**Project Title:** Land-sea metabolic coupling in temperate eelgrass beds: The role of watershed connectivity and environmental gradients on carbon sequestration of seagrass meadows

**Fellow Name:** Elizabeth Elmstrom

**University:** University of Washington

**NOAA Award #:** NA20NOS4200121

**Award Period:** September 1, 2020 - August 31, 2022

**Reporting Period:** March 1, 2021 – August 31, 2021

**Workplan:** Download the current version of the Work Plan from [GitHub](https://github.com/eelmstrom/padilla_bay/blob/main/documents/Davidson%20Fellowship%20Work%20Plan_ElmstromMarch2021Updates.docx)

**Timeline:** Download the current version of the Timeline from [GitHub](https://github.com/eelmstrom/padilla_bay/blob/main/documents/Davidson%20Fellowship%20-%20timeline_ElmstromMarch2021Updates.xlsx)

### Accomplishments

**Research Accomplishments**

1. Padilla and Samish Bay metabolism measurements

*Field Campaign:* Despite initial setbacks due to the COVID-19 pandemic, this summer we completed a successful field campaign. Beginning in April, dissolved oxygen sensors were deployed at 5 sites in Padilla and Samish Bays. Additional light, depth, and salinity sensors were also deployed to complete the suite of measurements needed to compute ecosystem metabolism. In a series of 3 deployments (1 two-week pilot study, and 2 separate month-long deployments), we successfully captured the necessary time stamps to estimate spring and summer seasonal metabolism. We are currently on track to meet the updated research objective for 1 year of seasonal metabolism data.

*In situ light calibration for PAR measurements:* To fit the light intensity data to ecosystem metabolism model, these units (in lumens m-2) first need to be converted to PAR (photosynthetically active radiation; in umol photons m-2 s-1). This relies on equations developed *in situ* to convert intensity units taken in the eelgrass meadow to PAR. A series of experiments to develop these equations was completed this September. Thus, in regards to the measurements needed to complete the ecosystem metabolism model, we are currently on track.

1. Estuarine ecosystem metabolism models (R scripts)

Ecosystem respiration (ER), gross primary productivity (GPP), and net ecosystem productivity (NEP; i.e. the three different rates of ecosystem metabolism) will be estimated via updates to an existing Bayesian Metabolic Model (described in more detail [here](http://usgs-r.github.io/streamMetabolizer/index.html)). R scripts for these models have been established, backed up to a GitHub repository, and are currently a work in progress. With the field season complete, and the model parameters in hand, we now anticipate a draft of these models by the end of the fall.

1. Multivariate autoregressive state space models (MARSS) (R scripts)

Multivariate autoregressive state-space models (MARSS) have been used extensively to understand species interactions and cross-scale interactions of ecological communities. MARSS models can also be used (through model fitting and selection) to ask questions about spatial structure and to test drivers of ecological variability (through the inclusion of model covariates). Here, we proposed to use MARSS models to examine ecosystem metabolism trends across Padilla and Samish Bays. Significant progress on the R scripts for these models have been made. R scripts have been updated, annotated, and backed up to a GitHub repository. We have the code ready to run the metabolism data once the data from this summer has been processed.

**Building stakeholder/community relationships**

Elmstrom has engaged in the local Samish and Padilla Bay community this summer. Through her fieldwork in Samish Bay, she has built relationships with Taylor Shellfish, a local aquaculture company, and Skagit Valley College, a two-year community college. In May, she met students from SVC’s BS of Applied Science and Environmental Conservation Program in the field to give a talk about her work, and her path to graduate school. She hopes to expand these relationships with her continued work in the field next summer.

**Engaging reserve sectors**

1. Research

From April – August, Elmstrom was based at Padilla Bay NERR every two-three weeks, following the tidal cycle for field access. Her presence at the reserve not only allowed her to complete her Davidson-related research, but also to assist in the research eelgrass biomonitoring program. Elmstrom now works closely with the research team on a routine basis, aiding in the development of experimental set up and deployment of other projects (such as the PAR calibration described above).

1. Education

While originally it was planned for Elmstrom to mentor a Hollings scholar, unfortunately the timing and interests of the research did not overlap. Elmstrom did briefly aid in the Hollings scholar’s research, helping to collect eelgrass samples for analysis. Mentorship for next field season will be reassessed in the spring of 2022.

1. Coastal Training

No progress has been made. Coastal training has shifted online due to COVID-19.

**Professional Learning and Networking Achievements**

Elmstrom completed two online professional learning workshops during this reporting period. The first, the Planning Effective Projects workshop, was completed over the course of two weeks in March. The second, Cathy Angell’s workshop: How to Explain Science, Share Data, and Build Trust, was completed in May.

### Challenges / Delays

**Field challenges**

1. Samish Bay access

One challenge this project faced was tideland access in Samish Bay. Originally, we had proposed total of 6 field sites, 3 sites in Padilla Bay, and 3 sites in Samish Bay. Unfortunately, due to private ownership of the tidelands, we were only able to gain access to two sites in Samish Bay.

1. Winter low tides

Looking forward, we anticipate tide-related challenges for our wet-season fall/winter sample. Specifically, in the fall and winter months, the low tide falls during the late-evening/early morning hours, i.e. when it is dark. Without summer-time field help, accessing all the sites at night will present a challenge. One of our sites in particular (Joe Leary) involves walking through the tidelands and navigating channels for ~1.5 miles. It is possible that we will limit our sites to make it more feasible to complete field work in a safe and responsible setting.

**Professional Development/Outreach**

Over the course of this pandemic, there have been social distancing-related setbacks. Certain education and outreach activities have been canceled due to COVID-19. Elmstrom has yet to fully engage with the Coastal Training Program or the Shoreline Education Programs. Classes offered through the Coastal Training Program have shift online and the Breazeal Interpretive Center remained closed until late August. Elmstrom’s engagement will be reassessed this winter.

### Budget

The original budget narrative requested tuition funds for two academic quarters in Year 1, with the remaining quarter of funding to be used over the summer when tuition costs decrease. The total amount requested for Year 1 was $12,686 ($11,0596: Fall, Winter, and $1,627: Summer).

In Year 2, we requested funds for 3 academic quarters, for a total of $17,417 (Fall, Winter, Spring).

However, to maximize professional learning opportunities during the time of remote work, we re-expensed tuition funds to cover 3 academic quarters in Year 1 at $XXX, and two academic quarters in Year 2 at $XXX. This allowed Elmstrom to complete enroll in coursework during Spring of 2021.

Other than this change to tuition expense allocation, no significant changes to the budget have been made.

### Accomplishments

**Project Deliverable Goals:**

1. Great Bay solute budgets

Currently on track to meet the Great Bay Solute Budget Milestone. Water chemistry data for the three tidal tributaries (Lamprey, Winnicut, and Squamscott) and Adams Point has been acquired from the NH Department of Environmental Services (NHDES) Environmental Monitoring Database. Precipitation volumes and chemistry have additionally been acquired. Nutrient loads, necessary for the solute budgets, are in the process of being calculated at annual and seasonal time-steps.

Supplemental field sampling of the three tidal tributaries and Adams Point is on schedule for January, February, and March of 2021. At the time of this report’s submission, the January sampling will be complete.

1. Annotated R scripts

R scripts have been established, partially annotated, and backed-up in a GitHub Repository. R Script development is ongoing, as it coincides with the solute budgets.

1. Field campaign to chase nitrogen within Great Bay habitats

The sampling field campaign for Part II of the research proposal is anticipated to start on-time. The fellow, advisor, and mentor have had several meetings for logistics planning. On January 14th, 2021, the fellow met with stakeholders/researchers to discuss the field sampling plan and receive feedback on field methods. Water chemistry sample analysis will start approximately one-month into the field campaign monthly sampling schedule. The work plan includes an up-to-date table on parameters that will be measured.

1. Two peer-reviewed publications

No progress has been made. This objective cannot be started until earlier phases are completed.

1. Incorporation of research into GBNERR community outreach/educational programming

The fellow has written one (of at least 4 total) blog posts for the GBNERR blog and has scheduled the remaining blog posts with the GBNERR education coordinator.

1. Development of “Next Steps/Related Opportunities” Document for GBNERR

No progress has been made. This objective cannot be started until earlier phases are completed.

**Reserve Sector Engagement Goals:**

The fellow has engaged all sectors of the reserve, by first presenting the research proposal to the GBNERR staff (September 17th, 2020) and to the Great Bay Stewards (November 12th, 2020). The fellow also met with individual reserve staff members to learn about each sector and to brainstorm ways to integrate the project with each sector. The fellow continues to meet approximately bi-weekly with her NERR mentor, Chris Peter. The fellow also attends the monthly Reserve staff meetings and works on-site in GBNERR office when possible.

Specific engagement with each sector has included:

* Research
  + Participation in salt-marsh biomonitoring
  + Submission of a project summary for the Hollings Program
  + Successful interview process to select a Hollings Scholar for summer 2021
* Education
  + Writing for the GBNERR Blog and social media platforms
  + The fellow will be presenting on her research project in March 2021 as part of GBNERR virtual Lunch and Learn series
* Stewardship
  + No progress has been made, waiting for spring volunteer days to start up
* Coastal Training
  + No progress has been made, as GBNERR is in the process of hiring a new CTP

**Stakeholder Relationship Goals:**

The fellow has continued to attend Piscataqua Regional Estuary Partnership (PREP) meetings to facilitate better understanding of PREP’s work and discuss how the fellowship research can contribute to PREP’s goals. The fellow is also participating in the NERR SSAM-2 SAV workgroup, as many of the workgroup’s goal overlap with the fellow’s research project and interests.

**Additional Accomplishments:**

The fellow completed the optional NERAA Season of Gratitude Video, which provided a one-minute summary of the fellowship and the specific project. Senator Maggie Hassan of NH shared the video to her social media – resulting in several hundred views!

The fellow also helped lead a pre-proposal submission to the NERR Science Collaborative Call. This was a successful application of the Collaborative Science Training offered to fellows as part of Professional Development in Fall of 2020. This pre-proposal will hopefully allow for continued work with GBNERR upon completion of the Margaret A. Davidson Fellowship.

### Challenges / Delays

One challenge the project faces currently is engaging with the Coastal Training sector and the Stewardship Sector. The research project doesn’t translate as easily into those two sectors and is further complicated by GBNERR currently searching for a new CTP. This will not hinder the project timeline, as engagement with these two sectors can be achieved once a new CTP is hired and stewardship volunteer days begin again in the spring.

To date, no challenges have resulted in delays to the project timeline. The project timeline remains accurate.

### Budget

The proposed budget narrative has been changed to reflect reduced cost of tuition in Year 1. The original budget narrative included graduate student tuition based on published rates. Year 1 tuition was originally expected to cost $\_\_\_, but only $\_\_\_ was needed due to a reduced number of credit hours taken by the graduate student. This leaves a remaining balance of $\_\_\_ in tuition.

Funds totaling $\_\_\_ will be re-budgeted to the following categories:

* Graduate Student Summer Stipend Year 1 (increase from $\_\_\_ to $\_\_\_)
* Fringe Benefits (increase from $\_\_ to $\_\_)
* Materials and Supplies (increase from $\_\_\_ to $\_\_\_)
* Indirect Costs (increase from $\_\_\_ to $\_\_\_)

Re-directing these funds remains within the original scope of the project, as the funds will support the fellow’s summer work and enable additional water sample collection. Overall, this re-budget will increase the period over which samples can be collected and analyzed for water chemistry and lends itself to a better understanding of biogeochemical cycling in Great Bay Estuary across multiple seasons.