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Expiration Date: 08/31/2021

DEPARTMENT OF COMMERCE
RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

For instructions, please visit
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AWARD INFORMATION	
1. Federal Agency: Department of Commerce / NOAA	2. Federal Award Number: NA16SEC4810007
3. Project Title: Living Marine Resources Cooperative Science Center	
4. Award Period of Performance Start Date: 09/01/2016	5. Award Period of Performance End Date: 08/31/2022
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REPORTING INFORMATION	
Signature of Submitting Official: Joshua Shockley	
16. Submission Date and Time Stamp: 09/30/2021	17. Reporting Period End Date: 08/31/2021
18. Reporting Frequency: ○ Annual ◉ Semi-Annual ○ Quarterly	19. Report Type: ◉ Not Final ○ Final
RECIPIENT ORGANIZATION	
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22. Recipient UEI: LNUBJQ26R2M5	23. Recipient EIN: 526002033

ACCOMPLISHMENTS

24. What were the major goals and objectives of this project?

Education Goals:
1. Prepare the future workforce for marine and fisheries sciences through the relevant degree programs.
2. Strengthen collaborations across partner universities and professional networks to enhance academic programs in marine and fisheries sciences

Research Goal:
1. Develop an exemplary capacity for scientific collaborations among partner institutions in the NOAA relevant fields of marine and fisheries sciences

Administration Goals:
1. Organizational excellence for effective and efficient management of the programs and activities of the Center
2. Effectively communicate the activities and accomplishments of the Center
3. Assess and evaluate the Center's goals and objectives

25. What was accomplished under these goals?

A total of 106 students have been recruited to the Center. Twenty-five (25) students have been identified/recruited to the Center as members of Cohort 1 (2016 – 2017), including 6 Ph.D., 6 M.S., and 13 B.S. Of these Cohort 1 students, eighteen (18) have graduated, including 4 Ph.D., 6 M.S., and 8 B.S. students. Twenty-five (25) students have been identified/recruited as members of Cohort 2 (2017-2018) including 8 Ph.D., 8 M.S., and 9 B.S. students. Of the Cohort 2 students, 17 have graduated, including 4 Ph.D., 7 M.S., and 6 B.S. students. Twenty-two (22) students have been identified/recruited as members of Cohort 3 (2018-2019) including 4 Ph.D., 7 M.S. and 11 B.S. students. Six students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S., and 3 B.S. So far, seventeen (17) students including 2 Ph.D., 9 M.S., and 6 B.S. students have been recruited into Cohort 4. Seventeen (17) students have been recruited into Cohort 5 including 3 Ph.D., 7 M.S., and 7 B.S. students. One B.S. student from Cohort 5 has graduated.

Sixteen (16) collaborative research projects (Table 25.1) were underway after selection for funding by the LMRCSC after reviews by the Technical Advisory Board (TAB). Other research projects supported with leveraged funds from agencies such as NOAA, NSF, USDA, are on-going at the LMRCSC.

The Center continues to hold monthly Executive Committee meetings during which plans to execute student development and professional activities were discussed.

Further details can be found in the attached document.

ACCOMPLISHMENTS *(cont'd)*

26. What opportunities for training and professional development has the project provided?

The Center provided direct support during this period for training of 63 students (22 B.S., 22 M.S., 11 Ph.D., and 8 additional non-degree students in the Geoscience Bridge Program). Plans were made to offer a Data Management Workshop in Fall 2021. Graduate and undergraduate students are required to take part in Scientific Ethics Training by completing the CITI Responsible Conduct of Research online training course. Graduate students at RSMAS, UMES, and UMCES are also required to complete a semester long course in ethics. All of these activities are captured through the completion of the Student Development Plan form, which is completed by the students in consultation with their advisors each semester. Additionally, the education committee procured and deployed a new learning management system (LMS) to better engage, track, and assess student participation. A list of supported students and their completion of these activities is available in Table 26.1 in the attached document.

During this period, seven students began or completed NERTO internships. A list of these students, their mentors, and their projects is available in Table 26.2 in the attached document.

27. How were the results disseminated to communities of interest?

• Center Scientists produced 19 journal articles, 4 of which included student authors.
• Eight (8) additional journal articles, including two (2) additional student authors, were In press or under review at the end of this reporting period.
• Center Scientists delivered 19 oral and 3 poster presentations at live and virtual professional meetings. Twelve (12) oral presentations and three (3) poster presentations of that number were made by students.
• To date, Center publications since September 2016 have been cited 960 times (128 from directly funded publications, 832 from leveraged publications).
• The Center continues to update its website regularly and publish newsletters. During this period, a newsletter was published in March and August, and another is in production for October 2021.

ACCOMPLISHMENTS *(cont'd)*

28. What do you plan to do during the next reporting period to accomplish the goals and objectives?

Education Goals: As examples, the Center will:
• Continue efforts to recruit students to the Center
• Continue to engage NOAA Scientists in order to enhance research collaborations and identify scientists to serve on graduate student thesis and dissertation committees; work with students to identify sites for NERTO.
• Continue to mentor students and encourage them to present research results at professional meetings, and publish their work in peer-reviewed journals.

Research Goals: As examples the Center will:
• Continue to seek leveraged funds to support students
• Solicit proposals to fund through the TAB process
• Continue research on TAB funded projects and projects supported through leveraged funds
• Continue efforts to publish results from prior awards and present at scientific meetings.

Administrative Goals: As examples, the Center will:
• Continue Executive Committee meetings monthly.
• Continue to collect data for evaluation of the Center's activities.
• Continue to disseminate information about the Center to the public, including producing Newsletters.
• Continue to monitor student development plans to ensure completion of Center Milestones.

PRODUCTS

29. Publications, conference papers, and presentations

• Center Scientists produced 19 journal articles, 4 of which included student authors. Full citations are available in the attached document in Table 29.1.
• Eight (8) additional journal articles, including 2 additional student authors, were In press or under review at the end of this reporting period. A detailed list is available in the attached document in Table 29.2.
• Center Scientists delivered 20 oral and 3 poster presentations at live and virtual professional meetings. Twelve (12) oral presentations and 3 poster presentations of that number were made by students. A detailed list is available in the attached document in Table 29.3 a and b.

PRODUCTS *(cont'd)*

30. Technologies or techniques

Nothing to Report

31. Inventions, patent applications, and/or licenses

Nothing to Report

Attach a separate document if more space is needed for #6-10, or #24-50.

PRODUCTS *(cont'd)*

32. Other products

In addition to the products listed above, Center students also produced a technical report for the California Department of Fish and Wildlife (Table 32.1) and five theses or dissertations (Table 32.2).

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

Eighty-seven (87) individuals have worked on the project, including scientists (24), graduate students (32), undergraduate students (28), and professional staff (3). Their details can be found in Table 33.1 of the attached document.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS *(cont'd)*

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Key personnel reported changes to 5 sources of support all of which were renewals of previous funding.

PD/PI or key personnel name	Description of support	Source of support	Description of change
Babcock, Elizabeth	Bycatch estimation project	NOAA SEFSC via CIMAS	Renewed
Babcock, Elizabeth	Global Shark Meat study	Shark Conservation Fund via Dalhousie Univ.	Renewed
Paulinus Chigbu, M. Sexton	UMES REU; 3/1/21 to 4/30/24	NSF	Renewed
Eric Schott	Nauplii culture and in vivo challenge to assess the ability of bacterial probiotics to protect shrimp against the pathogen	Bionetworks, Inc.	Funding ends this reporting period
Eric Schott	Of Animals and Microbes: A Baltimore Harbor Investigation	France Merrick	Funding ends this reporting period

35. What other organizations have been involved as partners?

The following organizations have been involved as partners:

Type of partner organization	Name	Location	Partners contribution to the project
1. State govt.	Virginia Aquarium	Virginia Beach, VA	Helped students collect samples
2. Private company	Wards Oyster Co.	Hampton, VA	Provided oysters for student research
3. State government	FWRI FWC	St. Petersburg, FL	Allowed new hire time to work on publishing dissertation research
4. Federal	NOAA SEFSW	Miami, FL	Allowed new hire time to work on publishing dissertation research
5. State government	GADNR	Brunswick, GA	Nets & gear, committee membership
6. Private industry	BF Consultants	McDonough, GA	Evaluation services and participation
7. Candelmo	Alli	REEF, team lead for Grouper Moon project	Committee member for J. Layton
8. Business	Manta Biofuels LLC	Maryland	Biotechnology partner with Li and Hill
9. Business	AlgaBT LLC	Maryland	Biotechnology partner with Li and Hill
10. MD DNR	Chuck Stence	Maryland	Helped student collect sturgeon data
11. NGO	Baltimore UnderGround Science SPace	Baltimore, MD	Community science of urban estuary
12. NGO	National Aquarium	Baltimore, MD	Community science of urban estuary
13. NGO	Blue Water Baltimore	Baltimore, MD	Water quality in urban tidal water
14. NGO	Waterfront Partnership of Baltimore	Baltimore, MD	Water quality in urban tidal water

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS *(cont'd)*

36. Have other collaborators or contacts been involved?

Forty-nine (49) NOAA Scientists and seventeen (17) scientists from other institutions have been involved in the project as collaborators during this period. Their names and involvement are listed in tables 36.1 and 36.2 in the attached document.

IMPACT

37. What was the impact on the development of the principal discipline(s) of the project?

During this period, the Center directly supported work that resulted in 3 peer reviewed journal articles in NOAA-mission sciences. All of these were related to the biology of fished or protected marine species.

IMPACT *(cont'd)*

38. What was the impact on other disciplines?

LMRCSC students at RSMAS are active in improving Diversity, Equity, and Inclusion at the University level. The two SSU B.S. graduates were URM men and contributed to an increase in the number of CSC post-secondary students trained in NOAA mission-related disciplines. Kris Howard's NERTO with Roldan Munoz was directly aligned with increasing skills to use large data sets, geographical information systems (GIS) and statistical analysis, computer modeling, and algorithm development. This also represented fulfillment of the center obligation to have students participate in on-site/virtual training at a NOAA facility. The presentation was shared widely on August 6, 2021. This training commitment is in process for two 2nd year M.S. students and has been planned for the two new LMRCSC students. One is planned for Galveston and the second is to be determined. At this time, three current LMRCSC M.S. students are prior LMRCSC undergraduates. Their success at the undergraduate level is reducing the attainment gap to URMs in NOAA mission-relevant fields and their succession to the graduate program is increasing the number of those who pursue higher education in the same areas. Scientific research capacity is increasing at SSU as a result of the collaborations being pursued with NOAA personnel. This year 2 proposals were submitted with NOAA-SSU collaborators. NOAA data and data needs are increasingly being used to drive student research. Chris Hintz and Jennifer Leo (NOAA) led a proposal to develop an ocean acidification system to elucidate the effects of acidifying conditions on invertebrate fisheries species in the GOM and South Atlantic. NOAA climate data is being used by undergraduate Savannah Clax as a basis of assessing sea level rise in the Gullah Geechee National Heritage Area. Connecting the effects of climate change on coastal communities, particularly the African American community of Gullah Geehcee people in the southeast, increases engagement of the CSC with URM communities who can see their interests and needs reflected in the work.

39. What was the impact on the development of human resources?

Students and faculty are receiving the financial support needed to stay in school, to be trained in research, to enter graduate programs, and to be gainfully employed to conduct NOAA research after graduation. The students in the table below earned degrees in NOAA relevant sciences. Three have secured employment in the field (2 NOAA, 1 State Government). Four are pursuing further degrees.

Last Name	First name	Institution	Degree	Cohort #	Graduation Date	Postgraduate information
1. McLean	Josette	HU	MS	2	May 1, 2021	Accepted to PhD program at Duke
2. Hildebrandt	Sierra	HU	MS	2	May 1, 2021	Accepted to PhD program at ODU
3. Denson	LaTreese	RSMAS	Ph.D.	2	July 21, 2021	Stock assessment scientist, NOAA SEFSC, Miami, FL
4. Cervera	Juan	RSMAS	MS	3	July 21, 2021	Environmental scientist, NOAA National Center for Coastal Ocean Sciences (NCCOS), Beaufort, NC
5. Pelekai	Keala	OSU	MS	3	June 1, 2021	Two jobs, first on with Idaho Fish and Game and just moved to permanent position with ADFG as Supervisory Fishery Biologist.
6. Day	Joe	SSU	BS	2	May 1, 2021	Accepted to M.S. program in Environmental Science at SSU
7. Burns	William	SSU	BS	3	May 1, 2021	Accepted to M.S. program in Environmental Science at SSU
8. Davis	Daquan	UMES	BS	3	May 15, 2021	Applying to Graduate Programs

IMPACT *(cont'd)*

40. What was the impact on teaching and educational experiences?

Students across the Center have access to courses at other Center institutions. This access broadens the diversity of courses available to our students. The Cohort Experience Workshop and other Center training and professional development further enhance our students' experience, making it more relevant to future NOAA mission careers.

41. What was the impact on physical, institutional, and information resources that form infrastructure?

At HU, institutional impact was achieved by providing additional funding to support faculty and student research, via upgrading lab space and equipment.

Support increases the critical mass of fisheries scientists at RSMAS, improving our ability to do NOAA relevant work and train students.

Attach a separate document if more space is needed for #6-10, or #24-50.

IMPACT *(cont'd)*

42. What was the impact on technology transfer?

Research results have been published, and presented at scientific meetings and stock assessment working groups.

43. What was the impact on society beyond science and technology?

Training offered to students at the LMRCSC is helping to diversity the workforce in marine and fisheries science. In particular during this funding period, five URM graduates from the Center secured employment in the field (3 NOAA, 1 State Government, 1 Academia)

IMPACT *(cont'd)*

44. What percentage of the award's budget was spent in foreign country(ies)?

0 , None

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

Pandemic restrictions have continued to require that traditionally in-person activities such as the Cohort Experience Workshop and NERTO be conducted virtually. The stoppage of field sampling may delay some students' degree completion. In some cases, university vaccine requirements have been a barrier to recruitment.

Attach a separate document if more space is needed for #6-10, or #24-50.

CHANGES/PROBLEMS *(cont'd)*

46. Actual or anticipated problems or delays and actions or plans to resolve them

Some partners report a delay in recruitment due to the pandemic. Issues include students who are recruited but never matriculate due to family or other personal circumstances and low GPAs among available undergraduate students. We are continuing to seek willing and qualified candidates.

47. Changes that had a significant impact on expenditures

Travel expenditures have ceased due to the pandemic while some students' research progress has been delayed. We will divert the unspent travel funds as well as supplemental funds provided by NOAA EPP to support the students to completion.

Attach a separate document if more space is needed for #6-10, or #24-50.

CHANGES/PROBLEMS *(cont'd)*

48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Nothing to Report

49. Change of primary performance site location from that originally proposed

Nothing to Report

Attach a separate document if more space is needed for #6-10, or #24-50.

PROJECT OUTCOMES

50. What were the outcomes of the award?

The Implementation Plan identifies four Education Outcomes and two research outcomes. The details of these outcomes are provided in the attached document. Highlights from this period include:

- 63 total students, 59 URM students trained in the Center
- 51 URM students pursuing higher education in NOAA mission fields
- 22 Seminars offered
- 8 students graduated, of which 7 are URM students
- 49 collaborations with NOAA Scientists
- 16 collaborative research projects

DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)

Gender:

- ◯ Male
- ◯ Female
- ◯ Do not wish to provide

Ethnicity:

- ◯ Hispanic or Latina/o Not
- ◯ Hispanic or Latina/o Do not
- ◯ wish to provide

Race:

- ◯ American Indian or Alaska Native Asian
- ◯ Black or African American
- ◯ Native Hawaiian or other Pacific Islander
- ◯ White
- ◯ Do not wish to provide

Disability Status:

- ◯ Yes
  - [ ] Deaf or serious difficulty hearing
  - [ ] Blind or serious difficulty seeing even when wearing glasses
  - [ ] Serious difficulty walking or climbing stairs
  - [ ] Other serious disability related to a physical, mental, or emotional condition
- ◯ No
- ◯ Do not wish to provide

Attach a separate document if more space is needed for #6-10, or #24-50.

Supplemental Text to the LMRCSC Semiannual Report

Text and tables are arranged using the same numbering system in the RPPR form:

25. What was accomplished under these goals?

a. Major Activities:

i. Education Activities:

Student Recruitment Activities: During this period, recruitment activities focused on recruiting qualified undergraduate and graduate students through outreach to summer program participants. Approximately 40 undergraduate interns were introduced to the LMRCSC and opportunities that exist immediately at partner institutions and in the future for those who plan to pursue graduate study. Additionally, we recruited undergraduate students from the pool of existing undergraduates at partner institutions. A selection of activities that took place during this period include:
DSU: Undergraduate students have been recruited from DSU natural resources courses. They will begin working Fall 2021 and Spring 2022**.**
RSMAS: We are currently seeking two graduate students.
UMCES: 10 URM undergraduate students were trained. This is a major tool for recruitment of URM graduate students. Schott, Jagus, Bachvaroff engaged IMET and UMCES graduate students mentoring 10 REU summer students in virtual projects examining the ecology and microbiology of estuaries and coastal sea. https://www.umces.edu/summer-internship-2021-blog
UMES: Introduced interns from the UMES REU, UMES Geoscience Bridge Program, and Maryland Sea Grant REU to the LMRCSC and opportunities within the center that are available to them now and in the future.

Experiential Training – The Center has continued to enhance its engagement with NOAA scientists in order to identify mentors for LMRCSC graduate and undergraduate students during the NERTO program and as members of their thesis or dissertation committees. During this period, most facilities were closed due to COVID-19. Several NERTO internships were conducted remotely with the assistance of the students' NOAA mentors.

ii. Research Activities – In 2021, 16 active TAB projects were investigated by students and scientists at LMRCSC partner institutions. Two of these began in 2018,three in 2019, 10 in 2020, and two in 2021. The following table describes only those projects that were active in the last year.

Table 25.1: LMRCSC TAB Projects During this Reporting Period*

Project Number	Principal Investigator	Title	Thematic Research Area
18-01	Brittany King	Underrepresentation in marine and fisheries science professions: how significant life experiences shape a diverse workforce	FESS
18-08	Eric Alexander Lewallen	Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys	HaBS
19-03	Carolina Bonin-Lewallen	Genetic approaches for monitoring the effects of climate change on leopard seals in the Antarctic Peninsula	CLIME
19-04	David Secor	Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts	SASI
19-07	Adrianne Wilson	Population structure and growth of lane snapper, a data limited species	SASI
20-01	Savannah M. Geiger	An analysis of distribution and abundance of microplastics in selected commercially important species in Northern Georgia coastal waters	HaBS
20-03	Kyarii Ramarui	Proteomic analysis of two *Haematococcus pluvialis* strains as aquaculture feedstock	SNAP
20-04	Eric Schott	Life history and disease ecology of the blue crab, a key benthic-pelagic link in tropical and temperate American estuaries	SASI
20-05	Matt Kenworthy	Evaluating the effects of landscape scale habitat variability on white shrimp (*Litopenaeus setiferus*) population dynamics in Georgia estuaries	HaBS
20-06	Scott Heppell	Genetic based methods for assessing the effects of climate change on the early life history stages of Nassau grouper	CLIME
20-07	Dennis McIntosh	Assessment of New Technologies for Post-Harvest Oyster Purification	SNAP
20-08	Shanelle Haughton	Evaluating physiological and immune responses of snow crabs (*Chionoecetes* sp.) to *Hematodinium* infection	SASI
20-09	Victoria Moreno (neé Williams)	Understanding Adaptive Capacity: An Analysis of Community Perceptions and Policy Responses to Ocean Acidification and other marine stressors on the West Coast	CLIME
20-10	Imani Wilburn	The Occurrence of Microplastics in Maryland Coastal Bay Fishes	HaBS
21-1	Rose Jagus	Sonar Censusing and Habitat Use by Spawning Run Atlantic and Green Sturgeon, *Acipenser oxyrinchus* and *A. medirostris*	SASI
21-2	Tunde Adebola	Developing a Coupled Human Ecological System for Chesapeake Bay Shellfish Fisheries	SASI

*Only currently active projects are included. CLIME: Climate Impacts on Marine Ecosystems; HaBS: Habitats and Biological Systems; SASI: Stock Assessment Support and Information; SNAP: Seafood, Nutrition, Aquaculture, and Pathology; FESS: Fishery Economics and Social Sciences

In addition, several projects supported with leveraged funds from various agencies including NOAA, NSF, and USDA are on-going at the Center, and new proposals were developed and submitted to various funding agencies.

Data Management and QA/QC: Based on feedback from students and the recommendation of the External Evaluation team, the Education Committee has elected to replace the Data Management for Scientists course, which graduate students took for credit. Instead, the Center will contract an organization called Data Carpentry to conduct a two day workshop entitled "Data Management and Visualization in R for Ecologists." The workshop will be required for all graduate students who have not already fulfilled the Data Management training requirement. Graduate students who have already completed the requirement and advanced undergraduates will also be invited to participate as space allows. All students will be encouraged and financially supported to take additional Data Carpentry courses that are relevant to their thesis and dissertation work.

Ethical Conduct of Research Training for Students and Faculty:
All center students are required at a minimum to complete online CITI Responsible Conduct of Research courses. The certificate of completion is submitted with the Student Development Form. In addition, graduate students at RSMAS, UMES, and UMCES are required to take a course in scientific ethics.

iii. Administrative activities:
1. The Center conducted its monthly Executive Committee, Education Committee, and Science Committee meetings.
2. The Center is organizing its annual BOV meeting to be held virtually Nov. 4, 2021

b. Specific Objectives
i. **Education Goal 1.** Prepare the future workforce for marine and fisheries sciences
1. Objective 1.1: Recruit students from under-represented groups into marine and fisheries science disciplines
2. Objective 1.2: Increase retention and degree completion rates for students in marine and fisheries sciences programs
3. Objective 1.3: Assess the value-added outcomes of degree programs in marine and fisheries sciences at the partner institutions

ii. **Education Goal 2.** Strengthen collaborations across universities and professional networks to enhance academic programs in marine and fisheries sciences
1. Objective 2.1: Use relevant research-based curricula to provide students with the highest quality education in marine and fisheries sciences
2. Objective 2.2: Use Virtual Campus technology to provide students with the opportunity to learn from some of the nation's leading scholars in marine and fisheries sciences
3. Objective 2.3: Ensure that curricula of degree programs at partner institutions address current challenges and emergent needs within the profession
4. Objective 2.4: Link students to professional networks and employment opportunities in marine and fisheries sciences

iii. **Scientific Research Goal 3.** Develop an exemplary capacity for scientific collaborations among partner institutions in the NOAA relevant fields of marine and fisheries sciences

1. Objective 3.1: Integrate the Center's research agenda with NOAA Fisheries research priorities in four key thematic areas: ecosystem change and prediction, stock assessment support, habitat research and protection, and safe seafood and aquaculture
2. Objective 3.2: Foster collaborative research programs to strengthen the research capacities of partner institutions by leveraging the significant strengths and resources of research universities as infrastructure for capacity building
3. Objective 3.3: Develop faculty recruitment and retention practices that ensure that the collective capacity of scholars affiliated with the Center represents significant concentrations of strength in the four key research thematic areas

iv. **Administration Goal 4.** Organizational excellence for effective and efficient management of the programs and activities of the Center
1. Objective 4.1: Establish an Administrative Structure to enhance center operations and provide supportive environment for training and mentoring of students, and for research in marine and fisheries sciences
2. Objective 4.2: Monitor and ensure compliance with Center Award Conditions

v. **Administration Goal 5.** Effectively communicate the activities and accomplishments of the center
1. Objective 5.1: Develop infrastructure for effective and efficient internal and external communication
2. Objective 5.2: Develop an effective strategy for communication with students, faculty and administrators within the center, and increase visibility of the center through enhanced communication of its accomplishments to external stakeholders

vi. **Administration Goal 6.** Assess and evaluate the center's goals and objectives
1. Objective 6.1: Assess and evaluate center educational programs
2. Objective 6.2: Assess and evaluate center research
3. Objective 6.3: Assess and evaluate center administration

c. Significant results:

i. Education goals:

Students Recruited and trained: Twenty-five (25) students have been identified/recruited to the Center as members of Cohort 1 (2016 – 2017), including 6 Ph.D., 6 M.S., and 13 B.S. Of these Cohort 1 students, eighteen (18) have graduated, including 4 Ph.D., 6 M.S., and 8 B.S. students. Twenty-five (25) students have been identified/recruited as members of Cohort 2 (2017-2018) including 8 Ph.D., 8 M.S., and 9 B.S. students. Of the Cohort 2 students, 17 have graduated, including 4 Ph.D., 7 M.S., and 6 B.S. students. Twenty-two (22) students have been identified/recruited as members of Cohort 3 (2018-2019) including 4 Ph.D.,7 M.S. and 11 B.S. students. Six students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S., and 3 B.S. So far, seventeen (17) students including 2 Ph.D., 9 M.S., and 6 B.S. students have been recruited into Cohort 4. Se venteen (17) students have been recruited into Cohort 5 including 3 Ph.D., 7 M.S., and 7 B.S. students. One B.S. student from Cohort 5 has graduated. A complete list of the students trained during this period and

the financial support provided to them is available in Appendix I.

a. Fifty-nine percent (59%) of those who received B.S. degrees have enrolled in graduate or professional schools. Six students completed their NERTO during this reporting period.
b. A new tool has been added to the LMRCSC Virtual Campus: the Learning Management System (LMS) Ispring Learn. The new LMS represents a significant upgrade from the previously used LMS, Schoology. It has already begun to enhance the engagement of students in Center activities as well as improve tracking of student progress and assessment of activities.

2. Building a Strong Center Cohort Community:
   a. One installment of the Graduate Student Seminar Series took place during this period (May 2021). Planning is underway for additional seminars to be held during the next reporting period.
   b. Due to restrictions to travel caused by the Covid-19 pandemic, the Cohort Experience Workshop was held virtually and included both synchronous and asynchronous components to engage students with Center Faculty and one another.
   c. Professional Development workshop was offered by Dr. Maggie Sexton biweekly for undergraduate students and monthly for graduate students during the academic year at UMES.
   d. PIs at HU, OSU, SSU, and UMCES report holding regular lab meetings with Center students.

ii. Research goals: 16 collaborative research projects (Table 25.1) were underway after selection for funding by the LMRCSC after reviews by the Technical Advisory Board (TAB). Reports on the TAB projects are included in Appendix II. Other research projects supported with leveraged funds from agencies such as NOAA, NSF, USDA, are on-going at the LMRCSC. A list of leveraged funds can be found in Appendix III.

iii. Administrative goals:
   1. The Center held its monthly Executive Committee meetings during which plans to execute student development and professional activities were discussed.
   2. The Center began planning for its annual Board of Visitors Meeting. The meeting was initially planned to be held in person in Baltimore, Maryland at the University of Maryland Center for Environmental Sciences-IMET. However, pandemic conditions, travel restrictions on some PIs, and general discomfort with long-distance travel during the pandemic have caused the Executive Committee to amend this to be a virtually meeting on November 4, 2021.
   3. The LMRCSC External Evaluators submitted to the Center their findings from assessment activities during this period. The report is available in Appendix IV.

d. Key outcomes or other achievements:
   i. A total of 106 students (25 in Cohort 1, 25 in Cohort 2, 22 in Cohort 3, 17 in Cohort 4, and 17 in Cohort 5) have been recruited to the Center
   ii. Eighteen (18) additional non-degree students were trained through internships.
   iii. External Evaluation of the LMRCSC is continuing.
   iv. New proposals have been submitted to various agencies to leverage funding in order to support additional students.

26. What opportunities for training and professional development has the project provided?

The project has provided students several training and professional development opportunities including the cohort experience workshop, NERTO, and training in Ethical Conduct of Research and Data Management (Tables 26.1, 26.2).

Table 26.1: Supported students, training opportunities and milestones.

First	Last	URM (y or n)	Cohort #	Degree	Partner	Cohort Experience	NERTO	Ethical Conduct of Research Training	Data Management Course	NOAA Mentor
Marcus	Teat	Y	2	B.S.	DSU	Spr. 22	Sum. 22	Spr. 21	Fall 21	TBD
Caitlyn	Czajkowski	N	3	M.S.	DSU	Spr. 21	Sum. 22	Spr. 21	Fall 21	TBD
Maria	Henson	Y	1	B.S.	HU	NA	NA	Fall 21	Spr. 21	NA
Sierra	Hildebrandt	N	2	M.S.	HU	Spr. 21	Sum. 20	Spr. 20	Fall 19	Y
Josette	McLean	Y	2	M.S.	HU	Spr. 21	Sum. 20	Spr. 20	Fall 19	Y
Amani	Tolin	Y	3	B.S.	HU	NA	NA	Spr. 20	Spr. 21	NA
Arona	Bender	Y	3	M.S.	HU	Spr. 22	Sum. 21	Spr. 20	Fall 20	Y
PaShun	Hawkins	Y	4	B.S.	HU	NA	NA	Spr. 21	Spr. 21	NA
Jaelyn	Leslie	Y	4	M.S.	HU	Spr. 23	Sum. 21	Fall 20	Fall 20	Y
Jonathan	Nash	Y	5	B.S.	HU	NA	NA	Spr. 21	Spr. 21	NA
T'Kiyah	Reeves	Y	5	B.S.	HU	NA	NA	Spr. 21	Spr. 21	NA
Derrick	Richardson	Y	5	B.S.	HU	NA	NA	Spr. 21	Spr. 21	NA
King	Brittany	Y	2	PhD	OSU	Spr. 18	Fall 20	Spr. 19	Spr. 20	Y
Layton	Janelle	Y	4	MS	OSU	Spr. 21	TBD	Fall 2020	Fall 21	TBD
Williams	Victoria	Y	4	MS	OSU	Spr. 21	Spr. 21	TBD	Fall 21	Y
Leann	Cohn	Y	5	MS	OSU	Spr. 22	Sum 21	TBD	Fall 21	Y
Clax	Savannah	Y	2	NA	RSMAS	NA	NA	NA	NA	NA
LaTreese	Denson	Y	2	PhD	RSMAS	Spr. 18	Sum 18	Fall 17	Fall 18	Sum 18
Adrianne	Wilson	Y	2	PhD	RSMAS	Spr. 19	Fall 18	Fall 15	Fall 18	Sum 18
Juan	Cervera	Y	3	MS	RSMAS	Spr. 21	Sum 20	Fall 19	Fall 19	Fall 19
Cristin	Mayes	Y	4	PhD	RSMAS	NA	Sum 22	Fall 19	NA	Fall 20
Chryston	Best-Otubu	Y	5	PhD	RSMAS	Spr. 21	Sum 22	Fall 20	Fall 20	Fall 21
Joe	Day	Y	2	BS	SSU	NA	Fall 18	NA	NA	NA
Sena	Tay	Y	2	M.S.	SSU	Spr. 21	NA	NA	NA	NA
Ambrose	Alexandria	Y	3	B.S.	SSU	NA	Fall 18	Fall 2018	NA	NA
Mackey	Shaneese	Y	3	M.S.	SSU	Sum 19	Fall 18	Spr. 19	Fall 19	NA
Chelsea	Spaulding	Y	4	B.S.	SSU	NA	NA	Sum 20	NA	NA
Savannah	Geiger	N	4	M.S.	SSU	Spr. 21	Sum 20	Sum 20	Fall 19	Y
William	Burns	Y	5	B.S.	SSU	NA	NA	Fall 20	NA	NA
Savannah	Clax	Y	5	B.S.	SSU	NA	NA	Spr. 21	NA	Y
Michon	Shaw	Y	5	B.S.	SSU	NA	NA	Fall 21	NA	NA
Kristafer	Howard	Y	5	M.S.	SSU	Spr. 21	Spr. 21	Fall 20	Fall 21	Y
Chloe	Lemaire	N	5	M.S.	SSU	Spr. 22	Sum. 22	Fall 21	Fall 21	TBD
Dante	Freeman	Y	2	B.S.	SSU	NA	Fall 18	NA	NA	Sum 19
Erianna	Hammond	Y	2	B.S.	SSU	NA	Fall 18	NA	NA	NA
Michael	Williams	Y	2	B.S.	SSU	NA	Fall 18	NA	NA	NA

Alexandria	Tennant	Y		B.S.	SSU	NA	NA	Fall 21	NA	NA
Lady	Volmar	Y		B.S.	SSU	NA	NA	Fall 21	NA	NA
Shadaesha	Green	Y	1	Ph.D.	UMCES	Spr. 18	Sum 19	Fall 17	Fall 17	Y
Nicholas	Coleman	Y	2	M.S.	UMCES	Spr. 21	TBD	TBD	Fall 21	Y
Benjamin	Frey	Y	3	M.S.	UMCES	Spr. 19	Spr. 19	Fall 19	Fall 19	Y
Kyarii	Ramarui	Y	4	Ph.D.	UMCES	Spr. 21	Spr. 21	Fall 19	Fall 20	Y
Olivia	Pares	Y	5	Ph.D.	UMCES	Spr. 21	TBD	TBD	Fall 20	Y
Kasondra	Rubalcava	Y	2	Ph.D.	UMES	Spr. 18	Sum. 19	Fall 19	Fall 19	Y
Teemer	Barry	Y	3	B.S.	UMES	N/A	N/A	Fall 18	Spr. 21	N/A
DaQuan	Davis	Y	3	B.S.	UMES	N/A	N/A	Sum. 18	Spr. 21	N/A
Shanelle	Haughton	Y	3	Ph.D.	UMES	Spr. 19	Sum. 19	Fall 19	Fall 19	Y
Ashley	Silver	Y	3	Ph.D.	UMES	Spr. 21	Sum. 21	Fall 20	Fall 20	Y
Glen	Colins	Y	4	B.S.	UMES	N/A	N/A	Spr. 21	Spr. 21	N/A
Shakira	Goffe	Y	4	M.S.	UMES	Spr. 21	Sum. 21	Fall 19	Fall 20	Y
Tahirah	Johnson	Y	4	M.S.	UMES	Spr. 21	Sum. 21	Spr. 21	Fall 20	Y
Imani	Wilburn	Y	4	M.S.	UMES	Spr. 21	Sum. 21	Spr. 20	Fall 20	Y
Malika	Brown	Y	5	B.S.	UMES	NA	NA	Fall 21	NA	NA
Angel	Delgado	Y	5	M.S.	UMES	Spr. 22	Sum. 22	Fall 21	Fall 21	TBD
Kaithlynn	Wade	Y	5	M.S.	UMES	Spr. 22	Sum. 23	Fall 21	Fall 21	TBD
Elyssa	Baker	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Cameron	Bennett	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Mikaela	Blackwood	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Indaya	Byer	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Amarim	Dupree	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Beverly	Malugin	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Jamar	Moody	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A
Ronald	Whatley	Y		No Degree	UMES	N/A	N/A	N/A	N/A	N/A

Table 26.2: NERTO internships completed or continuing during this reporting period.

Student Name	Activity/Project Title	NOAA Personnel Involved	Location
Leanne Cohn	Mapping the footprint of Rockfish Conservation Area on the US West Coast 2021	Flaxen Conway and Blake Feist	Virtual
Nicholas Coleman	Sonar Censusing and habitat use by spawning run Green Sturgeon, *Acipenser medirostris*	Steven Lindley and Peter Dudley	NMFS, SWFSC, Santa Cruz, CA
Shakira Goffe	Analyses and Comparison of American Plaice maturity parameters in the Georges Bank and Gulf of Maine Regions	Larry Alade	Virtual, NEFSC Woods Hole Lab, MA

Ashley Silver	Evaluating growth parameters for American Plaice in the Gulf of Maine and George's Bank	Larry Alade	Virtual, NEFSC Woods Hole Lab, MA
Arona Bender	Initial analysis of the foraging tactics and social behavior of Antarctic fur seals (*Arctocephalus gazella*) from animal-borne HD video footage	Douglas Krause	NOAA NMS/SWFSC/AERD La Jolla, CA
Jaelyn Leslie	Assessing the feeding ecology and prey preferences of Pacific lamprey	Laurie Weitkamp	National Marine Fisheries Service/NEFSC/ Newport Research Station
Kristafer Howard	Abiotic and Biotic Factors Influence the Community Composition of US Southeast Atlantic Fishes from 2015-2019	Roldan Munoz	NMFS Beaufort Laboratory, NC

29. Publications, conference papers, and presentations

Table 29.1: LMRCSC Publications in peer reviewed journals. Center students are identified with asterisk (*). Center scientists' names appear in bold**.**

Publications in journals	Justification
Allison, Nicola, Catherine Cole, Christopher Hintz, Kenneth Hintz, James Rae, Adrian Finch. 2021. Resolving the interactions of ocean acidification and temperature on coral calcification media pH. Coral Reefs. doi.org/10.1007/s00338-021-02170-2.	Leveraged
Blaisdell, J., Thalmann*, H. L., Klajbor, W., Zhang, Y., **Miller, J. A.,** Laurel, B., Kavanaugh, M. 2021. A Dynamic Stress-scape Framework to Evaluate Potential Effects of Multiple Environmental Stressors on Gulf of Alaska Juvenile Pacific Cod. Frontiers in Marine Science. 12 May 2021 | https://doi.org/10.3389/fmars.2021.656088	Leveraged
Clementi, G.M., **E. A. Babcock**, J. Valentin-Albanese, M. E. Bond, K.I. Flowers, M. R. Heithaus, E. R. Whitman, M. P. M. Van Zinnicq Bergmann, T. L. Guttridge, O. R. O'Shea, O. N. Shipley, E. J. Brooks, S. T. Kessel, and D. D. Chapman. 2021. Anthropogenic pressures on reef-associated sharks in jurisdictions with and without directed shark fishing. Marine Ecology Progress Series 661:175-18. doi:10.3354/meps13607	Leveraged
D. H. Secor, M. H. P. O'Brien, N. Coleman, A. Horne, I. Park, D. C. Kazyak, D. G. Bruce & C. Stence. 2021. Atlantic Sturgeon Status and Movement Ecology in an Extremely Small Spawning Habitat: The Nanticoke River-Marshyhope Creek, Chesapeake Bay, Reviews in Fisheries Science & Aquaculture, DOI: 10.1080/23308249.2021.1924617	Leveraged
da Silva, L. V., Ossai, S., **Chigbu, P.**, & **Parveen, S**. 2021. Antimicrobial and Genetic Profiles of *Vibrio vulnificus* and *Vibrio parahaemolyticus* Isolated From the Maryland Coastal Bays, United States. Frontiers in Microbiology, *12*, 676249. https://doi.org/10.3389/fmicb.2021.676249	Leveraged, LMRCSC PI

Elmer L, C Madliger, D Blumstein, C Elvidge, E Fernandez-Juricic, **A Horodysky**, N Johnson, L McGuire, R. Swaisgood and S. Cooke. 2021. Exploiting common senses: sensory ecology meets wildlife conservation and management. Conservation Physiology. 9(1):coab002. doi:10.1093/conphys/coab002	Leveraged
Frischer, Marc. E, et. al., **Gibson, D.M**. 2021. Selective feeding and linkages to the microbial food web by the doliolid, *Dolioletta gegenbauri* in the South Atlantic Bight. Limnology and Oceanography. https://doi.org/10.1002/lno.11740	Leveraged/LMRCSC Acknowledged
Jesse, J.A., Agnew, M.V., Arai, K., Armstrong, C.T., Hood, S.M., Kachmar, M.L., Long, J.T., McCarty, A.J., Ross, M.O., Rubalcava, K.D.*, Shaner, J., Tanaka, S., Wood, L., **Schott, E**. and Wilberg, M. 2021. Effects of Infectious Diseases on Population Dynamics of Marine Organisms in Chesapeake Bay. Estuaries and Coasts, pp.1-16. doi: 10.1007/s12237-021-00915-4	Direct, Cohort 2 student
Karlovic, T.C., Gomes, R.R., Paiva, P.C., **Babcock, E.A.** & Dias, J.F. 2021. Functionality and effectiveness of Marine Protected Areas in Southeastern Brazilian waters for demersal elasmobranchs. Frontiers in Marine Science. 8:694846.	Leveraged
Curran, C.M., Ramsey, A.L. & Bower, A.S. 2021. Learning about ocean currents one track at a time, Science Activities, 58:1, 13-22, DOI: 10.1080/00368121.2021.1885333	Leveraged
Morales-Núñez, A.G., **Chigbu P.** 2021. *Carinacuma umesi*, a new genus and species of bodotriid cumacean (Crustacea: Malacostraca: Peracarida) from shallow waters of the Maryland Coastal Bays, Mid-Atlantic region, USA. *PeerJ* 9:e11740	Leveraged, LMRCSC PI
O'Farrell* H. B. & **Babcock, E. A.** (in press). Shortfin mako hot sets-defining high bycatch conditions as a basis for bycatch mitigation. Fisheries Research. 244: 106123. doi:10.1016/j.fishres.2021.106123	Cohort 1 student
Omori K.L., Tribuzio C.A., **Babcock E.A.** & Hoenig J.M. (2021). Methods for identifying species complexes using a novel suite of multivariate approaches and multiple data sources: A case study with Gulf of Alaska rockfish. Frontiers in Marine Science 8:663375. doi: 10.3389/fmars.2021.663375	Leveraged
Williams EP, **Bachvaroff TR, Place AR**. 2021. A Global Approach to Estimating the Abundance and Duplication of Polyketide Synthase Domains in Dinoflagellates. Evol. Bioinform Online, doi: 10.1177/11769343211031871	Leveraged
Elena Legrand, Tsvetan Bachvaroff, Tracey B. Schock, **J. Sook Chung.** 2021. Understanding molt control switches: Transcriptomic and expression analysis of the genes involved in ecdysteroidogenesis and cholesterol uptake pathways in the Y-organ of the blue crab, *Callinectes sapidus*. PloS one 16 (9), e0256735	Leveraged
Haihui Ye, Marcy N Wilder, Heinrich Dircksen, **J Sook Chung** 2021. Recent Advances in Crustacean Endocrinology. Frontiers in Endocrinology	Leveraged
T.R. Bachvaroff, Ryan MacDonald, Louis Plough, **J. Sook Chung** 2021. Chromosome-level assembly of the *Callinectes sapidus* genome G3	Leveraged
A. Lawrence*, B. Shank, **B. Stevens, and J. Sook Chung** 2021. Morphometric and physiological maturity of male Jonah crab, Cancer borealis Stimpson, 1859 (Decapoda: Brachyura: Cancridae), in southern New England, USA. Journal of Crustacean Biology 41 (3), ruab030	TAB

Huang X, Green* S, **Sook Chung J**. 2021. The presence of an insulin-like peptide-binding protein (ILPBP) in the ovary and its involvement in the ovarian development of the red deep-sea crab, *Chaceon quinquedens*. General Comparative Endocrinology. 301:113653. doi: 0.1016/j.ygcen.2020.113653	leveraged

Table 29.2: Publications that were in press or under review at the end of the reporting period. Center students are identified by asterisk (*). Center scientists' names appear in bold.

Publications in journals	Justification	Status
Galvez*, B., **Smith, S.L.**, Townsend, H.*,* **Ozbay, G.** (in review). Generalized Linear Modeling of Weakfish (*Cynoscion regalis)* stable isotopes in the Delaware Bay. Estuaries and Coasts.	Direct, Cohort 1 Student	under review
Nichols H.J., Fuchs B., Paijmans A.J, Lewis G., **Bonin C.**, Goebel M.E.; Hoffman J.I. Where are the beachmasters? Unexpectedly weak polygyny among southern elephant seals on a South Shetland Island. Journal of Zoology. In review.	Leveraged/LMRCSC Acknowledged	under review
Cole, C, AA Finch, **C Hintz**, K Hintz, Y Yu, EIMF, N Allison. 2021. The K_D Sr/Ca in cultured massive *Porites* spp. corals are reduced at low seawater pCO_2. *Geochimica Cosmochimica Acta.*	Leveraged	in press
Schultz, E.*, LaCasella, E. Lewis, KA., **Hoskins-Brown, D**., Dutton, P. Genetic stock structure analysis of female green sea turtles, *Chelonia mydas*, nesting on the East End beaches of St. Croix, USVI: a regional analysis.	Other LMRCSC activity	under review
Lin, H., Y. Li and R. T. Hill. 2021. Microalgal and bacterial auxin synthesis: implications for algal biotechnology. Current Opinion in Biotechnology. In Press.	Leveraged	in press
Qi Chen, Feng Chen, Michael Gonsior, Yunyun Li, Yu Wang, Chen He, Ruanhong Cai, Jinxin Xu, Yimeng Wang, Dapeng Xu, Jia Sun, Ting Zhang, Quan Shi, Nianzhi Jiao, Qiang Zheng. 2021. Correspondence between DOM molecules and microbial community in a subtropical coastal estuary on a spatiotemporal scale. Environmental International. 154: 106558.	Other	in press
Secor, D.H., M.H.P. O'Brien, N. Coleman*, A. Horne, I. Park, D.C. Kazyak, D.G. Bruce, C. Stence. Atlantic sturgeon status and movement ecology in an extremely small spawning habitat: The Nanticoke-Marshyhope Creek Estuary, Chesapeake Bay. Reviews in Fisheries Science and Aquaculture. In review	Leveraged	in review

Table 29.3a: Oral presentations at virtual professional meetings. Center students are identified byasterisk (*). Center scientists' names appear in bold.

Oral presentations at professional meetings	Justification
Arona Bender*, Kathryn Cruz*, Michael Goebel, Douglas Krause, **Eric Lewallen, Carolina Bonin Lewallen.** (2021). Estimating effective population size and historical demography of leopard seals (*hydruga leptonyx*) in the antarctic peninsula. Hampton University School of Science Symposium, Virtual, April 2021. (*) Second place, graduate student presentation	Cohort 3
Bender*, Arona, Douglas Krause. Initial analysis of the foraging tactics and social behavior of Antarctic fur seals (*Arctocephalus gazella*) from animal-borne HD video footage. NERTO Final Presentation, Southwest Fisheries Science Center, La Jolla, CA (Virtual Talk), August 6th, 2021.	Cohort 3
Bonin, C.A. Epigenomics of dolphin skin. Virtual HBCU-UP/CREST PI-PD Meeting. Feb 4 & 5 2021. Recorded presentation with live Q&A.	Direct
Bonin, C.A., Roots, A., Cruz, K*. Investigating the epigenomic adaptations in dolphin skin. Hampton University Science Symposium. April 1 2021. Virtual live presentation.	Direct
Cervera* J.C and R. Araujo. 2021. Australian pine (*Casuarina equisetifolia*) invasion of Florida mangroves. SEMANGLARES IV. Red Colombiana de Estuarios y Manglares. Online conference presentation. July 26, 2021	LMRCSC Cohort 3 student
Cervera*, J.C. 2021. Modeling mangrove shift in response to sea-level rise in Miami-Dade County. University of Miami's 2021 Coastal Resilience Virtual Symposium. April 7, 2021.	LMRCSC Cohort 3 student
Cervera*, J.C. 2021. Essential fish habitat mapping tool. Invited Student Virtual Talk. NOAA EPP Forum. April 8, 2021.	LMRCSC Cohort 3 student
Hildebrandt*, Sierra, **Deidre Gibson**, Jason Spires, Shawn McLaughin. (2021). Investigating The Impacts of Oyster-Conditioned-Water on *Crassostrea virginica* Larval Direct Setting Efficiency. Hampton University School of Science Symposium, Virtual, April 2021. (*) First place, graduate student presentation	Cohort 2
Leslie*, Jaelyn, Douglas Krause. Assessing the mass and body condition of leopard and fur seals using aerial images. NERTO Final Presentation, Southwest Fisheries Science Center, La Jolla, CA (Virtual Talk), August 6th, 2021.	Cohort 4
Nash*, Jonathan, Heidi Sosik. Quantifying the distribution of gelatinous invertebrates and their habitat conditions on the Northeast US Shelf through imagery and associated environmental data. PEP Research Symposium, August 2021.	Cohort 5
Hill. R. T., Webinar, Microbial symbionts and nutrient cycling in marine sponges. Opening talk in "Advances in Microbial Biotechnology and the Use of Next-Generation Sequencing Platforms". United National University, Program for Biotechnology in Latin America and the Caribbean. 15 March, 2021	Leveraged
T. Bachvaroff, L. Plough and J. Sook Chung (2021) Cracking the Genome of the Blue Crab, *Callinectes sapidus*. 2021 National Shellfish Association conference	other
Louis V. Plough, Ben B. Lee, Eric J. Schott, Andrew Kough, Donald C. Behringer, Jamie Boijko, Tsvetan Bachvaroff, and J. Sook Chung (2021). Population Genomic Analysis of the Blue Crab, *Callinectes sapidus*, Across its Range: Insights Into Gene Flow, Local Adaptation, and the Potential for Geographic Source Tracking. 2021 National Shellfish Association conference (Virtual)	Leveraged
Elena Legrand, Tsvetan Bachvaroff, Tracey B. Schock, and J. Sook Chung Transcriptomic and expression analysis of the genes involved in ecdysteroidogenesis and cholesterol uptake in the Y-organ of the blue crab, *Callinectes sapidus*. 2021 National Shellfish Association conference	Other
Shadaesha Green*, Tsvetan Bachvaroff, and J. Sook Chung (2021). Understanding eyestalk neuropeptides influencing vitellogenesis of the red deep-sea crab, *Chaceon quinquedens*. 2021 National Shellfish Association conference	TAB
Amanda Lawrence*, S. Green, T. Wang, T. Bachvaroff, and J. Sook Chung (2021). Is there a relationship between sexual maturity and expression levels of crustacean male hormone, insulin-like androgenic gland hormone (IAG)? 2021 National Shellfish Association conference	TAB

Coleman*, N.C., Dudley, P. (2021). Estimating Green Sturgeon Abundance in the Sacramento River using DIDSON survey. Meeting of Interagency Ecological Program (IEP)	Leveraged
Frey*, B.A., Secor, D., Richards, A., & Jagus, R. NERTO Mentee Testimonial. Leadership Initiative for Networking and Collaboration Conference, April 2021	Leveraged
Williams, E. P., Bachvaroff, T.R., and Place, A.R. 2021. In-vitro and In-vivo Biochemical Methods to Distinguish Between Lipid and Toxin Biosynthesis in Dinoflagellates. 10.5 US Symposium on Harmful Algae, May 25-27, 2021 (Virtual Oral Presentation).	other
Rubalcava*, K. (2021). Mentee Testimonial. Presented at NEFSC-LMRCSC Leadership Initiative for Networking and Collaboration (LINC) Virtual Conference, April 2021.	Cohort 2

Table 29.3b: Poster presentations at virtual professional meetings. Center students are identified by asterisk (*). Center scientists' names appear in bold.

Poster presentations at professional meetings	Justification
Tolin*, Amani Shawn Dash, Benjamin Cuker. (2021). Evaluating the Impacts of Water Quality and Interspecific Interactions on the Larval Recruitment of Eastern Oysters (*Crassostrea virginica*) in the Hampton River. Hampton University School of Science Symposium, Virtual, April 2021.	Cohort 3
Leslie*, Jaelyn, Susan G. Barco, Alexander Costidis, **Tunde Adebola, Carolina Bonin Lewallen** (2021). The potential long-term impact of the 2013 morbillivirus outbreak in common bottlenose dolphin (*Tursiops truncatus*) strandings in Virginia (USA). Hampton University School of Science Symposium, Virtual, April 2021.	Cohort 4
O. Pares*, A. Fowler, M. Zhao, and E Schott. NSA poster National Shellfish Association (March 2021, virtual). Title: The Potential for Blue Crab Prey to be Host of the Crab Pathogen, CsRV1.	TAB

32. Other Products

Table 32.1: Other publications

Other publications	Justification
Cohn, L., and W. R. Chesney. 2017. Shasta River Juvenile Salmonid Out-migrant Study Multi-Year Report, 2000-2017. California Department of Fish and Wildlife, Anadromous Fisheries Resource Assessment and Monitoring Program, 1625 South Main Street, Yreka, CA 96097	Direct, Cohort 5 student

Table 32.2: Theses and Dissertations produced by Center students during the current reporting period.

Theses/Dissertations	Justification
McLean, Josette (May 2021 MS Thesis). Optimization of DNA extraction and PCR methods for Pacific Lamprey gut content analysis	LMRCSC Cohort 2 student
Hildebrandt, Sierra (May 2021, MS Thesis), Investigating The Impacts of Oyster-Conditioned-Water on *Crassostrea virginica* Larval Direct Setting Efficiency	LMRCSC Cohort 2 student
Tolin, Amani (April 2021, Sr Thesis). Evaluating the Impacts of Water Quality and Interspecific Interactions on the Larval Recruitment of Eastern Oysters (*Crassostrea virginica*) in the Hampton River	LMRCSC Cohort 3 student

Denson, L. S. 2021. The Effect of Environmental Variation at Differing Spatial and Temporal Scales on Stock Assessment Inputs and Outputs with a Focus on King Mackerel in the U.S. Gulf of Mexico. University of Miami. Dissertation. Doctor of Philosophy (PhD). Marine Biology and Fisheries. https://scholarship.miami.edu/discovery/fulldisplay/alma991031606758502976/01UOML_INST:Research Repository	LMRCSC Cohort 2 student/ TAB
Cervera, J. C. 2021. Modeling Mangrove Shift in Response to Sea Level Rise in Miami-Dade County, Florida Thesis. Master of Science (MS), University of Miami. Marine Ecosystems and Society. https://scholarship.miami.edu/discovery/fulldisplay/alma991031606763302976/01UOML_INST:ResearchRepository	LMRCSC Cohort 3 student
Evaluation of Pacific Lamprey *Entosphenus tridentatus* Anatomical Structures as Records of Age and Isotopic Histories	LMRCSC Cohort 3

33. What individuals worked on this project?

Table 33.1: Individuals who worked on the project during the reporting period

Last name	First Name	# of mths worked	Project Role	Contribution to project (briefly describe)	State, U.S. territory, and/or country of residence	Collaborated with individual in a foreign	Country(ies) of foreign collaborator	Travelled to foreign country	if traveled to foreign country(ies), duration of stay
Smith	Stacy	6	PD/PI	Worked with students/did research	Dover, DE	no		no	
McIntosh	Dennis	6	Faculty	Worked with students/did research	Dover, DE	no		no	
Ozbay	Gulnihal	6	Faculty	Worked with students/did research	Dover, DE	no		no	
Czajkowski	Caitlyn	6	Graduate Student	Aquaculture research	Dover, DE	no		no	
Teat	Marcus	6	Graduate Student	Oyster gardening research	Dover, DE	no		no	
Gibson	Deidre	6	PD/PI	Project Director; advised Sierra Hildebrand, Derrick Richardson, Jonathan Nash, and co-advised Amani Tolin	Virginia	no		no	
Lewallen	Carolina	6	Faculty	Advised Arona Bender, Jaelyn Leslie, and co-	Virginia	no		no	

				advised Josette McLean					
Lewallen	Eric	3	Faculty	Advised Josette McLean	Virginia	no		no	
Cuker	Benjamin	3	Faculty	Advised Amani Tolin	Virginia	no		no	
Dash	Shawn	3	Faculty	Advised Amani Tolin	Virginia	no		no	
Sharma	Indu	6	Faculty	Advised PaShun Hawkins and T'kiyah Reeves	Virginia	no		no	
Horodysky	Andrij	6	Faculty	Advised Maria Henson	Virginia	no		no	
Adebola	Tunde	6	Faculty	A research faculty; worked with graduate students on GIS training	Virginia	no		no	
Hildebrandt	Sierra	3	Graduate Student	Conducted research	Virginia	no		no	
McLean	Josette	3	Graduate Student	Conducted research	Virginia	no		no	
Bender	Arona	6	Graduate Student	Conducted research	Virginia	no		no	
Leslie	Jaelyn	6	Graduate Student	Conducted research	Virginia	no		no	
Tolin	Amani	3	Undergraduate Student	Conducted research	Virginia	no		no	
Hawkins	PaShun	6	Undergraduate Student	Conducted research	Virginia	no		no	
Nash	Jonathan	6	Undergraduate Student	Conducted research	Virginia	no		no	
Richardson	Derrick	6	Undergraduate Student	Conducted research	Virginia	no		no	
Reeves	T'Kiyah	6	Undergraduate Student	Conducted research	Virginia	no		no	
Henson	Maria	6	Undergraduate Student	Conducted research	Virginia	no		yes	8 months
Babcock	Elizabeth	0.6	PD/PI	PD for UM-RSMAS	Florida, USA	yes	Belize, Brazil, Canada, Guatemala	no	NA
Die	David	0.3	Co PD/PI	Co PI for UM-RSMAS	Florida, USA	yes	Australia, Spain, France, Madagascar, Senegal, Brazil	no	NA
Denson	LaTreese	0	Graduate Student	Finished dissertation on spatial variation and environmental data in king mackerel assessment	Florida, USA	no		no	

Wilson	Adrianne	0	Graduate Student	Working on dissertation on lane snapper growth variation	Florida, USA	no		no	
Cervera	Juan	3	Graduate Student	Completed MS thesis on mangrove response to sea level rise	Florida, USA	no		no	
Mayes	Cristin	6	Graduate Student	Working on dissertation on ecosystem modeling and climate change	Florida, USA	no		no	
Best-Otubu	Chryston	6	Graduate Student	Working on dissertation on ecosystem modeling and climate change	Florida, USA	no		no	
Clax	Savannah	2	Undergraduate Student	Did summer internship on Adrianne Wilson's lane snapper project	Georgia, USA	no		no	
Hoskins-Brown	Dionne	6	PD/PI	Performed research on oyster habitat, blue crabs, etc.	Georgia, USA	no		no	
Hintz	Chris	6	Faculty	Worked on ocean acidification effects on benthic invertebrates	Georgia, USA			no	
Cox	Tara	6	Faculty	Works on distribution, ecology, and health of bottlenose dolphins	Georgia, USA	no		no	
Ebanks	Sue	2.375	Faculty	She researches microplastics and coastal resilience	Georgia, USA	no		no	
Young	Victoria	6	Faculty	She has led student development, taught courses, and led education program development and assessment	Georgia, USA	no		no	
Geiger	Savannah	6	Graduate Student	Researched microplastics and mentored undergraduates	Georgia, USA	no		no	

Spaulding	Chelsea	6	Undergraduate Student	Updated and standardized NMFS ESA-listed species' global range files for the Office of Protected Resources' (OPR)	Georgia, USA	no		no	
Burns	William	6	Undergraduate Student	Researched landscape scale variability in penaid distribution	Georgia, USA	no		no	
Howard	Kristafer	6	Graduate Student	Researched effectiveness of bycatch reduction devices on terrapin exclusion and crab retention	Georgia, USA	no		no	
Clax	Savannah	6	Undergraduate Student	Researched Sea Level Rise scenarios for GGCHC using long-term NOAA datasets	Georgia, USA	no		no	
Day	Joe	2	Undergraduate Student	Researched microplastics in SAB/Assessments of implantable tags on short-finned pilot whales, *Globicephala macrorhynchus*	Georgia, USA	no		no	
Day	Joe	4	Graduate Student	Researched bottlenose dolphin populations	Georgia, USA	no		no	
Tay	Sena	6	Graduate Student		Georgia, USA	no		no	
Mackey	Shaneese	6	Graduate Student	Developed UAS approach to assess restored and natural oyster reefs	Georgia, USA	no		no	
Tennant	Alexandria	3	Undergraduate Student		Georgia, USA	no		no	
Shaw	Michon	2	Undergraduate Student	n/a	Georgia, USA	no		no	
Volmar	Lady	3	Undergraduate Student	n/a	Georgia, USA	no		no	
Lemaire	Chloe	2	Graduate Student	n/a	Georgia, USA	no		no	
Miller	Jessica	6	PI	Project Director	Oregon, USA	no		no	

Pelekai	Keala	6	Graduate Student	at OSU	Oregon, USA	no		no	
King	Brittany	6	Graduate Student	Conducted research	Oregon, USA	no		no	
Williams	Victoria	6	Graduate Student	Conducted research	Oregon, USA	no		no	
Layton	Janelle	6	Graduate Student	Conducted research	Oregon, USA	no		no	
Jagus	Rosemary	1.5	PD/PI	Supervised students and staff, wrote proposals, performed research	Maryland, USA			no	
Coleman	Nicholas	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Schott	Eric	1	Faculty	Mentor to Pares, research, outreach	Maryland, USA	Yes	Brazil	no	
Frey	Ben	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Green	Shadaesha	3	Graduate Student	Conducted research	Maryland, USA	no		no	
Pares	Olivia	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Ramarui	Kyari	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Chigbu	Paulinus	3	PD/PI	Supervised center activities, wrote proposals, trained students	Maryland, USA			no	
Sexton	Margaret	6	Faculty	Supervised center activities, student development activities	Maryland, USA	no		no	
Stevens	Bradley	4	Faculty	Supervised center research activities, research, trained students	Maryland, USA			no	
Hankerson	Tanesha	4.5	Other Professional	Communications activities	Maryland, USA	no		no	
Kessie	Alex	6	Other Professional	Budget and data management	Maryland, USA	no		no	
Tilghman	Ida	6	Other Professional	Administrative activities	Maryland, USA	no		no	
Rosales	Detbra	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Rubalcava	Kasondra	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Barry	Teemer	3	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	

Davis	DaQuan	3	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Fielding	Semaj	3	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Haughton	Shanelle	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Silver	Ashley	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Colins	Glen	3	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Goffe	Shakira	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Johnson	Tahirah	6	Graduate Student	Conducted research	Maryland, USA	no		no	
Wilburn	Imani	6	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Rufus	Mya	6	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Baker	Elyssa	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Bennett	Cameron	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Byer	Indaya	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Malugin-Ayala	Beverly	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Blackwood	Mikaela	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Dupree	Amari	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Moody	Jamarre	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Whatley	Ronald	2	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	

36. Have other collaborators or contacts been involved?

Table 36.1: NOAA scientists who have collaborated with the Center during this reporting period.

Last name	First name	Title/Affiliation	Description of Involvement
Ailloud	Lisa	SEFSC	NOAA mentor for Cristin Mayes
Allman	Robert	SEFSC	PhD committee member and NERTO mentor for Adrianne Wilson
Alvarez	Danielle	SEFSC	Research collaborator
Batchelor	Nate	SEFSC, Beaufort, NC	NERTO Mentor
Browder	Joan	SEFSC	Collaborator
Busch	Shallin	NMFS	NOAA Mentor to OSU Student
Deshpande	Ashok	NEFSC Sandy Hook, NJ	Committee member for Savannah Geiger
Doerr	Jennifer	SEFSC Galveston, TX	Grant Collaborator
Dudley	Peter	Project scientist, SWFSC	Collaborator and mentor
Dutton	Peter	NWFSC	Co-author
Ewing	Ruth	SEFSC	Program Collaborator (mentor recruitment)
Freidland	Kevin	Research Marine Scientist	Collaborator
Gerard	Trika	SEFSC Miami, FL	Program Collaborator (mentor recruitment)
Harvey	Chris	NMFS	NOAA Mentor to OSU Student
Hill	Ron	SESFC Panama City, FL	Committee member for Shaneese Mackey
Jacobs	John	NOAA NOS, COL, MD	NOAA mentor for Caiti Czajkowski; Collaborator at UMCES
Johnson	Matthew	SEFSC Galveston, TX	Grant Collaborator
Johnson	Melissa	EEO	Program Collaborator (development)
Johnson	Ed	Physical Scientist	NERTO mentor
Jones	Christian	SEFSC	Program Collaborator (drones)
Karnauskas	Mandy	SEFSC	Program Collaborator (mentor recruitment); potential NERTO mentor for O. Pares
Krause	Douglas	SWFSC	NERTO mentor for Arona Bender and Jaelyn Leslie
LaCasella	Erin	NWFSC	Co-author
Leo	Jennifer	SEFSC Galveston	Grant Collaborator, NERTO mentor
Lewis	Kemit-Amon	SSU	Co-author
Lindley	Steve	SEFSC, Santa Cruz	Collaborator
MacPherson	Matthew	SEFSC	Program Collaborator (mentor recruitment)
McElhany	Paul	Station Chief	NERTO training
McLaughlin	Shawn	Oxford Laboratory, MD	NERTO and outside committee member for Sierra Hildebrandt
Molineaux	Johnathan	Silver Spring, MD	Internship mentor
Munoz	Roldan	SEFSC Beaufort, NC	NERTO Mentor
Patterson	Jody	Grays Reef NMS	Non-LMRCSC student mentor
Richards	Anne	Research Fisheries Biologist, NEFSC, MA	NERTO mentor & collaborator
Robeson	Kimberly	Grays Reef NMS	NOAA mentor to Kris Howard; microplastics research with Sue Ebanks
Robillard	Eric	NEFSC, Woods Hole, MA	collaborator
Schultz	Emma	SEFSC Pascagoula, MS	Manuscript Collaborator

Serafy	Joe	SEFSC	Collaborator
Shank	Burton	Research Fisheries Biologist	NERTO mentor
Sharma	Rishi	NWFSC	Collaborator
Spires	Jason	Oxford Laboratory	NERTO and outside committee member for Sierra Hildebrandt
Stoffle	Brent	SEFSC	Research collaborator
Thorson	James	AFSC	NERTO mentor for LaTreese Denson
Townsend	Howard	NEFSC	Co-authored student paper
Vogt	Bruce	Ecosystem Science Manager	NERTO mentor
Walter	John	SEFSC	PhD. Committee member for LaTreese Denson; collaborator and mentor for UMCES student
Weinberg	James	Fishery Biologist	Collaborator
Weitkemp	Laura	NWFSC	NERTO mentor for Josette McLean
Werner	Kevin	NMFS	NOAA Mentor to OSU Student
Wickfors	Gary	NWFSC, Milford, CT	Collaborator and future NERTO mentor

Table 36.2: Other collaborators involved in Center activities during this reporting period.

Last name	First name	Title/Affiliation	Description of involvement
Alber	Merryl	Professor, UGA	Grant collaborator
Babcock	Elizabeth	Professor, RSMAS	Grant collaborator
Brandes	Jay	Professor, UGA	Use of Raman Spectroscopy instrumentation
Fortner	Sarah	Science Education Resource Center (SERC) at Carleton College	Grant collaborator
Frischer	Marc	Professor, UGA	Grant collaborator
Gleason	Daniel	Professor, Georgia Southern University	Grant collaborator
Grabowski	John	Professor, Northeastern University	Grant collaborator
Helmuth	Brian	Professor, Northeastern University	Grant collaborator
Johnson	Ronald	President, Sapelo Island Cultural and Revitalization Society	Grant collaborator
McIntosh	Dennis	Natural Resources Prof., DSU	Student Advisor
Ozbay	Gulnihal	Natural Resources Prof., DSU	Student Advisor
Ozbay	Gulnihal	Professor, DSU	Grant collaborator
Ricks-Santi	Luisiel	Asst. VP for Research	MS committee member for Josette McLean
Ross	Sarah	Director, Wormsloe CREW	Book editor
Stoffle	Richard	Professor, Arizona State University	Research Collaborator
Tripati	Aradhna	Professor, UCLA	Grant collaborator
Yager	Patricia	Professor, UGA	Grant collaborator
Fowler	Amy	George Mason Univ	Collaborator with O. Pares; E. Schott
Dahlenburg	Charmaine	National Aquarium	Collaborator with Schott; Bachvaroff
Frederick	Adam	MD Sea Grant	Collaborator with Schott; Bachvaroff
Tavares	Camila	PhD candidate, University of Parana, Brazil	Collaborator with Schott

50. What were the outcomes of the award?

a. Education Outcomes

1. **Outcome 1. Increased number, annually, of CSC post-secondary students, trained:** A total of 106 students have been recruited to the Center. Twenty-five (25) students have been identified/recruited to the Center as members of Cohort 1 (2016 – 2017), including 6 Ph.D., 6 M.S., and 13 B.S. Of these Cohort 1 students, eighteen (18) have graduated, including 4 Ph.D., 6 M.S., and 8 B.S. students. Twenty-five (25) students have been identified/recruited as members of Cohort 2 (2017-2018) including 8 Ph.D., 8 M.S., and 9 B.S. students. Of the Cohort 2 students, 17 have graduated, including 4 Ph.D., 7 M.S., and 6 B.S. students. Twenty-two (22) students have been identified/recruited as members of Cohort 3 (2018-2019) including 4 Ph.D., 7 M.S. and 11 B.S. students. Six students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S., and 3 B.S. So far, seventeen (17) students including 2 Ph.D., 9 M.S., and 6

B.S. students have been recruited into Cohort 4. Seventeen (17) students have been recruited into Cohort 5 including 3 Ph.D., 7 M.S., and 7 B.S. students. One B.S. student from Cohort 5 has graduated. A complete list of the students trained during this period and the financial support provided to them is available in Appendix I. Outputs include:

a. Increased quantitative and analytical skills – Students are acquiring quantitative and analytical skills by taking courses such as Data Management for scientists that was offered in Fall 2018, 2019, and 2020 and by participating in internships and REU programs. We have also developed and deployed an online training module to introduce undergraduates to the principles of Data Management.
b. Increased competence in applying STEM to decision-making, policy and management - This is addressed by the Cohort Experience Workshop, which will begin during the next reporting period.
c. Increased skills to use large data sets, geographical information systems (GIS) and statistical analysis, computer modeling, and algorithm development – An online course was offered covering Data Management in Fall 2018, 2019, and 2020 and will be offered every subsequent Fall. All undergraduate students are required to complete the course prior to graduation.

2. **Outcome 2: Increase number of CSC post-secondary students educated and graduated annually:** A total of 106 students have been recruited to the Center. Twenty-five (25) students have been identified/recruited to the Center as members of Cohort 1 (2016 – 2017), including 6 Ph.D., 6 M.S., and 13 B.S. Of these Cohort 1 students, eighteen (18) have graduated, including 4 Ph.D., 6 M.S., and 8 B.S. students. Twenty-five (25) students have been identified/recruited as members of Cohort 2 (2017-2018) including 8 Ph.D., 8 M.S., and 9 B.S. students. Of the Cohort 2 students, 17 have graduated, including 4 Ph.D., 7 M.S., and 6 B.S. students. Twenty-two (22) students have been identified/recruited as members of Cohort 3 (2018-2019) including 4 Ph.D., 7 M.S. and 11 B.S. students. Six students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S., and 3 B.S. So far, seventeen (17) students including 2 Ph.D., 9 M.S., and 6 B.S. students have been recruited into Cohort 4. Seventeen (17) students have been recruited into Cohort 5 including 3 Ph.D., 7 M.S., and 7 B.S. students. One B.S. student from Cohort 5 has graduated. A complete list of the students trained during this period and the financial support provided to them is available in Appendix I. Outputs include:
   a. Number of degrees earned annually in NOAA mission-related disciplines: Eight (8) students graduated during this period, including 1Ph.D., 4 M.S., and 3 B.S. student.
   b. Number of students (total and URM) who participated in professional development opportunities, to include at least one on-site experiential research and training opportunity at a NOAA Lab, office, or facility with tangible training and research: Seven graduate students took part in NERTO internships under the supervision of NOAA scientists. These activities were conducted remotely due to COVID-19.

3. **Outcome 3. Increased CSC capacity to train and graduate students.** Sixteen (16) active collaborative research projects continued or were newly funded during this reporting period, which have enabled center scientists to be available to mentor and advice undergraduate and graduate students. In addition, 47 NOAA scientists have been identified to serve as mentors of the students during the NERTO program or as collaborators in the TAB funded projects. The NERTO has increased exposure to NOAA training and encouraged faculty to increase their flexibility in scheduling graduate students' field work and academic schedules. Outputs include:
    a. Number of seminars: 22
    b. New courses: 2
    c. New programs: 0
    d. New degrees offered to develop working skills and functional competencies to support the NOAA mission and workforce: 0
    e. Total numbers of students supported by the LMRCSC: 63
    f. Total degrees awarded: 8
    g. Degrees awarded to URM students: 7
4. **Outcome 4**: **the attainment gap for URMs in NOAA mission-relevant fields.** The recruitment of new URMs (graduate and undergraduate students) during this reporting period is an important first step needed for preparing the students for careers in NOAA mission-relevant fields. This will ultimately help to reduce the attainment gap for the URMs in the fields. Outputs include:
    a. Increased number of URM students in student development activities that will lead them to the attainment of degrees and/or employment in NOAA mission fields = **58** URMs at the LMRCSC took part in student development activities.
    b. Increased number of URM students who select to pursue higher education in NOAA mission fields = **47** URMs at the LMRCSC are pursuing higher education in NOAA mission fields during this reporting period.

b. Research Outcomes:

1. Outcome 1. Increased NOAA mission-relevant research capacity at MSIs: NOAA scientists are already collaborating with Center scientists as well as working with some of the graduate students; suitable mentors are being identified for the remaining students. Additionally, research funds provided to scientists at the Center are enabling them to purchase equipment and supplies for their research in addition to Graduate Research Assistantship provided to support research endeavors. Outputs include:

a. Number of research collaborations with NOAA and LMRCSC faculty, staff and students: Each of the sixteen (16) LMRCSC TAB projects has a NOAA scientist as a collaborator. Those projects are ongoing.

b. Number of NOAA scientists serving as mentors and advisors for student research: 49 NOAA scientists and collaborators are working with the Center.

c. Number of intra-institutional collaborative partnerships established and

maintained in support of NOAA's mission = 28

d. Number of uses of NOAA data in research and tool development = 1. Kasondra Rubalcava (Ph.D. student at UMES) is using the long-term fish dataset collected by the Maryland Department of Natural Resources for her dissertation research aimed at developing an ecosystem model for the Maryland Coastal Bays.

2. Outcome 2. CSC-supported faculty, staff and students' research directly aligned with NOAA's mission and strategic priorities: Sixteen (16) collaborative research projects were funded by the LMRCSC. These projects were funded after they had been reviewed by the Technical Advisory Board (TAB) based on a number of criteria, one of which is their alignment with NOAA's mission and strategic priorities.

Outputs include:

	# from Projects Directly Supported with FY 16 Funds	**# from Leveraged Projects**
# of peer reviewed publications	2	11
# of presentations	13	0
# Tools developed	1	0
Use of LMRCSC research results and tools by NOAA & other stakeholders	1	0
# of instances LMRCSC publications are cited	128	832
# of LMRCSC students, staff or faculty recognized nationally for LMRCSC research	1	0

LMRCSC TAB-Funded Projects Currently Active

Project Number	**Principal Investigator**	**Title**	**Thematic Research Area**
18-01	Brittany King	Underrepresentation in marine and fisheries science professions: how significant life experiences shape a diverse workforce	FESS
18-08	Eric Alexander Lewallen	Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys	HaBS
19-03	Carolina Bonin-Lewallen	Genetic approaches for monitoring the effects of climate change on leopard seals in the Antarctic Peninsula	CLIME
19-04	David Secor	Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts	SASI
19-07	Adrianne Wilson	Population structure and growth of lane snapper, a data limited species	SASI

20-01	Savannah M. Geiger	An analysis of distribution and abundance of microplastics in selected commercially important species in Northern Georgia coastal waters	HaBS
20-03	Kyarii Ramarui	Proteomic analysis of two *Haematococcus pluvialis* strains as aquaculture feedstock	SNAP
20-04	Eric Schott	Life history and disease ecology of the blue crab, a key benthic-pelagic link in tropical and temperate American estuaries	SASI
20-05	Matt Kenworthy	Evaluating the effects of landscape scale habitat variability on white shrimp (*Litopenaeus setiferus*) population dynamics in Georgia estuaries	HaBS
20-06	Scott Heppell	Genetic based methods for assessing the effects of climate change on the early life history stages of Nassau grouper	CLIME
20-07	Dennis McIntosh	Assessment of New Technologies for Post-Harvest Oyster Purification	SNAP
20-08	Shanelle Haughton	Evaluating physiological and immune responses of snow crabs (*Chionoecetes* sp.) to *Hematodinium* infection	SASI
20-09	Victoria Moreno (neé Williams)	Understanding Adaptive Capacity: An Analysis of Community Perceptions and Policy Responses to Ocean Acidification and other marine stressors on the West Coast	CLIME
20-10	Imani Wilburn	The Occurrence of Microplastics in Maryland Coastal Bay Fishes	HaBS
21-1	Rose Jagus	Sonar Censusing and Habitat Use by Spawning Run Atlantic and Green Sturgeon, *Acipenser oxyrinchus* and *A. medirostris*	SASI
21-2	Tunde Adebola	Developing a Coupled Human Ecological System for Chesapeake Bay Shellfish Fisheries	SASI

*Only currently active projects are included. CLIME: Climate Impacts on Marine Ecosystems; HaBS: Habitats and Biological Systems; SASI: Stock Assessment Support and Information; SNAP: Seafood, Nutrition, Aquaculture, and Pathology; FESS: Fishery Economics and Social Sciences

TAB Project Abstracts

Project Number 18-01:

Title: Underrepresentation in marine and fisheries science professions: how significant life experiences shape a diverse workforce

Thematic Research Area: Fisheries Socio-economics

Abstract: NOAA Fisheries has a responsibility to provide the best available science for the management of living marine resources. Research has shown the value of diversified thinking and approaches in science and that diverse perspectives can improve our collective ability to solve problems. However, many racial and ethnic groups face the issue of being underrepresented in marine and fisheries science professions, resulting in a workforce that does not reflect the diversity of the United States. Understanding the factors that drive individuals to participate in environmental fields, such as marine, aquatic, and fisheries science, provides organizations and institutions with insight that can be incorporated into their

recruitment efforts. This is especially important in efforts to recruit and retain individuals from underrepresented and marginalized communities. This study builds on the research around career decisions and timing of science career interest, with a focus on marine, aquatic, and fisheries science and intersecting identities. This study explored the following research questions: 1) What factors influenced interest and career decisions in marine, aquatic and fisheries sciences at different life stages? 2) How does the timing of interest and decisions to pursue careers in marine, aquatic, and fisheries science professional vary across race, gender, and social class? The results of this study support previous literature on the importance of experiences with nature, family support, academic and research experiences, and advisor and mentorship on career decisions. Results also highlighted differences across intersections of identity (e.g., race, gender, and class). As researchers strive to understand the factors that influence career decisions in the natural resources field, it is important to explore how each of these social identities interacts and the role of their impact on decisions.

Principal Investigator: Name: Brittany King **Institution**: Oregon State University
Co-PI: Name: Kelly Biedenweg **Institution**: Oregon State University
NOAA Partner: Name: Kevin Werner **Lab/Facility**: NOAA/NWFSC
Other Partner: Name: **Lab/Facility:**
Students: Graduate Student; **Undergraduate Student:**
Keywords: Fisheries, Social Science, Diversity

Project Number 18-08:

Title: Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys

Thematic Research Area: HaBS - Habitats and Biological Systems

Abstract: The Pacific lamprey (*Entosphenus tridentatus*) is an anadromous species that occurs throughout the Northern Pacific Ocean and is important to humans for at least two key reasons: 1) Indigenous peoples near the Columbia River have a cultural value for them as a ceremonial food item, and 2) during their marine phase, lampreys parasitize many fish species and may reduce commercial harvests (e.g., Pacific hake, walleye pollock). Although culturally important, vulnerable (freshwater modifications reduce larval habitats), and ecologically interesting (parasites can exhibit dramatic fluctuations in abundance), the basic biology of Pacific lamprey in marine waters has not been well documented. The goal of this study is to identify prey items of Pacific lampreys and characterize their feeding ecology in the Northeastern Pacific Ocean, particularly where they overlap with commercially-targeted species (e.g., Pacific hake, shrimps).

Principal Investigator: Name: Eric A. Lewallen, PhD **Institution**: Hampton University
Co-PI: Name: Carolina B. Lewallen, PhD **Institution**: Hampton University
NOAA Partner: **Name**: Laurie Weitkamp, PhD
Lab/Facility: NWFSC - Northwest Fishery Science Center
Other Partner: **Name:** Linda Park, PhD
Lab/Facility: NWFSC - Northwest Fishery Science Center
Students: **Graduate Student;** Josette McLean, MSc
Undergraduate Student: Janelle Layton
Keywords: Bycatch, Fisheries, Marine Biology, Protected Species, Population Dynamics, Ecosystems

Project Number 19-03:

Title: Genetic approaches for monitoring the effects of climate change on leopard seals in the Antarctic Peninsula.

Thematic Research Area: Climate and Ecosystems: Effects on Marine Ecosystems

Abstract: The United States is one of the largest consumers of Antarctic fishery products, and is legally mandated to report on krill and krill-dependent predator abundance, diet and movements. These data have been collected for nearly 30 years in the South Shetland Islands (SSI), through the efforts of the NOAA Antarctic Marine Living Resources program. In the SSI, rapid warming has caused a dramatic decrease in sea-ice with consequences for the entire ecosystem. Interestingly, leopard seal numbers have also increased over this time period; understanding this intriguing pattern is key for the prediction of future scenarios in the Antarctic. Leopard seals are elusive pack ice breeders, and reliable data on the abundance of this species are lacking. Here we propose to investigate leopard seal abundance using samples archived by AMLR to: i) infer levels of genetic diversity and ii) estimate the number of breeding individuals.

Principal Investigator:
Name: Carolina Bonin Lewallen — **Institution**: Hampton University
Co-PI: Name: Eric Lewallen — **Institution**: Hampton University
NOAA Partner: Douglas Krause — **Name**: **Lab/Facility**: SWFSC
Other Partner: Felipe Barreto — **Lab/Facility:** Oregon State University
Graduate Student: Arona Bender — **Undergraduate Student:** Kathryn Cruz
Keywords: genetic diversity; climate change; predator; effective population size; Antarctic

Project Number 19-04:

Title: Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts

Thematic Research Area: Assessment: Support and Information

Abstract: Monkfish *Lophius americanus* sustains a key revenue stream for the stressed US Northeast groundfish fleets. Still, monkfish have been managed very conservatively because of major uncertainties in the stock assessment, the most significant of which is age structure and growth in this long-lived species. Access and allocation of this resource to New England and Mid-Atlantic fleets is highly dependent upon the underlying productivity of monkfish and its assessment, both of which are uncertain owing to the lack of a valid ageing procedure. We propose to develop and validate novel ageing procedures for this species supporting assessment goals and focused student training in state-of-the-art fisheries techniques, marine chemistry, and stock assessment. This project will provide support to LMRCSC graduate student, Mr. Ben Frey, to work with Dr. Anne Richards, lead scientist for monkfish assessments, and the NEFSC Fisheries Biology Program.

Principal Investigator: **Name**: Dr. Rose Jagus — **Institution**: UMCES/IMET
Co-PI: Name: Dr. David Secor — **Institution**: UMCES/CBL
NOAA Partner: **Name**: Dr. Anne Richards — **Lab/Facility**: NEFSC
Other Partner: Name: — **Lab/Facility:**
Students: Graduate Student: Mr. Ben Frey — **Undergraduate Student:**

Project Number 19-07:

Title: Population structure and growth of lane snapper, a data limited species

Thematic Research Area: Stock Assessment Support

Abstract: Lane Snappers (*Lutjanus synagris*) are a data-limited species that range from North Carolina,

the Gulf of Mexico (GOM) and south to Brazil. This study will collect 400 sagittal otoliths, fin clips, length/weight measurements from fish caught from East Florida to North Carolina. Otoliths will be processed, aged and two experienced readers will be used to ensure accurate ageing. A variety of growth models will be used to determine best fit. Genotyping by sequencing (GBS) will be used to determine genetic diversity. Results will compliment a recent NOAA supported study that examined spatial and temporal variation in the age and growth of Lane Snapper in the GOM and data will be used to support future NOAA stock assessments by providing information on population structure and growth.

Principal Investigator:
Name: Adrianne Wilson **Institution**: University of Miami - RSMAS
Co-PI:
Name: Dr. Elizabeth Babcock **Institution**: University of Miami - RSMAS
NOAA Partner:
Name: Robert Allman **Lab/Facility**: SEFSC: Southeast Fishery Science Center
Other Partner:
Name: Dr. Dionne Hoskins **Lab/Facility:** Savannah State University/NOAA
Graduate Student; Adrianne Wilson **Undergraduate Student:** Savannah Clax
Keywords: Fisheries, Marine Biology, Social science, Population dynamics

Project Number 20-01:

Title: An analysis of distribution and abundance of microplastics in selected commercially important species in Northern Georgia coastal waters
Thematic Research Area: HaBS: Habitats and Biological Systems
Abstract: The various densities of plastics allow for particulate plastics to settle or aggregate in different habitats in the marine environment, thereby increasing their prevalence in a variety of organisms that inhabit areas where particulate plastics accumulate. The proposed research is to study the microplastic abundance in organisms of economic importance in Georgia in an effort to understand the ecological impact of microplastics in the aquatic, estuarine, and marine environments. The objectives of this proposal are to: (1) analyze microplastics in selected commercially important species and (2) to analyze the spatial abundance of microplastics in selected waters near Savannah, GA, USA.

Principal Investigator: **Name**: Savannah Geiger **Institution**: SSU
Co-PI: Name: Sue C. Ebanks **Institution**: SSU
NOAA Partner: **Name**: Ashok Deshpande **Lab/Facility**: J.J. Howard Sandy Hook
Name: Kimberly Roberson **Facility**: Gray's Reef National Marine Sanctuary
Other Partner: Name: Ali Ishaque **Lab/Facility:** UMES
Graduate Student: Savannah Geiger
Undergraduate Student: Joe Day, Alexandria Tennant, Lady Volmar, Sophia Rodman, Brittany Thomas, Breanna Roland, Tela Fields-Reynolds, Aliyah Beach
Keywords: Microplastics, habitats,

Project Number 20-03:

Title: Proteomic analysis of two *Haematococcus pluvialis* strains as aquaculture feedstock
Thematic Research Area: Seafood, Nutrition, Aquaculture, and Pathology (SNAP)
Abstract: The green microalga *Haematococcus pluvialis* produces an antioxidant pigment, astaxanthin, which is widely used in salmon aquaculture as feed additive. Current algae industry uses phototrophic cultivation for *H. pluvialis* production, however, under these conditions the growth rate and astaxanthin productivity are low. A mutant strain of *H. pluvialis* has been generated through chemical mutagenesis

that demonstrates increased heterotrophic growth and astaxanthin productivity, addressing the bottlenecks of *Haematococcus* production. To understand the molecular underpinning of this phenotype, we propose further molecular characterization of these two mutant strains through LC-MS/MS based proteomic analysis. The knowledge generated will help development of rational engineering strategies for improved astaxanthin production in microalgae and promote its use in aquaculture.

Principal Investigator: **Name**: Kyarii Ramarui **Institution**: UMCES
Co-PI 1: **Name:** Dr. Yantao Li **Institution**: UMCES
Co-PI 2: **Name:** Dr. Allen Place **Institution**: UMCES
Co-PI 3: **Name:** Dr. Joseph Pitula **Institution**: UMES
NOAA Partner: **Name**: Dr. Gary Wikfors **Lab/Facility**: Milford Lab (NEFSC)
Other Partner: **Name:** N/A **Lab/Facility:** N/A
Graduate Student: Kyarii Ramarui, PhD, Marine Estuarine Environmental Sciences Program
Keywords: Aquaculture, Social Science, Plankton Other: Feedstock

Project Number 20-04:

Title: Life history and disease ecology of the blue crab, a key benthic-pelagic link in tropical and temperate American estuaries
Thematic Research Area: Assessment: Support and Information
Abstract: The blue crab, *Callinectes sapidus*, supports fisheries that define a way of life in coastal communities from New Jersey to Texas. Across their range, crabs display life history variation: overwintering in the north and year-round activity in the subtropics. They also inhabit true tropics, where there is a lack of data on crab biology. In Puerto Rico, crabs are harvested in an artisanal fishery that may grow as conch and lobster fisheries decline. If so, crucial data, (size at maturity, sex ratio, habitat use) will be needed for management, and have value for understanding Puerto Rico estuaries. Across their range, blue crabs are infected by viruses and protozoa that may interact with environmental and anthropogenic stressors to limit abundance. This project will enable a graduate student to gather blue crab life history and pathogen data in Puerto Rico and learn how life history data is applied to management by NOAA.

Principal Investigator: **Name**: Dr. Eric Schott **Institution**: UMCES/IMET
Co-PI: Name: Dr. Bradley Stevens **Institution**: UMES (retired)
NOAA Partner: Bruce Vogt, NOAA Chesapeake Bay Office
Other Partner: Name: Harold Manrique Hernández, San Juan Bay Estuary Program (http://relief.estuario.org) **Lab/Facility:**
Students: Graduate Student: Olivia Pares **Undergraduate Student:**
Keywords: Fisheries; Ecology; Pathology

Project Number 20-05:

Title: Evaluating the effects of landscape scale habitat variability on white shrimp (*Litopenaeus setiferus*) population dynamics in Georgia estuaries.
Thematic Research Area
SASI: Stock Assessment Support and Information and
HaBS: Habitats and Biological Systems
Abstract: Estuaries are recognized as important nursery habitats for penaeid shrimp species. Yet, there remain many questions about what exactly constitutes high-value, even critical, habitat for juveniles. In this study, we proposed to evaluate the nursery function of Georgia estuaries for white shrimp. We will evaluate relative abundance, growth, condition, and trophic dynamics of juvenile white shrimp among alternative landscape types. Furthermore, we will examine the use of stable isotope tags to identify areas within the estuary contributing greater proportions of individuals to the adult population. The results from

this study will provide a better understanding of the population dynamics of estuarine and nearshore habitats and their contribution to fishery productivity.

Principal Investigator: Matt Kenworthy, Savannah State University
Co-PI: Dionne Hoskins-Brown, Savannah State University
NOAA Partner: Jennifer Doerr, Southeast Fisheries Science Center
Other Partner: Maurice Crawford, LMRCSC UMES
Students: William Burns, Undergraduate SSU
Keywords: Healthy Habitat, White Shrimp, Landscape

Project Number 20-06:

Title: Genetic based methods for assessing the effects of climate change on the early life history stages of Nassau grouper

Thematic Research Area: CLIME: Climate Impacts on Marine Ecosystems

Abstract: Climate variability and change likely have major impacts on the early life history stages of commercially and recreationally valuable fish like Nassau Grouper. Understanding these impacts will be essential to conservation and management efforts. Studies to date have noted phenotypic and survival differences in early life history stages of Nassau Grouper reared at different temperatures. However, little is known of the drivers of these changes in bioenergetics and in gene expression during the early life history stages of this species. My goal is to measure bioenergetic activity and use established genetic methods to investigate temperature induced changes in gene expression of early life stage Nassau grouper, collected from a spawning aggregation on Little Cayman, Cayman Islands.

Principal Investigator: **Name**: Scott Heppell **Institution**: Oregon State University
Co-PI: Name: **Institution**:
NOAA Partner: **Name**: Steve Gittings **Lab/Facility**: National Ocean Service
Other Partner: Name: Brice Semmens **Lab/Facility:** Scripps Institution of Oceanography
Other Partner: Name: Dr. Carolina Bonin **Lab/Facility:** Hampton University
Students: Graduate Student; Janelle Layton **Undergraduate Student:** TBD
Keywords: Climate, early life history, Nassau Grouper, growth, survival, heat shock proteins

Project Number 20-07:

Title: Assessment of New Technologies for Post-Harvest Oyster Purification

Thematic Research Area: Safe Seafood, Shellfish Aquaculture

Abstract: It is imperative that aquaculturists can continue to provide consumers with safe seafood as the industry grows and adapts to a changing climate. Oyster aquaculture is particularly vulnerable to the intersection of seafood safety and climate change. Harvested oysters are at risk for carrying enteric bacteria and viruses that can make consumers ill, notably from *Vibrio* spp. bacteria. The prevalence of *Vibrio* spp. is expected to rise with increasing water temperatures. While post-harvest processing approaches currently employed to reduce risk of contaminated oysters are effective in reducing pathogens, they have specific drawbacks for growers, including requiring high levels of capital to gain access to treatment equipment, poor consumer reception of treated products, and death of treated oysters. As part of my thesis research, I aim to demonstrate efficacy of two new technologies, individually and combined, in removing pathogens from oyster tissues and aquaculture system water leading to a post-harvest treatment that is more effective than traditional depuration, has low oyster mortality and is cost-effective for growers. This will be accomplished through a series of controlled experiments at the DSU Aquaculture Research and Demonstration Facility in Dover, DE to establish calibration curves for the new technologies in RAS.

Principal Investigator: Stacy Smith **Institution**: Delaware State University
Co-PI: Dennis McIntosh **Institution**: Delaware State University
NOAA Partner: John Jacobs **Lab/Facility**: Cooperative Oxford Lab, MD
Students: Graduate Student; Caitlyn Czajkowski
Keywords: Oyster, aquaculture, seafood, shellfish, vibrio, food safety

Project Number 20-08:

Title: Evaluating physiological and immune responses of snow crabs (*Chionoecetes* sp.) to *Hematodinium* infection.

Thematic Research Area: Assessment: Support and Information

Abstract: A commercially important crustacean pathogen, *Hematodinium* sp., is a parasitic dinoflagellate of the *Hematodinium* genus that can cause Bitter Crab Disease/Bitter Crab Syndrome (BCD/BCS). There are high rates of *Hematodinium* sp. infection in snow crabs native to the Bering Sea, which can result in soiled crab meat and thus cause significant losses to commercial stocks. *Hematodinium* may affect regulation of metabolic gene expression in infected crabs, based upon observed changes in biochemical composition. This study will explore this effect, in addition to the regulation of genes involved in the immune response in snow crabs. The effect of climate change on host snow crab immune function, and susceptibility to disease, is currently unknown. This study provides an opportunity to assess these parameters using cutting edge tools like next-generation sequencing, and provide baseline information for assessment of the health of this fishery.

Principal Investigator: Name: Shanelle Haughton **Institution**: UMES
Co-PI: Name: Dr. Joseph Pitula **Institution**: UMES
NOAA Partner: Name: Dr. Pamela Jensen **Lab/Facility**: AFSC
Other Partner: Name: Dr. Sook-Chung **Lab/Facility:** UMCES-IMET
Students: Graduate Student: Shanelle Haughton **Undergraduate Student:**
Keywords: Fisheries; Marine Biology; Ecosystems; Crustaceans; *Hematodinium*; Disease;

Project Number 20-09:

Title: Understanding Adaptive Capacity to Environmental Change: An Analysis of Community Perceptions and Policy Responses to Ocean Acidification and other marine stressors on the West Coast

Thematic Research Area: CLIME: Climate Impacts on Marine Ecosystems

Abstract: Ocean acidification disrupts marine and coastal ecosystems' carbonate chemistry, directly and indirectly affecting communities that depend on critical marine organisms. Ocean acidification research typically seeks to understand natural system responses, yet there is insufficient research that examines community and institutional responses or, more generally, their vulnerability to ocean acidification. This lack of information represents a challenge for developing policies that might serve to combat OA, whether they involve mitigation or adaptation strategies. Given the inadequate information to direct policy efforts to combat ocean acidification, this project aims to understand members of the Oregon Dungeness Crab Industry's perceptions of their adaptive capacity to impacts of ocean acidification and other environmental stressors. Cinner et al.'s (2018) adaptive capacity framework guided the project, precisely 12 interviews with Oregon's Dungeness Crab Industry members. The adaptive capacity framework was also used in guiding the content and policy analysis of ocean acidification policy and Dungeness crab management and regulations. Through the qualitative analysis of interviews and policy documents, the adaptive capacity of Oregon's Dungeness Crab Industry was assessed. Results show that assets and agency were the two adaptive capacity domains most found in the industry.
In contrast, assets and learning were the two adaptive capacity domains that were needed to build upon. Additionally, it was found that economic modifications, modifying their gear, location, season, participating

in other fisheries, and scientific studies were the strategies that Dungeness crab fishers would gravitate towards. The policy and content analysis revealed that ocean acidification policy and Dungeness crab management have the infrastructure to build members' adaptive capacity through funding research efforts and providing financial support to industry members in need. While ocean acidification policy can support industry members build their adaptive capacity, there is potential for institutions to align their efforts to industry member's needs better. By understanding the perceptions of members in Oregon's Dungeness Crab Industry alongside the current ocean acidification policy and Dungeness crab management landscapes, the project hopes to contribute to broader efforts to support the adaptive capacity of industry participants who are dealing with environmental changes such as ocean acidification.

Principal Investigator:
Name: Victoria Moreno, neé Williams **Institution**: Oregon State University
Co-PI:
Name: Dr. Ana Spalding **Institution**: Oregon State University
NOAA Partner:
Name: Dr. Shallin Busch **Lab/Facility**: NOAA NWFSC
Other Partner: Name: n/a **Lab/Facility:** n/a
Students: Graduate Student: n/a **Undergraduate Student:** n/a
Keywords: Fisheries, Adaptive Capacity, Ocean Acidification

Project Number 20-10:

Title: The Occurrence of Microplastics in Maryland Coastal Bay Fishes
Thematic Research Area: HaBS: Habitats and biological systems
Abstract: An important problem is plastic pollution in the ocean with millions of tons of plastic flowing into the ocean every year. The breakdown of larger pieces of plastic can form microplastics (< 5 mm) that are easily consumed by marine organisms thereby posing a threat to their populations. The Maryland Coastal Bays are home to a variety of commercial and recreational activities but few studies have been done regarding microplastic pollution. For my master's research, I plan to quantify the presence of microplastics in Maryland Coastal Bay fishes by comparing the percentage of fish contaminated with microplastics by feeding type and location. I will also research the feasibility of a technique to remove microplastics from the water without harming the environment.

Principal Investigator: Name: Imani Wilburn **Institution**: UMES
Co-PI: Name: Dr. Maurice Crawford and Dr. Kausik Das **Institution**: UMES
NOAA Partner: Name: Dr. Ashok Deshpande **Lab/Facility**: NEFSC/ Sandy Hook
Other Partner: Name: Dr. Stacy Smith **Lab/Facility:** DSU
Keywords: Microplastics, Fisheries, Marine Biology

Project Number 21-1:

Title: Sonar Censusing and Habitat Use by Spawning Run Atlantic and Green Sturgeon, *Acipenser oxyrinchus* and *A. medirostris*
Thematic Research Area: Assessment: Support and Information
Abstract: This TAB project supports (1) NERTO training and research on sonar censusing Sacramento River green sturgeon at the NOAA SWFSC Santa Cruz Laboratory; (2) tests to distinguish Atlantic sturgeon and gar sonar images for Chesapeake Bay Atlantic sturgeon; and (3) provides field training opportunities for undergraduate minority students. Sturgeons across the US are managed by NMFS as protected species, where key challenges to recovery center on accurate assessment of spawner abundance and how spawner movement and reproduction is impaired by habitat alterations. In his thesis research, EPP LMRCSC Fellow Nicholas Coleman is deploying sonar censusing approaches on

spawning run Atlantic sturgeon in the Marshyhope Creek system (Chesapeake Bay) and using telemetry to better understand how spawner incidence is shaped by flow, temperature, dissolved oxygen, and bottom substrate. SWFSC scientists pioneered sonar censusing approaches evaluating spawning green sturgeon in the Sacramento River, for which a decade of historical data is available. During a NERTO, LMRCSC Fellow Coleman will receive training in side-scan and DIDSON sonar censusing technologies with SWFSC Santa Cruz scientists (S. Lindley and P. Dudley) and evaluate historical habitat associations of spawning run adults. A key challenge to Coleman's Atlantic sturgeon thesis work is distinguishing sturgeon and gar, the two largest fishes within the Marshyhope Creek, through sonar (ARIS) deployments. Laboratory trials are proposed to compare acoustic images of gar from similar sized Atlantic sturgeon. This work will complement and enhance the Fellow's thesis research and training through comparisons of sturgeon settings (water-stressed but large Sacramento River vs. very small Mashyhope Creek), spawning habitat associations in both systems, and exposure to the interface between science (sonar censusing) and conservation policy.

Principal Investigator: **Name**: Dr. Rose Jagus **Institution**: UMCES/IMET
Co-PI: Name: Dr. David Secor **Institution**: UMCES/CBL
NOAA Partner: **Name**: Dr. Steven Lindley **Lab/Facility**: SEFSC
Other Partner: Name: Dr. Peter Dudley **Lab/Facility:** SEFSC
Students: Graduate Student: Mr. Nicholas Coleman
Undergraduate Student: prevented by CoVID restrictions
Keywords:

Project Number 21-2:
Title: Developing a Coupled Human Ecological System for Chesapeake Bay Shellfish Fisheries

Thematic Research Area: Stock Assessment Support and Information
Abstract: Achieving sustainable use of aquatic living resources is a key challenge facing humanity today. Several ecological models have been developed to address questions about management and use of aquatic living resources, but these models often do not adequately capture human dimensions of natural resource management; making it necessary to direct more attention to human aspects of coastal fisheries such as in the Chesapeake Bay. Coupled human environmental modeling of ecosystems can enable us to better understand fleet behavior and devise better approaches to reducing anthropogenic impacts on the Bay ecosystem. Humans impact Chesapeake Bay (either directly or indirectly) by reducing water quality, increasing wildlife disease, applying harvest pressures, and influencing habitat integrity. In our proposed project, we aim to extend the current Chesapeake Bay Fisheries Ecosystem Model (CBFEM) developed by NOAA partners to include social information so we can more directly verify human impacts on shellfishes and other living aquatic resources of Chesapeake Bay.

Principal Investigator: **Name**: Tunde Adebola **Institution**: Hampton University
Co-PI: Name: Eric Lewallen **Institution**: Hampton University
NOAA Partner: **Name**: Howard Townsend **Lab/Facility**: Oxford Maryland
Students: Graduate Student: TBD **Undergraduate Student:**
Keywords: Ecosystem Fisheries Modeling, Agent Based Modeling, Artificial Intelligence

Appendix I: Student Funding During the 6 month Reporting Period

First	Last	URM (y or n)	Cohort #	Degree	Partner	Tuition	Stipend	Travel	NERTO	One-time Research Support	Professional Development
Marcus	Teat	Y	2	B.S.	DSU						
Caitlyn	Czajkowski	N	3	M.S.	DSU	$6,756.00	$10,499.91				
Maria	Henson	Y	1	B.S.	HU	$2,500.00					
Sierra	Hildebrandt	N	2	M.S.	HU	$3,072.00	$3,500.00				
Josette	McLean	Y	2	M.S.	HU	$3,072.00	$3,500.00				
Amani	Tolin	Y	3	B.S.	HU	$2,500.00					
Arona	Bender	Y	3	M.S.	HU	$3,422.00	$9,000.00				
PaShun	Hawkins	Y	4	B.S.	HU	$2,500.00					
Jaelyn	Leslie	Y	4	M.S.	HU	$3,422.00	$9,000.00				
Jonathan	Nash	Y	5	B.S.	HU	$2,500.00					
T'Kiyah	Reeves	Y	5	B.S.	HU	$2,500.00					
Derrick	Richardson	Y	5	B.S.	HU	$2,500.00					
King	Brittany	Y	2	PhD	OSU	$ 2,899.16	$ 5,834.10				
Layton	Janelle	Y	4	MS	OSU	$ 7,921.71	$ 14,838.92				
Williams	Victoria	Y	4	MS	OSU	$ 6,925.71	$ 15,088.82				
Leann	Cohn	Y	5	MS	OSU	$ 4,891.16	$ 5,713.90				
Keala	Pelekai	Y	3	MS	OSU	$ 5,022.55	$ 11,331.76				
Clax	Savannah	Y	2	NA	RSMAS	$0.00	$1,460.68				
LaTreese	Denson	Y	2	PhD	RSMAS	$0.00	$0.00				
Adrianne	Wilson	Y	2	PhD	RSMAS	$3,788.00	$0.00				
Juan	Cervera	Y	3	MS	RSMAS	$2,170.00	$7,652.10				
Cristin	Mayes	Y	4	PhD	RSMAS	$15,190.00	$7,578.00				
Chryston	Best-Otubu	Y	5	PhD	RSMAS	$8,680.00	$18,990.00				
Joe	Day	Y	2	BS	SSU	$0.00	$0.00	$0.00	NA	NA	NA
Sena	Tay	Y	2	M.S.	SSU	$3,075.00	$8,750.00	$0.00	NA	NA	NA
Ambrose	Alexandria	Y	3	B.S.	SSU	$0.00	$0.00	$0.00	NA	NA	NA
Mackey	Shaneese	Y	3	M.S.	SSU	$1,339.00	$10,500.00	-$997.60	$0.00	$0.00	Spr. 19
Chelsea	Spaulding	Y	4	B.S.	SSU	$3,000.96	$5,659.42	$0.00	NA	NA	NA
Savannah	Geiger	N	4	M.S.	SSU	$2,929.00	$21,000.00	$0.00	$435.38	$0.00	$0.00
William	Burns	Y	5	B.S.	SSU	$3,000.96	$7,424.00	$0.00	NA	NA	NA
Savannah	Clax	Y	5	B.S.	SSU	$0.00	$10,178.72	$0.00	NA	NA	NA
Michon	Shaw	Y	5	B.S.	SSU						

Kristafer	Howard	Y	5	M.S.	SSU	$1,477.00	$8,750.00	$0.00	$0.00	$0.00	$0.00
Chloe	Lemaire	N	5	M.S.	SSU						
Dante	Freeman	Y	2	B.S.	SSU	$0.00	$0.00	$0.00	NA	NA	NA
Erianna	Hammond	Y	2	B.S.	SSU	$0.00	$0.00	-$217.69	NA	NA	NA
Michael	Williams	Y	2	B.S.	SSU	$0.00	$0.00	$0.00	NA	NA	NA
Alexandria	Tennant	Y		B.S.	SSU						
Lady	Volmar	Y		B.S.	SSU						
Shadaesha	Green	Y	1	Ph.D.	UMCES	$1,209.00	$4,459.38	$0.00	$0.00	$6,900.00	$0.00
Nicholas	Coleman	Y	2	M.S.	UMCES	$1,536.00	$15,850.44	$0.00	$5,000.00	$0.00	$0.00
Benjamin	Frey	Y	3	M.S.	UMCES	$4,608.00	$13,544.60	$0.00	$0.00	$2,425.50	$0.00
Kyarii	Ramarui	Y	4	Ph.D.	UMCES	$0.00	$19,702.55	$0.00	$0.00	$0.00	$0.00
Olivia	Pares	Y	5	Ph.D.	UMCES	$5,376.00	$19,691.94	$4,781.61	$0.00	$2,436.23	$0.00
Kasondra	Rubalcava	Y	2	Ph.D.	UMES	$363.00	$17,059.61	$0.00	$0.00	$0.00	$0.00
Teemer	Barry	Y	3	B.S.	UMES	$0.00	$1,321.88	$0.00	$0.00	$0.00	$0.00
DaQuan	Davis	Y	3	B.S.	UMES	$0.00	$3,478.00	$0.00	$0.00	$0.00	$0.00
Shanelle	Haughton	Y	3	Ph.D.	UMES	$361.00	$17,414.67	$0.00	$0.00	$0.00	$0.00
Ashley	Silver	Y	3	Ph.D.	UMES	$2,205.00	$12,653.79	$0.00	$0.00	$0.00	$0.00
Glen	Colins	Y	4	B.S.	UMES	$4,279.00	$0.00	$0.00	$0.00	$0.00	$0.00
Shakira	Goffe	Y	4	M.S.	UMES	$885.00	$10,471.24	$0.00	$0.00	$0.00	$0.00
Tahirah	Johnson	Y	4	M.S.	UMES	$385.00	$13,738.68	$0.00	$0.00	$0.00	$0.00
Imani	Wilburn	Y	4	M.S.	UMES	$3,885.00	$10,709.20	$0.00	$0.00	$0.00	$0.00
Malika	Brown	Y	5	B.S.	UMES						
Angel	Delgado	Y	5	M.S.	UMES	$6,912.00	$402.74	$0.00	$0.00	$0.00	$0.00
Kaithlynn	Wade	Y	5	M.S.	UMES	$0.00	$805.48	$0.00	$0.00	$0.00	$0.00
Elyssa	Baker	Y		No Degree	UMES	$1,776.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Cameron	Bennett	Y		No Degree	UMES	$1,776.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Mikaela	Blackwood	Y		No Degree	UMES	$0.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Indaya	Byer	Y		No Degree	UMES	$1,776.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Amarim	Dupree	Y		No Degree	UMES	$0.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Beverly	Malugin	Y		No Degree	UMES	$1,776.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Jamar	Moody	Y		No Degree	UMES	$0.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Ronald	Whatley	Y		No Degree	UMES	$0.00	$2,653.00	$0.00	$0.00	$0.00	$0.00
Total						$118,501.92	$325,971.03	$3,566.32	$5,435.38	$11,761.73	$0.00

Appendix II: TAB Project Reports

18-01: Title: Underrepresentation in marine and fisheries science professions: how significant life experiences shape a diverse workforce

Thematic Research Area: Fisheries Socio-economics

Abstract: NOAA Fisheries has a responsibility to provide the best available science for the management of living marine resources. Research has shown the value of diversified thinking and approaches in science and that diverse perspectives can improve our collective ability to solve problems. However, many racial and ethnic groups face the issue of being underrepresented in marine and fisheries science professions, resulting in a workforce that does not reflect the diversity of the United States. Understanding the factors that drive individuals to participate in environmental fields, such as marine, aquatic, and fisheries science, provides organizations and institutions with insight that can be incorporated into their recruitment efforts. This is especially important in efforts to recruit and retain individuals from underrepresented and marginalized communities. This study builds on the research around career decisions and timing of science career interest, with a focus on marine, aquatic, and fisheries science and intersecting identities. This study explored the following research questions: 1) What factors influenced interest and career decisions in marine, aquatic and fisheries sciences at different life stages? 2) How does the timing of interest and decisions to pursue careers in marine, aquatic, and fisheries science professional vary across race, gender, and social class? The results of this study support previous literature on the importance of experiences with nature, family support, academic and research experiences, and advisor and mentorship on career decisions. Results also highlighted differences across intersections of identity (e.g., race, gender, and class). As researchers strive to understand the factors that influence career decisions in the natural resources field, it is important to explore how each of these social identities interacts and the role of their impact on decisions.

Principal Investigator: Name: Brittany King
Institution: Oregon State University
Co-PI: Name: Kelly Biedenweg
Institution: Oregon State University
NOAA Partner: Name: Kevin Werner
Lab/Facility: NOAA/NWFSC
Other Partner: Name:
Lab/Facility:
Students: Graduate Student;
Undergraduate Student:
Keywords: Fisheries, Social Science, Diversity

Start Date: 1 September 2018
End Date: 15 September 2021

Results to Date: The results of this study build on previous research related to career decisions and timing of science career interest, with a focus on marine, aquatic, and fisheries science, and intersecting identities. My first research question examined the factors that influenced interest and career decisions at different life stages. The timing of initial interest/decisions to pursue careers in marine, aquatic, and fisheries science was nearly split across participants: pre-college (48%, n= 21) and college (52%, n = 23). Four main themes represented factors influencing interest and decisions to pursue a career in marine, aquatic, and fisheries: experiences and exposure to nature; academic and research experiences; advisors and mentors; and family support. Research on significant life experiences suggests that early interactions with nature are amongst the top experiences resulting in decisions to participate in environmental action (Chawla, 1998; Tanner, 1980; Wells & Lekies, 2006). This was true for participants in this study who developed an interest in marine, aquatic, and fisheries science pre-college. While positive early experiences with nature were common for the majority of participants, academic coursework, research experiences, and advisor and mentors played a large role in influencing career interest decisions for participants who made their decision after beginning college. Moreover, findings from my second research

question revealed variations in the timing of career interest and decisions across race, gender, and social class, supporting the use of an intersectional approach to better understand career decisions across diverse backgrounds.

Relevance to NOAA: NOAA has acknowledged that in order to continue to meet its mission, a commitment to strengthening diversity and inclusion is critical. As a part of their strategic plans, multiple NMFS science centers have highlighted the importance of diversity and the need to recruit highly skilled and motivated employment candidates that reflect the diversity of the nation as one of their goals. This project contributes to science by examining the drivers that influence individuals from underrepresented communities' pursuing fisheries science careers and contributes to NOAA by providing a better understanding of how to recruit and retain individuals from underrepresented communities.

Broader Impacts: This study explored the social science and human dimensions aspects of marine and fisheries science. It aligns well with LMRCSC's mission to prepare a diverse student body for careers in marine and fisheries sciences through exemplary academic and research collaborations, by examining drivers that influence a diverse marine and fisheries science workforce. The project provided the LMRCSC student researcher, Brittany King, the opportunity to integrate social science research into the LMRCSC program to help better understand underrepresentation in marine and fisheries science professions.

Presentations & Publications:
Publication - (in-prep) King, B. Factors influencing timing of marine, aquatic and fisheries science career interest and decisions

Presentations

1. Research Advances in Fisheries, Wildlife, and Ecology Symposium (RAFWE), Corvallis, OR (May 2020)- Virtual

King, B. *Underrepresentation in marine and fisheries science professions: How social identities influence career experiences*

2. NOAA Living Marine Resources Cooperative Science Center Annual Science Meeting, Silver Spring, MD (April 2020) - Virtual

King, B. *Utilizing Cloud-Based Services in a Time of Uncertainty: Perceptions of Natural Marine Resource Management*

3. NOAA Living Marine Resources Cooperative Science Center Annual Science Meeting, Silver Spring, MD (June 2019)

King, B. *Underrepresentation of ethnic and racial groups in marine and fisheries science professions-Marine Science Identity*

4. OSU's Arts and Humanities Graduate Student Conference, Corvallis, OR (May 2019)

King, B. *Underrepresentation of ethnic and racial groups in marine and fisheries science professions*

5. International Symposium on Society & Resource Management. Snow Bird, UT.

King, B. *Underrepresentation of racial and ethnic groups in marine and fisheries science professions.*

Performance Measure: 3.4e: Number and percentage of actions ongoing or completed to recover endangered and threatened species
DOC Strategic Plan: 3.1.2: Advance holistic, integrative ecosystem research (NOAA).
NOAA RD Linkage: D1a: Improved understanding of the economic and behavioral elements ofcoastal resilience
Next Gen Priorities: Diverse and constantly evolving capabilities in NOAA's workforce

18-08: Title: Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys

Thematic Research Area: HaBS - Habitats and Biological Systems

Abstract: The Pacific lamprey (*Entosphenus tridentatus*) is an anadromous species that occurs throughout the Northern Pacific Ocean and is important to humans for at least two key reasons: 1) Indigenous peoples near the Columbia River have a cultural value for them as a ceremonial food item, and 2) during their marine phase, lampreys parasitize many fish species and may reduce commercial harvests (e.g., Pacific hake, walleye pollock). Although culturally important, vulnerable (freshwater modifications reduce larval habitats), and ecologically interesting (parasites can exhibit dramatic fluctuations in abundance), the basic biology of Pacific lamprey in marine waters has not been well documented. The goal of this study is to identify prey items of Pacific lampreys and characterize their feeding ecology in the Northeastern Pacific Ocean, particularly where they overlap with commercially-targeted species (e.g., Pacific hake, shrimps).

Principal Investigator: **Name**: Eric A. Lewallen, PhD **Institution**: Hampton University
Co-PI: **Name:** Carolina B. Lewallen, PhD **Institution**: Hampton University

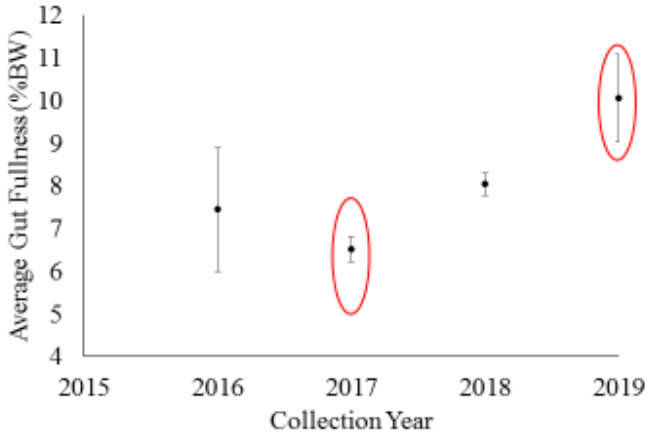
NOAA Partner: **Name**: Laurie Weitkamp, PhD
Lab/Facility: NWFSC - Northwest Fishery Science Center
Other Partner: **Name:** Linda Park, PhD
Lab/Facility: NWFSC - Northwest Fishery Science Center
Students: **Graduate Student;** Josette McLean, MSc
Undergraduate Student: Janelle Layton

Keywords: Bycatch, Fisheries, Marine Biology, Protected Species, Population Dynamics, Ecosystems

Start Date: 04/01/2019 **End Date:** 05/01/2021

Results to Date: Ms. Janelle Layton began working on this project as an undergraduate participant in the LMRCSC program from 2018-2020. Her aims were to calculate the gut fullness of individuals by size class, geographic region, collection gear, collection year, and fishery. Our NOAA collaborator (Dr. Weitkamp) collected 1307 Pacific lamprey individuals, and provided the following data for each individual: fishery (Pacific hake, groundfishes, or shrimp), collection date, species, total length, total weight, gut weight, latitude, longitude, fishing depth, and bottom depth. Ms. Layton proceeded to calculate gut fullness by a variety of measures, arriving at % body weight as a most informative metric. Subsequently, Ms. Layton provided analyses of gut fullness by total length, fishery type, and collection date. Significant differences in gut fullness were detected between collection years [p = 6.25e-12]; however, no statistically significant differences were observed among other variables. Gut fullness data suggest that Pacific lamprey feed opportunistically on prey available in the habitat they occupy. Preliminary geographic analyses of gut fullness did not reveal clear patterns of niche specialization within the collected specimens, although fishery data are often biased to include regions of high abundance for targeted species. In summary, the results of this first phase of the project suggest that overall lamprey feeding efficiency changes from year to year (**Fig. 1**), but does not seem to be correlated with the sizes (**Fig. 2A**), locations of captured individuals (**Fig. 2B**), fishing modality (**Fig. 2C**), or fishery type (**Fig. 3**). An initial set of 20 Pacific lamprey specimens were mailed to Hampton University in April 2018. These specimens were dissected, measured, weighed, and included in subsequent molecular analyses. Ms. Layton assisted in training Ms. Josette McLean (LMRCSC graduate student from 2019-2021) on basic molecular laboratory techniques during their one-year period of overlap at Hampton University. Ms. Layton began a PhD program at Oregon State University during the fall semester of 2020.

Figure 1. Gut Fullness by Collection Year



One-way ANOVA; F = 18.79, d.f. = 3, **p < 0.01**

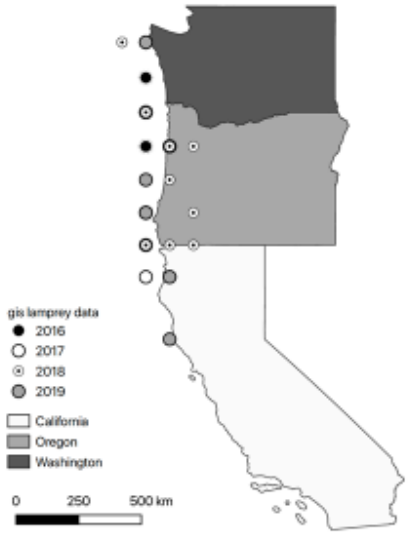
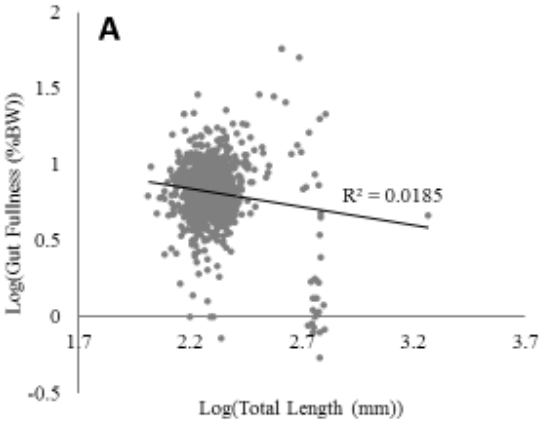
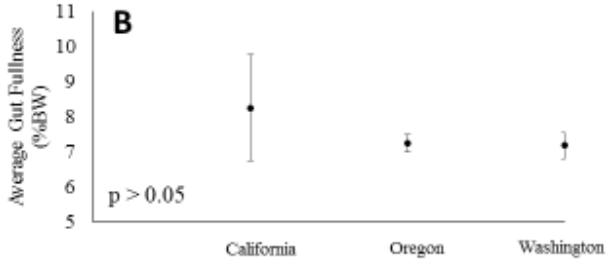
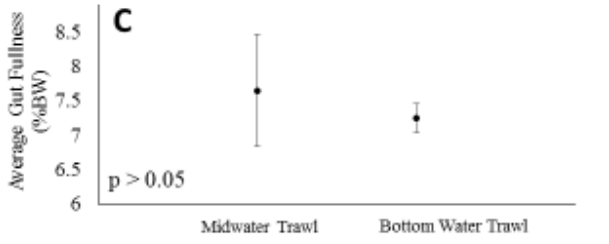
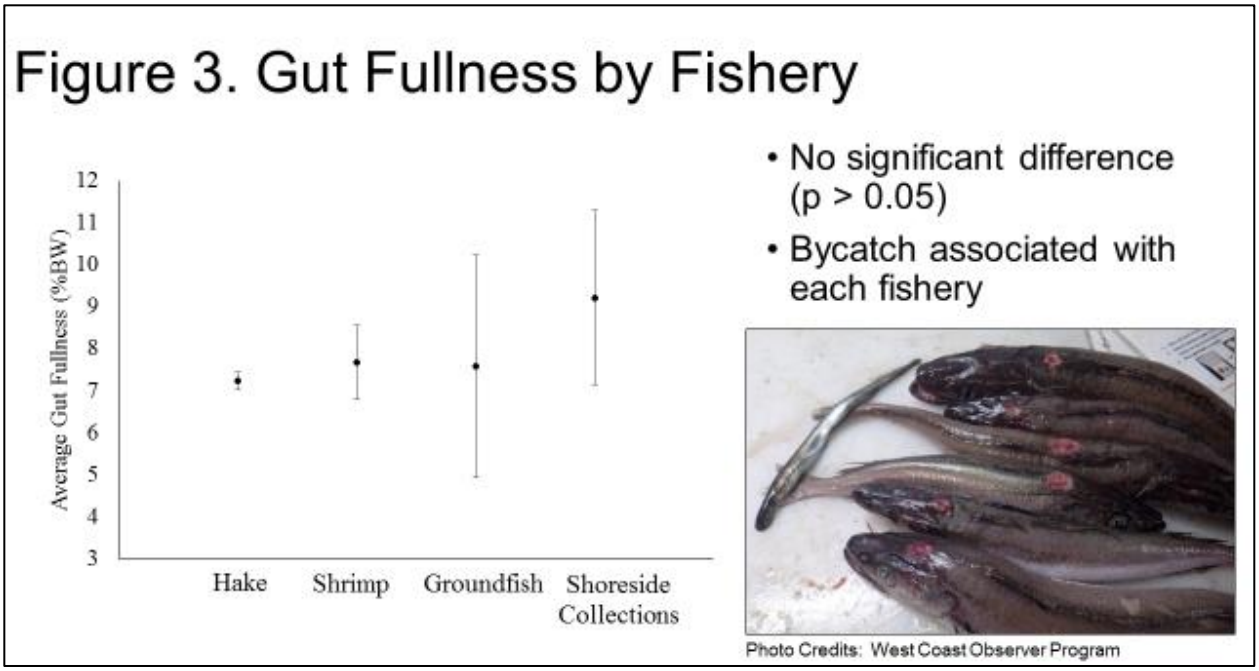


Figure 2. Gut Fullness vs. length, location, gear



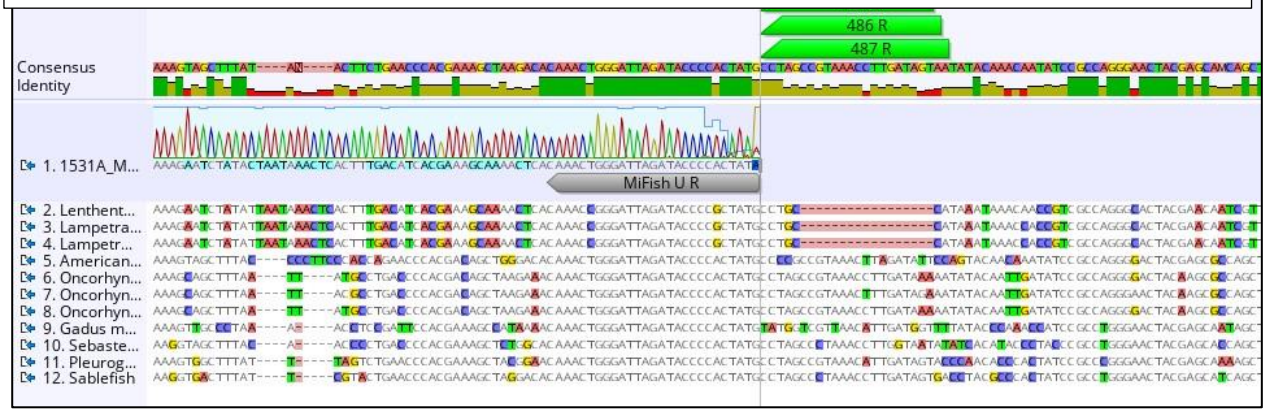






Using an expanded subset (n=120) of the entire at-sea Pacific lamprey collection (obtained by Dr. Weitkamp), Ms. McLean proceeded to prioritize specimens by gut fullness for extraction of DNA, analysis of DNA for purity, and sequencing of extracted DNA using a variety of published and customized primers for the targeting of 2 distinct regions of genomic DNA (CO1 and 12S rRNA). Extracting DNA in triplicate from 18 individuals resulted in 64 total DNA extractions. Whole genomic DNA was extracted using standard Qiagen DNeasy Blood & Tissue Kit protocols; and verified using nano-spectrophotometry. Customized primers were designed based on previously published data as part of the MiFish project for detailed metabarcoding of marine fishes and other vertebrates. DNA sequences obtained using this strategy were identified as Pacific lamprey after 'blasting' the sequences against the publicly available data within GenBank (NCBI). However, sequencing data revealed an intriguing region lacking DNA that is unique to lampreys (revealing a newly-described insertion in the genomes of bony fishes), which is adjacent to the 12S rRNA gene (**Fig. 4**).

Figure 4. A screenshot of the DNA sequence alignment that includes 4 lamprey and 8 bony fishes to highlight the inserted region (pinkish color below) that exists in bony fishes but not lamprey.



This information will prove useful for designing additional primers that will target lamprey host DNA and

inhibit amplification of Pacific lamprey DNA that is abundant in the gut contents. As a result of the COVID-19 pandemic, Ms. McLean and other students had limited access to our campus during the period of February 2019 to May 2021. This greatly hindered progress toward the deliverable objective of this project, which was primarily to identify prey species in the guts of Pacific lamprey. However, using all available preliminary data, Ms. McLean successfully defended her Master's thesis during the spring 2021 semester (April 14th, 2021) and graduated on time. Since then, she has started a PhD program at Duke University with support from an NSF-GRFP award.

Students are currently allowed full access to the HU campus and our molecular laboratory, so the project is advancing rapidly into the next phase of using molecular tools to identify lamprey prey items. We are optimistic that high-quality DNA will be extracted from all 120 gut samples in the next month, and hope to include these data in a publishable manuscript later this year. We have also prepared a review paper as a research group, including both LMRCSC students and faculty, that will contribute much-needed perspectives on the topic (and challenges) of gut content analysis by molecular data collection (e.g., eDNA tools).

Relevance to NOAA: As stated in the RFP for this funding mechanism: “The LMRCSC will conduct research that supports stock assessment of fish, invertebrates, and marine mammals, by describing and understanding population abundance, migration and distribution patterns, predator-prey relationships, habitat use, age structure, growth, mortality, reproductive biology and behavior, and responses to environmental variability.” We will specifically provide fundamental data for the direct assessment of Pacific lampreys by analyzing predator-prey relationships and habitat use, as well as distribution patterns. As a research program, we have the ability to perform large-scale training in laboratory-based genetics, gut content analysis, and forensics for students at Hampton University. In addition, we will provide students with opportunities for field-based research in marine and freshwater habitats.

Broader Impacts: During the first year of this project we finalized specimen collections and sample processing (e.g., voucher preservation, gut dissection, gut content preservation) with assistance from undergraduate student Janelle Layton. Josette McLean joined the research team in August 2019, and was trained in genetic laboratory techniques. Ms. McLean completed a 3 month internship with Dr. Weitkamp of the NOAA Northwest Fisheries Science Center during the summer of 2020. The second year of this project focused on collecting genetic data, analysis of genetic and geospatial data, preparation of manuscripts (review and thesis), and presentation of results at online symposia. Josette McLean graduated in May 2021 from the Department of Marine and Environmental Science at Hampton University.

Presentations & Publications:

McLean J. Optimization of DNA Extraction and PCR Methods for Pacific Lamprey Gut Content Analysis. Thesis Defense, Master of Science, Hampton University, April 14, 2021.

Layton J, Bonin CA, Park LK, Weitkamp LA, Lewallen EA. The Feeding Ecology of Pacific Lampreys Assessed by Gut Fullness and Prey Identification. 24th Annual School of Science Research Symposium, Hampton University, Hampton, VA, April 16-17, 2019. Abstract #21

Layton JM, Bonin CA, Pressley N, Park LK, Weitkamp LA, Lewallen EA. Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys. American Society of Limnology and Oceanography, San Juan, PR, February 23 - March 1st, 2019 (podium).

Layton JM, Bonin CA, Pressley N, Park LK, Weitkamp LA, Lewallen EA. Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys. Emory University, Atlanta, GA, September 30 - October 2, 2018 (poster).

Layton JM, Bonin CA, Pressley N, Park LK, Weitkamp LA, Lewallen EA. Genetic-based methods for assessing prey composition and feeding ecology of Pacific lampreys, 9th Biennial NOAA EPP Science and Education Forum. Howard University, Washington, DC, March 18-21, 2018 (poster).

Performance Measure: 3.4c: Percentage of protected species stocks with adequate population assessments and forecasts 2.0

DOC Strategic Plan: 3.4.1: Strengthen capabilities to assess and monitor fish and protectedresources

NOAA RD Linkage: C4a: Improve survey capabilities to provide more accurate, precise and synoptic information of key marine populations.

Next Gen Priorities: Improved understanding of ecosystems to inform resource managementdecisions

19-03: Title: Genetic approaches for monitoring the effects of climate change on leopard seals in the Antarctic Peninsula.

Thematic Research Area: Climate and Ecosystems: Effects on Marine Ecosystems

Abstract: The United States is one of the largest consumers of Antarctic fishery products, and is legally mandated to report on krill and krill-dependent predator abundance, diet and movements. These data have been collected for nearly 30 years in the South Shetland Islands (SSI), through the efforts of the NOAA Antarctic Marine Living Resources program. In the SSI, rapid warming has caused a dramatic decrease in sea-ice with consequences for the entire ecosystem. Interestingly, leopard seal numbers have also increased over this time period; understanding this intriguing pattern is key for the prediction of future scenarios in the Antarctic. Leopard seals are elusive pack ice breeders, and reliable data on the abundance of this species are lacking. Here we propose to investigate leopard seal abundance using samples archived by AMLR to: i) infer levels of genetic diversity and ii) estimate the number of breeding individuals.

Principal Investigator:
Name: Carolina Bonin Lewallen **Institution**: Hampton University
Co-PI: Name: Eric Lewallen **Institution**: Hampton University
NOAA Partner: Douglas Krause **Name**: **Lab/Facility**: SWFSC
Other Partner: Felipe Barreto **Lab/Facility:** Oregon State University
Students:
Graduate Student: Arona Bender **Undergraduate Student:** Kathryn Cruz

Keywords: genetic diversity; climate change; predator; effective population size; Antarctic

Start Date: Jan 2020 **End Date:** April 2021*
(*The graduate student stipend was extended for six months due to the pandemic— HU base funding is being used to extend this student's funding package)

Results to Date: We obtained genomic DNA from 80 leopard seals, which were sequenced for mitochondrial DNA (mtDNA) control region (Dloop; 405bp). Our analyses revealed high nucleotide and haplotype diversity (π= 0.013; Hd= 0.96) comparable to other ice seals (e.g., Weddell seals). We also reconstructed a maximum likelihood haplotype network which revealed highly divergent haplotypes (>20 mutational steps apart) suggestive of a large population size. This was corroborated by an estimated effective population size (Ne > 300,000 individuals), which is several orders of magnitude higher than the most recent circumpolar estimate of 15,000 animals (3,500-65,000). Interestingly, our findings are in line

with other indirect estimates (e.g., passive acoustics monitoring). In addition, our genetic analyses suggest a recent demographic expansion (τ= 3.64), contrasting with patterns of Pleistocene population expansions described for other Antarctic ice seals. Our study provides the first assessment of mtDNA diversity for leopard seals while providing valuable demographic data that can serve as a foundation for predicting population-level patterns of change among marine species within the most rapidly warming region of the planet.

Relevance to NOAA: The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) has 25 signatory nation-members and establishes a body (Commission and scientific committee) for the management of living Antarctic resources using an ecosystem-based approach (ccamlr.org). The United States has commercial fisheries in Antarctic waters and is one of the largest consumers of Antarctic products, and must therefore comply with CCAMLR mandates and participate in fisheries regulation and management. In 1982 a public law created the US Antarctic Marine Living Resources Program (managed by NOAA's Antarctic Ecosystem Research Division) as a response to the US' obligation to engage in CCAMLR (swfsc.noaa.gov). Since 1986 the US AMLR activities include the monitoring of krill biomass and its dependent populations of seabirds and seals. At Livingston Island, US AMLR has monitored Pinniped populations since 1997 by conducting systematic studies of recruitment of juveniles, annual pup production and foraging behavior. Ancillary to these studies, the US AMLR Program has archived a large amount of observational data and numerous tissue samples. This proposal leverages these unique datasets and samples, thereby maximizing invaluable resources already spent by NOAA-AMLR in the field, and by its tissue national archive in La Jolla, CA. This work is highly relevant not only to NOAA's mission but also to LMRCSC thematic area "Climate and Ecosystems: Effects on Marine Ecosystems".

Broader Impacts: Hampton University has one of the top marine science majors among HBCUs in the country. The proposed project opened up unique new opportunities for our undergraduate and graduate students to engage in polar science and Antarctic ecosystem management. This project involved one undergraduate student, Kathryn Cruz (graduated in Spring 2021) and one graduate student, Arona Bender (expected to graduate in May 2022). Arona just spent the summer working on her NERTO with our NOAA collaborator D. Krause. Besides learning technical/ scientific skills, Arona actively participated in all AMLR upper division meetings and met one on one with a nearly dozen of SWFSC NOAA scientists. The PI (Dr. Bonin Lewallen) also participated in an online national career awareness event promoted by the Virginia Aquarium (Career Day, March 20th 10am-3pm, attended by 75 high school students) in which she featured marine mammal research and leopard seals. Locally, PI Lewallen also lead a workshop about marine science careers for middle school students attending the Hampton University Science Academy (June 25th; five students). In this workshop, the PI highlighted NOAA science careers and this project.

Presentations & Publications (2021):

Students:

Bender, A.*, **Cruz**, K., Goebel, M., Krause, D., Lewallen, E., **Bonin, C.** (2021). Estimating Effective Population Size and Historical Demography of Leopard Seals (*Hydruga leptonyx*) in the Antarctic Peninsula. Hampton University, Hampton VA. Feb 5, 2021.
(*) Second place, graduate student presentation.

Bonin Lewallen-- 2021 publications

Nichols, H.J., Fuchs, B., Paijmans, A.J., Lewis, G., **Bonin**, C.A., Goebel, M.E. & Hoffman, J.I. (2021). Where are the beachmasters? Unexpectedly weak polygyny among southern elephant seals on a South Shetland Island. Journal of Zoology. https://doi.org/10.1101/2021.05.20.444924

Bonin, C.A. (2020). The Genetic consequences of philopatry, dispersal and reproductive behaviors. In: Ethology and Behavioral Ecology of Otariids and the Odobenid. C. Campagna & R. Hacourt. Springer, 2020. ISBN 978-3-030-59183-0.
https://www.springer.com/gp/book/9783030591830

19-04: Title: Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts

Thematic Research Area: Assessment: Support and Information

Abstract: Monkfish *Lophius americanus* sustains a key revenue stream for the stressed US Northeast groundfish fleets. Still, monkfish have been managed very conservatively because of major uncertainties in the stock assessment, the most significant of which is age structure and growth in this long-lived species. Access and allocation of this resource to New England and Mid-Atlantic fleets is highly dependent upon the underlying productivity of monkfish and its assessment, both of which are uncertain owing to the lack of a valid ageing procedure. We propose to develop and validate novel ageing procedures for this species supporting assessment goals and focused student training in state-of-the-art fisheries techniques, marine chemistry, and stock assessment. This project will provide support to LMRCSC graduate student, Mr. Ben Frey, to work with Dr. Anne Richards, lead scientist for monkfish assessments, and the NEFSC Fisheries Biology Program.

Principal Investigator: **Name**: Dr. Rose Jagus **Institution**: UMCES/IMET
Co-PI: Name: Dr. David Secor **Institution**: UMCES/CBL
NOAA Partner: **Name**: Dr. Anne Richards **Lab/Facility**: NEFSC
Students: Graduate Student: Mr. Ben Frey **Undergraduate Student:**

Start Date: 1 September 2019 **End Date:**

Results to Date: The project goal was to test for seasonal chemical cycles in hardpart constituents of monkfish for a series of sample years, corresponding to the strong 2015 year-class, evaluating these cycles against optical zonation patterns interpreted as annuli. Related objectives included, (1) training in monkfish hard part processing, age interpretations, otolith microchemical analysis, and age-structured stock assessments, (2) deploying the same analysis for a control species, black sea bass, for which annuli have been confirmed to form at an annual rate, (3) conduct microprobe analysis on monkfish and black sea bass hard parts, and (4) conduct time series analysis to identify dominant periodicities in microchemical profiles.

Training: During fall 2019, Mr. Frey undertook a NERTO Internship at the NEFSC. The NERTO occurred between 9/9/19 and 12/3/19 and included a 2-week RV Bigelow leg from 10/9/19 to 10/25/19. This included work with (1) the NEFSC Fishery Biology Division (E. Robillard, S. Sutherlands, and J. Dayton), (2) the RV Bigelow Fall Bottom Trawl Survey (Chief Scientist J. Kircun and Watch Chief A. Poquette) and (3) the Population Assessment and Biology Branch (A. Richards, L. Alade, G. Shepherd, P. Nitschke, T. Sheehan). Key training related to the TAB contract included hard part processing and interpretation of monkfish and black sea bass otoliths, illicia and vertebrae. Initial precision trials and analyses were conducted on hardpart interpretations. To better understand the assessment process and obtain samples of monkfish, Frey participated in leg three of the Fall Bottom Trawl Survey aboard the NOAA Ship, Henry B Bigelow. This experience trained Frey on how to classify, dissect, determine gender, and identify stomach contents of not only monkfish but the majority of species trawled in the Georges Bank. Frey also received exposure and training in the assessment process with Dr. Anne Richards. Hardpart samples

were procured for monkfish and black sea bass and returned to UMCES for further processing in support of Frey's thesis research.

Training sessions occurred at the University of Maryland Nanotechnology Center (College Park), where Secor worked with Center lead, Dr. Philip Piccoli (Geology Dept.) to train Mr. Ben Frey on operation of the wave-length-dispersive electron microanalyzer (March 2020). Training sessions for the ESI NWR193 excimer laser ablation system (193nm, 4ns pulse width) coupled to an Agilent 7500ce ICP-MS (LA-ICP-MS) occurred at the University of Texas at Austin Department of Geosciences under the supervision of Laboratory Manager Dr. Nathan Miller and consultant Dr. Michelle Sluis during August 2021.

Hardpart preparation and analysis: From NEFSC hardpart archives and laboratory samples of black sea bass, 200 black sea bass otoliths, 144 monkfish illicia, 50 monkfish otoliths, and 21 monkfish vertebrae were procured for initial analyses. Of these 125 black sea bass otoliths, 87 monkfish illicia, and 42 monkfish otoliths, and 20 monkfish vertebrae have been processed for age interpretation and microprobe analysis. In five visits to the microprobe facility during July 2020, 60 black sea bass otoliths, 40 monkfish otoliths, 5 monkfish illicia, and 1 monkfish vertebrae were analyzed for Ca, Sr, P, and Mg. Hardpart profiles are being analyzed for periodicity and alignment with annular optical zones. Images of the mounted black seabass (n=60) and monkfish (n=40) hardparts captured via reflected light microscopy have been overlain with the backscatter electron images from the microprobe point assays through image manipulations to confirm and reveal the path of the assay along annular zonation.
Elemental variations through radial growth of black seabass otoliths (n=41) and monkfish otoliths (n=40), vertebrae (n=25) and illicia (n=57) were measured by LA-ICP-MS to confirm periodicity of elemental concentrations at a finer resolution than the microprobe. The elements profiled in these line analyses were ^{24}Mg, $^{43-44}$Ca, ^{88}Sr, ^{25}Mg, ^{31}P, ^{55}Mn, ^{59}Co, ^{63}Cu,^{66}Zn, and $^{137-138}$Ba. 2D maps of 9 elements $^{43-44}$Ca, ^{88}Sr, ^{55}Mn, ^{138}Ba,^{24}Mg, ^{65}Cu, and ^{66}Zn were conducted on 2 monkfish illicia, 1 monkfish otolith, and 1 black sea bass otolith to reveal annular patterns. Preliminary results are shown in figure 1.

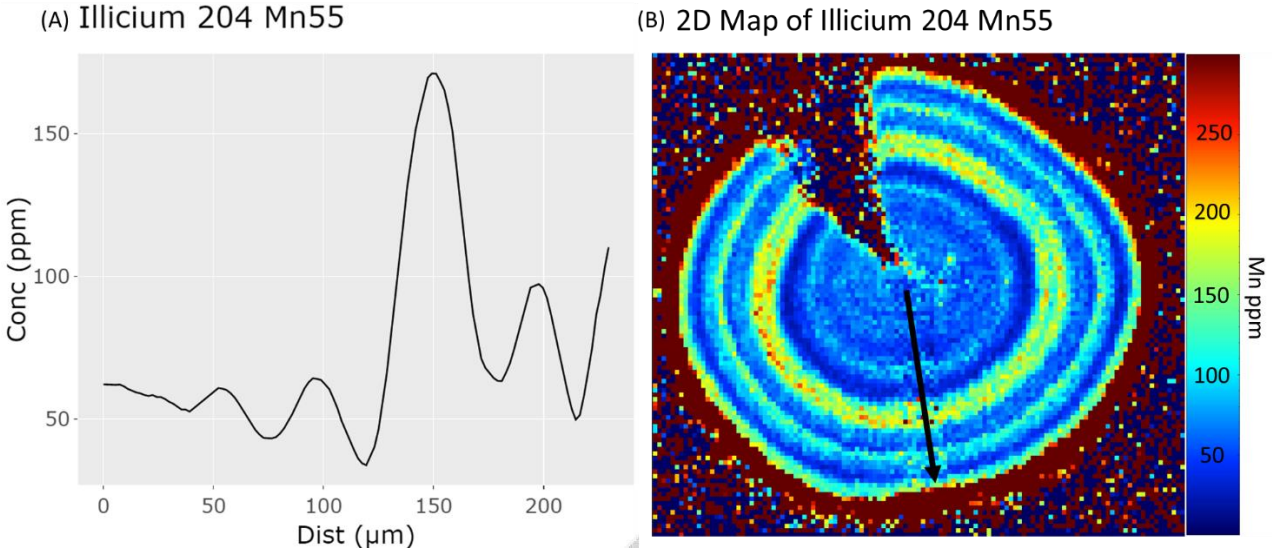


Figure 1. LA-ICP-MS analysis of same Monkfish Illicium, "known" age 3. (A) Derived elemental time-series smoothed by consecutive average filters using a 7-point boxcar width (13 and 26µm equivalent distances), resulting in smoothed, locally weighted, signals free from high-frequency outliers. (B) 2D map of illicium Mn, the imaged area involved contiguous line traverses using 5µm round aperture, spaced by diameter. Arrow indicates transverse analyzed in (A).

Relevance to NOAA: This project has the potential to resolve uncertainties about monkfish growth and cohort assignment, and thereby provide validation for an ageing method that can be used to estimate population age structure and a growth model for use in quantitative assessment. This project seeks to validate a new aging method for monkfish through use of archived samples at NEFSC, and to develop a new growth curve, which is critical for assessment of this economically valuable species. In addition, this work may provide a method for correcting the 22-year time series of population age structure estimates based on inaccurate readings of vertebrae.

Broader Impacts: A central impact is in EPP LMRCSC training and NOAA workforce development. Projects related to hard part analysis for ageing are particularly amenable for student training and thesis topics as they are discrete with well-defined goals and are central to the best available approaches for assessing and managing species of commercial importance and conservation concern. Another important impact is initial recruitment of an LMRCSC student to the Chesapeake Biological Laboratory campus, which houses UMCES expertise in fisheries assessment science. The novel approach to age validation developed in this project is applicable to any unvalidated species to certify stock status.

Presentations & Publications:

Frey, B.A., Richards, A., Jagus, R., Piccoli, P., Lyubchich, V., Sluis, M., Miller, N., & Secor, D. (2021). Age validation using periodicity of annulus formation and hardpart microconstituents in black sea bass (*Centropristis striata*). American Fisheries Society Annual Meeting 2021, Baltimore, MD, November 2021.

O'Brien, M., **Frey, B.A.,** & Secor, D. (2021). Trading space for time: The Chesapeake Biological Laboratory's temporally-intensive juvenile fish survey. American Fisheries Society Annual Meeting 2021, Baltimore, MD, November 2021.

Frey, B.A., Secor, D., Richards, A., & Jagus, R. (2021). NERTO Mentee Testimonial. Leadership Initiative for Networking and Collaboration Conference, Virtual, April 2021.

Frey, B.A., Secor, D., Richards, A., & Jagus, R. (2020). Current age and growth methods of Monkfish (*Lophius americanus*) The Need for Validation. LMRCSC 2020 Virtual Science Meeting. April 2020.

Frey, B.A., Secor, D., Richards, A., & Jagus, R. (2019). Monkfish Age Validation Using Hardpart Analysis of "Known" Age Samples. LMRCSC Science Meeting, NOAA Silver Spring HQ, MD, June 2019.

Frey, B.A., Secor, D., Richards, A., & Jagus, R. (2019). Monkfish Age Validation Using Hardpart Analysis of Known-age Cohorts. AFS Tidewater Meeting, Salisbury, MD, February 2019.

Performance Measure: 3.4b: Percentage of FSSI fish stocks with adequate population assessments and forecasts

DOC Strategic Plan: 3.4.1: Strengthen capabilities to assess and monitor fish and protectedresources

NOAA RD Linkage: D4b: Region-specific, nationwide, operational capability for ecological forecasting.

Next Gen Priorities: Sustainable fisheries and safe seafood for healthy populations and vibrant communities

19-07: Title: Population structure and growth of lane snapper, a data limited species

Thematic Research Area: Stock Assessment Support

Abstract: Lane Snappers (*Lutjanus synagris*) are a data-limited species that range from North Carolina, the Gulf of Mexico (GOM) and south to Brazil. This study will collect 400 sagittal otoliths, fin clips, length/weight measurements from fish caught from East Florida to North Carolina. Otoliths will be processed, aged and two experienced readers will be used to ensure accurate ageing. A variety of growth models will be used to determine best fit. Genotyping by sequencing (GBS) will be used to determine

genetic diversity. Results will compliment a recent NOAA supported study that examined spatial and temporal variation in the age and growth of Lane Snapper in the GOM and data will be used to support future NOAA stock assessments by providing information on population structure and growth.

Principal Investigator:
Name: Adrianne Wilson **Institution**: University of Miami - RSMAS
Co-PI:
Name: Dr. Elizabeth Babcock **Institution**: University of Miami - RSMAS
NOAA Partner:
Name: Robert Allman **Lab/Facility**: SEFSC: Southeast Fishery Science Center
Other Partner:
Name: Dr. Dionne Hoskins **Lab/Facility:** Savannah State University/NOAA
Students:
Graduate Student; Adrianne Wilson **Undergraduate Student:** Savannah Clax
Keywords: Fisheries, Marine Biology, Social science, Population dynamics

Start Date: 09/23/2019 End Date: 2022

Results to Date: Restrictions on travel due to the covid-19 pandemic has impacted research.

Relevance to NOAA: This study aims to address concerns raised in the recent SEDAR 49 data poor species assessment by increasing sampling of otoliths and tissue samples to examine stock structure and growth over the lane snappers US range. The evidence of multiple stocks will be investigated using the data we collect, thus improving the accuracy of assessment and allowing better advice on management decisions and the impact these decisions may have on anglers and coastal communities. Our project objectives directly align with NOAA's goal of the conservation of living marine resources. We will provide reliable and current information on Lane Snapper populations, growth, and age structure. Furthermore, the spatial and temporal comparisons will examine impacts caused by fishing and will enhance managers' ability to accurately quantify the abundance and distribution of Lane Snapper. Previous studies indicated the potential for female Lane Snapper to experience heavier fishing pressure than males (Aiken 2001). This selection likely has an influence on the size structure of the species and must be further examined. Using the data collected from this study, we can determine if different populations have different life history traits, which will enhance stock assessment and management recommendations. The genetic analysis will provide data that will define how populations are connected and also rates of adaptive change (Crawford and Oleksiak 2016). Data from this study will be used to increase confidence in estimates of population size, demographic patterns, and stock status. In the past, Lane Snapper have been grouped with other data limited species when developing management plans, landings data, and annual catch limits. This study will provide new age, growth, and genetic data that may find that Lane Snapper have unique life history traits and should be managed as such. Since Lane Snapper are data-limited, this study is vital to maintain the sustainability of the species and develop "optimal harvest strategies and determine the tradeoffs between alternative policy choices" (Hilborn and Walters 1991).

Broader Impacts: Assessing a data-limited species can be very difficult for the scientists; however, the outcome of a stock assessment, and the management decisions that are made, can influence the lives of the communities that depend on the Lane Snapper. This study aims to collect data that will contribute to the long-term sustainability of the fishery and the genetic information will be used to identify population connectivity, thus increasing "the resilience of ecosystems, economies, and communities" that depend on Lane Snapper (Hilborn and Walters 1991). Collecting specimens through dockside sampling will encourage collaboration with local fishermen and allow us to build upon the relationship NOAA has within the fishing communities. These relationships are vital in order to have better cooperation with fishermen

when management practices are being developed. The Lane Snapper fishery is driven by recreational fishermen. The NOAA Fisheries Economics of the United States Report, 2016 stated that Florida had the highest number of recreational fishing trips, the most money spent on trips ($646.3 million), and the most recreational anglers to participate in fishing (3.7 million anglers), in the nation. Landings in the South Atlantic Region (East Florida, Georgia, North Carolina and South Carolina) totaled $190.9 million and North Carolina had the highest revenue in the region (NOAA 2016). With Lane Snapper falling within the regions with the largest number of recreational fishers and landings, new and accurate data is needed immediately. This study will provide much needed information on the population structure and growth of Lane Snapper. Our findings will then be used to conduct a management strategy evaluation so we can provide new recommendations for management practices, such as regional size and catch limits. Therefore, with the collaboration of the anglers, we will increase our understanding of Lane Snapper and assist managers in making better predictions to prevent overfishing or even the collapse of the stock. Thus, our results will help protect the livelihoods of the coastal communities and people that depend on the Lane Snapper fishery.

Presentations & Publications:
Wilson, A. (2019). Age and Growth of Lane Snapper in the Gulf of Mexico. Oral session presented at the annual American Fisheries Society meeting, Reno, NV.
LMRCSC Section
Wilson, A. (2019, April 12). Age and Growth of Lane Snapper in the Gulf of Mexico. Lecture presented at Student Seminar Series in Florida, Miami. University of Miami Student Seminar Series
Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)**DOC**
Strategic Plan: 3.4.1: Strengthen capabilities to assess and monitor fish andprotected resources
NOAA RD Linkage: C4c: Develop integrated models that take advantage of synoptic data atvarious scales, to inform ecosystem-based management
Next Gen Priorities: Improved understanding of ecosystems to inform resourcemanagement decisions

20-01: Title: An analysis of distribution and abundance of microplastics in selected commercially important species in Northern Georgia coastal waters

Thematic Research Area: HaBS: Habitats and Biological Systems

Abstract: The various densities of plastics allow for particulate plastics to settle or aggregate in different habitats in the marine environment, thereby increasing their prevalence in a variety of organisms that inhabit areas where particulate plastics accumulate. The proposed research is to study the microplastic abundance in organisms of economic importance in Georgia in an effort to understand the ecological impact of microplastics in the aquatic, estuarine, and marine environments. The objectives of this proposal are to: (1) analyze microplastics in selected commercially important species and (2) to analyze the spatial abundance of microplastics in selected waters near Savannah, GA, USA.

Principal Investigator: **Name**: Savannah Geiger **Institution**: SSU
Co-PI: Name: Sue C. Ebanks **Institution**: SSU
NOAA Partner: **Name**: Ashok Deshpande **Lab/Facility**: J.J. Howard Sandy Hook
Name: Kimberly Roberson **Facility**: Gray's Reef National Marine Sanctuary

Other Partner: **Name:** Ali Ishaque **Lab/Facility:** UMES

Students: Graduate Student: Savannah Geiger
Undergraduate Student: Joe Day, Alexandria Tennant, Lady Volmar, Sophia Rodman, Brittany Thomas, Breanna Roland, Tela Fields-Reynolds, Aliyah Beach

Keywords: Microplastics, habitats,

Start Date: 1 June 2020 **End Date:** 31 July 2021

Results to Date:
Geiger contribution: In surface waters, there were the most microplastics within the Wilmington River (5.05 x 10-4 ± 2.23 x 10-4 MPs/L) and the least within Wassaw Sound (3.38 x 10-4 ± 2.25 x 10-4 MPs/L). The Herb and Skidaway rivers had a similar mean microplastic abundance, 4.19 x 10-4 ± 1.51 x 10-4 MPs/L, and 4.19 x 10-4 ± 2.25 x 10-4 MPs/L, respectively. In sediments, there were the most microplastics within the Skidaway River (0.39 ± 0.23 MPs/g) and the least within Gray's Reef National Marine Sanctuary (0.07 ± 0.05 MPs/g), followed by the Herb River (0.13 ± 0.09 MPs/g), and the Wilmington River and Wassaw Sound had similar means, 0.22 ± 0.21 MPs/g, and 0.25 ± 0.11 MPs/g, respectively.

Day contribution: Microplastics were present in 46% of Spot *Leiostomus xanthurus* samples and identified particles included polyethylene, acrylic, polyurethane, and polyvinyl chloride. High density polyvinyl chloride, acrylic, and polyurethane was statistically greater in most Spot (p=>0.05). The benthic forager, Spot had a greater frequency of occurrence of high-density polymers of polyurethane, acrylic, and polyvinyl chloride. The results of microplastic abundance in Spot suggest that ingestions and interactions are different depending on microplastic concentrations in environments.

Fields-Reynolds is working on method determination for microplastics in *Penaeus* spp. shrimps that has stemmed from Day's work. Currently, Fields-Reynolds is in the final stages of determining what digestion method works best for attaining as complete digestion as possible of the organism while maintaining particulate plastics for analyses. She is utilizing 10% potassium hydroxide (KOH) and a range of 5-30% hydrogen peroxide (H_2O_2) concentrations. Preliminary results indicate the most complete digestion in the 30% H_2O_2, and Raman analyses should be completed before the end of the year.

Rodman, Tennant, and Volmar contributions: These 3 undergraduate students determined presumed microplastic concentrations in historic and more recent sediment samples from the Savannah River Estuary and associated shelf waters. To date, these samples that were collected during NSF-funded EDGE cruises in 2009 and LMRCSC and NSF Bridge to REU at SSU cruises in 2019 have been processed through primary analysis, and await secondary analysis via Raman spectroscopy. While the analyses were slowed by the substantial periods of downtime and inability to travel associated with COVID-19, we anticipate completion of the Raman spectroscopic analyses in the coming months.
At the time of this report, **Volmar** (now an LMRCSC undergraduate fellow in cohort 4) has developed her own project after her experience with the TAB project. She has collected one of 4 anticipated months of samples to study the difference in sediment and water microplastic concentrations associated with oyster beds in the upper Wassaw Sound Estuary, with a focus on Wylly Creek, Country Club Creek, and the Herb River.

Roland contribution: Results displayed an average Silver Perch *Bairdiella chrysoura* length of 12.06±4.45 cm. Average gill particle count was 0.75±0.89. Average GI tract particle count was 1.50±2.29. The GI tracts have higher particle counts than gills.

Thomas Contribution: A total of 142 possible microplastic particles discovered in all Niskin bottle

samples. From mid-water column, there were a total of 42 possible plastic particles from bottles fired when descending and 20 possible particles from bottles filled when ascending. At the surface, the total count of microplastics from bottles fired when descending was 49 and the total was 31 from bottles filed when ascending. This preliminary study indicates that more particulate plastics are captured when Niskin bottles are descending through the water column on a CTD Rosette system.

Beach is in the early stages of project planning, however, this project focuses on the concentration of microplastics in wastewater effluent from a to-be-determined number of wastewater treatment plants. This work is cross-cutting and will lay the foundation for further study of wastewater effluent (land use, wastewater management). Additionally, Beach is interested in the study of microplastics and drinking water management processes.

Relevance to NOAA: The research project correlates to the NOAA mission, namely to support habitats and biological systems (HaBS). The ecological role of microplastics in the marine environment was addressed and provided necessary preliminary work for continued microplastics research at Savannah State University. This information is relevant to the NOAA mission and focal point of creating sustainable, healthy habitats. Additionally, this proposal aligns with the 2019 NOAA Fisheries Priorities and Annual Guidance, specifically by amplifying the economic value of commercial and recreational fisheries while ensuring their sustainability. Furthermore, the research aligns with NOAA's Marine Debris Program Strategic Plan for 2016-2020, namely to identify, assess and reduce the impacts of marine debris through detection, monitoring, source identification, and innovative solutions. Investigating the prevalence of microplastics in commercially important species allowed for the discovery of applicable information to pass regulations related to plastic use in Georgia. By identifying the specific microplastic compounds through Raman analysis, a better understanding of the plastic origin was gained.

Broader Impacts: Products that have resulted from this research include a master's thesis, presentations at scientific conferences; collaboration between Savannah State University and Gray's Reef National Marine Sanctuary, the NMFS; and an LMRCSC partner institution. Also, a valuable product has been the extensive involvement of multiple undergraduate students. Working with undergraduates has provided recruitment opportunities for this STEM-relevant project and toward undergraduates considering to continue their studies in graduate school. Field and laboratory training for undergraduates increases their marketability for becoming NOAA employees and graduate students in the future. This research is another valuable step in increasing appeal through establishing a microplastics analysis program at an HBCU and in a region where these studies are really beginning to garner interest. Co-PI Ebanks has already accepted 3 additional graduate students to work on microplastics, thus the breadth of study increases from Graduate Student PI Geiger's work, which has been a valuable catalyst for future work on this environmental issue.

Presentations & Publications:

Geiger, S.M. (2021). An analysis of distribution and abundance of microplastics in water and sediments from the lower Wassaw Sound Estuary and Gray's Reef National Marine Sanctuary. Master's Thesis. Savannah State University.

Geiger, S.M., S.C. Ebanks, and M.C. Curran. (*In Prep*). Microplastics: Count them like a scientist! The Journal of Marine Education: Current.

Geiger, S.M. and S.C. Ebanks. (*In Prep*.). An analysis of distribution and abundance of microplastics in surface water from the lower Wassaw Sound Estuary. Marine Pollution Bulletin.

Geiger, S.M. and S.C. Ebanks. (*In Prep*.). An analysis of distribution and abundance of microplastics in

sediments from the lower Wassaw Sound Estuary. Marine Pollution Bulletin.

Geiger, S.M. (2021). “An analysis of distribution and abundance of microplastics in water and sediments from the lower Wassaw Sound Estuary and Gray’s Reef National Marine Sanctuary” (Oral Presentation) Master’s Thesis Defense. Savannah State University. 29 Apr 2021.

Day, J. (2021). “Analyzing microplastic abundance in common fish species along coastal Savannah, GA, USA” (Oral Presentation) Savannah State University. 27 Apr 2021.

Geiger, S.M. (2021). “An analysis of microplastic abundance in organisms with varying foraging strategies near Savannah, GA, USA” (Oral Presentation) NOAA LMRCSC Seminar Series. 1 Feb 2021.

Day, J. (2020). “Analyzing microplastic abundance in common fish species along coastal Savannah, GA, USA” (Oral Presentation) Savannah State University. 18 Nov 2020.

*Geiger, S.M. (2020). “An analysis of microplastic abundance in organisms with varying foraging strategies near Savannah, GA, USA” (Poster Presentation) NOAA EPP Forum. Spring 2020.

*Geiger, S.M. (2020). “An analysis of microplastic abundance in organisms with varying foraging strategies near Savannah, GA, USA” (Poster Presentation) Savannah State University Annual Research Conference. Spring 2020.

*Day, J. (2020). “Analyzing microplastic abundance in common fish species along coastal Savannah, GA, USA” (Poster Presentation) NOAA EPP Forum. Spring 2020.

*Day, J. (2020). “Analyzing microplastic abundance in common fish species along coastal Savannah, GA, USA” (Poster Presentation) Savannah State University Annual Research Conference. Spring 2020.

*Roland, B. (2020). “Microplastic Abundance in the Silver Perch *Bairdiella chrysoura*” (Poster Presentation) Savannah State University Annual Research Conference. Spring 2020.

*Thomas, B. (2020). “Analyzing the difference in microplastic abundance in water collection via ascending or descending Niskin bottles” (Poster Presentation) Savannah State University Annual Research Conference. Spring 2020.

**Cancelled due to COVID-19. Abstracts submitted and accepted for all. Geiger and Day also finalized a poster to present.*

Performance Measure: 3.4f: Number of habitat acres restored
DOC Strategic Plan: 3.1.2: Advance holistic, integrative ecosystem research (NOAA).
NOAA RD Linkage: C1b: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems.
Next Gen Priorities: Improved coastal water quality supporting human health and coastal ecosystem services

20-03: Title: Proteomic analysis of two *Haematococcus pluvialis* strains as aquaculture feedstock

Thematic Research Area: Seafood, Nutrition, Aquaculture, and Pathology (SNAP)

Abstract: The green microalga *Haematococcus pluvialis* produces an antioxidant pigment, astaxanthin, which is widely used in salmon aquaculture as feed additive. Current algae industry uses phototrophic cultivation for *H. pluvialis* production, however, under these conditions the growth rate and astaxanthin productivity are low. A mutant strain of *H. pluvialis* has been generated through chemical mutagenesis that demonstrates increased heterotrophic growth and astaxanthin productivity, addressing the bottlenecks of *Haematococcus* production. To understand the molecular underpinning of this phenotype, we propose further molecular characterization of these two mutant strains through LC-MS/MS based proteomic analysis. The knowledge generated will help development of rational engineering strategies for improved astaxanthin production in microalgae and promote its use in aquaculture.

Principal Investigator:	**Name**: Kyarii Ramarui	**Institution**: UMCES
Co-PI 1:	**Name:** Dr. Yantao Li	**Institution**: UMCES
Co-PI 2:	**Name:** Dr. Allen Place	**Institution**: UMCES
Co-PI 3:	**Name:** Dr. Joseph Pitula	**Institution**: UMES
NOAA Partner:	**Name**: Dr. Gary Wikfors	**Lab/Facility**: Milford Lab (NEFSC)
Other Partner:	**Name:** N/A	**Lab/Facility:** N/A

Graduate Student: Kyarii Ramarui, PhD, Marine Estuarine Environmental Sciences Program

Keywords: Aquaculture, Social Science, Plankton Other: Feedstock

Start Date: May 1, 2020 **End Date:** August 31, 2021

Results to Date: Three rounds of a two-step cultivation experiments were conducted to compare a mutant *H. pluvialis* strain (KREMS 23D-3) against the wild type *H. pluvialis*. In each round, culture conditions were slightly modified with the goal of achieving the most ideal set of samples for proteomic and phosphoproteomic analysis. The two-steps of the cultivation period included a 6-day heterotrophic growth period in which cultures were grown heterotrophically with a carbon source provided in the liquid growth medium in the form of sodium acetate. On Day 6, when cultures reached their maximum cell densities (cells/mL), they were transferred to bubbling columns where they were provided 1.5% CO_2 and were exposed to stressful levels of high light (*c.a.* 400 µmol m^{-2} s^{-1}). Cultures were exposed to high light stress for five days. Throughout this entire cultivation period, various samples were collected to understand growth characteristics and nutrient consumption rates of the two strains. Growth curves were monitored by measuring cell density (cells/mL), optical density (750 nm), biomass concentration (mg/L), and cell morphology (microscopic digital photos) every day. Supernatant samples were also harvested to measure the rate of consumption of acetate, nitrate, and phosphate. Additionally, biomass samples for proteomic, phosphoproteomic and for transcriptomic analyses were collected in the early time points of each stage of cultivation. At the end of high light stress, cultures were harvested, and the biomass was freeze dried for astaxanthin content, lipid content, and lipid composition analysis.

Overall, the mutant strain was able to achieve higher cell densities and optical densities than the wild type on several days throughout both stages of the experiment, with statistically significant differences on 50% or more of the days (Figure 1). The mutant strain started achieving higher cell density than the wild type by Day 3 of heterotrophic growth. The mutant maintained higher cell density than the wild type with statistically significant differences on Days 3-6 (t-test, p-value < 0.05), with a very statistically significant difference on Day 6 (t-test, p-value < 0.01). Optical density data corroborated this trend. The mutant achieved a maximum cell density of around 3.0 x 10^5 cells mL^{-1} on Day 6 of heterotrophic growth, whereas

the maximum cell density of the wild type was 1.92 x 10^5 cells mL^{-1}. Both strains demonstrated a slight drop in cell density after a full day of high light stress but started to increase cell density again starting on Day 2 of high light stress and increasing dramatically after Day 3. However, while the mutant continued to dramatically increase cell density as the high light stress continued, the wild type plateaued by Day 10. Again, optical density data corroborated this trend.

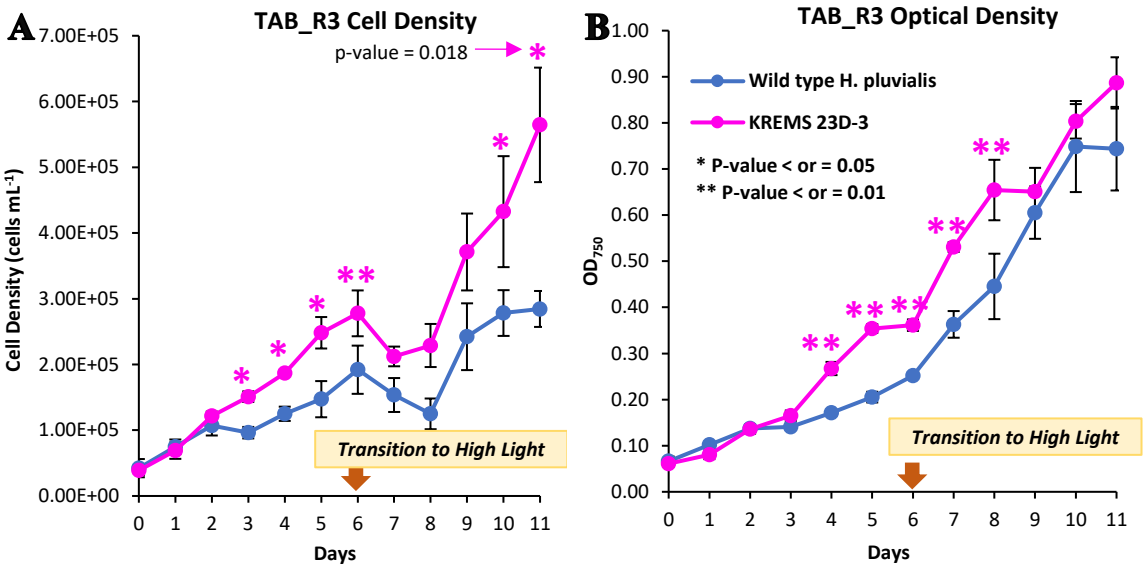


Figure 1: Mutant K achieved higher cell density and optical density than the wild type
A) Several days had differences between the strains that were statistically significant (t-test, p-value < 0.05 or 0.01). B) Mutant optical density higher than the wild type starting on Day 3 of stage 1 and continuing for the duration of the experiment. Several days had differences that were statistically significant (t-test, p-value < 0.05 or 0.01).

Interestingly, biomass per cell, astaxanthin content, and astaxanthin per cell of the wild type strain was higher than the mutant after high light induction (Figure 2). It is possible that the high cell density of the mutant strains is creating a considerable cell shading effect in the mutant cultures, thus decreasing the light intensity experienced by the individual cell and leading to a less robust stress response. This results in higher cell densities achieved by the mutant, but lower biomass and astaxanthin productivity in the high light stage. Overall astaxanthin productivity of the mutant was slightly higher than the wild type, except for Day 11, however this difference was not significant (Figure 2).

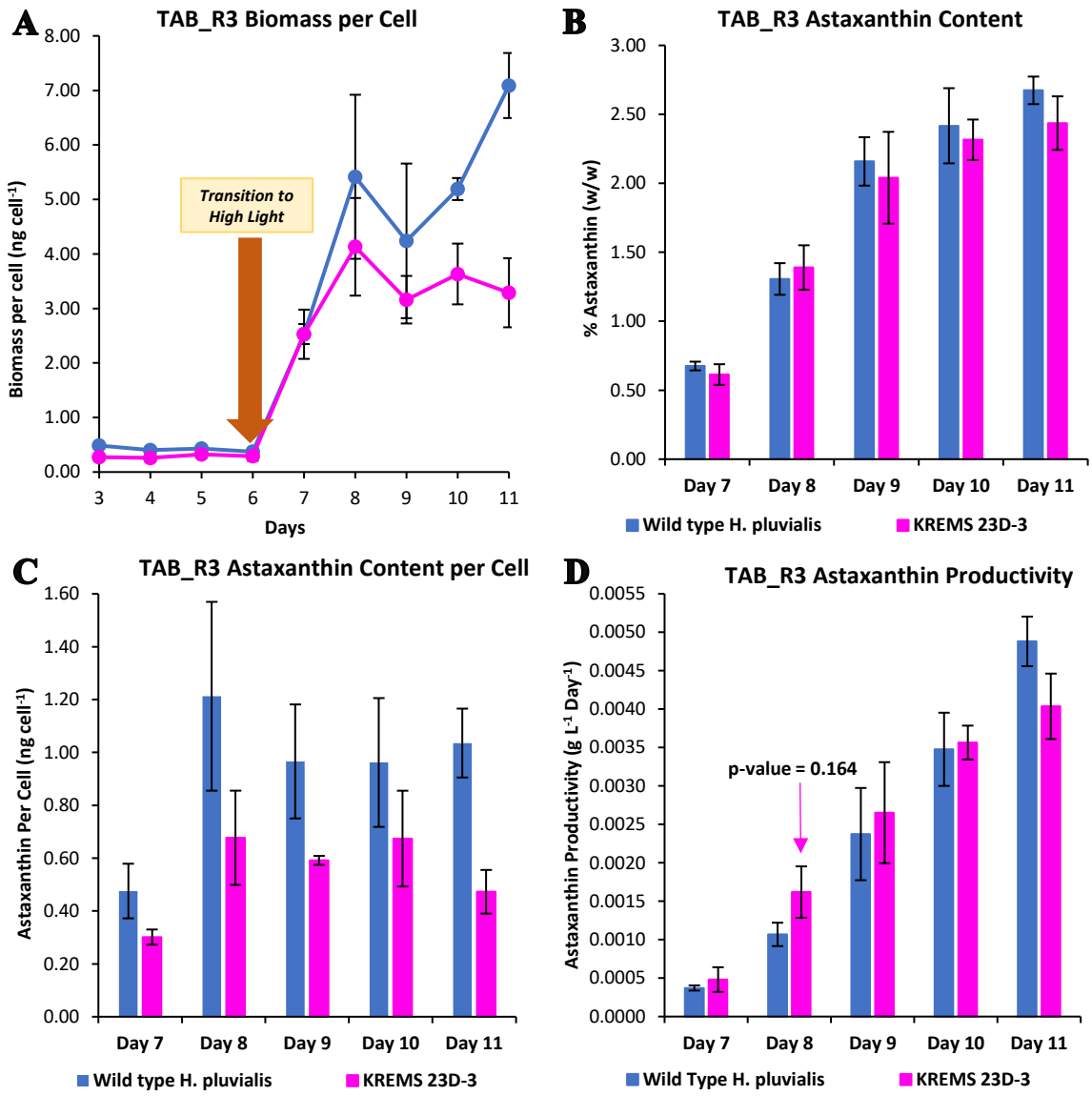


Figure 2: Wild type performed better under high light in terms of biomass and astaxanthin per cell, mutant astaxanthin productivity slightly better than wild type

A) While the mutant cell density was much higher than the wild type during the high light stage, the biomass concentrations of the two strains were comparable. For this to be possible, the wild type biomass per cell was much higher than the mutant, which is demonstrated in the graph. B) Overall, the mutant and wild type astaxanthin content was comparable, with the wild type achieving slightly higher astaxanthin contents overall, except for Day 8. C) Wild type cells had much higher levels of astaxanthin than the mutant on all days. D) Overall astaxanthin productivity was slightly higher for the mutant than the wild type on all days except for Day 11, when wild type productivity was higher. The difference between the mutant and wild type astaxanthin productivity had a p-value of 0.164 on Day 8.

Another round of this experiment will be conducted in which the cell density of both strains will be adjusted to the same starting level before high light induction in an effort to optimize astaxanthin accumulation potential. Cultures will also be grown under a low light intensity for a brief period to acclimate cells to an illuminated environment. Additionally, a high carbon:nitrogen contributes to encystment and astaxanthin accumulation. To optimize the carbon:nitrogen ratio, cultures will be resuspended in nitrogen and carbon free growth medium during the dilution and acclimation stage to allow any residual nutrients to be consumed before transition into the high light stage. Overall, the results of the heterotrophic stage of

cultivation show that the mutant is demonstrating a desirable phenotype. Several additional culture conditions will be optimized for the high light stage to best promote the desirable phenotype of the mutant. Once the most ideal set of samples are harvested, they can be sent for proteomic and phosphoproteomic analysis.

In additional preparation for proteomic and phosphoproteomic analyses, I developed a bioinformatics analysis pipeline. Samples of wild type *H. pluvialis* cells were grown under mixotrophic and high light conditions to generate green and red samples, respectively. These samples have been sent to Dr. Zhong of DeltaOmics so he can finalize the protein extraction and mass-spec method. So far, data from trial proteomics and phosphoproteomics comparing the green (Day 6 under low light) and red stages (Day 3 under high light) samples have been received. The data have been normalized by dividing the abundance of peptide detected by the amount of protein extracted to obtain the abundance of peptide per mg of protein. The differential abundance upon transition to high light stress was calculated by dividing the normalized red stage data by the normalized green stage data. The general cut-off for statistically significant up or downregulation is a p-value of less than 0.05 and a greater than or equal to 2-fold change in abundance. These parameters will be used to down-select peptides and phosphopeptides to focus on. I also translated a published, publicly available, *H. pluvialis* transcriptome that can be used as a database to identify assembled peptides. Through analyzing this trial data, the analysis pipeline for proteomic and phosphoproteomic data that will be used after processing the TAB samples consists of the following steps: 1) Normalize the data by amount of protein, 2) Calculate fold-change difference between strains at different time points, 3) Filter out peptides that do not meet criteria of a p-value < 0.05 and $\geq$ 2-fold change, 4) BLAST peptides against database of translated *H. pluvialis* transcriptome to identify them, 5) Make a heatmap of up/down-regulated peptides and phosphopeptides, 6) Conduct pathway analysis to see if there are patterns of expression associated with specific pathways of interest, specifically acetate metabolism or carotenoid biosynthesis.

Relevance to NOAA: This research addresses the Seafood, Nutrition, Aquaculture, and Pathology (SNAP) Research Thematic Area. This study will elucidate the molecular basis of acetate metabolism and astaxanthin biosynthesis in the microalga *H. pluvialis*. The knowledge generated will help development of rational engineering strategies for improved astaxanthin production in the algae and aquaculture industry. Greater yield of algae-derived astaxanthin can allow its increased use as a feedstock in aquaculture, where astaxanthin is beneficial both for achieving a pink flesh color and for improving the health of fish stocks. Our work will thus address NOAA's mission in developing economically and environmentally sustainable marine aquaculture. The project findings will be continuously reported to the LMRCSC in six-month reports, submitted for publication in peer reviewed journals, and presented at scientific conferences.

Broader Impacts: Currently, the primary bottlenecks for the algae astaxanthin industry are the low biomass and astaxanthin yield of the producer microalga *H. pluvialis.* As a result, the algae astaxanthin price is as high as *ca.* \$7000/kg. Our work will address these challenges to reduce cost and allow for stable, high-yield production of *Haematococcus* astaxanthin. Success of this technology will generate a novel culture system for commercial scale production of natural astaxanthin that could ultimately lower the production cost to <\$1,000/kg crystalline, much lower than current algae industry (*ca.* \$7000/kg). This would lead to a paradigm shift in algae astaxanthin production and its application in aquaculture, making algae astaxanthin competitive in the aquafeed market (predicted to be about \$500M in 2022). We will estimate and compare the production cost and economic efficiency of our technology with current technology in the aquafeed market. Through this project, one LMRCSC PhD student (Ms. Ramarui) and at least one undergraduate intern from UMES will be trained. The broader impact of our work including the improved economics of aquafeed will be communicated to the public through NOAA EPP meetings, the annual IMET Open House event (over 600 attendees in 2019), etc.

Presentations & Publications: None yet, plans to submit abstracts to Ocean Sciences Meeting 2022 and Phycological Society of America meeting 2022 with data from this project.

Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)
DOC Strategic Plan: 3.4.2: Improve recovery of listed species through innovative partnerships
NOAA RD Linkage: C5c: Create new technologies for better siting aquaculture facilities
Next Gen Priorities: Sustainable fisheries and safe seafood for healthy populations and vibrant communities

20-04: Title: Life history and disease ecology of the blue crab, a key benthic-pelagic link in tropical and temperate American estuaries

Thematic Research Area: Assessment: Support and Information

Abstract: The blue crab, *Callinectes sapidus*, supports fisheries that define a way of life in coastal communities from New Jersey to Texas. Across their range, crabs display life history variation: overwintering in the north and year-round activity in the subtropics. They also inhabit true tropics, where there is a lack of data on crab biology. In Puerto Rico, crabs are harvested in an artisanal fishery that may grow as conch and lobster fisheries decline. If so, crucial data, (size at maturity, sex ratio, habitat use) will be needed for management, and have value for understanding Puerto Rico estuaries. Across their range, blue crabs are infected by viruses and protozoa that may interact with environmental and anthropogenic stressors to limit abundance. This project will enable a graduate student to gather blue crab life history and pathogen data in Puerto Rico and learn how life history data is applied to management by NOAA.

Principal Investigator: **Name**: Dr. Eric Schott **Institution**: UMCES/IMET
Co-PI: Name: Dr. Bradley Stevens **Institution**: UMES (retired)
NOAA Partner: Bruce Vogt, NOAA Chesapeake Bay Office
Other Partner: Name: Harold Manrique Hernández, San Juan Bay Estuary Program (http://relief.estuario.org) **Lab/Facility:**
Students: Graduate Student: Olivia Pares **Undergraduate Student:**

Start Date: 1 September 2020 **End Date:** August 2023

Activities and results: The main goals of the project were to 1) assess the relative seasonal abundance of *Callinectes sapidus* and congeneric crabs from the San Juan Estuary; 2) assess size at maturity for *C. sapidus* and other species of *Callinectes*, 3) determine whether known infectious disease agents are present in these populations. The main activities included crab collections in La Torrecillas estuary 4 times over the year, assessment of species, measure size, sex and condition, and testing all crabs for the prevalence of the virus CsRV1 and the protozoan *Hematodinium*.

Olivia has made all four planned trips to Puerto Rico, overcoming a number of logistical hurdles created by COVID19 travel limitations. The first trip in October 2020 included the transport and assembly of 20 crab traps that were fabricated in Maryland. All of the logistics of charter boat contracting, site validation, deploying traps, collecting metadata, measuring and preserving crab samples from the estuary were completed (Fig. 1). Subsequent trips (January, April, October) were conducted successfully as well, with extensive outreach to students in high schools in Puerto Rico (CROEV in Villalba, and the Math Science Technology school in San Juan) as well as participation by high school teachers from Maryland (The Park School, see Fig. 2).

Note: Dr. Stevens retired as of June 2021. Olivia has asked Beth Babcock at RSMAS to assume the role of LMRCSC partner collaborator on this project.

Blue crab ecology in the San Juan estuary:

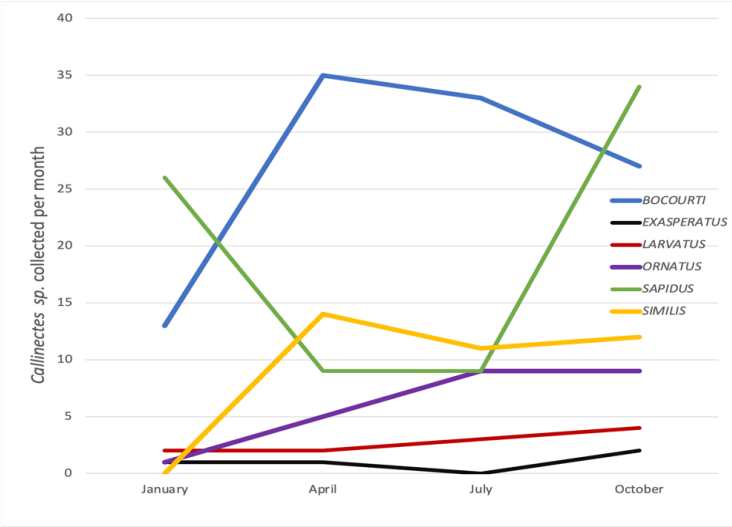


Fig. 1. Trap-based capture of *Callinectes* spp. in La Torrecillas in 2020- 2021. Note that the two abundant species, *C. sapidus* and *C. bocourti*, have complementary abundances.

Table 1. The number of *C. sapidus* and other *Callinectes* sp. collected over the course of the study.

	Oct. '20	Jan. '21	April '21	July '21
C. sapidus	9	26	34	9
Callinectes sp.	53	14	48	54

Compiling data of *Callinectes* sp*.* in Puerto Rico shows a visible variation in the overall abundance per month. Additionally, a collection of juvenile *Callinectes* sp. will allow for size at maturity analysis.
To address the disease ecology aspect of this study two pathogens have been examined in the sampled population, CsRV1 and *Hematodinium* sp. The prevalence of CsRV1 has remained at 0% across all sampling months. *Hematodinium* sp. was seen in all 5 species with varying degrees of prevalence per species. The presence of *Hematodinium* sp. in the tropics has not been previously reported. The PCR-based prevalence of *Hematodinium* will be confirmed with histology and electron microscope investigations.
Training: Several meetings with potential NERTO partner Bruce Vogt and Mandy Bromilow at the NOAA Chesapeake Bay Office were conducted over the past year. Olivia has the option to conduct her NERTO at NCBO, but has also recently met with a NOAA scientist in the SEFSC who works on advancing data-limited stock assessment methods and ecosystem approaches to resource management.
Olivia has learned a great amount about histology and microscopy this year. Training on the University of MD School of Medicine electron microscope was completed in June 2021, and she met with NOAA NCCOS (Oxford Lab) scientist Gretchen Messick to review histological slides and EM images. Messick is an expert on health and diseases of blue crab. She has offered to continue to informally advise Olivia on the interpretation and preparation of histological slides.

Fig. 2. Olivia (right) with students from CROEV school, teacher Julie Rogers from the Park School (seated left) and fellow PhD student Mingli Zhao (standing).

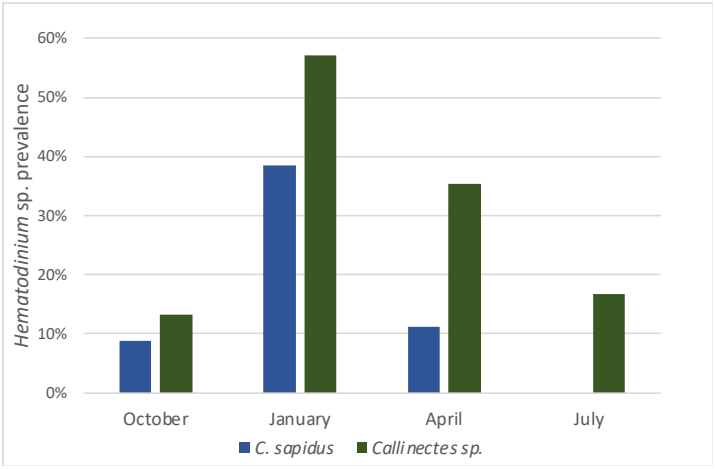


Fig. 3. PCR-based prevalence of *Hematodinium* in *Callinectes sapidus* and in other *Callinectes* spp. in La Torrecillas. *Hematodinium* was detected in at least one individual of all 5 species of *Callinectes*. Data on non-*sapidus Callinectes* are presented as a pool.

Relevance to NOAA:

This is the first systematic survey of blue crabs in the San Juan estuary. Though not a federally managed fishery, the *Callinectes* harvest is crucially important to an unknown number of Puerto Rico fishermen, who may shift effort to/from other critical fisheries of spiny lobster and conch as those species become more or less abundant.

Broader Impacts: The many contacts that Olivia has made in Puerto Rico have created a network of relationships with two schools in PR, and one in the US. The network includes PR DNR, the Jobos Bay NERR, a non-profit (San Juan Estuary), and two ecologists that do public engagement and education for the resort in Bahia Beach.

Presentations & Publications:

Abstract submitted to American Fisheries Society Annual Meeting (November 2021, Baltimore MD). Title: Life history and Reproductive Strategies of *Callinectes* sp. in a Tropical Urban Estuary. O. Pares*, M. Zhao, B. Stevens, and E. **Schott**

NSA poster National Shellfish Association (March 2021, virtual). Title: The Potential for Blue Crab Prey to be Host of the Crab Pathogen, CsRV1. O. Pares*, A. Fowler, M. Zhao, and E **Schott**

LMRCSC 2020 Virtual Science Meeting. Title: Life History and Disease Ecology of the Blue Crab, *Callinectes sapidus*, a Key Benthic-Pelagic Link, in Puerto Rico. O. Pares*

Performance Measure: 3.4b: Percentage of FSSI fish stocks with adequate population assessments and forecasts

DOC Strategic Plan: 4.2 - Provide Accurate Data to Support Economic Activity

NOAA RD Linkage: C1b: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems.

Next Gen Priorities: Sustainable fisheries and safe seafood for healthy populations and vibrant communities

20-05: Title: Evaluating the effects of landscape scale habitat variability on white shrimp (*Litopenaeus setiferus*) population dynamics in Georgia estuaries.

Thematic Research Area

SASI: Stock Assessment Support and Information and
HaBS: Habitats and Biological Systems

Abstract: Estuaries are recognized as important nursery habitats for penaeid shrimp species. Yet, there remain many questions about what exactly constitutes high-value, even critical, habitat for juveniles. In this study, we proposed to evaluate the nursery function of Georgia estuaries for white shrimp. We will evaluate relative abundance, growth, condition, and trophic dynamics of juvenile white shrimp among alternative landscape types. Furthermore, we will examine the use of stable isotope tags to identify areas within the estuary contributing greater proportions of individuals to the adult population. The results from this study will provide a better understanding of the population dynamics of estuarine and nearshore habitats and their contribution to fishery productivity.

Principal Investigator: Matt Kenworthy, Savannah State University
Co-PI: Dionne Hoskins-Brown, Savannah State University
NOAA Partner: Jennifer Doerr, Southeast Fisheries Science Center
Other Partner: Maurice Crawford, LMRCSC UMES
Students: William Burns, Undergraduate SSU

Keywords: Healthy Habitat, White Shrimp, Landscape

Start Date: May 2020 **End Date:** 12/31/2021

Results to Date: During summer and fall of 2020 we conducted monthly trawl and cast net sampling surveys for white shrimp at our nine primary tidal creeks across the three main regions of the estuary being evaluated. We compared shrimp catch per unit effort (CPUE) among the different regions, and marsh platform elevations (high, medium, and low). Preliminary analysis of trawl survey data suggests that there are differences in CPUE among the different regions of the estuary; however there were no statistical differences between the three marsh platforms elevations considered (Fig. 2).

During our monthly collection surveys we retained up to 100 individual shrimp to quantify Fulton's K condition indices. Preliminary analysis suggests that there is an effect to region, and marsh platform elevation on mean condition index of white shrimp (Fig. 3). On average, mean condition indices were higher for individuals collected at medium and high marsh platform elevation tidal creeks.

To further evaluate effects of different habitat characteristics on CPUE and Condition Indices at our study locations, we quantified the total area of individual habitat classifications (saltmarsh, intertidal mudflat, subtidal habitat), the proportion of each habitat to the total area surveyed, saltmarsh edge to area ratio (patchiness), ratio of intertidal mudflat to saltmarsh, and mean saltmarsh platform elevation. This was accomplished using supervised image classification of aerial imagery obtained for our creeks (Fig. 4). We quantified these metrics within a buffer area that extended 200m upstream/downstream from the sample collection zone and 75m onto the marsh platform for each study creek. Mean marsh platform elevation for each creek was quantified using Lidar data within the buffer areas. No significant correlations were observed between the habitat metrics quantified and CPUE (Fig. 5). However, we did observe significant positive and negative relationship between shrimp condition indices and saltmarsh edge to area ratio and marsh platform elevation, respectively (Fig. 6).

We quantified stable isotope signatures for juveniles collected across the nine primary study creeks as well as two additional locations within the estuary. Stable isotope data is being used to gain a better understanding of resource use across the regions of the estuary and the different marsh platform elevation creek classifications. Additionally, we are evaluating the spatial variability in isotope signatures to be able to identify putative nursery areas (Fig 7). Stable isotope signatures from adults emigrating from the estuary will be compared with juvenile signatures to identify where individuals came from. We are currently prepping adult tissue samples to be sent off to the UGA stable isotope laboratory for analysis.

Relevance to NOAA: This study will directly address top goals and priorities outlined by NOAA Fisheries. Specifically the data collected will address needs to "Incorporating an understanding of ecosystem, climate, and habitat condition into assessments and management of U.S. fisheries" by "quantifying the linkages between habitat and fishery productivity", which are priorities highlighted in the NOAA Fisheries Priorities and Annual Guidance 2019. Furthermore this study will address the goal of "Conserving Habitat for Managed Fisheries and Protected Resources" outlined in the NOAA Fisheries Habitat Enterprise Strategic Plan 2016-2020. Specifically, these data can help stock scientists incorporate habitat specific data on white shrimp population dynamics into assessments of shrimp stocks in southeastern U.S. estuaries. Whereas these efforts have been prevalent in Gulf of Mexico states, to the best of our knowledge, efforts to quantitatively link habitat and white shrimp production are limited along southeastern U.S. coastlines.

Broader Impacts: Our overarching goal is that coastal fisheries and habitat managers can use these data to rank the "value" of individual locations within Georgia estuaries and that this information can guide resource managers in prioritizing conservation plans to maximize ecosystem function and fishery production. For example, managers can use this data to establish regulations for the recreational shrimp and commercial bait shrimp fisheries in Georgia to protect highly productive locations within the estuary. Currently there are no limitations on the locations where these fishing activities can occur.

Presentations or Publications:

1) Matt Kenworthy presented preliminary results as part of an invited seminar given to the University of Georgia Department of Marine Science

2) Matt Kenworthy gave a virtual presentation on this project at the 2021 Georgia Water Resources Conference

3) Matt Kenworthy presented a poster for this project at the 2021 Georgia Climate Conference

Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)
DOC Strategic Plan: 3.1.2: Advance holistic, integrative ecosystem research (NOAA). **NOAA RD Linkage:** C1b: Increase our knowledge and understanding of the mechanisms andimpacts of environmental changes on marine species and ecosystems.
Next Gen Priorities: Healthy habitats that sustain resilient and thriving marine resourcesand communities

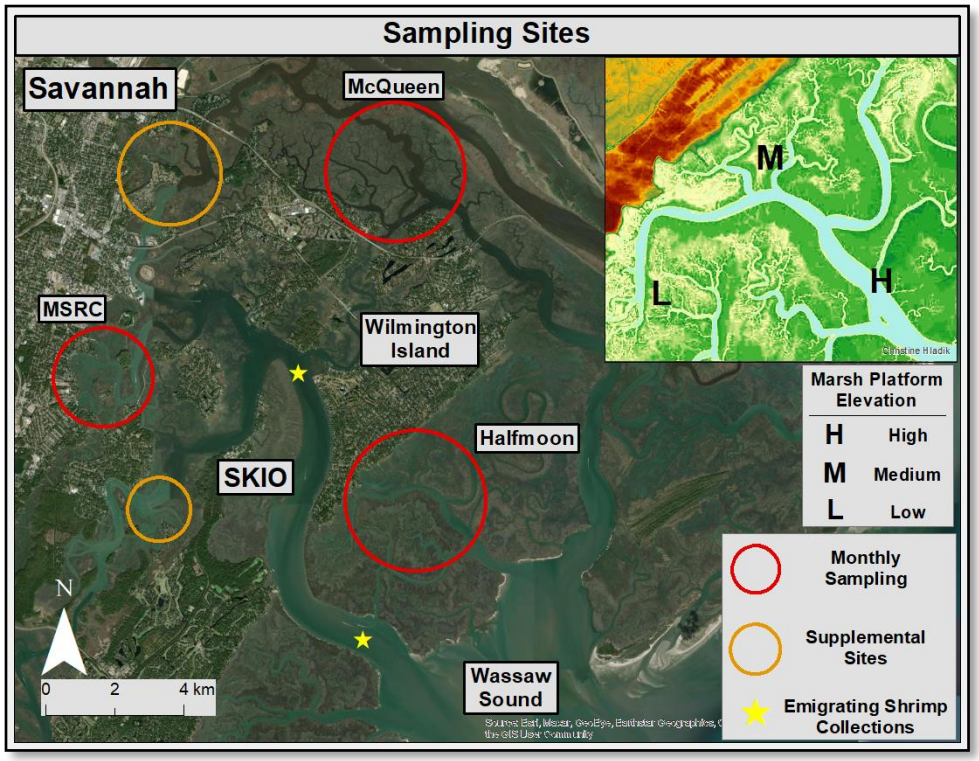


Figure 1. Sampling sites within Wassaw Sound Estuary. Example of Lidar imagery used to classify marsh platform elevations is displayed in the upper right panel.

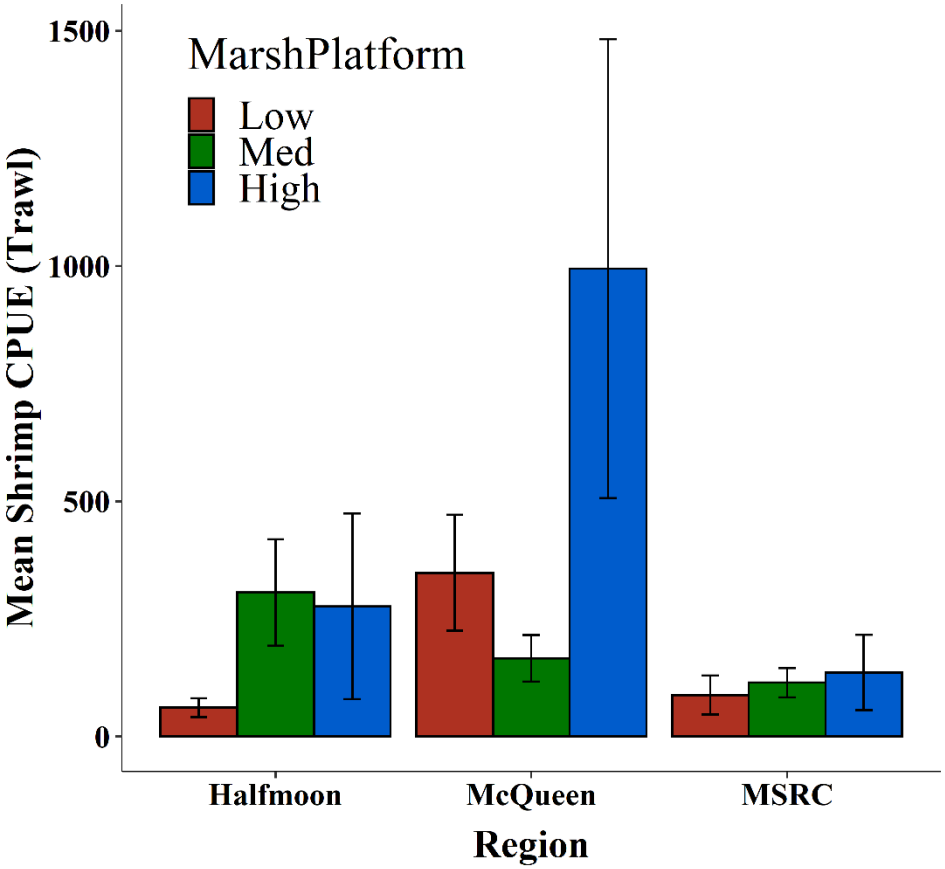


Figure 2. Results from mixed effect model evaluating influence of region and marsh platform elevation on Mean Shrimp CPUE. Significantly greater CPUE in McQueen Region. No significant effects of marsh platform elevation on mean CPUE.

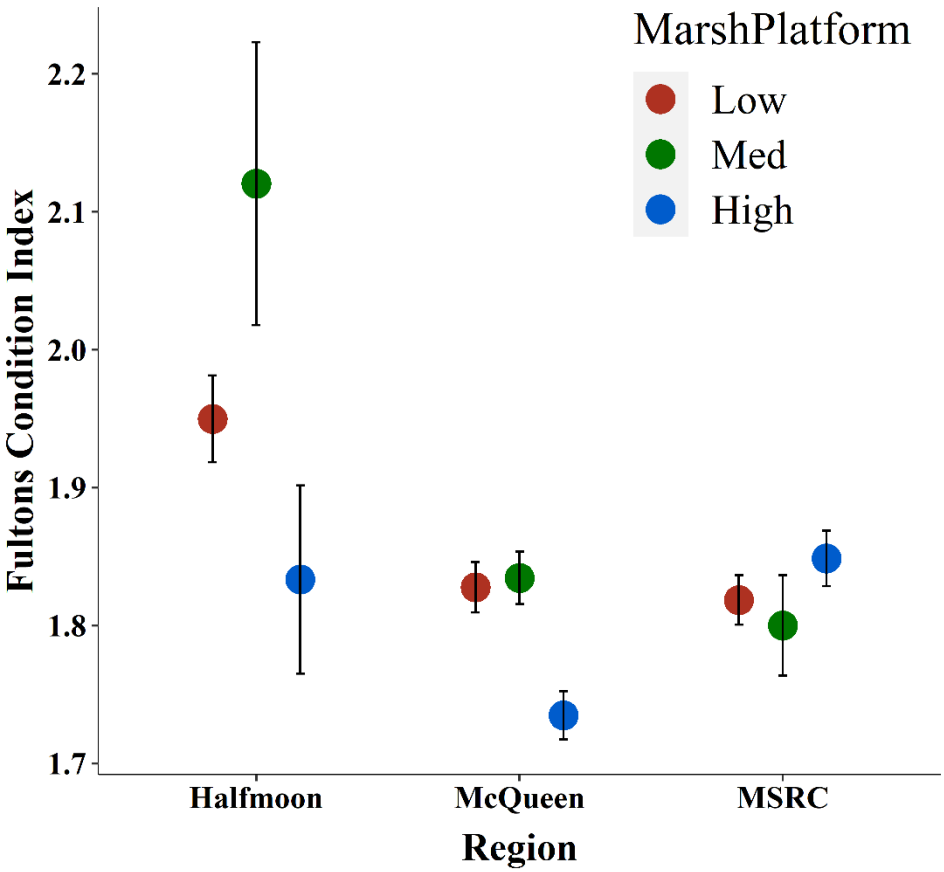


Figure 3. Results from mixed effect model evaluating influence of region and marsh platform elevation on Mean Condition Index. Significantly greater condition index values in McQueen Region and at low and medium marsh platform elevations.

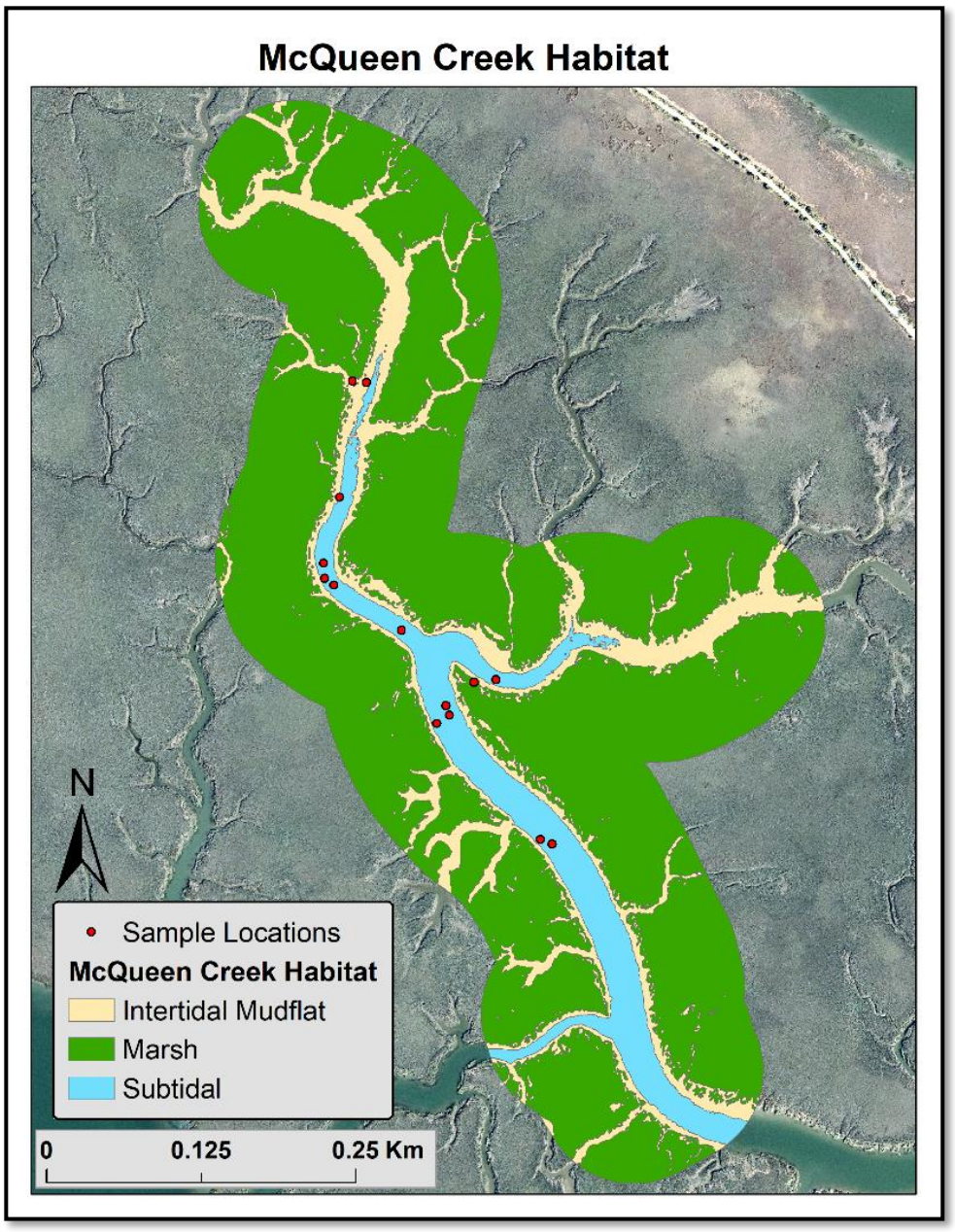


Figure 4. Example of supervised image classification from aerial imagery obtained for the study creeks. Image classification displayed in this figures is for McQueen Creek.

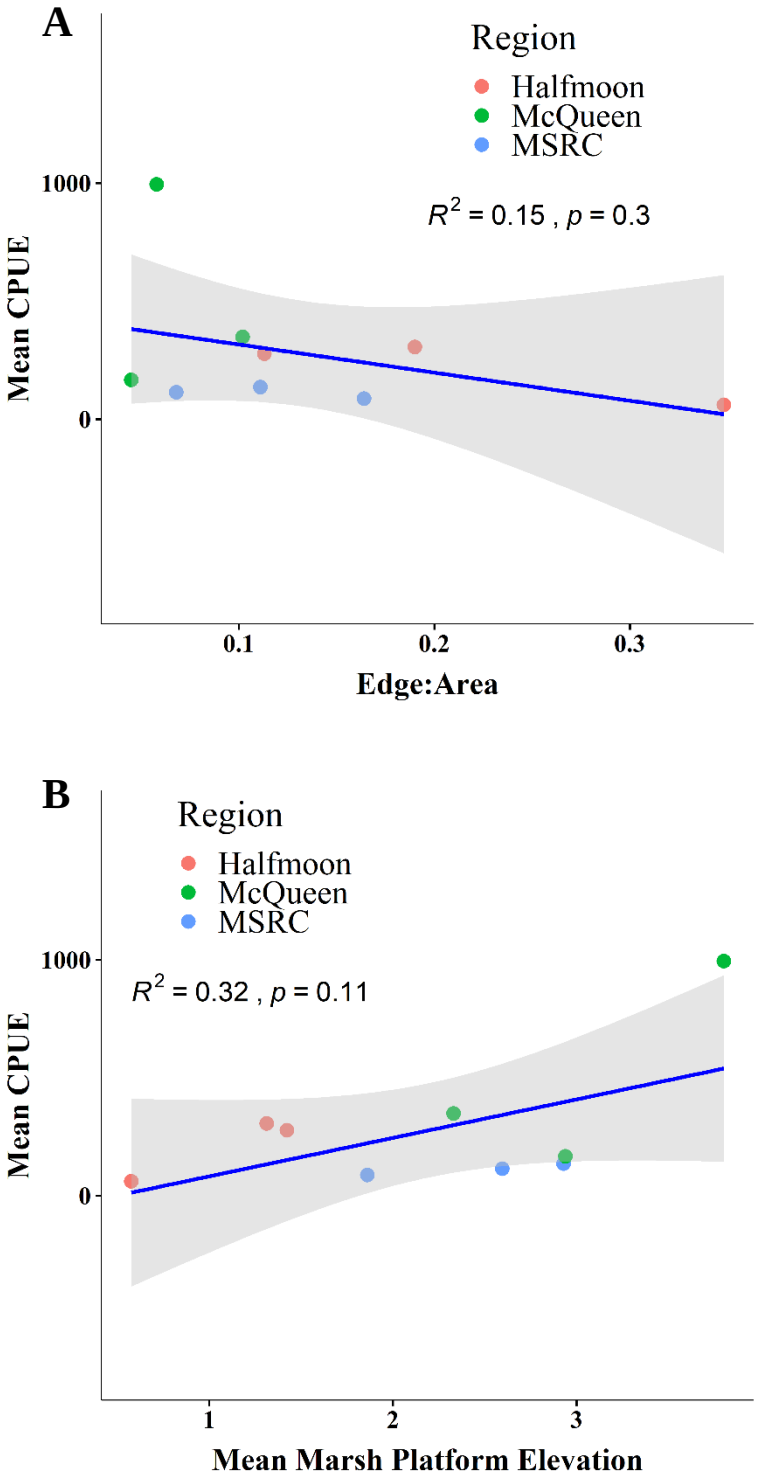


Figure 5. Results from Pearson correlation test evaluating the relationship between mean CPUE and habitat characteristics. Displayed here are relationships between CPUE and A) saltmarsh habitat edge to area ratio, and B) the mean saltmarsh platform elevation. Mean saltmarsh platform elevations are in feet relative to NAVD88. Only notable relationships displayed here.

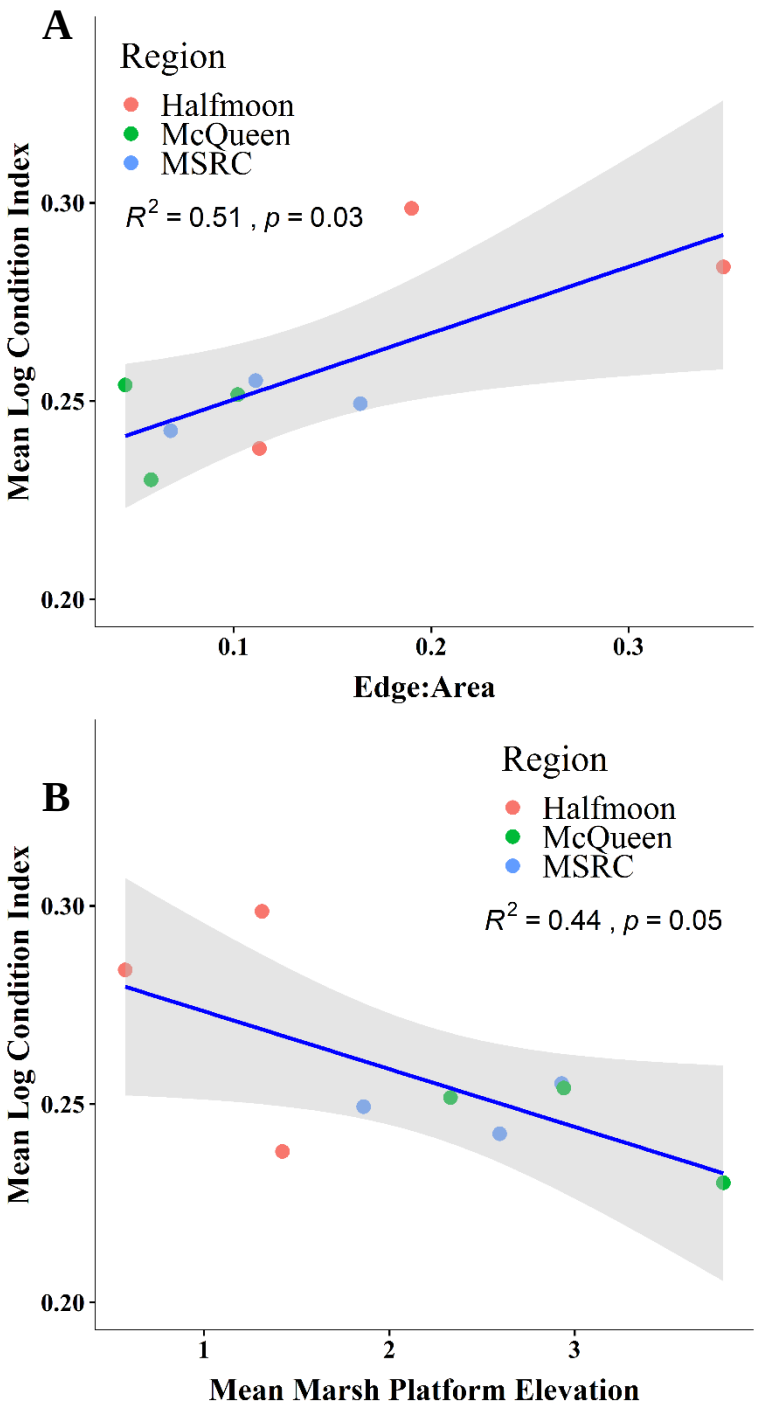


Figure 6. Results from Pearson correlation test evaluating the relationship between mean condition index and habitat characteristics. Displayed here are relationships between condition index and A) saltmarsh habitat edge to area ratio, and B) the mean saltmarsh platform elevation. Mean saltmarsh platform elevations are in feet relative to NAVD88. Only notable relationships displayed here.

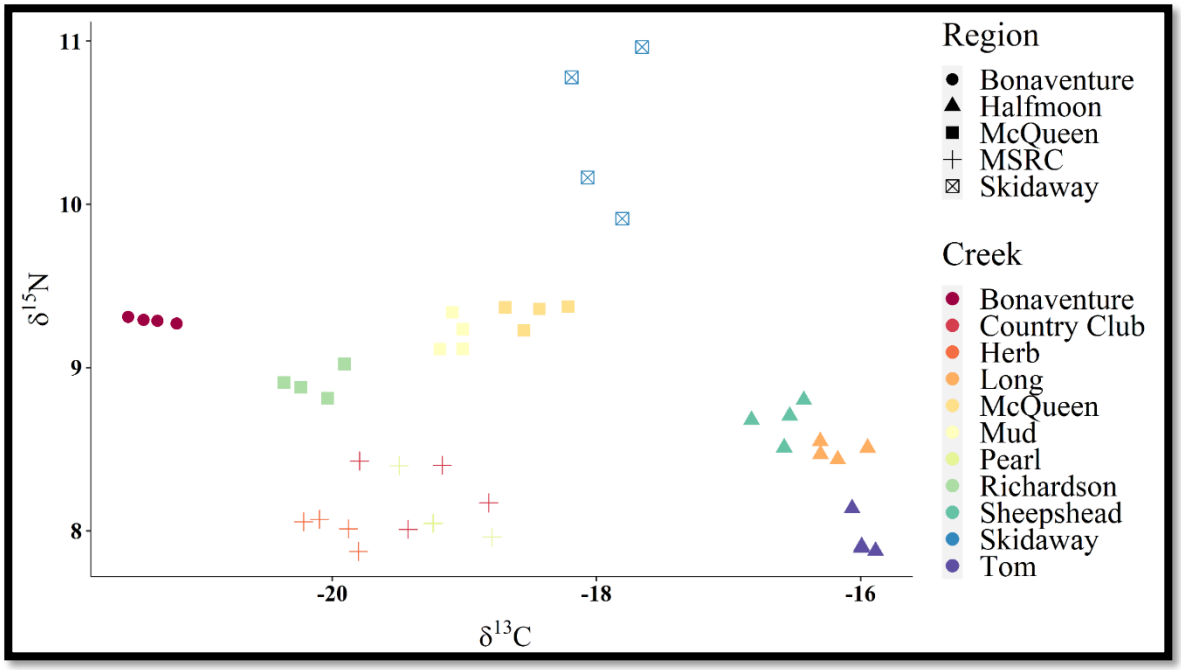


Figure 7. Carbon and Nitrogen stable isotope signatures from juvenile white shrimp collected from 11 tidal creek systems in Wassaw Sound Estuary.

20-06: Title: Genetic based methods for assessing the effects of climate change on the early life history stages of Nassau grouper

Thematic Research Area: CLIME: Climate Impacts on Marine Ecosystems

Abstract: Climate variability and change likely have major impacts on the early life history stages of commercially and recreationally valuable fish like Nassau Grouper. Understanding these impacts will be essential to conservation and management efforts. Studies to date have noted phenotypic and survival differences in early life history stages of Nassau Grouper reared at different temperatures. However, little is known of the drivers of these changes in bioenergetics and in gene expression during the early life history stages of this species. My goal is to measure bioenergetic activity and use established genetic methods to investigate temperature induced changes in gene expression of early life stage Nassau grouper, collected from a spawning aggregation on Little Cayman, Cayman Islands.

Principal Investigator: **Name**: Scott Heppell **Institution**: Oregon State University
Co-PI: Name: **Institution**:

NOAA Partner: **Name**: Steve Gittings **Lab/Facility**: National Ocean Service
Other Partner: Name: Brice Semmens **Lab/Facility:** Scripps Institution of Oceanography
Other Partner: Name: Dr. Carolina Bonin **Lab/Facility:** Hampton University
Students: Graduate Student; Janelle Layton **Undergraduate Student:** TBD
Keywords: Climate, early life history, Nassau Grouper, growth, survival, heat shock proteins

Start Date: August 2020 **End Date:** May 2022

Results to Date: Graduate Student Layton has completed her first year of graduate classes, written her

University-required research proposal, and conducted laboratory analysis on the early life history of Yellowfin Grouper (*Mycteroperca venenosa*), a previously undescribed life history stage for this species. This project overall has been delayed by at least year due to Covid-19 related travel restrictions. We were not allowed to enter the Cayman Islands in 2021, meaning that the primary fieldwork and laboratory rearing of larval fish, upon which this project is based, could not be conducted. During the week of September 6, 2021 we confirmed with our Cayman partners that those travel restrictions will be lifted by 2022, and this project will continue at that time.

Relevance to NOAA: We will provide fundamental data for the direct assessment of Nassau Grouper by analyzing and comparing the impacts of climate change on the early life history stages of this species. We will have the ability to perform student training in fish collection and rearing, laboratory-based genetics, and data analysis. In addition, the data directly relate to the mission of NOAA fisheries by influencing science-based conservation and management of living marine resources that will lead to the protection of healthy ecosystems. As Nassau Grouper are directly managed by three different Fishery Management Councils (SAFMC, GFMC, CFMC), these results have a direct impact on a federally managed species.

Broader Impacts: The data from our work will provide the information necessary to help conserve and manage Nassau grouper. Economically, these fish are extremely valuable for commercial and recreational practices. Throughout the Caribbean region the fishing industry contributes about $85-90 million annually to the economy. Sales from Nassau grouper contributes about $1.5 million to this industry (BREEF, 2014). This industry employees thousands of fishermen and these fishers will need to be able to continue their livelihood overtime. Plus, tourists from around the world visit the Caribbean. The opportunity to encounter threatened species like Nassau grouper in the wild adds value to tourism. Furthermore, Nassau grouper has a high cultural importance to several communities within the Caribbean. This species is an important food fish for Bahamian culture. A popular dish, boil fish, is traditionally created with Nassau grouper.

Presentations & Publications:

Layton, J, A Candelmo, B Semmens and SA Heppell (2021). *Investigating the Impacts of Increasing Temperatures on Early Life History Stages of Nassau Grouper*. Planned for the 150st Annual Meeting of the American Fisheries Society, Baltimore MD, November 2021

Performance Measure: 3.4e: Number and percentage of actions ongoing or completed to recover endangered and threatened species

DOC Strategic Plan: 3.4.1: Strengthen capabilities to assess and monitor fish and protected resources

NOAA RD Linkage: C1b: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems.

Next Gen Priorities: Recovered and healthy marine and coastal species

20-07: **Title:** Assessment of New Technologies for Post-Harvest Oyster Purification

Thematic Research Area: Safe Seafood, Shellfish Aquaculture

Abstract: It is imperative that aquaculturists can continue to provide consumers with safe seafood as the industry grows and adapts to a changing climate. Oyster aquaculture is particularly vulnerable to the intersection of seafood safety and climate change. Harvested oysters are at risk for carrying enteric bacteria and viruses that can make consumers ill, notably from *Vibrio* spp. bacteria. The prevalence of *Vibrio* spp. is expected to rise with increasing water temperatures. While post-harvest processing approaches currently employed to reduce risk of contaminated oysters are effective in reducing

pathogens, they have specific drawbacks for growers, including requiring high levels of capital to gain access to treatment equipment, poor consumer reception of treated products, and death of treated oysters. As part of my thesis research, I aim to demonstrate efficacy of two new technologies, individually and combined, in removing pathogens from oyster tissues and aquaculture system water leading to a post-harvest treatment that is more effective than traditional depuration, has low oyster mortality and is cost-effective for growers. This will be accomplished through a series of controlled experiments at the DSU Aquaculture Research and Demonstration Facility in Dover, DE to establish calibration curves for the new technologies in RAS.

Principal Investigator: Stacy Smith **Institution**: Delaware State University
Co-PI: Dennis McIntosh **Institution**: Delaware State University
NOAA Partner: John Jacobs **Lab/Facility**: Cooperative Oxford Lab on Maryland's Eastern Shore
Students: Graduate Student; Caitlyn Czajkowski
Keywords: Oyster, aquaculture, seafood, shellfish, vibrio, food safety

Start Date: August 2020 **End Date:** December 2022

Results to Date: Restrictions due to covid-19 impacted the study.

Relevance to NOAA: Change in our climate, ocean and coasts from climate change will have far reaching impacts. Oyster aquaculture is one such industry that will face many challenges in the face of a changing climate. One potential impact is the effect of rising ocean temperature on *Vibrio* bacteria. The range, virulency and prevalence of *Vibrio* will all potentially be expanded as an effect of rising ocean temperatures. This poses a major challenge to the industry as Vibrios impact the safety of consuming raw oysters and further impacts consumer opinion and safety concerns over consumption.
The industry must continue to innovate further methods and technologies to increase the resiliency of the industry to such impacts. Innovation must also be shared with the industry, particularly in an industry categorized by small producers, particularly in developing post-harvest processing (PHP) methods that are lower cost and effective in improving safety.

Wild oysters are a keystone species that provide a variety of ecosystem services and are an important natural resource. Farmed oysters also provide similar benefits as they are grown in estuarine systems where they still provide some of the same ecological benefits as wild oysters, particularly filtering water. Continued research and innovations into the improvement of aquaculture methods has the capability to be an essential food source while also providing benefits to ecosystem.

Broader Impacts: Seafood safety particularly that of raw oysters is a concern of many consumers. Safety concerns impact people's willingness to consume oysters and overall opinion of the industry. Post-harvesting processing (PHP) can increase the biosecurity of raw oysters and bolster consumer confidence in consumption. Incorporating Puradigm LLC technologies into depuration has the potential to help small oyster growers meet the requirements of the National Shellfish Sanitation Program (NSSP) to expand their market access by allowing them to export. Ideally this technology would also be available, particularly to the small farmers that make up the industry at a reduced cost compared to other PHP methods.

Presentations & Publications: None yet.

Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)
DOC Strategic Plan: 3.1.2: Advance holistic, integrative ecosystem research (NOAA).
NOAA RD Linkage: C5a: Enhance current species culture methods and identify new commercially viable species.

Next Gen Priorities: Sustainable fisheries and safe seafood for healthy populations and vibrant communities

20-08: Title: Evaluating physiological and immune responses of snow crabs (*Chionoecetes* sp.) to *Hematodinium* infection.

Thematic Research Area: Assessment: Support and Information

Abstract: A commercially important crustacean pathogen, *Hematodinium* sp., is a parasitic dinoflagellate of the *Hematodinium* genus that can cause Bitter Crab Disease/Bitter Crab Syndrome (BCD/BCS). There are high rates of *Hematodinium* sp. infection in snow crabs native to the Bering Sea, which can result in soiled crab meat and thus cause significant losses to commercial stocks. *Hematodinium* may affect regulation of metabolic gene expression in infected crabs, based upon observed changes in biochemical composition. This study will explore this effect, in addition to the regulation of genes involved in the immune response in snow crabs. The effect of climate change on host snow crab immune function, and susceptibility to disease, is currently unknown. This study provides an opportunity to assess these parameters using cutting edge tools like next-generation sequencing, and provide baseline information for assessment of the health of this fishery.

Principal Investigator: Name: Shanelle Haughton **Institution**: UMES
Co-PI: Name: Dr. Joseph Pitula **Institution**: UMES
NOAA Partner: Name: Dr. Pamela Jensen **Lab/Facility**: Alaska Fisheries Science Center (AFSC)
Other Partner: Name: Dr. Sook-Chung **Lab/Facility:** UMCES-IMET
Students: Graduate Student: Shanelle Haughton **Undergraduate Student:**

Keywords: Fisheries; Marine Biology; Ecosystems; Crustaceans; *Hematodinium*; Disease;

Start Date: May 2021 **End Date:** May 2022

Results to Date: Thus far, samples have been collected and processed for further application. 200 immature Tanner crabs were collected (115 females and 85 males), physiological observations recorded, and blood and tissue samples from each individual were collected. RNA has been extracted from hepatopancreas tissue of all individuals, with RNA yielded from 94 of the 200 samples. DNA extractions have also been completed for all 200 individuals, with yields from all 200 samples. 16s PCR has been completed for all 200 samples to detect presence of bacteria in blood samples; 108 of 200 samples tested positive for 16s. Traditional PCR and 16s qPCR has been completed for all 200 samples to detect the presence and load of bacteria in each individual. Of the 200 individuals, 154 had a high bacterial load ($>10^6$ cell/mL), 25 had a moderate bacterial load ($=10^6$ cell/mL), and low bacterial load ($<10^5$ cell/mL). Currently, 18s qPCR to determine *Hematodinium* infection status of all 200 individuals is underway; so far qPCR has been completed for 120 of 200 individuals, with 52 of the 120 tested individuals showing presence of *Hematodinium*. Next, individual samples will be selected and Flow Cytometry will be completed to detect the number of immune cells in blood samples; trehalose and ecdysteroid assays will also be completed. RNA-seq analysis will also be performed to determine changes in gene expression of select immune and metabolic genes.

Relevance to NOAA: The effect of climate change on host snow crab immune function and susceptibility to disease is currently unknown. This study provides an opportunity to assess these parameters within the context of a disease known to seriously impact this economically important species. Therefore, we are

fulfilling NOAA's mission of science and stewardship as our results can provide credence to arguments that attempt to demonstrate the consequences of climate change, in an effort to sustain crustacean (and other) fisheries. We are also providing baseline data for general studies into immune function in the system. This work is complementary to a funded project in the lab of our NOAA collaborator (Pam Jensen), helping to build partnerships between NOAA and UMES. Dr. Jensen will continue to act as a committee member for my dissertation. It also will serve as the foundation for a comparative study between infections of *Chionoecetes* and *Callinectes sapidus*.

Broader Impacts: *Chionoecetes* sp. crustaceans are an economically important fishery of Alaska and the United States. High rates of *Hematodinium* infection can potentially cause drastic population decline, leading to loss of a fishable resource and commercial losses from BCD. At monitoring sites set up for *Hematodinium* sp. in *Chionoecetes*, infection rates have steadily and annually climbed from 2014 to 2017 from single digit infection rates to all-time highs of 54% & 49% in immature snow crabs, respectively (Pam Jensen, personal communication). This increase is thought to be linked to climate change, and has important implications for the impact on the fishery and dependent communities in Alaska.

Presentations & Publications:
Haughton, S. and Pitula, J. (May 2021) "Evaluating Physiological and Immune Responses of Tanner crab (*Chionoecetes bairdi*) to *Hematodinium* sp. Infection". LMRCSC Graduate Seminar Series.

Haughton, S. and Pitula, J. (April 2021) "Evaluating Physiological and Immune Responses of Tanner crab (*Chionoecetes bairdi*) to *Hematodinium* sp. Infection". UMES Annual Graduate Research Symposium.

Haughton, S., Jensen, P. and Pitula, J. (September 2020). "Evaluating Physiological and Immune Responses of Tanner Crab (*Chionoecetes bairdi*) to *Hematodinium* sp. Infection". AFS 2020 Virtual Meeting.

Haughton, S. and Pitula, J. (April 2020). "Evaluating Physiological and Immune Responses of Tanner crab (*Chionoecetes bairdi*) to *Hematodinium* sp. Infection". LMRCSC 2020 Virtual Science Meeting.
Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)
DOC Strategic Plan: 3.1.2: Advance holistic, integrative ecosystem research (NOAA).
NOAA RD Linkage: C1b: Increase our knowledge and understanding of the mechanisms and impacts of environmental changes on marine species and ecosystems.
Next Gen Priorities: Improved understanding of ecosystems to inform resource management decisions

20-09: Title: Understanding Adaptive Capacity to Environmental Change: An Analysis of Community Perceptions and Policy Responses to Ocean Acidification and other marine stressors on the West Coast

Thematic Research Area: CLIME: Climate Impacts on Marine Ecosystems

Abstract: Ocean acidification disrupts marine and coastal ecosystems' carbonate chemistry, directly and indirectly affecting communities that depend on critical marine organisms. Ocean acidification research typically seeks to understand natural system responses, yet there is insufficient research that examines community and institutional responses or, more generally, their vulnerability to ocean acidification. This lack of information represents a challenge for developing policies that might serve to combat OA, whether they involve mitigation or adaptation strategies. Given the inadequate information to direct policy efforts to combat ocean acidification, this project aims to understand members of the Oregon Dungeness Crab

Industry's perceptions of their adaptive capacity to impacts of ocean acidification and other environmental stressors. Cinner et al.'s (2018) adaptive capacity framework guided the project, precisely 12 interviews with Oregon's Dungeness Crab Industry members. The adaptive capacity framework was also used in guiding the content and policy analysis of ocean acidification policy and Dungeness crab management and regulations. Through the qualitative analysis of interviews and policy documents, the adaptive capacity of Oregon's Dungeness Crab Industry was assessed. Results show that assets and agency were the two adaptive capacity domains most found in the industry.

In contrast, assets and learning were the two adaptive capacity domains that were needed to build upon. Additionally, it was found that economic modifications, modifying their gear, location, season, participating in other fisheries, and scientific studies were the strategies that Dungeness crab fishers would gravitate towards. The policy and content analysis revealed that ocean acidification policy and Dungeness crab management have the infrastructure to build members' adaptive capacity through funding research efforts and providing financial support to industry members in need. While ocean acidification policy can support industry members build their adaptive capacity, there is potential for institutions to align their efforts to industry member's needs better. By understanding the perceptions of members in Oregon's Dungeness Crab Industry alongside the current ocean acidification policy and Dungeness crab management landscapes, the project hopes to contribute to broader efforts to support the adaptive capacity of industry participants who are dealing with environmental changes such as ocean acidification.

Principal Investigator:
Name: Victoria Moreno, neé Williams **Institution**: Oregon State University
Co-PI:
Name: Dr. Ana Spalding **Institution**: Oregon State University
NOAA Partner:
Name: Dr. Shallin Busch **Lab/Facility**: NOAA NWFSC
Other Partner: Name: n/a **Lab/Facility:** n/a
Students: Graduate Student: n/a **Undergraduate Student:** n/a
Keywords: Fisheries, Adaptive Capacity, Ocean Acidification

Start Date: 09/20/2019 **End Date:** December 2021

Results to Date: Due to COVID, I was unable to make actual site visits and conduct in-person interviews with community members. As to date, the TAB funds have not been used. However, I was able to persist and complete 12 interviews and have completed analysis. Additionally, the policy analysis component has also been completed.

Relevance to NOAA: The project seeks to develop a framework to analyze the adaptive capacity of Oregonian wild-capture reliant communities to inform OA policy. NOAA has several intersecting missions, including studying vulnerability and increasing awareness of the current environmental challenges, including impacts on marine ecosystem businesses and communities. Vulnerability is typically understood to be a combination of exposure, sensitivity, and adaptive capacity (Folke 2006, Folke et al., 2005). This project will directly study the adaptive capacity, a crucial segment of vulnerability, and will explore how wild-capture reliant fisherman and community members perceive the issue of OA. Stakeholder interviews will help us understand vulnerability by providing insight on whether stakeholders have the necessary socioeconomic tools and readiness to adapt to the impacts of OA (Reiblich et al., 2019, Salomon et al., 2019). Understanding wild-capture reliant crab fishermen's awareness levels will shed light on the alignment of current policies with stakeholder concerns. This study can provide evidence of where efforts to increase awareness of OA impacts and adaptation strategies can be refined by analyzing policy alignment. This study will also help increase awareness in government and academic readers about how

OA affects various social and economic processes within the Crab Industry in Oregon.

Broader Impacts: Adequately measuring the adaptive capacity of wild-capture reliant communities will provide insights for policymakers at local scales that can then translate into better regional policies and initiatives. This study will contribute to our growing understanding of how ocean acidification (OA) affects human behavior, traditionally studied primarily from a natural and physical science perspective. By uncovering the perceptions of OA impacts and needs associated with adaptation strategies to respond to said impacts, we aim to help policymakers devise and implement policies that are better aligned with the community's needs.

Presentations & Publications:

Victoria Moreno (2021). An Analysis of Community Perceptions and Policy Responses to Ocean Acidification on the West Coast, Cape Perpetua Area Collaborative Young Scientist Webinar Series. Tuesday, April 13, 2021.

Performance Measure: 3.4d: Number of protected species designated as threatened, endangered or depleted with stable or increasing population levels
DOC Strategic Plan: 3.4.3: Enhance place-based conservation
NOAA RD Linkage: C2a: Understand the processes of ocean acidification and its consequences for marine organisms, ecosystems, and human communities.
Next Gen Priorities: Resilient coastal communities that can adapt to the impacts of hazards and climate change

20-10: **Title:** The Occurrence of Microplastics in Maryland Coastal Bay Fishes

Thematic Research Area: HaBS: Habitats and biological systems

Abstract: An important problem is plastic pollution in the ocean with millions of tons of plastic flowing into the ocean every year. The breakdown of larger pieces of plastic can form microplastics (< 5 mm) that are easily consumed by marine organisms thereby posing a threat to their populations. The Maryland Coastal Bays are home to a variety of commercial and recreational activities but few studies have been done regarding microplastic pollution. For my master's research, I plan to quantify the presence of microplastics in Maryland Coastal Bay fishes by comparing the percentage of fish contaminated with microplastics by feeding type and location. I will also research the feasibility of a technique to remove microplastics from the water without harming the environment.

Principal Investigator: Name: Imani Wilburn **Institution**: UMES
Co-PI: Name: Dr. Maurice Crawford and Dr. Kausik Das **Institution**: UMES
NOAA Partner: Name: Dr. Ashok Deshpande **Lab/Facility**: Northeast Fisheries Science Center/ Sandy Hook
Other Partner: Name: Dr. Stacy Smith **Lab/Facility:** Delaware State University
Keywords: Microplastics, Fisheries, Marine Biology

Start Date: June 1, 2020 **End Date:** 12/31/2021

Results to Date: We have been able to collect almost 800 fish that currently need to be processed, both from the Northern bays and the Southern bays. We were also able to collect some fish from the Delaware Inlet Bays that also still need to be processed. The first batch of fish faced some technical difficulties such

as the vacuum pump not working and most of the samples being contaminated, so at least 100 fish were thrown out. The data I am prepared to report on are in the tables below.

Total Fish Collected by Species

Species	Northern bays	Southern bays	Total
Bay Anchovy	274	69	343
Silverside	70	182	252
Silver Perch	4	2	6
Spot	86	94	180

Average Length and Weight of Processed Fish

Species	Average Length (mm)	Average Weight (g)
Bay Anchovy	48.03	1.73
Spot	119.29	24.50

Percentage of Plastics Found per Species

Species name	Sample size	% of plastic found
Bay Anchovy	29	50
Spot	52	71

Most of the plastics found so far resemble small plastic fibers. I have seen these fibers in multiple different colors such as red, blue, and black.

Relevance to NOAA: My research supports NOAA's long-term goal to improve and protect the health of marine ecosystems, habitats, species, and populations. This research falls under the LMRCSC thematic research area of the habitats and biological systems, specifically touching on the impacts of human activities on marine habitats and species. The project also supports the goal of NOAA's resilient coastal communities because of my efforts to develop a method to remove microplastics from water.

Broader Impacts: Plastics and microplastics have serious impacts on wildlife, but little is known about how they may affect human health. Kosuth et al. (2018) found microplastics present in packaged sea salt, beer, bottled water and tap water, confirming that people have been ingesting microplastics, directly and indirectly, but the possible health effects are still not clear. The widespread presence of microplastics in fish could discourage customers from purchasing fish and negatively affect the industry. Overall, the issue of microplastics is not well known to the public. I plan to create educational materials for the public so they can learn more about microplastics. I intend to develop flyers and hands-on activities for K-12 students so they may learn about microplastics and their effects. These materials would be disseminated during outreach events conducted by the UMES AFS Subunit at local environmental events like Earth Day at the Salisbury Zoo and Bay Day hosted by the Maryland Coastal Bays Program. Because of the Covid19 pandemic, no K-12 activities have taken place at this time.

Presentations & Publications: none yet
Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)
DOC Strategic Plan: 3.4.3: Enhance place-based conservation
NOAA RD Linkage: D2a: Determine combined effects of environmental stressors on coastal species and ecosystems.
Next Gen Priorities: Healthy habitats that sustain resilient and thriving marine resources and communities

21-1: Title: Sonar Censusing and Habitat Use by Spawning Run Atlantic and Green Sturgeon, *Acipenser oxyrinchus* and *A. medirostris*

Thematic Research Area: Assessment: Support and Information

Abstract: This TAB project supports (1) NERTO training and research on sonar censusing Sacramento River green sturgeon at the NOAA SWFSC Santa Cruz Laboratory; (2) tests to distinguish Atlantic sturgeon and gar sonar images for Chesapeake Bay Atlantic sturgeon; and (3) provides field training opportunities for undergraduate minority students. Sturgeons across the US are managed by NMFS as protected species, where key challenges to recovery center on accurate assessment of spawner abundance and how spawner movement and reproduction is impaired by habitat alterations. In his thesis research, EPP LMRCSC Fellow Nicholas Coleman is deploying sonar censusing approaches on spawning run Atlantic sturgeon in the Marshyhope Creek system (Chesapeake Bay) and using telemetry to better understand how spawner incidence is shaped by flow, temperature, dissolved oxygen, and bottom substrate. SWFSC scientists pioneered sonar censusing approaches evaluating spawning green sturgeon in the Sacramento River, for which a decade of historical data is available. During a NERTO, LMRCSC Fellow Coleman will receive training in side-scan and DIDSON sonar censusing technologies with SWFSC Santa Cruz scientists (S. Lindley and P. Dudley) and evaluate historical habitat associations of spawning run adults. A key challenge to Coleman's Atlantic sturgeon thesis work is distinguishing sturgeon and gar, the two largest fishes within the Marshyhope Creek, through sonar (ARIS) deployments. Laboratory trials are proposed to compare acoustic images of gar from similar sized Atlantic sturgeon. This work will complement and enhance the Fellow's thesis research and training through comparisons of sturgeon settings (water-stressed but large Sacramento River vs. very small Mashyhope Creek), spawning habitat associations in both systems, and exposure to the interface between science (sonar censusing) and conservation policy.

Principal Investigator: **Name**: Dr. Rose Jagus **Institution**: UMCES/IMET
Co-PI: Name: Dr. David Secor **Institution**: UMCES/CBL
NOAA Partner: **Name**: Dr. Steven Lindley **Lab/Facility**: SEFSC
Other Partner: Name: Dr. Peter Dudley **Lab/Facility:** SEFSC
Students: Graduate Student: Mr. Nicholas Coleman

Undergraduate Student: prevented by CoVID restrictions

Keywords:

Start Date: 1 April 2021 **End Date:** 31 March 2022

Results to Date: Project goals were to (1) support LMRCSC Fellow N. Coleman's NERTO, which will exceed available funds ($5000); (2) overcome a key constraint in application of sonar censusing – distinguishing similar size Atlantic sturgeon and gar *Lepisosteus osseus* species; and (3) provide field training opportunities to undergraduate LMRCSC students. Principal support for N. Coleman's thesis

research comes from a separate NOAA Section 6 Award to PI D. Secor and Maryland DNR collaborators, entitled “Spawning movement behaviors, habitat dependencies and run size of Nanticoke River Atlantic sturgeon.” This award provides funding for fieldwork and analyses related to ARIS, side scan, and telemetry deployments in the Marshyhope Creek during Aug-Oct 2019-2021. Thesis research focuses on developing robust estimates of abundance through intensive assessment of key spawning reach segments, simultaneously deploying ARIS, side-scan sonar, and biotelemetry. TAB support will augment thesis research through support of the NERTO, mentoring undergraduate interns, and conducting a key test to confirm identification of Atlantic sturgeon.

LMRCSC Fellow Coleman engaged in all parts of the Sacramento green sturgeon acoustic surveys. DIDSON sturgeon sampling took place from June 7th to June 18th, 2021, from just above Chico (river km 323) to Keswick Dam (river km 477), covering an area of approximately 154 kilometers (Figure 1). A total of 42 units (sites) were sampled in 2021. DIDSON was towed on the side of the boat at an angle of approximately 85º to optimize field of view of the river bottom. As depth changed, the camera was adjusted with a manual crank to maintain field of view of the river bottom. Each transect was surveyed with seven DIDSON passes and three side scan passes. A GPS unit attached to the boat recorded the paths of each transect pass to calculate area surveyed during data analysis. Side scan sonar surveys were also conducted. After the collection of the acoustic video, three reviewers analyzed the video from each transect and counted the number of sturgeon they observed. Buffer width was measured from the width of the DIDSON beam on each video recording the transect and the number of observed fish was divided by the area to obtain a value of density. Densities from all seven passes were averaged and the density was multiplied by total area surveyed to get estimated abundancies. The sum of estimated abundances from each spawning location was summed to obtain an annual spawning run estimate. Annual estimates of abundance were corrected with telemetry data to account for fish that migrated out of the sampled area before sampling occurred or migrated into the spawning area after sampling and fish that were missed because they were moving between spawning areas.

Figure 1. Map of the extent of the Upper Sacramento River sampled during DIDSON surveys. Cities are marked by blue hexagons, major dams are marked by grey circles, and the red area highlights the survey extent.

Temperature (ºC) and flow (m^3/s) data for the surveyed area were obtained from the River Assessment for Forecasting Temperature (RAFT). RAFT simulates river temperature and flow using in the longitudinal direction as a one-dimensional model. In this analysis, RAFT modeled daily temperature and flow from 2010 to 2017. Average temperature for each month from March to August was used to index the temporal window in which sturgeon occupied the sampled reaches of the Sacramento River. Annual estimates of abundance were correlated with mean monthly temperature and flow to explore the possibility of cueing behavior to monthly environmental conditions. Average Distance Upstream (ADU) was calculated and correlated with average temperature to understand how these variables influenced the extent of travel for sturgeon. ADU was calculated from the following equation:

$ADU = \frac{annual\ sum\ of (rkm\ at\ transect\ x \times fish\ obsered\ at\ transect\ x)}{total\ annual\ estimation\ of\ fish}$ "Hot spots" were defined as units where 50 or more sturgeon were observed for at least three years or areas that had 100 or more sturgeon for a given year. The abundances from 2010-2019 were plotted for four identified hotspots to examine annual fluctuations in habitat utilization. Average flow for April and average temperature for March were correlated the strongest with spawning run abundance using R-squared values (Figures 2; temperature not shown). The results have implications in how spawning run estimates are interpreted in terms of green sturgeon conservation and rebuilding.

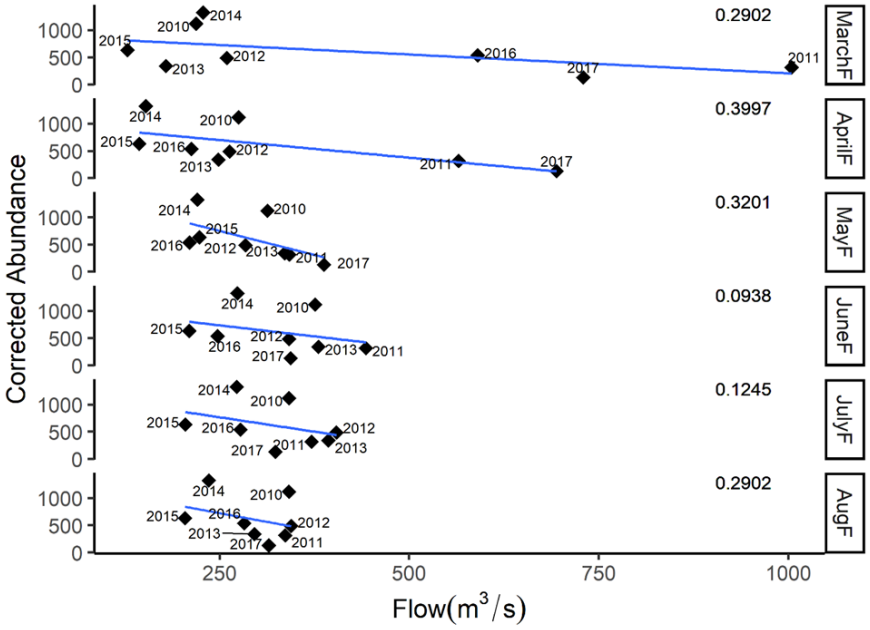


Figure 2. Scatter plot showing the relationship between average monthly flow and annual abundance from 2010 to 2017. R-squared values each month are represented in the top right of each graph.

Relevance to NOAA: NOAA is committed to the management and conservation of marine resources and the ecosystems that support them. The NMFS Office of Protected Resources is responsible for implementing the Endangered Species Act (ESA), which assesses the vulnerability of native species and the habitat they use, does so through a process that collaboratively engages fishery managers and stockholders to develop recovery plans and continued monitoring programs. The Chesapeake Bay distinct species segment (DPS) of Atlantic sturgeon is "Endangered" (NOAA 2017) and the southern distinct species segment (sDPS) of green sturgeon is "Threatened" (NMFS 2018). Spawning reaches for Nanticoke River Atlantic sturgeon and Sacramento River green sturgeon, although vastly different in dimension and legacy threats represent key assessment areas for quantifying population recovery. Further, habitat protections and restoration projects have been put into place for both species. Despite major advances in sturgeon sonar censusing approaches, uncertainties related to biases and efficiencies of these methods persist, which can be evaluated through (1) deployment and integration of multiple platforms (ARIS/DIDSON and side scan sonar) and biotelemetry, and (2) laboratory tests of key sonar censusing assumptions related to size estimates and species identification

Broader Impacts: A key outcome of this proposal is the training of LMRCSC student Nicholas Coleman and possible future recruitment into a NOAA science career path through his thesis research, course work, and NERTO experience. Dr. Steve Lindley will advise the student. Dr. Lindley is the director of the Fisheries Ecology Division at the Southwest Fisheries Science Center (SWSFC) in Santa Cruz, California where he serves as a member of the Green Sturgeon Recovery Team. Dr. Peter Dudley, is a quantitative ecologist and also a member of the Fisheries Ecology Division and will support NERTO training and green sturgeon data analysis.

Presentations & Publications:
Secor, D.H., M.H.P. O'Brien, N. Coleman, A. Horne, I. Park, D. Kazyak, D. Bruce, and C. Stence. (2021). Atlantic sturgeon status in an extremely small spawning habitat: the Nanticoke-Marshyhope Creek Estuary, Chesapeake Bay. Reviews in Fisheries Science and Aquaculture DOI: 10.1080/23308249.2021.1924617.

21-2: Title: Developing a Coupled Human Ecological System for Chesapeake Bay Shellfish Fisheries

Thematic Research Area: Stock Assessment Support and Information

Abstract: Achieving sustainable use of aquatic living resources is a key challenge facing humanity today. Several ecological models have been developed to address questions about management and use of aquatic living resources, but these models often do not adequately capture human dimensions of natural resource management; making it necessary to direct more attention to human aspects of coastal fisheries such as in the Chesapeake Bay. Coupled human environmental modeling of ecosystems can enable us to better understand fleet behavior and devise better approaches to reducing anthropogenic impacts on the Bay ecosystem. Humans impact Chesapeake Bay (either directly or indirectly) by reducing water quality, increasing wildlife disease, applying harvest pressures, and influencing habitat integrity. In our proposed project, we aim to extend the current Chesapeake Bay Fisheries Ecosystem Model (CBFEM) developed by NOAA partners to include social information so we can more directly verify human impacts on shellfishes and other living aquatic resources of Chesapeake Bay.

Principal Investigator: Name: Tunde Adebola **Institution**: Hampton University
Co-PI: Name: Eric Lewallen **Institution**: Hampton University
NOAA Partner: Name: Howard Townsend **Lab/Facility**: Oxford Maryland
Students: Graduate Student: TBD **Undergraduate Student:**

Keywords: Ecosystem Fisheries Modeling, Agent Based Modeling, Artificial Intelligence

Start Date: January 2022 End **Date:** January 2024

Results to Date: Dr. Eric Lewallen and Dr. Tunde Adebola of Hampton University Virginia are working to extend the Ecosystem model of the Chesapeake Bay in partnership with Dr. Howard Townsend of NOAA, Oxford Maryland. We also have the support of Mr. Jeroen Steenbeek who has been actively developing the Ecopath with Ecosim (EwE) software. We began preliminary code construction for an AI plugin with the aim to integrate this plugin into EwE using Goal Oriented Action Planning in C# and Unity Engine.

Ecospace the spatial dynamic simulation module of EwE already has rudimentary agent-based modeling capabilities. Our goal is to improve this using AI algorithms in Unity Engine that will drive outcomes in the simulated world modeled in both EwE and Unity Engine.
We have identified potential students and look forward to recruiting one of these to continue work on this project beginning from January 2022.

Relevance to NOAA: We propose the use of cutting-edge technologies that will be at the intersection of ecological and behavioral science with a potential of improving our understanding of how human behavior impacts managed common pool resources. Our goal for this project is to develop a methodology that will improve harvest strategies for Chesapeake Bay Shellfish species to promote their assessment and sustainable utilization in the face of alternative options for management.

Broader Impacts: We aim to involve and train an early career scientist from a minority and underrepresented population in the US. Hampton University is very well positioned to do this, because we are situated right at the mouth of the Chesapeake Bay where it opens into the Atlantic Ocean and are a Historically Black University. Our faculty collaborate among the Social, Biological and Marine Sciences, Engineering and Computational Sciences researchers and have a range of expertise that we can use as leverage to achieve maximum impact. Furthermore, we will work closely with other LMRCSC institutions including the University of Miami-RSMAS and with researchers across the US and beyond as this project grows and improves over time.
Presentations & Publications: None yet

Appendix III: Leveraged funds

Source	Type	Start date - end date	Total amount	Current 6 month period	PI	Project title	Contribution to Center
NSF-HRD	Grant	09/19-08/22	$400,000	$0	Horodysky and Gibson	Targeted Infusion Project: Mathematical Engagement for the Marine, Biological, and Environmental Realms of Science (MEMBERS)	Funds are used to support Horodysky and and Gibson, and student internships.
NSF-OCE	Grant	8/18-7//22	$741,820	$30,000	Cuker and Lewallen	Multicultural Diversity in the Aquatic Sciences	Funds are used to support students to ASLO conference.
NSF-OCE	Grant	5/21-4/26	$60,500	$0	Gibson	Cold Tongue Mixing	Funds used to support student travel for research in Ghana.
NSF-BIO-IOS	Grant	8/19 - 7/24	$700,000	$0	Horodysky	CAREER: Investigating environmental acidification and temperature as drivers of morphological alteration and physiological deficits in auditory systems of soniferous fishes	Reseach topics provided for LMRCSC funded student
NSF RIA	Grant	8/20-7/23	$299,999	$5,000	Lewallen	Epigenomic adaptations of dolphin skin	Reseach topics and supplies provided for LMRCSC funded student
NSF-OCE	Grant	8/21-7/23	$914,000	$0	Gibson and Cuker	Multicultural Diversity in the Aquatic Sciences	Funds are used to support students to ASLO conference.
NSF-ECCS	Grant	08/21-07/24	$600,235	$0	Sun and Gibson	Excellence in Research: Integrated Sensor-Robot Networks for Real-time Environmental Monitoring and Marine Ecosystem Restoration in the Hampton River	Funds will be used to fund research projects for LMRCSC students.

Shark Conservation Fund via Dalhousie Unversity	Grant	7/21-6/22	$16,500	$0	Elizabeth Babcock	Unlocking the global shark meat trade	Provides partial salary support for E. Babcock
CIMAS	Grant	Sept 2021-Aug 2022	$49,198	0.00	Elizabeth Babcock	Shark bycatch estimation project	Funding supports one MS student and partial salary support for E. Babcock
Bonnevile Power Administration	Grant	2019-2023	$35,000	25000	JA Miller	Columbia River basin juvenile salmonids: survival and growth in the Columbia River plume and northern California Current: early marine residence:	Support for lab technician that aids LMRCSC students and salary support for Miller
North Pacific Research Board	Grant	2020-2023	$291,000	55000	JA Miller	Thermal effects on spawn timing and early growth of Gulf of Alaska Pacific cod: Implications for survival & recruitment	Support for lab technician that aids Hillary Thalmann, CSC student, research and salary support for Miller
NOAA/NMFS	MOU	Jan. 2000-continuing	~$100,000	~$50,000	Dionne Hoskins	NOAA CMER	Support a NMFS FTE for a CMER program
Ocean Leadership	Grant	Dec. 1, 2020 – June 30, 2021	$10,000	$10,000	Dionne Hoskins, Victoria Young	NOSB Regional Site	Produce the GA-SC NOSB competition
NSF-IUSE	continuing grant	7/18-7/21	$517,552	not reported	Sue Ebanks, Edith Davis, Reginald Archer	Expanding HBCU Pathways for Geoscience Education	students available for recruitment; leveraged funds
NSF	Supplement	7/18-7/21	$103,507	not reported	Sue Ebanks, Edith Davis, Reginald Archer	Expanding HBCU Pathways for Geoscience Education	students available for recruitment; leveraged funds
NOAA Ocean Acidification Program	grant	Oct. 2021-Sept. 2024	$182,306	n/a	Jennifer Leo, Jennifer Doerr, Chris Hintz, Dionne Hoskins-Brown, Matthew Johnson	Synergistic science to advance HBCU student learning in changing ecosystems: Scaling up education and the ecological effects of OA on coastal marsh systems	support for an LMRCSC grad student
NSF LTER Program	ROA +REU	2021-22	$32,844	0.00	Merryl Alber, Dionne Hoskins-Brown	Local Ecological Knowledge in Gullah Geechee Communities	support for social science in fisheries
NSF Coastlines and People	grant	Oct. 2021-Sept. 2024		award in process	Kim Cobb, Jill Gambill, Phillip Omunga, Mildred mcClain	Harnessing sea level sensors as tools for advancing climate justice in coastal Georgia communities	partial salary for Young, program support

NSF	Grant	9/16 – 8/22	$5,000,000	500000.00	P. Chigbu; M. Sexton; A. Ishaque; S. Parveen	CREST Center for the Integrated Study of Coastal Ecosystem Processes and Dynamics	Funds support PIs salaries, students, research
NSF	Grant	3/18-4/22	$298,905	99635.00	P. Chigbu; M. Sexton	Univ. of Maryland Eastern Shore Research Experience for Undergraduates in Marine and Estuarine Science	Funds support summer interns
NSF	Grant	2/21-2/24	$323,985		P. Chigbu; M. Sexton	REU Site: University of Maryland Eastern Shore Research Experience for Undergrad.	Funds support summer interns
NASA	Grant	2021-2026	$158,335	5278.00	P. Chigbu	Student Airborne Science Activation for MSI (SaSa) for training students in remote sensing	Funds support student training
Anonymous Donor	Award	01/21-12/21	$20,000	$20,000	Rosemary Jagus	Contribution to the IMET Summer Internship program	Funding supports IMET Summer Internship, 2021
Bunting Foundation	Award	01/21-12/21	$50,000	$50,000	Rosemary Jagus	Contribution to the IMET Summer Internship program	Funding supports IMET Summer Internship, 2021
Charles & Lois Miller Foundation	Grant	2/21 - 1/22	$10,000	$10,000	Russell Hill	Contribution to the IMET Summer Internship program	Funding supports IMET Summer Internship, 2021
Dept. of Energy	Grant	09/20 – 09/23	$3,000,000		Li, Chen, Hill	A Highly Efficient Microalgae-Based Carbon Sequestration System to Reduce CO2 Emissions from Power Plant Flue Gases	Research activity involves REU students from URM
France Merrick	Grant	5/18 - 4/21	$71,383	$0	Eric Schott	Of Animals and Microbes: A Baltimore Harbor Investigations	Funds support PI's salary
Jim and Patty Rouse Foundation	Grant	1/20 - 6/21	$3,000	$0	Eric Schott	Molecular screening for human pathogens in the Middle Branch, Baltimore's other waterfront	Funding supports former IMET Summer Interns
Jim and Patty Rouse Foundation	Grant	4/21 - 5/25	$3,000	$0	Eric Schott	Expanding access to marine science for High School student in under-served communities with an Open House private tour	Funding supports IMET Open House, 2022
MD DNR	Grant	8/19 - 6/22	$515,421	$0	David Secor	Reproductive Habitat of Chesapeake Bay Distinct Population Segment in the Nanticoke River	Funds support Nicholas Coleman (Cohort II) stipend and research
Md Sea Grant	Grant	05/21-04/22	$10,000	$0	Eric Schott	Assessing the risk of introducing novel viruses into the Chesapeake Bay crab fishery	research activity involves REU students from URM

MIPS	Grant	2/20 - 7/21	$100,000	$8,439	Yantao Li	In situ astaxanthin production in microalgae	Funds support Kia Ramarui (Cohort IV) research
NSF	Grant	8/18-7/22	$362,947	$27,166	Eric Schott	Collaborative research: Determining how variation in life history and connectivity drive pathogen-host dynamics and genetic structure in a trans-hemispheric pathosystem	research activity involves REU students from URM
NSF supplement	Supplement	7/18-7/21	$12,798	$4,663	Eric Schott	Support for REU	Supports participation of a URM in the IMET internship program
Ratcliffe Foundation	Grant	7/14 - 6/23	$1,895,947	$78,160	Russell Hill	Award to cultivate the leadership and business skills necessary to bring their research into commercial markets and to provide students with an enhanced appreciation of the potential business implications of their research.	Funds support graduate student stipends
Stephenson Pope Babcock Foundation	Grant	1/20 - 12/21	$8,000	$2,896	Feng Chen	Microbial communities on microplastic particles in marine environments	Funds support IMET outreach and interns
United Way	Grant	10/19 - 3/21	$234,574	$0	Russell Hill	FISH Project: Providing fresh and healthy seafood to underserved communities	Funding to support food insecurity
Various Donors	Award	7/16 - 6/21	$215,079	$0	J. Sook Chung	Blue Crab Genome Initiative	Funds provide data for intern research
Venable Foundation	Grant	12/20 - 11/21	$10,000	$10,000	Eric Schott	Support for underrepresented minorities to participate in the IMET Summer Internship	Funding supports IMET Summer Internship, 2021
Waterfront Partnership of Baltimore	Grant	06/21-12/21	$17,306	$7,878	Eric Schott	Molecular Screening for Microbes in Baltimore's Harbor 2021	Created data and narrative that summer interns use in their projects

Appendix IV: LMRCSC External Evaluation: Year 5 Report

LMRCSC Year Five Annual Report
July 14, 2021

The Living Marine Resources Cooperative Science Center (LMRCSC) was "established in October 2001 as a cooperative agreement between NOAA's Educational Partnership Program (EPP), and a collective of universities to address environmental, natural resources management and STEM workforce challenges…." The mission of the Center "is to prepare a diverse student body for careers in marine and fisheries science through exemplary academic and research collaborations" (all quotes from the Project Narrative). The LMRCSC received an additional five years of funding, which began in Fall 2016. The project leadership contracted with The College of Exploration's (TCOE) Dr. Tina Bishop, Peter Tuddenham, and Dr. Howard Walters to develop and implement an external evaluation of the project. This evaluation plan was reviewed and approved by internal project leadership, and also was submitted with the project proposal for review and approval by NOAA EPP. This annual report for program year five has been developed by Drs. Bishop and Walters and submitted to the LMRCSC Project Director. It should be noted that year five has been substantially impacted due to the SARS-COVID Emergency Response conditions which have been implemented across the nation, implicating each of the institutions where LMRCSC is implemented. These responses have included significant shifting of face-to-face activities to online communications methods, and creating programming planning and implementation complications. Due to these responses, NOAA EPP has issued a one year no-cost extension to the LMRCSC to continue and finalize planned activities for the project period. The external evaluators included select response items on the student survey reported below to attempt to ascertain some of the impact of these COVID responses on the LMRCSC students themselves. The evaluators have continued to participate in monthly leadership committee calls and recurring education committee calls during the COVID response period in year five and have provided evaluation updates at these committee meetings.

Among the significant programs implemented under LMRCSC is the *Data Management for Scientists* graduate course taught online as a requirement for all students in the program. This annual report provides summaries of a survey which was implemented for a second year on this graduate course, with some cross-comparisons from the findings and observations from the first implementation of this same survey.

Additionally, on a rotating basis across the project period, the evaluators have collected response data directly from the graduate students (and undergraduates, although after the undergraduate evaluation report was distributed in fall 2020, no undergraduate students completed the survey). This report includes summaries of these graduate student responses for this current programming year, as well as the responses to the COVID related items as noted above.

Finally, the annual Cohort Experience, an annual meeting of the new cohort of students for intensive professional and science training, was redesigned and implemented as a virtual experience this year due to the Covid pandemic response in place across the nation. These participants were also surveyed, with responses included in this annual report.

Data Management Course Survey Report 2020

There were thirteen graduate students sequenced to take the data management course this cycle. Of this number, ten completed the course, one only audited the course, one deferred until next year, and one did not pass. Five of the students completed a twenty-two question survey about the Fall 2020 data management course, after three invitations to complete the survey which were sent out by the LMRCSC administration staff.

Students' Data Management Foundation and Background

The respondents conveyed mixed ratings of their ability in data management prior to taking this course, with only one person stating, "above average." Each of the five respondents listed either one-three

credit hours or four-six credit hours as hours of statistics or data management that they had previously taken. After taking the course, all five respondents rated their ability as "average." This was interesting in that one person's self-rating dropped to average from above average and two people's understanding increased to "average." The respondents learned about the class from several sources, including an advisor, cohort members and mentors as well as noting that it was recommended or mandatory for their program.

Overall Ratings

The overall course rating (Question ten) given by four of the respondents was: "low quality." (three people) And Neither "high" nor "low" (one person). The overall rating of instruction (Question seventeen) was rated "average" by four of the five respondents and one person rated it "Below Average." One person said, "it has been easier to understand this course watching videos on YouTube." It should be noted that LMRCSC administrative team and the external evaluators have begun a conversation in concern over these ratings (even though the survey response is low) and are planning structured interviews with the graduate students on the specific topic of this data management course to pursue solutions to possible concerns.

The Structure of the Course

The perception of the pace of the course was mixed, with three people saying it was too fast, one student too slow, and one suggesting it was paced perfectly. The amount of work required was also viewed in different ways by the different respondents. For two respondents the work exceeded their expectations. For two people their expectations were met, with one person saying it was below expectations for amount of work. Quotes reveal the difficulties with the amount of work required: *"The class was very slow and the communication with the instructor was not the best."" "The material was very difficult to grasp so I ended up spending a lot more time doing assignments."*

When asked about the appropriateness of the course software, two of the five respondents felt it was appropriate. However, the other three respondents said it was not appropriate with one person explaining about their inability to get the software running and the ensuing damage to their computer. Two people clearly felt that this software was not helpful for their research and the data they collect. One person felt R programming or even SAS would have been more beneficial than MySQL. A quote illustrated this frustration, " Most assignments were to take our own data and use the software to analyze it but I felt like that did not make sense. Using this software for my own research would not make my data analysis easier or more organized." One person expressed a positive view of the course structure, saying that it was positive: "He taught us the format of the computing language before we even started coding."

When asked about the effectiveness of the online course format, the reaction was mixed, with two students saying it was effective and three respondents saying it was not effective. Comments about the online format included:

- "To be effective more than just talking live in a computer is needed."
- "Give the assignments written because it is hard to get all the instructions by hearing them one time with a connection that is cutting off."
- "The Professor could not physically see the error codes and messages being displayed to the students so his response to us was to just look it up on google."
- "While the lessons were being recorded, very often the screen cut off so what the professor was showing could not even be seen, making the recordings unhelpful."
- One person said, "This course does not need to be taught online."

The Usefulness and Timing of this Course

All five respondents indicated that the course content was not used by them in either a NERTO or a TAB. When asked (item eight) if the course was helpful for their career, two answered "yes" and three answered "no." When asked about the helpfulness of this course for meeting other LMRCSC students, two students said "yes" and three people said "no." Even with the low response rate (about fifty percent) to

the survey, this proportion of negative reactions is a concern and part of the current conversation about the course that was noted above.

When asked if this course was offered at a helpful time in their academic course of study, the responses were mixed. Although two people indicated that it was at an appropriate academic time, three disagreed. One person said it would have been better at the beginning semester and one person said it conflicted with another course, therefore creating difficulty. One person explained with a strong statement about the inappropriateness of this course: "I answered no because I really didn't find this course helpful or relevant for my research, so it really doesn't matter when it is offered." An additional quote took the same, negative approach: "I did not find this course helpful for my future career as majority of my data has to do with numbers; Nothing that could help me in the case of organizing colony counts, sample sizes, etc." And a third concerning response: "Course gave me insight on some data management tools but background information on how to utilize it was not clear." Two respondents felt it was helpful to learn the concepts, but one said, "I don't think that will be useful in my future work or career. We did not delve deeply into the topic for me to feel like I can use this programming language in the future."

Student Learning Outcomes and Benefits

When asked about their improvement of ability to develop a data management plan, responses indicated various perspectives: two said "yes", two said "no," and one person was "not sure." This mixed reaction was also reflected in their responses to the ability to manipulate and analyze data, with one student stating this skill improved because of the class, two students saying "no," and two students being "Not Sure." A similar pattern of mixed reactions was also articulated when asked about the effectiveness of the hands-on activities supporting their learning. The students did indicate that there were some beneficial skills developed in the course:

- Getting a general overview of how databases are made and managed
- Learning how to create a database
- Creating parent and child databases
- Creating a data management plan using DMP tool

Question thirteen of the survey asked respondents the primary benefits of taking this course. While two respondents listed skills such as using data management tools and increasing knowledge of computational tools, other respondents reflected less positive reactions. One person said the main benefit was fulfilling the LMRCSC requirement and meeting other LMRCSC students. Three quotes illustrate lack of benefits associated with this course:

"No benefits, this class gave me so much stress that it is affecting me in other classes."
"I couldn't complete the course because the program need for this course damaged my computer…."
"I honestly do not know what the primary benefit of this course was. I felt as though I had a much harder time organizing my data on the MySQL software than using excel."

Challenges and Criticisms

Question fourteen asked specifically about course challenges, and the difficulties mentioned elsewhere were reiterated and expanded in responses to this question. This question evoked strong responses. Some respondents indicated great difficulty following the course and understanding the content that was being presented. Two of the students said they did not have a clear understanding of assignments or what the course expectations were. Furthermore, Wi-Fi difficulties and challenges with using Mac software, learning how to correctly use MySQL Workbench, setting up problems correctly, and correcting script errors created challenges. One person mentioned lack of interaction with the other students to be a challenge. There was an issue with incompatibility with the professor using a Windows computer and student having a MacBook, forcing the student to use YouTube for information to complete assignments. Again, students' narrative responses highlight their perceptions related to challenges with this class:

- “Downloading a program affected my computer and my studies in other classes as this computer is only tool for everything we do.”
- “Couldn’t download a data management program into my computer.”
- ”Often the professor gave us homework assignments but completed them in class.”
- “I did not feel as though the information was being thoroughly shared and explained…”
- “I learned more in a couple you tube videos than in this class, which was very slow and unclear. It was hard to know what I was being asked.” Additionally, this person stated that “the recordings of this class are very bad.”
- “He kept switching between languages, so it was hard to tell what the right syntax was for a given language. Sometimes materials provided were only compatible with one syntax or software, so those students who were using the other version either could not use the file or had to significantly edit the file in order for it to work, which required a lot of additional work.”

One quote highlights a substantive difficulty: “It was also challenging because people were using different computers (Mac vs PC) and coding languages (My SQL vs SQL server) and we kept jumping back and forth between all of those, so it was hard to get a grasp on the syntax that would work best for my computer.”

Suggestions and Ideas for Improvement

The overall sense from the student responses was this course needs to be improved. This follows on from and reiterates the 2019 survey results, which also indicated that there were definite improvements needed. In comparing the student responses from the 2019 administration of the course and the follow-on survey, it is difficult to see that the course has improved, with many examples of student concerns continuing into this second-year survey. However, in fairness to the instructor and the LMRCSC team, only five of the ten students who completed the course took the time to complete the survey, and so sampling bias toward negative responses is an authentic concern in interpreting these course evaluation data. This is in part the motivation for an ongoing conversation among LMRCSC administration staff and external evaluators to design and conduct further data collection from a larger set of course student participants to seek concrete and actionable interventions to revise this data management course moving forward. This process will be part of the external evaluation annual report this coming summer.

Based on the student surveys for both 2019 and 2020, looking for replicated concerns from students, the following ideas seem to warrant consideration for course revision moving forward:

- Delineate clearer expectations in the master syllabus and distribute this to students;
- Provide written material to support the classes (this was requested by the student but not received);
- Provide a syllabus or hub where all class materials could be stored. These suggestions were mentioned in both program years. It is imperative that a syllabus be presented to the students and this should be remedied. It is unclear how a university could allow a credit course to be offered without distributing a syllabus to students;
- The syllabus should state the software and hardware requirements and where these are to be obtained;
- Effort should be invested to enhance the interactivity of the course, between and among students and the faculty;
- Consider the match between student learning outcomes and objectives and the assignments and assessments incorporated in the class;
- Explore screen-sharing capability to enhance learning;
- Consider the use of prerecorded instructions for software and hardware use and common or typical problems which may be encountered; and
- Seek handouts from the software publisher with common terminology, syntax error codes, and guidance—these are commonly available upon software adoption and seem not to have been distributed to students.

Final Observations

A final question asked for any other comments the respondents wished to share with the evaluators. One person reiterated the stress that this course generated and the frustration that the course caused in damaging the laptops used for the course. This person exclaimed "I need to find the way to pass this course…. Required work on a program I don't have, and I need it to graduate from my program." Another person mentioned the difficulty to get properly enrolled in the course at their university, saying that "the course number and name should be in the online course catalog." And once more the respondent mentioned the absolute need for a syllabus and online hub to keep track of all course materials and when assignments were due. The concerns and frustrations which are apparent in these survey responses need to be considered, and with suggestions for improvement being carefully reviewed, addressed, and remedied. Given the recurrence of some of these negative responses from multiple students in multiple years, it is not clear to the external evaluators that the course survey data was used for continuous quality improvement of this data management course.

LMRCSC Graduate Student Survey Fall 2020

Of the eleven graduate students enrolled in this cohort, seven responded to this thirty-one-question survey. Given the funding provided to graduate and undergraduate students by LMRCSC, it is recommended that consideration be given to requiring participation in the external evaluation of the project by select and periodic survey responses be required of students. The survey questions ranged from student academic information to background questions on their interest in science. Queries were made about extracurricular activities, course work and meaningful career preparation. Benefits and challenges were explored. These categories further serve as the framing categories of the structured student interviews which are conducted annually by the external evaluators to enhance the credibility and reliability of the overall evaluation process and to aid data interpretations. The responding students were from each LMRCSC participating university except Savannah State and the University of Miami. Six of the seven students were pursing an MS degree and one respondent was a PhD student.

The degrees students are seeking are in Biology and Environmental Science (two students). Fisheries (two students), Marine Estuarine Environmental Science (two students) and Natural Resources (one student). None of the seven respondents had changed their major because of their participation in LMRCSC. When asked about their undergraduate degree, five students said their undergraduate degree was in Biology and two had degrees in Marine Science.

The survey then considered a set of career related questions. When asked about their ideal job, several respondents specifically indicated that they would prefer to work for NOAA. Several others desired a job in their field or in laboratory research; other goals mentioned included to work on an aquaculture farm, serve as a policy advisor, or to become a professor. When asked how and when they began considering a career in science, it was interesting to note that childhood experience played a key role. They used phrases to represent this early interest "I've always been interested in science since I was a child…as early as I can remember." Two students mentioned that high school was the starting point of their interest and two others mentioned this occurred at the undergraduate level. When asked about the reason why they wanted to pursue a career related to science, a strong sentiment emerged on the part of the responding students that this was interesting and fulfilling. The altruistic motivation was illustrated by comments such as "help make the world a better place", "contributing to a cause greater than myself and desire to add diversity to the field." One student wanted to bridge science and policy.

When describing the research or field experiences they had participated in because of LMRCSC, respondents mentioned virtual NERTO and TAB projects with description of specific research about oysters and leopard seals. Two new students had not conducted research yet. The research projects mentioned were:

- New technology for oyster post-harvest treatment (aquaculture)
- Impact of oyster conditioned water on oyster setting efficiency

- Qualifying microplastics in coastal bay fish
- Impact of climate change on Nassau grouper
- Effects of climate change on leopard seals
- Proteomics

In addition to the specific research topic, the respondents mentioned that the value was also in learning how to implement a research project, create mentorships, acquire statistical and analytical skills, present findings, and build a network. One person stated, “It provides me the opportunity to fully develop, run, analyze, and report on a scientific project of my own….” One comment eloquently stated that the LMRCSC funding allowed” me to grow as a scientist and a scholar.”

An additional set of questions probed awareness of LMRCSC, source of that awareness, and mentoring background. Six out of seven students had received an orientation or information about the LMRCSC from someone at their home institution. The students described professional mentors who have guided them academically, helping students navigate the science field, providing guidance on several issues and helping students in the lab. Likewise, supportive faculty were identified and glowing positive comments about specific individuals were made. The specifically named mentors and faculty with these appreciative comments can be found in the attached raw data. An example comment illustrates the appreciation “The advice she gives comes from a place of caring and wanting the best for me as a student.”

Students mentioned several organized, school-based science programs, including conferences and meetings, courses, and publications from which they had benefited. Two of the respondents were EPP/MSI scholars. For extracurricular science-related activities, four out of seven respondents indicated involvement in extracurricular and community service activities, including citizen science projects, Governor School, AFS, and a Diversity Collaborative, and volunteering at a museum. All seven students said they remain in communication with a key high school or undergraduate faculty member. When asked about immediate family in a science career, only two indicated they had a family member engaged in science. Key adults in their lives were important in encouraging these students’ interest in a science career. They mentioned their parents, and an uncle as specifically supportive of their interest. When asked about employment prospects in science, the respondents perceived their employment prospects within their chosen career as very employable (three students) and moderately employable (four students).

Students were asked about positive or beneficial LMRCSC activities from the prior year. The responses included:

- ASLO.
- Graduate seminar series.
- OSU virtual monthly meetings; and
- TAB proposal process “This was the first grant that I’ve ever applied for, so it was a very informative and valuable experience.”

The students said that these activities were the most significant because in many cases the listed activity was the only activity due to the emergency responses tied to COVID. The most beneficial courses were listed as Marine Population Dynamics, Conservation Biology, Fisheries Management and Life History of fishes, Biostatistics and Statistics. One student listed next generation sequence analysis using Unix based tools as a good introduction to computing languages.

Of key interest in this program is how LMRCSC has enhanced the students’ knowledge of NOAA. Students mentioned that the program has made them aware of more job opportunities across NOAA. One person stressed the increased realization of the importance of diversity to NOAA. One person highlighted increased knowledge of international treaties, and agreement to protect Antarctic marine Living resources, which NOAA leads.

The respondents acknowledged limited interaction with other students or professors in the

LMRCSC. Five people said this interaction was “low.” When asked about their knowledge of NOAA EPP, the responses were mixed. Two people said they had high knowledge while two said medium knowledge and three people said they only had low knowledge. When asked about continuing interaction LMRCSC through an Alumni Association, all seven students were interested or very interested in a potential alumni association. This seems to be an opportunity for a sustainability element for the LMRCSC moving forward, to leverage the involvement of these alumni.

When asked to reflect on their perceived greatest challenge moving forward in completing their career-related education, the responses were varied and offered some insight for potential remedies. The COVID-19 pandemic responses and challenges to the national economy and workforce were near the top of the list for a couple students. Other challenges included:

- Funding.
- Expenses for a cross-country move for potential job.
- Lack of help by professors when courses are on other campuses; and
- Public speaking and science communication weaknesses.

These comments point to possible solutions to be considered by the LMRCSC team. One suggestion would be to offer short courses or webinars on public speaking and science communication, taught by experts in these fields. The concern about professorial help when courses are offered at other campuses could be remedied through a structured online support or centralized advisement process. Perhaps there could be a team-teaching approach to involve a professor at the student’s own institution.

A final question was asked about students’ university responses to COVID and the impact on the students’ education. Responses included:

- Curtailed travel
- Decreased time in laboratories and decreased learning of lab techniques.
- Limited meetings with advisors or committee members.
- Some impact on course work with some professors, though it was mentioned that some university courses were already set up for virtual teaching.
- Difficulty in adapting to online work; and
- Feeling disconnected from LMRCSC and the other students.

When asked to offer ideas for additional support that would be helpful, the students provided some insights, which included:

- Career pathway meetings or discussions;
- Networking on a virtual platform;
- Fellowships or internships; and
- One person commented, “I feel that more information and resources from the LMRCSC would be helpful, especially in regards to making sure we are aware of all the requirements we need to fulfill for the LMRCSC.”

Additional Activity by the External Evaluators and Final Summary Discussion at the Mid-Year

While this current mid-year report is a snapshot of some student responses to two ongoing LMRCSC activities during the program year, there are additional activities which the evaluators have conducted or participated in which have involved significant effort.

First, in response to the year four IERT panel recommendations, the external evaluators invested significant effort to create a TAB post-project summative assessment which was built on the review criteria used to award these grant projects to students. This post-assessment instrument was revised several times and then provided to the LMRCSC administration for dissemination to the TAB students as they finish their projects—including any current or continuing students who have already completed a TAB

project. As of this mid-year report date, this post-assessment has not been distributed to students, or else the students have simply not responded to the survey. The evaluators are maintaining this survey as an "open" instrument in data collection software and would like guidance from the LMRCSC director for this ongoing cost—if the survey is not going to be administered, it should be closed out.

In addition to this TAB post-assessment, again, recommended by the IERT panel report, an additional set of instruments and rubric were prepared in view of an assessment of the Core Professional Skills and Competencies which students develop across their LMRCSC participation. This process has not moved forward, and it is likely that the various institutional responses to COVID have certainly impacted the discussions and timetable for implementing this assessment item. It is recommended that this process and activity by further discussed at a monthly leadership team conference call in view of continuing this effort.

Third, there was an undergraduate student survey which was developed during year four based on the rotation plan for assessing student perceptions and activities in the LMRCSC. This survey was distributed electronically to the undergraduate students by LMRCSC leadership. Unfortunately, no useful sample of students responded to the survey this year. It is likely that the fall semester was hectic and somewhat chaotic for these young adults due to the COVID responses at their respective universities, nevertheless, it is critical that students participate in these evaluation efforts as a part of their support commitments for LMRCSC. This issue should be discussed by the project leadership team. There were reminders emailed out to prompt students, but these failed to yield additional responses.

Finally, significant effort was invested in developing, implementing, and reporting on the Data Management Course post-assessment in 2019 (with a final written report) and again in 2020 (reported above). The strong similar concerns of students over two consecutive years of the course have warranted an ongoing conversation among the LMRCSC administration and external evaluators which should continue. To effectively demonstrate continuous quality improvement through the use of performance assessment data, the LMRCSC team should demonstrate some response to the persistent student negative assessments of the course in a tangible manner. Surely, the low sample size may in fact indicate that the larger proportion of student completers have no concerns to warrant their attention to completing the post-assessment survey—this would be a typical sample bias here—but this should be ascertained through follow-up communication with a larger set of these students to ensure a quality experience of this critical program element.

LMRCSC Virtual Cohort Experience

An extensive, virtual workshop was designed for the LMRCSC cohort experience during year five due to continued meeting restrictions related to the COVID pandemic. Working with the LMRCSC leadership and education director, the evaluators created a survey for participants in the virtual cohort experience and distributed this immediately following the last session (included with this report). Ten of the participants completed the survey.

Respondents included students from all LMRCSC affiliated institutions except for Delaware State University. Fifty percent of these respondents (n=5) had been part of the LMRCSC for two years, three respondents less than two years and one person five years.

One important element of LMRCSC is establishing and supporting network relationships between cohort students and NOAA scientists. Item two of the survey asked respondents to identify or list these scientists, who included:

- Kimberly Roberson
- Dr. Larry Alade
- Dr. Ashok Deshpande
- Dr. Paulinus Chigbu
- Laurie Weitkamp
- Jason Spires
- Shawn McLaughlin
- Bruce Vogt

- Mandy Bromilow
- Douglas Krause
- Steve Gittings

When asked (Item four) if the cohort experience fully met their expectations, half of them stated they were *Neutral*, while four respondents *Agreed* that it met their expectations. Only one respondent *Disagreed*. Their narrative responses tell the reasons for their choice of response. The biggest negative that was expressed by several of the respondents was the timing, which was a problem for them. Comments such as “timing was horrible,” “labor intensive in the middle of the semester,” “way too much for this time of year”, “would have been less stressful during the summer.” Positive comments related to liking the recorded lectures, valuing interesting and important content, and enjoying getting to know other LMRCSC students.

One person did not find value the discussion board posts, saying they failed to help with learning. Two people used the term “busy work” to describe some of the tasks. Although there seemed to be a preference by one responder for in person interactions, one person highlighted that “it was a solid experience overall.”

Item six asked respondents to identify benefits of having the cohort experience online instead of face to face. These types of inputs will be valuable in the future as organizations or programs consider lessons learned and technologies used during the Covid period. Benefits which were mentioned included:

- Flexibility; working at own pace and at one’s preferred timetable
- Interaction with more people; meeting with science center people
- Not having to travel; making it easier to do other academic tasks

Items seven and twenty asked about challenges encountered during the cohort experience. The challenge of time requirements seemed to be emphasized in responses. Balancing classes and thesis writing at the same time as the cohort experience was challenging. One person suggested that a time earlier in the semester would have been preferred. Time to meet with groups was seen to be difficult. Having the program run on eastern time was mentioned as a problem for a west coast participant. And finally, the extended length of the experience was seen as a problem for several respondents. One person reiterated dislike of the discussion posts, saying that they “were more work than necessary and created additional stress.”

Communication issues presented challenges. Expectations of when tasks were due or late posting were also mentioned as problems. Select quotes related to this included: “It would have been great if all the material was posted at the start of the cohort experience.” “It was unclear when things were due.” “The notifications only worked during the discussion comments.” Another person failed to receive important announcements due to an email problem.

Item eight solicited rating responses for the components of the Cohort Experience areas. Rating was on a scale of 1 to 5, with 5 being of highest importance. These responses are included on the table as follows:

Content Area and Rating (N=10)

	1 (lowest)	***2***	***3***	***4***	***5 (highest)***
Social science and human dimensions	0	0	2	5	3
Stock assessment and fishery management	1	1	1	3	4
Healthy habitats	1	0	0	5	4
Safe seafood/aquaculture	0	1	1	7	1
Grant writing	2	2	0	1	5

Grant writing was given the highest rating by half of the respondents, but on the other hand, 40% of respondents gave it low ratings. One person thought that grant writing would be more useful to undergraduates. This dichotomy of response pattern to grant writing should be considered moving forward should this element remain in the program. Healthy habitats, social science, and safe seafood/aquaculture were rated four or five by 80-90% of the respondents. Stock assessment had mixed ratings, but one person indicated that "stock assessment gave me insight on modeling."

Item nine included an extensive rating matrix to obtain responses on the various potential personal and professional benefits of participation in the workshop. These responses are included on the table as follows:

Personal and Professional Benefits Rating (N=10)

	1 (lowest)	***2***	***3***	***4***	***5 (highest)***
Developing relationships with other students	0	1	1	4	4
Developing relationships with faculty from my institution	1	0	6	2	1
Developing relationships with faculty from other institutions	2	1	2	4	1
Developing relationships with other LMRCSC personnel	1	1	2	3	3
Developing relationships with NOAA scientists	1	0	0	4	5
Obtaining career opportunities and pathways	1	0	0	1	8
Developing time management skills	2	1	2	4	1
Fostering cooperation and collaboration in research	0	1	1	5	3
Enhancing communication skills	0	0	1	5	4

Obtaining career opportunities and pathways was highly rated (scores of four or five) by 90% of the respondents, with 80% of the respondents giving it the highest rating of five. Developing relationships with NOAA scientists was rated four or five by 90% of the respondents as well. Mixed ratings with some low ratings were given for developing relationships with faculty from other institutions. These low and mixed ratings were also given to fostering time management skills.

Unanimously, the respondents said that the cohort experience helped them better understand LMRCSC's goals and better understand NOAA's mission science (items ten and eleven). These are important findings and a good accomplishment and outcome of the LMRCSC cohort experience.

The most frequently mentioned helpful information (items twelve and thirteen) received during the cohort experience was grant writing (which was interesting, as in the ratings matrix this focus did not emerge), and budgeting was cited. Other information that was listed included stock assessment, social science, and the NOAA Scientist meeting. One person negatively expressed "I didn't receive a lot of information that was extremely helpful."

The Cohort experience was seen to help advance or refine academic goals (again from item thirteen) in that it provided students with ideas and approaches that were:

- Holistic
- Interdisciplinary
- Connected to SNAP
- Wider in scope
- Supportive group work

One respondent wrote, "The video with the ten philosophies helped with academic goals by providing more knowledge on my topic as well as others."

With respect to advancing or career goals (Question fourteen) only seven people responded. Three respondents said it di not help with career goals. A couple respondents said the experience showed them the large scope of career opportunities and one person said it gave insight on networking. One respondent noted a NOAA related outcome: the workshop "further confirmed that I want to work for NOAA."

When asked about the ways the cohort experience fostered collaboration with students or faculty from other institutions the respondents acknowledged the grant writing project as a key collaborative experience. They expressed the importance of meeting with students from other institutions.

To item sixteen, ways in which the cohort experience provided support from NOAA scientists, there seemed to be quite a difference of opinion. Four out of the seven respondents to this item said the NOAA scientists were supportive; offering ideas of how and where to look for jobs. One person perceived that the experience "further proved that they are all approachable and willing to help." However, three people indicated that the experience did not offer support from NOAA scientists, with one person saying "I feel there was no support given." These contrasting opinions warrant further investigation into why these different opinions occurred. It may be that some students already have placements or institutions where they have a greater interaction with NOAA personnel than the workshop afforded, and thus have skewed perceptions. In the next funding/programming cycle, it may be that greater use of interviews and focus groups and fewer anonymous surveys could provide a different view of the experiences.

Seven people responded to the query about the single greatest benefit they derived from the cohort experience (item seventeen). The top responses were meeting students from other institutions, those with the same goals and grant writing. Learning NOAA's goals was also mentioned.

When asked to provide suggestions about additional activities to strengthen their cohort experience (item eighteen), several students recommended more live sessions, more interactivity and socializing. This was deemed more desirable than the discussion board. One person suggested replacing grant writing with manuscript writing.

Other ideas for follow-up information arose from responses to item nineteen. Several respondents indicated "none" to wanting follow-up information, but pro-positive suggestions included:

- Grant writing
- Career preparation
- Stock assessment
- Social science
- Ecosystems
- Climate change

The amount of time for the experience was viewed by seven out of ten respondents to be "too much." The other two respondents said it was "just right."

Item twenty-two inquired how the experience fostered enhanced relationships among key groups and the respondents offered uplifting remarks about networking with other students and with the NOAA scientists. One respondent indicated that the workshop "broke down barriers and encouraged us to reach out." Another responded that the workshop "had individuals from varying backgrounds and research interests come and work together towards a common goal." One negative comment suggested that the cohort experience would develop relationships in person but "online it was mostly awkward, and no key relationships were formed."

Comments about a journal assignment evoked different responses, with most people indicating they did not keep one, though one person said it "showed me how each included core workshop component related in some way to my project."

The combined cohort experience, Northeast Fisheries Science Meeting, and the NOAA EPP Forum (addressed in item twenty-four) offered a unique opportunity for the LMRCSC cohort participants. They were seen to enhance knowledge, connect with students and other researchers, and support future academic and career path. "They all fit well together, but it was a lot jammed into a little bit of time." "The

NOAA EPP Forum was great."

In summary, the post-cohort experience workshop survey seemed compellingly positive given the significant social impediments and emotionally fraught cultural moment of the Covid pandemic response. It is likely that the overwhelming shift to online communications and professional work, training and education over the past year influenced the participation and perceptions of these students. Understanding this will require wider venues of research than this evaluation study. Nevertheless, it seems warranted to conclude that the online cohort experience met its intended goals.

Report Conclusions

This final year of the LMRCSC brought challenges which would have been nearly insurmountable for a less cohesive leadership team with a less well-organized communications structure. The evaluation team, as through the first four years, participated monthly in overall administrative leadership team phone meetings, as well as monthly education committee meetings. In addition to these formal meetings, consistent email communications across the year reflected, taken together, a shared commitment to managing the COVID-required pandemic response in a way that best allowed the LMRCSC core functions to continue unabated. The positive feedback across the various interviews, meetings, and stakeholder surveys suggests that these core functions succeeded in moving the graduate and undergraduate students toward their eventual personal and professional goals.

It is also noted that in preparation for the IERT panel review at the end of Year 4, a comprehensive archive (three-ring binder) of each mid-year and annual report and each survey instrument created across the first four years was provided to the LMRCSC Director for the IERT Panel, along with a comprehensive PowerPoint slide presentation of the full assessment history.

In response to the concerns of the IERT, the evaluation team created an additional evaluation instrument and procedure for reviewing and assessing the quality of completed TAB projects. The instrument as created, and then revised, by the project leadership, and then provided to the LMRCSC Director and the Chief Research Scientist. The scientific expertise required to review the project-specific assessment data necessitated that these data be initially interpreted by science staff. Unfortunately, the project leadership has not followed through to date with ensuring this survey was administered. While some data have been collected on the TAB projects in the ongoing evaluation surveys administered regularly by the evaluation team to students, this gap in TAB assessment should be considered for subsequent years.

In addition to this TAB assessment issue, and also in response to the IERT panel recommendations, the evaluation team created an assessment rubric and draft instrument to assess and monitor the acquisition of core competencies and work skills among LMRCSC students. The concern with core competencies continues to be refined and addressed by LMRCSC leadership, and so the issue of assessment relative to these is also fluid and ongoing. As this effort continues, nevertheless, as with the TAB assessment, the evaluation team has collected feedback on core competencies from students in an ongoing basis across the past five years and will continue to evolve this strategy. Evaluation team members, moving forward, will continue their practice of fully participating in leadership and education committee monthly meetings to monitor internal plans and discussions and to be responsive.

Appendix V: Performance Metrics from Implementation Plan

Education Performance Metrics:

	2020/21		
Activities/Programs	**Proposed (12 months)**	**Accomplished(9/1/20-2/28/21)**	**Accomplished (3/1/21-8/31/21)**
# Students trained in NOAA related	56(42*)	61(58*)	63(59*)
# B.S. Students who graduate in NOAA	6(4*)	1(1*)	3(3*)
# M.S. Students who graduate in NOAA	11(9*)	1(0*)	4(4*)
# Ph.D. Students graduating in NOAA	1*	1(1*)	1(1*)
# of internships (e.g. NERTO) at NOAA facilities	12	2	7
# of URM students in development activities that will lead them to attain degrees and/or employment	12*	57	58
# of EPP-funded graduates who participate in and complete agency mission-related postdoc. Level programs	2	2	2
Amount of leveraged funds ($) for education and training	500K	$615,000	$347,798
# of student presentations at conferences (average)	20	3	15
# of student co-authored publications	10	5	4

Research Performance Metrics:

Activities	**2020/21**		
	Proposed **(12 months)**	**Accomplished** **(9/1/20-2/28/21)**	**Accomplished** **(3/1/21-8/31/21)**
Science Meeting date	June	Planned for April	April
# of collaborative research projects (TABProposals) funded	6 to 10	Currently under review	3 plus 13 continuing projects
# of new & continuing proposals funded (leveraged funding)	12	35	51
# of scientific presentations at conferences	50 (15*-90)	10(3*)	23(15*)
# of theses & dissertations produced	12	2	5
# of peer-reviewed publications	10*-30 (25)	34(5*)	19 (4*)
Amount of leveraged funds ($)	$3 million	$1.1 Million	$999,114
of NOAA scientists serving as mentors andadvisors for student research each year	>20	47	27
# of intra-institutional partnerships in support of NOAA's mission	Average of 4	15	35
# of times LMRCSC publications have been cited	Will be documented	627 (92 from directly funded papers)	960 (128 from directly funded papers)

Administrative Performance Metrics:

	2020/21		
Activities	**Proposed (12 months)**	**Accomplished (9/1/20-2/28/21)**	**Accomplished (3/1/21 - 8/31/21)**
Submission of monthly invoices to UMES	Monthly	Average time between invoices = 1.06 months	Accomplished
Successful execution of sub-awards (<60 days of receiving award notification from NOAA EPP)	October or earlier	Oct. (DSU,UMCES), Nov. (HU,OSU, SSU), Jan. (RSMAS)	N/A
Evaluate budget to ensure center funds are expended in accordance with budgets approved by NOAA EPP and incompliance with federal and state guidelines	Every 6 months	Every 6 months	Every 6 months
Holding of LMRCSC Science meetings at NOAA facilities	Summer	Planned for 4/6-4/7/2021	Executed Virtually in collaboration with NOAA NEFSC 4/6 - 4/7/21
Funding of collaborative research projects via TAB review process	Spring	Summer	Summer
Submission of semi-annual reports	Every 6 months	Every 6 months	Every 6 months
Submission of student tracker data	Every 6 months	Sept. 2020	Planned Sept. 2021
Executive Committee meetings	Monthly	Monthly	Monthly
Updating of the LMRCSC Website	Weekly	Weekly	Weekly
Meeting of the LMRCSC Education/Outreach Committee	Once every four months	Sept. 2020, Oct. 2020, Feb. 2021	April, June 2021
# of featured articles in print or digitalmedia per year referencing LMRCSC	At least 50	2	10