Effects of Increased Temperature and Ocean Acidification on Juvenile Lobsters

SOAR Project Proposal, Summer 2019

Faculty Mentor – Joshua Lord, Assistant Professor of Biological Sciences
Student – Kathleen Mayer
Major: Environmental Science
Rank: Junior
Graduation Date: 2020

Project Background:

The primary focus of this project is on the environmental impacts of ocean acidification. To understand ocean acidification, it is important to note that Earth's oceans act as the lungs of our planet because of their ability to absorb massive amounts of carbon dioxide (CO_2) from the atmosphere. While absorption of CO_2 by the oceans is a natural process, the unprecedented high levels of CO_2 in our atmosphere due to the burning of fossil fuels are changing our planet's seawater chemistry. This change in the seawater chemistry of our oceans is termed ocean acidification and this process affects many marine species, particularly those that have calcified shells. Marine organisms that create calcified structures need carbonate molecules in order to grow and maintain these structures. Because CO_2 reacts with carbonate in water, it has begun to interfere with the growth of shelled organisms by reducing the availability of these shell building blocks (carbonate). When carbon dioxide reacts with seawater, it also releases hydrogen ions, which make the ocean more acidic and create an abnormal and hostile environment for many marine organisms. Acidified ocean conditions also interfere with the ability of organisms like hermit crabs, fish, and snails to sense the presence of predators and prey. Most marine organisms use chemical cues in the water to detect food, predators, or appropriate habitat, much as rabbits may run from the scent of a fox (or we follow the smell of cookies!). The disruption of cue-sensing by acidified seawater can substantially alter the population sizes and ecological roles of the affected species (as it would if rabbits were unable to sense when predators were near).

The organism that will be used in this study to research the effects of ocean acidification will be the American lobster (*Homarus americanus*). The American lobster is a crustacean that lives in the colder waters off the northeastern coast of the United States. Lobster is a very popular food choice for many seafood lovers on the coast, which keeps many lobster fisheries in business. With a warming ocean, lobsters are being forced to move to colder waters further up the coast, threatening the income of people who fish for lobsters in southern New England. While relocation of lobster populations is a negative consequence of human-induced climate change for those that rely on lobsters as a source of income, the acidification of lobster habitats is arguably even more detrimental. A previous study investigated the effects of acidified ocean conditions on the larvae (i.e. stage before juvenile) of the European lobster, which is closely related to the American lobster, and researchers observed deformities in both the larvae and juvenile stages (Agnalt et al. 2013). These deformities are speculated to affect respiration, the

lobster's ability to swim, its ability to find food, and its ability to find sexual partners. Not only does acidification affect lobsters individually but ecologically, a drop in lobster populations will reduce an important food source for many organisms higher on the food chain (Whiteley 2011). Of the acidification studies on lobsters that presently exist, many have researched the larval stages but few have investigated impacts on the adult or juvenile stages of the lobster. In addition, virtually no studies have been conducted to study the effects of both rising temperature and acidification on lobsters; one study noted that "The synergistic effects of warming and OA on the life cycle of *H. gammarus* (and other lobster species) are unknown and urgently need to be studied" (Agnalt et al. 2013). Currently, there is a need to study the effects of both pH increase and temperature increase on the adult American lobster.

Project Summary:

No studies have experimented with juvenile lobsters to gather evidence of whether or not they have a decreased cue-sensing ability under acidified conditions. Therefore, the main goal of the study that I hope to conduct is to determine how acidified ocean conditions affect the juvenile lobster's ability to detect chemical cues from food (effectively forage). The experiment would expose juvenile lobsters to different sets of environmental conditions that reflect future ocean pH levels. Dr. Lord's lab is equipped with the necessary-sized tanks to properly house 100 juvenile lobsters and expose them to the right experimental conditions. These experimental conditions would reflect pH levels of 7.7 and 8.1 as well as temperatures of 15 and 20 degrees Celsius, both of which are predicted to occur in coastal environmental within 50 years. Dr. Lord's lab also has a functioning CO_2 control system that would allow me to maintain acidified conditions in the lobster tanks. In addition, a temperature control system has already been built through an unrelated experiment of mine, which would assist with maintaining the right set of tank temperatures. To test whether the cue-sensing abilities of the lobsters are affected by the experimental conditions, I would conduct feeding experiments; after placing food in the tank, I would record the amount of time and in what direction the lobster swims to find it (foraging efficiency). After analyzing these data, I can infer whether or not their cue-sensing abilities were compromised by the acidified conditions or increased temperatures. With the data gathered from this study, I could help fill in the missing gaps in scientific literature about lobsters and ocean acidification. The behavioral effects of acidification have only recently been discovered, and interference with cue-sensing is a particularly fertile area of research because of the potentially large ecosystem consequences. This study would take an important step in this field by examining potential impacts of acidification on the feeding of one of the most commercially and ecologically important species on the east coast of North America.

Student Role in Project: My role as the student in this research is to conduct background research regarding the experimental species before experimentation. I will conduct various pilot experiments to hone the methods before conducting the actual experiment to gather data for

analysis. I will analyze the data that are gathered and make conclusions based on these analyses. Also, a big part of my role will be to take care of the lobsters as they are live animals and must be fed regularly. I will also take part in the maintenance of the seawater system. With Dr. Lord's guidance, I will be conducting these large-scale experiments myself and learning to analyze and present scientific results.

Faculty Role: I (Josh Lord) will work closely with Katie to design and conduct the previously described experiments; I will also teach her how to care for the juvenile lobsters we will use for this study. I have already arranged for purchase of the juvenile lobsters from the New England Aquarium in Boston (using my startup funds), and I have made arrangements with a collaborator at the Downeast Institute in Maine to provide us with very small (young) lobsters later in the summer. Katie will basically take the lead on this project as the summer progresses and she becomes more comfortable with the lab setting and experiment. I encourage her (and all of my students) to make the project their own—pursue any elements that they find interesting or surprising over the course of the experiment. The experimental design process involves both great creativity and great attention to detail, so I will work closely with Katie to ensure she has the support she need to conduct these lobster experiments but also allow her the freedom to modify things as she sees fit. Katie and I have already discussed this project at great length, and testing the impact of seawater temperature (in addition to acidification) was something we added at her request, because it is something that she is interested in. While I'll see my research student(s) every day, I will meet frequently with Katie to troubleshoot the experiment and check in with her at various stages of the scientific process.

Project Timeline: The first two weeks of this ten-week project will be committed to obtaining the lobsters and doing some pre-experimentation to ensure an efficient experiment. During this pre-experimentation period, pilot experiments will be run to test how the lobsters forage in the lab and the CO_2 and temperature controls will be assembled. The following six weeks will be for experimentation, including measurements of feeding rate and foraging efficiency; this will include a significant amount of time analyzing videos or time-lapse photos on the computer. The last two weeks will be time to analyze all the data gathered from the experiment and draw conclusions. We will present the results not only over the summer and at Scholar's Day, but also at the Lehigh Valley Ecology and Evolution Symposium or the Benthic Ecology Meeting (in Wilmington, NC) in April 2020—this is an international conference in marine ecology.

Literature Cited

Agnalt, A., Grefsrud, E. S., Farestveit, E., Larsen, M., & Keulder, F. (2013). Deformities in larvae and juvenile European lobster (*Homarus gammarus*) exposed to lower pH at two different temperatures. Biogeosciences Discussions, 10(5), 7579-7615. doi:10.5194/bgd-10-7579-2013

Whiteley, N. (2011). Physiological and ecological responses of crustaceans to ocean acidification. Marine Ecology Progress Series, 430, 257-271. doi:10.3354/meps09185

SOAR Student Statement of Purpose, Summer 2019

Project Title: Effects of Increased Temperature and Ocean Acidification on Juvenile Lobsters
Student: Kathleen Mayer (**I am requesting summer housing**)
Major: Environmental Science
Graduation Date: May 2020
Faculty Mentor: Joshua Lord

Back when I was applying for colleges, I knew I wanted to study at an institution that could help me identify my passions within the environmental science field while encouraging me to pursue my scientific interests. Moravian has proved to be the right place for me because it has exceeded my educational expectations, and I'm grateful for my Moravian education because it focuses on both the sciences and humanities, which has helped me to become a well-rounded student. During the pursuit of my Moravian education and Environmental Science degree, I registered for a Marine Ecology class. The reason I registered for this class was not out of interest in the marine aspect of the course, but out of curiosity about the ecology part of it. Little did I know that this class would help shape the student scientist in me today. I knew virtually nothing about ocean ecology before this class and I can confidently say that after completing the course, I'm looking forward to a rewarding career in marine sciences. The ocean is an extremely biodiverse but unexplored place, with new discoveries happening frequently. This offers students like me the ability to dive head first into an area of scientific research that contains opportunities for great discovery. Unfortunately, some of the most biodiverse places in the ocean are facing threats from excess marine plastic, sea-temperature rise and ocean acidification, just to name a few hot-button topics. Some of the issues that the ocean currently faces have sparked intriguing research questions that can hopefully be answered.

The purpose of my research is to shed light on some of the ecological questions that remain regarding the effect of ocean acidification on marine species. Dr. Lord has helped me to understand what some of the most pertinent acidification questions are currently in the marine science field. The rationale behind my involvement in this project is that I am excited to develop experiments that can help answer these questions. Conducting a study that helps me to understand ocean acidification and how it affects the ecology of organisms will also help propel me into graduate studies. My post-graduation goal is to continue my education at the graduate level in a marine science program, and this type of research will help refine my skill set for graduate school applications. This research project will not only help me to achieve my educational goals, but personal goals as well. Growing up at the Jersey shore has helped me foster a love of some of the most well-known marine areas along the East coast. As a student expanding her education, participating in this type of research will help me to achieve my personal goal of understanding how some of the most pertinent climate change issues will affect the marine areas I hold close to my heart. I hope that the outcome of this project will help illustrate for me how marine organisms experience disruptions in both their physiology and habitat. Reading about these disruptions in journal articles is different than seeing them happen

in a lab, which makes this research experience very valuable. I hope that by the end of this project, I can gain a better understanding of not only how acidification affects lobsters but also of the how scientific experiments are designed, conducted, and presented.

SOAR Expense Proposal, Summer 2019

Project Title: Effects of Increased Temperature and Ocean Acidification on Juvenile Lobsters
Student: Kathleen Mayer
Faculty Mentor: Joshua Lord

Item	Cost
Gas: round-trip to Downeast Institute (ME) ($2.66 x 1200 miles ÷ 25mpg)	$128
Tolls: trip to Downeast Institute (ME)	$20
2 dorm rooms at Downeast Institute (ME) ($60/night x 2, 2 nights)	$240
TOTAL	$388

We plan to use 2 sizes of juvenile lobsters for these experiments; the larger (2-year-old) lobsters have been purchased from the New England Aquarium for $500, using Dr. Lord's startup funds. Because first-year (small, young) lobsters are especially vulnerable, it is important to include them in the experiments and compare their vulnerability to the older individuals. One of the only places that raises juvenile lobsters of this size is the Downeast Institute in Maine, and after Dr. Lord reached out to their director, they have agreed to provide us 50+ small lobsters free of charge and allow us to use their lab space for a couple days over the summer. To take advantage of this opportunity, we just need funds to support the travel up to this marine facility in northern Maine over the summer. We are not asking for mileage costs ($0.50+/mile), just gas and toll and lodging reimbursement, to minimize SOAR costs. Juvenile lobsters are very sensitive and cannot easily survive shipping, which is why we'd need to go get them in person, with a little aquarium set up in the back of the car! While the experiments could be conducted solely with the larger lobsters from the New England Aquarium, it would improve the project and make our conclusions far more sweeping if we could use multiple size ranges as we intend.