scale-dependent recovery of the benthos: effects of larval and post-larval life-stages. Pages 181-197. In: Woodin, S.A. and J.Y. Aller (eds.). **Organism-Sediment Symposium**. University of South Carolina Press, Columbia
Thrush, S.F. and R.B. Whitlatch. 2001. Recovery dynamics in benthic communities: balancing detail with simplification. Pages 297-316 In: K. Reise (ed). **Ecological Comparisons of Sedimentary Shores**. Springer-Verlag, Berlin.
Stachowicz, J. J., H. Fried, R. W. Osman and R. B. Whitlatch. 2002. Reconciling pattern and process in marine bioinvasions: how important is diversity in determining community invasibility. **Ecology**: 83: 2575-2590 (***Ecological Society of America, 2004 Mercer Award***)
Stachowicz, J.J., J.R. Terwin. R.B. Whitlatch, and R.W. Osman. 2002. Linking climate change and biological invasions: ocean warming facilitates non-indigenous species invasions. **Proceedings of the National Academy of Sciences**, 99: 15497-15500.

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Zajac, R.N. and R.B. Whitlatch. 2003. Community and population-level responses to disturbance in a sandflat community. **Journal of Experimental Marine Biology and Ecology** 294: 101-125.
Waldbusser, G.G., R.L. Marinelli, R.B. Whitlatch and P.T. Visscher, 2004. The effects of infaunal biodiversity on the biogeochemistry of coastal marine sediments. **Limnology and Oceanography**
Weslawski, J.M., Snelgrove, P.V.R., Levin, L.A., Austen, M.C.V., Kneib, R.T., Iliffe, T.M., Garey, J.R., Hawkins S.J., Whitlatch, R.B. 2004. Marine Sedimentary Biota as Providers of Ecosystem Goods and Services. IN: D.H. Wall (ed.). **Sustaining Biodiversity and Ecosystem Services in Soils and Sediments**, SCOPE Series, vol. 64. Island Press, Washington, D.C.

Lawrence Williams
President/Owner, JessieD, Inc.

Panelist: Installation and Maintenance Impacts
Mollusks

Employment: 1968-1972 (Self-employed, part time) Lobsterman; 1973-1980 (Self-employed, full time)Seed oyster harvesting; 1980-1983 Captain of F/V Half Shell, engaged in shellfish harvesting. Employed by – Jessie D., Inc., 46 Dock Road, Milford, CT.; 1983 – present, Owner of Jessie D., Inc., 68 Anchorage Drive, Milford, CT. Involved in all aspects of shellfish cultivation and harvesting (clams & oysters).

Education: Graduated 1968 Point Beach Grammar School, Milford, CT; Graduated 1972 Milford High School, Milford, CT.

Summary of Qualifications: I am experienced in boat building, fabrication and design of shellfish dredges. I have participated in shellfish transplant programs, and shelling of oyster beds for oyster setting. I have sub-contracted my services to Long Island Oyster Farms in 1982, and Tallmadge Brothers from 1987-1995. I have been involved in litigation under the Clean Water Act for pollution in Long Island Sound, and have been active in many shellfish industry issues locally and at the state and federal level. I lease approximately 2000 acres of shellfish beds in the state of CT. While seed oystering, I fished in the towns of Westport, Fairfield, Bridgeport, Stratford, Milford, New Haven, East Haven, Branford, Clinton, Madison, and New London. My clamming experience has been equally as wide spread with activities in Greenwich, Stamford, Darien, Norwalk, Westport, Southport, Fairfield, Milford, West Haven, New Haven, East Haven, Branford, Groton, and Stonington. I currently own two shellfish harvesting vessels.

I have implemented a pilot suspended mussel culture project in conjunction with UCONN Sea Grant and Tessa Simlick.

Volunteer Experience: I served on Coastal Embayment Advisory Board, CT DEP; Current member of CT Seafood Council

Roman N. Zajac, PhD
Professor of Biology and Environmental Sciences, University of New Haven

Panelist: Installation and Maintenance Impacts
Benthic Habitat Classification and Mapping

Education: Tufts University, Biology B.S., 1975; University of Connecticut, Zoology M.S., 1981 University of Connecticut, Ecology Ph.D., 1985

Current Research and Recent Invited Presentation: Working with CT Dept. Env. Protection Fisheries to assess lobster population dynamics in Long Island Sound relative to sea floor habitats and environmental factors, and the development of a GIS in support of those studies; Applications of Landscape Ecology Approaches to Coastal Systems - 19th Annual Symposium of the International Association for Landscape Ecology - North America; Developing a Benthoscape Ecology for Coastal Sea Floor Environments - U.S. EPA Atlantic Ecology Division; The Coastal Landscapes, Seascapes and Benthoscapes of Long Island Sound - Critical Connections and Prospects - Mystic Seaport Long Island Sound Environmental Lecture Series.

APPENDIX G (CONTINUED)

Selected publications related to the symposium:

Twichell, D.C., Zajac, R.N., Poppe, L.J., Lewis, R.S., Cross, V., Nichols, D. Side scan sonar image, surficial geologic interpretation and bathymetry of the Long Island Sound seafloor off Milford, Connecticut. Geologic Investigations Series Map I-2632. U.S. Geological Survey, U.S. Department of the Interior. 1998.

Zajac, R.N. , R.B. Whitlatch and S.F. Thrush. 1998. Recolonization and succession in soft-sediment infaunal communities: The spatial scale of controlling factors. Hydrobiologia 375/376: 227-240.

Zajac, R.N. 1999. Understanding the seafloor landscape in relation to assessing and managing impacts on coastal environments. in: J.S. Gray, W. Ambrose Jr., A. Szaniawska (eds) Biogeochemical Cycling and Sediment Ecology, pp 211-227, Kluwer Publishing, Dordrecht.

Zajac, R.N., & D. Whitelaw.1999. An Assessment of Imaging Technologies for Mapping Shallow Water Habitats along the Connecticut Coast. CT Dept. Environmental Protection, Office of Long Island Sound Programs

Zajac, R.N. 2000. Ecologic mapping and management-based analyses of benthic habitats and communities in Long Island Sound: GIS Coverages, Images and Data. Office of Long Island Sound Programs. Hartford, CT.

.Zajac, R.N ., Lewis, R.S., Poppe, L. J.Twichell, D.C., Vozarik, J. and DiGiacomo-Cohen, M.L. 2000. Relationships among sea-floor structure and benthic communities in Long Island Sound at regional and benthoscape scales. Journal of Coastal Research 16: 627-640.

Zajac, R.N . 2001. Organism - sediment relations at multiple spatial scales: Implications for community structure and responses to disturbance. In: J. Aller, S.A. Woodin & R.C. Aller (eds) Sediment-Organism Interactions. pp. 119-139, 2001. University of South Carolina Press. Columbia, SC.

Zajac, R.N ., Lewis, R.S., Poppe, L. J.Twichell, D.C., Vozarik, J. and DiGiacomo-Cohen, M.L. 2003. Responses of infaunal populations to benthoscape structure and the potential importance of transition zones. Limnology and Oceanography 48: 829-842.

APPENDIX H

STUDY COMMITTEE BIOGRAPHICAL SKETCHES

Gale F. Hoffnagle, CCM, QEP *(Chairman, Study Committee; Academy Member)*
Senior Vice President and Technical Director, TRC Environmental Corporation

Gale F. Hoffnagle, CCM, QEP is Senior Vice President and Technical Director of TRC Environmental Corporation (TRC) in Windsor, Connecticut. At TRC, Mr. Hoffnagle is responsible for ensuring that the Company maintains the highest level of air quality expertise and that TRC's services are fully responsive to client requests.

A 36-year veteran of the air consulting field, Mr. Hoffnagle has consulted to clients across many industry segments and in virtually every region of the country. He has served as atestifying expert troughout his career in two basic venues: Clean Air Act regulatory matters, and Toxic Torts Resulting from Accidental Releases or Continuous Emissions.

He has served as an expert in over 50 cases nation-wide, involving a wide range of industrial facilities. TRC, under Mr. Hoffnagle's leadership, provided assistance to over 300 facilities throughout the nation in preparing and updating their Clean Air Act Title V permits and Risk Management Plans

Mr. Hoffnagle holds an M.S. in Meteorology and a B.S. in Meteorology and Oceanography from New York University, as well as an MBA from Golden Gate University and is a Certified Consulting Meteorologist (CCM) and a Qualified Environmental Professional (QEP).

He has previously served as a Captain in the U.S. Air Force at the USAF Environmental Health Laboratory and at Intera Environmental Consultants and Environmental Research and Technology.

Mr. Hoffnagle has been an Air & Waste Management Association member since 1969 and served the Association in many capacities. He was President in 1988-1989 and had previously served two terms on the Board of Directors. Mr. Hoffnagle is also a member of the Connecticut Academy of Science and Engineering previously serving as Chairman of the Board on the Environment and currently serving as Secretary.

Roger D. Flood, PhD
Associate Professor, Marine Sciences Research Center
State University of New York at Stony Brook

This information has been extracted from the SUNY-Stony Brook website – updated 1998:
I am presently studying sedimentation processes and patterns in several marine and fresh water environments. I am particularly interested in the use of high-resolution methods, including geophysical techniques (side-scan sonar, seismic profiling, physical property analysis, and high-resolution bathymetry), photography, submersible studies and sediment analysis, to provide new insights into sedimentary processes. My current research includes sedimentation patterns in modern environments (including the Great Lakes, the Hudson River, and local estuaries), the structure and evolution of sedimentary bodies on the continental margin, and new methods of rapid sediment characterization. Precise characterization of sedimentary environments is important for understanding marine and freshwater environmental problems. We have been using high-resolution geophysical techniques in studies of contamination problems in Lake Ontario (PCB resuspension and ship-derived wastes) and in the Hudson River (PCBs) as well as in benthic habitat surveys in Long Island's Great South Bay (hard-clams). These studies, undertaken in multidisciplinary groups, provide new insights into long-standing management issues.
It is important to understand the structure and development of submarine fans and sediment drifts on the continental margin. Submarine fans contain much of the sediment eroded from continents during sea level lowstands and significant hydrocarbon reserves. A drilling program on the Amazon Fan in 1994 (ODP Leg 155) studied the sedimentary processes, facies, and climate records of this modern deposit. Sediment drifts on continental margins collect sediment transported to the site by bottom currents. High sedimentation rates result in expanded climate records, and bedforms created by flowing waters contain a record of those flows. ODP Leg 172 studied bed forms and climate records on the Blake Bahama Outer Ridge in early 1997.

APPENDIX H (CONTINUED)

John W. Ladd, PhD
Benthic Mapping Coordinator
Hudson River National Estuarine Research Reserve, Hudson River Estuarine Program
New York State Department of Environmental Conservation

After receiving his Ph.D. in marine geology and geophysics from Columbia University in 1974, John worked for 19 years as a research scientist at the University of Texas and Columbia University conducting research in marine geology. In 1993 he became Science Coordinator for the Museum of the Hudson Highlands where he developed a research project to evaluate fish use of a restored wetland that the Museum had built on the Cornwall waterfront. In 1997 he became the Habitat Restoration Coordinator and then the Benthic Habitat Coordinator for New York State Dept Environmental Conservation where he has helped develop wetland restoration plans on the Hudson River and participated in developing and managing the Hudson River Estuary benthic mapping project, a project of the Hudson River Estuary Program.

Ralph S. Lewis
Associate Professor in Residence of Marine Sciences, University of Connecticut
State Geologist, Connecticut Department of Environmental Protection (ret.)

Education: 1974, M.S., Franklin and Marshall College, Lancaster, PA (Geology); 1970, B.A., Franklin and Marshall College, Lancaster, PA (Geology)

Ralph Lewis was the State Geologist between 1997 and 2003. In this capacity he was responsible for overseeing the activities of the State Geological and Natural History Survey of Connecticut. The Survey develops and conducts geological and biological programs involving basic research, data collection, inventories, monitoring and analysis, habitat and species protection, resource evaluations, technical assistance and outreach.

Ralph is now retired, but serves as the part-time Director of the Long Island Sound Resource Center where he is involved in collecting, synthesizing and disseminating data and information relating to Long Island Sound. Ralph is a Certified Professional Geologist with 26 years of professional experience. He has published over 100 papers and abstracts culminating in a Thematic Section of the Journal of Coastal Research, which he co-edited.

Matthew S. Mashikian, PhD *(Academy Member)*
Professor of Electrical Engineering, University of Connecticut (ret.)
President & CEO, IMCORP

Matthew S. Mashikian (IEEE Life Fellow) holds a doctorate in Electrical Engineering from the University of Detroit, and is the founder and CEO of Instrument Manufacturing Company (IMCORP™), an international company (with subsidiary in Belgium) specializing in cable diagnostic testing. His professional experience includes 5 years with ASEA (now ABB), 16 years with Detroit Edison Company, 4 years as the President of his own consulting company and 15 years as Professor of Electrical Engineering and Director of The Electrical Insulation Research Center, University of Connecticut. Dr. Mashikian holds a dozen of patents and has published extensively on electrical insulation, cable accessory designs, cable testing, partial discharge measurement, electric vehicles and load leveling rechargeable batteries. He is past chairman of the IEEE/PES Insulated Conductors Committee and past chairman of the IEEE/DEIS Education Committee. He is a member of the Connecticut Academy of Science and Engineering.

Edward C. Monahan, PhD *(Academy Member)*
Director, Connecticut Sea Grant College Program & Professor of Marine Sciences & Resource Economics, University of Connecticut

Academic administrator, marine science educator; b. Bayonne, N.J., July 25, 1936; s. Edward C. and Helen G. (Lauenstein) M.; m. Elizabeth Ann Eberhard, Aug. 27,1960; children: Nancy Elizabeth, Carol Frances, Eîlís Marie. Grad. Teaneck (NJ) H.S., 1954. B.of Engineering Physics, Cornell U., 1959; MA (Physics), U. Tex., 1961; PhD (Oceanography), MIT, 1966; DSc (published work), Nat. U. Ireland, 1984; Cert., Adv.Eng. Stud.,Cornell U.,1991. Rsch.

APPENDIX H (CONTINUED)

asst. Woods Hole (Mass.) Oceanographic Inst., 1964-65; asst. prof. physics No. Mich. U., Marquette, 1965-68; asst. prof. oceanography Hobart and William Smith Coll., Geneva, N.Y., 1968-69; asst. prof. dept. meteorology & oceanography U. Mich., Ann Arbor, 1969-71, assoc. prof. dept. atmospheric and oceanic sci., 1971-75; dir. edn. and rsch. Sea Edn. Assn., Woods Hole, 1975-76; statutory lectr. phys. oceanography U. Coll., Galway, Ireland, 1976-86; G.J. Haltiner Rsch. Chair prof. meteorology, Naval Postgrad. Sch., Monterey, 1981-82; prof. Marine Scis. U. Conn., Avery Point, 1986-; director, Conn. Sea Grant Coll. Program, Avery Point, 1986-; adj. prof. Ag. & Res. Econ. UConn, Storrs, 2001- . editor: (with G. MacNiocaill) *Oceanic Whitecaps and Their Role in Air-Sea Exchange Processes,* 1986; (of English lang. edition of R.S. Bortkovskii's) *Air-Sea Exchange of Heat and Moisture During Storms,* 1987; (with P. Van Patten) *Climate and Health Implications of Bubble-Mediated Sea-Air Exchange,* 1989; (with B. Jähne) *Air-Water Gas Transfer,* 1995; contributed some 316 journal articles, technical reports, and other publications; writings cited over 1,880 times in books and numerous issues of at least 145 different sci. journals pub. in 16 or more countries. Recipient to date of 151 grants($20.4M) = 73 rsch. grants ($2.8M) + 78 grants ($17.7M) to CT Sea Grant Program. Numerous field exped. incl. rsch. cruise on F.S. *Polarstern* to 81° 31' N. Serves on numerous Bds and Adv. Comms, incl. Board on Oceans and Atmosphere of the National Association of State Universities and Land-Grant Colleges (UConn deleg.,1993-), EPA Long Island Sound Study Management Committee (1999-), Board of Advisors, Goodwin-Niering Center for Conservation Biology and Environmental Studies, Connecticut College (1999-), Atlantic States Marine Fisheries Commission-Lobster Research Board's Steering Committee for L.I.Sd. Lobster Disease Research (2000-), Southeastern Connecticut Water Authority (2003-) Recent honors: elected (1996) Fellow of Am. Meteorol. Soc., selected for 1997 Editor's Award of Am. Meteorol. Soc. *(J. Phys. Oceanogr.),* elected (1998) Fellow of Acoustical Soc. Am., elected (1999) to the 200-member Connecticut Academy of Science and Engineering, twice recipient (2000, 2001) of President's Award of Sea Grant Assoc. Fellow Royal Meteorol. Soc.; mem. AAUP, Am. Geophys. Union, Am. Soc. Limnology and Oceanography, Internat. Assn. Theoretical and Applied Limnology, Irish Meteorol. Soc., The Oceanography Soc. (life). Avocation: sculling. Home: 18 Monticello Dr., Gales Ferry CT 06335-1944 Office: UConn at Avery Point, 1080 Shennecossett Rd, Groton CT 06340-6048. Tel.: (860) 405-9110. Fax: (860) 405-9109. E-mail: sgoadm0l@uconnvm.uconn.edu, or edward.monahan@uconn.edu

Six recent pubs: ECM and H.G. Dam, Bubbles: An estimate of their role in the global oceanic flux of carbon, *Journal of Geophysical Research, 106,*9377-9383 [2001]; ECM, Whitecaps and Foam, 3213-3219, Encyclopedia of Ocean Sciences, J. Steele, S. Thorpe, and K. Turekian, eds.,Academic Press [2001]; ECM, Comments on "Bubbles produced by breaking waves in fresh and salt water", *Journal of Physical Oceanography, 31,*1931-1932 [2001]; ECM, The Physical and Practical Implications of a CO_2 Gas Transfer Coefficient that Varies as the Cube of the Wind Speed, 193-197, Gas Transfer at Water Surfaces, M.A. Donelan et al, eds., AGU [2002]; ECM, Environmental Problems?, *Weather, 57,* 112 [2002], ECM, Oceanic Whitecaps:Sea surface features detectable via satellite that are indicators of the magnitude of the air-sea gas transfer coefficient, *Proceedings of the Indian Academy of Sciences(Earth & Planet.Sci.),111,* 315-319 [2002].

Linda C. Schaffner, PhD
Associate Professor of Marine Science, Virginia Institute of Marine Science
College of William and Mary
Also, 2003-2005 President, Estuarine Research Federation

Dr. Linda Schaffner is an Associate Professor of Marine Science at the Virginia Institute of Marine Science, School of Marine Science, College of William and Mary. Her areas of expertise include estuarine processes and benthic community ecology. Current research projects include a study to investigate relationships between benthic community structure and ecosystem functional processes in shallow water habitats, and a study to examine the sublethal impacts of sediment contaminants on benthic secondary production. With support from EPA's Chesapeake Bay Program, Schaffner was part of the team that developed the Benthic Index of Biotic Integrity (B-IBI) for Chesapeake Bay, which is now routinely used as a management tool by the Chesapeake Bay Program. She is the current president of the Estuarine Research Federation, an international organization representing academic researchers, public sector managers, teachers, consultants, students and others interested in the science and management of the coastal oceans. During the past 15 years, she has served on professional panels or committees for EPA's Chesapeake Bay Program, the National Science Foundation, Maryland's Chesapeake Bay Monitoring Program, the Virginia Department of Environmental Quality (DEQ), and the Swedish Environmental Protection Board, among others. In recognition of her efforts to enhance the participation of women and minorities in science, Schaffner was the recipient of the 2003 Outstanding Faculty Award from the Virginia State Council of Higher Education.

APPENDIX H (CONTINUED)

Study Manager

Tom Filburn, PhD
Assistant Professor of Mechanical Engineering, University of Hartford

Tom Filburn joined the University of Hartford in August 2001 as an Assistant Professor of Mechanical Engineering. He is primarily responsible for teaching undergraduate courses in the thermal sciences, including heat transfer, fluid mechanics and an undergraduate thermal/fluids laboratory course. Prior to joining the University of Hartford, Tom worked in the Power and Aerospace Industries for over 20 years. He spent 5 years working in the Nuclear power industry both in a manufacturing and plant engineering capacity. The last 16 years of his industrial experience were chiefly in the Research and Development area. He worked for 5 years developing a liquid metal, Rankine cycle, power plant for underwater propulsion. He spent the final 11 years of his industrial experience working within the R&D laboratory of Hamilton Sundstrand, developing Advanced Life Support technologies for NASA's use on board the Space Shuttle Orbiter, Space Suit EMU and the International Space Station. Tom has written numerous conference and journal papers on life support issues and holds 5 patents on various technologies useful for revitalizing air and water.

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Ladd, J.W., R.E. Bell, E.A. Blair, H. Bokuniewicz, S. Carbotte, R.M. Cerrato, S. Chillrud, V.L. Ferrini; R.D. Flood, N. P. Maher; C.M.G. McHugh, F. O. Nitsche, W.B.F. Ryan, D. L. Strayer, J. Thissen; R. Versteeg, 2002, Mapping the Hudson Estuary's submerged lands, Clearwaters, 32(1), 5-7.

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Poppe, L.J. and C. Polloni (editors), 1998, Long Island Sound environmental Studies CD-ROM, U.S. Geological Survey Open File Rpt 98-502.

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MAJOR STUDIES OF THE ACADEMY

2004

- A Study of Railcar Lavatories and Waste Management Systems

2003

- An Analysis of Energy Available from Agricultural Byproducts, Phase II: *Assessing the Energy Production Processes*
- Study Update: Bus Propulsion Technologies Available in Connecticut

2002

- A Study of Fuel Cell Systems
- Transportation Investment Evaluation Methods and Tools
- An Analysis of Energy Available from Agricultural Byproducts, Phase 1: *Defining the Latent Energy Available*

2001

- A Study of Bus Propulsion Technologies in Connecticut

2000

- Efficacy of the Connecticut Motor Vehicle Emissions Testing Program
- Indoor Air Quality in Connecticut Schools
- Study of Radiation Exposure from the Connecticut Yankee Nuclear Power Plant

1999

- Evaluation of MTBE as a Gasoline Additive
- Strategic Plan for CASE

1998

- Radon in Drinking Water

1997

- Agricultural Biotechnology
- Connecticut Critical Technologies

1996

- Evaluation of Critical Technology Centers
- Advanced Technology Center Evaluation
- Biotechnology in Connecticut

1994

- Science and Technology Policy: Lessons from Six Amer. States

1992

- A State Science and Technology Policy
- Electromagnetic Field Health Effects

1990

- Biotechnology (Research in Connecticut)
- Economic Impact of AIDS Health Care in Connecticut

1989

- Science and Engineering Doctoral Education in Connecticut

1988

- Indoor Pollution: Household Survey
- Vocational-Technical High School Curriculum Evaluation

1987

- Waste Conversion for State Construction
- High Technology Plan for Connecticut

1986

- Automobile Emissions Testing
- Health Standard (for EDBs)

Connecticut Academy of Science and Engineering
179 Allyn Street, Suite 512, Hartford, CT 06103
Phone or Fax: 860-527-2161
e-mail: acad@ctcase.org
web: www.ctcase.org

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Connecticut Academy of Science and Engineering
179 Allyn Street, Suite 512, Hartford, CT 06103
Phone or Fax: 860-527-2161
e-mail: acad@ctcase.org
web: www.ctcase.org