Summer Research Proposal 2017

Name(s) of applicants: Sarah Sojka, Department of Environmental Studies and Department of Physics, Tyrah Cobb-Davis, Physics, Class of 2019 (Minors in Engineering and Math), Elizabeth (Libby) Exline, Environmental Studies, Class of 2019

Title of the project: Using artificial seagrass beds to study restoration

Abstract: Seagrass populations are declining worldwide and the loss of this ecosystem engineer has implications for everything from fisheries to climate change. Artificial seagrass beds could be a powerful tool in understanding how seagrass ecosystems function and in developing improved methods for restoration. This summer, we will construct artificial seagrass beds for a pilot study to begin research in artificial seagrass. These beds can help us understand conditions for seagrass growth and the physical effects of seagrass on ecosystems.\

Project Description

*B*ackground and context

Between the tomato and soybean fields of Virginia's Eastern Shore and the Atlantic Ocean lie Virginia's coastal bays (Fig. 1). These shallow estuaries were once home to abundant scallop fisheries and large brant (a species of goose) populations. Both of these economically and ecologically valuable species virtually disappeared in the 1930's when a wasting disease and a hurricane led to the local extinction of seagrass (Orth et al 2006). Seagrass is a type of submerged aquatic vegetation (SAV), meaning that the plant is entirely submerged at all times (Fig. 2), and is an important refuge for fish and food source for some birds. While seagrass populations in other areas of Virginia and throughout the mid-Atlantic that were affected by the wasting disease recovered, seagrass remained locally extinct in Virginia's southern coastal bays for almost 70 years. Beginning in the late 1990's, scientists from the Virginia Institute of Marine Science (VIMS) and the Nature Conservancy working in collaboration with scientists from the University of Virginia began an extensive seagrass restoration project distributing 37.8 million viable seagrass seeds which have now expanded to cover approximately 1,700 ha (Orth et al 2012).

Along with the restoration of seagrass comes restoration of ecosystem services, such as primary productivity, carbon and nitrogen sequestration and shoreline protection. Ecosystem services are benefits to humans provided by natural ecosystems, such as flood protection from wetlands. The restored seagrasses in Virginia's coastal bays are trapping nitrogen and carbon (McGlathery et al 2012) and decreasing wave and current activity (Hansen and Reidenbach 2012). While the seagrass beds in

the Virginia coastal bays have not fully matured to function like established seagrass beds, research in Australia indicates that restored beds can serve as carbon sinks as effectively as original beds (Marba et al 2015). The seagrass beds have also improved water quality in the bays (Orth et al 2012). While scallops did not return naturally to the bay, restoration efforts of scallops are re-establishing their populations (Schmitt et al 2016).

Figure 2: A restored seagrass meadow.

The success of seagrass restoration in Virginia is a bright spot in a dim picture of seagrass populations globally. Despite locally successful seagrass restoration efforts, seagrass populations are declining worldwide (Fonseca et al 1998, Waycott et al 2009). Since 1980, the rate of loss of seagrass has been 5% per year (Waycott et al 2009). This loss of seagrass leads to an estimated release of 299 Tg of carbon per year (Fourqurean et al 2012). Because of this, loss of seagrass, like loss of forests, can be an important factor in climate change. Similarly, recovery and restoration of seagrass beds can be an important step in mitigating climate change. Because of the threats to seagrass ecosystems and the myriad benefits of these ecosystems, understanding seagrass restoration and recovery is crucial. The Virginia coastal bays, which are home to the Virginia Coast Reserve –Long Term Ecological Research site is an ideal place for studying these systems because of the existing infrastructure (lab space, boats, dorms and the extensive research already conducted at the site.

Project goals

Our use of artificial seagrass to study restoration has two main goals:

1. *Determine the role of the physical structure of seagrass in ecosystem services:* Seagrass is considered an "ecosystem engineer," a species that changes an ecosystem creating better conditions for other species and/or enhancing ecosystem services. Seagrass alters waves and currents, creating an area of relatively calm water within the bed (e.g. Hansen and Reidenbach 2012). This traps sediment (including carbon) and provides protected habitat for fish. Seagrass also alters nutrient storage (nitrogen and phosphorus) and movement in the sediment, populations of macroinvertebrates and much more about an ecosystem. Using artificial seagrass, which should produce the same wave and current altering effects as natural seagrass but does not do any biological processing, will let us examine the impacts of the physical structure of seagrass, improving our understanding of how seagrass affects ecosystems.

2. Test the bistable state model: Numerical modeling of the seagrass ecosystems on the Eastern Shore has shown that between 1.6 and 1.8 m water depth, developed seagrass beds can survive, but seagrass cannot grow in bare sediment areas (Carr et al 2012). In this sense, the region can exist in one of two stable states, seagrass or bare. Field sampling of the seagrass restoration has shown that 1.6 m is the depth limit for seagrass in the Virginia coastal bays, supporting this theory (McGlathery et al 2012). However, to truly test the theory, we need to mimic the establishment of seagrass beds at depths between 1.6 and 1.8 m and then seed real seagrass in the artificial beds. The bistable state model has important implications for how seagrass beds will respond to climate change and sea level rise making testing of the model important for our understanding of these ecosystems.

Significance of the project

Artificial seagrass beds have been used to test hydrodynamic conditions in flumes (e.g., Fonseca and Koehl 2006) and in the field to examine fish recruitment (e.g., Kenyon et al 1999), but studies have not examined the hydrodynamic impacts in the field, the potential carbon impacts, or the possibility of using artificial seagrass for restoration. This project begins an important contribution to the field.

Methods for SRP

The ultimate goal of this project is beyond the expectations for a single summer research project. The goal for the summer is the installation of three 3m x 3m artificial seagrass beds at approximately 1 m depth. We are using these three beds as a pilot study before installing deeper artificial beds. We have selected a pilot study site with a reference restored seagrass bed adjacent to a large bare sediment area. We will install the 9 m^2 artificial beds in the bare sediment area and sample sediment grain size, benthic chlorophyll, exchangeable ammonium, benthic macroinvertebrates and porewater nutrients in the newly installed beds, the reference seagrass bed and an adjacent control bare sediment area. We also plan to measure waves and tides in these three areas and deploy light sensors that will provide a continuous record of light availability for approximately one month. The beds will remain in place for at least one year and we will return and sample the same characteristics at that time. If possible, we will also conduct intermediate sampling throughout the year, though many of these characteristics can be expected to change gradually. We are unsure how long constructing the artificial beds will take, but have included an ideal timeline below.

Week 1: Proposal presentation preparation, analysis of previous work
Week 2-3: Construction of the artificial seagrass beds
Week 4: Installation of the artificial seagrass beds in the Virginia coastal bays and initial sampling
Week 5-6: Lab work on initial samples and analysis of wave and current data
Week 7: Return to the coastal bays for seagrass synoptic survey and possible follow up sampling. The synoptic survey involves scientists, grad students and undergraduates from a range of institutions who assess the health of the restored seagrass beds. While slightly tangential to the summer project, this is a fantastic opportunity for the Randolph students to meet potential graduate school advisors and graduate students.
Week 8: Analyze data and prepare for the final presentation.

NOTE: I (Sarah Sojka) will be able to actively oversee and work with the students while they are at Randolph. However, I will be unable to travel for much of June because of the expected arrival of my first child in the middle of June. A colleague (Dr. Joel Carr of the USGS) is working with me on the project and will be able to supervise and work with the students when they are at the Eastern Shore. The site director, Dr. Art Schwartzschild, will also be available as a resource for the students. The students are aware that I may not be able to travel with them and were selected because of their ability to work well with others and my trust that they will be responsible representatives of Randolph College in this setting. The students will never travel without a designated resource that I trust. We also have a graduate student (Mo Tatlhego from the University of California- Berkeley) working on the project who will be available to work with the students.

Previous work

During the academic year, students are working on prototypes for the artificial seagrass beds. We have already selected the materials to use a seagrass blades and have two preliminary designs for creating a full seagrass bed. In both designs, the artificial blades will be attached to a net stretched over a PVC frame with approximately 700 plants per square meter. We are planning to deploy small (1m x

1m) prototypes in late March or early April to determine if the prototypes can withstand the conditions at the site and if the artificial seagrass modifies flow as expected. We will use one of the two designs from the prototypes to build our artificial seagrass beds this summer.

Project continuation

The first step in continuation of the project is monitoring of the artificial beds. Because we expect the changes to be gradual, the monitoring will need occur at most quarterly. Students in research classes (EVST 394 or PHYS 394) will assist with the monitoring and if possible, this project will lead to another summer research project in 2018 to finish a full year of monitoring, analyze the data, and prepare the data for publication. We will also use this pilot study to apply for funding to use the artificial seagrass beds to test the bistable states theory and continue to monitor the artificial beds we will put in this summer. We will apply to the Research in Undergraduate Institutions program from the National Science Foundation. The Summer Research Program will be a success as long as we are able to build and deploy the artificial beds and collect preliminary data and we will be able to continue monitoring the beds and developing the project from this base. Future research may include the students who will participate this summer and/or other students.

Course release The faculty member is not applying for a course release.

References:

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Dissemination goals: The work completed during the Summer Research Program will not be enough for a publication alone, but will be enough for a publication when combined with work over the following year. Journals such as *Estuaries and Coasts* or the *Marine Ecology Progress Series* would be appropriate for the paper. The work from the Summer Research Program will likely be enough for a poster presentation at a national conference such as the American Geophysical Union or a regional conference, such as the Atlantic Estuarine Research Society.

Past outcomes: The faculty member has participated in the Summer Research Program for three years. In all cases, students have successfully completed their projects and three of the projects have been awarded travel grants from the Summer Research Program. Four projects have been presented at national conferences and I am planning to write up the research from two of the projects as journal articles this semester.

External funding: We will receive a small amount of support from the Virginia Coast Reserve Long Term Ecological Research site for this project. The chief scientist of the project has committed up to $2,000 for materials and the project will provide housing and use of the research boats at no cost. If possible, we will also apply for funding from the Virginia Foundation for Independent Colleges to support the project.

Academic credit: The students on the project are not electing academic credit in place of a stipend.

Budgetary needs:

Travel: $580 - Travel is the most expensive part of the project. The research site is 265 miles away and a $24 toll is required to reach the site. We have included two trips in the budget assuming a reimbursement of $0.50 per mile and a small buffer for additional mileage.

Artificial seagrass materials: $380 - We will need PVC piping, netting, and polypropylene film to construct the artificial seagrass. The total cost of these materials is more than $380 but we will use funding from the VCR-LTER to make up the additional cost.

Lab materials: $40 - We will need lab chemicals and sampling equipment to sample for and then analyze benthic chlorophyll, exchangeable ammonium, porewater nutrients and organic content.

Total budget : $1,000

Human or Animal Research: Our research project does not involve human subjects or vertebrate animals. We will be in touch with IACUC to determine if we need any approval because the research project may impact vertebrate animals.

Statement about student researchers

The students will primarily be responsible for building/assembling the artificial seagrass beds, deploying the beds, gathering initials samples and measurements and data analysis. While this project originated with the faculty member, the work will be student-driven. While the students are in Lynchburg,

I will meet with them at least three times per week to check progress. In addition, I will be present for lab work as necessary. When the students travel to the Virginia coastal bays, I will be in touch daily and they will be working with/supervised by a colleague from the US Geological Survey. Both students will gain problem-solving and critical thinking skills from developing sampling plans and building the artificial seagrass. They will also develop lab and field skills including nutrient analysis and biomass surveying. Finally, the students will get the opportunity to see how a large research site functions and meet students and professors from a range of institutions including the University of Virginia and the Virginia Institute of Marine Science. This is an opportunity to get a glimpse at graduate school life that we are rarely able to offer our students. I have selected the two students because of the differences in their educational backgrounds. Libby is an environmental studies major who is currently taking botany and brings more life science background to the project. Tyrah is an physics major who brings Matlab experience and a better understanding of the physics of the system to the project. Because the students need to understand biological/ecological processes and physical system dynamics, having both students on the project is essential. Both of the student applicants are strong students. Tyrah's GPA is just below [redacted] and she is a very conscientious and hard-working student. Libby's GPA is [redacted]. Libby has been proactive about improving her GPA and earned a [redacted] this fall. Both students are also athletes which has taught them time management which will be essential for success in student research.

As noted above, I am expecting a child in mid-June. Because of this, I will not be away from Lynchburg at all this summer, but I may be entirely unavailable for a few days. I will plan with the students in advance for work for them to do during this time.

Statement from each student

Elizabeth (Libby) Exline:

Why are you interested in this project?

I am majoring in Environmental Studies and I believe that working alongside Dr. Sojka and Tyrah Cobb-Davis for summer research would not only better me academically but also allow me to attain skills that many others in my major will not get to experience. This project is focused specifically on marine science which happens to be my area of interest. I plan to attend grad school after completing my career here at Randolph and focus on a marine science program. This summer research opportunity will give me an enormous amount of background knowledge that will better prepare me for my future endeavors.

What do you believe you can add to the project?

As stated before, I am an environmental studies major which has allowed me to take several courses that have prepared me for summer research. Last semester I participated in a data collection analysis at Hollins Mill Dam on macroinvertebrates. Based on what I have learned during my time collecting and analyzing data, I believe that I can be of great help to Dr. Sojka as we take on this research.

What do you hope to gain from the summer research experience?

I hope to better my knowledge regarding our environment and more specifically the ecosystems with in it. In addition to bettering my education, I hope to strengthen my networking skills and professionalism. Having the opportunity to work with the Virginia Institute of Marine Science researchers will allow me to gain several new connections. Working with Dr. Sojka and Tyrah will give me the experience of collaborating with others on extensive projects which is a necessary skill for everyone in the

workforce.

If you have participated in the summer research program in the past, please describe what new this you will learn this summer.
N/A

If you participated in the summer research program in the past, please describe outcomes and dissemination that resulted from the project.
N/A

Current GPA: [redacted]

During the spring semester of my freshman year I began to struggle with my time management. I am a college athlete so free time is hard to find. I became very stressed and my grades suffered. Since then I have met with Tina Barnes each semester to assess my course load and construct a plan of action. Last semester I received a [redacted] for the term and I only plan to move forward from there. I hope you do not view my GPA as a reflection on who I am as a student and my capabilities in the academic realm.

Tyrah Cobb-Davis

I am interested in this research project because it combines my interests in both environmental science and physics. I recently gained an interest in environmental science last semester when I took an entry level course. It was not a subject that I was exposed to a lot prior to that, and I learned that it is very important for people work together to find solutions to fix things that are impacting our environment. The seagrass restoration project is very interesting to me because the loss of something as small as seagrass can cause harm and impact the economy in some way.

I believe that I can contribute to this project overall by helping construct large patches of seagrass that can be tested on the Eastern Shore. This restoration process has been very successful and a lot of data has been collected so far. As part of our research, we would be making and testing seagrass patches. After our data is collected we can then look at the impacts of the artificial seagrass overall.

I hope to gain lab and field work experience from this project. I have never been in an environment that worked on projects long-term so I think that this opportunity would help me determine if I want to continue in research as a career or if I want to do more hands-on jobs in the future. This would also allow me to work together with another student on the same project. Working with someone from a different academic discipline from my own is also a learning experience because we can learn from each other. Being able to work with and collaborate with people is a skill that will be useful in all aspects of life.

I have not participated in the Summer Research Program in the past, but hope to learn more about seagrass and about the efforts that have been made to restore the ecosystems that were affected if given the opportunity this summer.

My current cumulative is a [redacted] which is just below the [redacted] mark. I think that I would be a strong student in this program because I am determined to work hard to reach the end goal. I am a hard worker and have both the drive and the independence needed to be successful in research.