Long Island Sound
Tidal Wetlands Loss Workshop

October 22-23, 2014
Danfords Hotel and Marina, Port Jefferson, New York

Workshop Proceedings and Recommendations to the Management Committee of the Long Island Sound Study

Proceedings produced by:
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Acknowledgements

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Introduction

Tidal wetlands, particularly salt marshes, are primarily composed of smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*) and can be found throughout Long Island Sound (LIS) in protected bays and harbors. These wetland habitats serve as the interface between the marine and the terrestrial environment, providing buffers to storm surge, filtering the water of pollutants to improve water quality, and serving as spawning, nursery, and feeding grounds for fish, invertebrates, waterfowl, and wading birds.

Despite their benefits, tidal wetland ecosystems were not fully understood or appreciated until the mid-20th century and until this time suffered from years of dredging and filling related to land and port development. By the 1970s, legislation was initiated in New York and Connecticut to protect tidal wetlands from destruction. Despite these protections, in 1999 the New York State Department of Environmental Conservation (NYSDEC) staff identified significant losses in intertidal marshes in Jamaica Bay, Queens, NY, and documented similar intertidal marsh losses in other New York estuaries. At the same time, Connecticut Department of Environmental Protection (today, the Connecticut Department of Energy and Environmental Protection (CTDEEP)) noted consistent and continued wetland loss in the tidal portions of the rivers that drain into LIS. As a result of these findings, the Long Island Sound Study (LISS) Management Committee funded a Long Island Sound Tidal Wetland Loss Workshop in 2003 to bring together experts and investigate this phenomenon. Ultimately, the workshop determined that the causative factors of marsh loss were largely unknown and that more research, monitoring, restoration, and management were needed.

A major recommendation of the 2003 workshop was to reconvene for a follow-up workshop at a later date to discuss recent developments in the study of wetland loss. On October 22-23, 2014, approximately 70 professionals in tidal wetland research, monitoring, restoration, and management came together for the 2014 Long Island Sound Tidal Wetlands Loss Workshop that was held at Danfords Hotel and Marina in Port Jefferson, NY. The primary goal of the 2014 workshop was to have an engaging learning experience and discussion among leading marsh managers, researchers, practitioners, and regulators regarding tidal wetland loss and change in Long Island Sound and the region over the last decade. Essentially, the workshop attendees were charged with the following:

- Review the activities and recommendations produced as a result of the 2003 workshop –make a list of what has been completed and what still remains (identify data gaps);
- Create a suite of prioritized management, habitat restoration, research, and monitoring recommendations moving forward for LIS; and
- Discuss short-term, mid-term, and long-term adaptation strategies.

Workshop Format

The 2014 workshop was organized into theme topic presentations and breakout sessions. Day 1 and the first half of Day 2 of the workshop focused on presentations. Presenters at the workshop updated attendees on recent projects occurring in and around LIS and the region that focused on key theme topics such as submergence, sudden vegetation dieback, marsh modelling efforts, ecological indicators, surface elevation tables, trends analyses, marine transgression, and innovative restoration and monitoring efforts. Each theme was presented by a team of experts (panel team) that had contributed data and/or slides to the presentation. Topics were presented by one or more individuals in the panel team and the presenters received questions from the audience at the end of all of the presentations.

Breakout sessions occurred during Day 2 of the workshop. During breakout sessions, attendees identified the factors that cause marsh loss and changes and how these factors impact marsh health. Attendees also identified data gaps in understanding marsh loss and created a revised set of research, monitoring, restoration, and management recommendations for LIS and the region. These recommendations have been summarized into official workshop proceedings and are incorporated into Implementation Actions in the revised version of the LISS Comprehensive Conservation & Management Plan (CCMP). The 2014 workshop proceedings, presentations, agenda, biographies of presenters, attendee contact list, *Sound Update* newsletter highlighting the workshop, and photos from the workshop are posted on the LISS website: http://longislandsoundstudy.net/issues-actions/habitat-quality/2014-lis-twl-wksp/.

Agenda

**Please note that all of the names of those listed under the theme topic contributed to the presentations. Contributors whose names are bolded presented the topic at the workshop. The agenda has been slightly modified since the workshop.*

Day 1-October 22, 2014

Theme- What have we learned since the first Tidal Wetlands Loss Workshop?

8:30 to 9:00 a.m.	**Registration & Light Breakfast** *(Diplomatic Room)*
9:00 to 9:15	**Welcome & Introductions** -- ***Dawn McReynolds (NYSDEC), Mark Tedesco (USEPA LISO)***
9:15 to 9:45	**Submergence - wetland changes since late 1800s** *Panel Team: Scott Warren (Connecticut College), Rich Orson (consultant),* ***Ron Rozsa (CTDEEP, ret.)****, Ralph Tiner (USFWS)*
9:45 to 10:30	**Submergence - The Role of Nitrogen and other Chemical Stressors** *Panel Team:* ***Shimon Anisfeld (Yale FES), Scott Warren (Connecticut College), Cathy Wigand (USEPA AED), Beth Watson (USEPA), Nicole Maher (TNC)***
10:30 to 11:15	**Sudden Vegetation Dieback** *Panel Team: Wade Elmer (CT Agricultural Experiment Station),* ***Roman Zajac (UNH)****,* ***Ron Rozsa (CTDEEP, ret.)****, Shimon Anisfeld (Yale FES)*
11:15 to 12:00	**SLAMM (Sea Level Affecting Marshes Model) Migration Modeling** *Panel Team:* ***Amy Polaczyk (Warren Pinnacle Consulting, Inc.)***
12:00 to 12:45	**Lunch Break** *(Harbor View Room & Coastal Room)*
12:45 to 1:15	**Ecological Indicators of Wetland Change: Wildlife & Plants** *Panel Team:* ***Chris Elphick (UConn)****, Chris Field (UConn),* ***Roman Zajac (UNH)***
1:15 to 1:45	**Expansion of Pannes** *Panel Team:* ***Ron Rozsa (CTDEEP, ret.)****, Beth Watson (USEPA), Cathy Wigand (USEPA AED),* ***Nicole Maher (TNC)***
1:45 to 2:45	**Elevation and Sediment Accumulation-Surface Elevation Tables (SETs)**

	Panel Team: ***Nicole Maher (TNC)****,* ***Ellen K. Hartig (NYC Parks)****,* ***Sarah Fernald (NYSDEC HRRR)****,* ***Shimon Anisfeld (Yale FES)****,* ***Scott Warren (Connecticut College)****,* ***Victoria O'Neill (NYSDEC/NEIWPCC)****,* ***Tristen Tagliaferri (USGS)****,* ***Troy Hill (Yale)***
2:45 to 3:30	**NY Tidal Wetland Trends Analyses & Conditions Assessment** *Panel Team:* ***Will Bowman (Land Use Ecological Svcs, Inc)****,* ***Robert Svadlenka (Cameron Engineering)****,* ***Chris Haight (Natural Areas Conservancy)****, Marit Larson (NYC Parks), Ellen K. Hartig (NYC Parks), Rebecca Swadek (NYC Parks)*
3:30 to 4:00	**Coffee Break** ***(****Diplomatic Room)*
4:00 to 4:45	**Marine Transgression** *Panel Team: Ralph Tiner (USFWS),* ***Shimon Anisfeld (Yale FES)****,* ***Ron Rozsa (CTDEEP, ret.)****,* ***Roman Zajac (UNH)****,* ***Chris Elphick (UConn)****, Chris Field (UConn), Jamie O'Connell (Yale FES), Kate Gehron (Yale)*
4:45 to 5:00	**Next Steps for Tomorrow--** ***Dawn McReynolds (NYSDEC)***
5:00	**End of Day 1**

Day 2-October 23, 2014

Theme- Where do we go from here?

8:00 to 8:30 a.m.	**Light Breakfast** ***(****Diplomatic Room)*
8:30 to 9:00	**Welcome & Introductions--** ***Dawn McReynolds (NYSDEC), Vicky O'Neill (NYSDEC)***

Site Specific: Innovative Planning, Restoration Activities, & Long Term Monitoring

9:00 to 10:00	**Saving our marshes – Spotlight on Jamaica Bay, NY and Narrow River Estuary, RI** *Panel Team:* ***Patti Rafferty (NPS)****,* ***Steve Zahn (NYSDEC)****,* ***Cathy Wigand (USEPA AED)****,* ***Rebecca Swadek (NYC Parks)****, Ellen K. Hartig (NYC Parks)*
10:00 to 11:00	**Barn Island- 60+ years of wetland change** *Panel Team: Scott Warren (Connecticut College),* ***Ron Rozsa (CTDEEP, ret.)****, Chris Elphick (UConn), Chris Field (UConn)*

Breakout Sessions

Individual sessions will last for 30 minutes each with a 5 minute stretch break between the two sessions. Facilitators will review with their groups the causes that were identified from the last workshop. -- Vicky O'Neill (NYSDEC)

11:00 to 12:05 Review the Findings of 2003 Workshop and Identify the Current Issues Impacting Tidal Marshes: For each session make a list of what we know and what still remains to be known (identify data gaps)

Breakout Session 1: What are the causes for marsh loss and change?
In this session the group will review and discuss biological, chemical, physical, and hydrological factors/stressors that impact marsh loss.

Breakout Session 2: How do marshes respond to these factors/stressors?
In this session the group will review and discuss how biological, chemical, physical, and hydrological factors impact marshes.

Breakout Sessions End - Group reconvenes for discussion

12:05 to 12:30 Each group will identify one person to present the results of the group discussion regarding current issues impacting marshes to the entire workshop.

12:30 to 1:15 **Lunch Break** *(Harbor View Room & Coastal Room)*

Breakout Sessions

Individual sessions will last for 18 minutes. Attendees will remain stationary while facilitators and note takers move from group to group to ensure that attendees contribute to all topics. Facilitators will review with their groups the causes that were identified from the last workshop. --Vicky O'Neill (NYSDEC)

1:15 to 2:30 Review the Recommendation from 2003 Workshop and Discuss the Ways Forward: What has been accomplished on this list? What still needs to be accomplished? In light of the presentations, conversations, and the identified issues, let's come to consensus on these lists:

Breakout Session 1: Research Recommendations
Breakout Session 2: Monitoring Recommendations
Breakout Session 3: Restoration Recommendations
Breakout Session 4: Management Recommendation

Breakout Sessions End - Group reconvenes to wrap-up the discussion

2:30 to 3:00 Review Recommendations and Discuss short-term, mid-term, and long-term adaptation Strategies. Each group from the previous breakout session will identify individuals to present their recommendations to the entire workshop.

This is an opportunity for all attendees to express their final thoughts on strategies and recommendations moving forward past the workshop (i.e. identifying funding priorities, creating conceptual plans, initiating a monitoring networks, possible future workshops). This is a chance to prioritize these recommendations and thoughts.

3:00 **End of Day 2---- *Dawn McReynolds (NYSDEC)***

Day 2 Morning Breakout Sessions: Identify the Current Issues Impacting Tidal Marshes

Breakout Session summaries were compiled by Victoria O'Neill using the Day 2-Raw Notes (Appendix B) and audio recordings from the workshop.

Session Moderator & Timekeeper: Victoria O'Neill (NYSDEC/NEIWPCC)
Facilitators: Charlie deQuillfeldt (NYSDEC), Harry Yamalis (CTDEEP), Sarah Deonarine (NYSDEC)
Recorders: Cassie Bauer (NYSDEC), Julie Nace (NYSDEC/NEIWPCC), Kaitlin Willig (Stony Brook University)

Breakout Session 1: What are the Causes of Marsh Loss/Change?

During Breakout Session 1, attendees were asked to create a list of top issues they believe to be causing wetland loss and change in Long Island Sound. The top three stressors identified as causing marsh loss and change were (in no particular order):

- Hydroperiod/hydrologic regime change due to sea level rise (SLR);
- Excessive nutrients (nitrogen); and
- Lack of a natural sediment supply.

Changes in the hydroperiod, hydrologic regime, caused by sea level rise (SLR) was thought to have a major influence on wetland health. Low marsh areas within a marsh complex are thought to be the most susceptible to an increase in hydroperiod, resulting in low marsh converting to tidal flats. As much, more water present, for longer periods of time on the marsh surface is thought to result in a decrease in vegetation and an increase panne formation

Nutrients, specifically nitrogen, was thought to have a big impact on marsh development. Excess nitrogen into a system was thought to come from sewage treatment plants, combined sewer overflows (CSOs), septic system contribution through groundwater, and stormwater runoff (fertilizers). Attendees acknowledged that nitrogen runoff will only increase with the increase in precipitation and storm events caused by climate change. Many suggested that the amount of nitrogen entering a marsh system was embayment specific.

Overall sediment input into a tidal wetland was discussed as a major issue affecting marsh loss and change. Overall, attendees thought that LIS is a sediment starved system where each marsh complex has its own sediment input and output regime. Attendees agreed that years of marsh ditching, damming and channelizing rivers, and altering coastal systems with groins, bulkheads, and tide gates has impacted the sediment budgets within tidal wetlands.

Other stressors noted as minor, but still contributing to wetland loss and change, included groundwater contributions of nutrients, burrowing action of native and invasive crab species (*Sesarma reticulatum*), recreational activities (boat wakes, people walking through marshes),

pathogenic fungus (*Fusarium palustre*), water temperature increases, herbivory (waterfowl), and microalgae (*Ulva*) decomposition.

Overall Discussion on Causes for Marsh Loss and Change
While attendees agreed that hydroperiod, nutrients, and sediment input, and hydroperiod were the top three stressors impacting wetlands, those in attendance qualified the statement by stating that all possible factors must be considered in order to make a true determination of causes for marsh loss and change. Several stressors may have a compounded effect on wetlands and can be synergistic. One breakout group noted that while crab burrowing or herbivory may not be a factor in marsh loss on a healthy marsh, it may be an issue on a marsh already stressed by other factors.

Attendees also noted that there was no "one-size-fits-all" or "smoking gun" answer to the cause of wetland loss and change that could be extrapolated to all tidal wetland systems. It was noted that each wetland complex must be analyzed independently of others in order to determine the true cause for loss and change in that particular system. Attendees also discussed how important it was to keep in mind that tidal wetland complexes will differ in sediment budget, freshwater input, and nitrogen input across the Sound.

Breakout Session 2: How do Marshes Respond to these Factors/Stressors?

During Breakout Session 2, attendees were asked to create a list of the top tidal wetland responses to the identified stressors causing marsh loss and change in Long Island Sound. The top three responses (in no particular order):

- Changes in vegetation;
- Changes in plant health; and
- Marshes getting wetter/panne formation.

All sessions acknowledged that the stressors noted in the previous session, in particular, the top three: hydroperiod, nitrogen, and sediment) all have a dramatic effect on vegetation loss and change. Most noted changes occur in a vegetation/marsh zone shift as marshes migrate inland with SLR. The most notable vegetation shift is high marsh converting to low marsh and low marsh converting to mud flat.

Change in plant health was a major concern for participants in all sessions. Excess nitrogen in a marsh system results in an increase in above ground growth and decrease in below-ground growth, root structure and morphology, resulting in a decrease in the stability of the marsh structure. Nitrogen and SLR may change decomposition rates and microbial levels in marsh soil. It was discussed that warmer and wetter conditions in a marsh may result in an increase in decomposition. All of these changes in marsh health will result in a decrease in ecosystem services.

All sessions agreed that marshes were getting wetter due to SLR and greater hydroperiod. This increase in water in the marsh system seemed to be causing more water on the marsh, resulting in a decrease in vegetation and increase in panne formation. Attendees described the marshes they work on as having a "Swiss cheese," "holey," or "waffle with syrup" look to them. Many in attendance thought their marshes exhibited an increase in hummocks of marsh vegetation. Many wondered if pannes are indicative of marsh loss or are ecologically sustainable, leading to the following questions. What are the ecological impacts of pannes on birds, fish, and invertebrates? How extensive were pannes prior to mosquito ditching and other stressors? Should the greater wetland research and management community be concerned? Also, loss of vegetation and expansion, due to hydroperiod or erosion, was noticed along marsh edges, in particular along creeks and ditches.

Other tidal wetland responses noted as a result of factors identified in the previous session included impact on marsh dependent wildlife, such as the saltmarsh sparrow (*Ammodramus caudacutus)*.

Overall Discussion on How Marshes Respond to the Factors that Cause Marsh Loss and Change
Attendees agreed that a major impact on tidal wetlands was the vegetation regime shift. Most thought that high marsh was converting to low marsh at a slow rate and that low marsh was converting to mudflat at a fast rate. Many believed that early signs for marsh loss can be seen in the marsh edges (i.e., upper border, creek banks, and ditches) and at the pannes. Pannes were heavily discussed in all sessions and it was agreed that there is a lack of information regarding the impact of panne formation on vegetation, soils, and wildlife. Also, many believed that not much is understood of the relationship between wetland loss patterns and land use patterns.

Day 2 Afternoon Breakout Sessions: Discuss the Ways Forward

Breakout Session summaries were compiled by Victoria O'Neill using the Day 2-Raw Notes (Appendix B) and audio recordings from the workshop.

Session Moderator & Timekeeper: Victoria O'Neill (NYSDEC/NEIWPCC)

Breakout Session 1: Research Recommendations
Facilitator: Charlie deQuillfeldt (NYSDEC)
Recorder: Cassie Bauer (NYSDEC)

Breakout Session 2: Monitoring Recommendations
Facilitator: Harry Yamalis (CTDEEP)
Recorder: Julie Nace (NYSDEC/NEIWPCC)

Breakout Session 3: Restoration Recommendations
Facilitator: Sarah Deonarine (NYSDEC)
Recorder: Kaitlin Willig (Stony Brook University)

Breakout Session 4: Management Recommendations
Facilitator: Alison Branco (Suffolk County)
Recorder: Amy Mandelbaum (LISS/NY Sea Grant)

During the afternoon Breakout Sessions, attendees were asked to discuss recommendations for research, monitoring, restoration, and management that will enhance our understanding of tidal wetland loss and change in Long Island Sound. The top responses from all the groups are provided for each recommendation category:

Breakout Session 1: Research Recommendations

The top three research recommendations from Breakout Session 1 were (in no particular order):

- Create a conceptual model for tidal wetland systems;
- Conduct manipulative experiments on tidal wetlands; and
- Study the known factors impacting tidal wetlands.

Every group recommended the creation of a conceptual model, or a diagnostic matrix, that would include several factors influencing marsh growth and loss. Possible factors to contain in the model include accretion rates, sediment availability, SLR, nutrient levels (nitrogen), groundwater input, surface water hydrology, LiDAR, and tidal wetland size. Some groups discussed that following a conceptual model, a dynamic model should also be created. All of these tools will allow practitioners to classify and analyze how different marshes (e.g., size, geography) respond in different ways to the various factors influencing marsh growth and loss. Perhaps these models could create a list of priority sites to study further, protect, and restore.

Conducting manipulative experiments on tidal wetlands was a major recommendation from the groups. Many thought that there were not enough manipulative experiments happening in our area and that our understanding of marsh loss and change will not be sufficient on observation monitoring alone. Some thought that the creation of the conceptual model will help determine which manipulative experiments should be conducted. Experiments could focus on stressor response relationships, soil chemistry, impacts of mosquito ditching, and applying different thresholds of factors. These experiments could help determine spatial variability and identify places and situations that are fragile and experience loss. All of these experiments will need to be permitted so it is essential to include regulators in these discussions. Many questioned where the funding will come from for these experiments.

All groups agreed that more research must be conducted on the known factors impacting marsh loss. The primary stressors that need to be studied in more detail include nutrients (nitrogen), groundwater inputs, bulkheads and hardened shorelines, processes controlling production, and decomposition in below ground biomass, surface water hydrology, and sediment input. Many agreed that there are too many data gaps and questions regarding these factors and that more research is needed to fully understand their impact on marsh loss and change. Others discussed the need to determine the value of pannes and if panne formation, or marshes with "waffling," "Swiss cheese" look, is a true indicator of marsh loss.

Other Recommendations for Research:
Aside from the top three recommendations listed above, groups identified several other recommendations including creating a pre-storm protocol to address the impacts of storms on tidal wetlands (metrics to be collected before, during, and after storm events to determine the impacts), creation of long term research projects around the LIS (50 years or more), and have LISS create the basis for long-term research project grant.

Breakout Session 2: Monitoring Recommendations

The top three monitoring recommendations from Breakout Session 2 were (in no particular order):

- Creation of a central database/repository/clearinghouse for tidal wetland information;
- Organize a regional marsh monitoring framework; and
- Create standard marsh monitoring protocols/metrics.

All of the groups discussed the need for a regional marsh monitoring framework/network and the creation of centralized database/repository/clearinghouse for tidal wetland information. The network and clearinghouse could serve as a way for wetland practitioners to disseminate information and communicate to different user groups. The clearinghouse could hold contact information for those working on tidal wetland issues, research articles for reference, modules for different data, monitoring protocols, funding opportunities, and information on successful projects. One group thought there should be a separate network and database, or perhaps sub-network and database, to the regional marsh monitoring framework for Surface Elevation Table

(SET) practitioners that could serve to identify data gaps, areas needed for new SETs, and track current regional SET data. Some questioned where the proposed clearinghouse should be housed and many suggested LISS, National Parks Service, or United States Fish & Wildlife Service (USFWS) websites.

Aside from the creation of a framework/network and clearinghouse, group conversation focused on standardizing marsh monitoring protocols throughout the region. Attendees acknowledged that this is a difficult goal to achieve, but the benefit to standardized protocols was needed in order to compare and combine data, which is not possible using a variety of units, timelines, and measures. Many suggested adaptive management based monitoring and monitoring that focuses on a few core metrics. Others suggested identifying tidal wetland reference sites, something that could be accomplished through the creation of a small, select committee, which could be monitored long term. Monitoring could focus on comparing restored sites to natural/reference sites. Others emphasized the need for a standard rapid assessment of mash loss and overall marsh health/condition. Many mentioned the need for panne monitoring to understand the ecological role of pannes and panne development.

Other Recommendations for Monitoring:
Aside from the top three recommendations listed above, groups identified several other recommendations including monitoring focused on marine transgression and long-term marsh migration (e.g., migrating into lawns), trends analysis, and creating low impact marsh monitoring techniques, such as limited sampling and more photography. Others suggested changing the LIS Futures Fund grant to include funding for monitoring past projects and new projects.

Breakout Session 3: Restoration Recommendations
The top three restoration recommendations from Breakout Session 3 were (in no particular order):

- Create standard pre- and post- restoration tidal wetland monitoring protocols/metrics;
- Reuse sediment for tidal wetland restoration efforts; and
- Permit and implement new hybrid shoreline/living shoreline projects.

All groups discussed the need for proper pre- and post- restoration monitoring protocols. First, there is a need for funding the monitoring efforts. Many thought that practitioners should not start a restoration project if there is no funding in place for monitoring. Practitioners need to quickly assess and diagnose marsh loss in their system prior to restoration. Also, these pre-restoration monitoring protocols could assess marsh health/quality, which could determine where to focus restoration efforts, such as marshes with pannes. This will help determine the essential factors to monitor. Second, monitoring protocols and metrics should be similar across sites so that results can be comparable and the approach can be improved if needed. A better way is needed to determine if a restoration project is a success or a failure. This will help inform future restoration efforts. Many also thought it might be possible to link up with graduate students to help create these monitoring protocols and conduct monitoring efforts.

All of the groups discussed the issues of sediment and how to best use it in restoration efforts. Many discussed the beneficial reuse of dredge materials for tidal wetland restoration. As long as sediment is not contaminated, many thought that dredging projects should be coordinated with restoration efforts. Dredging removes sediment from an already sediment starved system and efforts should be made to keep the dredge material in the sediment transport system through restoration. Others discussed the benefits of using dredge material for thin layer deposition/spraying. Discussion focused on the need to increase the height of marsh in light of SLR and that future restoration efforts should target higher elevations. The discussion of thin layer deposition advised those thinking about conducting this practice to learn about where sediment is going in a system and where is coming from before they implement the project. Also, practitioners need to properly time their thin layer spraying, specifically in understanding the seasonality of below ground activity, perhaps using a sulfide loggers. Beneficial reuse criteria should be developed to guide practitioners.

Innovative restoration efforts were a major topic of discussion among the groups. Many focused on the benefits of hybrid/living shorelines for protection and providing a stop gap in reducing wetland loss. While some living shorelines could be a mitigating technique, others could be a true restorative effort. Incorporating oyster reefs and/or reef balls with planting could provide several benefits including sediment build-up behind the structure to encourage marsh development, creation of 3-D structure to attract fish and invertebrates, and provide an effective wave break to storms and boat wakes. Along with the incorporation of hybrid/living shorelines in restoration efforts, many discussed the issues with obtaining permits. Many want to make sure that the permitting process for hybrid/living shoreline and tidal wetland restoration projects in general are more user friendly.

Other Recommendations for Restoration:
Aside from the top three recommendations listed above, groups identified several other recommendations including the removal of culverts, hardened barriers, and upstream dams to restore hydrology to wetlands, including volunteers and graduate students in restoration efforts, determining target restoration projects for Long Island Sound using predetermined marsh health/condition assessments, and developing *Fusarium*-resistant *Spartina alterniflora*. Most groups discussed the need for a centralized database, possibly hosted by LISS, that could house systematic lists of LIS restoration projects and explanations for their success and failures, serve as a site to connect graduate students to various projects, serve to coordinate between states, towns, agencies, and universities about restoration efforts, and provide references to those that need it.

Breakout Session 4: Management Recommendations
The top three management recommendations from Breakout Session 4 were (in no particular order):

- Improve communication among public and experts;
- Increase funding opportunities for tidal wetland work; and

- Creation of a central database/repository/clearinghouse for tidal wetland information.

A common recommendation among all groups was to improve communication. The improvement in communication focused on communication between tidal marsh experts and the public and between the experts themselves. Groups discussed the need to educate the public and build public support for tidal wetlands and coastal systems. Some ways to do this might be including the public in wetland plantings with help from LISS, invest in outreach and communications efforts, and create focus groups and task forces on marshes. The message relayed to the public should focus on why marshes are important, such as flood control and wildlife, and habitat, and tie it to the economic benefit of marshes. However, it is important that while delivering this message, practitioners should be careful not to overpromise marsh benefits, but rather make a connection between healthy shorelines and healthy communities. Some suggested partnering with the Connecticut Institute for Resilience & Climate Adaptation (CIRCA) to work with a professional marketing outreach team and create a report card for habitat quality and quantity. Communication also needs to improve among the experts working on tidal wetlands, specifically, an increase in communication between New York and Connecticut, between researchers, and between researchers and land managers, town planners, and regulators.

Increasing the funding opportunities for tidal wetland work was a major recommendation among all of the groups. Groups felt that funding for tidal wetland restoration should be tied to monitoring or made a requirement. Many thought that a stable source of funding should be identified and funding organizations should get together and identify five major goals for funding. Ultimately, funding should be connected to the most needed areas.

Most groups discussed the need for a centralized database to serve as a repository for scientific information, such as literature and current research, host a dialogue among experts, possibly through blogs, compile research questions that managers need, integrate marsh management, connect researchers to management needs, and include links to data. Some thought to revisit the LIS Resource Center, house the database on the LISS website, and create a biennial LIS Conference to share information from around the Sound.

Other Recommendations for Management:
Aside from the top three recommendations listed above, groups identified several other recommendations including developing better guidelines for wetland migration, reviewing land preservation policies, including upland areas, in respect to marsh migration, and streamlining permitting among all levels of government and realigning them with research, with particular emphasis on climate change adaptation and resiliency. Other recommendations included involving the regulatory agencies in the development of restoration projects to help with future permitting and rethinking the scale of restoration by focusing on more expansive, large scale restoration projects.

Next Steps

Based on workshop attendee survey results (Appendix A), it is recommended that another, in-person Long Island Sound Tidal Wetlands Loss Workshop be conducted within five years of the 2014 workshop. Many attendees appreciated the short, informative presentation format, the time for networking, and the breakout sessions. Many felt that at the next meeting more time should be given to the breakout sessions and overall discussion.

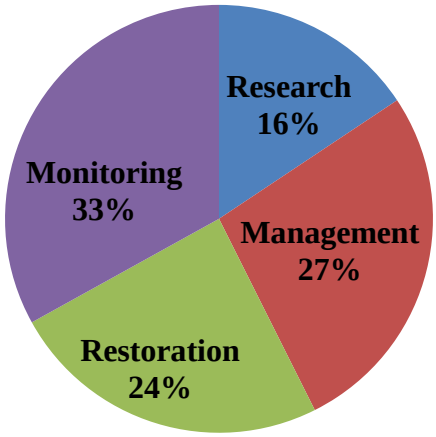
Appendix A

Workshop Attendee Details

A total of 62 people attended the workshop. During registration, attendees were asked the following questions regarding their work and experience:

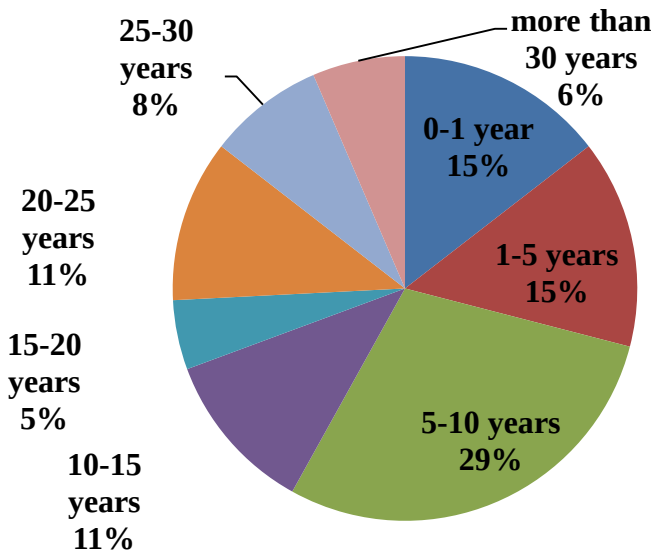
1. What is your area of tidal wetland expertise?

- 33% indicated that their area of tidal wetland expertise includes monitoring;
- 27% indicated that their area of tidal wetland expertise includes management;
- 24% indicated that their area of tidal wetland expertise includes restoration; and
- 16% indicated that their area of tidal wetland expertise includes research.



2. How long have you been working on tidal wetland related issues?

- 15% indicated that they have been working on tidal wetland issues for 0-1 year;
- 15% indicated that they have been working on tidal wetland issues for 1-5 years;
- 29% indicated that they have been working on tidal wetland issues for 5-10 years;
- 11% indicated that they have been working on tidal wetland issues for 10-15 years;
- 5% indicated that they have been working on tidal wetland issues for 15-20 years;
- 11% indicated that they have been working on tidal wetland issues for 20-25 years;
- 8% indicated that they have been working on tidal wetland issues for 25-30 years; and
- 6% indicated that they have been working on tidal wetland issues for more than 30 years.



Attendee Workshop Evaluation Form Results

Attendees were asked to complete a two page survey after the workshop to gather information regarding their thoughts and opinions of the event. The survey consisted of statements (#1-8) that required attendees to rank their answer numerically. Attendees were asked to agree with the statements on a scale of 1-5, with 1 as 'Strongly Disagree' to 5 as 'Strongly Agree,' or Not Applicable (N/A). Figure 2 summarizes the total number of attendee responses and average response to these statements.

Agreement with statement (on a scale of 1-5, with 1 as 'Strongly Disagree' and 5 as 'Strongly Agree')	Total Responses (n)	Mean
1. The workshop was well organized.	39	4.49
2. The workshop sessions went smoothly.	39	4.62
3. There was enough time for questions and answers.	39	3.92
4. The presenters were well prepared.	39	4.46
5. The breakout sessions were productive.	32	4.28
6. I can use ideas and concepts from the workshop in my tidal wetlands work.	38	4.47

7. The workshop increased my knowledge of tidal wetland loss in Long Island Sound and the region.	39	4.67
8. The workshop met my expectations.	39	4.56

The survey also asked attendees open ended questions (#9-15) to elicit unique responses regarding workshop content and logistics. The following summarizes the top answers for these questions.

9. What were the best aspects of the workshop?
- Short, informative presentations (n=14);
- Networking (n=6);
- Very well run/ well organized (n=5);
- Breakout sessions (n= 5); and
- Helped me identify the need to better monitor and report results of ongoing projects (n=1).

10. How can the workshop be improved?
- More time (n= 13);
- It seemed to go well/ no negative feedback (n=4);
- Increased frequency of event (n=3);
- Add a field trip (n=2);
- Add more interaction opportunity interspersed with presentations (n=1);
- Addition of topics such as anthropogenic effects/structures, dredging, fishing/shellfishing (n=1);
- More diverse speakers- perhaps a few from outside the LIS area (n=1);
- Some of the presentations were very anecdotal. Would be great to have had those presenters provide data to support conjecture/observations (n=1);
- Workshop should be broken down based on region (n=1);
- Would like to hear more about wide scale restoration in Jamaica Bay (n=1); and
- As a presenter, I felt like the way the sessions were organized was 100% confusing (n=1).

11. What did you think of the venue (Danfords Hotel and Marina) and the food served?
- Excellent (n=33); and
- Fine (n=2).

12. When do you think we should have another Long Island Sound Tidal Wetlands Loss Workshop?
- 93% of attendees responding to this question said “5 or less years” (n=27, out of n=29).

13. What suggestions do you have for the next workshop?

- Results/examples of restoration projects (n=5);
- Workshop should be broken down based on region (n=2);
- More targeted questions from facilitators in the discussions (n=2);
- Additional time (n=2);
- Arrange seats in a circle to allow for more interaction (n=1);
- Include a field trip (n=1); and
- Develop a conceptual model beforehand and structure the workshop around filling in details of that model and identifying where new knowledge is needed (n=1).

14. Would you like the next workshop to be done through an online format (e.g., webinars) or in person?

- 71% of attendees responding to this question said "in person" (n=22, out of n=31).

15. Do you have any other comments or suggestions for the workshop organizers?

- Great workshop! (n=13);
- Need to have a bigger screen or have presenters simplify their slides (=1); and
- Focus on practical, on-the-ground projects and their successes and failures. What policies/ways of doing things have changed as a result of research/management? (n=1).

Planning Team Event Evaluation

After the event, the workshop planning team (Victoria O'Neill (LISS/NYSDEC/NEIWPCC), Amy Mandelbaum (LISS/NY Sea Grant), Ron Rozsa (CTDEEP, ret.), and Judy Preston (LISS/CT Sea Grant)) convened to discuss and highlight the successes of the workshop and areas of improvement for future workshops. The following lists these highlighted areas that were discussed by the team:

Areas of Success

- Planning Team work ethic;
- Day before and day of volunteers;
- Day of "To Do Lists" for volunteers and speakers;
- Workshop binders; and
- Workshop surveys.

Areas for Improvement

- House funds within another entity;
- To expedite spending funds, notify presenters and attendees sooner;
- Need a larger planning team;
- Identify an easier website registration system; and
- Allow for more discussion time for participants during breakout sessions.

Appendix B

Day 1: Raw Notes

The notes from Day 1 were transcribed by volunteer Kaitlin Willig (Stony Brook University graduate student).

- Welcome- Dawn McReynolds
    - Widespread loss of wetlands despite cessation of filling
    - Trends of wetland loss increasing in acreage
        - More loss west to east
    - Suspect the following causes of wetland loss
        - Sediment loss
        - Climate change
        - Nutrient
        - Hydrologic modifications
    - Wetlands in storm resiliency capacity has increased in focus since Superstorm Sandy
    - Goals for today
        - Bring together stakeholders to talk about wetland loss
    - At the end of tomorrow, breakout groups will be formed to update statements from 2003 tidal wetland loss workshop about wetland loss
- Welcome- Mark Tedesco
    - Challenge everyone to make sure that this workshop results in a clear set of recommendations and a clear summary of where we are now in terms of wetland loss/management
    - 2003 workshop directed resources toward the recommendations within the plan
    - this workshop is a good opportunity to make sure we incorporate the recommendations directly into the LISS management plan being worked on right now
    - Want to assess where we are now and where we want to be in the future
- **Submergence-** 2 panel discussions with one QA period
    - Ron Rozsa
        - Submergence- multi-decadal conversion of tall *S. alterniflora* in the low marsh zone to mudflats
        - Submergence seems to be localized to western LIS
        - Pattern of submergence in the middle of an estuary
            - health at the mouth but extensive loss in the middle
            - seen in five mile river and in other areas
        - Trend analysis
            - No change in high marsh acreage
            - decrease in low marsh corresponding with tidal flat increases
            - Percent loss varies from site to site
        - Long term conversion of low marsh to mud flat
        - Habitat shift- not a die back (because die backs happen more rapidly)

- Scott Warren
  - 2 experimental studies addressing the question of nitrogen loading *to* salt marshes (rather than to the adjacent waters)
  - conclusion-
    - high marsh was not really affected by nitrogen addition
    - chronic nitrogen loading did have some ecosystem level consequences- creek bank started "falling apart"
      - calving (slumping) of peat was accelerated with addition of nitrogen
      - early slumping by creak bank *S. alterniflora* (started about 1.5 months before expected)
        - more slumping than control creeks
      - these consequences were measurable and statistically significant
    - Added NO3 is the ultimate cause but what is the proximal cause?
      - Below ground biomass depressed in fertilized marshes
      - Root:shoot ratios depressed in fertilized marshes
      - Increase soil water content
      - All three suggest weakened soil structure
  - What's the big deal?
    - Intertidal area is most linked to the rest of the subtidal estuary and the coastal ocean
    - Loss of ecological function and services as a result
    - Also negatively affects fish stocks
- Shimon Anisfeld- Anisfeld Lab Marsh Nitrogen Studies
  - 1. Fertilization Study
    - N fertilized plots had larger aboveground production but identical belowground production
    - Higher respiration in N-fertilized plots
      - Suggests that carbon in peat would be decreased
      - Difference is not huge and not necessarily consistent
    - No net elevation change with N-fertilization
  - 2. Cross-site comparison- Troy Hill
    - Looked at 12 sites from 1974-2010 using coring, aerial photos, field samples, etc.
    - more NO3 → more vegetation loss
    - hypothesis: marsh loss may actually lead to higher NO3 because the marsh can take up less
    - most loss occurred from 1974-1995
    - used dated sediment cores and their C:N ratios in the 1970's- using these C:N ratios and 1974-1995 marsh loss, the earlier trend completely disappears
  - 3. Is nutrient enrichment a marsh stressor?- Cathy Wigand

- In south east U.S. coast, with minerogenic sediments, there have been observations of an increase in belowground marsh growth with N-fertilizations
- In Jamaica Bay-
    - Higher density of roots and rhizomes at higher elevations→ doing better
        - Smaller rhizomes
    - Lower densities of roots and rhizomes with fatter rhizomes→ doing worse
- Sulfides found in lower elevations can act to inhibit salt marsh growth (sulfides are toxic to the plants)
- Nutrient load effects are controlled by soil type, elevation (amounts of inundation), and likely other factors as well
- Found that root/rhizome density seems to relate to high nitrogen and poorer marsh conditions

- Q&A for Submergence Panels
    - For Scott- Did you see removal % of N change over time?
        - Budgeting was really done during the first 4 years so they don't know if there have been any trends. They have the samples but have not done the analysis
    - For Shimon- how might site-specific characteristics Cathy spoke about have affected the fertilization study done?
        - Study was done on the low marsh a few meters from the creek bank
        - ~20% inundation duration
        - large areas in low marsh that are converting to mudflats are the main focus of concern
    - In regards to plum island and the fish populations crashing- did you control for bird populations or foraging changes in birds
        - there have been some bird studies and they have not seen any correlation
        - I don't think you can attribute it to birds but maybe other predatory fish species- but doesn't seem likely
    - For Cathy- one thing that seems to be missing is that all of the time series generally start when the sewage treatment plants were put in. There seems to be issues with the creek beds from before sewage treatment plants due to raw sewage and dead horse bay, etc. Sewage treatment plants probably resulted in *lower* nitrate concentrations. Has anyone looked at the large very biologic nitrogen inputs from before the STPs?
        - We did look at dated cores. Results show that since the 1850's there was an increase in percent nitrogen that seemed to correlate with increased population.
        - It seems that since the 1850s there was an increase in nitrogen but that the marshes only started decreasing recently
        - Thought is that there was a tipping point where soil became largely organic rich and sulfides increased and then marsh health decreased

- Did you look at groundwater contribution in terms of flow or nutrient concentrations
  - No we didn't. On the Connecticut coast, SGD is likely minimal due to geology. Not sure about LI coast
  - On LI they did not measure it directly but they are modeling watersheds and may be including SGD in those models

- **Sudden Vegetation Dieback**
  - Ron Rozsa-Sudden Vegetation Dieback-
    - Sudden saltmarsh dieback- progressive decline that begins with thinning and browning of the above-ground material and leads to plant death over a period of *months*
    - The earliest occurrence was in 1995 in Florida
    - Have occurred all along the Eastern coast and along the gulf coast
    - In Louisiana, winds can keep water levels similar to low tides for weeks on end, leading to aeration to peat which can cause diebacks
    - Pathogens
      - LA pathologist reports showed *Fusarium* pathogen that could lead to leaf spotting and stem rot but they did not cause mortality in isolation
      - Found high levels of *Fusarium* in Sudden Vegetation Dieback (SVD) areas locally
  - Roman Zajac- vegetation loss due to *Sesarma* herbivory
    - Quick onset suggests threshold events
    - More patches of areas that have been grazed down- small remnant patches of s. patens
    - *Sesarma* grazing has been mapped out over time into the high marsh areas where *S. alterniflora* is present
    - In terms of activity patterns, the peak of activity is in June/July, and they are active from early summer to early fall
    - There is significant loss of vegetation due to *Sesarma* grazing
  - Shimon Anisfeld Lab *Sesarma* Studies
    - Trying to distinguish between herbivory and submergence
    - Interested in developing a soil signature
    - Are they different in terms of restoration/revegetation
    - *Sesarma* changes elevations of vegetated, transition, and unvegetated zones. When sesarma are active, transition and even some unvegetated areas are at low levels of inundation whereas a non-*Sesarma* affected area has higher levels of inundation correlating with lower levels of vegetation
    - Soil differences:
      - *Sesarma* burrows affect soil composition (reduced mineral content) and leave a bizarre pattern you can identify visually
      - Submergent areas- high bulk density but low shear strength
      - *Sesarma* site- high redox potential due to the burrows
      - More concerned about soil characteristics in terms of re-vegetation for submergent zones

        - Conclusions from Wade Elmer
            - Suggests that *Sesarma* prefers diseased, drought suffering plants
- Q&A for Dieback Session
    - Have you looked at role that N-loading and N-content in *S. alterniflora* tissue has on the predation rates? I think this is one of the confounding factors looking at predation rates
        - Have looked at Differential predation on patens vs. *S. alterniflora* (*Sesarma* prefer *S. alterniflora*) but not sure if this has anything to do with nitrogen content in the plant
        - We haven't looked at this but we probably should start thinking about it
    - Is there anything to note about the scale of loss from *Sesarma*? Any thoughts on the relationship between predators of *Sesarma*?
        - May be something about soil without plants that is attractive to plants
        - In some of our analyses, if you account for the regular un-vegetated area, the losses can be anywhere from 1-4 meters in areas that look to be consistent with *Sesarma* herbivory
        - Not as concerned about *Sesarma* activity as about other methods of losses because it is more of a limited, local effect
    - For Ron- Are diebacks associated with 18.5 year lunar tidal signal?
        - Will be discussed later on and is actually associated with the eroded marsh edge not diebacks.
- **SLAMM-** Amy Polaczyk
    - Goal- to present map based/numerical projections of what the potential effects of sea level rise may be in the marshes
    - Used extensive accretion feedbacks, and incorporated a stochastic uncertainty analysis
    - Has modest data requirements
    - Can be applied to many sites at a reasonable cost
    - SLAMM using tidal range to identify elevation ranges
    - Developed seamless SLAMM results for all of LIS
    - Key inputs to the model are elevation, erosion, and accretion data. Most important for getting accurate results
    - Elevation data- LIDAR
    - Erosion rates- site specific data was shared with them to feed into the model
        - Model is not too sensitive to erosion. Definitely more sensitive to accretion
    - Tidal Marsh Accretion
        - Investigated feedback relationships.
        - Found accretion measurements throughout the CT coast in each of the study areas but they were generally for high marsh areas, not lower marsh areas.
        - Did not find a clear feedback accretion to elevation relationship.
        - Used different values for low and high marsh areas
        - Used NY data to help inform accretion curves
    - Summary of Deterministic Results

        - The main marsh type- high marsh- is really in peril from any sea level rise scenario.
        - Minimum loss is 50% from these projections
        - Low marsh is increasing during this time
        - There is also an increase of transitional marsh
        - There is still a general loss of habitat richness and a loss of high marsh
    - Both high and low marsh convert to open water more rapidly in the eastern portion of the study area where lower tide ranges place this habitat at greater risk
    - Uncertainty maps are a good way of showing the likelihood of marsh's existence under sea level rise conditions
    - Model limitations
        - Not a hydrodynamic model
            - No feedback between hydrodynamics and ecology
        - Anthropogenic changes are not included
            - Shoreline armoring, nitrogen loading
        - Large storm events are generally undercounted
        - There are also some data limitations, accretion data being a notable one
    - Findings
        - NY: uncertainty analysis suggests uncertainty in sea level rise is more important than other model and data uncertainties
        - Effects of sea level rise vary across the study area
    - Model outputs will be available to the public in ESRI, QGIS, MapWindow
    - Where could marshes migrate?
        - Additional GIS analyses using these tools would help tease this out
- Q&A for SLAMM presentation
    - When will the GIS layers be available?
        - By the end of the year
    - Concerns with elevation data- is it a true bare-earth elevation or is it based on vegetation cover
        - At this time, all of the simulations are run so using true bare-earth elevations would need to be incorporated in future projects but not this one.
        - Accretion is one of the weak spots. We tried to account for this in the uncertainty analysis both in terms of elevation and actual accretion rate
    - Have you been able to reconstruct past marsh loss in LIS because it seems to have different implications?
        - The only driving factor in this model is sea level rise for marsh loss so there are a number of other factors that are not included. This is a limitation that would inhibit its use to explain previous cases of marsh loss
        - Looks like accretion rates are approximately equal to sea level rise so that is probably not the cause of these previous marsh losses.
    - Comment- An important point is that the difference in tidal ranges is one of the driving factors for marsh loss patterns due to sea level rise in the future (more marsh loss in the eastern LIS) which is opposite of what we have previously seen for LIS

        - Presenters confirmed
    - Marsh migration pathways would be really helpful as an end product. Is it going to be?
        - It is out of the scope of the work at the moment but the results of the report will allow others to do this in the future
    - The outputs for inundation and migration. Will there be outputs that will be available to use in conjunction with other studies to analyze?
        - This project tried to generate all the projection rasters. The spatial analysis of these results is not part of the scope but people will be able to do this with the products of this report
        - Yes, the data are there but the scope of this project would not include it.
    - How is this model different or similar to Mark Hoover's model?
        - These findings are very in-line with Hoover's study and maybe a little bit more refined due to more refined data inputs.
        - This model includes land cover aspects that hoover does not necessarily include.
- **Ecological Indicators of Wetland Change**
    - Roman Zajak
        - Assessment of long term marshland changes using image analysis
        - From 1934-2010 significant loss of s. patens
            - Patch structure has changed quite a bit
            - How have the biota been affected by this?
        - Front marsh erosion
            - causes probably have to do with geomorphology of the system
        - habitat expansion by *Uca pugnax*- have expanded to high marsh areas and are no longer limited to low marsh areas- variable with sites but still happening in many sites at least on the north LIS coast
        - *Melampus bidentatus* responses to marsh change
            - populations that occur in areas with higher flooding/inundation have lower population sizes and get wiped out via predation
            - habitat effect on number of eggs per egg case
    - Chris Elphick- Sentinels of Climate Change- used many different marsh sites and compared
        - *Juncus* has generally decreased in # of occurrences in the past 10 years
        - *S. alterniflora* has generally increased in # of occurrences in the past 10 years
        - *S. patens* does not show change in occurrence but the abundances declined
        - *Distichlis* is more complicated
        - Saltmarsh sparrow
            - think they will go extinct within the next 4-5 decades
            - nesting data shows that all three birds shown have declined in population
            - all salt marsh specialist species are declining- seem to be region-wide
- Q&A- Ecological Indicators of Wetland Change

  - Why do you think it first increases and then decreases?
    - Due to cycling within tides that makes them generally more favorable within the first 20 years and then definitely not after that

- **Expansion of Pannes**
  - Ron Rozsa
    - More focused on open water panne habitat
    - Very little pre-ditching data
    - Post-1984 no maintenance ditching
    - Increased panning from 1974-2014
    - Pannes provide ecological services for invertebrates & water fowl
  - Roman Zajack
    - Increase in number of pannes
    - Marsh is showing more and more bare areas when analyzing low-level areal imagery in comparison with vegetated areas or pannes
  - Beth Watson
    - With high nutrient loading, pannes and ponds can be highly sulfidic and not amenable to wildlife
    - Marsh vegetation loss as a function of tidal height→ very strong relationship. Seems to show SLR as a main driver in this area for marsh loss
  - Nicole Maher
    - What to do about pannes?
    - Different for different marshes
- Q&A- Expansion of Pannes
  - What are the deciding factors for when pannes are good or bad?
    - It depends what our goals are
    - There is no good answer at this point- we need to discuss it more tomorrow
    - restoration is not necessarily filling in pannes- could be cutting drainage spurs or other options not yet discussed
    - there is some precedence to go back to historical conditions
  - Relating this question of expansion of pannes with the sea level rise issue. Would it be worth it to sacrifice some ponds to get ahead of sea level rise?
    - No answer
- **Elevation and Sediment Accumulation- Surface Elevation Tables (SETs)**
  - Nicole Maher
    - Oldest of stations are only 6 years old
    - Measuring elevation in multiple ways at multiple stations across LI
    - Accretion and elevation changes are variable between marshes
  - Ellen Hartig
    - 6 SETs across Boroughs of NYC
    - Sandy led to an abrupt change in marsh elevation
    - Superstorm Sandy definitely added to the elevation but we are still having trouble keeping pace with SLR
    - Looking at extending marsh out waterward.

- Victoria O'Neill
  - Showed flax pond and how the inlet was closing- 25% marsh loss
  - Set up SETs across LI on North coast of LI
  - All sites installed in 2008. Not monitored until 2012
  - Began to monitor them in 2012 and then there was another gap
  - They are now being monitoring them consistently for the past few seasons
- Tristen Tagliaferri
  - USGS monitors tidal elevation, wind speed/direction and some other parameters at 4 sites on LI
  - USGS sampling stations allow study of the effect of storm events on these sites
  - Publish results annually
- Shimon Anisfeld
  - Working at 3 sites in CT
  - How are marsh surface elevations changing in CT marshes that are experiencing different conditions?
  - Submergence vs restoration? Two sites with the approximately the same amount of water but one is a problem and one is not
    - Restoration site is actually being restored- shows increased rates of accretion
  - Different elevation measurement methods capture different methods of elevation change
  - measuring organic content can also be a useful measurement to include
    - high organic matter content could be a sign of marsh drowning
  - measurements in Quinnipiac river- all sites seem to be doing relatively well in terms of keeping up with SLR- this is a puzzle because it is in an area we consider submerging
- Scott Warren
  - Looked at 3 sites in CT
  - Marshes are not keeping up
  - S. patens is losing out to *S. alterniflora*
  - % of time spend inundated is increasing
  - 1994-2006 accretion rate was ~3 mm/year at one site
  - seems like accretion may be keeping up with sea level rise (if not exceeding it by a bit) if you take a 20 year average
- Sarah Fernald
  - Looked at the Hudson river
  - North and South Tivoli bays- study area
  - Contrary Ellen's data, these sites showed a decrease in surface elevation after Sandy- likely due to compaction from surge
  - South Tivoli bay- not seeing as much accretion as expected
- Troy Hill
  - 12 sites in CT, NY along north shore of LIS
  - accretion rates have accelerated over time and at this point are exceeding SLR

        - elevation of marsh relative to sea level has decreased leading to increased flooding of the marsh but has leveled out more recently
        - organic relationship between accumulation and accretion is quite strong and quite stable
            - for every unit of accumulation of additional organic material there is a large change in accretion
            - for the latter part of the century ('56-2011) mineral accumulation is not as important in affecting accretion
            - seems to show that there is ample mineral material for the salt marshes
                - could be due to marsh cannibalization
- Q&A- Elevation and Sediment Accumulation- Surface Elevation Tables (SETs)
    - Jim Lynch- important take home point is that SET data is a *relative* elevation measurement over time but it is important to relate it to hydrologic information.
    - Jim Lynch- It is really hard to get a localized sea level rise measurement for a specific marsh. Short term sea level rise is much different from longer term average. But local sea level rise is also a really useful thing to have
    - Are more SET sites needed?
        - This is one of the questions USGS is grappling with now
        - USGS has funds to install more SET stations strategically in areas that they think are lacking
        - Absence of accretion data noted in SLAMM presentation seems to point to need for more SETs
        - We have the SET locations but tide gauges are also very important and somewhat lacking- do we need more of these rather than more SETs?
        - It takes 5-7 years for SET data to become useful
        - Sediment cores have their own problems but can be useful to see changes in elevation for 100 years ago
- **NY Tidal Wetland Trends and Analyses and Conditions Assessment**
    - Robert Svadlenka
        - study area includes Nassau Suffolk, part of queens, part of Hudson
        - mapped 'current' tidal wetlands
        - had to enhance 1974 tidal wetlands mapping
        - trends analysis- will
        - *Phragmites australis* was difficult to distinguish when using spectral analysis to map current tidal wetlands
    - Will Bowman
        - Tidal wetlands loss in southern LIS
            - Increasing rates of marsh loss as you go west
            - But there is a lot of spatial variability
            - Western towns have lost largest % of marshes but eastern towns have lost more total acreage (generally speaking)
        - Think about anthropogenic impacts from recreation- there is a lot of recreation in marshes that have lost a large amount of the marsh- what is the role of the impacts of our recreation on that loss?

        - Widening of creeks has been observed throughout the study area
        - Some signals are independent of adjacent land uses (for example where marsh loss was occurring in parks or refuges)
        - There were a very few marshes that have been seen to be holding its own and possibly gaining marsh- very small silver lining. What makes these sites successful?
    - Chris Haight- Multi-tier assessment of NYC salt marshes
        - Goal is to develop a vulnerability index to identify sites where restoration and management can be implemented and where that will be most impactful and feasible
        - Net marsh loss on the waterward edge- average loss is ~20%
        - Sites that have the most loss are situated in LIS and Jamaica Bay
        - 3 study areas- LIS, Jamaica Bay, and Staten Island
        - conditions index development
            - still in development
            - need to add more data
        - want to use index and data to help identify sites for potential waterward marsh restoration projects
- Q&A- NY Tidal Wetland Trends and Analyses and Conditions Assessment
    - For Chris- Can you separate vulnerability from conditions? Have you done that yet?
        - Working on conditions index at this point
        - Once all of the data is collating including trend analysis, they will have more of an index of vulnerability
    - For Will- Have you quantified the identified patterns of marsh loss? How hard would that be to do?
        - It is not feasible to do so for the entire study due to the sheer number of marshes included but it is definitely feasible for any given marsh
        - A lot of potential for mining the images to get numbers and comparing it to other data that is out there
        - The dataset will definitely be useful for all of the experts
        - They are picking key marshes to do this kind of analyses
    - For Chris- I was interested in seeing that you were measuring sheer stress in the soils- To what depth? Have you considered doing a profile with depth maybe down to 1 meter?
        - We went down to 10 cm but they have done measurements at both 10 and 50 cm for some individual sites. Data showed that the shallower the depth, the stronger the sheer vane strength.
        - We also did unvegetated vs vegetated areas. Vegetated areas had higher sheer vane strength
    - For Will- from the work that you are doing, are you observing potential restoration sites
        - I think there will definitely be the ability to find potential restoration sites from the dataset
- **Marine Transgression**

- Chris Elphick
  - Forest edge does not seem to be moving at a large picture scale.
  - In terms of sea level rise and marine transgressing actually causing tree mortality, there is no evidence of this occurring
  - No reduction in growth rate which you would suspect if there were salt water intrusion
  - Tree coring actually shows increased growth along marsh edge
    - This shows that sea level rise hasn't yet become a factor in stunting growth
    - Increased growth is likely due to increased availability of sunlight along the edges of the marsh
  - Basically, we haven't see any migration of marshes landward and it looks like high marshes will likely just get crowded out as sea level rises and existing high marsh becomes low marsh
- Ron Rozsa- Barn Island Sea Level Fens
  - Eroded Edge returns in 2008- brackish border known as the *Juncus* belt
    - Not a dieback
      - Groundwater erodes the aerobic peat, no peat- no *Juncus*
    - Eroded edge has typically been seen every 20-ish years
    - Metonic Cycle leading to variations in tide range with peaks 18.6 years apart. Peat blocks are what remains in the eroded edge.
    - *Panicum* belt- gone today
    - Behind the fen, some of the trees are dead- hypothesis that sea level rise is bringing water table up reducing the vadose zone and drowning trees. Is that paving way for marine transgression?
  - Edge Forest
    - Narrow belt, usually several meters wide, growing in the seepage zone in the same elevation as *Panicum* fens
    - *Panicum* cannot compete in shade so they are outcompeted as they try to transgress landward
    - *Juncus* is really tolerant of shade and there is some evidence it is moving up into the highlands- evidence of transgression
    - *Juncus* belt is short-lived. Exists over former sea level fen habitat
    - In order to save the state endangered Thistle- do we need to clear cut forest to create sunlit habitat for migration of *Panicum* fen?
- Shimon Anisfeld
  - Are marshes actively migrating into locations/elevations that are often considered upland
  - In the lawns, there are forams above the highest astronomical tide but this is not so in the wooded areas
  - Seems that there are areas we are treating as "lawns" which are actually a combo of *Juncus* and *Spartina patens*→ marshes
  - No-mow vs. mow has not changed types of plants growing but has obviously changed plant heights

        - Using aerial photos they were able to identify changes in the mowing regime
        - There seems to be a wedge of marsh overlying upland
            - That wedge only works if the sediment is being deposited tidally rather than old soil being biologically transformed into peat
        - Hoping forams may allow estimation of marsh migration

- Q&A
    - How reliably might the width of *Juncus* belt be an indicator of SGD contribution to that system?
        - Any *Juncus* you see next to the uplands is influenced by groundwater
        - Juncus and silverweed are clear indications of SGD but no full measurements
    - For Shimon- Is there any difference between glutinated and carbonate forams?
        - Generally looking at glutinated ones
    - Chris- have you looked at regeneration of trees moving away from the marsh edge?
        - Mortality data was separated by size (and age). Mortality does seem to vary with distance from the edge for very small trees suggesting some migration impact but not very large
    - For Chris- did you consider the understory at all?
        - We didn't do an exhaustive vegetation studies but we did do quadrats for marsh species every 10 meters once you were out of the main marsh area
        - Don't see evidence at this point of migration in the understory
    - For Chris- is there elevation data for this?
        - Not at this point
        - Recently bought Real Time Kinematic (RTK) elevations to try to get at the elevations
    - For Chris- Maybe you could rent a cheap laser level to use that as a way to measure inland. On the south shore they are seeing some marsh migration
        - Chris agreed that it is happening in some places but it is not necessarily sound-wide
    - Is it affected by the gradient of the slope? Are you taking slope into account?
        - Picked sites only where transgression would be predicted in terms of elevation, etc.
    - Does it make a difference? If we think we know it's going to happen at a longer scale, what info do we need to say that it is a good allocation of resources to obtain and manage these areas for future migration
        - Chris' comment-if you care about preventing organisms from going extinct, the timescale matters because these species don't have the time to wait for the migration to occur.
        - Ron's comment- In natural marshes, wherever you see new blackgrass it has gone uphill and into the *Panicum*- there is transgression in this sense. Historically *Panicum* is moving landward. marine transgression is real and is occurring
    - Do you have much of the salt scrub thicket and how is that responding?

- There are some different plants that do not dieback with the SGD and some of those are found in CT. mostly Nyssa is the boundary organism
- If there are marsh associated plants we could look at width of each species distribution looking landward we could study those distributions and band thicknesses
- They also have the salt scrub thickets but have not studied their responses as much (*Phragmites australis*, *Baccarus*, *Iva*, poison ivy mix)

Day 2: Raw Notes

The notes from the presentation section on Day 2 were transcribed by volunteer Kaitlin Willig (Stony Brook University graduate student). Notes for the breakout sessions on Day 2 were transcribed by the breakout session recorders during the workshop and organized by Victoria O'Neill (NYSDEC/NEIWPCC) after the workshop.

Day 2 Presentations

- **Saving our Marshes: Spotlight in Jamaica Bay, NY and Narrows River Estuary, RI**
  - Steve Zahn- Assistant Regional Director Region 2-NYSDEC
    - Jamaica Bay
      - Loss was extremely high. Went from 2300 acres to 800 acres
      - 2 tracks of remediation:
        - Determining the causes
        - Restoration Efforts
          - pilot project- thin layer spraying to place material back up on the marsh- successful (2 acre project)
            - was not a large enough scale
          - commercial grade pumping of material and physical planting of the area
            - intensive, exhaustive, *expensive*
          - community involvement in planting have been very successful and have driven costs down dramatically
      - restoration projects seem to be very successful at this point (~8 yrs later)
  - Patti Rafferty- Evaluating Methods to establish vegetation for salt marsh island restoration in Jamaica Bay, NY
    - Marsh restoration goals
      - Focus of this talk will be evaluating various techniques of establishing vegetation
    - Elders East Marsh Restoration
      - Planted plugs and quart pots

- difference in species composition and abundance but total percent plant cover was higher than reference site within the target time period

- Elders West Marsh Restoration
  - Planting methods: Hummock transplants, planted plugs, natural recruitment
  - Relying on natural recruitment was not successful in this case
  - Hummock transplants was semi-successful. May have reached 50% coverage but there is definitely no equivalency to reference sites
  - High marsh area- there is some vegetative cover but we are not seeing same kind of response as we did at elders east
  - Don't know why
    - Can look at elevation data but they don't think that is the problem
    - There is a lot of sand movement- no hydrodynamic data but it seems like wave energy is moving sand around a lot and making it hard for plants to establish
- Yellow Bar Marsh Restoration
  - Planting- hummock transplants, planting plugs, seed drill
  - Only a few years of data- project is ongoing
  - Response of hummock transplants at yellow bar after 3 years is similar to response at elders west after 5 years
  - Seeded treatment seemed very successful (cheaper treatment)
  - High marsh also successful
- Canopy cover is just one of multiple metrics being used to assess success

- Rebecca Swadek
  - want to look at conditions of NYC marshes to see where the most vulnerable marshes are, and then to prioritize restoration and management efforts
  - trends analysis and site conditions: Jamaica bay
    - overall losses- just a matter of degree
    - a lot of debris removal and a lot of waterward restoration a goal
  - go back to all restoration projects and examine and evaluate design elements in order to revise restoration guidelines
  - want to get debris removed from these marshes
- Cathy Wigand
  - Rhode Island
  - FWS project – Narrow River Estuary
  - Losing a lot of high marsh habitat to ponding and panne formation
  - Concerns:
    - Salt marsh sparrows
    - Flood abatement
    - Water quality maintenance

        - recommend a climate-change adaptive management strategy
        - some of the pilots are building resistance at the shoreline, building resiliency, enable marsh transition (facilitating upland migration)
- Q&A for Panel 1
    - For Cathy
        - How hard is it to get approval for and create the runnels
            - It seemed like the process went really smoothly because CRMC was involved from the start
            - In our state the CRMC is allowed to approve things that the corps would typically approve in other state, which may have made it easier
        - For Jamaica bay people: did you find a difference in goose resistance between these planting methods?
            - Geese are a big perceived problem but there may not be evidence to support that
                - Tried to collect quantitative data for goose grazing but found that it would be cost prohibitive to do
                - All of the projects Patti described did have goose fencing to try to mitigate goose impact
                - 2 new projects Steve Zahn spoke about did not have goose fencing and have not seen any issues
            - don't have a way to quantitatively address this question
            - Jim Brown has seen some evidence of grazing at Big Egg
    - Comment from Chris- There is an enormous amount of literature on goose grazing in salt marshes in other areas of the world- it could be easy to apply that literature to this area. We should not ignore this data. We should also try to put our restoration data into the widely available literature.
        - Plug for Journal of Coastal Conservation- open access- linked to database of other literature in the topic of restoration so it can be a useful resource for management efforts.
    - Concerning Jamaica Bay- was there any research if sand placed on top of peat was just compressing peat?
        - Compression was not originally accounted for and so original estimates of amounts of sand needed to meet appropriate elevations turned out to be underestimates.
        - There is some evidence of compaction
        - At Elders West, there is a lot of sand moving around and it is just too much for vegetation to establish
    - Can you comment on target elevation in terms of creating marshes- in west coast areas they are more interested in high marsh because they think it will be more resilient in terms of sea level rise
        - Jamaica bay also tried to go to the higher end of the elevation range tolerable to *S. alterniflora* so that they could last a little longer
        - It's not so simple- we really need to adapt on the fly to different questions

        - Try to use many methods to determine target elevation and then err on the higher side of elevation
        - In a degrading system, your biobenchmarking just benchmarks what's left, which is not the best condition. So biobenchmarking should be based on healthier marshes in order to get a better benchmark for target conditions
    - Are there different recommendations for island marshes vs marshes connected to the mainland on one side?
        - High marsh is always really hard to work with- you don't want to go to the highest elevation that *S. alterniflora* will grow at but you want to be at the higher end of the range
        - You do have to deal with intrusive species like *Phragmites australis*
    - How did other sites in Jamaica bay do after Superstorm Sandy?
        - There is some evaluation going on right now
        - Anecdotally don't see any large changes from sandy in natural or restored marshes
    - Other plans for addition large-scale restoration in Jamaica bay?
        - Yes, there are intentions but they need federal funding matching
        - Timing is important
- **Barn Island More than 60 years of Wetland Change-** Ron Rozsa
    - Wealth of imagery from photostations that allows for analysis of species change trends
    - Evidence of marine transgression in some areas
        - Pattern of *Juncus* moving upland and pushing out trees (n name) dying off at eroded edge which is then taken over by Spartina
    - Working on compiling and georeferencing vegetation coverage maps
    - New contribution to Barn Island- upland vegetation studies
- Q&A- Barn Island More than 60 years of Wetland Change
    - Is there any evidence that fire was used to prevent forestation especially when cows were grazing there? Is fire being considered for the future?
        - Fire did not figure into early 20th century history
        - Fire is being used by DEEP to keep main interior road open so that they have a fire break
        - Don't think there has been any fire treatments up in the marshes, at least not recently
    - What is the panel's opinion on removing stone walls- in some walls they are perpendicular to the upland – do walls protect the marshes or prevent migration?
        - There is a break in the wall at Barn Island and it is also very porous
        - Sits on upland soil
        - There are various stonewalls in the area. Sometimes they can be a partial impediment to flow- depends on wall and marsh conditions
    - The types of human uses at Barn Island have evolved over the century. There are all these different uses and people competing for the use. Are there plans to manage uses in the future as part of this study and can they all coexist?

        - Have identified potential issues but the objective of barn island needs to be established in order to determine how the potential uses are impacting the objective to manage the site for wildlife
        - Part of the planning effort is trying to get DEP to identify objectives
        - There was a suggestion that we do more observation of shore birds and Chris commented on the bird blinds that are used elsewhere fairly successfully- where those might be placed on Barn Island is to be determined
    - Struggle of balancing human use is really difficult- we want to study it but in researching we end up impacting the area.
        - Barn island is a wildlife management area- this management plan- permitting and enforcement is going to be an eye opening experience
        - Need to identify current and past research so that DEP can try to protect certain areas from major physical modifications.
            - Want to make sure future proposed research does not impact past or ongoing research efforts
            - DEP needs to be vigilant to look at that
        - This is a fairly large exercise to compile all of the information and pull together options for DEP to choose for to create the next management plan
        - Broader coordination issue is a major one not just at barn island but more generally throughout Connecticut
            - Important management question.

Day 2 Morning Breakout Sessions

Breakout Session 1: What are the causes for marsh loss/change?

Group A

Biological/Chemical

- From the 2003 recommendations, what can we take out/
    - Boat wakes
    - Lime?
    - Herbicides, creosote? Not broad
- Some overarching stressors and then more smaller scale stressors
- Burrow pits are a problem

Physical/Hydrological

- Disease
- No significant periwinkle
- Burrowing action by fiddler crabs more of a secondary factor--burrowing of *Sesarma* is!
- Macroalgae (*Ulva*) –smothering and release of ammonia, decomposition of *Ulva*
- Algae in general cause changes un marsh and panes
    - Widespread problem
- Stormwater-widespread problem changing invertebrate community

- Stormwater outfall has not changed much
- Change more historical but continues to this day
- Change in sewage composition/
- Stormwater has been huge problem for NYC
    - Increase in population
    - CSO
- Edge erosion with storms
- Metonic cycle and groundwater—significant role in how marsh transgresses
- Hydrodynamic feedback when you lose marsh
- Feeding it with sediment (sediment budget)
- Panne formation at alarming rate
- Sudden vegetation dieback
- Did not talk about ditching in 2003
- Marsh on N & S side of LIS are different
    - Sediment freshwater input
- Geologic setting and geomorphology
- Bedrock control vs. glacial till
    - Kettle holes on LI
    - Sandy planes in CT
- Conceptual models in systems has that been done/
    - Would speak to geographic setting can identify what are overarching things with conceptual model

Group B

- Many variables/multiple stressors
- Move bulkhead to physical stressor section
- Identify causes associated with specific types of marsh loss
- Specific case by case study
- Diagnostic marsh loss matrix-measurement of stressors
- Keep biotic factors (insect, bird, crustaceans, etc)
    - *Sesarma* and other crabs has been ID'ed as major stressor (more research needed to understand crab population patterns)
- Pollutants: IDed in 2003 not accredited as major stressors (except nutrients)
    - Lower priority
    - Change to pesticides to include all pollutants
- Multiple stressors/synergistic effect!!!
- Priority list of Stressors:
    - Accelerated SLR
    - Eutrophication
    - Climate change/weather patterns/drought/storms/floods
    - Crab (primary or secondary?)
    - ID suite of stressors
    - Altered hydrology (partner with coastal engineers)
        - Channelization/sedimentation-tide gate/restrictions
        - Work with natural conditions/metonic cycle

        - Loss of sediment input ---dams, groins, barrier beach roll
    - Compounded effects/synergistic
    - Invasive/loss of diversity/loss of seedbank
    - Hydrogeology-altered
    - Tidal flow restrictions (tide gate/culverts)
    - Groundwater contributions
    - Regulatory/permit issues
    - *Fusarium*, african dust (Ron)
    - Geese/swans (secondary)
    - Coastal development/limited area for migration
    - Boat wakes (localized)
    - Storm response
        - Bulkhead rebuilding
    - Greenhouse gas

Group C

- Nutrients-Nitrates
    - Good start for research
    - No 1 size fits all response
    - Low marsh is much more susceptible
        - Investigate why some area are more susceptible
    - Climate change
        - Increase large precipitation events-nutrients and salinity issues from CSOs
- Pollutants?-not exhausted w.r.t. research
    - Organisms other than plants may be susceptible to pollutants
    - Gut reaction: nutrients are more important than pollutants
- Recreational activities
    - Boat wakes
    - Cumulative impacts
    - Recreation activities easier to identify and manage
        - Volume of moorings/boats
        - Not as important as nutrients
- Causes more important than nutrients?
    - Sediments, SLR
- Sediment transport
    - Area for more research
    - Generally the areas around here seem to be sediment poor
    - Dams tend to inhibit sediment transport
    - Hardening of shorelines also affects sediment budgets
- Biotic factors are NOT a big deal for marsh loss
- More research into layer of sediment where roots and rhizomes ae present
- Effects of dredging-site specific
    - Changes in tidal range are important
- Understanding sediment transportation on/off the marsh is very important
- Have started looking at characteristics of fragmented marshes but still need more research
- Sea level rise and tidal prisms

    - Very important for future research
- Separating transitions back to pre-ditching conditions vs. other changes in marsh ecology
- SET sites
    - High marsh converts to low marsh and more gradually than low marsh converts to tidal flats
- Low marshes are more susceptible than high marshes to changes in the hydroperiod (SLR); we need to understand why. (i.e., HM converts to LM much slower than LM converts to mudflats).
- After some discussion, it was decided that pollutants were not a priority issue.
- Neither were invasive species (i.e., green crab burrows) and other biotic factors – they fell out at the bottom of the list.
- Recreational use (i.e., we'll be bringing more research and class field trips onto these marshes, plus people walking their dogs) is on the rise, but this is not as important as nitrogen.
- Boat moorings (especially with pumping wastes) have an impact, but wouldn't be the highest, either. There has been some research on boat wakes, but not much else related to boating impacts.
- It was eventually decided that the top three factors leading to marsh loss (in priority order) are: 1) an increased hydroperiod due to sea level rise (SLR) and local manipulations (i.e, dredging, etc); 2) a lack of sediment (caused by less erosion up river and other factors); and, 3) nitrogen pollution (specifically nitrogen, not nutrients in general).
- The LIS system as a whole is sediment starved, but the science is unsure as to where the sediments are coming from in each marsh.
- There is no integration of marsh aerials with adjacent area aerials to look for links between bulkheads and other land uses and marsh loss. This represents a large need in research.
- We also need a lot more research on the impact of nutrients (nitrogen) and sea level rise in the root/rhizome area. It is unknown if this area can keep up with SLR.
- The top three priority research areas finally fell out as (not in priority order): understanding sediment movement, the hydroperiod, and nitrogen and their impacts. But it was recognized that this is intensive work and very site specific.
- A fourth top research need was also recognized: gathering data to put into SLAMM and other models.
- A comparison of fragmenting marshes is also needed. This was sort of started, but not really.

Breakout Session 2: How do Marshes Respond to These Factors/Stressors?

Group A

- Fundamental change in idea of marsh zonation
    - Change in high marsh-loss of sp. Patens
- Marshes with high nutrients may be able to do ok if not inundated
- Increase inundation and decrease belowground biomass puts more energy into above ground biomass
- Invasive species-same feeling as last time?
- Low marsh losses-Sudden Vegetation Dieback
- Significant changes in marsh biota (sparrow) Changes in use patterns
- Does marsh function affect marsh loss?
- Feedbacks with birds
- Start to understand marsh accumulation
- Missing 3-D view!
- Removal of reefs can change hydrological cycle
- How to protect marsh edges-management questions
- Marsh response to removal of oyster reefs
    - Sensitivity to erosion
- Understanding the changes
- Response of marsh to loss will change as marsh degrades
    - Ex: outfalls may not have changed but marsh is more susceptible
- Vegetation change vs. marsh loss
- The ability of marsh to retain itself over time
- Shift in ecological services with shift in vegetation
- Marshes getting wetter
- Temperature a factor in drying marsh or stressing plants
- Impact of climate change on growing season
- Ice impact on marshes
- Milder winters – less ice
- Hotter/wetter increases decomposition
- SLR

Group B

- Marsh loss (upper border, creek expansion, increase in panes/pools, creek bank vegetation loss)
- Rapid vs. gradual loss
- Change in vegetation type
- Marsh migration
- Swiss cheese/"holey" marsh—marsh loss
- Waffling—marsh loss
- Hummock/water logged—marsh loss
- Soil characteristics (organic vs. mineral) geochemical
    - Change in decomposition process, structural (change in root rhizome morphology)
- Change/loss of biodiversity

- Below ground marsh health (soils, plants, microbes)
- Plant health (ecosystem services reduced)
    - Lodging
    - Structural integrity of above ground plant
- Positive feedback/accelerated loss

Group C

- Marsh equilibrium model
    - Find missing data and populate the model
- Research areas where belowground biomass production occur
- What are loading rates onto low marsh and high marsh of nutrients
    - Not into water-into the marsh
- Role of Phosphorous-probably minor
- Role of eelgrass as canary in the coal mine not crucial for research
- Can't put dredge material over peat
    - There has been some research on how long it takes to form organic structures on dredge islands
- Impact of invasive species
    - Not as big of an issue on a healthy marsh, but can be a problem in an already stressed marshes
    - Green crabs burrowing may be damaging marsh sediment structure
    - *Phragmites australis*-pretty extensively researched
- Data Gaps
    - Panne formation-elevation and draining issue
        - Field experiments needed to understand effect of draining panes by human intervention
    - Need to study the effects of changing drainage systems in our restoration efforts
    - Big question: what are we managing to?
    - What is ecological impact of newly developing panes
    - Question of energy transfer budget into/out of the marsh system
    - Need more data to fill in gaps of data that we already know are important such as identified gaps in the SLAMM needed!!
    - Seems like we are finding too many panes in our marshes
    - What developing panes are doing/
        - Should we be concerned?
    - Have patterns of marsh loss been correlated to land use patterns?
        - Estuarine input seems to be more important than local land use
- Further discussion on needing to fill the data gaps for the various models.
- Need research into the contribution of inorganic v. organic sediments (and whether the bulk of vertical growth is due to in situ production)
- Need a handle on what the actual nutrient loading rate into the marshes is. And how much is coming through groundwater.

- Jamaica Bay wetlands did well on dredged material because it was all sand, but it needs to be understood that this may not necessarily be the case in all systems. It will also be interesting to see how long it takes for the organic layer to build.
- While there is research on the impacts of channel dredging to hydroperiods of various systems, research on whether larger waves are generated with deeper dredging is lacking.
- Other data gaps:
    - Lack of knowledge about the root zone (repeated from session 1)
    - Waffling: what happens with water sitting on the marsh? Is this a drainage issue or something else?
    - Careful field experiments are needed on pannes and habitat restoration involving panne formation. We're not really sure how extensive pannes were in the 1820s.
    - What is the ecological impact of new pannes? i.e., birds, fish, inverts, and energy transfer
    - Energy transfer is a critical question that doesn't seem like anyone is addressing
    - Again, we know what characteristics are important (to determining marsh survival/loss), but we don't have the marsh-specific data to plug into the models
    - Is panne formation ecologically sustainable or is it an indication of a big issue?
    - We need more research on the impacts of changing the drainage structure of the marsh.
- It's dangerous to try and replicate historical conditions. Marshes were very different historically and it's difficult to pinpoint exactly what they were like. Also, we can't recreate the watershed/land use conditions of the past. This brings up the million dollar question, "What are we managing to?" We don't really know.
- Research has shown that ditch plugging is bad.
- Most important: we need research on pannes and the effects thereof.
- We also need to look for a correlation between loss patterns and land use patterns
- Other points:
    - Phosphorous is likely not a big issue, as was thought in 2003.
    - No correlation between eelgrass bed loss and marsh loss. Steve said, "I wouldn't want to manage by that."

Invasive species are likely only important in systems that are already stressed (which, they all are).

Day 2 Afternoon Breakout Sessions

Breakout Session1: Research Recommendations

Overarching recommendations:

- Central database, likely managed by LISS, of techniques and where they do and don't work. Also for monitoring.

Group 3:

- We need to identify what the correct amount and types of pannes are. Secondly, we need to identify what needs to be done with pannes.
- We need to figure out what to do with sediment contamination in a marsh (this is a hindrance to habitat restoration).
- Before every habitat restoration project, we need to be identifying what we're restoring for (i.e., wave energy v. bird habitat) and use that to identify the objectives.
- We need site specific analyses of geologic and hydrographic conditions.
- Across the sites, we need to measure the same things and compare so we can identify what works and where (i.e., standardized monitoring protocols)
- Need to identify how do we fund for monitoring
- People need to be willing to point out what went wrong
- We need more experimentation into what is the effectiveness of different techniques.
- We need to compile (central repository) techniques and where they worked and where they didn't
- We need to make sure we're always identifying the stressors before doing the restoration (further discussion seemed to indicate that this is generally the case).
- We need to implement hybrid/living shorelines and monitor these. This would require engaging a coastal engineer (or more).

Group 4:

- Need research into waffling, edge erosion, and the impacts of maintaining navigational channels.
- Do geese choose different grasses?
- Need to figure out which sediment is best for restoration.
- Do experimental plots in conjunction with restoration (need a control and references; need up front monitoring – maybe there's something new (technique) we don't know about)
- Explore possibility of "picking-up" the sloughed-off marsh and use elsewhere as a "rescue mission." Jamaica Bay did something similar with hummocks, but not as a rescue mission.
- Thin-layer spreading makes sense where dredging is already happening, but don't dredge where you don't need to, because there are impacts on both ends.

- Need sulfide loggers to understand the underground cycle and determine when to do thin-layer spreading (i.e., what time of year is best).
- Remove hardened barriers to allow for upland migration and remove upstream dams – when and where appropriate.
- Living shorelines are good as a stop-gap measure (for wave breaks, etc), but it is more mitigation than a way to save habitat.
- Could LIS beneficially reuse its silt and mud?
- Research genetically modified *Spartina* that is resistant to *Fuserium*.

Group 1:

- Explore the possibility of extending the marsh waterward. In a post-Sandy world, DEC is getting more open to it, but the permitting is tricky. And it can't be for land expansion.
- Identify new restoration priorities (i.e., CT also preserves tidal mudflats).
- We need systematic monitoring that feeds into a central database or bibliography.
- What are we going to do about marshes extending landward with SLR?
- We need to reconsider restoration ecology in a changing system.
- We need to develop an adaptive management strategy – this is the first step in identifying what we do (Ron R) and this needs to go beyond the HRI team.
- Prioritize removing restrictions (tidal gates, etc.); HOWEVER, this needs to be done with monitoring so that we don't remove a tidal gate and then flood a slumped marsh (marshes slump behind tide gates).
- We also need to know where salt marsh sparrows nest, so our restoration efforts don't drown them.
- We need target elevations: we've been grading low in order to keep the *Phragmites* out, but then we don't get high marsh, which is important. We need to reassess and get ACOE on board, because they do not like restoring high marsh, because it's difficult. This would also help in planning for SLR. We need to start targeting elevations at the higher end of the spectrum. This would also save money, since excavation is the most expensive part of a restoration project.
- Assess what you're restoring for and you may actually want *Phragmites* (it's good for protection).
- Tidal wetland regulations may change if salt marsh sparrows get listed federally (which seems likely).
- There are regulatory issues (in CT, at least): *Spartina alterniflora* is considered essential fish habitat (EFH), so if it is impacted in a restoration attempt, it has to be restored at a ratio of 3-to-1. This dissuades otherwise good habitat restoration projects.
- We need a huge shift (in both states) in regulator perception.

Group 2:

- Don't start a restoration project unless you can monitor.
- We need a better sense of the typologies of marsh loss.
- We need a rapid assessment of marsh loss, so we can identify what's wrong and target marsh restoration.
- We need to know what we should be monitoring. But, also, we need to know what the minimum is for monitoring/what are the key variables.
- We need to connect labs doing research with habitat restoration projects (and groups).
- Need to assemble a database of the habitat restoration projects and what has worked.
- Currently, we don't know how best to spend habitat restoration money.
- We need to identify priority targets.
- Need to figure out how to recruit volunteers and keep them on-board long-term.
- Use dredge materials where they're removed as we need to keep sediments in the system. Currently, all DM is placed upland or dumped at sea. Make the permits for this easier
- Don't make all permits easier. The permitting process is there for a reason. Instead, look at the antiquated processes and make smoother and more consistent.
- Make LISS the repository for project information. We need this housed some place that will stay afloat and LISS has long-term viability.
- In doing this, LISS needs to track projects that were also funded with other monies not LISS.
- Better coordination between towns, universities, state/federal agencies, etc. is needed.

Group 1

- Create a conceptual model (what parameters would you need?)—YES!
- Pieces of model have been illustrated
- SLAMM captures SLR
- Models Scott Warren showed for N
- Priority-groundwater hydrology – impacting panes, high marsh, below ground
- Cameron Engineering take a sample to get a sense of how much loss is caused by each of these things
- Efforts to look at metrics
- Classification or analysis of different marshes responding in different way (size, geographic)
- Let the model generate the list?
- Storms-what protocol do we want to roll out to address impacts of storms. Be proactive
- USGS pre-storm roles out tidal level recording devices-existing network determines what is the surge during hurricanes
- Patterns across multiple marsh
- Cross gradient –chemical/physical/hydrological conditions
- Repeat #2

- #3 manipulating marshes
- Do we have enough manipulation that are happening?
- Manipulate experiments of interactions that come out of conceptual models
- A lot of understanding of surface of marsh but need to characterize what is happening below the marsh
- What will serve as indicators?
- Surface water hydrology
- Marine transgression
- Needs to be relevant to the management to inform decision making
- The 2003 list describes scientific model operating backwards

Group 2

- Conceptual model of salt marsh system
    - Data gaps
    - Good model with forces effecting marsh accretion, marsh growth, and development
    - Focus it more—formalize marsh growth and loss. Need good testable hypothesis
- Comparative evaluations, value is to find similarities
- Conduct manipulative experiments
    - Won't get it all done by observation
    - Unless we can play around with nutrient sources, panes, etc.
    - Need permits
- DO we have classification system that will tell us the similarities/
    - FWS has classification for different wetlands. Whether it is tidal/freshwater wetland
- Not in 2003
    - Development question. What are the ecological impacts/
- Anthropogenic effects
    - Nutrients
    - Substantial data gaps
    - Processes controlling production and decomposition in below ground
    - Effects of shoreline hardening
    - Looking at hydrology, use radioisotopes
    - What are groundwater inputs/

Group 3

- Conceptual model
    - Need to look at how marshes are different
        - Nutrient regimes
        - There are a lot of data gaps
- We have a new set of trends analysis on LI need to figure out which stressors are responsible for marsh changes (diagnostic matrix)
    - Interdisciplinary (soil, water, hydrology, etc.)
    - Nutrient availability, DO, site specific tide gauges,

  - Sediment availability
  - Need affordable way to get high resolution data
  - LIDAR
- Anthropogenic
  - N load, septic, groundwater, bulkhead, shoreline.
- Conduct manipulative experiments
  - Establishing a stressor response relationship
  - Pilots-new techniques
  - 2003 recommendations are good
  - Need more research with chemistry mineralized vs organic rich sediments
  - Draw patterns out of spatial variability
  - Mosquito ditching
  - Different thresholds
  - Identify places that are fragile etc. where you have floating marshes
  - Regulatory agency has to be keeper people out in field to feed this info
  - Funding

Group 4

- Conceptual model
  - We need to look at what a healthy marsh looks like
  - If we are doing restoration projects, what is out end point?
  - More funding into paleoecological research
    - But can't restore marsh to those conditions
    - Learn from those conditions
  - Optimize these systems
  - Dynamic model would be better than conceptual model that allow you to scenario test and forecast
  - We need conceptual model first before dynamic model
  - Think in terms of a "healthy enough marsh"
  - Climate change adaptations applied research with references and controls
  - Monitoring and research are some
  - Restoration should be more research
  - Long term research projects
  - Test resiliency
  - Should LISS create basis for long term grant
  - Maintain studies for 50 years
  - CDC gets more long term money than we do
- Data gaps
  - Large scale understanding of SLR and other phenomenon
  - Need more info on sedimentation
  - More site specific work

Breakout Session 2: Monitoring Recommendations

Group 1

- Ecological services of panes/ponds
- Collaborative (low impact)
- Standard protocol
- Nekton use of marshes
- Reference sites identified- need long term- smaller committee should decide
- No plans to continue currant reference sites (bird use marshes)
- No central database for information sharing—LISS funding? Tie together sentinel monitoring-need lead to get data into this program, is data comparable?
    - Report (climate change) –just submitted-sentinel monitoring funded—recommendations
- SET network-user forum (1-2x/year)
    - ID gaps, more SETs
    - Track current SETs
- Marine Transgression/long term marsh migration (into lawns)
- Equipment sharing

Group 2

- Regional marsh sampling framework (NPS, USFWS, SC)
    - Smaller efforts
    - Central repository (LIS? NPS? Need links)
    - Disseminate information
    - LISS should host—protocols/SOPs
    - Natural and restored sites
- Temporal/Spatial definition
    - Link landscape to local level
- Trends analysis
    - Need low marsh accretion info
- "Anti-Monitoring"-low impact to marsh
    - Limited sampling-photographs

Group 3

- Regional marsh monitoring framework
    - Repository by LISS?
    - Different modules for different data
    - Monitoring for condition
    - Rapid assessment vs. long term
    - First need, updated set of reference materials
    - First need, Reference sites with metrics (appropriate for project)
- Minimize impacts while monitoring?—coordination/scheduling
- Trends analysis? Need protocols, timeline/--need standards? Similar methods?
    - Sentinel site program? Long term trends
    - Statistician/GIS analysts to interpret results (use academic institution)
- Identification of metrics for monitoring

Group 4

- Monitoring framework
    - Scale/ larger than LISS watershed?
- Clearinghouse/
    - Use existing database? Hard to maintain
    - Hard to combine data (different units)
    - LIS FF grants should include time/money for monitoring (past projects/)
    - Need adaptive management based on monitoring
    - Projects should include a monitoring plan (use for funding)
    - Regional standardized monitoring important but difficult to achieve
    - Determine metrics/standards—may not apply regionally but need for long term trends (ex; USFWS Rapid Assessment)
    - Core metrics with project specific items
- Broader inventory-timeframe? Definition?
    - Vulnerability index (management implications)
    - Condition index

Breakout Session 3: Restoration Recommendations

Group 1

- How much are we going to do to extend marsh waterward?
    - Tricky politically
- Time to revisit what we do w.r.t marsh restoration
    - Transforming habitat
- Systematic monitoring feeding into a common database (bibliography) to allow for broad conclusions/analysis
- What are we going to do with extending landward?
- Build a criteria for good areas for restoration
- Removal of restrictions like culverts to restore marsh?
    - Sometimes is detrimental due to lower elevation of marshes before removal of culverts leading to increased flooding
- May need to increase elevation of restoration efforts to increase high marsh areas
    - With SLR we need to look to the future and increase target elevations.
    - For storm resiliency purposes, *Phragmites* may not be so bad
- In certain areas, issue of space and intruding on human development impedes restoration efforts.
- Going waterward, policy issue of reducing fish habitat by switching low marsh to high marsh
    - Need to shift management perspective

Group 2

- Don’t start unless you have money for monitoring
- Being able to quickly assess/diagnose marsh loss to aid restoration
- What can you measure/what should you measure given limited funding
    - What are the most essential variables to monitor

- Time constraint and funding constraints
    - Connecting with graduate students is a good tool
- Systematic lists of LIS restoration projects and their success/failure
- What is our goal? How should we spend our money?
    - Come up with priority targets
    - Biggest bang for the buck
- Oyster reefs and accretion behind the reefs but permitting is a hurdle
    - Who? What? When? Where? How?
- Coordination of volunteer efforts
    - Can be really useful with planting projects, etc
    - Graduate students and post grads
- Beneficial reuse of dredge materials
    - Coordinating dredging with restoration efforts
    - Dredging removes sediment from an already sediment starved system-try to keep dredge materials in the sediment transport system
- Making permitting more user friendly
    - Make it smoother
    - Still need a burden of proof
- LISS could play a role as a repository for restoration efforts
    - Better coordination between state/towns/agencies/universities about restoration efforts and their successes/failures

Group 3

- Figure out what to do with contaminated sediment
- Come up with a strategy for targeting marshes with pannes that need restoration
    - Sites where it would be appropriate to address pannes
    - Goal-to increase vegetation
- Develop planning steps for restoration
    - Goals-different approach
    - Set of questions to help start planning
        - Site specific analysis
- Measuring same things across sites so success can be compared and approach can be improved
    - Identify/develop metrics and protocols
    - Funding for monitoring is always a problem.
    - Need to find a way for both successes and failures are reported and thought about to better inform future restoration efforts
- Need to employ experimentation to explore efficacy of various techniques. Incorporating experimentation into restoration
- Understanding stressors is important, but it is impossible to figure it all out 1st
    - Need to address stressors not just symptoms
- Hybrid shoreline protection
- Understanding your site is critical

Group 4

- Need for more detailed research looking at types of grass being planted w.r.t. goose grazing
- State recommendation is for Sandy sediment but cores show more fine sediment
- Research aspect, need to have central and references and built in monitoring in restoration efforts
- Has anyone done any mitigation projects where salt marsh that was sloughed off would be taken to rejuvenate in other areas where calving won't be an issue.
- Use of dredge material for restoration may be interesting
    - Especially thin layer deposition/spraying
    - Need to think about both ends-where sediment is going and where it is coming from
    - Timing of thin layer spraying-understanding seasonality of below ground activity.
- Removal of hardened barriers and upstream dams when appropriate
- Living shorelines may be a stop gap (reducing calving from boat wakes for ex) mitigating technique more than anything else
    - Implementing oyster reefs-potential to be restorative and mitigate
        - In this area oyster reefs may not be 3-D in structure and so not as effective as wave breaking
- Pilot project using reef balls
    - Tried it in Jamaica Bay-not successful
- Using dredge materials for marsh restoration could be really useful if it is not contaminated
    - Developing beneficial reuse ideas and criteria would be great
- Develop *Fusarium* resistant *Spartina alterniflora*

Breakout Session 4: Management Recommendations

Group 1

- Stable funding for Sound-wide monitoring
- Better coordination of management, research, and monitoring
    - Revisit LIS Resource Center
    - LISS website to include more information on literature and current research and where dialogues can take place
    - Biennial LIS Conference to share information
- Build Public support of coastal marsh systems
    - Involve people in plantings
    - Invest in outreach and communications
    - LISS to help connect volunteers with restoration projects
    - Focus groups on specific issues
    - Get task force together on marshes
    - Update tidal marshes of LIS

Group 2

- Better organization of research and monitoring and maintenance
    - Central electronic depository
    - Include data links
- Fund restoration projects along with monitoring (requirement)
- Need case studies of restoration projects
- Make stronger connections between NY & CT
- Enable networks of researchers
- Connect between science and land managers and town planners and regulators
- Look at policies that make it difficult to preserve and restore, wetland management
- Develop better guidelines for wetland mitigation
- Connect funds to needed areas
- Streamline permitting among all levels of government
- Review land preservation policies and don't forget the upland.

Group 3

- Prioritize a stable source of funding and coordination
- Get funding organizations together and identify 5 major goals and get them involved
- Need to communicate the economics of marsh restoration
- Economic analysis of marshes
- Rethink marketing and communication messages
    - Listen and "translate" real works stories
    - Don't over promise salt marshes
    - Make connection between healthy shorelines and benefits
- Repository of science information and make it easy for managers to use
    - Compile research questions that managers need
    - Integrated marsh management
    - Connect researchers to management needs

Group 4

- Conduct full literature search-done by LISS and habitat database on LISS website
- CCMP aims to increase habitat restoration acres
- Communication to lay-people about habitat restoration
    - Show how marshes are beneficial for flood control and wildlife benefits
    - Partner with CT Resiliency Institute
        - Work with professional marketing outreach team
        - Report card for habitat quality and quantity
- Permitting-revisit to align with research (and climate change adaptation and resiliency)

- Involve regulatory agencies in projects (help with future permitting)
- Rethink scale of restoration-more expansive scale and large projects