LONG ISLAND SOUND STUDY
EPA ASSISTANCE AWARD
SEMI-ANNUAL PROGRESS REPORT

Semi-annual progress reports are due to the EPA Project Officer within 30 days of the end of each six month reporting period. Progress reports should be submitted in electronic format via email using commonly available word processing software (e.g., WordPerfect® or Microsoft Word®) or in PDF format. Progress reports must be submitted to the EPA Project Officer (specified on your grant agreement). EPA may post progress reports on the internet. Progress reports should generally not exceed five 8.5" X 11" pages using the below format and these reports shall provide the following information:

EPA Grant Number: LI96196201

1. **Project Title:** Long Island Sound Scientific Research

2. **Grantee Organization:** Connecticut Sea Grant

3. **Contact Name:** Dr. Sylvain De Guise

4. **Grant Project/Budget Period:** October 1, 2015 – September 30, 2020

5. **Reporting Period:** 10/1/2018- 3/31/2019

6. **Project Description:** *Provide a brief overview of the project, including a reiteration of the goals and objectives of your project and the management implications of your work.*
   The Connecticut and New York Sea Grant programs (CTSG and NYSG) jointly administer a competitive research program to address the needs of the Long Island Sound Study (LISS). The *Long Island Sound 2008 Agreement* and the sub-documents supporting it, such as the 12/07 *2008 Research, Monitoring, and Assessment Needs to Attain LISS Goals and Targets* report, and the recently released *LIS Comprehensive Conservation and Management Plan 2015*, serve as the foundation for the program, with the LISS Science & Technical Advisory Committee (STAC) identifying the highest research priorities. The first objective of this proposal is to identify and fund high priority, high quality research needed in order to best achieve the vision of the 2008 Agreement and the goals of the LIS Comprehensive Conservation and Management Plan. The second objective is to promptly share the results of the research, providing critical, new, science-based information that can inform decision-making and actions towards reaching the vision and goals for Long Island Sound.

7. **Project Narrative Summary/Accomplishments:** *Briefly describe accomplishments during the reporting period, including a comparison of actual accomplishments with the outputs and outcomes specified in the work plan. [Add project Program Elements from the work plan in the below chart; add or delete rows as necessary.]*

Beginning in the winter 2015/16, discussions began among CTSG, NYSG, the Science and Technical Advisory Committee (STAC) of the Long Island Sound Study (LISS) and LISS staff to develop a request for proposals (RFP) for the 2017-2019 funding cycle. A schedule for the 2017-19 cycle was developed and circulated. It was assessed that the priority research topics identified in the previous 2015-17 RFP which were based on research recommendations from the Long Island Sound Synthesis book are still current and relevant. There was preference for a focused initiative, rather than a broad initiative with diverse sets of priorities. The draft RFP topics and process questions were presented to the STAC at their February 2016 meeting and they were given the opportunity to have input to the process. The STAC was consulted with regards to the magnitude of funding for individual projects and the majority favored a cap although there was no consensus on the size of the cap. Finally, staff at the LISS office provided input to the topical research foci and the RFP was finalized and disseminated on the 24th of March, 2016. Thirty-five preliminary proposals were submitted on June 6, 2016. Three out-of-state independent academic reviewers were invited to join five in-state reviewers representing CTSG, NYSG, LISS, NY DEC, and CT DEEP. The Pre-Proposal Review Panel met via web-conference on August 8, 2016. Nine of these PIs were encouraged to submit full proposals. All 35 PIs received a summary of the Review Panel comments in August. Peer reviewers were identified to review the full proposals.

Three mailed peer reviews were solicited and received for each of the 13 full proposals submitted on October 3, 2016. An 8-person Review Panel was assembled comprised of representatives from CTSG, NYSG, LISS, CT DEEP, NY DEC, and three independent, academic reviewers. The Review Panel was held via webinar on December 9th, 2017. Proposals were evaluated and ranked. The top two ranked proposals were selected for full funding, however, there was some unallocated funds available after this initial allocation that made it possible to fund a portion of a 3rd proposal. All PIs were contacted regarding the funding outcome on December 16, 2016. Summaries of the Review Panel discussions and blinded peer reviews were sent to all PIs on January 11, 2017.

The funded projects included:

1) *How will sea level rise-driven shifts in wetland vegetation alter ecosystem services?* PIs Beth Lawrence, Ashley Helton, Chris Elphick of the University of Connecticut received $238,371 from LISS and $79,457 match from CIRCA, for a total of $317,828. Research conducted by these University of Connecticut researchers will increase our understanding and improve coastal management by explicitly quantifying the direct and indirect effects of sea level rise on carbon and nitrogen cycling. The results will be extended to a broad audience by developing a series of questions and problems for high school students that integrates a case study of how sea level rise is altering coastal ecosystems associated with Long Island Sound.

2) *Nutrient and Carbon Fluxes through Long Island Sound, Linking River Sources to Impacted Areas*. PIs Michael Whitney and Penny Vlahos of the University of Connecticut received $278,851. These University of Connecticut marine scientists will study sources, movement, and fates of nitrogen, phosphorus and carbon, as well as their flow from wastewater treatment plants, to understand the input from river sources and impacted areas. This will help determine the nature of sources and whether certain locations can store carbon. The results will inform management decisions for the Sound.

3) *Sources and fluxes of excess nitrogen supplied by fresh submarine groundwater discharge (FSGD) to Long Island Sound (LIS)*. PIs Troy Rasbury, Kirk Cochrane and Henry Bokuniewicz from Stony Brook University will receive $119,776 from LISS and utilize $39,775 in matching funds for their study. These researchers from Stony Brook University will use a unique combination of isotope tracers to fingerprint the sources of nitrogen to groundwater as well as processes that affect nitrogen concentrations. The team will be able to quantify atmospheric, septic, animal waste, and fertilizer sources of new nitrogen entering the Sound via groundwater discharge in three "hot spots" with varying land use: a residential area/ golf course, a park near a sewage treatment plant, and an agricultural area. Such source information is critical in developing management strategies to reduce nitrogen loadings.

It was decided that the funded researchers would not necessarily benefit from a PI meeting during the 1st year due to the topical differences in the foci of the research projects providing little room for collaboration or the sharing of samples, data and other resources. All PIs have completed QAPPs that have been approved by EPA and research efforts have been initiated. Ten month progress reports were solicited for January 2018 and received. Projects were determined to be making adequate yearly progress and year two funding has been made available to the PIs.

A meeting of LISS funded PIs was convened on August 6, 2018. CTSG, LISS staff, and CT-based PIs assembled at the Avery Point UConn to present an update on their research. NY-based PIs and NYSG staff convened at the Stony Brook University and the two groups were connected via web conferencing. The research presentations were made available to all attendees along with a request for confidentiality.

PI Beth Lawrence requested a one year no cost extension on the completion of her project and it was granted through February 2020. She submitted a progress report which is attached.

PI Whitney requested a one year no cost extension on the completion of his project and it was granted through February 2020. He submitted a progress report which is attached. His rationale was that they had been unable to conduct one of their planned survey sets that is necessary to link spring conditions in Central and Western Long Island Sound. Weather issues and boat-availability led

them to cancel the central sound survey and they were not able to reschedule within the targeted sampling window. Additionally, the team changed analysis methods and was forced to recalculate their direct atmospheric loads and the survey data revealed nutrient, carbon, and current patterns that had not been previously observed and this has increased the time needed to interpret it.

PI Rasbury has completed his project and his completion report is attached.

Work Plan Activity	Deliverable(s)	Timeline or % Time	Expected Output	Actual Output	Expected Outcome	Actual Outcome
Task:						
A. Select research projects through an open, competitive, peer reviewed process.	• Finalize priority list of topics for the Call for Pre-proposals with the STAC.	1. February 2016 STAC meeting	1-2. Deliverable: Call for Pre-proposals. • 3-7. Deliverable: List of research selected for funding.	RFP finalized in consultation with STAC winter/spring 2016	Highest priority research and assessment work relevant to the LISS CCMP and policy agreements is defined, openly-solicited, and selected for funding using a well-developed, respected process that is fair and technically-based.	Highest priority research and assessment work relevant to the LISS CCMP and policy agreements is defined, openly-solicited, and selected for funding using a well-developed, respected process that is fair and technically-based.
	• Distribute Call for Pre-proposals.	April,1 2016		• Distributed RFP March 24, 2016		
	• Pre-proposals due.	June 6, 2016		• 35 pre-proposals received on June 6, 2016		
	• Review panel screens pre-proposals, full proposals invited.	Aug. 8, 2016		• A Pre-Proposal Review Panel was assembled and met on August 8 to evaluate and rank the most meritorious pre-proposals. Nine PIs were encouraged to submit full proposals.		
	• Full proposals due.	Oct. 3 2016		• 13 Full Proposals received on October 3, 2016.		
	• Mail peer review interval	August-November 2016		• 3 mailed peer reviews solicited and received for each full research proposal submitted.		

Work Plan Activity	Deliverable(s)	Timeline or % Time	Expected Output	Actual Output	Expected Outcome	Actual Outcome
	• Review panel meets, funding decisions made, PIs notified.	October – December 2016		• Review Panel members solicited and Review Panel meeting convened December 9, 2016; PIs notified of selection results on Dec. 16, 2016. PIs sent review panel summaries and blinded peer reviews on January 11, 2017.		
Research B. Administer the selected projects	Award grant funds for Year 1	March 1, 2017	• 1-7. Deliverables: 2 progress reports and 1 final report per research project.	• Research funding available for researchers on March 1.	New science-based information will be provided to inform decision-making and actions towards reaching the vision and goals for Long Island Sound.	•
	• Convene meeting of all PIs to share plans and look for collaborations.			• No PI meeting convened since it was determined there was little commonality among research topics.		•
	• 10-month progress report requested and due; SG shares report with STAC and LISS office.			10 month progress reports received by February 2018.		•
	• Evaluate for sufficient progress.			Research projects were assessed and deemed to have made adequate yearly progress		•
	• Award grant funds for Year 2.			Year 2 funding has been made available to PIs.		•
	• Convene meeting of all PIs to share preliminary results			A meeting of the PIs was convened on Aug. 6, 2018. CT based PIs assembled at the Avery Point UConn		•
	• 22-month progress			•		•

Work Plan Activity	Deliverable(s)	Timeline or % Time	Expected Output	Actual Output	Expected Outcome	Actual Outcome
	report requested and due; SG shares with STAC and LISS office.					
	• Research project end date.			•		•
	• Final Report requested and due; SG shares report with STAC and LISS office.			•		•

8. **Challenges/Changes:** *Address difficulties you have encountered in carrying out this project, any slippages in meeting stated outputs or outcomes, and remedial actions (to be) taken. If the aims of the project have not changed from the original application, state this. If these have been modified, provide the revised aims and discuss the reason for the modification.*

   Both projects have requested and been granted one-year no-cost extensions to enable them to complete their work and expend all funds.

9. **Participants:** *Provide basic information about each person who worked on the project – name, role on project, extent of time put in, and what the person has done on the project. Discuss any absence or changes of key personnel involved in the project. Describe the role of any partner organizations (if applicable) that have been involved with the project. Partner organizations may provide financial or in-kind support, supply facilities or equipment, or otherwise contribute.*

   Sylvain De Guise worked on this project in the capacity of CTSG's Director. He was involved with: RFP development, review of proposals, selection of proposals for funding.

   Syma Ebbin, CTSG Research Coordinator worked on this project and was substantially involved with the development, distribution and web posting of the RFP, review of proposals, selection of proposals for funding.

   Michelle MarcAurele, CTSG Fiscal Officer, also assisted in RFP development and dissemination.

10. **Quality Assurance:** *If applicable, address how the requirements of the Quality Assurance Project Plan (if applicable) are being met.*

    CTSG administered PIs have completed QAPPs for their research activities. These QAPPS have been reviewed and approved by EPA.

11. **Funding Status:** *Describe any funding issues that have affected your progress toward stated goals and provide information on changes that need to be made or have been made to the budget. Pay particular attention to percent of fund remaining against percent of project period remaining.*

    Budget expenditures are on track. No changes are needed or expected.

12. **Future Activities/Events:** *Describe any significant planned activities or events for the next reporting period that may be of general or public interest, e.g., press events, workshops, conferences, training sessions, webinars etc*.

13. **Presentations/Publications/Outreach:** *Describe any major presentations you have made about your project and discuss any outreach efforts related to this project. Provide copies of any publications produced as part of the project or provide links or web addresses. Report any articles or papers resulting*

from this project appearing in scientific, technical, or professional journals, if applicable. Copies of publications and reprints that have not previously been submitted should be enclosed with the report.

See attached research progress reports for a listing of presentations and publications.

14. **Other Information:** *Attach any materials that represent or highlight project accomplishments during the reporting period or that support the explanations provided above*.

NYSG Completion Report

Report Written By: Troy Rasbury, Henry Bokuniewicz and J.Kirk Cochran **Date:** 1/2/19

A. Project Number and Title: : R/CMC-13-NYCT Sources and fluxes of excess nitrogen supplied by fresh submarine groundwater discharge (FSGD) to Long Island Sound (LIS)

B. Project Personnel:

Principal Investigator: Troy Rasbury
Co-Principal Investigator: J. Kirk Cochran
Co-Principal Investigator: Henry Bokuniewicz
Sea Grant Scholar: Caitlin Brown

C Project Results:

C1. Meeting the Objectives:

Objective 1: "Quantify the flux of fresh submarine groundwater discharge (FSGD) at three "hot-spots" along the shoreline of Long Island Sound (LIS), which have been identified in our preliminary research using thermal infrared (TIR) imagery, surveys of radon-222 and vented-benthic chambers [aka seepage meters]".

Seepage meters. Seepage meter measurements of total SGD fluxes were extrapolated to a distance of 200 m offshore to an 8.35 km shoreline to incorporate discharge from changing land use from surrounding areas. Seepage meters at Callahans beach gave an up-scaled total SGd flux between (4.2 ± 1.7) $*10^8$ m^3 y^{-1} and (1.9 ± 1.2) $*10^8$ m^3 y^{-1} during June, while the mean freshwate of SGD was between (0.10 ± 0.12)and (0.16 ± 0.09). Total scaled up SGD fluxes from seepage meters at Iron Pier Beach were (0.69 ± 0.00) 10^8 m^3/yr in July and (0.65 ± 0.07) 108 m3/yr in September with freshwater fluxes of (0.07 ± 0.00) 10^8 m3/yr in July and (0.03 ± 0.02) 108

m3/yr in September.

*Radionuclides.*At Callahans Beach, pore water 222Rn activity ranged from 814 to 5836 Bq/m3 and generally increased with depth in the sediment until a depth of 6 m after which activity decreases. At Iron Pier Beach, pore water 222Rn activity ranged from 525 to 2890 Bq/m^3 and showed a maximum at 3 m depth.

Submarine groundwater discharge fluxes were calculated by short-lived radionuclide 222Rn. These SGD fluxes are on the same order of magnitude as those calculated from seepage meters. Total SGD fluxes in July were (0.40 ± 0.26) *108 m^3/yr and were greater than total fluxes in September. Freshwater SGD fluxes of nitrogen calculated from 222Rn measurements were the same within error in July and in September.

Objective 2: "Characterize the nitrogen (N) loading to Long Island Sound via FSGD at these locations". Both Callahans Beach and Iron Pier Beach had well-oxygenated, low salinity, and low pH pore water. Because the porewater were well oxygenated, the dominant form of nitrogen was nitrate. Scaled up freshwater SGD nitrogen fluxes were (9.82 ± 3.37)*10^6 mol N/yr and were greater than the scaled up freshwater SGD nitrogen fluxes in September, which were (3.27 ± 1.52)*10^6 mol N/yr. Nitrogen fluxes from freshwater SGD are also the same order of magnitude as previous estimates reported by Tamborski et al. (2017) for Smithtown Bay. The SGD nitrogen flux at Iron Pier Beach was higher than other reported fluxes on Long Island probably because of the higher concentrations observed in groundwater measurements in the agricultural areas of eastern Suffolk County than in the residential areas of western Suffolk County. Callahans Beach was located immediately adjacent to a golf course within a low density residential area. Lower nitrogen fluxes at Callahans Beach may suggest less frequent applications of fertilizer or less leaching from septic tanks.

Objective 3: "Use N, O, and B isotopic ratios to characterize the non-point sources of N in the FSGD" Nitrogen and oxygen isotopes were measured to distinguish potential anthropogenic sources of nitrates. The nitrogen and oxygen isotope signatures of porewater collected at Callahans Beach (δ15N=1.9‰–4.7‰, δ18O=-0.4‰–4.7‰) showed no seasonal trends or trends

with depth. Samples from both Callahans Beach and Iron Pier Beach (δ15N=0.6‰–5.0‰, δ18O=-0.2‰–7.0‰) are consistent with isotopic signatures of an ammonium fertilizer source or nitrification of an ammonium fertilizer source or septic source.

Pore water from Iron Pier Beach also have similar δ15N-NO3 and δ18O-NO3 values as Callahans Beach. There are no seasonal changes in δ15N-NO3 and δ18O-NO3, but samples at 1.5 m and 4.5 m depth have a similar δ15N-NO3 and δ18O-NO3 signature to samples from Callahans Beach, while samples at 3.0 m depth have a higher δ18O signature. The pore water at 1.5 m depth has a lower δ15 N value relative to the other pore water samples at Iron Pier Beach perhaps because of nitrification processes within the aquifer at a shallow depth where oxic conditions persisted.

Higher values of δ18O may be due to denitrification or the δ15N and 1δ8O in the pore water may have been influenced by a leaky, very small, confining unit immediately above or below 3 m depth.

Boron Isotopes: When pore water samples are the δ11B and δ15N-NO3 from both Callahans Beach and Iron Pier Beach fell within the mineral fertilizer source field or between mineral fertilizer and seawater. Some samples just fall within source fields of septic and manure waste, but the average δ11B suggested that seawater, not septic waste or manure, is the source of the elevated δ11B in porewater samples from both beaches.

Most pore water samples from Callahans Beach and Iron Pier beach lie along vertical mixing curves between seawater and a groundwater source that is influenced by a hypothetical mineral fertilizer. The elevated δ11B values at Callahans Beach indicates a larger input of seawater than pore water samples from Iron Pier Beach. This may be due to sea spray. Mixing processes and time within the STE is another possible reason for Callahans Beach high δ11B values. Plotting boron isotopes against oxygen isotopes suggested mixing between seawater and mineral fertilizer best describes the data.

C2. **Scientific Abstract:** Submarine groundwater discharge (SGD) is an important source of freshwater and nutrients into Long Island Sound, yet has been underestimated in nitrogen budgets. New total SGD and freshwater fluxes are presented for Iron Pier Beach, which is located in an agricultural area on the north fork of Long Island. Freshwater fluxes calculated from seepage meter measurements

yield (0.03–0.07)*10^8 m^3/yr and are consistent with fluxes reported at Callahans Beach. Terrestrial fluxes calculated from 222Rn total SGD fluxes are on the same order of magnitude as those calculated from seepage meters. Estimates of nitrogen fluxes from terrestrial SGD, (3.27–9.82) *10^6 mol N/yr, are also greater than previous estimates at other points along the north shore. Based on stable isotopes, δ15N, δ18O, δ11B, nitrogen fluxes at Callahans Beach and Iron Pier Beach are derived primarily from ammonium fertilizers. At Callahans Beach, there is greater mixing between groundwater and seawater than at Iron Pier Beach, based on δ11B and boron concentrations, either due to greater influence of sea spray or from differences in pore water residence time. Boron isotopes were successfully used as a supplement to δ15N-δ18O measurements to determine anthropogenic sources of nitrogen contamination in groundwater. However, in a coastal setting, boron isotopes from seawater may overwhelm the δ11B, making identification of anthropogenic sources difficult based on δ15N, δ18O, and δ11B alone.

C3. **Problems Encountered:** Sampling installations were lost in Port Jefferson Harbor; they could not be maintained, reinstalled, so sampling had to be suspended here. Vandals pulled out Iron Pier Beach wells between July and August but they were reinstalled successfully in September. Because of overlap between the isotopic composition of different sources, it could not be unequivocally determined if the dominant isotopic signature at Callahans Beach and Iron Pier beach was mineral fertilizer or the result of a process, in the STE, such as mixing or the nitrification of septic or animal waste.

C4. **New Research Directions:** While boron isotopes have been used successfully in groundwater to identify anthropogenic sources of nitrogen, high boron concentrations in seawater will overwhelm the signature of groundwater, making it difficult to separate and identify sources. Because of this, it may be necessary to use additional markers to trace nitrates in coastal areas, especially when considering areas where fertilizers and sewage and animal waste may be the dominant source of nitrates and are indistinguishable using N-O isotopes. Fecal indicators such as pharmaceuticals and metabolites are also useful in separating out animal waste and human waste due to differences in types of pharmaceuticals used for animals and people and differences in the metabolites that are produced. Pharmaceuticals and metabolites can be conservative in both groundwater and seawater

therefore sources are identifiable despite biological activity in groundwater. Coastal groundwater near the unsewered Northport Harbor was found to contain an anticonvulsant compound in groundwater samples but no pesticides, indicating that wastewater or septic waste could be contributing more nitrogen into the harbor than fertilizer. Previous studies were unable to distinguish between septic waste and fertilizer using N and O isotopes alone. Pharmaceutical may be a more efficient, direct way of identifying anthropogenic sources of nitrates than boron is.

C5. Interactions: LISS 2017-2019 Research: PIs Meeting, August 6, 2018

C6. Presentations and Publications:

Brown, C., 2018. Using Boron to Trace Anthropogenic Sources of Nitrogen in Long Island Sound, MS Thesis, Stony Brook University: 66pp.

Bokuniewicz, H, 2018. Using N, O, and B isotopes to identify anthropogenic sources of nitrogen entering Long Island Sound via freshwater SGD. Presentation, Long Island Sound project meeting August 6.

In preparation: Brown, C., H. Bokuniewicz, J.K.Cochran, T. Rasbury, 2019. Isotopic Tracers of Nitrogen Sources Supplied by Submarine Groundwater Discharge to Coastal Waters. For: Frontiers in Environmental Science, Groundwater Resources and Management.

D. Accomplishments:

D1. Impacts & Effects: Isotopic tracers suggested that nitrate in SGD was dominated by fertilizer inputs. Other chemical tracers may be more effective in distinguishing septic sources

D2. Scholar(s) Status: Analytical Chemist at US Environmental Protection Agency (EPA)

D3. Patents: None

E. Stakeholder Summary:

F. Pictorial:

Study site on Long Island’s north shore

HB/ed 2CompletionReportJAN2019

CONNECTICUT SEA GRANT PROJECT REPORT

Please complete this progress or final report form and return by the date indicated in the emailed progress report request from the Connecticut Sea Grant College Program. Fill in the requested information using your word processor (i.e., Microsoft Word), and e-mail the completed form to Syma Ebbin (syma.ebbin@uconn.edu), Research Coordinator, Connecticut Sea Grant College Program. Do NOT mail or fax hard copies. Please try to address the specific sections below. If applicable, you can attach files of electronic publications when you return the form. If you have questions, please call Syma Ebbin at (860) 405-9278.

Please fill out all of the following that apply to your specific research or development project. Pay particular attention to goals, accomplishments, benefits, impacts and publications, where applicable.

Name of Submitter: Michael M. Whitney

Date of Report submission: 1/14/19

Project #: R/CMC-14-CTNY Check one: [X] Progress Report [ ] Final report

Duration (dates) of entire project, including extensions: From [3/1/17] to [2/28/19].

Project Title or Topic: Nutrient and Carbon Fluxes through Long Island Sound, Linking River Sources to Impacted Areas

Principal Investigator(s) and Affiliation(s):

1. Michael M. Whitney (UCONN, Department of Marine Sciences)

2. Penny Vlahos (UCONN, Department of Marine Sciences)

A. <u>COLLABORATORS AND PARTNERS</u>: *(List any additional organizations or partners involved in the project.)*

John Mullaney, CT USGS

B. PROJECT GOALS AND OBJECTIVES:

Objectives:

1. Quantify the nitrogen, phosphorus, and carbon fluxes through across-estuary sections bounding the eastern, central, and western Long Island Sound (LIS) basins by combining data from the CT-DEEP LIS Water Quality Monitoring Program, new observations, and an existing hydrodynamic model.

2. Link inter-basin nutrient fluxes to individual major-tributary, coastal-river, and major-WWTP sources using calculated fluxes, observed loads, and model-based river-water tracers.
3. Determine if and to what extent each basin is net heterotrophic, indicating eutrophication, using net organic carbon fluxes and relating these conditions to nutrient fluxes and sources.

The scientific methods are designed to complete the project objectives and test the following hypotheses: **H1)** The Housatonic, Southwest coastal rivers, and incoming Hudson and WWTP waters through the East River transport the highest nutrient concentrations (and stratification) into western LIS. **H2)** Much of the Connecticut River nutrient load is mixed with incoming shelf water and transported into central LIS and only a small fraction reaches western LIS within a month of entering the estuary. **H3)** The western LIS shifts from net autotrophic to heterotrophic (representing a net carbon sink) during summer due to organic carbon inputs from the central LIS and East River. **H4)** The eastern and central LIS remain net autotrophic (carbon exporters) throughout the spring and summer. Education and outreach efforts include: 1) a new UCONN course and companion open-source web videos designed around the book *Long Island Sound: Prospects for an Urban Sea*, 2) A Coastal Perspectives Lecture featuring a panel discussion on LIS nutrient and carbon issues, and 3) a workshop with scientists and managers to discuss results in the context of LIS management.

C. <u>PROGRESS</u>: (*Summarize progress relative to project goals and objectives. Highlight outstanding accomplishments, outreach and education efforts; describe problems encountered and explain any delays.)*

We have conducted three field surveys in Western Long Island Sound (October 2017, June 2018, and August 2018) and one field survey in Central Long Island Sound (August 2018). Samples for carbon and nutrients along with shipboard measurements of currents and physical water properties were collected. The bounding sections were across the sound near Execution Rocks and near the Throgs Neck Bridge. The currents and physical water properties have been processed and quality controlled. The carbon and nutrient analysis of water samples has been completed and quality controlled. These data have been combined with the water currents to compute fluxes through the western Long Island Sound and estimate the carbon and nitrogen budgets.

Working with John Mullaney (USGS) we calculated a time series of nitrogen loading to Long Island Sound. The methods involved extending the approach Mullaney used previously for Connecticut watersheds and including results of recent LISS work by Jamie Vaudrey. The loading time series now spans 1994 to 2016. Direct atmospheric loading has been calculated using wet and dry deposition of nitrogen based on data from the National Atmospheric Deposition Program.

The hydrodynamic model has been run for the 1994 to 2016 period and been compared to and then calibrated to CT-DEEP hydrographic observations and NOAA tidal observations. Nitrogen budgets using this loading, hydrodynamic model results, and CT-DEEP Long Island Sound Monitoring station data have been completed for years 1994 to 2016.

Project results and the overall project goals were included with related CTSG project results in an oral and poster presentations at the AGU Fall Meeting 2017, LISS PI meeting, Ocean Sciences 2018, Physics of Estuaries and Coastal Seas 2018 Meeting, and the AGU Fall Meeting 2018.

One major finding is nitrogen concentrations in Long Island Sound have decreased as loading from the East River (predominantly from NYC wastewater treatment plants) has decreased through nitrogen management. As East River has decreased, other nitrogen sources (chiefly local rivers and direct atmospheric inputs) have become relatively more important to the total nitrogen budget. Our observations show nutrients from the East River are quickly attenuated as they enter Western Long Island Sound and confirm nitrogen limitation in this area. A major finding for the entire Long Island Sound nitrogen budget is about a third of the loading is exported to the shelf and the rest is consumed, buried, or denitrified.

Our major issue is we unable to conduct all of the field surveys because of weather issues and ship availability. We also need to complete analysis and write-up of our project results We are requesting a no-cost-extension to complete a field survey of Central and Western Long Island Sound in May 2019 and complete analysis and write-up of results.

D. <u>PROJECT PUBLICATIONS, PRODUCTS, PRESENTATIONS AND PATENTS</u>: *(Include published materials with complete references, as well as those which have been submitted but not yet published and those in press. Please attach electronic versions of any journal articles, reports, and abstracts not previously provided.)*

Journal Articles (List URLs): None

Conference Papers: None

Proceedings or book chapters: None

Web sites, Software, etc.: https://cprime.uconn.edu/nitrogen

Technical Reports/Other Publications: None

Other Products (including popular articles):

Benson, J. Chemistry in Motion, *Wracklines*, CTSG, 17 (2), 7-9. https://seagrant.uconn.edu/wp-content/uploads/sites/1985/2017/12/wracklines-Fall2017-web.pdf

Publications planned / in progress: Vlahos, Whitney, Mullaney, Menniti, Nitrogen Loading and Transport in Long Island Sound, L*imnology and Oceanography*, in prep.

Menniti, Whitney, and Vlahos, Linking nitrogen management to decreases in nitrogen and hypoxia in western Long Island Sound, *Environmental Management*, in prep.

Byrd, Vlahos, Whitney, Warren, High-Resolution Observations of Organic Carbon Exchange through the Eastern Long Island Sound Shelf Boundary, Estuaries, in prep.

Byrd, Vlahos, Whitney, Warren, High-Resolution Observations of Nitrogen and Phosphorus Exchange through the Eastern Long Island Sound Shelf Boundary, Estuaries, in prep.

Patents: None

Presentations and Posters:

Vlahos and Whitney, Variations in organic carbon fluxes from Long Island Sound to the Continental Shelf, AGU Fall Meeting 2017, Oral Presentation.

Byrd, Vlahos, Whitney, Warren, Carbon, Nitrogen, and Phosphorus Exports from Long Island Sound to the Mid-Atlantic Bight, Oral Presentation.

Byrd, Warren, Vlahos, Whitney, Constraining the Exchange of Carbon and Nitrogen in Eastern Long Island Sound, AGU Fall Meeting 2017, Oral Presentation.

Vlahos, Whitney, Mullaney, Morrison, Menniti, Nitrogen Budgets in the Long Island Sound Estuary, Ocean Sciences 2018, Poster Presentation.

Whitney, Vlahos, Menniti, Byrd, River influences on Nitrogen and Organic Carbon Fluxes in Long Island Sound, Physics of Estuaries and Coastal Seas 2018, Oral Presentation.

Vlahos, Whitney, Mullaney, Morrison, Menniti, Resolving Shifting Nitrogen Budgets of the Long Island Sound Estuary, AGU Fall Meeting 2018, Poster Presentation.

Byrd, Vlahos, Whitney, Nutrient Exchange in Western Long Island Sound through the Highly Urbanized East River Tidal Strait, AGU Fall Meeting 2018, Oral Presentation.

E. <u>FUNDS LEVERAGED</u>: *(If this Sea Grant funding facilitated the leveraging of additional funding for this or a related project, note the amount and source below.)*

None

F. <u>STUDENTS</u>: ***(****Document the number and type of students supported by this project.)*
*Note: **"Supported"** means supported by Sea Grant through financial or other means, such as Sea Grant federal, match, state and other leveraged funds. "**<u>New"</u>** students are those who **have <u>not</u>** worked on this project previously. "**<u>Continuing"</u>** students are those who **have** worked on this project previously. If a student volunteered time on this project, please use section G, below.*

Total number of **new*** K-12 students who worked with you: 0
Total number of **new** undergraduates who worked with you: 0
Total number of **new** Masters degree candidates who worked with you: 0
Total number of **new** Ph.D. candidates who worked with you: 0

Total number of **continuing**** K-12 students who worked with you: 0
Total number of **continuing** undergraduates who worked with you: 1
Total number of **continuing** Masters degree candidates who worked with you: 0
Total number of **continuing** Ph.D. candidates who worked with you: 2

Total number of volunteer hours: 0

*(Note: ***New** students are those who have not worked on this project previously. ****Continuing** students are those who have worked on this project previously.)*

In the case of graduate students, please list student names, degree pursued, and thesis or dissertation titles related to this project.

Student Name: Allison Byrd
Degree Sought: PhD Oceanography
Thesis or Dissertation Title: TBD
Date of thesis completion: 5/15/22
Expected date of graduation: 5/15/22

Student Name: Allison Staniec
Degree Sought: PhD Oceanography
Thesis or Dissertation Title: TBD
Date of thesis completion: 5/15/20
Expected date of graduation: 5/15/20

G. VOLUNTEER HOURS:

(List the number of hours provided to the project by volunteers, i.e., individuals who were not compensated in any way or for whom involvement is not part of their paid occupation. This could be students or citizens. What was their contribution?)

None

H. PICTORIAL: Please provide high resolution images/photos of personnel at work, in the field or laboratory, equipment being used, field sites, organism(s) of study. Attach images as separate files (do not embed). Include links to websites associated with the research project. Please include proper photo credits and a caption with date, location, names of people, and activity. These images are useful to document your project in future CTSG publications, websites and presentations.

https://cprime.uconn.edu/nitrogen

https://seagrant.uconn.edu/wp-content/uploads/sites/1985/2017/12/wracklines-Fall2017-web.pdf

I. HONORS AND AWARDS: *(List any honors or awards received during the reporting period, for anyone working on the project. This can be for best paper or poster, university awards, etc.*) Specify:

a) Name of person or group receiving recognition: N/A
b) Name of award or honor: N/A
c) Group or individual bestowing the award or honor: N/A
d) What it was for: N/A
e) Date: N/A

CONNECTICUT SEA GRANT PROJECT REPORT

Please complete this progress or final report form and return by the date indicated in the emailed progress report request from the Connecticut Sea Grant College Program. Fill in the requested information using your word processor (i.e., Microsoft Word), and e-mail the completed form to Syma Ebbin (syma.ebbin@uconn.edu), Research Coordinator, Connecticut Sea Grant College Program. Do NOT mail or fax hard copies. Please try to address the specific sections below. If applicable, you can attach files of electronic publications when you return the form. If you have questions, please call Syma Ebbin at (860) 405-9278.

Please fill out all of the following that apply to your specific research or development project. Pay particular attention to goals, accomplishments, benefits, impacts and publications, where applicable.

Name of Submitter: Beth Lawrence

Date of Report submission: February 28, 2019

Project #: R/CMB-42-CTNY Check one: [x] Progress Report [ ] Final report

Duration (dates) of entire project, including extensions: From [3/1/2017] to [2/28/2020].

Project Title or Topic: How will sea level rise-driven shifts in wetland vegetation alter ecosystem services?

Principal Investigator(s) and Affiliation(s):

1. Beth Lawrence/University of Connecticut/Dept. of Natural Resources & Environment, Center for Environmental Science & Engineering

2. Ashley Helton/University of Connecticut/ Dept. of Natural Resources & Environment, Center for Environmental Science & Engineering

3. Chris Elphick/University of Connecticut/ Dept. of Ecology & Evolutionary Biology, Center of Biological Risk

A. <u>COLLABORATORS AND PARTNERS</u>: *(List any additional organizations or partners involved in the project.)*

- Kimberly Williams, Smithtown High School
- Cadence Cambrial, North Haven High School
- Natural Resources Conservation Academy
- Roger Wolfe, CT DEEP

B. PROJECT GOALS AND OBJECTIVES:

Our overarching objectives are to quantify carbon (C) and nitrogen (N) cycling services in Long Island Sound (LIS) tidal marshes, project how those services will change under sea-level rise (SLR) scenarios, and develop educational materials to better communicate these changes and their implications to high school students. Specifically, the original objectives of the project were to:

1. Quantify carbon- and nitrogen-based services provided by dominant coastal marsh plant species.
2. Forecast how shifts in dominant marsh species will alter ecosystem service provision of LIS coastal wetlands.
3. Promote understanding of the complex interactions among climate change, SLR, coastal wetlands, and ecosystem services among diverse audiences in the LIS region.

C. <u>PROGRESS</u>: (*Summarize progress relative to project goals and objectives. Highlight outstanding accomplishments, outreach and education efforts; describe problems encountered and explain any delays.)*

We have made great progress in achieving the majority of our project milestones. The majority of our efforts to date have been focused on the collection of empirical data via a field survey and marsh organ experiment related to objective 1. Now that we have finished up our data collection in the field and are finalizing laboratory analysis, we are developing ecosystem service maps (Obj. 2), developing the climate change outreach module with regional high school teachers (Obj. 3), and preparing manuscripts for publication in the peer reviewed literature (Obj. 3). However, since this will require additional time beyond the original Feb. 28, 2019 project end date, we requested (and were granted) a one-year no cost extension in order to meet the project objectives.

<u>*Year 1*</u>: We developed and received EPA approval for our QAPP in April 2017. Two MS-level graduate students began working on the project during summer 2017 and were integral to the site selection process. We received permission to sample from candidate sites, and during August 2017, we began our coastal wetland field campaign to investigate the role of tidal restoration and vegetation zonation on carbon and nitrogen-based ecosystem services. We sampled a total of 20 sites (10 restored, 10 unrestored) for a range of biological (% plant cover, above- and below-ground biomass, microbial community composition), soil physical and chemical parameters (pH, EC, SO_4^-, Cl^-, NO_3^-, NH_4^+, %OM, total C and N), and microbial process rates (denitrification, substrate induced respiration, carbon mineralization).

Given time and logistical constraints, we were unable to sample the total number of sites that we had intended to sample; we had proposed to sample 30 sites (10 unrestored sites, 10 tidally restored, 10 *Phragmites*-herbicide sites), but only sampled 20 (10 unrestored, 10 tidally restored). The *Phragmites* management sites were typically brackish marshes (more inland) where tidal flow restoration was not an option, and did not have all three plant species of interest (*Spartina alterniflora, Spartina patens*, and *Phragmites*). The on-the-ground reality of the marshes did not conform to our proposed experimental design. We considered sampling the *Phragmites* management sites differently, by comparing herbicide-managed areas with

Phragmites-dominated areas and native-dominated areas within each site. However, this experimental design addresses a different question than the one we proposed; thus, given time constraints, we did not pursue it in 2017.

Year 2: We conducted a marsh organ experiment at Barn Island NWR (Stonington, CT) during the 2018 growing season to test the interactive effects of sea-level rise and plant species composition. Manipulating the elevation of the marsh by installing PVC pipes of different heights allowed us to examine how different flooding frequencies altered plant biomass allocation patterns, as well as the suite of soil physical and chemical parameters measured during Year 1 of the project. Preliminary findings indicate that carbon-based microbial processes were more greatly affected by plant treatment than by SLR treatments, highlighting the importance of plant-mediated ecosystem services. We are in the process of wrapping up laboratory analyses associated with these samples, and have been working with our QA officer (Dr. Lauren Koenig; see attached letter) to ensure high quality data.

We made significant progress on Obj 3 this year. We presented our preliminary research findings to a wide variety of audiences during ten oral presentations in 2018 (see list below). MS students Aidan Barry and Sean Ooi served as "community partners" for the Natural Resources Conservation Academy's Conservation Ambassador Program, mentoring a high school student on a salt marsh ecology project. Additionally, we had a workshop with partner teachers in January 2019 to develop plans for the interactive climate change module; we identified learning objectives, outlined module components, created a time line and assigned tasks. We will reconvene in summer 2019 to finalize module development and implement the rollout to a variety of online platforms.

D. PROJECT PUBLICATIONS, PRODUCTS, PRESENTATIONS AND PATENTS:
(Include published materials with complete references, as well as those which have been submitted but not yet published and those in press. Please attach electronic versions of any journal articles, reports, and abstracts not previously provided.)

Journal Articles (List URLs): NA

Conference Papers: NA

Proceedings or book chapters: NA

Web sites, Software, etc.: NA

Technical Reports/Other Publications: NA

Other Products (including popular articles):

- "Scientists investigate effects of sea level rise on coastal wetlands." Naturally@UConn article (College of Agriculture, Health and Natural Resources), available at: https://naturally.uconn.edu/2017/07/04/scientists-investigate-effects-of-sea-level-rise-on-coastal-wetlands/

- "Connecticut's Marshes: Past, Present, and Uncertain Future." UConn Today article, available at: https://today.uconn.edu/2018/11/connecticuts-marshes-past-present-uncertain-future/

Publications planned / in progress:

- Barry, A., Ooi, S., Elphick, C., Helton, A., Stevens, B. and B. Lawrence. *In prep.* Salt Marsh Vegetation Influence on Carbon-based Services and Microbial Communities.
- Barry, A., Ooi, S., Elphick, C., Helton, A., Stevens, B. and B. Lawrence. *In prep.* Plant-mediated carbon turnover overrides effects of sea level rise in a salt marsh field experiment
- Ooi, S., Barry, A., Elphick, C., Lawrence, B., and A. Helton. *In prep.* Potential denitrification rates vary with dominant vegetation zones in southern New England coastal salt marshes.

Patents: *(List those awarded or pending as a result of this project.)*: NA

Presentations and Posters: *(Include name and date of the conference or meeting, whether it was a talk or poster, if it was invited, and who the presenter was.*):

1. Lawrence, B. (presenter), Helton, A, Elphick, C. How will sea-level rise driven shifts in wetland vegetation alter carbon and nitrogen based ecosystem services? Long Island Sound Study, Science Technical Advisory Committee meeting (invited talk). November 16, 2018, Groton, CT.
2. Lawrence, B. (presenter). Marsh madness: invasive macrophytes and ecosystem service tradeoffs during wetland restoration. Carey Institute of Ecosystem Studies Fall Seminar Series (invited talk). November 2, 2018, Millbrook, NY
3. *Barry, A (presenter), *Ooi, S., Elphick, C., Helton, A. Steven, B., Lawrence, B. Salt marsh vegetation influence on carbon-based services and microbial communities. Connecticut Symbiosis Symposium (invited talk). October 2018. Connecticut Agricultural Experiment Station, New Haven, Connecticut.
4. *Ooi, S, Barry A (co-presenters), Steven B, Elphick C, Helton A, Lawrence B. Effects of salt marsh tidal restoration on soil microbial process rates. Society of Ecological Restoration- New England Chapter Meeting (poster). October 2018. New Haven, CT
5. Lawrence, B. (presenter), Helton, A, Elphick, C. How will sea-level rise driven shifts in wetland vegetation alter carbon and nitrogen based ecosystem services? New York-Connecticut Sea Grant & Long Island Sound Study Principal Investigator Forum (invited talk). August 6, 2018, Groton, CT
6. *Barry, A. (presenter), *Ooi, S., Elphick, C., Helton, A. Steven, B., Lawrence, B. Salt marsh vegetation influence on carbon-based services and microbial communities. Society of Wetland Scientists Annual meeting (talk). June 2018. Denver, Colorado.
7. Lawrence, B (presenter). Towards a conceptual framework for understanding tradeoffs in biodiversity and carbon function in coastal wetlands. Society of Wetland Scientists Annual meeting (talk). June 2018. Denver, Colorado.

8. *Ooi, S. (presenter), *Barry, A., Lawrence, B., Elphick, C., Helton, A. Potential denitrification rates vary with salt marsh vegetation zones. Society of Wetland Scientists Annual meeting (talk). June 2018. Denver, Colorado.
9. *Barry, A (presenter), *Ooi, S., Elphick, C., Helton, A. Steven, B., Lawrence, B. Salt marsh vegetation influence on carbon-based services. New England Estuarine Research Society Spring 2018 Meeting. April 27, 2018. Portsmouth, New Hampshire.
10. *Ooi, S. (presenter), *Barry, A., Lawrence, B., Elphick, C., Helton, A. Potential denitrification rates vary with salt marsh vegetation zones. New England Estuarine Research Society Spring 2018 Meeting. April 27, 2018. Portsmouth, New Hampshire.
11. *Barry, A. (presenter), *Ooi, S., Elphick, C., Helton, A. Steven, B. Lawrence, B. Salt marsh vegetation influence on carbon-based services. Connecticut Conference on Natural Resources. March 12, 2018. Storrs, Connecticut.
12. *Ooi, S. (presenter), *Barry, A., Lawrence, B., Elphick, C., Helton, A. Potential denitrification rates vary with salt marsh vegetation zones. Connecticut Conference on Natural Resources (talk). March 12 2018. Storrs, Connecticut.
13. Ooi, S. (presenter), Barry, A., Helton, A., Elphick, C, and Lawrence, B. How does shifting wetland vegetation influence nutrient cycling in Connecticut coastal marshes? Joint Natural Resources and Environmental Engineering Graduate Student Symposium (poster). September 2017. University of Connecticut, Storrs, CT.
14. Lawrence, B. (presenter), Helton, A, and Elphick, C. How will sea-level driven shifts in wetland vegetation alter carbon and nitrogen based ecosystem services? Connecticut Institute for Resilience and Climate Adaptation Forum (invited poster). May 2017. University of Connecticut, Storrs, CT.

E. <u>FUNDS LEVERAGED</u>: *(If this Sea Grant funding facilitated the leveraging of additional funding for this or a related project, note the amount and source below.)*

- We received 25% match ($79, 457) for this project from Connecticut Institute for Resilience and Climate Adaptation (CIRCA)
- B. Lawrence received Development Funds ($2,981) from Connecticut Sea Grant. "Translating climate science to high school audiences: developing a regionally relevant climate change module for southern New England." November 30, 2018- September 1, 2019.
- UConn Work-Study program. Undergraduate research assistant processing project-related samples (~8 hours/week x 14 weeks x 2 semesters= ~224 student technician hours). August 2018- May 2019.

F. <u>STUDENTS</u>: ***(****Document the number and type of students supported by this project.)*
*Note: **"Supported"** means supported by Sea Grant through financial or other means, such as Sea Grant federal, match, state and other leveraged funds. "**<u>New"</u>** students are those who **have <u>not</u>** worked on this project previously. "**<u>Continuing"</u>** students are those who **have** worked on this project previously. If a student volunteered time on this project, please use section G, below.*

Total number of **<u>new*</u>** K-12 students who worked with you: 1
Total number of **<u>new</u>** undergraduates who worked with you: 4

Total number of **new** Masters degree candidates who worked with you: 0
Total number of **new** Ph.D. candidates who worked with you: 0

Total number of **continuing**** K-12 students who worked with you: 0
Total number of **continuing** undergraduates who worked with you: 1
Total number of **continuing** Masters degree candidates who worked with you: 2
Total number of **continuing** Ph.D. candidates who worked with you: 0

Total number of volunteer hours: 80

*(Note: ****New*** *students are those who have not worked on this project previously.*
******Continuing*** *students are those who have worked on this project previously.)*

In the case of graduate students, please list student names, degree pursued, and thesis or dissertation titles related to this project.

Student Name: Aidan Barry
Degree Sought: MS
Thesis or Dissertation Title: Salt Marsh Vegetation Influence on Carbon-based Services and Microbial Communities
Date of thesis completion: NA
Expected date of graduation: June 2019

Student Name: Sean Khan Ooi
Degree Sought: MS
Thesis or Dissertation Title: Potential denitrification rates vary with dominant vegetation zones in southern New England coastal salt marshes
Date of thesis completion: NA
Expected date of graduation: June 2019

G. VOLUNTEER HOURS:

An undergraduate student helped collect and process samples during 2017 (80 hours).

H. PICTORIAL:

Please provide high resolution images/photos of personnel at work, in the field or laboratory, equipment being used, field sites, organism(s) of study. Attach images as separate files (do not embed). Include links to websites associated with the research project. Please include proper photo credits and a caption with date, location, names of people, and activity. These images are useful to document your project in future CTSG publications, websites and presentations.

- Lawrence Lab website: https://lawrencelabuconn.weebly.com/projects.html
- Attached photo ("Marsh org group"): UConn MS students Aidan Barry and Sean Ooi, with BS students Alaina Bisson and Kayleigh Granville at Barn Island NWR (Stonington, CT) in front of experimental marsh "organ" field test of how flooding frequency and plants alter carbon and nitrogen-based ecosystem services. Date: May 2018. Photo credit: Beth Lawrence

I. HONORS AND AWARDS: *(List any honors or awards received during the reporting period, for anyone working on the project. This can be for best paper or poster, university awards, etc.*) Specify:

- Sean Khan Ooi received the Graduate Student Excellence in Research and Creativity Award from the College of Agriculture, Health, and Natural Resources, University of Connecticut, 2019.
- Sean Ooi and Aidan Barry (MS students associated with project) received a best poster award at the Society for Ecological Restoration (New England Chapter); October 2018
- Alaina Bisson and Kayleigh Granville (undergraduate students associated with the project, mentored by Beth Lawrence and Ashley Helton, respectively) both received a Summer Undergraduate Research Fellowship ($4000 each) to pursue independent research related to project objectives; summer 2018
- Aidan Barry (MS student) was awarded a research grant ($1000) to support analysis of sediment microbial communities from the Society of Wetland Scientists- New England Chapter; May 2018
- Mary Donato and Kayleigh Granville (undergraduate students associated with the project, mentored by Beth Lawrence and Ashley Helton, respectively) received a Connecticut Association of Wetland Scientists Micheal Leflor Award ($1000 each) to pursue independent research related to project objectives; March 2017
- Ashley Helton (co-PI) received UConn's College of Agriculture Health and Natural Resources Kinsmen Teaching Award for excellence in undergraduate teaching and mentoring; April 2017
- Kayleigh Granville (undergraduate student) was accepted as a UConn "University Scholar," a prestigious undergraduate program at UConn that will allow her to pursue in-depth research related to project objectives; December 2017

FOR FINAL DEVELOPMENT AND RESEARCH GRANT REPORTS, PLEASE COMPLETE THIS SECTION: *NA*

J. PROJECT OUTCOMES AND IMPACTS

RELEVANCE OF PROJECT: *(Describe briefly the issue/problem / identified need(s) that led to this work.)*

RESPONSE: *(Describe briefly what key elements were undertaken to address the issue, problem or need, and who is/are the target audience(s) for the work.)*

RESULTS: *(Summarize findings and significant achievements in terms of the research and any related education or outreach component; cite benefits, applications, and uses stemming from this project, including those expected in the future. Include qualitative and quantitative results.)*

Consider the following as they apply to your research and any related outreach/education.

- What new tools, technologies, methods or information services were developed from this work? Have any been adopted / implemented for use and by whom?

- What are the environmental benefits of this work? Have policies been changed? How has conservation (of ecosystems, habitats or species) been improved?

- What are the social payoffs of this work? Who has benefited from this work? Have attitudes / behaviors of target audience changed? Elaborate. Have policies been changed?

- What are the economic implications / impacts of this work? (Where possible, please quantify.) Have new businesses been created /or existing businesses retained as a result of this research? Have new jobs been created or retained? Are new businesses or jobs anticipated?

K. Stakeholder Summary (This is an abstract of your research and findings written for a lay audience)

Dr. Beth Lawrence
Primary Investigator
Natural Resources and Environment
University of Connecticut

4 January 2018

Dear Dr. Lawrence,

The purpose of this memorandum is to summarize: 1) any deviations between the QA Project Plan (QAPP) and the field sampling and laboratory analyses conducted in 2017, 2) the results of QA/QC tests, and 3) whether the data meet the data quality objectives outlined in the QAPP. Field surveys and laboratory analyses associated with project objective one – to quantify how restoration and dominant coastal marsh plant species alter carbon and nitrogen-based ecosystem services – were conducted during summer and fall 2017. Field and laboratory methods generally followed protocols described in the QAPP. There was one substantial deviation between experimental procedures and the proposed project plan: 30 sites were initially proposed as part of the field survey, but due to logistical constraints, only 20 sites were sampled in 2017 (including 10 tidal flow restoration sites and 10 unrestored sites). In addition, an alternative protocol developed by the Lawrence Lab at the University of Connecticut was used to measure CO_2 mineralization in place of the SOP included in the QAPP (the new protocol is enclosed).

For each of the variables included in the salt marsh field survey, 10% of the 60 total samples (20 sites x 3 vegetation zones) were measured in triplicate in the field or the laboratory and treated as quality assurance samples to assess method precision and overall performance. The relative standard deviation of each set of triplicate samples was calculated as part of the QA/QC protocol, and was less than or equal to 20% for most measured variables, including CO_2 gas flux (C mineralization), sediment core pH, electrical conductivity, ash-free dry mass (AFDM), and most soil ions (SO_4^{2-}, Cl^-, and PO_4^{3-}). For lab replicates of NH_3, one out of six of the NH_3 QA replicate checks had a relative standard deviation greater than 20%. The relative standard deviation was greater than 20% for 3 out of 5 sets of QA replicate checks for denitrification potential (DEA), and greater than 20% for 4 out of 6 sets of QA replicate checks for NO_3^-. Relative plant cover was measured in duplicate in 18 plots spanning different sites and vegetation zones, and the calculated percent difference in plant cover was less than 25% in 16 of these QA plots.

From the QA/QC results described above, most variables collected and analyzed as part of project objective one meet or exceed the data quality objectives listed in the QAPP, and approximately 89% of plant cover QA samples met the data quality objectives. However, the majority of DEA and NO_3^- QA samples fell outside of the data quality targets, and I recommend that future tests should be conducted to determine why replicate DEA measurements from sediment cores are highly variable, whether modifications to the DEA protocol are warranted, and whether the extractable soil NO_3^- concentrations observed in the field survey (median 20 µg N L^{-1}) are below the limits of analytical quantification. Sample completeness was 100% for most variables measured, although a sample loss of 20% was experienced for sediment core bulk density due to sample handling error in the laboratory. Data preservation practices outlined in the QAPP were used for the 2017 field survey data. Raw data files indicate the personnel who

performed each task, all samples have a unique sample ID, and field sheets have been electronically copied and are stored in multiple locations.

Sincerely,

Lauren E. Koenig, Ph.D.
Quality Assurance Officer,
Postdoctoral Research Associate
University of Connecticut

Dr. Beth Lawrence
Primary Investigator
Department of Natural Resources and the Environment
University of Connecticut

26 February 2019

Dear Dr. Lawrence,

In this memorandum I have summarized: 1) any deviations from the QA Project Plan (QAPP) and the field sampling and laboratory analyses conducted during project year 2018, the results of QA/QC tests, and 3) whether the data meet the data quality objectives outlined in the QAPP. Field data collection and laboratory analyses associated with project objective two – to experimentally test how plant species, salinity, and hydroperiod alter carbon and nitrogen cycling – were conducted during summer and fall 2018. As outlined in the project QAPP, an in situ marsh organ experiment was implemented at the Barn Island Wildlife Management Area in summer 2018. The marsh organ experiment included three different locally-dominant species of salt marsh vegetation including *Spartina alterniflora*, *Spartina patens*, and *Phragmites australis*.

Field and laboratory methods generally followed protocols described in the QAPP, although the marsh organ sampling design ultimately deviated from the proposed project plan in three ways: Two salinity levels were initially proposed, but only one salinity environment was imposed during the field deployment. In addition, five elevations were proposed, but three elevations were simulated in the field (0, 8, and 15). Finally, two different types of un-vegetated experimental units were included in the marsh organ design (including soil plugs from high-elevation sites in the salt marsh often associated with the higher-elevation species, *S. patens* and *P. australis*, and from low-elevation sites in the marsh, often associated with *S. alterniflora*). These un-vegetated units were included in addition to the 3 focal vegetation species to act as control or reference samples. Five marsh organ platforms were deployed, and within each platform, three elevation treatments were considered for each of the five vegetation species, which includes the low and high-elevation un-vegetated controls (5 species x 3 elevations x 5 platform replicates = 75 samples for most variables, or 45 samples for variables related to plant biomass allocation).

For each of the variables included in the field and lab data collection, 10% of samples were measured in triplicate and treated as quality assurance samples to assess method precision and overall performance. The relative standard deviation of each set of triplicate samples was calculated as part of the QA/QC protocol, and was considered valid if equal to or less than 20%. The relative standard deviation was less than 20% for the majority of QA replicate sets for most reported variables (e.g. for pH, all 7 sets of QA replicate checks were below 20%; for biomass ash-free dry mass, 5 out of 7 sets of QA replicate checks were below 20%; for soil carbon mineralization, 4 out of 6 sets of QA replicate checks were below 20%). For lab replicates of substrate-induced respiration (SIR), the relative standard deviation exceeded 30% for 4 out of 6 sets of QA replicate checks, indicating poor agreement among repeated samples for this variable. Due to the design of the marsh organ experiment, above- and belowground biomass samples were assessed for each pipe within a platform and therefore could not be taken in triplicate.

As of February 2019, samples for %C and %N (plant biomass; soil) and soil ions have not yet been run in the laboratory, and data for field CO_2, CH_4, N_2O, and N_2 fluxes are still being processed, so I have not evaluated whether these data meet the proposed data quality objectives here. However, from the QA/QC results described above, most variables collected and analyzed as part of project objective two meet or exceed the data quality objectives listed in the QAPP. The one notable exception is SIR, for which all QA samples fell outside of the data quality targets; I recommend comparing the values reported from this field study with other ranges from the scientific literature to determine whether the SIR rates are below the limits of analytical quantification. For each of the variables included in the field and lab data collection, no sample loss was reported and the respective datasets are 100% complete (n = 75 or 45 samples, respectively). Data preservation practices outlined in the QAPP were used for the 2018 marsh organ experiment: field environmental data have been transferred to Excel files, raw data files indicate a unique sample ID, and all data are stored in multiple locations.

Please do not hesitate to contact me if you have any additional questions about the information presented here.

Sincerely,

Lauren E. Koenig, Ph.D.
Quality Assurance Officer
Postdoctoral Research Associate
University of Connecticut