New York Seagrass Experts Meeting

Meeting Proceedings and Priority Recommendations

May 22, 2007
East Setauket, NY

Photo by: Cornell Cooperative Extension of Suffolk County Marine Program
Acknowledgements

This meeting was sponsored by the New York State Department of Environmental Conservation, New York Sea Grant, Peconic Estuary Program, Cornell Cooperative Extension, The Nature Conservancy and the Long Island Sound Study.

A special thank you to members of the Steering Committee for their many months of strategic planning, and the Experts Panel for their unsurpassed dedication and enthusiasm.
# Table of Contents

Introduction 1

Workshop Format 2

Agenda 4

Appendix A: New York State Seagrass Taskforce Legislation 6

Appendix B: Expert Panel Bios 10

Appendix C: Presenter Bios 14

Appendix D: List of Meeting Attendees 17

Appendix E: Presentation Abstracts/Slides 20

Appendix F: Research, Management, and Monitoring Priorities 68

Appendix G: Pre-Meeting Potential Research Questions 73

Appendix H: Other Supplemental Materials 76

Maps
- Research Conducted in the Peconic Estuary Regarding Eelgrass
- Actions and Recommendations Involving Eelgrass in the Peconic Estuary
- Comprehensive Conservation and Management Plan
- Local Management Affecting Eelgrass in the Peconic Estuary
- New York State Management Impacting Eelgrass
- Long Island Estuary Systems: Snapshot
Introduction
Seagrasses are rooted, underwater vascular plants which grow in shallow coastal waters. While several different species of seagrasses exist, the two most commonly found species in New York’s coastal waters are eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). These submerged aquatic vegetation (SAV’s), are considered to be some of the most productive ecosystems in the world and are biologically, ecologically and economically important. Seagrass beds stabilize benthic sediments, support nutrient cycling, oxygenate waters, improve water quality, and provide critical habitat for aquatic species (e.g., fluke, bluefish, bay scallops and hard clams). The presence of seagrass is often used as an indicator of estuarine health and high water quality.

Long Island marine waters once supported bountiful populations of seagrass. The onset of a wasting disease (*Labyrinthula zostorae*) in the early 1930’s was responsible for the significant decline of eelgrass beds along the entire Atlantic seaboard. Light shading effects of Brown Tide occurrences in the 1980’s further decimated eelgrass populations. Long Island seagrass populations may also continue to be impacted by nutrient enrichment, fishing and shellfishing practices, and recreational use of shallow waterways. Despite management and restoration efforts and significant improvements in water quality, populations are still declining and have not rebounded. Monitoring efforts in Long Island Sound, the Peconic Bays, and the South Shore Estuary indicate that these individual estuarine systems have each experienced separate and distinct trends. If qualitative and quantitative improvements in eelgrass beds are sought, these systems and their respective trends must be examined further.

Acknowledging the importance of seagrass and the necessity to protect and restore this valuable natural resource, Governor George Pataki enacted Chapter 404 of the Laws of 2006 on July 26, 2006, which established a New York Seagrass Task Force within the New York Department of Environmental Conservation. This Task Force is charged with examining the current state and make recommendations on means of restoring, preserving, and properly managing seagrass. Task Force meetings have since commenced in early 2008; the legislation can be found in Appendix A.

In the meantime, several representatives from various agencies and organizations decided to proceed with heightening awareness of declining seagrass trends, and drawing attention to the need of directing resources to foster an increased understanding. Consequently, a Steering Committee was formed. Members included:

Rick Balla, *United States Environmental Protection Agency/ Peconic Estuary Program*
Marci Bortman, *The Nature Conservancy*
Jerry Churchill, *Adelphi University*
Karen Chytalo, *NYS Department of Environmental Conservation, Bureau of Marine Resources*
Corey Garza, *National Oceanic and Atmospheric Administration/Long Island Sound Study*
Jack Mattice, *New York Sea Grant*
Brad Peterson, *State University of New York*
Chris Pickerell, *Cornell Cooperative Extension*
Cornelia Schlenk, *New York Sea Grant*
Laura Stephenson, *NYS Department of Environmental Conservation/Peconic Estuary Program*
This Steering Committee would organize a Seagrass Experts Meeting that would help establish a body of background information look at past and current trends, facilitate discussion between local seagrass experts, and gain insights from nationally renowned seagrass scientists and managers.

**Meeting Format**

The main goal of the Seagrass Experts Meeting was to have a scientific panel of experts reach a consensus about what information gaps would be the most important to fill in order for New York to move forward most efficiently and effectively toward preserving and/or restoring seagrass habitat.

The first step was to establish a panel of seagrass experts. In an attempt to create a diverse panel, individuals were selected based on unique expertise and complementary knowledge and experience. The Steering Committee was extremely fortunate in being able to secure the interest and participation of several key, nationally-recognized seagrass experts; some located on Long Island, while others based in Alabama, Florida, Maryland, New Hampshire and North Carolina (see Figure 1). Brief biographies of Expert Panel members can be found in Appendix B. The Expert Panel was asked to attend a meeting to learn about conditions in New York, synthesis and integrate information through discussion, and then develop recommendations on research, management and monitoring priorities.

*Figure 1- Experts Panel (L to R):*  
Paul Carlson (Florida Fish and Wildlife Conservation Commission), Bradley Peterson (Stony Brook University), William Dennison (University of Maryland), Kenneth Heck, Jr., (University of South Alabama), Mark Fonseca (NOAA National Ocean Service), Chris Pickerell (Cornell Cooperative Extension), A. Coolidge Churchill (Adelphi University), Fred Short (University of New Hampshire).
The next step was to identify local scientists, researchers, and managers to present the local context and set the stage for the Experts Panel’s deliberations. These individuals were to address the relevant physical, biological, and chemical characteristics of Long Island Sound, the Peconic Bays, and the South Shore Estuary, as well as past and current status of seagrasses in those systems. Brief biographies of those presenters may be found in Appendix C.

The New York Seagrass Experts Meeting was held on May 22, 2007 at the New York State Department of Environmental Conservation Bureau of Marine Resources Headquarters located in East Setauket, New York. To keep the Meeting as focused and productive as possible, invitees were limited essentially to the Steering Committee, the local presenters, and the Experts Panel (see Appendix D). The agenda (see following page) began with presentations of local information to set the stage (see Appendix E for presentation abstracts and slides). Question and answer periods followed, proceeded by Expert Panel deliberations which continued late into the evening. The output of the Expert Panel deliberations was a table of priority actions (see Appendix F) which identifies:

- The ranked order of priority;
- Whether it is a research, monitoring or management activity;
- What the recommended action is;
- Tasks to be undertaken to accomplish the action;
- An estimate of the time period required; and
- An estimate of the costs involved

Expectations of the Steering Committee were well exceeded. An incredible amount of information was shared and valuable new connections between individuals made. Most importantly, priority recommendations reflect those of informed, interested, and impartial experts. Those recommended actions provide a needed, well-founded direction for New York’s future efforts to preserve and restore the seagrass beds of its estuarine waters.
AGENDA
Seagrass Experts Meeting
May 22
NYSDEC Bureau of Marine Resources

8:00am Registration and Continental Breakfast

8:30am Welcome
Jack Mattice, Ph.D- Director, NY Sea Grant

Overview of Meeting
Karen Chytalo- Section Chief, Marine Habitat Protection, New York State Department of Environmental Conservation, Bureau of Marine Resources

8:45am Snapshot of Long Island Marine Waters: Physical Characteristics
Short presentations, each followed by questions/discussion

1. Water Quality-Nutrients, Phytoplankton (approx 8:45-9:00am)
Chris Gobler, Ph.D.- Associate Professor, Marine Sciences Research Center, Stony Brook University

2. Linking Groundwater, Pesticides and SAV's (approx 9:00-9:15am)
Ron Paulsen- Hydrogeologist. Suffolk County Department of Health Services, Office of Water Resources

3. Marine Sediment Geo-chemistry (approx 9:15-9:30am)
Kirk Cochran, Ph.D.- Professor, Marine Sciences Research Center, Stony Brook University

4. Habitat Modification & Loss of Suspension Feeders (approx 9:30-9:45am)
Brad Peterson, Ph.D.- Assistant Professor, Marine Sciences Research Center, Stony Brook University

9:55am Break
Display of current and historical eelgrass maps

10:10am Status, Historical Distributions, and Current Management and Research Approaches

1. South Shore (approx 10:10-10:25am)
Chris Clapp- Estuary Specialist, The Nature Conservancy

2. Peconic Estuary (approx 10:25-10:40am)
Steve Schott- Marine Botany Educator, Cornell Cooperative Extension
Kim Petersen- Habitat Restoration Educator, Cornell Cooperative Extension
3. **Long Island Sound** (approx 10:40-10:55am)
   Tom Halavik- *Senior Biologist, United States Fish and Wildlife Service*

11:00am  **A Brief History of Long Island Restoration Efforts**
   Chris Pickerell- *Habitat Restoration Specialist, Cornell Cooperative Extension*

11:15am  **Introduction to Panel Discussion**
   Overview of Panel Discussion and Introduction of Potential Research Questions (see Appendix G)
   Karen Chytalo- *Section Chief, Marine Habitat Protection, New York State Department of Environmental Conservation, Bureau of Marine Resources*

11:30am  **Working Lunch** (Provided)
   Expert Panel will convene with facilitator to discuss presented information
   Cornelia Schlenk- *Assistant Director, NY Sea Grant*

12:15pm  **Expert Panel Questions for Speakers**

12:35pm  **Group Discussion: Discussing Research and Monitoring Priorities**

3:15pm  **Narrowing the Focus and Prioritizing**
   Expert Panel convenes with facilitator to refine and prioritize research and monitoring agenda. Provide timeframes and estimated costs where applicable.
   Cornelia Schlenk- *Assistant Director, NY Sea Grant*

4:15pm  **Meeting Wrap Up- Next Steps**
   Expert Panel will reconvene with group to present and discuss fully developed priorities

4:45pm  **Adjourn**
Appendix A:
New York State
Seagrass Task Force Legislation
BILL NUMBER: S8052

SPONSOR: JOHNSON

TITLE OF BILL:
An act to establish a seagrass research, monitoring and restoration task force and providing for its powers and duties; and providing for the repeal of such provisions upon expiration thereof

PURPOSE:
To establish a task force that will examine and make recommendations on means of restoring, preserving and properly managing seagrass.

SUMMARY OF PROVISIONS:
Section one establishes a seagrass research, monitoring and restoration task force. The Task force will consist of five voting members and ten non-voting members.

Sections two, three and four provide for the organization of the task force by establishing that the chairperson will be the commissioner of environmental conservation or his or her designee and requires that any vacancies on the task force be filled in the manner provided by the initial appointment.

Sections five, six and seven authorize the task force to hold public hearings and meetings to enable it to accomplish its duties; and requires that every state agency, local agency and public corporation having jurisdiction over areas of native seagrass habitat or over programs relating to the purposes and goals of this act offer full cooperation and assistance to the task force in carrying out the provisions of this act. Defines "native seagrass," as native underwater plants found in Long Island bays and estuaries including, but not limited to, eelgrass and widgeon grass.

JUSTIFICATION:
Long Island seagrass populations were severely decimated by wasting disease in the 1930s and again by a massive brown tide event in the 1980s. Despite the absence of these events in some areas like the Peconic Bays and Long Island Sound over the past 20 years, local seagrasses have not recovered. The intent of this legislation is to set up a task force to develop recommendations for regulations to improve seagrass protection, restoration, research and monitoring.

This task force will establish the necessary framework for reducing the impact of direct and indirect threats and restoring and properly managing seagrass into the future. Direct impacts include physical damage from boat groundings, incompatible fishing practices, docks and bulkheads, and other potentially destructive activities. Indirect impacts include water quality effects from nutrients, sedimentation and toxic contaminants.

Effective regulations for seagrass protection and restoration will depend greatly on the State's ability to understand the severity of these impacts. This task force will identify and assess severity of indirect and direct
threats, develop restoration goals, recommend short-term and long-term
research and monitoring and propose public outreach and education tools.
Seagrass, which is designated as Essential Fish Habitat and a Habitat Area of
Particular Concern for many of New York State's recreationally and
commercially important marine species, is a vital component to successful and
lasting restoration of Long Island finfish, shellfish, crustacean, and
waterfowl populations, which has far reaching benefits for improved quality
of life and economic growth opportunities for present and future generations
on Long Island.

LEGISLATIVE HISTORY:
New bill.

FISCAL IMPLICATIONS:
Minimal.

EFFECTIVE DATE:
This act shall take effect immediately and be deemed repealed January 1,
2009.

LAWS OF NEW YORK, 2006
CHAPTER 404

AN ACT to establish a seagrass research, monitoring and restoration task
force and providing for its powers and duties; and providing for the repeal
of such provisions upon expiration thereof

Became a law July 26, 2006, with the approval of the Governor.
Passed by a majority vote, three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do
enact as follows:

Section 1. Seagrass research, monitoring and restoration task force. There is hereby established, within the department of environmental
conservation a seagrass research, monitoring and restoration task force("task
force") which shall consist of five voting members and ten non-voting members
who shall be appointed as follows:
(a) the commissioner of environmental conservation or his or her
desigee;
(b) the commissioner of parks, recreation and historic preservation or
his or her desigee;
(c) the secretary of state or his or her desigee;
(d) one member upon the recommendation of the temporary president of
the senate;
(e) one member upon the recommendation of the speaker of the assembly;
(f) ten non-voting members to be selected by the department of envi-
ronmental conservation representing: recreational anglers, town
marine law enforcement, estuary programs, the commercial fishing
industry, recreational boaters, the director of New York sea grant,
local government officials, the marine resources advisory council, New
York businesses and advocates for the environment.
§ 2. Task force members shall receive no compensation for their services but shall be reimbursed for actual and necessary expenses incurred in the performance of their duties.

§ 3. The chairperson of the task force shall be the commissioner of environmental conservation or his or her designee. The task force shall meet no less than four times and at other times at the call of the chairperson.

§ 4. Any vacancies on the task force shall be filled in the manner provided for in the initial appointment.

§ 5. The task force shall be authorized to hold public hearings and meetings to enable it to accomplish its duties.

§ 6. Every state agency, local agency and public corporation having jurisdiction over areas of native seagrass habitat or over programs relating to the purposes and goals of this act shall, to the fullest extent practicable, offer full cooperation and assistance to the task force in carrying out the provisions of this act.

§ 7. As used in this act, "native seagrass" shall mean native underwater plants found in Long Island bays and estuaries including, but not limited to, eelgrass (zostera marina) and widgeon grass (ruppia maritima); "native seagrass meadows" shall mean those habitats in estuarine waters vegetated with one or more species of native seagrass.

§ 8. No later than December 31, 2008, the task force shall transmit to the governor, the temporary president of the senate and the speaker of the assembly a report containing recommendations on how to accomplish the following:

(a) Recommendations on elements of a seagrass management plan including, but not limited to, regulatory and/or statutory alterations required to preserve, restore, protect and map the native seagrass population on Long Island.

(b) Recommendations on means of preserving and restoring seagrass and native seagrass meadows that will bring about a lasting restoration of finfish, shellfish, crustaceans, and waterfowl, that is compatible with an improved quality of life and economic growth for the future of the region. Such proposals shall also include any recommendations for monitoring, additional research, and public education to ensure the success of the effort.

§ 9. This act shall take effect immediately and shall expire and be deemed repealed January 1, 2009.

The Legislature of the STATE OF NEW YORK ss:
Pursuant to the authority vested in us by section 70-b of the Public Officers Law, we hereby jointly certify that this slip copy of this session law was printed under our direction and, in accordance with such section, is entitled to be read into evidence.

JOSEPH L. BRUNO  SHELDON SILVER
Temporary President of the Senate  Speaker of the Assembly
Appendix B: 
Expert Panel Bios
Brief Biographies of the Seagrass Experts Panel

Paul Carlson received his BA in Biology from New College in Sarasota, FL and his PhD in Ecology from UNC-Chapel Hill. After postdocs at U. Maryland Horn Point Environmental Laboratory and Harbor Branch Oceanographic Institution, he joined the Florida Marine Research Institute as a research scientist in 1984 working on seagrass, mangrove, and salt marsh habitat monitoring, assessment, and restoration. Significant projects have included seagrass mortality in Florida Bay, water quality management in mosquito control impoundments, bioturbation impacts on seagrass beds in Tampa Bay, and seagrass mapping and monitoring in Florida’s Big Bend.

A. Coolidge Churchill earned a PhD at the University of Oregon studying marine algae under Richard Castenholz. His first and only full-time job has been at Adelphi University where he has worked for 40 years and from which he will retire in August 2007. While at Adelphi, he supervised numerous Master’s theses and taught courses that run the gamut from marine biology to electron microscopy. His research work focused initially on the ecology of the marine alga Codium fragile, which at the time was a relative newcomer to the East coast and of some environmental concern. In the mid-1970’s and supported by New York Sea Grant, he embarked on efforts to stabilize subtidal dredge spoil in Great South Bay via the transplantation of eelgrass. The potential significance of transplanting seagrasses was well appreciated at the time, but different methods were in the early stages of testing. While the results of the plantings were initially encouraging, their near total demise within 15 months reflects familiar experiences, even today, with transplant efforts. Subsequent work and also funded in part by New York Sea Grant included the study of heavy metal mobilization by eelgrass shoots, a description of anthesis and seed production in plants from Great South Bay, field studies on eelgrass seed banks, and the seasonal timing of seed germination. More recently, he has investigated the key role of dissolved oxygen in eelgrass seedling development, and together with Wyllie-Escheverria have helped to define the variation in seed size among and within eelgrass plants from different populations. He plans to continue his research on eelgrass at Adelphi after retirement.

Dr. Bill Dennison is a Professor of Marine Science and Vice President for Science Applications at the University of Maryland Center for Environmental Science (UMCES). Dr. Dennison’s primary mission within UMCES is to coordinate the Integration and Application Network, a group of scientists committed to solving, not just studying, environmental problems. Bill rejoined UMCES in 2002 following a ten year stint at the University of Queensland in Brisbane, Australia. He originally started at UMCES (then the Center for Environmental and Estuarine Science) in 1987 as a Research Assistant Professor based at Horn Point Laboratory. In Australia, Bill worked with an active Marine Botany group at the University of Queensland. Bill obtained his academic training from Western Michigan University (B.A), the University of Alaska (M.S), The University of Chicago (Ph.D), and State University of New York at Stony Brook at Stony Brook (Postdoc). Bill began studying seagrasses for his MS in Alaska in 1978, did his PhD research in Woods Hole, and then joined Stony Brook to study Long Island seagrasses. However, the “brown tide” algal blooms changed his focus, and the seagrass research effort was confined to documenting the brown tide impacts and studying Caribbean seagrasses. Bill is currently working with an international group of seagrass scientists through the National Center for Ecological Analysis and Synthesis on global trajectories of seagrasses, building a global seagrass database, writing a series of scientific papers and producing a suite of science communication products to raise the profile of seagrasses and seagrass conservation.

Mark S. Fonseca is the Chief of the Applied Ecology and Restoration Research Branch of NOS/NOAA, National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research in
Beaufort, North Carolina. **Research:** Project leader in basic and applied studies of marine and estuarine ecology with a focus on ecosystem restoration and management, as well as factors influencing seagrass ecology and faunal utilization particularly in the context of hydrodynamic and landscape processes. Duties are concentrated in the area of seagrass ecology, management and restoration. Studies have focused on exploring hydrodynamic interactions with marine ecosystems at a number of scales, developing seagrass planting techniques and management strategies for seagrasses in various parts of the world. Other studies include comparisons of planted vs. natural seagrass bed functions, light limitations of seagrasses and their population ecology. Recent investigations focus on the influence of hydrodynamic and disturbance processes in the formation and maintenance of marine landscapes, living marine resource use of contrasting landscape patterns and consequences of mitigative actions in these landscapes. Modeling research includes effects of scale on habitat characterization, GIS-based spatial modeling of habitat injury recovery and application of both spatial models and economic strategies in quantifying habitat injury assessment. Other active studies include developing GIS-based operational tools for wave exposure computation, boat wake effects on estuarine environments, a tidally corrected optical water quality model, as well as study of deepwater seagrass beds of the west Florida shelf, and evaluation of the Tortugas Ecological Reserve – coral reef ecosystem. **Management:** Develop, transfer and assist in the implementation of management strategies for marine ecosystems, assist in damage assessment and recovery analysis as well as permit reviews and expert witness testimony for the Government. Broad discretion is given by NOAA management to define research goals and strategies, procure support, execute and publish findings.

**Kenneth L. Heck, Jr.** is a marine ecologist whose research has focused on plant-animal interactions in coastal wetlands, and on elucidating the importance of seagrass meadows and salt marshes in the production of finfish and shellfish. From 1976-1986 he was Assistant, and then Associate Curator, and also Director of the Patrick Center for Environmental Research at the Academy of Natural Sciences in Philadelphia. Since 1986 he has been a Senior Scientist at the Dauphin Island Sea Lab (DISL) and an Associate and Full Professor at the University of South Alabama (USA). He currently serves as Chair of University Programs at DISL and as Associate Director of the Alabama Center for Estuarine Studies at USA. Dr. Heck has edited two volumes of scholarly works and published more than 100 peer-reviewed articles. He has been appointed to editorial positions at the journal Systematic Zoology, Estuaries and Coasts and is currently Contributing Editor for the international journal Marine Ecology Progress Series. In addition, he regularly serves on review panels for a wide variety of federal agencies, including the National Science Foundation, the Environmental Protection Agency and NOAA Sea Grant. Dr. Heck received his B.S. in Biology from the University of West Florida (1970) and after serving in the U.S. Army obtained his M.S. (1973) and PhD (1976) in Biology from Florida State University.

**Bradley J. Peterson** received the B.S. degree in Marine Biology from the Florida Institute of Technology, Melbourne, FL, in 1989, the M.S. degree in Zoology from the University of Rhode Island in 1993, and the Ph.D. degree in Marine Science from the Dauphin Island Sea Lab / University of South Alabama in 1998. His graduate research investigated the role of suspension feeding bivalves in fertilizing seagrass productivity through their biodeposits. From 1998 to 2000, he was a Tropical Biology Post-Doctoral Scholar at the Florida International University, where he was primarily responsible for overseeing the Florida Keys National Marine Sanctuary Seagrass Status and Trends Monitoring Program. From 2000 to 2002, he was a Research Scientist at the Southeast Environmental Research Center at FIU investigating the role of the sponge communities in controlling phytoplankton blooms within Florida Bay and the concomitant effect on seagrass productivity. From 2002 to 2005, he was an Assistant Professor of Marine Science at Southampton College of Long Island University. Currently, Brad is an Assistant Professor at the Marine Sciences Research Center of Stony Brook University. His research interests include positive biological interactions, bentho-pelagic coupling, ecosystem engineering, biogeochemistry of the coastal ocean, nutrient cycling in the marine environment and ecosystem modeling.
Chris Pickerell is a Habitat Restoration Specialist with Cornell University Cooperative Extension of Suffolk County. Chris has 14 years experience working on the management and restoration of salt marshes and eelgrass on Long Island. His work over the last decade has included overseeing eelgrass long-term monitoring and restoration efforts in the Peconic Estuary, Long Island Sound and, most recently, in the South Shore Estuary Reserve.

Fred Short has been studying seagrasses for 30 years, starting in the eelgrass ponds of Rhode Island and later including work in Texas, Alaska, Florida, and throughout New England. He is the founding director of a worldwide seagrass monitoring program, SeagrassNet, which began in 2001 and now has 60 sites in 21 countries, and has traveled extensively to establish that program. He is the co-editor of Global Seagrass Research Methods (2001), the World Atlas of Seagrasses (2003) and more than 70 peer-review publications. His interests include seagrass restoration and two of his papers, particularly, address restoration issues of site selection (Short et al 2002) and success criteria (Short et al 2000). In the 1990s, Short directed a large and successful eelgrass restoration in the Great Bay Estuary on the border of New Hampshire and Maine as mitigation for a port construction project. He has conducted other eelgrass restoration projects, including New Bedford Harbor, Massachusetts and Penobscot Bay, Maine. Fred is based at the University of New Hampshire’s Jackson Estuarine Laboratory, where he is a research professor. He is also the chair of UNH’s largest Ph.D. program: Natural Resources and Earth Systems Science.
Appendix C:
Presenter Bios
**Brief Biographies of Presenters**

**Tom Halavik** is the Acting Project Leader with the U. S. Fish and Wildlife Services’ Southern New England / New York Bight Coastal Program. Tom has served as the Senior Fish and Wildlife Biologist for the Coastal Program for the last 15 years. Prior to that Tom worked as the Research Aquarium Manager and member of the Early Life History Investigation at the NOAA - National Marine Fisheries Service Laboratory in Narragansett, RI for 23 years. Tom has served as the Services’ representative to the LISS and PEP and has been an active participant on the STAC and Habitat Restoration Workgroups. He was the principal investigator for the LISS Ecological Inventory and the Inaugural Stewardship Ecological Sites as well as the PI for the PEP’s Critical Natural Resource Area designations. Tom is a USCG Licensed Captain and led the LISS Eelgrass “ground truth” efforts in 2002 and 2006.

**Kimberly Petersen** has a BS in Marine Science/Biology from the University of Tampa. She has worked for CCE’s Marine Program since she began seasonally in 2003 and is now a year round staff member, working with Chris Pickerell and Steve Schott in the eelgrass restoration program. Kim also maintains the seagrassli.org website.

**Bradley J. Peterson** received the B.S. degree in Marine Biology from the Florida Institute of Technology, Melbourne, FL, in 1989, the M.S. degree in Zoology from the University of Rhode Island in 1993, and the Ph.D. degree in Marine Science from the Dauphin Island Sea Lab / University of South Alabama in 1998. His graduate research investigated the role of suspension feeding bivalves in fertilizing seagrass productivity through their biodeposits. From 1998 to 2000, he was a Tropical Biology Post-Doctoral Scholar at the Florida International University, where he was primarily responsible for overseeing the Florida Keys National Marine Sanctuary Seagrass Status and Trends Monitoring Program. From 2000 to 2002, he was a Research Scientist at the Southeast Environmental Research Center at FIU investigating the role of the sponge communities in controlling phytoplankton blooms within Florida Bay and the concomitant effect on seagrass productivity. From 2002 to 2005, he was an Assistant Professor of Marine Science at Southampton College of Long Island University. Currently, Brad is an Assistant Professor at the Marine Sciences Research Center of Stony Brook University. His research interests include positive biological interactions, benthic-pelagic coupling, ecosystem engineering, biogeochemistry of the coastal ocean, nutrient cycling in the marine environment and ecosystem modeling.

**Chris Pickerell** is a Habitat Restoration Specialist with Cornell University Cooperative Extension of Suffolk County. Chris has 14 years experience working on the management and restoration of salt marshes and eelgrass on Long Island. His work over the last decade has included overseeing eelgrass long-term monitoring and restoration efforts in the Peconic Estuary, Long Island Sound and, most recently, in the South Shore Estuary Reserve.

**Stephen Schott** has a BS in Botany and MS in Biology, specializing in marine botany and ecology, from the University of Rhode Island. He has been employed by Cornell Cooperative Extension since 2000, working with the wetland and eelgrass monitoring/restoration programs.

**Christopher Clapp** has been working in the Great South Bay for The Nature Conservancy since the conservancy’s efforts to restore shellfish populations in Great South Bay began in 2004. He holds an MS in Marine and Environmental Sciences form Stony Brook University’s Marine Science Research Center where he employed side-scan and multi-beam sonar to identify benthic habitats in Great South Bay.
Ron Paulsen is a Hydrogeologist with the Suffolk County Department of Health Services, Office of Water Resources. Ron has 25 years experience working on groundwater, surface water and groundwater/surface water interaction studies and investigation. Work includes investigation of various land uses (agricultural, industrial, residential) on groundwater and surface water. Several new techniques for sampling and measuring groundwater discharge have been developed in a cooperative effort with Cornell Cooperative of Suffolk and Stony Brook University. Development of an ultrasonic seepage meter and pore water sampling probes has led to new insight into the dynamic of groundwater discharge. Several studies are ongoing using these tools to characterize groundwater impacts in our local estuaries. Current work includes investigating agricultural impacts in the Peconic Estuary.

J. Kirk Cochran received his B.S. degree from Florida State University in 1973 and his Masters and Ph.D. degrees from Yale University in 1975 and 1979, respectively. He worked as a Research Staff Geologist in the Department of Geology and Geophysics at Yale University and as an Assistant Scientist in the Department of Chemistry at the Woods Hole Oceanographic Institution. Past notable appointments include Dean and Director of the Marine Sciences Research Center of Stony Brook University. Currently, Kirk is a Professor at the Marine Sciences Research Center of Stony Brook University. His research interests include marine sediment geochemistry and the use of radionuclides as geochemical tracers.

Christopher J. Gobler is an associate professor at the School of Marine and Atmospheric Sciences (SoMAS) of Stony Brook University, as well as faculty coordinator of activities for SoMAS at Stony Brook – Southampton. Prior to his appointment at Stony Brook, he was an associate professor and program coordinator of the marine sciences program for Southampton College of Long Island University. He has been researching the bays and estuaries of Long Island for more than 15 years, having published more than 30 peer reviewed scientific articles on the subject. Gobler is best known for his work on harmful algal blooms in general, and brown tides on Long Island in particular, and is an associate editor of the international journal published by Elsevier, Harmful Algae. Gobler is a Long Island native who received a bachelor’s degree in biology from the University of Delaware and his Master’s and Doctorate degrees from Stony Brook University.
Appendix D:
List of Attendees
Meeting Participants (L to R):
Front row: Jack Mattice (NY Sea Grant), Bradley Peterson (Stony Brook University), Kenneth Heck, Jr. (University of South Alabama), A. Coolidge Churchill (Adelphi University), J. Kirk Cochran (Stony Brook University), Marci Bortman (The Nature Conservancy).
Middle rows: Paul Carlson (Florida Fish and Wildlife Conservation Commission), Christopher Gobler (Stony Brook University), Tom Halavik (US Fish & Wildlife Service), Corey Garza (Long Island Sound Study Office), Chris Pickerell (Cornell Cooperative Extension), Jeffrey Fullmer (South Shore Estuary Reserve Office), Fred Short (University of New Hampshire), Karen Chytalo (NYS Dept. of Environmental Conservation), Chris Clapp (The Nature Conservancy), Carol Pesch (US EPA), Kim Petersen (Cornell Cooperative Extension), Laura Stephenson (NYS Dept. of Environmental Conservation).
Back row: Cornelia Schlenk (NY Sea Grant), Mark Fonseca (NOAA National Ocean Service), William Dennison (University of Maryland), Steve Schott (Cornell Cooperative Extension), Carl LoBue (The Nature Conservancy), Ronald Paulsen (Suffolk County Dept. of Health Services).
<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ron Paulsen</td>
<td>SCDHS</td>
<td>631.852.5774</td>
<td><a href="mailto:Ronald.Paulsen@suffolkcountyny.gov">Ronald.Paulsen@suffolkcountyny.gov</a></td>
</tr>
<tr>
<td>Laura Stephenson</td>
<td>NYSDEC/PEP</td>
<td>631.444.0871</td>
<td><a href="mailto:lbstephe@gw.dec.state.ny.us">lbstephe@gw.dec.state.ny.us</a></td>
</tr>
<tr>
<td>Corey Garza</td>
<td>NOAA/LISS</td>
<td>203.882.6505</td>
<td><a href="mailto:corey.garza@noaa.gov">corey.garza@noaa.gov</a></td>
</tr>
<tr>
<td>Jack Mattice</td>
<td>NYSG</td>
<td>631.632.6905</td>
<td><a href="mailto:jmattice@notes.cc.sunysb.edu">jmattice@notes.cc.sunysb.edu</a></td>
</tr>
<tr>
<td>Carol Pesch</td>
<td>USEPA AED</td>
<td>401.782.3081</td>
<td><a href="mailto:pesch.carol@epa.gov">pesch.carol@epa.gov</a></td>
</tr>
<tr>
<td>Brad Peterson</td>
<td>MSRC</td>
<td>631.632.5044</td>
<td><a href="mailto:bradley.peterson@stonybrook.edu">bradley.peterson@stonybrook.edu</a></td>
</tr>
<tr>
<td>Mark Fonseca</td>
<td>NOAA</td>
<td>252.728.8729</td>
<td><a href="mailto:Mark.Fonseca@noaa.gov">Mark.Fonseca@noaa.gov</a></td>
</tr>
<tr>
<td>Bill Dennison</td>
<td>UMCES</td>
<td>410.228.9250</td>
<td><a href="mailto:dennisonn@umces.edu">dennisonn@umces.edu</a></td>
</tr>
<tr>
<td>Chris Pickerell</td>
<td>CCE</td>
<td>631.852.8660</td>
<td><a href="mailto:cp26@cornell.edu">cp26@cornell.edu</a></td>
</tr>
<tr>
<td>Fred Short</td>
<td>UNH</td>
<td>603.862.5134</td>
<td><a href="mailto:fred.short@unh.edu">fred.short@unh.edu</a></td>
</tr>
<tr>
<td>Stephen Schott</td>
<td>CCE</td>
<td>631.852.8660</td>
<td><a href="mailto:ss337@cornell.edu">ss337@cornell.edu</a></td>
</tr>
<tr>
<td>Carl LoBue</td>
<td>TNC</td>
<td>631.367.3384</td>
<td><a href="mailto:clobue@tnc.org">clobue@tnc.org</a></td>
</tr>
<tr>
<td>Cornelia Schlenk</td>
<td>NYSG</td>
<td>631.632.6905</td>
<td><a href="mailto:cschlenk@notes.cc.sunysb.edu">cschlenk@notes.cc.sunysb.edu</a></td>
</tr>
<tr>
<td>Jeff Fullmer</td>
<td>SSER</td>
<td>516.398.2368</td>
<td><a href="mailto:jfullmer@dos.state.ny.us">jfullmer@dos.state.ny.us</a></td>
</tr>
<tr>
<td>Jerry Churchill</td>
<td>Adelphi</td>
<td>516.877.4192</td>
<td><a href="mailto:Churchill@adelphi.edu">Churchill@adelphi.edu</a></td>
</tr>
<tr>
<td>Chris Clapp</td>
<td>TNC</td>
<td>631.367.3384</td>
<td><a href="mailto:cclapp@tnc.org">cclapp@tnc.org</a></td>
</tr>
<tr>
<td>Kirk Cochran</td>
<td>MSRC</td>
<td>631.632.8733</td>
<td><a href="mailto:kcochran@notes.cc.sunysb.edu">kcochran@notes.cc.sunysb.edu</a></td>
</tr>
<tr>
<td>Tom Halavik</td>
<td>USFWS</td>
<td>401.364.9124</td>
<td><a href="mailto:Tom_Halavik@fws.gov">Tom_Halavik@fws.gov</a></td>
</tr>
<tr>
<td>Karen Chytalo</td>
<td>NYSDEC</td>
<td>631.444.0430</td>
<td><a href="mailto:knchytal@gw.dec.state.ny.us">knchytal@gw.dec.state.ny.us</a></td>
</tr>
<tr>
<td>Kim Petersen</td>
<td>CCE</td>
<td>631.852.8660</td>
<td><a href="mailto:kp92@cornell.edu">kp92@cornell.edu</a></td>
</tr>
<tr>
<td>Marci Bortman</td>
<td>TNC</td>
<td>631.637.3225</td>
<td><a href="mailto:mbortman@TNC.ORG">mbortman@TNC.ORG</a></td>
</tr>
<tr>
<td>Chris Gobler</td>
<td>SBU</td>
<td>631.632.5043</td>
<td><a href="mailto:christopher.gobler@stonybrook.edu">christopher.gobler@stonybrook.edu</a></td>
</tr>
<tr>
<td>Ken Heck</td>
<td>Dauphin Island Sea Lab</td>
<td>251.860.2533</td>
<td><a href="mailto:kheck@dilist.org">kheck@dilist.org</a></td>
</tr>
<tr>
<td>Paul Carlson</td>
<td>Florida Fish and Wildlife Research Institute</td>
<td>727-896-8626</td>
<td><a href="mailto:Paul.Carlson@MyFWC.com">Paul.Carlson@MyFWC.com</a></td>
</tr>
</tbody>
</table>

SCDHS- Suffolk County Department of Health Services  
NYSDEC- New York State Department of Environmental Conservation  
PEP- Peconic Estuary Program  
NOAA- National Oceanic and Atmospheric Administration  
LISS- Long Island Sound Study  
NYSG- New York Sea Grant  
USEPA- United State Environmental Protection Agency  
AED- Atlantic Ecology Division  
MSRC- Marine Sciences Research Center (SUNY Stony Brook)  
UMCES- University of Maryland Center for Environmental Science  
CCE- Cornell Cooperative Extension  
UNH- University of New Hampshire  
TNC- The Nature Conservancy  
SSER- South Shore Estuary Reserve  
USFWS- United States Fish and Wildlife Service  
SBU- Stony Brook University
Appendix E: Presentation Abstracts and Slides
Long Island’s primary estuaries are Long Island Sound, which is bordered by Connecticut to its north and Long Island to its south, the south shore estuary system (Great South Bay, Moriches Bay, and Shinnecock Bay), which consists of barrier island estuaries along the Island’s south shore, and the Peconic Estuary, which is situated between the north and south forks of Long Island. The water quality of each estuarine system is extremely different with differing consequences for native eelgrass populations. The south shore estuaries are characterized by shallow depths (mean = 1.2 m) and gradients in water quality. Regions located near ocean inlets are cool, salty, clear, and contain low levels of algal biomass, whereas back bay regions are warmer, more fresh, and more turbid with algal biomass. While the bay bottom of inlet regions receive more than 20% of surface irradiance (the level required for robust eelgrass growth), the benthos of mid-and back-bay regions are below the 20% threshold and receive less than 1% of surface irradiance during intense algal blooms which can be common there. The Peconic Estuary contains strong gradients in depth and water clarity, with the western extreme of the estuary being shallow (2 – 3 m) but turbid and the eastern portion of the estuary being clear but deep (15 – 20m). As a consequence, Flanders Bay to the west is the only sub-estuary which likely receives > 20% of surface irradiance throughout its benthos. Eastern basins of the Peconics (Great Peconic, Little Peconic, Gardiners Bay) have levels of irradiance high enough to support eelgrass growth in their shallow, nearshore regions only. Long Island Sound also displays a strong eutrophication gradient, with high levels of phytoplankton biomass and low water quality to the west in the vicinity of New York City and clearer water to the east. Long Island Sound is also an extremely deep estuary (mean = 20 m; max = 50 m). As such, only the nearshore waters and harbors of the Sound are hospitable for eelgrass growth, with a greater likelihood of clear water and high bottom irradiance in the eastern extreme of the system.
Water quality in Long Island’s estuaries: South shore estuary reserve, Peconic Estuary, and Long Island Sound

Christopher J. Gobler
Marine Sciences Research Center
Stony Brook University

Great South Bay
- Primary ocean influence is Fire Island Inlet.
- Average mean low water depth is 1.3 m (Wilson et al. 1991).
- Residence time is up to 96 days (Wilson et al. 1991; Conley 2000).
- Phase-shifts in algal communities: Bloom-forming ‘small forms’ to diatom-based mixed assemblages.

Moriches Bay
- Connected to Great South Bay by Narrow Bay
- Smaller than GSB, similar to Shinnecock in size
- Moriches Inlet formed in 1931. Reclosed naturally in 1951.
- Reopened again in 1954 by Hurricane Edna, and made a permanent fixture with stabilizing jetties
- Received heavy input of duck farm waste

History of Phytoplankton in Great South Bay

<table>
<thead>
<tr>
<th>Year</th>
<th>Study/Authors</th>
<th>Algal Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1907</td>
<td>George Whipple</td>
<td>Diatoms, Chlorophytes</td>
</tr>
<tr>
<td>1950's</td>
<td>John Ryther</td>
<td>Diatoms, Chlorophytes</td>
</tr>
<tr>
<td>1971-74</td>
<td>Carpenter &amp; Dunham</td>
<td>Diatoms, Chlorophytes</td>
</tr>
<tr>
<td>1980</td>
<td>Lively et al.</td>
<td>Cyanobacteria, Dinoflagellates</td>
</tr>
<tr>
<td>1983</td>
<td>Carpenter &amp; Dunham</td>
<td>Pennate Diatoms, Dinoflagellates</td>
</tr>
<tr>
<td>1985-2001</td>
<td>Lonsdale, Gobler, Casper</td>
<td>Pennate Diatoms, Nanoflagellates</td>
</tr>
<tr>
<td>2001</td>
<td>Greenfield et al.</td>
<td>Pennate Diatoms, Nanoflagellates</td>
</tr>
</tbody>
</table>

Moriches Bay
- Connected to Great South Bay by Narrow Bay
- Smaller than GSB, similar to Shinnecock in size
- Moriches Inlet formed in 1931. Reclosed naturally in 1951.
- Reopened again in 1954 by Hurricane Edna, and made a permanent fixture with stabilizing jetties
- Received heavy input of duck farm waste
History of Phytoplankton in Moriches Bay

Leptocylindrus, Thalassiostrum, Skeletonema

Chlorophytes

Diatoms

History of Phytoplankton in Moriches Bay

1950's
John Ryther

Leptocylindrus, Thalassiostrum, Skeletonema

1960 - 1961
Carl Lorenzen

Diatoms

1951 Closure of Moriches Inlet

1954 Moriches Inlet Opened Again

Temperature, Salinity, Turbidity
Total dissolved nitrogen & phosphorus
Total chlorophyll a & size fractionated (<10µm)

Temperature
Salinity
Secchi

Chl a (µg L⁻¹)

Percent <10 µm Chl a

Mean total dissolved nitrogen (µM)
Mean total dissolved phosphorus (µM)

Synechococcus sp., Picoeukaryotes, and 2-5 µm cells

Inlet
Estuary

23
Pigment Ratios

Light in the South Shore Estuary Reserve

Eelgrass distributions in SSER, Peterson surveys, 2004-2005

Peconic Estuary

Eelgrass are sensitive indicators of declining water quality because of their high light requirements (15-25% surface irradiance).

Dennison et al. (1993): Seagrasses are sensitive indicators of declining water quality because of their high light requirements (15-25% surface irradiance).

Dennison et al. (1993): Seagrasses are sensitive indicators of declining water quality because of their high light requirements (15-25% surface irradiance).

Eelgrass distributions in SSER, Peterson surveys, 2004-2005

Shinnecock Bay

Great South Bay

Inlet

Inlet

Inlet

20% light
1% light

Maximum depth
Mean depth

Peconic Estuary

• Two month residence time of western basin
• Shallow, but more eutrophic with low water clarity / quality to the west
• Strong tidal flushing yielding high water clarity to the east; also deeper to the east
Chlorophyll a levels in the Peconic Estuary

Light levels in the Peconic Estuary

HABs in the Peconics

Peconics, 15-year trend in chlorophyll a

Peconics, 20-year trend in secchi disc depths

Long Island Sound
Chlorophyll a in Long Island Sound

Conclusions

- The South Shore Estuary Reserve has a mean depth of 1.2 m, but is likely light limited in regions away from inlets due to dense blooms of small phytoplankton and resuspension.
- The Peconic Estuary is shallow but turbid in the west, and clearer but deeper to the east.
- Peconic water clarity has increased during the past 20 years.
- Long Island Sound is a deep water estuary (20 – 40 m), with turbid waters to the west, but clearer waters to the east.

Long Island Sound

- Mean depth = 20 meters
- Deepest = 50 meters
- Bottom of main basin < 1% light level
- Shallows of western basin also probably low light
- Higher light availability in eastern shallows
Over the last thirty years Suffolk County Department of Health Service’s Office of Water Resources has been monitoring nutrient and pesticide impacts to the ground and surface waters in Suffolk County, New York. Thousands of samples have been collected within the watershed of the Peconic Estuary over this period. In 2007 over thirty-seven different pesticides, herbicides and fungicides have been detected in groundwater in Suffolk. The ultimate fate of this pesticide-impacted groundwater is to discharge into surface water through submarine groundwater discharge (SGD). Monitoring of the near shore groundwater, offshore porewater and SGD in the Peconic Estuary has revealed that several of these pesticides and herbicides are present at levels of concern. Impacts to the phytoplankton, algae and submerged aquatic species is a distinct possibility and may explain some of the difficulties faced in restoring SAV communities and understanding the trigger mechanisms for harmful algal blooms. Although many of these pesticides have been banned decades ago in will take many years for them to be purged from the aquifer system. This passive discharge can have prolonged and significant affects on the estuary for decades to come. Currently several studies are under way in the Peconic Estuary to determine impacts of SGD on near shore environments.
Linking Groundwater, Pesticides & SAV’s

Nitrogen & Pesticide Studies
- LI 208 Study (1978)
- Status of Aldicarb contamination (1981)
  - 8,000 aldicarb samples 1979-1980
- North & South Fork Reports (1982)
- Assessment of nitrate, aldicarb, dichloropropane
- Comprehensive Water Resources Management Study
  (1987)
  - 20 year (1975-1994) nitrate avg 11.3 mg/L
  - Aldicarb, carbafuran, oxamyl concentrations declining
  - TCPA found in high concentrations
- NYSDEC Pesticide Monitoring Program 1999-2006

Recent Monitoring Program Findings
- 63 Pesticide Related Compounds Detected
  - 46 parent compounds
  - 13 pesticide degradates
  - 3 pesticide impurities, i.e., perchlorate,
    1,2,3-trichloropropane (DCP),
    pentachlorobenzene (PCNB fungicide)
  - New issues Imidachloprid & DEET

1996 Pesticide Reporting Law - SCDHS Annual Reports
on Water Quality Monitoring Program to NYSDEC
- 1998
  - 24 pesticides & metabolites identified, 8 exceed MCLs
- 1999
  - 32 pesticides & metabolites detected, 10 exceed MCLs
- 2000
  - 44 pesticides & metabolites detected, 12 exceed MCLs
  - 3,143 public, private, & monitoring wells tested in Nassau & Suffolk
    - 25.6% contained pesticides
    - 7.8% exceed MCLs
- 2002
  - 52 pesticides & metabolites identified, 13 exceed MCLs
  - 50.6% of private wells impacted
  - 90.7% of private wells exceeding MCLs impacted by agricultural chemicals

Recent Monitoring Program Findings
- 15 pesticide compounds exceed MCLs
- 50% of private wells tested contain one or more pesticides
- 23% of community supply wells contained pesticides
- Co-occurrence of multiple pesticides - 15% of private wells contained 5 or more pesticide compounds
Land Use Impacts

<table>
<thead>
<tr>
<th>Land Use</th>
<th># Monitoring Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>16</td>
</tr>
<tr>
<td>Lawn Care &amp; Landscapers</td>
<td>7</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>33</td>
</tr>
<tr>
<td>Golf Courses</td>
<td>37</td>
</tr>
<tr>
<td>Vineyards</td>
<td>28</td>
</tr>
<tr>
<td>Lawn Care &amp; Landscapers</td>
<td>5</td>
</tr>
</tbody>
</table>

Comparative Pesticide Impacts

Pesticides Exceeding MCLs in LI Groundwater

- DBCP (banned 1979)
- Aldicarb (banned 1980)
- Chlordane (banned 1983)
- EDB (banned 1983)
- Dinoseb (banned 1986)
- 1,2 DCP (banned 1987)
- TCPA (banned 1988)
- Atrazine (banned 1989)
- Metolachlor (banned 2000)
- Simazine (banned 2002)
- 1,3,5 TCP (contaminant)
- DEHP (inert ingredient)
- Imidachloprid (Restricted 2004)
- DEET active

Suffolk County Pesticide Monitoring Program

Pesticide Issues
- Lack of MCLs – Only carbaryl of 10 most frequently detected chemicals has a specific MCL (UOC standard 50 ppb)
- Occurrence of multiple compounds - MCL for multiple organic compounds is 100 ppb for total POCS & UOCs (NYS Sanitary Code)
- Metabolites routinely detected in greater concentrations than parent compounds
- Alachlor & metolachlor herbicides widely applied from ~1980 through 2000 – ESA & OA metabolites were not analyzed for prior to 1999

Nitrogen Issues
- Private wells exceeding 10 mg/L MCL – lack of access to public water
- Nitrogen discharge through stream flow and groundwater underflow to estuary – algae blooms, low dissolved oxygen

North Fork Cross Section
Ag Nitrogen Monitoring 1998 - 2006

Long-term Trends in Groundwater
North Fork Stream Water Quality

Pesticide monitoring at 16 creeks & streams discharging to the Peconic Estuary

Sta. #       Stream
200010 Peconic River (gage)
200160 Brushes Creek
200004 Crescent Duck Farm
200170 Deep Hole Creek
20041 Meetinghouse Creek
200180 Halls Creek
200110 Sawmill Creek
200190 Downs Creek
200120 Terry Creek
200200 West Creek
200130 Reeves Creek
200210 East Creek (Cutchogue)
200140 East Creek (S Jamesport)
200230 Pipes Creek
200150 West Drain
200260 Narrow River (south)

North Fork Stream Water Quality

Multiple pesticides/herbicides/degradates are present in groundwater and streams discharging to Peconic Estuary
37 pesticide-related compounds detected in streams

More frequently detected
- aldicarb sulfone
- aldicarb sulfoxide
- alachlor ESA
- metolachlor ESA
- metolachlor OA
- metalaxyl

Less frequently detected
- alachlor OA sulfoxide
- alachlor OA sulfone
- metolachlor OA ESA
- metalaxyl BAM

Sampling Stations

Stream analyses show herbicide cocktails
(concentrations in ug/L)

<table>
<thead>
<tr>
<th></th>
<th>Reeves Creek</th>
<th>Cutchogue</th>
<th>Brushes Creek</th>
<th>Laurel</th>
</tr>
</thead>
<tbody>
<tr>
<td>aldicarb OA</td>
<td>&lt;0.4</td>
<td>1.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alachlor OA</td>
<td>0.27</td>
<td>0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metalaxyl</td>
<td>2.91</td>
<td>0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metolachlor OA</td>
<td>3.41</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metalaxyl BPM</td>
<td>0.19</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dichlobenil</td>
<td>&gt;0.2</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>simazine</td>
<td>&gt;0.2</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>desipropylatrazine</td>
<td>&lt;0.4</td>
<td>&lt;0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinoseb</td>
<td>4.4 DDD</td>
<td>0.94</td>
<td>BAM</td>
<td></td>
</tr>
</tbody>
</table>

Average Pesticide Concentrations (when detected) in 16 North Fork Streams

<table>
<thead>
<tr>
<th></th>
<th>Reeves Creek</th>
<th>Cutchogue</th>
<th>Brushes Creek</th>
<th>Laurel</th>
</tr>
</thead>
<tbody>
<tr>
<td>aldicarb OA</td>
<td>&lt;0.4</td>
<td>1.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alachlor OA</td>
<td>0.27</td>
<td>0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metalaxyl</td>
<td>2.91</td>
<td>0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metolachlor OA</td>
<td>3.41</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metalaxyl BPM</td>
<td>0.19</td>
<td>&lt;0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dichlobenil</td>
<td>&gt;0.2</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>simazine</td>
<td>&gt;0.2</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>desipropylatrazine</td>
<td>&lt;0.4</td>
<td>&lt;0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinoseb</td>
<td>4.4 DDD</td>
<td>0.94</td>
<td>BAM</td>
<td></td>
</tr>
</tbody>
</table>
**Herbicide Contaminant Issues**

**EPA Alachlor RED (1998)**
- EC\textsubscript{50} for green algae is 1.64 ug/L
- No effect level is 0.35 ug/L
- "Aquatic plants may be adversely affected by alachlor in groundwater, in places where groundwater discharges into surface water."

**EPA Metolachlor RED (1995)**
- "...where groundwater discharges to surface water, metolachlor residues could present a threat to non-target plants."

**Herbicide Contaminant Issues**

- What is the potential for herbicide cocktail in stream flow and groundwater underflow to alter bay ecology?
- Impacts on phytoplankton and eelgrass?

**Overall Concerns**

- Detections of pesticides increasing
- Long Residual affects (Aldicarb 30 years impact)
- Potential significant impacts from agricultural activities that produce concentrated waste
- Community well impacts/understanding SWAP
- Affects of contaminated groundwater on surface water
- Need for cooperative effort, sound management practices and monitoring

**Groundwater/Surface Water Interactions**

Newly Developed Equipment and Methods

- Temperature Sampler
- Conductivity
- Air Hammer Push Rod
- Waste Site Plume
- Tidal Mixing Zone
- Fresh Groundwater
- Saline Groundwater
- Flow meter
- Water Sampler
- Controller
- Funnel
- Batt. Logger
Sediment Geochemistry Pertinent to Health of SAV
J. Kirk Cochran, Ph.D.
Professor
Marine Sciences Research Center, Stony Brook University

Geochemical reactions occurring in the upper ~30 cm of marine sediments have implications for the health of submerged aquatic vegetation. In particular, bacterial oxidation of organic matter leads to the presence of solutes in pore water that are phytotoxic. Perhaps the most important of these is hydrogen sulfide, produced from reduction of seawater sulfate as organic matter is oxidized. Dissolved hydrogen sulfide can also be removed from pore water as reduced iron reacts with it to form solid phase iron sulfides. In addition, SAV is adapted to handle elevated sulfide in pore water, but multiple stressors (light penetration in water column, eutrophication) may occur that hamper the plant’s ability to moderate the effects of sulfide. This presentation reviews the available data on sulfur geochemistry in sediments of Long Island Sound, the Peconic Bay system and Great South Bay.
New York Sea Grant
Seagrass Workshop

Sediment Geochemistry
J. Kirk Cochran
Marine Sciences Research Center

Sediment Geochemical Issues Related to Health of SAV
- Bacterial oxidation of organic matter in sediments leads to presence of solutes in pore water that are phytotoxic (e.g. sulfide)
  \[2\text{CH}_2\text{O} + \text{SO}_4^{2-} \rightarrow \text{H}_2\text{S} + 2\text{HCO}_3^-\]
- SAV adapted to handle elevated sulfide in pore water, but must consider multiple stressors (light penetration in water column, eutrophication)

Bacterial Oxidation of Organic Matter
Stupakopf (1993)

Sulfide in Sediment
- Sulfide produced by sulfate reduction: \[2\text{CH}_2\text{O} + \text{SO}_4^{2-} \rightarrow \text{H}_2\text{S} + 2\text{HCO}_3^-\]
  - \(\Sigma\)H2S represents H2S, HS- and S0
- H2S reacts with Fe to produce FeS and ultimately, FeS2
  Burdige (2006)

Sediment Geochemistry in Long Island’s coastal waters
- Long Island Sound
- Peconic Bay
- South Shore Estuarine Reserve

Long Island Sound
- Yale University (1970s)
- Long Island Sound Study (1986-7)
FOAM (Friends of Anoxic Mud) Site

Pore Water Sulfate

Pore Water Sulfide

Solid Phase Sulfur Pools

\[ \text{Fe}^{2+} + \text{H}_2\text{S} \rightarrow \text{FeS} \rightarrow \text{FeS}_2 \]

H₂S in Jamaica Bay Marshes

Long Island Sound

• Long Island Sound Study (1988-89)

LISS- Sediment Oxygen Fluxes

Peconic Bays

• Peconic Estuary Program (PEP)
• Zostera and \( \sum \)H₂S (I. Stupakopf, 1993)
• Benthic Fluxes (Howes et al. 1998)
• Sediment radionuclides (accumulation, mixing: Cochran et al. 1995)
Pore water solutes and SAV roots

Stupakopf (1993)

- Smith Point, Narrow Bay
- Sampled pore water (0-6 cm) inside (dark bars) patch of Zostera and in sediment outside (light bars) of patch
- $\Sigma H_2S$ inversely correlated with irradiance, significantly different inside vs. outside

Peconic Bays- Sediment Oxygen Fluxes

Howes et al. (1998)

Great South Bay

- Sampling for sediment metal distributions, basic sediment properties (Schubel et al. 1980)
- Large scale sampling of sediments for radionuclides ($^{234}$Th, $^{7}$Be, $^{210}$Pb) for sediment dynamics (Cochran et al. 2006-)

Summary

- Large scale sediment geochemical data for Long Island’s coastal waters has tended to focus on benthic fluxes
- Muddy sediments sampled most often
- Less emphasis on shallow water, coarse grained sediments
- Few data on pore water sulfide; more on sulfate, solid phase iron sulfides
Impacts of Habitat Modification on Eelgrass Populations in New York South Shore Estuaries
Brad Peterson, Ph.D.
Assistant Professor
Marine Sciences Research Center, Stony Brook University

Within the State of New York, there is broad recognition that action is needed to understand, protect, enhance and restore coastal ecosystems and that ecosystem-based management is the most effective approach to accomplish such action. Recently, New York passed legislation (Bill A10584B) mandating that the state begin using ecosystem-based management for its coastal and marine resources making it the second state in the U.S. to take such action. This new mandate has resource managers re-evaluating how decisions are made and what data is required to make critical regulatory choices. In an effort to understand the strength and interaction of multiple stressors on eelgrass populations in NY estuaries, the state has recently passed legislation to set up a task force to develop recommendations for regulations to improve seagrass protection, restoration, research and monitoring. The bill states "effective regulations for seagrass protection and restoration will depend greatly on the State’s ability to understand the severity of these impacts. This task force will identify and assess severity of indirect and direct threats and develop restoration goals.”

Potential stressors on eelgrass populations in NY coastal waters include habitat modification, light shading, sulfide toxicity, and increased water temperature (Fig 1). The potential consequences and mechanisms of each of these stressors on eelgrass populations will be addressed below.

Habitat modification resulting from fisheries related loss of suspension feeders
Long Island’s south shore estuaries (LISSE) represent a series of contiguous barrier island estuaries including Great South Bay. LISSE have been documented as some of the most productive estuaries in the nation with regard to benthic and pelagic primary productivity and the harvest of shellfish (1-3). The most successful shellfishery in the LISSE has been that of the northern quahog or hard clam, Mercenaria mercenaria. During the 1970s, two out of every
three hard clams eaten on the east coast of the United States came from LISSE and accounted for 54% of the total US hard clam harvest (4). These peak hard clam landings were followed by a precipitous decline in clam densities, as harvest mortalities greatly exceeded natural recruitment during the 1980s (3). More recent observations suggest that current settlement, growth and survival of hard clams in the LISSE are at an unprecedented low level (5) with recent harvest levels nearly two orders of magnitude lower than that observed in the mid 1970s. Concurrently, eelgrass coverage within LISSE has declined dramatically (Dennison et al 1989).

As "ecosystem engineers," hard clams played an important role by controlling the species diversity and abundance of phytoplankton and enhancing ecosystem stability (6). The benthic environment of a healthy clam bed consists of numerous individuals that create burrows, circulate water, and translocate the primary and secondary production from the water column to the benthos. It is therefore reasonable to assume that hard clams have an important influence on eelgrass abundance and survival by oxygenating the sediments, trapping seeds and supplying organic matter and nutrients to the benthos.

Filter feeders enhance water clarity. Chesapeake Bay represents a dramatic example of how the absence of suspension feeders has changed water clarity. There, the loss of historical oyster reefs has been implicated in phytoplankton blooms, reduced water clarity, and loss of submerged aquatic vegetation (7-9). Eelgrass is extremely sensitive to light levels and oysters played the central role of transforming pelagic organic matter into benthic production and keeping the water column clear (9). That role has been lost in many east coast estuaries, but in some areas it has been replaced by introduced filter feeders. The arrival of Corbicula fluminea in the Potomac River estuary improved water clarity and allowed eelgrass to reappear in areas from which it had been absent for 50 years (10). Similarly, Poamocorbula amurensis in San Francisco Bay are reducing phytoplankton and zooplankton densities (11, 12).

During the past quarter century, changes in LISSE microalgal communities have strongly influenced SAV communities. During the 1970’s, when Long Island’s hard clam fishery was the most productive in the nation (13), eelgrass covered 40% of LISSE (1). In 1985, the first brown tide bloom of the pelagophyte, Aureococcus anophagefferens occurred in LISSE. The annual reoccurrence of these blooms in the subsequent two decades has substantially altered the ecology of these estuaries. The negative impact of A. anophagefferens on eelgrass beds is well known. The severe light attenuation which occurs during brown tides reduces light levels and thus causes the destruction of eelgrass beds (1). It has been postulated that almost all eelgrass beds in LISSE currently subsist under subsaturating light (14).

Benthic filter feeders fertilize estuarine sediments. In addition to improving water clarity, grazing activity of filter feeders elevate submerged aquatic vegetation growth and productivity by increasing the nutrients available to the rhizosphere (15-18). By removing water column particulates, suspension feedings also alter the sediment characteristics. Feces and pseudofeces produced by bivalves can increase both sediment organic content and nutrient levels in sediment pore water (Fig 2).

Figure 2. Conceptual model of hard clam role in elevating eelgrass productivity
Previously, Peterson and Heck (1999, 2001) found that the presence of the tulip mussel, *Modiolus americanus*, significantly increased the sediment nutrient pool and productivity of the seagrass, *Thalassia testudinum*. In addition, Reusch et al. (1994) working with the blue mussel, *Mytilus edulis*, and eelgrass, *Zostera marina*, on the west coast of the U.S. found that sediment porewater concentrations of ammonium and phosphate doubled in the presence of mussels, suggesting that the mussels fertilize eelgrass growth by the deposition of feces and pseudofeces. Similarly, Reusch and Williams (1998) demonstrated that the introduced mussel, *Musculista senhousia*, fertilized beds of *Z. marina* at moderate densities of individuals in the coastal waters off San Diego.

**Benthic filter feeders influence eelgrass recruitment, germination and seedling survival.**

There are three possible mechanisms by which filter feeders may influence eelgrass recruitment, germination and seedling survival. First, by providing a larger boundary layer and slowing water current speed, filter feeders may increase recruitment of floating seeds whether the seeds travel singly or within detached reproductive shoots. Seed entrapment can also be facilitated by the structure bivalves provide. Seed dispersal is limited outside *Zostera marina* beds (~80% seeds travel within 10 m of parent plants; (19, 20) so this effect is only important when eelgrass beds are near by or during the establishment of a new population. In addition, filter feeders might provide refuge for newly dispersed seeds from crustacean seed consumers (21, 22). The second mechanism by which hard clams may enhance eelgrass reproductive success is that bivalves can provide superior conditions for seed germination by filtering seawater and increasing sediment organic content. *Z. marina* seed germination is dependent on burial depth with the highest germination occurring at the anaerobic / aerobic interface (23). Filter feeders can act to bury and fertilize seeds at a depth that is appropriate for germination. Finally, filter feeders can increase the survival of seedlings, which have very high mortality rates (19, 20), by increasing light levels and nutrients and by protecting against erosion and herbivory. Despite the clear bottlenecks at these stages, there is surprisingly little information about the factors influencing eelgrass bed maintenance and formation, especially as they are related to the influence of other species interactions.

**Light Shading**

*Phytoplankton abundance in LISSE.* The composition and productivity of phytoplankton communities within LISSE have been well studied for over 50 yrs (2, 24-29) during which changes in microalgal communities have strongly influenced resident eelgrass communities. In the 1950’s, Ryther (1954) documented green tides of the ‘small form’ (2 - 4 μm) chlorophytes, *Nannochloris* sp. and *Stichococcus* sp. in Moriches Bay and Great South Bay (GSB). Blooms of these species lasted over six months each year (spring through fall) during which chlorophyte cell densities often exceeded $10^7$ cells ml$^{-1}$. Poor estuarine flushing and inputs of duck farm waste along affected bays were identified as factors promoting the green tides of the 1950’s (24, 30). When a channel was dredged in the late 1950s and LISSE became well flushed with ocean water, the green tide blooms terminated.

During the 1970s, phytoplankton communities documented within LISSE were markedly different from those observed in the 1950s. While “small forms” or picoplankton were present at that time, they were part of a mixed assemblage of phytoplankton. For example, Weaver and Hirshfield (1976) indicated that pennate diatoms were the most abundant phytoplankter in western GSB. Similarly, Cassin’s (1978) demonstrated that small phytoplankton (< 10 μm) represented a small portion (< 35%) of phytoplankton biomass across GSB and also noted an
abundance of diatom species, as well as dinoflagellates. During a 1979-1980 study, Lively et al. (1981) reported that small phytoplankton comprised approximately half of the phytoplankton biomass in GSB and that diatoms, cryptophytes and flagellates were also abundant. It was also during the 1970’s, when larger phytoplankton were more abundant and monospecific algal blooms were not reported, that hard clam landings and eelgrass bed coverage in LISSE reached maximal levels (40%; COSMA, 1985; Dennision et al., 1989).

Overharvesting was responsible for a tremendous decline in hard clam populations through the late 1970s and early 1980s (COSMA, 1985). Concurrently, the phytoplankton community in LISSE changed from the one described during the peak of the hard clam industry in the 1970s. In 1985, the first brown tide bloom of the pelagophyte, Aureococcus anophagefferens occurred in LISSE. The annual reoccurrence of these blooms in the subsequent two decades has substantially altered the ecology of these estuaries. The negative impact of *Aureococcus anophagefferens* on the growth and survival of eelgrass beds is well known (1, 31). The severe light attenuation which occurs during brown tides reduces benthic light levels and thus causes the destruction of eelgrass beds.

In addition to the obvious impacts of brown tide on eelgrass in LISSE, it seems those phytoplanktons which currently dominate LISSE, even when brown tide is not in bloom, may also be deleterious to eelgrass beds. While the LISSE was dominated by moderate sized phytoplankton species during the 1970s (2, 26, 27), recent data demonstrates that phytoplankton smaller than 5 µm now comprise the majority of phytoplankton biomass in these ecosystems. For example, during multiple studies we have undertaken in LISSE since 1998, we have found that small phytoplankton (< 5 µm) now dominate (up to 90%) of algal assemblages in LISSE such as Great South Bay, Quantuck Bay, and Mecox Bay (Fig 3). This is in stark contrast to earlier studies (2, 26, 27), which found a smaller percentage of “nano-phytoplankton”, despite the use of a 10 µm size cut-off to define this algal group. The dominance of small phytoplankton (< 5 µm) in phytoplankton communities within multiple LISSE sites has also been observed by other investigators using flow cytometric techniques (32).

This abundance of small phytoplankton is likely to have a negative impact on eelgrass beds. *Zostera* typically requires 15 – 25% of incident light for maximal growth (33) and light penetration generally has the greatest ecological impact on the growth, distribution and biomass of eelgrass beds (33, 34). Moreover, almost all eelgrass beds in LISSE currently subsist under subsaturating light, and thus any change in light levels in LISSE will impact photosynthesis and biomass of existing *Zostera* populations (14). Since small particles tend to scatter light more than larger particles (35), the current abundance of picoplankton in LISSE (Fig...
3) has likely contributed to reduced light levels and hence reduced eelgrass distribution

The most recent change in phytoplankton community structure also does not bode well for eelgrass in Long Island estuaries. During the past three summers, harmful dinoflagellates blooms caused by *Cochlodinium* sp. have occurred in eastern Long Island waters, including Shinnecock Bay. The extremely high biomass associated with these blooms (> 100 µg chlorophyll a L\(^{-1}\)) results in a shading effect equal to or greater than brown tides (Gobler et al submitted). Moreover, these blooms have a direct lethal effect on shellfish. Bay scallops exposed to bloom densities of *Cochlodinium* sp. for one week experienced 70% mortality and a 50% decrease in growth rate relative to control treatments (Gobler et al submitted). Other filter-feeding bivalves (hard clams, oysters) also experience significantly enhanced mortality relative to control treatments (Gobler et al submitted). Clearly, these blooms will negatively impact filter feeding bivalves and as well as eelgrass.

**Sulfide Toxicity**

Recent studies have shown that sediment sulfide concentrations can also act alone or synergistically to cause chronic, sublethal or acutely lethal stress on seagrasses (36-38). Sulfide is produced naturally in anaerobic marine sediments by heterotrophic bacteria which use sulfate as a terminal electron acceptor in breakdown of organic matter (39). Because seagrass sediments typically have high organic matter content, sulfate reduction rates in seagrass sediments are higher than in unvegetated marine sediments (36, 40). Sulfide is also a potent cytotoxin, irreversibly binding enzymes involved in electron transport for both photosynthesis and respiration (41). Sulfide also causes hypoxia in seagrass roots and rhizomes by reacting with photosynthetically-produced oxygen diffusing from leaves to below-ground tissue. Marine plants and animals vary in their ability to tolerate sulfide, using a variety of avoidance strategies to exclude sulfide and accommodation strategies to detoxify sulfide (41). However, the tolerance limits of seagrasses can be exceeded if sulfide accumulates to toxic levels in sediment porewater. The amount of sulfide which accumulates in seagrass bed sediments depends on a number of physical and chemical characteristics. Tidal currents, wave action, and sandy sediments facilitate exchange of sediment porewater with the overlying water column, resulting in oxidation or export of sulfide produced by bacteria. In contrast, sulfide concentrations are generally higher in quiescent areas with fine grained sediments. Eelgrass may be affected by both the direct and indirect sulfide toxicity effects. The direct, cytotoxic effects will result from the reaction of sulfide with enzymes required for photosynthesis and respiration. Indirect toxicity effects are caused by hypoxia when photosynthetically-produced oxygen oxidizes sulfide which enters roots and rhizomes. Oxygen production and transport within plants is the key to resistance to hypoxia and sulfide toxicity, and eelgrass survival will depend on a balance between the plant’s oxygen supply and sediment porewater sulfide (Fig 4). Any process which causes the elevation of sediment sulfide increases
hypoxia or sulfide toxicity in eelgrass. Sulfide toxicity can also be increased by factors which decrease eelgrass photosynthesis (e.g. reduced light levels or increased water temperature).

**Temperature**

The Intergovernmental Panel on Climate Change (IPCC) has predicted that global temperatures may rise by as much as 6 °C over the next century (42). Temperatures in Long Island waters have increased by 1.5°C between 1976 and 2000 (43), which represents typical patterns seen in the northeast US coast. Consistent with these findings, our analysis of summer (June – August) temperatures recorded by the Suffolk County Department of Health Services, Office of Ecology, in the shallow bays of eastern Long Island, have revealed that the maximum summer temperatures have steadily increased during the past two decades (Fig 5). In addition to stress on eelgrass populations caused by light limitation, sulfide toxicity, and habitat modification, higher sustained temperatures during summer months are likely to limit the productivity and recovery of this population.

Critical thermal stress has been reported in temperate seagrasses at temperatures above 25 °C (44-46). The effects of thermal stress on photosynthesis, productivity and morphology of seagrasses have been examined (47-50). Thorhaug et al. (1978) reported that at temperatures elevated 3–4 °C above ambient, seagrasses showed evidence of reduced standing crop and productivity, and that tropical species were more tolerant than temperate species, such as eelgrass, to elevated temperature. In addition to reducing photosynthesis and productivity, high temperatures have a dramatic effect on the internal oxygen balance of eelgrass. Increasing water temperatures stimulate plant respiration more than photosynthesis, and the meristems go anoxic, even in the light, at water temperatures above >25 °C. It has been hypothesized that low meristematic oxygen content resulting from increasing water temperatures may be a key factor in observed events of seagrass die-off (51).

![Temperature graph](image)

**Figure 5.** June–August temperatures in Fire Island Bay, NY, 1996-2000. Frequent monitoring of this system ceased after this time period.

**Literature Cited**


Habitat modification through the loss of suspension feeders

Great South Bay

Length = 40 km
Width = 2.5 – 8 km
Ave. dept = 1.3 m
Area = 235 km²
RT = 54 – 84 days

- Separated from ocean by barrier island – Fire Island (150-750 m wide)
- Direct connection to ocean through Fire Island Inlet
- Indirect connection to ocean through Jones Inlet (west) & Moriches Inlet (east)

Stressors
Structure
Ecosystem Function

Habitat modification (loss of filter feeders)
Light Shading (increased phytoplankton and turbidity)
Sulfide toxicity (decreased bioturbation and oxygen injection by eelgrass)
Increasing water temperature (global climate change)

Sediment stabilization (reduced turbidity)
Eelgrass Biomass And Associated Community
Fisheries Resource (nursery ground and predation refuge)
Carbon Export (detrital food resource)
Sediment oxygenation (reduced sulfide toxicity and enhanced nutrient regeneration)

Fisheries related habitat modification

1. During the 1970s, 2 out of every 3 hard clams eaten on the east coast of the US came from LISSE and accounted for 54% of the total US hard clam harvest (McHugh, 1991). Population clearance rate ≈ 40% of the bay volume day⁻¹ and clams exerted control on plankton assemblage (Kassner, 1993)
2. These peak hard clam landings were followed by a precipitous decline in clam densities, as harvest mortalities greatly exceeded natural recruitment during the 1980s (Cosma, 1985)
3. Most recent observations suggest that current settlement, growth and survival of hard clams in the LISSE are at an unprecedented low level (NYDEC 2001) with recent harvest levels nearly two orders of magnitude lower than that observed in the mid 1970s. Under current conditions, population clearance rate < 1% of the bay volume and clams exert no control on plankton assemblage.

Fisheries Related Habitat Modification

Time to filter GSB:
1976: 3 days
2005: > 3 months

CBP: Chesapeake Bay, Past; NB: Narragansett Bay; DB: Delaware Bay; CBBP: Chesapeake Bay, Present (From Dame, 1996)
**Habitat Modification #1: Decrease in water clarity**

1. During the 1970’s, eelgrass covered 40% of LISSE.

2. In 1985, the first brown tide bloom occurred and eelgrass coverage was reduced by 40-50% by 1988 and more restricted to Fire Island and the western region (Dennison et al. 1989).

3. It has been postulated that almost all eelgrass beds in LISSE currently subsist under sub-saturating light (Findlay 2001).

**Tank without clams**

<table>
<thead>
<tr>
<th>SB1</th>
<th>SB2</th>
<th>SB3</th>
<th>SB4</th>
<th>SB5</th>
<th>SB6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chl a (μg L⁻¹)</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

**Tank with clams:**

Brown tide densities < 10⁴

**Consequences for light scatter**

1. During the 1970s, the LISSE was dominated by moderate sized phytoplankton species

2. Small phytoplankton (< 5 µm) now dominate (up to 90%) of algal assemblages in LISSE such as Great South Bay, Quantuck Bay, and Mecox Bay

3. This abundance of small phytoplankton is likely to have a negative impact on eelgrass beds since small particles tend to scatter light more than larger particles (Morel 1987)

**Mesocosm Experiment**

**Habitat Modification #2: Reduction in the translocation and burial of nutrients from the water column to the sediments**

1. Suspension feeders have been repeatedly demonstrated to translocate PON, POP from the water column to the sediment.

2. These biodeposits increase sediment pore water nutrient concentrations which are available for seagrass production.

3. Eelgrass productivity in some areas of the LISSE have been demonstrated to be limited by sediment nutrient availability.
Fertilization Experiment

Newell et al. 2002

Habitat Modification #3
Reduction in sediment oxygenation?

Habitat Modification #3
Reduction in sediment oxygenation?

Carlson et al., 2001

2005 Benthic Survey

2005 Benthic Survey
Great South Bay

Habitat Modification #4: Reduction in seed germination and survival?

1. Seed entrapment can be facilitated by the structure a mature hard clam community provides.
2. Hard clams can provide superior conditions for seed germination by increasing sediment organic content. Zostera seed germination is dependent on burial depth, with the highest germination occurring at the anaerobic/aerobic interface (Bugley 1981). Filter feeders can aid in burying and fertilizing seeds at a depth that is appropriate for germination.
3. Finally, filter feeders can increase the survival of seedlings, which have very high mortality rates (Orth et al. 1994a, Ruckelshaus 1996), by increasing light levels and nutrients and by protecting against erosion and herbivory.

Food web

- Reduced clam, filtration
- Nutrients
- Reduced density
- Filtration
- Eelgrass shaded out
- No oxygen
- No predation refuge
- Enhanced benthic nutrient flux

Before Schramm, 1999

After Schramm, 1999

Phytoplankton
Free floating macroalgae
Seasonal opportunistic epiphytes
Perennial macrophytes
Increasing phases of eutrophication

I
II
III
IV

1970s GSB

Present GSB

High Light
Low Phytoplankton biomass

High filtration

Low Light
High Phytoplankton biomass
Low phytoplankton biomass

After Schramm, 1999
Seagrass Distribution in Long Islands South Shore Bays
Chris Clapp
Estuary Specialist
The Nature Conservancy

This presentation summarizes the current state of seagrass distribution in Long Islands South Shore Bays compares the relevant datasets available and presents data on what might be driving the trends in seagrass trends. The South Shore Bays include Hempstead Bay, South Oyster Bay, Great South Bay, Moriches Bay and Shinnecock Bay. Particular attention was focused upon the Great South Bay as there is more data available for this body of water.

The two data sets available that illustrate seagrass distribution are Data presented includes a survey performed using discreet grab samples performed by Jones and Schubel in 1979 giving the baseline of seagrass distribution for Great South Bay from the Wantagh Parkway to the Smith Point Bridge. The second dataset was supplied by the New York Department of State Office of Coastal Services and is based upon geographically referenced aerial photos taken in 2002 and includes all of the South Shore Bays. While the methods for the two datasets are very different and cannot be directly compared for trends it is possible to get a broad perspective of change between the two datasets.

The focal point of this presentation was Great South Bay. The bay was broken into townships which also correspond to geographical regions within the bay. The data revealed that seagrasses had apparently made a resurgence (~2000 acre gain) in the western bay (Town Of Babylon) and lost acreage (~5000 acre loss) in the eastern end of the bay (Town of Brookhaven), the central part of the bay (Town of Islip) remained relatively stable. While some of the discrepancy may be due to the difference in survey methods the amount of change would likely exceed the error due to methodology.

Additional data presented included sewage district maps and the out fall plants, a 2 meter contour chart, and a draft map of shoreline hardening. This data was presented to give the expert panel some background knowledge of the system and what might be contributing to or inhibiting seagrass growth.
SAV Distribution and Trends In South Shore Bays

Chris Clapp, The Nature Conservancy
Brad Peterson, MSRC; Stony Brook University
A. Coolidge Churchill, Adelphi University

South Shore Bays

- Hempstead Bay
- South Oyster Bay
- Shinnecock Bay
- Moriches Bay
- Great South Bay
- South Oyster Bay

SAV Distribution in Great South Bay

<table>
<thead>
<tr>
<th>Town</th>
<th>Area in 1979</th>
<th>Area in 2002</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babylon</td>
<td>2813</td>
<td>3913</td>
<td>1100</td>
</tr>
<tr>
<td>Islip Town</td>
<td>4773</td>
<td>4071</td>
<td>-699</td>
</tr>
<tr>
<td>Brookhaven</td>
<td>-4999</td>
<td>3761</td>
<td>8760</td>
</tr>
</tbody>
</table>

Source data: NOAA, NYS DOS, Jones and Schubel 1979
Hempstead Bay and South Oyster Bay

<table>
<thead>
<tr>
<th>Source data; NOAA, NYS DOS, Jones and Schubel 1979</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Area in Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
</tr>
<tr>
<td>2002</td>
</tr>
<tr>
<td>change</td>
</tr>
</tbody>
</table>

Legend
- Suitable Habitat
- Seagrass Distribution
- Hardened Shoreline

Shinnecock Bay

Suitable Habitat

Current Seagrass coverage extends over 40-50% of all the area <2m depth

Legend
- Seagrass Distribution
- Hardened Shoreline
- Suitable Habitat

Hardened Shoreline and Current Seagrass Distribution

Legend
- Hardened Shoreline
- Seagrass Distribution
Sewer Districts and Current Coverage

Source data; NOAA, NYS DOS, Suffolk County Dept. of Public Works

Nature Conservancy’s Restoration Efforts

Sewage Outfalls and Current Coverage - West

Legend
- Treatment plant outfalls
- Treatment plant lines
- SAV (i.e.)

Nature Conservancy’s Restoration Efforts
Prior to the implementation of the Comprehensive Conservation and Management Program (CCMP), there was no baseline data on the health or extent of eelgrass (*Zostera marina* L.) in the Peconic Estuary. The Long-term Eelgrass Monitoring Program (LTEMP) was initiated in 1997 to provide baseline data on several eelgrass meadows in the Estuary and continue with annual monitoring to identify trends in population dynamics and areal extent of these beds over time. In support of the LTEMP and restoration efforts, historic eelgrass coverage for the Estuary was determined using 1930 aerial photographs and compared to an aerial survey conducted in 2000. In 1930, eelgrass covered approximately 8,720 acres of the Estuary, whereas, the 2000 study found only 1,552 acres of eelgrass remained. This represents an average rate of loss of almost 100 acres per year. The trend since 2000 finds that the six LTEMP reference populations have shown a relatively steady decrease in shoot density and areal extent and, currently, two of the monitoring sites no longer support eelgrass.
Eelgrass Status in the Peconic Estuary: Historic vs. Present distribution and current trends
Stephen Schott
Cornell Cooperative Extension
Marine Program

Overview
1) Distribution of Eelgrass (Zostera marina L.) in the Peconic Estuary
   - Historic versus Current Distribution
2) PEP Long-term Eelgrass Monitoring Program
   - Background
   - Methodology
   - Trends

Eelgrass Distribution
Historic vs. Present: Peconic Estuary

Summary
• The Peconic Estuary contained 8,720 acres of eelgrass in 1930 (This is a conservative estimate and does not include 1,990 acres of unconfirmed beds).
• The Tiner report (2003) calculated 1,552 total acres of eelgrass based on 2000 aerials, though that number is likely low as undocumented beds have since been identified.
• This represents a loss of over 80% in a 70 year period (~100 acres/year).

PEP Long-term Eelgrass Monitoring Program
Background
• The PEP contracted Cornell Cooperative Extension, Marine Program to develop and conduct long term eelgrass monitoring in 1997
• The Program includes 6 reference beds from around the Estuary: Bullhead Bay (BB), Gardiners Bay (GB), Northwest Harbor (NWH), Orient Harbor (OH), Southold Bay (SB) and Three Mile Harbor (TMH).
### PEP Long-term Eelgrass Monitoring Program

**Trend Analysis**

1) Overall, eelgrass shoot densities have been on a decline since 2000.

2) 2002-2004 saw significant losses to several beds (75% and 78% for OH and TMH, respectively).

3) 2006 found complete loss of eelgrass for 2 of the reference sites (SB and TMH) and a significant reduction in density at 2 other sites (GB and NWH).

4) In 2006, BB showed a significant increase in shoot density from the previous year with eelgrass re-colonizing stations that were unvegetated in 2005.

### Summary

- The major trend evident in the eelgrass data is the almost constant decline of eelgrass shoot densities in the six monitoring beds since 2000.

- Major declines in Bullhead Bay, Orient Harbor and Three Mile Harbor recorded in 2004 may be linked to the severe winters from 2002 through 2004. The extremely cold conditions froze the Estuary and resulted in ice scour in shallow areas and removal of eelgrass. Eelgrass decline in Southold Bay (2005) may be a result of burial by dredge spoils.

- Evidence of recovery in Bullhead Bay in 2006 indicates that extant beds may be able to reverse declining trends if/when causative pressures are relieved.
Current Management and Research Approaches Involving Eelgrass in the Peconic Estuary

Kim Petersen
Habitat Restoration Educator
Cornell Cooperative Extension

Current Management and Research Approaches Involving Eelgrass in the Peconic Estuary includes a compilation of the following:

• Current management efforts which impact eelgrass, including local (towns bordering the Peconic Estuary) as well as state regulations.
• Proposed management actions addressed in the Peconic Estuary Program Comprehensive Conservation and Management Plan.
• Research which has taken place in the Peconic Estuary concerning or involving eelgrass.

Please see Appendix H.
The U.S. Fish and Wildlife Service’s National Wetlands Inventory Program (NWI) initiated this study in 2002 and produced a report on the distribution of eelgrass beds in the eastern portion of Long Island Sound: “Eelgrass Survey for Eastern Long Island Sound, Connecticut and New York” (Tiner, et al. 2003). This survey was intended to be the baseline study for monitoring the status of eelgrass in this area of Long Island Sound.

In 2004, the U.S. Environmental Protection Agency provided funding to update this survey in 2005. This presentation outlines the methods used in the survey, summarizes inventory results, compares the findings with the 2002 survey, and provides detailed maps showing the location of eelgrass (Zostera marina) beds detected during the 2006 survey.

The project study area encompasses the eastern end of Long Island Sound, including Fishers Island and the North Fork of Long Island. It included all coastal embayments and near shore waters (i.e., to a depth of –15 feet at mean low water) bordering the Sound from Clinton Harbor to the Rhode Island border and including Fishers Island and the North Shore of Long Island from Southold to Orient Point and Plum Island. The 2006 survey located and mapped 1,905 acres of eelgrass beds in eastern Long Island Sound. Eelgrass beds were mostly present from Rocky Neck State Park east to the Rhode Island border and the north shore of Fishers Island. Four beds were found on the North Shore of Long Island, New York, with three in the Mulford Point area. No eelgrass was found from the Old Lyme Shores sub-basin to Clinton Harbor, except for two small beds (totaling 6.4 acres) associated with the Duck Island breakwater in the Duck Island Roads sub-basin. The largest loss of eelgrass was observed in Mumford Cove where 11 acres disappeared (probably due to increased sedimentation).

Funding for this project was provided by the U.S. Environmental Protection Agency, Office of Ecosystem Protection, Region I. Ralph Tiner was the principal investigator for U.S. Fish and Wildlife Service (Service) and was responsible for study design, coordination, and report preparation. Herb Bergquist did the bulk of the mapping work: photo interpretation, digital database construction, and GIS processing and prepared the maps and figures. The Southern New England Estuary Program (SNEP) was responsible for field review of potential eelgrass beds, with Andrew MacLachlan and Tom Halavik taking lead roles in this effort. Aerial photography was acquired and converted to digital images by James W. Sewall Company, Old Town, Maine.
Eelgrass Survey for Eastern LIS 2002 & 2006
US Fish and Wildlife Service
• National Wetlands Inventory Program
• Southern New England Coastal Program
• Ralph Tiner, Herb Bergquist, Tom Halvick, Andrew MacLachlan, Don Henne
• Funded by the EPA Long Island Sound Study

Long Island Sound
Eelgrass (Zostera marina)
Historical Distributions, Present Status, Current Management and Research Approaches

Historical Distributions NY

Charles Perrett, NYS DEC

Historical Distributions CT

LISS Habitat Restoration Manual

2002 Eelgrass Survey

2006 Survey
NOAA Coastal Change Analysis Program
C-Cap Protocol
Environmental Considerations
• Phenology
• Clouds and Haze
• Turbidity
• Tides
• Wind and Surface Waves
• Sun Angle

On The Water “Ground truth”
2002 Pattern Recognition

Equipment
• 2 – GPS’s
• Color Sounder/Plotter
• Coastal Radar
• SeaTracker and Monitor
• 2- VHF radios

SeaViewer U/W Video
• Color Camera Specs:
  • 420 Lines of Resolution
  • 1/3 inch Color CCD area sensor
  • 572 x 431 pick up array
  • -25 C to +60 C Operating Temperature
  • 76° degrees field of View Angle
  • Operating Voltage: 9.6V DC
  • Power Consumption: Max: 1W AC
  • Video out: 75 ohm , 1Vp-p Composite signal
  • Wide Angle Lens with Auto Focus & Gain

Underwater Camera with Directional Control
Capture video or stills with Sony Digital 8 TRV740i

SEA - TRAK™ GPS Overlay
2002 – 2006 Comparisons
1,598 acres – 1,905 acres

- Acreage Change in Sub-basin
- Change # of Beds

- Little Narragansett Bay -2.8 -2
- Stonington Harbor +28.0 +4
- Quiambog Cove +70.7 +6
- Mystic Harbor +61.9 --
- Palmer-West Cove +0.1 -2
- Mumford Cove -11.0 -1
- Paquonock River -2.9 -1
- New London Harbor -3.5 +1
- Goshen Cove +4.9 --
- Jordan Cove +5.5 -4
- Naugatuck Bay +130.2 -1
- Rocky Neck State Park +7.7 --
- Duck Island Roads +5.3 --
- Thames River, NY +7.6 +1
- North Shore, NY +9.2 +1
- Plum Island, NY +8.5 +1
- Total +306.2 +12

Table 6. Differences in eelgrass survey results 2002-2006. + indicate gains and – losses.

Previous and Current Studies

- ZOSTERA MARINA BIBLIOGRAPHY FOR THE NEERS REGION

Previous and Current Studies

- LISS Habitat Restoration Manual

Previous and Current Studies

- LISS Funded Study

- Establishment Restoration Objectives for Eelgrass in Long Island Sound

The project will focus primarily on how nutrient loading may be affecting eelgrass in Connecticut’s coves, embayments, and tidal rivers and identify management measures that can be taken to restore eelgrass.
Management

While deemed an "Important Habitat" in both CT and NY, there is little protection.

State
- Dredging
- Docks

Local
- Mooring and mooring fields
- Shellfishing practices
A Brief History of Eelgrass Restoration on Long Island
Chris Pickerell
Habitat Restoration Specialist
Cornell Cooperative Extension

INTRODUCTION
Long Island has three distinct estuaries, Long Island Sound (LIS), Peconic Estuary (PE) and the South Shore Estuary Reserve (SSER). LIS is characteristic of southern New England estuaries with a rocky high energy shoreline, the SSER is a coastal lagoon system that has extensive shallow flats characteristic of Mid-Atlantic estuaries, and the PE has characteristics of both New England and Mid-Atlantic estuaries. Table 1 provides a qualitative assessment of typical meadow characteristics for each area. Given these differences, restoration methods vary considerably between estuaries.

Table 1. Meadow characteristics for Z. marina growing around Long Island.

<table>
<thead>
<tr>
<th>Range</th>
<th>Meadow Type</th>
<th>Fetch</th>
<th>Sediment Type</th>
<th>Z. marina Depth</th>
<th>Temps.</th>
<th>Water Clarity</th>
<th>1° Stressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Island Sound &amp; Gardiners Bay</td>
<td>High-Energy</td>
<td>&gt;8 miles</td>
<td>Sand to Rock &amp; Cobble &lt;OM</td>
<td>0.5m to 4.5m</td>
<td>“Low”</td>
<td>Good</td>
<td>Disturbance (Waves)</td>
</tr>
<tr>
<td>Peconic Bay</td>
<td>Sheltered</td>
<td>≤2 miles</td>
<td>Mud to Silty Sand &gt;OM</td>
<td>1m to 2m</td>
<td>“High”</td>
<td>Poor</td>
<td>Water Quality (Temp./Vis.)</td>
</tr>
<tr>
<td>South Shore Estuary Reserve</td>
<td>Shallow Lagoon</td>
<td>&lt;4 miles</td>
<td>Mud to Sand ~OM</td>
<td>0.5m to 2m</td>
<td>“Var”</td>
<td>~poor</td>
<td>WQ (Vis.) &amp; Disturbance (Waves)</td>
</tr>
</tbody>
</table>

Z. marina distribution in New York waters has been reduced to 10-25% of historic populations (from 1930 estimates) (Schott, pers com). In LIS and PE, eelgrass has been lost in most shallow, protected coves and harbors and retreated to deeper open waters. In the SSER, grass persists on many shallow subtidal flats. Much of the grass along the mainland shoreline in the SSER has been lost while populations ringing the north shore of the barrier island have fluctuated over the years. In some areas, meadows on these shallow sandy flat adjacent to the barrier island have expanded (e.g., parts of Shinnecock Bay).

Causes for this precipitous decline include, the wasting disease (1931), cultural eutrophication, nuisance algae blooms (i.e., “brown tide” Aureococcus anophagefferens) (1985+) and human-induced disturbance.

Extant eelgrass meadows grow subtidally in depths ranging from 0.5m to 4.5m, in mud to cobble and rock. In the early 20th century, ONE intertidal population was identified (Cold Spring Harbor), but this small meadow was lost later in the century.

There is considerable phenotypic plasticity within and between meadows depending on depth, wave exposure, light levels, bottom type, temperature and nutrient regime. Temperature appears to be a major controlling factor in these differences. Figure 1 shows a graph of typical bottom temperatures at extant meadows within each estuary. Both flowering period, and seed production can vary within and between the three estuaries (Table 2). Shoot length ranges from 20cm to 1.8meters. Epiphytic fouling varies greatly with site conditions from complete
fouling with macroalgae, diatoms and or bryozoans to almost nothing. There is also a distinct seasonal shift in epiphyte and drift macroalgae assemblages with changes in water temperature and light levels.

**Weekly Average Water Temperatures (2006)**

(Long Island Eelgrass Meadows)

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-May</td>
<td>12</td>
</tr>
<tr>
<td>4-Jun</td>
<td>14</td>
</tr>
<tr>
<td>11-Jun</td>
<td>16</td>
</tr>
<tr>
<td>18-Jun</td>
<td>18</td>
</tr>
<tr>
<td>25-Jun</td>
<td>20</td>
</tr>
<tr>
<td>2-Jul</td>
<td>22</td>
</tr>
<tr>
<td>9-Jul</td>
<td>24</td>
</tr>
<tr>
<td>16-Jul</td>
<td>26</td>
</tr>
<tr>
<td>23-Jul</td>
<td>28</td>
</tr>
</tbody>
</table>

**Table 2.** Seed maturation and collection windows for eelgrass (*Z. marina*) meadows on Long Island, NY.

<table>
<thead>
<tr>
<th>Site</th>
<th>Estuary</th>
<th>Seeds per Shoot (Average)</th>
<th>Peak Release &amp; Collection Window</th>
<th>Source/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith Point</td>
<td>South Shore</td>
<td>31</td>
<td>June 10-28</td>
<td>Gates/1984</td>
</tr>
<tr>
<td>South Oyster Bay</td>
<td>South Shore</td>
<td>52</td>
<td>June 14-July 7</td>
<td>Gates/1984</td>
</tr>
<tr>
<td>Great South Bay</td>
<td>South Shore</td>
<td>41</td>
<td>June 26-July 2</td>
<td>Churchill et al./1978</td>
</tr>
<tr>
<td>Bullhead Bay</td>
<td>Peconic</td>
<td>42</td>
<td>June 7-14</td>
<td>CCE/2002 &amp; 2006</td>
</tr>
<tr>
<td>Hallocks Bay*</td>
<td>Peconic</td>
<td>36</td>
<td>June 24-30</td>
<td>CCE/2002</td>
</tr>
<tr>
<td>Noyack Creek*</td>
<td>Peconic</td>
<td>(107)</td>
<td>June 24-July 7</td>
<td>CCE/2001 &amp; 2003</td>
</tr>
<tr>
<td>Sag Harbor</td>
<td>Peconic</td>
<td>54</td>
<td>July 1-14</td>
<td>CCE/2002</td>
</tr>
</tbody>
</table>

* These meadows have greatly diminished if not completely disappeared.
EELGRASS RESTORATION ACTIVITIES BY DECADE

The concept that eelgrass was something of value was first realized soon after the occurrence of the wasting disease and the resultant crash of the brant goose and bay scallop populations during the 1930’s. However, it wasn’t until the 1970’s that eelgrass restoration on Long Island really began. Prior to this, especially in Great South Bay, there was a general disregard for eelgrass as a nuisance to boaters and bathers alike. In the late 60’s the Town of Hempstead commissioned a study to determine how this species could be controlled.

1930’s
The first recorded eelgrass planting effort on Long Island occurred near Jones Beach using plantings gathered from Mecox Bay (Southampton), Virginia and Washington State. Only the Washington plants survived long enough to set seed. No follow-up monitoring was conducted.

1970’s
The first comprehensive restoration efforts involving eelgrass were initiated in the mid 1970’s by Dr. Jerry Churchill of Adelphi University. Churchill and a series of graduate students investigated the use whole plant transplantation as well as seeds in Great South Bay (SSER) and the Peconic Estuary. Other work involved testing various transplant methods for restoration. One important result of this work was the observation that Z. marina seeds could be transported via air bubbles. Dr. Churchill and his students also identified the most appropriate times to collect flowers to yield the most seeds.

1980’s
Churchill continued work in both the SSER as well as the Peconic Estuary developing methods to use seeds for restoration. In the late 1980’s Dr. Bill Dennison, working with staff from CCE conducted a small-scale test planting of seeds in the Peconic Estuary as part of a study of the effect of brown tide on local eelgrass populations.

1990’s
With the coming of the brown tide in the mid 1980’s, there was a new found interest in protecting and restoring resources in the Peconic Estuary. During the early 1990’s money was made available for various “demonstration projects” to restore resources in the PE. During the period of 1994-1999, CCE and Town of East Hampton Trustees and Natural Resources Department conducted transplants at multiple sites in town waters. Seeds were not investigated during this period. Although the results of this work were mostly discouraging, it led the way to future efforts. This was the first indication that many creeks and harbors which historically supported eelgrass may no longer be able to support this species.

2000’s
After a couple year hiatus, CCE again initiated restoration activities with funding from various sources. The first projects focused on sites within the inner estuary.

2001-2004 CCE – Seeds were investigated again as a potential restoration method. Advice was sought from Dr. Jerry Churchill (Adelphi), Dr. Robert Orth (VIMS) and Steve Granger (URI). In 2002, the first Buoy Deployed Seeding (BUDS) system was constructed and deployed in the Peconic Estuary. Although this system as well as broadcast seeding produced large numbers of seedlings, long-term survival of seedlings was poor at all sites. Similar observation were made at extant meadows where natural seedling recruitment had occurred, raising questions.
regarding the efficacy of using seeds as a primary restoration tool until the cause of these failures can be identified.

2002 CCE – *Z. marina* meadows “discovered” in Long Island Sound at Mulford Point, a very high energy site.

2003-2004 CCE – Based on observations at Mulford Pt., restoration site selection underwent a significant paradigm shift to high-energy, exposed sites along the LIS shore and points east in the Peconic Estuary.

2003- present CCE – Transplants were initiated in Long Island Sound and eastern Peconic Estuary with the first large-scale successes in the region. The “rock-planting” method was developed and high density, (unanchored plantings) were tested at several sites with suitable bottom conditions. Current work is conducted at the multiple-acre scale.

RESTORATION TECHNIQUES

SITE SELECTION
Early restoration work on Long Island focused on the most obvious places to plant including the shallow creeks and coves where the grass most recently grew. While some of this work in the SSER was at least initially successful, most transplant and seeding efforts eventually failed. Eventually, a Transplant Suitability Index (TSI) GIS-based model was created for the PE based on the work of Dr. Fred Short (UNH) and others. This model identified eastern portions of the Estuary as the most appropriated planting areas. Verification of this model was achieved through test plantings, but physical disturbance was a confounding factor at several sites. A similar model for Shinnecock and eastern Moriches Bays is currently under development. For LIS, a Wave Exposure Model (WEMO) is being developed in collaboration with Dr. Mark Fonseca of NOAA.

RESTORATION METHODS
Numerous restoration methods involving transplantation of adult shoots and seeding have been attempted on Long Island over the last 70 years. See restoration summary tables for a detailed overview of restoration activities to date. The following section covers lessons learned on Long Island.

TRANSPLANTS
Successes
Fall and winter plantings (mostly TERFS) were initially successful at most sheltered sites in the Peconic Estuary with survival through the winter and into the following summer. However, most transplants died by late summer.

Year-round plantings have been successful at high energy sites in Long Island Sound using the rock method.

Fall and winter plantings in Gardiners Bay have been mostly successful using high-density (200 shoots/m²) 1m² circular plots.
Tracking of individual plots using labeled rocks has allowed for close monitoring of factors such as donor source, planting date, weather conditions, time of year and diver error at restoration sites.

**Failures**

Spring and summer transplants, using free-planting, the staple method and TERFS were not successful when attempted at sheltered sites within the Peconic Estuary on bottom types ranging from silty sand to sand.

**SEEDS**

**Successes**

Although the early seed work in the SSER did not result in meaningful establishment of plants, it did lead to an understanding and appreciation for the potential of using seeds for restoration and lead to development of flower harvest and handling methods.

Planting of seeds into sheltered embayments throughout the Peconic Estuary using the broadcast method and buoy deployed seeding indicated that seedling recruitment was not limiting to restoration efforts.

Limited success was achieved when seeding into and around existing grass at restoration sites in high-energy sites (LIS).

**Failures**

Despite all the successes of seedling establishment in various sheltered sites (e.g., harbors and creeks) throughout the Peconic Estuary, with the exception of two sites, all seeding sites suffered catastrophic losses of shoots some time during the first summer.

Seedling recruitment never occurred in any appreciable rate at high-energy, coarse-textured sediment sites unless there were adult plants nearby.
A Brief History of Eelgrass Restoration on Long Island

Chris Pickerell, CCE-Marine Program
Email: cp26@cornell.edu Website: www.seagrassli.org

Long Island Eelgrass Workshop February 15, 2007

Eelgrass in Long Island waters

Loss of seagrass meadows around Long Island have been staggering since 1930, the year when the first comprehensive aerial photos were taken. Losses are estimated at 75-90% for the three estuaries. (S. Schott, pers. com.)

Why is restoration necessary?

LI has suffered numerous episodic losses of grass (e.g., wasting disease in 1931+ and “brown tide” 1985+) that have eliminated many meadows in areas where conditions are still suitable for growth.

Although many areas that have been affected by the wasting disease have recovered (except for Long Island Sound), areas impacted by the “brown tide” have not recovered. Is it just a matter of time?

Given the geographic and hydrological separation of extant meadows and potential restoration sites, we believe propagule limitation is preventing natural recovery in many areas.

Restoration can overcome this and speed the process of recovery.

Eelgrass restoration milestones on LI

1936 - The first documented eelgrass transplant took place near Jones beach and involved planting plants from Mecox Bay, Virginia and Washington in response to the wasting disease of 1931.

1960's - 1970's - In Great South Bay several researchers looked at transplanting grass into various depths and bottom types. During the latter part of this period Churchill (Adelphi) was the first to investigate the use of seeds for transplants.

Late 1980's - CCE organized an “Eelgrass Planting Workshop” in response to loss of grass caused by the “brown tide”. Transplant and seeding efforts were also attempted by Dennison.
Almost exactly 20 years ago, the invited experts were.......... Some things never change!

Eelgrass Restoration: LI Case Studies
Peconic Estuary - TERFS planting X 5

During 2001 a small-scale test planting was conducted outside of Town Creek, Southold to determine the potential for large-scale restoration. 4 TERFS were planted (61 shoots each) on 11/02/01 using plants from a nearby meadow. Survival through winter and into the following spring was excellent. During summer of 2002 the entire planting failed. Possible causes of failure include: disturbance, high water temperatures and/or poor water clarity. Subsequent LTM at Mill Creek indicated a drastic decline in the natural meadow from ~500 shoots/m² in 2001 to almost complete loss by 2006.

May 2002 (7 months post planting)
Eelgrass Restoration: LI Case Studies
Peconic Estuary - Seeding

On September 18th of 2001 the first attempts to deploy seeds using a floating cage (later to be called BuDS) took place at Jessups Cove, Southampton. Seedling recruitment the following spring was very good and seedlings grew rapidly. By mid summer all shoots were lost. Possible causes of failure include: Shellfishing, high water temperatures and/or poor water clarity. Since that time, the donor site at Noyack Creek has suffered periodic losses and recoveries in subsequent years. In some cases large numbers of adult shoots were lost and seedling recruitment was excellent only to fail in the summer.

Peconic Estuary – Natural Seedling Recruitment

In May 2004 evidence of a large-scale natural seeding event was documented using photographs and direct counts of individual shoots. Follow-up observations of the site ~55 days later indicated complete loss of ALL seedlings. Similar observations were made at another site (Bullhead Bay) in the PE that same year. The cause of these losses are unknown, but they do not appear to be linked to physical disturbance (i.e., bioturbation or shellfishing).

Restoration Site Selection
Paradigm shift ('02/'03)

New Restoration Sites
Former Restoration Sites

"Historic" eelgrass distribution

Creeks & Harbors
Bays & LIS
Atlantic Ocean

Physical Disturbance Regime (Wave Energy)

NW wind

Are these Creation sites?
Eelgrass Restoration: LI Case Studies
Long Island Sound – Seeding and Transplants

In October 20, 2003 the first ever seeding effort along LI’s north shore was initiated. Approximately 60,000 seeds were broadcast between two sites resulting in ONE group of plants the following season. Large-scale plantings were initiated during fall of 2005 and continued into the 2006 season. The project is a success resulting in a 2-acre meadow at St. Thomas Pt. and a work at Terry Point is underway to create a ¾ acre meadow. Once a canopy had formed, additional seeds were broadcast at the site and there appears to have been some natural seedling recruitment. Test plots at Terry Pt. indicate a 9-fold increase in shoot density after 13 months.

Eelgrass Restoration: LI Case Studies
Shinnecock Bay – Natural Recovery

As part of an Eelgrass and Bay Scallop Restoration planning project for the Town of Southampton we determined that one area in Shinnecock Bay has experienced considerable natural recovery from 2001 to 2007. Comparing photo graphs of the same site indicates that seeding as well as rhizome expansion have contributed to infilling at this site, resulting in a significant increase in aerial coverage at this location. Other parts of Shinnecock Bay have seen a gradual decline in aerial coverage of grass. These observations

What have we learned?
1. Each estuary is VERY different (e.g., what works in LIS will probably not work in the SSER).
2. Site selection is CRITICAL and criteria need to be refined further.
3. Transplants are labor intensive, but will work if done properly and at the right time of year.
4. Seeding has potential as a site selection screening tool and possibly in large-scale restoration, but additional work is necessary.
5. Initial success is no guarantee of long-term survival for seeds and transplants; losses typically occur during the end of the first summer.
We have to avoid the overwhelming tendency to focus only on the most obvious areas for planting (e.g., lagoons and creeks) since they have shown to be unsuitable.

What have we learned?
Site Selection is CRITICAL: “Just because it used to grow there doesn’t mean it will grow there again!”

LI Eelgrass Restoration - Lessons Learned
Within-site or “mesoscale” (10’s of meters) variability can be considerable.

- Sediment texture, fetch, wave exposure, depth and other abiotic factors can vary greatly within a site at the scale of 10’s of meters.
- When designing pilot planting or seeding efforts spread TEST PLOTS across depth and bottom type changes.

Even if the entire site was covered with grass historically there may be only a small area where plantings will take (to begin the process of restoration).

What have we learned?
TRANSPLANTS: Labor intensive, but works when the site is suitable and the timing is correct.

Criteria:
- Temperatures
- Water clarity
- Water movement
- Bioturbation
- Grazers
- Fall/winter planting

What have we learned?
SEEDS: Seeds are a natural means of meadow recovery that may be suited for use in restoration if the site is suitable.

Criteria:
- Silty Sand sediment
- Water movement
- Bioturbation
- Summer/Fall
What’s Next?

• Expand on current successes in LIS and eastern PE.
• Make additional attempts in middle PE.
• Expand seeding and transplant work in the SSER.

THE END
Appendix F: Research, Management, and Monitoring Priorities
## Research, Management, and Monitoring Priorities

<table>
<thead>
<tr>
<th>Ranked Order</th>
<th>Group Priority</th>
<th>ID#</th>
<th>Category</th>
<th>Action</th>
<th>Task</th>
<th>Time</th>
<th>Cost (w/o overhead)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
<td>1</td>
<td>Management</td>
<td>Establish a working group for coordination, and ongoing dissemination</td>
<td>Define seagrass habitats, monitoring schemes, indicators, leveraging efforts, take role in synthesis</td>
<td>Immediate and regular meetings</td>
<td>10% total budget</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
<td>2</td>
<td>Management</td>
<td>Synthesis of existing data, merge the datasets, fit coordinator</td>
<td>Follow up on May 2007 map, produce a report, generating OII data layers</td>
<td>By end of 2007</td>
<td>$10K</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
<td>5</td>
<td>Monitoring</td>
<td>Monitoring physical conditions of the seagrass beds</td>
<td>Light/temperature loggers in grass beds, use satellite imagery, spatial scale, and more frequent or continuous light sampling</td>
<td>Need high resolution in summer, quarterly thereafter.</td>
<td>$24-30K</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>16</td>
<td>Management</td>
<td>Public education/perception</td>
<td>Reduce impacts to seagrasses through changes in resource use and vessel operations; potentially through vessel management and regulation. Outreach with signs at boat ramps, etc.</td>
<td>Follow synthesis</td>
<td>$25K - $50K</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
<td>3</td>
<td>Monitoring</td>
<td>New mapping of seagrass, with standardization, metadata</td>
<td>Best estimate to be determined by working group; i.e., aerial photography, hyperspectral satellite data, acoustic surveys on seafloor areas; May be advantageous to do LII, PRI, SIDER in same years. Develop a universal metric for defining seagrass habitat</td>
<td>Starting now, do every 2-3 years</td>
<td>$150/acre mile total (photo= 1/3 of core); Interpretation = 2/3. Ground truthing of remote data necessary.</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
<td>6</td>
<td>Monitoring</td>
<td>Monitor seagrass beds themselves; as examples: Seagrassnet, Seagrass Talk, etc.</td>
<td>Visual assessment for density and cover, do not count individual shoots. To be decided by working group, general toward question being asked</td>
<td>Ongoing quarterly</td>
<td>10-15 FTE days per quarter</td>
</tr>
<tr>
<td>7</td>
<td>High</td>
<td>13</td>
<td>Research</td>
<td>Needs to look at multiple stressors together; e.g., light and substrate, pH, oxygen, etc.</td>
<td>E.g., manipulate organic matter in common garden experiment? Need information on any crowding from the syntheses section</td>
<td>Years 2-3</td>
<td>$100K</td>
</tr>
<tr>
<td>8</td>
<td>High</td>
<td>9</td>
<td>Research</td>
<td>Is there a biological disturbance inhibiting persistence, restoration, reclamation?</td>
<td>Uptake solution cages 1 ft deep and above the grass to test with and without planting</td>
<td>Immediate</td>
<td>$15K</td>
</tr>
<tr>
<td>9</td>
<td>Phase 1 = high, Phase 2 = Low to High</td>
<td>8</td>
<td>Monitoring</td>
<td>Identify sources of light attenuation</td>
<td>Light attenuation testing to guide use to focus on. Phase 1 = regression model (color, TSS, Chl a), Gapmodel. Use secchi and turbidity data. Phase 2 would be using these and other factors to do your restoration design</td>
<td>Part of Synthesis</td>
<td>0 Phase 1 = $130K</td>
</tr>
</tbody>
</table>
|   | Medium to High | 4 | Monitoring | Need bathymetry of SSIE before, then PE, then LIS. Flight limitation is one of the principal causes of seagrass mortality. Categorical data will offer recovery where possible given incremental improvements in water quality. | Once | Weak green laser (lidar) $1K/82 km. Look to NOAA/AACOE for pro bono

|   | Medium to High | 18 | Research | Restoration strategy including integration of landscape ecology into planning | Follows synthesis | 30K

|   | ??? Priority depends on synthesis | 7 | Research | Is GIW having a negative effect on seagrass? As a transport pathway for H and pesticides, includes sewage/pesticides as affecting H (high variable 0.5 m threshold) - direct toxicity and increased phytoplankton | TBD | 0 for A and B; C = $20K

|   | Low to High | 17 | Research | Nitrogen budget needed for PE (mainly) and SSIE to determine potential controlling sources may be... Integrate with synthesis work | Follows synthesis | $25K

|   | Medium | 15 | Research | Epiphyte and seagrass interactions - are changes in abundance or absence of species influencing current distribution or restoration | Indicators of limitation to colonization and bed maintenance. This is examining how these species may facilitate survival of seagrass e.g. areas where there are potentially high epiphyte loads that would reduce light availability to the plants. | 1-3 years | $50K

|   | Low to High | 12 | Research | Impact of shepherding (damage) and connection (positive feedback) between seagrass and shepherding BPEL as a control and set up other test areas, soft vs hard bottom differences also consider recreational impacts - i.e. all local gear types with manipulative planting experiments | Years 2-3 | $120K

|   | Medium | 14 | Research | What is the genetic diversity of seagrasses in the various estuarine systems (SSIE, PE, LIS)? | Lack of data genetic analysis; initial screening with appropriate scale of sampling | Years 2-3 | $70K

|   | Low to Medium | 11 | Research | Determine effects of physical disturbance of seagrass bed areas, including dredging, hardening, and building | BPEL could be used as a control for some disturbances, and set up other test areas | Build out of information synthesis | $25K - $100K

|   | Low | 10 | Monitoring | Characterize biota in seagrass beds | How have impacts to the bays influenced the functions and secondary production of seagrass beds? This is about how animals use seagrass beds and conversely, the larger community value of seagrass beds in your area | Year 3 | $50K

<p>|   |   |   |   |   |   |   | 76 |</p>
<table>
<thead>
<tr>
<th>ID #</th>
<th>Dennison</th>
<th>Short</th>
<th>Carlson</th>
<th>Peterson</th>
<th>Pickerell</th>
<th>Average</th>
<th>Sorted Average</th>
<th>ID# Sorted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.2</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.2</td>
<td>2.2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>4.75</td>
<td>4.75</td>
<td>4.75</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td></td>
<td></td>
<td>6.5</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3.5</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5.4</td>
<td>5.4</td>
<td>5.25</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>7.6</td>
<td></td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>5.25</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>8.4</td>
<td></td>
<td>6.5</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.6666667</td>
<td>6.6666667</td>
<td>7.6</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>8</td>
<td>4</td>
<td></td>
<td></td>
<td>6.6666667</td>
<td></td>
<td>8.4</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>8.5</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>10</td>
<td>7</td>
<td></td>
<td>8.5</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>18</td>
<td>7</td>
<td>5</td>
<td></td>
<td>8</td>
<td></td>
<td>6.6666667</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>ID#</td>
<td>Carlson</td>
<td>Dennison</td>
<td>Short</td>
<td>Heck</td>
<td>Peterson</td>
<td>Fonseca</td>
<td>Collective Rankings</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>----------</td>
<td>-------</td>
<td>------</td>
<td>----------</td>
<td>---------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>high</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>high</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>high</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>medium</td>
<td>medium</td>
<td>2-High; 3-Med; 1-Low</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>high</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>high</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>???</td>
<td>???</td>
<td>High for A and B</td>
<td>Low</td>
<td>???</td>
<td>???</td>
<td>??? Depends on Synthesis</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Medium</td>
<td>Phase 1 = High</td>
<td>Phase 1 = high</td>
<td>Low</td>
<td>Phase 1 = high</td>
<td>Phase 1 = High</td>
<td>Phase 1 = 4-High; 1-Low</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>3-Med; 2-Low</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>2-High; 2-Low</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>3-High; 2-Medium</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sorted ID#</th>
<th>Sorted Rankings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>2-High; 3-Med; 1-Low</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>??? Depends on Synthesis</td>
</tr>
<tr>
<td>8</td>
<td>Phase 1 = 4-High; 1-Low</td>
</tr>
<tr>
<td>9</td>
<td>High</td>
</tr>
<tr>
<td>10</td>
<td>Low</td>
</tr>
<tr>
<td>11</td>
<td>3-High; 2-Medium</td>
</tr>
<tr>
<td>12</td>
<td>2-High; 2-Low</td>
</tr>
<tr>
<td>13</td>
<td>Medium</td>
</tr>
<tr>
<td>14</td>
<td>Medium</td>
</tr>
<tr>
<td>15</td>
<td>Medium</td>
</tr>
<tr>
<td>16</td>
<td>Medium</td>
</tr>
<tr>
<td>17</td>
<td>3-Med; 2-Low</td>
</tr>
<tr>
<td>18</td>
<td>Low</td>
</tr>
</tbody>
</table>
Appendix G:
Potential Research Questions
Potential Research Questions
Long Island Seagrass Experts Workshop
(in no particular order of importance)

Ecology
Reproduction-Seeds
1. What factors affect seedling recruitment in extant meadows?
2. Why is seedling survival low at some extant meadows (e.g., Peconic Estuary sites)?
3. What is the role of the seed bank in meadow maintenance and recovery?
4. How can we better predict the timing of seed release?

Reproduction-Vegetative
5. What factors affect lateral shoot formation?
6. What factors affect below-ground biomass allocation?

Fauna-Grazers
7. What is the role of Lacuna vincta in meadow maintenance?
8. What environmental factors control the temporal and geographic aspects of Lacuna vincta’s distribution?
9. What is the role/impact of mud snails on seedling and adult shoot survival?
10. What is the role of Mute swans and other waterfowl in grazing on seagrass?

Fauna-Bioturbation
11. What is the impact of whelk feeding on grass coverage?
12. What is the impact of crab (various sp.) burrowing and feeding activities on grass coverage?

Genetics
13. Could a lack in genetic diversity or some other related genetic difference be a possible cause as to the poor viability of seagrass in the Peconic Estuary as compared to other Long Island bays?

Physical Environment
14. What is the impact of increased water temperature on eelgrass distribution?
15. What is the impact of sea level rise on eelgrass distribution? Will seagrasses keep pace with Sea Level Rise? If not, what would you recommend for seagrass restoration?
16. What is the impact of groundwater/contaminants on eelgrass distribution? In particular, herbicides like atrazine, which may be used by farmers in the Peconic Estuary watershed?
17. What are the typical trends in meadow dynamics (e.g., percent cover and shoot density) in high energy environments?
18. What impact does hydrogen sulfide and ammonia toxicity in the sediments have on survival of seedlings and adult shoots?

Management and Restoration
19. How can we better refine our restoration site selection models (especially in light of Sea Level Rise)?
20. What do we know about the relationship between nitrogen and eelgrass?
21. How much nitrogen, as a load or concentration, is too much?
22. Do different forms of nitrogen affect seagrass in different ways?
23. How do different characteristics (flushing, depth, etc.) of the receiving waters affect potential water quality criteria?
24. What is our understanding of the loading from the landscape?
25. What ancillary conditions or stressors (variability of nitrogen load, seasonal effects, temperature/nitrogen interplay, other factors listed under physical environment) are important?
26. Is there a potential for water quality restoration in the range of what’s needed for eelgrass?
27. How can user conflicts be resolved such that shellfishing and eelgrass restoration can co-exist?
28. How can planting methods be improved to increase success in high energy environments?
29. Is there a critical minimum size and/or density threshold for plantings to ensure survival?
30. Seagrass in the Peconic Estuary has recently disappeared from areas where it has been for decades (e.g., Hallocks Bay and Orient Harbor) although they were historically more resilient to disturbance like brown tide relative to other areas. Are there other temperate areas where there is recent, significant seagrass loss without any indication of the presence of persistent/harmful algal blooms?

Monitoring
31. What are the best indicators of meadow health?
32. What are the most appropriate monitoring protocols (methods and timing)?
33. Is the Peconic Estuary Program Long Term Monitoring program on track?
34. What are the appropriate selection criteria for establishing new sampling stations when existing stations no longer contain seagrass?
35. How long and how often should we sample declining sites?

General
36. Why is the grass in the Peconic Estuary declining at a greater rate than other estuaries on Long Island?
37. What was the historic distribution of eelgrass along Long Island’s north shore?
38. What are the specific environmental services offered by Long Island’s seagrasses?
39. What fishery and shellfishery resources are dependent on Long Island’s seagrasses?
40. What is the relationship between shoreline armoring and seagrass distribution?
Appendix H:
Other Supplemental Materials
Long Island Estuary Systems
Peconic Estuary
South Shore Estuary Reserve
<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Location within Peconic Bay</th>
<th>Citation</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934-1935</td>
<td>n/a</td>
<td>Cottam, C. 1935. The Present Situation Regarding Eelgrass (Zostera marina). USDA Biological Survey. Leaflet BS-3.</td>
<td>This paper addresses the condition throughout the Atlantic including Europe post “wasting disease”, mentioning that “Peconic bay conditions are still bad, although reports offer some encouragement.” Contains valuable information on the history and extent of disappearance, effects of disappearance, and potential causes (“fungal disease... similar to Labyrinthula”). Note: Disease still present in Shinnecock and Mecox Bays, but have shown progressive betterment compared to the rest of LI bay.</td>
</tr>
<tr>
<td>1936-1937</td>
<td>n/a</td>
<td>Lynch, J. J., and C. Cottam. 1937. Status of eelgrass (Zostera marina) on the North Atlantic Coast. USDA Biological Survey. Leaflet BS-94.</td>
<td>Follow up of previous paper (above). Indicates no sign of eelgrass in Peconic bays yet, with reports of only a few struggling plants in the past 6 years. Note: “Shinnecock Bay has one of the best growths on the N. Atlantic coast”. Details locations and morphology of eelgrass in these bays.</td>
</tr>
<tr>
<td>July 78’ and July ’79</td>
<td>Northwest Creek</td>
<td>Churchill, A.C., 1983. Field studies on seed germination and seedling development in Zostera marina. Aquatic Botany 16: 21-29.</td>
<td>The main findings were that a high percentage of seeds germinate, but a distinct seasonality exists in the time of germination. 50% of seedlings survived into autumn/winter but the remainder were lost during spring. Predation a possible factor. Stages of seedling development were classified.</td>
</tr>
</tbody>
</table>
| Sept ’81-Jan ’83 | Northwest Creek          | Bodner, P.J.Jr., 1985. A field study on seed production and sediment seed reserves in a Long Island population of Zostera marina. Masters Thesis, Adelphi University. | This study compared the potential seed yield of a Zostera meadow to the actual number of seeds recovered in the meadow sediments. Potential seed yield was high (2,125 seeds/m²), but the maximum
<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Authors</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer 1984</td>
<td>Northwest Creek</td>
<td>Churchill, A.C., Nieves, A., Brenowitz, A.H. 1985. Flotation and Dispersal of eelgrass seeds by gas bubbles. <em>Aquatic Botany</em> 4: 83-93.</td>
<td>Though most observations were made in Meriches, some measurements of dispersal distance and float time were recorded at NW Creek. Findings included approximately 5-13% of seeds were dispersed by flotation; dispersal distance ranged from 1-200+ m and float time ranged from 0.5-40+ minutes.</td>
</tr>
<tr>
<td>Summers of 1985 and 1986</td>
<td>Reeves Bay and New Suffolk (others in GSB)</td>
<td>Cosper, E. M., W.C. Dennison, E.J. Carpenter, V. Monica Bricelj, J.G. Mitchell, S.H. Kuenstner, D. Colflesh, and M. Dewey, 1987. Recurrent and persistent brown tide blooms perturb coastal marine ecosystem. <em>Estuaries</em> 10(4):284-290.</td>
<td>This study not only identified a previously undescribed microalgal species making up the monospecific bloom which occurred throughout Long Island embayments during the summer months of 1985-86, but it documented the effect on local eelgrass and scallop populations. An estimated ~55% (65 km) of areas capable of supporting eelgrass growth pre-bloom became incapable of sustaining the seagrass.</td>
</tr>
<tr>
<td>1988</td>
<td>All L.I. Estuaries</td>
<td>Dennison, W.C., G.J. Marshall, and C. Wigand, 1989. Effect of “brown tide” shading on eelgrass (<em>Zostera marina L.</em>) distributions. <em>Coastal Estuarine Studies</em> 35: 675-692.</td>
<td>Pre-bloom aerials from 1967 (NYS DEC) were compared to several aerial surveys conducted in 1988 for this study. No eelgrass was found in western Peconic Bays in 1988 surveys. Eelgrass in the Shelter Island area was significantly affected by brown tide, but eelgrass east of S.I. was not affected.</td>
</tr>
<tr>
<td>Aug 30-Sept 21, 1989</td>
<td>Lake Montauk (field experiments)</td>
<td>Pohle, D.G., V.M. Bricelj, S. Garcia-Esquibel, 1991. The eelgrass canopy: an above-bottom refuge from benthic predators for juvenile bay scallops <em>Argopecten irradians</em>. Marine Ecology Progress Series 74: 47-59.</td>
<td>Both field and lab experiments revealed highly significant enhancement of scallop survival in the upper canopy (20-35 cm above bottom) relative to shoot base. A highly inverse relationship between scallop size and attachment performance for 6-20 mm scallops was found, and the “critical window” of vulnerability to predation for post settled scallops was discussed.</td>
</tr>
<tr>
<td>Year</td>
<td>Location</td>
<td>Author(s)</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1990-1993</td>
<td>Lake Montauk, Napeague Harbor,</td>
<td>Strieb, M.D., V.M. Bricelj, and S.I. Bauer. 1995. Population biology of</td>
<td>Though this study was conducted mainly for implications regarding scallop predation, mud crab densities within 4 eelgrass meadows in the Peconic were found. Hallock Bay eelgrass was characterized which included canopy height, shoot density, %silt/clay, and crab densities within muddy vs. sandy substrates were compared. In Napeague Harbor, mud crabs were rare if not absent in unvegetated habitat.</td>
</tr>
<tr>
<td></td>
<td>Northwest Harbor, Hallock</td>
<td>the mud crab, <em>Dyspanopeus sayi</em>, an important predator of juvenile bay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bay</td>
<td>scallops in Long Island (USA) eelgrass beds. Journal of Shellfish Research</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14(2): 347-357.</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>Northwest Harbor, Napeague</td>
<td>Garcia-Esquivel, Z. and V. M. Bricelj. 1993. Otogeneric changes in</td>
<td>Though this study was conducted for implications regarding scallop recruitment and settlement, valuable density and shoot height information as well as macroalgae presence was noted.</td>
</tr>
<tr>
<td></td>
<td>Harbor, Hallock Bay</td>
<td>microhabitat distribution of juvenile bay scallops, <em>Argopecten irradians</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>irradians</em> (L), in eelgrass beds, and their potential significance to</td>
<td></td>
</tr>
<tr>
<td>August 1997</td>
<td>East Hampton</td>
<td>Protocols for harvesting and transplanting eelgrass in the Peconic Estuary.</td>
<td>Describes step by step protocols for harvesting and transplanting eelgrass using plugs and staples. Photos of each step are included.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prepared by EEA, East Hampton Town Natural Resources Dept. and Cornell</td>
<td></td>
</tr>
<tr>
<td>Spring and</td>
<td>Northwest Harbor, Orient Harbor,</td>
<td>Paulsen, R., C. Smith, and D. O’Rourke. 2002. A preliminary analysis of</td>
<td>Though SGD zones were located and seepage measurements were conducted at all three locations, only the two transects in Northwest harbor were selected for water, soil, and sediment analysis. Major differences in grain size distribution between vegetated and non-vegetated transects was noted; the sediment pore water and groundwater was found to have low concentrations of nitrogen and phosphate, therefore the main source of these nutrients might have been the sediment and plant detritus.</td>
</tr>
<tr>
<td>Summer 2001</td>
<td>Flanders Bay</td>
<td>the relationship between submarine groundwater discharge (SGD) and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>submerged aquatic vegetation in the Peconic Estuary. U.S. Environmental</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protection Agency, Washington, D.C.</td>
<td></td>
</tr>
<tr>
<td>Section(s)</td>
<td>Directly/Indirectly benefits eelgrass</td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>HLR-7</td>
<td>I</td>
<td>Develop and implement an Estuary-wide Habitat Restoration Plan (HRP)</td>
<td>7.1-7.7 Complete!</td>
</tr>
<tr>
<td>HLR-8</td>
<td>D</td>
<td>Develop and implement specific restoration projects</td>
<td>8.3 Quantitative goal for eelgrass restoration complete! Plan for eelgrass is no net decrease; 10% increase in 10 yrs.</td>
</tr>
<tr>
<td>HLR-6</td>
<td>D</td>
<td>Evaluate current policies preserving eelgrass/develop ways to increase protection for all extant eelgrass</td>
<td>6.1 Priority Evaluate current protection; develop increased protection. 6.2 Monitor existing; protect extant; restore degraded. 6.3 Evaluate effects of dredging, anchor dragging, prop scarring; 6.4 hold workshop</td>
</tr>
<tr>
<td>HLR-1</td>
<td>D</td>
<td>Use CNRA’s (critical natural resource areas) to develop and implement management strategies to protect high quality habitats and concentrations of species of special emphasis</td>
<td>1.8 Examine possibility of establishing marine reserves (e.g. eelgrass beds) within CNRA’s</td>
</tr>
<tr>
<td>HLR-4</td>
<td>D</td>
<td>Promote non-destructive (to eelgrass and salt marshes) methods of shellfish harvesting</td>
<td>4.1 Determine methods of harvesting shellfish that are most compatible with eelgrass establishment and growth. Develop recommendations for methods, frequency, timing etc. allowing recovery of eelgrass and enhancement of shellfish productivity</td>
</tr>
<tr>
<td>HLR-3</td>
<td>D</td>
<td>Assess the impacts of dredging activities on habitat and natural resources and develop recommendations and guidelines for reducing impacts.</td>
<td>3.2 Priority Assess navigational dredging in creeks and embayments for damages or impacts to eelgrass beds and other habitats; develop permit conditions to minimize impacts; Determine if dredging impairs water quality precluding restoration of eelgrass. 3.1 Priority &quot;dredging summit&quot;; analyze impacts including on benthic communities</td>
</tr>
<tr>
<td>Section(s)</td>
<td>Directly or Indirectly affected</td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>HLR-5</td>
<td>I</td>
<td>Implement, enforce, encourage continuation of wetland policies and regulations</td>
<td>5.1 Ensure continued protection through implementation and enforcement of current regulations Enhancement recommended</td>
</tr>
<tr>
<td>HLR-12</td>
<td>D</td>
<td>Foster sustainable recreational and commercial finfish and shellfish uses in the PE that are compatible with biodiversity protection</td>
<td>12.2 Priority I.D., protect, and restore key shellfish and finfish spawning, nursery, and feeding habitats to enhance stocks and incorporate into essential fish work conducted under ASMFC (Atlantic States Marine Fisheries Commission)</td>
</tr>
<tr>
<td>HLR-14</td>
<td>I</td>
<td>Protect Sea Turtles and Marine Mammals</td>
<td>14.1 Review areas identified as turtle feeding areas, consider what restrictions could protect these spp. and their food sources.</td>
</tr>
<tr>
<td>HLR-16</td>
<td>both</td>
<td>Develop and implement a living resource research, monitoring, and assessment program</td>
<td>16.3 Support research on interaction between eelgrass and dominant macroalgae species in the PE to determine impacts on eelgrass distribution and abundance 16.5 Perform research on ecology of food sources of sea turtles to eval. importance of PE to them and potential threats to these endangered and threatened spp. 16.7 Determine effects of dredging on benthic communities and recovery time of these communities 16.8 Evaluate progress of eelgrass restoration goals</td>
</tr>
<tr>
<td>HLR-2</td>
<td>I</td>
<td>Manage Shoreline Stabilization, Docks, Piers, and Flow Restriction Structures to Reduce or Prevent Additional Hardening and Encourage Restoration of Hardened Shorelines to a Natural State.</td>
<td>2.1 Quantify and map all hardened shoreline, docks and piers, and flow-restriction structures in the Pecos Estuary and assess the overall impacts of stabilization structures on natural resources. 2.2 review existing regulations for shoreline hardening structures at all levels of government, encourage consistent policies and strength regulations where appropriate.</td>
</tr>
</tbody>
</table>
|   |   | **2.3 Priority** Establish and enforce a policy of "no net increase" of hardened shoreline in the Peconic Estuary and, if possible, a net decrease in hardened shoreline.  
**2.4 Priority** Develop a variety of financial incentives and programs to encourage property owners to remove or modify hardened shoreline structures. |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>B-1 (Brown Tide Management Plan)</strong>&lt;br&gt;Ensure cont'd brown tide monitoring, research, coordination, and info sharing&lt;br&gt;1.1-1.7 Continue existing efforts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>N-1 (Nutrients Management Plan)</strong>&lt;br&gt;Continue to use and refine water quality standards and guidelines&lt;br&gt;1.2 Priority Integrate monitoring, modeling, and research data to evaluate the use of recommended 0.4 mg/l total nitrogen guideline for the shallow waters of the estuary to optimize eelgrass habitats.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>N-4</strong>&lt;br&gt;Control Point Source Discharges from STPs and Other Dischargers&lt;br&gt;4-Priority <strong>“”</strong> (same as description)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>N-5</strong>&lt;br&gt;*N-5.1 Ensure that the Section 6217(g) management measures of CZARA are appropriately implemented in support of the overall nitrogen management plan&lt;br&gt;*N-5.2 Investigate feasible implementation mechanisms and develop a plan to prevent increases and encourage decreases in nitrogen in groundwater underflow due to domestic fertilizer use.&lt;br&gt;*N-5.3 Investigate feasible implementation mechanisms and develop a plan to prevent increases and encourage decreases in nitrogen in groundwater underflow due to on-site disposal systems (sanitary systems).&lt;br&gt;*N-5.4 Develop a regional implementation plan for agricultural nitrogen load reductions which would include promoting agricultural best management practices, expanding agricultural environmental management (AEM) strategies, and promoting</td>
</tr>
<tr>
<td>CLPP-7 (Critical Lands Protection Plan)</td>
<td>Develop a strategy for the management of underwater lands which conserves and enhances the region's natural resources.</td>
<td>7.1 &quot;&quot;&quot;&quot; (same as description)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
</tbody>
</table>
| T(1-S) (Toxics management plan)        | Review historical monitoring data and conduct new monitoring studies where needed to further characterize sources, landings, and impacts of toxic contaminants; ensure dredged material is placed in a way as to reduce toxic impacts associated with contaminated sediments; explore management strategies emphasizing the elimination or reduction of toxics. | 1.1 - Include toxics in the FEP long-term monitoring plan  
1.5 Priority Identify toxics present at low levels that individually or cumulatively may be affecting aquatic resources.  
8.1 and 8.2 - Ensure that all permits and applications are protective of Peconic ecosystem and its food chain.  
6.6 Develop model guidelines for use of treated wood in the marine environment |
<table>
<thead>
<tr>
<th>Responsible Entity</th>
<th>Chapter in Code</th>
<th>Section/Article</th>
<th>Direct/Indirect Impact</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>219 - Shellfish and other Marine Resources</td>
<td>219-20: Vegetation removal prohibited</td>
<td></td>
<td>DI</td>
<td>No wetland vegetation of any kind can be removed or soil placed thereon during shellfishing activities.</td>
</tr>
<tr>
<td></td>
<td>219-16: Culling shellfish and restoration of underwater lands</td>
<td>I</td>
<td>Bottom must be returned to previous state upon taking of shellfish.</td>
<td></td>
</tr>
<tr>
<td>275 (formerly 97) - Wetlands and Shoreline</td>
<td>275-2: Definitions</td>
<td>I</td>
<td>Basically same as DEC wetlands regs., but up to 5' depth @mlw; 100' from wetland boundary.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>275-11: Construction and Operation standards</td>
<td>D</td>
<td>Dredging or close to seagrass is prohibited.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Whether or not seagrasses (including eelgrass and widgeon grass) will be damaged or prevented from growth is considered before permitting dock placement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>Use of lumber treated with CCA, creosote, pent products or homemade wood preservatives prohibited.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No new bulkheads in creeks and bays unless low-sill.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No new jetties or groins unless results in a total net decrease in the subject area.</td>
<td></td>
</tr>
<tr>
<td>Mooring and Anchoring Draft Chapter 34 (new chapter) Dec 11, 2006</td>
<td>34-15: Moorings in Designated Mooring Areas created by the Town</td>
<td>D</td>
<td>In designating mooring areas, the Town Board shall ensure town mooring areas avoid seagrass beds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>34-14 (A.C): Moorings Assignments: General rules for Town waters</td>
<td></td>
<td>Bottomyard, Marina, Yacht club, and riparian moorings only allowed based on considerations including locations of seagrass meadows.</td>
<td></td>
</tr>
<tr>
<td>Responsible Entity</td>
<td>Chapter in Code</td>
<td>Section/Article</td>
<td>Direct/Indirect Impact</td>
<td>Details</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>------------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| Town of Easthampton| 255- Zoning    | 255-1-20: Definitions | I                     | "Lands lying within or beneath tidal waters shall also be deemed to be ‘tidal wetlands,’ regardless of the type or amount of vegetation growing thereon or the absence of the same.”  
                     |                 | 255-5-50: Special Permit Uses: Specific standards and safeguards | I                     | "No permit shall issue for any structure which would unduly interfere with ... marine life or habitat or which would destroy other than minimal practicable areas of existing wetland vegetation..."  
<pre><code>                 |                 |                  | D                     | Dock permit issuance will consider “whether the dock will result in the destruction of beds of eelgrass or shellfish.” |
</code></pre>
<p>|                    |                |                  | I                     | Use of wood treated with CCA, ACQ, or creosote will be allowed for coastal structures &quot;unless it can be shown that no reasonable alternative material will serve the purpose&quot; |
|                    |                |                  | I                     | No new docks unless floating and seasonally removed; coastal erosion structures only permitted if “imminent, rapid or sudden loss of the property, or a substantial portion thereof, to erosion caused by rain, current, wind, wave or storm tidal action”, and structures shall be minimum necessary. |
|                    |                | 255-4-20: Natural resources special permit; regulations | I                     | Like DEC wetland regs, but w/in 150ft of wetland boundary |</p>
<table>
<thead>
<tr>
<th>Responsible Entity</th>
<th>Chapter in Code</th>
<th>Section/Article</th>
<th>Direct/Indirect Impact</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Town of Southampton</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shellfish Permits and Regulation Article II (not in Town Code)</td>
<td>Section 8E. Soft Clams</td>
<td>D</td>
<td>• &quot;Churning over or through submerged eelgrass beds is strictly prohibited&quot; Regulated by bay constables.</td>
<td></td>
</tr>
<tr>
<td>278 - Shellfish</td>
<td>278-8, 9: Escallops and Hard Clams</td>
<td>I</td>
<td>• Scallops and crabs may be harvested with a dredge only if same as DEC requirements for scallops. • No plant life (or hard clams) may be removed by mechanical means.</td>
<td></td>
</tr>
<tr>
<td>330 - Zoning</td>
<td>330-40: Tidal Wetland Regulations</td>
<td>I</td>
<td>• Bulkheading prohibited unless in Waterfront Business District or to protect the natural environment from erosion, silting etc.</td>
<td></td>
</tr>
<tr>
<td>111-Beaches, Parks and Waterways</td>
<td>111-28: Removal of Beach Grass</td>
<td>?</td>
<td>• &quot;No person shall remove, impair, damage or destroy any beach grasses or wetland vegetation of any kind nor place spoil thereon in any other area of the Town of Southampton without prior written approval by the Director of Natural Resources of the Town of Southampton and the Board of Trustees.&quot;</td>
<td></td>
</tr>
<tr>
<td>325-Wetlands</td>
<td>325-3: Definitions</td>
<td>I</td>
<td>• Tidal wetland definition includes &quot;All lands lying in the area inundated by tidal action and/or peak lunar tides&quot;, &quot;all estuaries&quot;, &quot;littoral zones&quot;, though no depth limit specified. • Same regulated activities as DEC except 200 ft from wetland boundary.</td>
<td></td>
</tr>
<tr>
<td><strong>Town of Riverhead</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47-Bays and Creeks</td>
<td>47-21: Docks, basins and ramps</td>
<td>D</td>
<td>• The potential for destruction of eelgrass or shellfish bed is considered by the Conservation Advisory Council before issuing a dock permit.</td>
<td></td>
</tr>
<tr>
<td>Article II - Shellfish</td>
<td></td>
<td>I</td>
<td>• No commercial copper quat (ACQ), pentachlorophenol, or creosote treated wood may be used for shoreline structures. CCA can only be used for pilings.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Same as Southampton Town regs</td>
</tr>
<tr>
<td>Responsible Entity</td>
<td>Chapter in Code</td>
<td>Section/Article</td>
<td>Direct/ Indirect Impact</td>
<td>Details</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>------------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Town of Riverhead** cont’d | 107-Tidal and Freshwater Wetlands | 107-3.4 –Definitions and Regulations | I | • Littoral zone (up to 6ft at mlw) included in tidal wetlands definition.  
• Same wetland regs. as DEC except 150ft from wetland boundary. |
| **Town of Shelter Island** | 129-Wetlands | 129-3: General guidelines to activities within regulated area. | I | • “The depositing or removal of the natural products of wetlands during recreational or commercial fishing, shellfish or aquaculture is allowed so long as there is no undue disturbance of the wetlands.” |
| | 129-8: Definitions | 129-3: General guidelines to activities within regulated area. | I | • No new bulkheads will be allowed unless property is in imminent peril of destruction from erosion and that other measures are not viable |
| | 108-Shellfish | 108-5: Regulations | I | • Wetlands def. includes “all lands generally covered or intermittently covered with, or which border on, tidal waters, or lands lying beneath tidal water such as...littoral zones”, though no depth mentioned.  
• Same regulated activities as DEC; 100ft from wetland boundary  
• No chumming for soft clams  
• Same scallop, hard clam regs. as DEC |
<table>
<thead>
<tr>
<th>Responsible Entity</th>
<th>Chapter in Code</th>
<th>Section/Article</th>
<th>Direct/Indirect Impact</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>6NYCRR Part 661-Tidal Wetlands Land Use Regulations (Statutory authority: Environmental Conservation Law, §§ 1-0101, 3-0301, 25-0302)</td>
<td>661.4 (hh)-Tidal Wetlands classifications</td>
<td>I</td>
<td>• Littoral zone included in tidal wetland definition (up to 6 ft depth @mlw)</td>
<td></td>
</tr>
</tbody>
</table>
| | 661.4(ee)-Regulated Activity | I | • Any form of dredging or dumping of aggregates  
• The erection of any structures whether or not changing the seabed and flow of the tide  
• Any other activity which may substantially impair or alter the natural condition of the tidal wetland area |
| | 561.5 Uses | n/a | ***No permit necessary for depositing or removing the natural products of a tidal wetland (or adjacent area) in the process of recreational or commercial fishing, shellfishing, aquaculture, hunting or trapping, including the erection and maintenance of temporary hides or blinds. |
| 6 NYCRR Part 46-Public Use of State-Owned Tidal Wetlands | 46.7 Prohibited Activities | D | • Removal of naturally occurring or introduced flora, whether living or dead, except for specifically permitted research or educational activities |
| | | I | • Disposal of any solid, liquid or toxic waste material. |
| 6 NYCRR Part 49-Shellfish Management-Gear restrictions | Soft clams | n/a | • No mechanical means except churning by propeller allowed below low tide |
| Protection of Waters | Article 15 of the ECL. Part 608 | I | • Requires a permit before construction, reconstruction or expansion of a dock, wharf, goin, mooring or any other structure in or above waters in state-owned underwater lands. |
## Long Island Estuary Systems: Snapshot

<table>
<thead>
<tr>
<th></th>
<th>Peconic Estuary</th>
<th>South Shore Estuary</th>
<th>Long Island Sound</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Watershed Land Acres</strong></td>
<td>125,783 acres</td>
<td>208,640 acres</td>
<td>10,764,800 acres</td>
</tr>
<tr>
<td><strong>Surface Water Acres</strong></td>
<td>158,056 acres</td>
<td>208,640 acres</td>
<td>8,444,800 acres</td>
</tr>
<tr>
<td><strong>Watershed Population</strong></td>
<td>100,000 winter; 280,000 summer</td>
<td>1,500,000</td>
<td>8,500,000</td>
</tr>
<tr>
<td><strong>Flushing Times</strong></td>
<td>56 days Western; 22 days Eastern</td>
<td>1,500,000</td>
<td>8,500,000</td>
</tr>
<tr>
<td><strong>Average Depth</strong></td>
<td>4.7 m</td>
<td>1-3 m</td>
<td>19.2 m</td>
</tr>
<tr>
<td><strong>Secchi Depth (ft)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter mean</td>
<td>9.2</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>2.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>25.0</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>7.1</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>2.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>15.0</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td><strong>Surface Water Temperature (C)</strong></td>
<td></td>
<td></td>
<td>32F winter; 73F summer</td>
</tr>
<tr>
<td>winter mean</td>
<td>3.2</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>11.0</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>22.4</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>15.3</td>
<td>16.9</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>27.8</td>
<td>27.8</td>
<td></td>
</tr>
<tr>
<td><strong>Total Nitrogen (mg/ L)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter mean</td>
<td>0.21</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>0.80</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>0.28</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>1.40</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td><strong>Basin Morphology</strong></td>
<td>2 Separate: Peconic Bay and Gardiner's Bay</td>
<td>Interconnected coastal bays</td>
<td>Eastern and Western Basins</td>
</tr>
<tr>
<td><strong>Circulation</strong></td>
<td>Classic estuary; FW riverine and tidal influence</td>
<td>Inlet-fed and small rivers</td>
<td>NYC metro area FW inputs; Western tidal</td>
</tr>
<tr>
<td><strong>Eelgrass Acres</strong></td>
<td>Historic: 8,720</td>
<td>Current: 1,552</td>
<td>2006: 1,905</td>
</tr>
</tbody>
</table>

*Peconic mainstem stations (Flanders, Great Peconic, Little Peconic, Noyac Bay, Shelter Island Sound, Orient Harbor, NW Harbor, Gardiners Bay) 2000-2005; Great South Bay/South Shore Estuary open bay sites (no ocean or inlet) 2000-2005.*