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DEPARTMENT OF COMMERCE
RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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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
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
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13. Title: Director of Research	
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REPORTING INFORMATION	
Signature of Submitting Official: Joseph S Pitula	
16. Submission Date and Time Stamp: 03/30/2022	17. Reporting Period End Date: 02/28/2022
18. Reporting Frequency: ○ Annual ◉ Semi-Annual ○ Quarterly	19. Report Type: ◉ Not Final ○ Final
RECIPIENT ORGANIZATION	
20. Recipient Name: UNIVERSITY OF MARYLAND EASTERN SHORE	
21. Recipient Address: 11868 ACADEMIC OVAL, PRINCESS ANNE, MD 21853-1295 USA	
22. Recipient DUNS: 082611302	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 112 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, 18 have graduated, including 5 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 (6) 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 3 Ph.D., 8 M.S., and 6 B.S. students have been recruited into Cohort 4. Of the Cohort 4 students two (2) have graduated including 1 M.S. and 1 B.S. student. Twenty-three (23) students have been recruited into Cohort 5 including 4 Ph.D., 8 M.S., and 11 B.S. students. One B.S. student from Cohort 5 has graduated.

Ten (10) 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. During this period, we also held our annual Board of Visitors meeting virtually using Google Meet on November 4, 2021.

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 47 students (15 B.S., 20 M.S., 12 Ph.D.). Sixteen graduate students participated in the Data Carpentry for Ecologists workshop in November 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. The education committee continued to deployed asynchronous training modules for undergraduate students in Social Science and Data Management. Undergraduate students will continue to complete these modules in coming reporting periods. 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. A list of supported students and their completion of these activities is available in Table 26.1 in the attached document.

During this period, nine students 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 9 journal articles, 5 of which included student authors, and chapters in books
• One additional journal article, including one additional student author, was in press or under review at the end of this reporting period.
• Center Scientists delivered 7 oral and 2 poster presentations at professional meetings, all by student presenters.
• To date, Center publications since September 2016 have been cited 1062 times (155 from directly funded publications, 907 from leveraged publications).
• The Center continues to update its website regularly and publish newsletters. During this period, a newsletter was published in January, and another is in production for March 2022.

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 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
• 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 9 journal articles, 5 of which included student authors, and 3 chapters in books. Full citations are available in the attached document in Table 29.1a and b.
• One additional journal article, including one additional student author, was in press or under review at the end of this reporting period. A detailed citation is available in the attached document in Table 29.2.
• Center Scientists delivered 7 oral and 2 poster presentations at professional meetings, all by student presenters. A detailed list is available in the attached document in Table 29.3.

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, the Center also produced two chapters in books (Table 32.1) and one thesis (Table 32.2).

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

33. What individuals have worked on this project?

Seventy-seven (77) individuals have worked on the project, including scientists (19), graduate students (34), undergraduate students (20) and professional staff (4). 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 1 source of support including one renewed sources of support. Details can be seen in Table 34 in the attached document.

35. What other organizations have been involved as partners?

Four organizations including three state agencies and on private organization were involved as collaborators in the project. The details of these collaborations can be seen in Table 35 of the attached document.

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

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

36. Have other collaborators or contacts been involved?

Forty-two (42) NOAA Scientists and thirteen (13) 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 5 peer reviewed journal articles in NOAA-mission sciences.

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. Some LMRCSC scientists collaborated with LMRCSC alum Dr. Tiara Moore to continue the efforts of the organization Black in Marine Science to "highlight and amplify Black voices in the field and encourage younger generations."

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. Three students earned degrees in NOAA relevant sciences and have secured or are seeking employment in the field. Details can be seen in Table 39 in the attached document.

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

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.
At RSMAS, 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. At HU, faculty and students are being invited to give talks, serve on panels, and work with K-12 students on Center related research. In addition, RSMAS Ph.D. students participated in outreach activities for elementary and high school students, and participated in the RSMAS diversity committee and the U Miami Black Students Association. At SSU, the existence of the center and students within is enabling grant collaborations with NGOs in stakeholder communities.

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 required that traditionally in-person activities such as the Cohort Experience Workshop and NERTO be conducted virtually.
At SSU, the institutional PI is on mandatory telework and is not in the building. Students who are in the building are being managed by Dr. Victoria Young.

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

Nothing to Report

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

- 55 total students, 50 URM students trained in the Center
- 50 URM students pursuing higher education in NOAA mission fields
- 11 Seminars offered
- 3 students graduated, of which 3 are URM students
- 42 collaborations with NOAA Scientists
- 10 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 (September 2021 – February 2022); Revised April 21, 2022

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: Recruitment activities for this award have ended.

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, 10 active TAB projects were investigated by students and scientists at LMRCSC partner institutions. Three of these began in 2019, 5 in 2020, and 2 in 2021. The following table describes only those projects that were active in the last year.

Table 25.1: TAB Projects During this Reporting Period*

Project Number	Principal Investigator	Title	Thematic Research Area
19-04	David Secor	Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts	SASI
19-06	Hillary Thalmann	Thermal impacts on juvenile Pacific Cod (*Gadus macrocephalus*) foraging and growth in Gulf of Alaska nursery habitats	CLIME
19-07	Adrianne Wilson	Population structure and growth of lane snapper, a data limited species	SASI
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
20-06	Janelle Layton	Investigating the effects of climate change on heat shock proteins and development in the early life history stages of Nassau grouper	CLIME
20-10	Imani Wilburn	The Occurrence of Microplastics in Maryland Coastal Bay Fishes	HaBS

20-11	Carolina Bonin	Estimating the effective population size and historical demography of leopard seals (*Hydrurga leptonyx*) in the Antarctic Peninsula	SASI
21-01	Tunde Adebola	Developing a Coupled Human Ecological System for Chesapeake Bay Shellfish Fisheries	SASI
21-02	Nicholas Coleman	Sonar Censusing and Habitat Use by Spawning Run Atlantic and Green Sturgeon, *Acipenser oxyrinchus* and *A. medirostris*	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 contracted an organization called Data Carpentry to conduct a two day workshop entitled "Data Management and Visualization in R for Ecologists." The workshop was held November 13 and 14, 2021 and was required for all graduate students who had not already fulfilled the Data Management training requirement. Graduate students who had already completed the requirement and advanced undergraduates were also invited to participate as space allowed. Sixteen (16) graduate students took part in this activity. 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 through the ISpring Learning Management System (LMS). 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 organized its annual BOV meeting that was 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: A total of 112 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., 6M.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, 18 have graduated, including 5 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 (6) students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S. and 3 B.S. Seventeen (17) students including 3 Ph.D., 8 M.S., and 6 B.S. students have been recruited into Cohort 4. Of the Cohort 4 students two (2) have graduated including 1 M.S. and 1 B.S. student. Twenty-three (23) students have been recruited into Cohort 5 including 4 Ph.D., 8 M.S., and 11 B.S. students. One B.S. student from Cohort 5 has graduated.
      a. Dr. Rich McBride, Northeast Fisheries Science Center, Population Biology Branch Chief offered a workshop for LMRCSC Undergraduate and Graduate Fellows entitled “The architecture of a scientific article: perspectives for readers and authors.” (Sept. 7, 2021). Eighteen (18) fellows participated.
      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. During this period, we have focused on building content and developing reports through the system. 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.
      c. UMES LMRCSC Doctoral Fellow Kasondra Rubalcava was awarded the Scott B. Gudes Public Service Graduate Scholarship in Marine Resource Conservation
   2. Building a Strong Center Cohort Community:
      a. Four installments of the Graduate Student Seminar Series took place during this period (Oct., Dec. 2021, Jan., Feb. 2022). Planning is underway for additional seminars to be held during the next reporting period.
      b. Four installments of the LMRCSC Fellow Forum were held during this period (Sept., Oct., Nov. 2021, Jan. 2022).
      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.
      e. Center staff have participated in plans for the upcoming 10th Biennial Science and Education Forum. Center Director Dr. Paulinus Chigbu sits on the Steering Committee. Center Assistant Director sits on the Sponsorship and Exhibitors Committee. Dr. Dan Cullen represents LMRCSC on the Technical Program Committee.
   ii. Research goals: 10 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 held its annual Board of Visitors Meeting on November 4, 2021. The meeting was initially planned to be held in person in Baltimore, Maryland at the University of Maryland Center for Environmental Sciences. However, pandemic conditions, travel restrictions on some PIs, and general discomfort with long-distance travel during the pandemic caused the Executive Committee to amend this to be a virtually meeting.
3. The LMRCSC External Evaluators submitted to the Center their findings from assessment activities during this period. The report is available in Appendix IV.
4. OSU LMRCSC Program Director received approval to organize a special session sponsored by the LMRCSC at the next Annual American Fisheries Society Meeting. Abstracts are currently being accepted for the session, which will focus on collaborative research that advances our understanding and management of marine and estuarine fisheries and the habitats that support them. Center students and scientists are being encouraged to submit abstracts.

d. Key outcomes or other achievements:
   i. A total of 112 students (25 in Cohort 1, 25 in Cohort 2, 22 in Cohort 3, 17 in Cohort 4, and 23 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 NERTO, and training in Ethical Conduct of Research and Data Management (Table 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	NOAA Mentor
Marcus	Teat	Y	2	B.S.	DSU	Spr. 22	Sum. 22	Spr. 21	Fall 21	2022
Caitlyn	Czajkowski	N	3	M.S.	DSU	Spr. 21	Sum. 22	Spr. 21	Fall 21	2020
Emily	Andrade	Y	4	M.S.	DSU		2022	2021	2021	2022
Kendall	Metz	N	5	B.S.	DSU	N/A	N/A	2021	Spr. 2022	N/A

Kayla	McKinley	Y	5	B.S.	DSU	N/A	N/A	2022	Spr. 2022	N/A
Maria	Henson	Y	1	B.S.	HU	NA	NA	Fall 21	Spr. 21	NA
Arona	Bender	Y	3	M.S.	HU	Spr. 21	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		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
Noah	Tait	N	5	M.S.	HU		Sum. 22	Spr. 22	Fall 19	Y
King	Brittany	Y	2	Ph.D.	OSU	Spr. 18	Fall 20	Spr. 19	Spr. 20	Y
Layton	Janelle	Y	4	M.S.	OSU	Spr. 21	TBD	Fall 2020	Fall 21	TBD
Moreno	Victoria	Y	4	M.S.	OSU	Spr. 21	Spr. 21	TBD	Fall 21	Y
Leann	Cohn	Y	5	M.S.	OSU		Sum. 21	TBD	Fall 21	Y
Hillary	Thalmann	N	1	Ph.D.	OSU	Apr-19	Mar.-Jun. 22	Fall 19	Fall 19	Y
Jennifer	Wong Ala	Y	5	Ph.D.	OSU	TBD	Jun. to Aug. 22	Fall 21	Fall 21	Y
Adrianne	Wilson	Y	2	Ph.D.	RSMAS	Spr. 19	Fall 18	Fall 15	Fall 18	Sum 18
Cristin	Mayes	Y	4	Ph.D.	RSMAS		Sum 22	Fall 19	NA	Fall 20
Chryston	Best-Otubu	Y	5	Ph.D.	RSMAS	Spr. 21	Sum 22	Fall 20	Fall 20	Fall 21
Joe	Day	Y	5	M.S.	SSU		Sum 22	Spr 20	Fall 21	Y
Sena	Tay	Y	2	M.S.	SSU	Spr. 21	Fall 21	Fall 18	Fall 21	Y
Mackey	Shaneese	Y	3	M.S.	SSU	Sum. 19	Fall 18	Spr 19	Fall 19	Y
Savannah	Clax	Y	5	B.S.	SSU	NA	NA	Spr 21	Spr. 2022	Y
Michon	Shaw	Y	5	B.S.	SSU	NA	NA	Fall 21	Spr. 2022	NA
Kristafer	Howard	Y	5	M.S.	SSU	Spr. 21	Spr 21	Fall 20	Fall 21	Y
Chloe	Lemaire	N	5	M.S.	SSU		Sum. 22	Fall 21	Fall 21	TBD
Alexandria	Tennant	Y		B.S.	SSU	NA	NA	Fall 21	Spr. 2022	NA
Lady	Volmar	Y		B.S.	SSU	NA	NA	Fall 21	Spr. 2022	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	Sum 22	Spr. 22	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	Spr. 21	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
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	Collins	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	Fall 2022	Sum. 22	Fall 21	Fall 21	TBD
Kaithlynn	Wade	Y	5	M.S.	UMES	Fall 2022	Sum. 23	Fall 21	Fall 21	TBD

Table 26.2: NERTO internships completed 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 (OSU) and Blake Feist (NWFSC)	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 (NEFSC)	Virtual, NEFSC Woods Hole Lab, MA
Ashley Silver	Evaluating growth parameters for American Plaice in the	Larry Alade (NEFSC)	Virtual, NEFSC Woods Hole Lab, MA

	Gulf of Maine and George's Bank.		
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	NMFS/NWFSC/ Newport Research Station, OR
Kristafer Howard	Abiotic and Biotic Factors Influence the Community Composition of US Southeast Atlantic Fishes from 2015-2019.	Roldan Munoz	NMFS Beauford Lab, NC
Savannah Geiger	An analysis of fish abundance correlation to live-bottom habitat within Gray's Reef National Marine Sanctuary	Kimberly Robeson	Gray's Reef National Marine Sanctuary, GA
Sena Tay	Common bottlenose dolphin contaminant analysis	Irvin Schultz	NWFSC/ Environmental and Fisheries Sciences Division

29. Publications, conference papers, and presentations

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

Publications in journals	Justification	Status
Boyer, J., Rubalcava*, K., Booth, S. & Townsend, H., (2022). Proof-of-concept model for exploring the impacts of microplastics accumulation in the Maryland coastal bays ecosystem. Ecological Modelling, 464, p.109849.	Cohort 2 student	Published
C. Cole, A.A. Finch, C. **Hintz, K.** Hintz, Y. Yu, EIMF, N. Allison, The KD Sr/Ca in cultured massive Porites spp. corals are reduced at low seawater pCO2, Geochimica et Cosmochimica Acta, Volume 314, 2021, Pages 55-67, ISSN 0016-7037, https://doi.org/10.1016/j.gca.2021.09.007.	Leveraged	Published

Flowers, K. I., **Babcock, E. A**., Papastamatiou,Y. P., Bond, M. E., Lamb, N., Miranda, A., Nuñez, R., Valentin-Albanese, J., Clementi, G. M., Kelley, M. C. & Chapman,D. D. (2022). Varying reef shark abundance trends inside a marine reserve: evidence of a Caribbean reef shark decline. Marine Ecology Progress Series 683:97-107. DOI: https://doi.org/10.3354/meps13954.	Leveraged	Published
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, 66,1993-2010	Leveraged	Published
Lawrence*, A., Green, S.*, Wang T., Bachvaroff T., & **Chung J.S**. (2022) Seasonal changes in the expression of insulin-like androgenic hormone (IAG) in the androgenic gland of the Jonah crab, *Cancer borealis*. PLoS ONE 17(2): e0261206. https://doi.org/10.1371/journal.pone.0261206	Cohort 1 Student	Published
O'Farrell*, H. & **Babcock, E. A.** (2021). Shortfin mako hot sets – Defining high bycatch conditions as a basis for bycatch mitigation. Fisheries Research 244: 106123 doi: 10.1016/j.fishres.106123	Cohort 1 student	Published
Ortega, P., Vitorino, H., Green, S.*, Zanotto, F.P., **Chung, J.S.,** & Moreira, R. G. (2022) Experimental effects of cadmium on physiological response of *Callinectes danae* (Crustacea, Portunidae) from environments with different levels of Cd contamination. Comparative Biochemistry and Physiology, Part C 251. https://doi.org/10.1016/j.cbpc.2021.109210.	Cohort 1 student	Published
Wilson M.N., Laufer A.E., Howard E.M. & Wong-Ala* J.A.T.K. (2021). Lessons From the Trenches: Students' Perspectives of Their Own Marine Transdisciplinary Education. Front. Mar. Sci. 7:592368. doi: 10.3389/fmars.2020.592368	Student supported by LMRCSC during paper development	Published
Adebola, T., Hart, D. & **Chigbu, P**. (2022). Bathymetric trends in the body size, and diet of *Astropecten americanus* in the Northwest Atlantic Ocean. Estuarine Coastal and Shelf Science, https://doi.org/10.1016/j.ecss.2022.107814	LMRCSC supported scientist & Center Director	Published

Table 29.1b: LMRCSC Publications as book chapters. Center students are identified with asterisk (*). Center scientists' names appear in bold**.**

Book chapters	Justification	Status
Bonin, C. A. (2022). "Genetic consequences of dispersal, philopatry and reproductive behaviors" In: Ethology and Behavioral Ecology of Eared Seals and the Walrus. Harcourt, R. & Campagna, C. editors. Springer. (Sole authorship).	Leveraged	Published
Marin Jarrin, J.R., Shanks, A.L. & **Miller, J.A.** (2022). The Biology and Ecology of Sandy Beach Surf Zones. In Sandy Beaches as Endangered Ecosystems: Environmental Problems, Possible Assessment and Management Solutions. edited by Sílvia C. Gonçalves, Susana M.F. Ferreira	Leveraged	Published

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
Avila, A.M., Munger, J.E., Rosemond, C., Haver, S.M., Boisen, O., Layton*, J.M., Monneedy, M.-y.H., Lasdin, K.S. and Heppell, S. (Accepted), Book Review: Fishery Ecosystem Dynamics. Fisheries.	Student supported by LMRCSC during paper development	In press

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

Oral presentations at professional meetings	Justification
Bender*, A., **Bonin, C., Lewallen, E.** (2022). Estimating effective population size and historical demography of leopard seals (*Hydrurga leptonyx*) in the Antarctic Peninsula. Presented at the Ocean Sciences Meeting 2022 (ASLOMP), Feb. 2022.	Cohort 3
Haughton*, S. Jensen, P. **Pitula, J**. (2022). Evaluating Physiological and Immune Responses of Tanner Crab (*Chionoecetes bairdi*) to *Hematodinium sp*. Infection. Invited speaker, IUPAC Global Women's Breakfast event (a global networking event), Feb. 2022.	Cohort 3
Henson*, M., **Horodysky, A**. (2022). Linking growth rate to metabolic rate in fish species of the Mid-Atlantic Bight. Presented at the Ocean Sciences Meeting 2022 (ASLOMP), Feb. 2022.	Cohort 1
Leslie*, J., **Bonin, A.** (2022). Assessing the changes in mass and body condition of leopard seals (*Hydrurga Leptonyx*) using aerial images. Presented at the Ocean Sciences Meeting 2022 (ASLOMP), Feb. 2022.	Cohort 4
Nash*, J. et al. (2022). Quantifying the distribution of gelatinous invertebrates and their habitat conditions on the Northeast US Shelf through imagery and associated environmental Data. Presented at the Ocean Sciences Meeting 2022 (ASLOMP), Feb. 2022.	Cohort 5

Pares* O., Fowler A., Zhao M., **Stevens B., Schott E.** (2021) Life History and Reproductive Strategies of *Callinectes* sp. in a Tropical Urban Estuary Presented at the 151st American Fisheries Society Annual Meeting	Cohort 5
Thalmann*, HL, B Laurel, and **JA Miller**. Catching the Heatwave: Juvenile Pacific Cod diet composition and growth in response to anomalous warming in Gulf of Alaska nursery habitats. 2022 Alaska Marine Science Symposium. Virtual Meeting. January 2022. Oral Presentation. (Best Student Oral Presentation).	Cohort 1

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
Rubalcava*, K., **Chigbu, P**. (2021). Assessment of the abundance of brown shrimp (*Farfantepenaeus aztecus*) in the Maryland Coastal Bays in relation to Environmental Factors. American Fisheries Society Annual Meeting, November 6-10, 2021, Baltimore MD. Poster Presentation.	Cohort 2
Silver*, A. and Alade, L. (2022). Working Group Collaboration to Explore Growth Parameters of American Plaice (*Hippoglossoides platessoides*) in the Georges Bank and Gulf of Maine for 2022 Research Track Assessment. Presented at ASLO for Education and Outreach Posters, Honolulu, Hawaii, March, 2022. Poster Presentation	Cohort 3

32. Other Products

Table 32: Theses and Dissertations produced by Center students during the current reportingperiod.

Theses/Dissertations	Justification
Bender, A. N. (Submitted Feb. 2022). Effective population size and historical demography of leopard seals in the Antarctic Peninsula	Cohort 3

33. What individuals worked on this project?

Last name	First Name	Total number of months worked during this time period	Project Role	Contribution to project (briefly describe)	State, U.S. territory, and/or country of residence	Collaborated with individual in a foreign country	Country(ies) of foreign collaborator	Travelled to foreign country	if traveled to foreign country(ies), duration of stay

Smith	Stacy	6	PD/PI		Delaware, U.S.A.	no		no	
McIntosh	Dennis	6	Faculty		Delaware, U.S.A.	no		no	
Ozbay	Gulnihal	6	Faculty		Delaware, U.S.A.			no	
Czajkowski	Caitlyn	6	Graduate Student (research assistant)	Conducted research	Delaware, U.S.A.	no		no	
Andrade	Emily	6	Graduate Student (research assistant)	Conducted research	Delaware, U.S.A.	no		no	
Teat	Marcus	6	Graduate Student (research assistant)	Conducted research	Delaware, U.S.A.	no		no	
Metz	Kendall	6	Undergraduate Student	Conducted research	Delaware, U.S.A.	no		no	
McKinley	Kayla	6	Undergraduate Student	Conducted research	Delaware, U.S.A.	no		no	
Gibson	Deidre	6	PD/PI	Program Director of LMRCSC at HU; advised Sierra Hildebrand, Derrick Richardson, Jonathan Nash, & co-advised Amani Tolin	Virginia	no		no	
Lewallen	Carolina	6	Faculty	Dr. Lewallen advised Arona Bender, Jaelyn Leslie, & co-advised Josette McLean	Virginia	no		no	
Lewallen	Eric	6	Faculty	Dr. Lewallen advised Arona Bender &Noah Tait	Virginia	no		no	
Sharma	Indu	6	Faculty	Dr. Sharma advised PaShun Hawkins	Virginia	no		no	
Horodysky	Andrij	6	Faculty	Dr. Horodysky advised Maria Henson,	Virginia	no		no	

				Ti'Kiyah Reeves, and Jonathan Nash					
Adebola	Tunde	2	Faculty	Dr. Adebola advised Noah Tait	Virginia	no		no	
Tait	Noah	2	Graduate Student (research assistant)	Conducted research	Virginia	no		no	
Bender	Arona	6	Graduate Student (research assistant)	Conducted research	Virginia	no		no	
Leslie	Jaelyn	6	Graduate Student (research assistant)	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		no	
Miller	Jessica	1.5	Co PD/PI	Programmatic and fiscal management of award, facilitation of student progress, recruiting and retention activities	Oregon, USA				
King	Brittany	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	
Williams	Victoria	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	
Layton	Janelle	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	
Cohn	Leann	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	

Pelekai	Keala	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	
Wong-Ala	Jennifer	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	
Thalmann	Hillary	6	Graduate Student (research assistant)	Conducted research	Oregon, USA	no		no	
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, Brazil	no	NA
Wilson	Adrianne	0	Graduate Student (research assistant)	Working on dissertation on lane snapper growth variation	Florida, USA	no			
Mayes	Cristin	6	Graduate Student (research assistant)	Working on dissertation on ecosystem modeling and data poor species assessment	Florida, USA	no			
Best-Otubu	Chryston	6		Working on dissertation on ecosystem modeling for Biscayne Bay	Florida, USA	no			
Alexandria	Ambrose	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Spaulding	Chelsea	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Burns	William	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Clax	Savannah	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Shaw	Michon	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Freeman	Dante	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	

Hammond	Erianna	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Williams	Michael	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Tennant	Alexandria	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Volmar	Lady	6	Undergraduate Student	Conducted research	Georgia, USA	no		no	
Day	Joe	6	Graduate Student (research assistant)	Conducted research	Georgia, USA	no		no	
Tay	Sena	6	Graduate Student (research assistant)	Conducted research	Georgia, USA	no		no	
Shaneese	Mackey	6	Graduate Student (research assistant)	Conducted research	Georgia, USA	no		no	
Geiger	Savannah	6	Graduate Student (research assistant)	Conducted research	Georgia, USA	no		no	
Howard	Kristafer	6	Graduate Student (research assistant)	Conducted research	Georgia, USA	no		no	
Lemaire	Chloe	6	Graduate Student (research assistant)	Conducted research	Georgia, USA	no		no	
Hoskins-Brown	Dionne	6	PD/PI	Performed research on oyster habitat, blue crabs, SLR, and LEK	Georgia, USA	no		no	
Young	Victoria	6	Faculty	Led student development, taught courses, and led education program development and assessment	Georgia, USA	no		no	
Jagus	Rosemary	1.5	PD/PI	Supervised students and staff, written proposals, performed research	Maryland, USA	no		no	

Coleman	Nicholas	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Schott	Eric	1	Faculty	Mentored Olivia Pares, research, outreach	Maryland, USA	Yes	Brazil	no	
Frey	Ben	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Green	Shadaesha	3	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Pares	Olivia	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Ramarui	Kyari	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Chigbu	Paulinus	3	PD/PI	Supervised center activities, written proposals, trained students	Maryland, USA			no	
Sexton	Margaret	6	Faculty	Supervised center activities, student development activities	Maryland, USA	no		no	
Hankerson	Tanesha	4.5	Other Professional	Communications activities	Maryland, USA	no		no	
Kessie	Alex	6	Other Professional	Budget & data management	Maryland, USA	no		no	
Tilghman	Ida	6	Other Professional	Administrative activities	Maryland, USA	no		no	
Wasike	Norrah	1	Other Professional	Administrative activities	Maryland, USA	no		no	
Barry	Teemer	6	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	

Colins	Glen	6	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	
Goffe	Shakira	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Wilburn	Imani	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Delgado	Angel	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Haughton	Shanelle	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Johnson	Tahirah	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Wade	Kaithlynn	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Rubalcava	Kasondra	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Silver	Ashley	6	Graduate Student (research assistant)	Conducted research	Maryland, USA	no		no	
Brown	Malika	6	Undergraduate Student	Participated in student development activities	Maryland, USA	no		no	

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

Table 34: Active other support for LMRCSC PD/PIs and senior/key personnel 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

35. What other organizations have been involved as partners?

Table 35: Organizations that have been involved as partners

Type of partner organization	Name	Location	Partners contribution to the project
State government	Virginia Aquarium and Marine Science Center	Virginia Beach, VA	Provided samples for Jaelyn Leslie
State government	Florida FWC	St. Petersburg, FL	Collaboration on horseshoe crab assessment
State government	GADNR	Brunswick, GA	Nets & gear, committee membership
Private industry	BF Consultants	McDonough, GA	Evaluation services and participation

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	Collaborator
Allman	Robert	SEFSC	PhD committee member and NERTO mentor for Adrianne Wilson
Alade	Larry	NEFSC	NERTO mentor for Shakira Goffe & Ashley Silver
Alvarez	Danielle	SEFSC	Research collaborator
Batchelor	Nate	SEFSC Beaufort, NC	NERTO mentor
Browder	Joan	SEFSC	NOAA mentor for Chryston Best-Otubu
Busch	Shallin	NWFSC	NERTO mentor
Deshpande	Ashok	NEFSC Sandy Hook, NJ	Committee member for Savannah Geiger
Doerr	Jennifer	SEFSC Galveston, TX	Grant Collaborator
Dutton	Peter	NWFSC	Co-author
Ewing	Ruth	SEFSC	Program Collaborator (mentor recruitment)
Feist	Blake	NWFSC	NERTO mentor
Fonner	Robby	NWFSC	NERTO mentor

Gerard	Trika	SEFSC Miami, FL	Program Collaborator (mentor recruitment)
Harvey	Christian	NWFSC	NERTO mentor
Hill	Ron	SESFC Panama City, FL	Committee member for Shaneese Mackey
Huff	David	NWFSC	NERTO mentor
Jacobs	John	NEFSC/Cooperative Oxford Lab	NERTO mentor
Johnson	Matthew	SEFSC Galveston	Grant Collaborator
Johnson	Melissa	EEO	Program Collaborator (development)
Jones	Christian	SEFSC	Program Collaborator (drones)
Kaplan	Isacc	NWFSC	NERTO mentor for Chryston Best-Otubu
Karnauskas	Mandy	SEFSC	Program Collaborator (mentor recruitment)
Karnauskas	Mandy	SEFSC	Collaborator
Krause	Douglas	SWFSC	NERTO mentor for Arona Bender and Jaelyn Leslie
LaCasella	Erin	NWFSC	co-author
LaTreese	Denson	SEFSC	Collaborator
Laurel	Ben	NWFSC	NERTO mentor
Leo	Jennifer	SEFSC Galveston	Grant Collaborator, NERTO mentor
Lewis	Kemit-Amon	SSU	Co-author
MacPherson	Matthew	SEFSC	Program Collaborator (mentor recruitment)
Molineaux	Johnathan	Silver Spring	Internship mentor
Munoz	Roldan	SEFSC Beaufort	NERTO Mentor
Patterson	Jody	Grays Reef NMS	Non-LMRCSC student mentor
Robeson	Kimberly	Grays Reef NMS	NOAA mentor to Kris Howard; microplastics research with Sue Ebanks
Schultz	Emma	SESFC Pascagoula	Manuscript Collaborator
Serafy	Joe	SEFSC	NERTO mentor for Cristin Mayes
Smith	Brian	NEFSC, Woods Hole	NERTO mentor for Angel Delgado
Spires	Jason	NEFSC/Cooperative Oxford Lab	NERTO mentor
Stoffle	Brent	SEFSC	Research collaborator
Thorson	James	AFSC	Collaborator
Walter	John	SEFSC	Collaborator
Werner	Kevin	NWFSC	Graduate student committee member
Wren	Joanna	NWFSC	NERTO mentor

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

Last name	First name	Title/Affiliation	Description of involvement
Heres	Berlynna	Florida FWC	Collaboration on horseshoe crab assessment
Venello	Theresa	Postdoctoral Researcher	Helped students collect samples
McGowan	Andrew	Environmental Scientist, DIB	Assisted with student research
Gleason	Daniel	Professor, Georgia Southern Univ.	Grant collaborator
Alber	Merryl	Professor, UGA	Grant collaborator
Yager	Patricia	Professor, UGA	Grant collaborator
Babcock	Elizabeth	Professor, RSMAS	Grant collaborator
Ozbay	Gulnihal	Professor, DSU	Grant collaborator
Frischer	Marc	Professor, UGA	Grant collaborator
Johnson	Ronald	President, Sapelo Island Cultural and Revitalization Society	Grant collaborator
Brandes	Jay	Professor, UGA	Use of Raman Spectroscopy instrumentation
Fortner	Sarah	Science Education Resource Center (SERC) at Carleton College	Grant collaborator
Tripati	Aradhna	Professor, UCLA	Grant collaborator
Ross	Sarah	Director, Wormsloe CREW	Book editor
Stoffle	Richard	Professor, Arizona State University	Research Collaborator
Helmuth	Brian	Professor, Northeastern University	Grant collaborator
Grabowski	John	Professor, Northeastern University	Grant collaborator

39. What were the outcomes of the award?

Table 39: LMRCSC Graduates during this period:

Last Name	First name	Institution	Degree	Cohort #	Graduation Date	Postgraduate information
King	Brittany	OSU	PhD	2	Dec. 2021	Environmental Scientist with NOAA's National Centers for Coastal Ocean Science (NCCOS) Competitive Research Program (CRP). Within NCCOS the position is described as an Environmental Justice Specialist.
Moreno	Victoria	OSU	MS	4	Dec. 2021	Knauss Fellow
Rufus	Mya	UMES	B.S.	4	Dec. 2021	Seeking employment

50. What were the outcomes of the award?

a. Education Outcomes

i. **Outcome 1. Increased number, annually, of CSC post-secondary students, trained:** A total of 112 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, 18 have graduated, including 5 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 (6) students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S. and 3 B.S. Seventeen (17) students including 3 Ph.D., 8 M.S., and 6 B.S. students have been recruited into Cohort 4. Of the Cohort 4 students two (2) have graduated including 1 M.S. and 1 B.S. student. Twenty-three (23) students have been recruited into Cohort 5 including 4 Ph.D., 8 M.S., and 11 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, the Data Carpentry Workshop offered in Fall 2021, statistics courses, 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. In 2021, the course was replaced with at two day workshop from Data Carpentry based on feedback from students. All graduate students are required to complete either the course or the workshop prior to graduation.

ii. **Outcome 2: Increase number of CSC post-secondary students educated and graduated annually:** A total of 112 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, 18 have graduated, including 5 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 (6) students from Cohort 3 have graduated so far including 1 Ph.D., 2 M.S.

and 3 B.S. Seventeen (17) students including 3 Ph.D., 8 M.S., and 6 B.S. students have been recruited into Cohort 4. Of the Cohort 4 students two (2) have graduated including 1 M.S. and 1 B.S. student. Twenty-three (23) students have been recruited into Cohort 5 including 4 Ph.D., 8 M.S., and 11 B.S. students. One B.S. student from Cohort 5 has graduated. A complete listof 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: Three (3) students graduated during this period, including 1Ph.D., 1 M.S., and 1 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: Nine graduate students completed NERTO internships under the supervision of NOAA scientists during this period.

iii. **Outcome 3. Increased CSC capacity to train and graduate students.** Ten collaborative research projects were funded in the previous reporting period, which enable center scientists to be available to mentor and advice undergraduate and graduate students. In addition, 42 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: 11
b. New courses: 0
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: 55
f. Total degrees awarded: 3
g. Degrees awarded to URM students: 3

iv. **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 = **50** 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 = **50** 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 ten (10) LMRCSC TAB projects that were funded during the period has a NOAA scientist as a collaborator. Those projects are ongoing.

b. Number of NOAA scientists serving as mentors and advisors for student research: 42 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 = 21

d. Number of uses of NOAA data in research and tool development = 3. 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. For their NERTO projects, Center students used long term data sets (1980 – 2021) collected by NEFSC during spring and autumn bottom trawl surveys to conduct analyses and compare growth (Ashley Silver, Ph.D. student at UMES) and maturity (Shakira Goffe, M.S. student at UMES) parameters of American Plaice from the Georges Bank and Gulf of Maine regions. NOAA will use information from the studies in research track assessment of the species in 2022.

2. Outcome 2. CSC-supported faculty, staff and students' research directly aligned with NOAA's mission and strategic priorities: Ten (10) collaborative research projects funded by the LMRCSC are currently active. 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	5	4
# of presentations	9	0
# Tools developed	3	0
Use of LMRCSC research results and tools by NOAA & other stakeholders	2	0
# of instances LMRCSC publications are cited	155	9.7
# of LMRCSC students, staff or faculty recognized nationally for LMRCSC research	0	0

LMRCSC TAB-Funded Projects Currently Active

Project Number	Principal Investigator	Title	Thematic Research Area
19-04	David Secor	Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts	SASI
19-06	Hillary Thalmann	Thermal impacts on juvenile Pacific Cod (*Gadus macrocephalus*) foraging and growth in Gulf of Alaska nursery habitats	CLIME
19-07	Adrianne Wilson	Population structure and growth of lane snapper, a data limited species	SASI
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
20-06	Janelle Layton	Investigating the effects of climate change on heat shock proteins and development in the early life history stages of Nassau grouper	CLIME
20-10	Imani Wilburn	The Occurrence of Microplastics in Maryland Coastal Bay Fishes	HaBS
20-11	Carolina Bonin	Estimating the effective population size and historical demography of leopard seals (*Hydrurga leptonyx*) in the Antarctic Peninsula	SASI
21-01	Tunde Adebola	Developing a Coupled Human Ecological System for Chesapeake Bay Shellfish Fisheries	SASI
21-02	Nicholas Coleman	Sonar Censusing and Habitat Use by Spawning Run Atlantic and Green Sturgeon, *Acipenser oxyrinchus* and *A. medirostris*	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 SocialSciences

TAB Project Abstracts

Project Number 19-04
Title: Validation of Monkfish Age and Growth Using Microconstituent Analysis of Hardparts
Thematic Research Area SASI: Stock 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: David Secor, University of Maryland Center for Environmental Science
Co-PI: Rosemary Jagus, University of Maryland Center for Environmental Science
NOAA Partner: Anne Richards, NEFSC: Northeast Fishery Science Center
Other Partner:
Students: Benjamin Frey (MS, UMCES)
Keywords: Fisheries; Population dynamics

Project Number 19-06
Title: Thermal impacts on juvenile Pacific Cod (*Gadus macrocephalus*) foraging and growth in Gulf of Alaska nursery habitats
Thematic Research Area CLIME: Climate Impacts on Marine Ecosystems
Abstract: The Gulf of Alaska is influenced by thermal variation including climatic phenomena and marine heatwaves such as the 2014-2016 and 2019 heatwaves. Warming events are expected to impact age-0 Pacific Cod (*Gadus macrocephalus*) during summer growth in coastal nurseries and can influence patterns of foraging, selective mortality, and overwinter survival. Understanding thermal impacts on juvenile Cod is especially relevant given their recent declines in adult abundance and the closure of the fishery in 2020. I will examine juvenile Cod in Kodiak Island nurseries between 2006 and 2019 during representative warm and cold years in order to describe variability in nursery growth, diet composition, and trophic position using otolith increment, stomach content, and stable isotope analysis. Expected results will inform cod recruitment patterns in the face of climate change and contribute to nursery management during future warming.
Principal Investigator: Hillary Thalmann, Oregon State University
Co-PI: Jessica Miller, Oregon State University
NOAA Partner: Ben Laurel, AFSC: Alaska Fishery Science Center
Other Partner: Bradley Stevens, University of Maryland Eastern Shore
Students: Hillary Thalmann (MS, OSU)
Keywords: Fisheries; Protected Species; Population dynamics; Ecosystems; Habitats; Climate variability

Project Number 19-07
Title: Population structure and growth of lane snapper, a data limited species
Thematic Research Area SASI: Stock Assessment Support and Information
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 complement 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: Adrianne Wilson, University of Miami - Rosenstiel School of Marine and Atmospheric Science
Co-PI: Elizabeth Babcock, University of Miami - Rosenstiel School of Marine and Atmospheric Science
NOAA Partner: Robert Allman, SWFSC: Southwest Fishery Science Center
Other Partner: Dionne Hoskins-Brown, Savannah State University
Students: Adrianne Wilson (PhD, RSMAS); Savannah Clax (Undergraduate, RSMAS)
Keywords: Fisheries, Marine Biology, Population dynamics

Project Number 20-03
Title: Proteomic analysis of two *Haematococcus pluvialis* strains as aquaculture feedstock
Thematic Research Area SNAP: Seafood, Nutrition, Aquaculture, and Pathology
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. Two mutant strains of *H. pluvialis* have been generated through chemical mutagenesis that demonstrate 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: Kyarii Ramarui, University of Maryland Center for Environmental Science
Co-PI: Yantao Li, University of Maryland Center for Environmental Science
NOAA Partner: Gary Wikfors, NEFSC: Northeast Fishery Science Center
Other Partner: Allen Place, Joseph Pitula, UMCES, UMES
Students: Kyarii Ramarui (PhD, UMCES)
Keywords: Aquaculture; Social science; Plankton; 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 SASI: Stock Assessment Support and Information
Abstract: The blue crab, *Callinectes sapidus*, is an adaptable estuarine species that lives in Atlantic coastal regions from New England to Argentina. The species is a crucial part of the estuarine food web and supports a fishery worth $200 million annually in the US. Across their range, blue crabs are infected by pathogenic viruses and protozoa that may interact with environmental and anthropogenic stressors to limit crab abundance. In Puerto Rico, *C. sapidus* is targeted by an artisanal fishery and provides income important to communities. Currently, no size or sex restrictions are in place to sustainably manage *Callinectes* spp. in Puerto Rico, and there is a lack of data on which to base fisheries management. In the tropics, *C. sapidus* is often sympatric with several other *Callinectes* species. Basic knowledge of *Callinectes* spp. distribution in estuaries in the San Juan metropolitan region can provide valuable insights into their ecological role and provide baseline data for monitoring abundance to inform resource management strategies. To address this knowledge gap, we plan to measure the abundance, sex ratio, female reproductive status, and diseases of *C. sapidus* and other *Callinectes* spp., including *C. exasperatus, C. ornatus, C. larvatus,* and *C. bocourti* by sampling 4 times per year, in a range of habitats (and environmental parameters) within a polyhaline estuary in the San Juan metropolitan area in Puerto Rico.
Principal Investigator: Eric Schott, University of Maryland Center for Environmental
Co-PI: Bradley Stevens, University of Maryland Eastern Shore (UMES)
NOAA Partner: Mandy Bromilow, NOAA: Chesapeake Bay Office
Other Partner:
Students: Olivia Pares (MS, UMCES)
Keywords: Fisheries; Ecology; Pathology

Project Number 20-06
Title: Investigating the effects of climate change on heat shock proteins and development in 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 on the drivers of these changes in bioenergetics and in gene expression during the early life history stages of this species. Our 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 Island.
Principal Investigator: Janelle Layton, Oregon State University
Co-PI: Scott Heppell, Oregon State University
NOAA Partner: Steve Gittings, NOS: National Ocean Service
Other Partner:
Students: Janelle Layton (MS, OSU)
Keywords: Fisheries; Ecosystems

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: Imani Wilburn, University of Maryland Eastern Shore
Co-PI: Dr. Maurice Crawford, University of Maryland Eastern Shore (UMES)
NOAA Partner: Dr. Ashok Deshpande, NEFSC: Northeast Fishery Science Center
Other Partner: Dr. Kausik Das, The University of Maryland Eastern Shore
Students: Imani Wilburn (MS, UMES)
Keywords: Fisheries; Microplastics; Maryland Coastal Bays

Project Number 20-11
Title: Estimating the effective population size and historical demography of leopard seals (*Hydrurga leptonyx*) in the Antarctic Peninsula
Thematic Research Area: Ecosystem change and prediction
Abstract:
The leopard seal (*Hydrurga leptonyx*) is an apex marine predator in the Antarctic ecosystem with a determinant role in ecosystem functioning through top-down control of other mesopredator prey. Recently, summer leopard seal sightings have steadily increased in the Northern Antarctic Peninsula (NAP), where they predate Antarctic fur seal (*Arctocephalus gazella*) pups at high rates, partially contributing to this species population collapse in the NAP. Leopard seal abundance is difficult to estimate directly because observational surveys are costly and hold a high degree of uncertainty. Therefore, population trends are largely unknown. In this study, we used molecular genetic methods to estimate the effective population size (N_E) and historical demography of leopard seals. We sequenced a 405-base pair (bp) fragment of the mitochondrial DNA (mtDNA) control region of 90 seals sampled at the NAP by the US Antarctic Marine Living Resources Program (US AMLR) during the austral summers of 2008 – 2019. Our genetic diversity assessment revealed moderate to high nucleotide and haplotype diversity relative to other Antarctic ice seals (π= 0.013; Hd= 0.96). We estimated a theta value (Θ = 0.039), which resulted in a large N_E > 500,000 individuals. Our analyses also rejected the null hypothesis of constant population size (Fu F*s* = –14.76) with a demographic expansion around 35,000 years before present (YBP; τ = 3.64). This timing of expansion contrasts the pattern of Pleistocene population increase estimated to have occurred earlier in the Pleistocene for other Antarctic ice seals. Our study provides valuable baseline population estimates for a poorly known apex predator in one of the most rapidly warming regions of the planet.

Principal Investigator: Dr. Carolina Bonin
Co-PI: Dr. Eric Lewallen
NOAA Partner: Dr. Douglas Krause
Graduate Student: Arona Bender
Institution: Hampton University
Institution: Hampton University
Lab/Facility: NOAA SWFSC AERD
Undergraduate Student: Kathryn Cruz

Project Number 21-01
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 the 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: Tunde Adebola
Institution: Hampton University
Co-PI: Eric Lewallen
Institution: Hampton University
NOAA Partner: Howard Townsend
Lab/Facility: Oxford, Maryland
Graduate Student: Noah Tait
Undergraduate Student:

Project Number 21-02
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) to provide 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 v. 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. Dave Secor **Institution**: UMCES/IMET
Co-PI: Name: Dr. Rose Jagus **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

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
Emily	Andrade	Y	4	M.S.	DSU	$8,707	$15,000				
Caitlyn	Czajkowski	N	3	M.S.	DSU	$5,863	$18,000				
Kayla	McKinley	Y	5	B.S.	DSU		$8,000				
Kendall	Metz	N	5	B.S.	DSU		$8,000				
Marcus	Teat	Y	2	B.S.	DSU	$4,045	$15,000				
Arona	Bender	Y	3	M.S.	HU	$6,200	$9,500				
PaShun	Hawkins	Y	4	B.S.	HU	$10,000					
Maria	Henson	Y	1	B.S.	HU	$5,000					
Jaelyn	Leslie	Y	4	M.S.	HU	$6,200	$9,500				
Jonathan	Nash	Y	5	B.S.	HU	$10,000					
T'Kiyah	Reeves	Y	5	B.S.	HU	$10,000					
Derrick	Richardson	Y	5	B.S.	HU	$10,000					
Noah	Tait	N	5	M.S.	HU	$6,200	$3,000				
Leann	Cohn	Y	5	MS	OSU	$6,851	$21,380				
Brittany	King	Y	2	PhD	OSU	$2,899	$8,897				
Janelle	Layton	Y	4	MS	OSU	$6,799	$7,601	$1,404			
Victoria	Moreno	Y	4	MS	OSU	$5,119	$7,522				
Hillary	Thalmann	N	1	PhD	OSU	$5,119	$5,888				
Jennifer	Wong Ala	Y	5	PhD	OSU	$10,238	$14,823				
Chryston	Best-Otubu	Y	5	PhD	RSMAS	$8,852	$19,086				
Cristin	Mayes	Y	4	PhD	RSMAS	$8,852	$15,156	$1,217			
Adrianne	Wilson	Y	2	PhD	RSMAS			$3,941			
Savannah	Clax	Y	5	B.S.	SSU	$6,000					
Joe	Day	Y	5	MS	SSU	$3,075	$10,500				
Kristafer	Howard	Y	5	M.S.	SSU	$1477	$10,500				
Chloe	Lemaire	N	5	M.S.	SSU	$8,905	$10,500	$150			

Michon	Shaw	Y	5	B.S.	SSU	$6,000					
Sena	Tay	Y	2	M.S.	SSU	$ 3,075.00	$ 8,750.00				
Alexandria	Tennant	Y		B.S.	SSU	$6,000					
Lady	Volmar	Y		B.S.	SSU	$8,610					
Nicholas	Coleman	Y	2	M.S.	UMCES	$ 3,072.00	$ 15,772.45	$ 4,818.57			
Benjamin	Frey	Y	3	M.S.	UMCES		$ 16,837.16	$ 1,415.71		$ 6,841.93	
Olivia	Pares	Y	5	Ph.D.	UMCES		$ 22,281.77			$ 2,479.00	
Kyarii	Ramarui	Y	4	Ph.D.	UMCES	$ 3,840.00	$ 19,107.22				
Elyssa	Baker	Y		No Degree	UMES	$0	$538	$1,196			
Teemer	Barry	Y	3	B.S.	UMES	$0	$1,716	$41			
Cameron	Bennett	Y		No Degree	UMES	$0	$538	$1,196			
Mikaela	Blackwood	Y		No Degree	UMES	$1,776	$538	$1,196			
Malika	Brown	Y	5	B.S.	UMES	$4,362	$0	$0			
Indaya	Byer	Y		No Degree	UMES	$0	$538	$1,196			
Glen	Collins	Y	4	B.S.	UMES	$9,672	$526	$0			
Angel	Delgado	Y	5	M.S.	UMES	$10,302	$11,831	$41			
Amarim	Dupree	Y		No Degree	UMES	$699	$538	$1,196			
Shakira	Goffe	Y	4	M.S.	UMES	$0	$9,746	$47			
Shanelle	Haughton	Y	3	Ph.D.	UMES	$1,409	$12,931	$0			
Tahirah	Johnson	Y	4	M.S.	UMES	$3,094	$13,032	$41			
Beverly	Malugin	Y		No Degree	UMES	$0	$538	$1,196			
Jamar	Moody	Y		No Degree	UMES	$699	$538	$1,196			
Kasondra	Rubalcava	Y	2	Ph.D.	UMES	$713	$15,056	$307			
Ashley	Silver	Y	3	Ph.D.	UMES	$1,356	$11,745	$0			
Kaithlynn	Wade	Y	5	M.S.	UMES	$10,324	$9,746	$41			
Ronald	Whatley	Y		No Degree	UMES	$699	$538	$1,196			
Imani	Wilburn	Y	4	M.S.	UMES	$2,034	$9,814	$0			

Appendix II: TAB Reports

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
Students: Graduate Student: Mr. Ben Frey **Undergraduate Student:**
Keywords: Fisheries, Population Dynamics
Start Date: 1 September 2019 **End Date:** 31 August 2022

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. 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 for black sea bass and Atlantic monkfish are shown in figures 1 and 2.

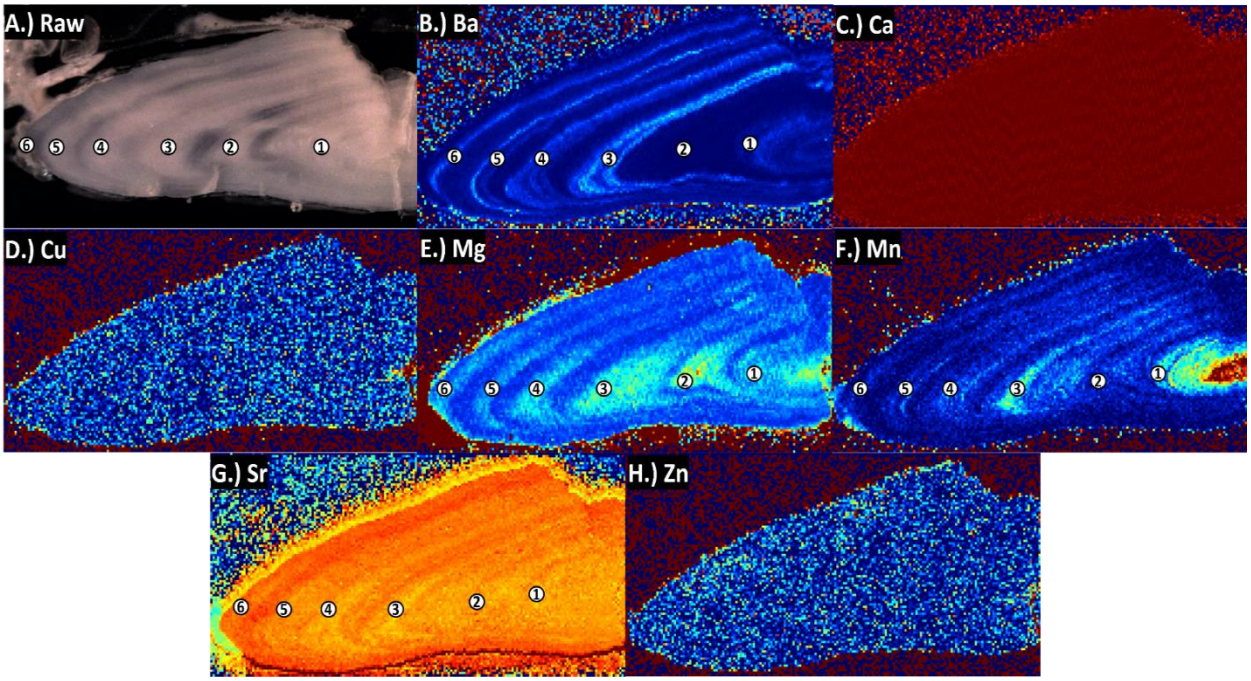

Figure 1. 2D elemental maps and light micrograph (Raw) image for two black sea bass (top and lower panels). Concentration scales from blue (low) to red (high). Note that contrast is optimized for each map and is not common across elements. Annuli annotations are depicted in circles. Encircled numbers indicate estimated age.

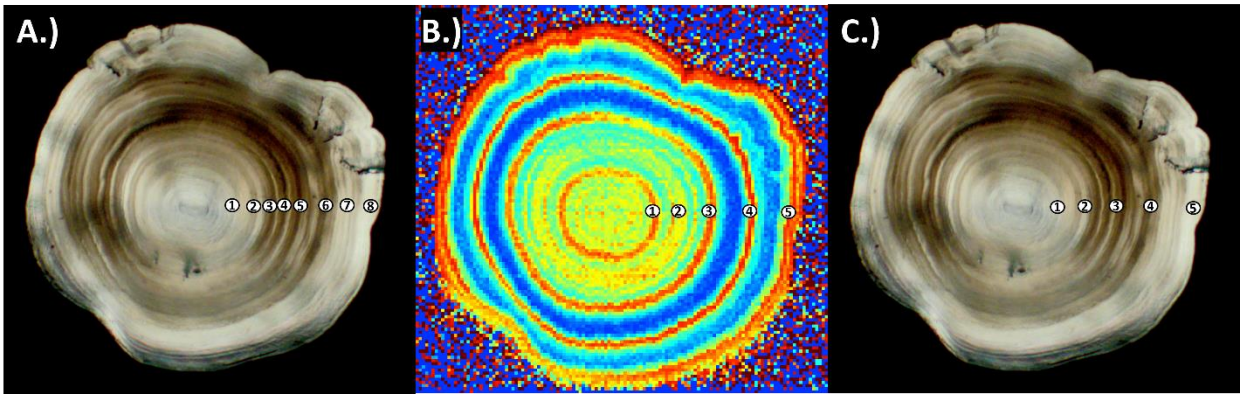

Figure 2 (A) Current expert assignment of a sectioned Atlantic monkfish illicium annuli, (B) assignment of chemical annuli, and (C) assignment of annuli using chemical ageing conventions. Encircled numbers indicate estimated age.

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. 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. 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. NERTO Mentee Testimonial. Leadership Initiative for Networking and Collaboration Conference, Virtual, April 2021.

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

An M.S. thesis has been drafted and will be defended by graduate student Ben Frey on April 14, 2022.

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 protected resources
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

Project Number 19-06 (An Update)
Title: Thermal impacts on juvenile Pacific Cod (*Gadus macrocephalus*) foraging and growth in Gulf of Alaska nursery habitats
Thematic Research Area CLIME: Climate Impacts on Marine Ecosystems
Abstract: The Gulf of Alaska is influenced by thermal variation including climatic phenomena and marine heatwaves such as the 2014-2016 and 2019 heatwaves. Warming events are expected to impact age-0 Pacific Cod (*Gadus macrocephalus*) during summer growth in coastal nurseries and can influence patterns of foraging, selective mortality, and overwinter survival. Understanding thermal impacts on juvenile Cod is especially relevant given their recent declines in adult abundance and the closure of the fishery in 2020. I will examine juvenile Cod in Kodiak Island nurseries between 2006 and 2019 during representative warm and cold years in order to describe variability in nursery growth, diet composition, and trophic position using otolith increment, stomach content, and stable isotope analysis. Expected results will inform cod recruitment patterns in the face of climate change and contribute to nursery management during future warming.
Principal Investigator: Hillary Thalmann, Oregon State University
Co-PI: Jessica Miller, Oregon State University
NOAA Partner: Ben Laurel, AFSC: Alaska Fishery Science Center
Other Partner: Bradley Stevens, University of Maryland Eastern Shore
Students: Hillary Thalmann (MS, OSU)
Keywords: Fisheries; Protected Species; Population dynamics; Ecosystems; Habitats; Climate variability
Start Date: 9/16/2018 **End Date:** 6/30/2021

Results to Date
We are close to completing all diet analyses for juvenile Pacific Cod captured in July and August from 2006-2019, with the goal of these analyses to determine if prey community structure varies in relation to heatwave conditions in the Gulf of Alaska and to identify which prey taxa differ between heatwave years and the years before and between heatwave events. Preliminary results, using non-metric multidimensional scaling (NMS), Multiple Response Permutation Procedure (MRPP), and Indicator Species Analysis, suggest that community composition of juvenile Pacific Cod prey is associated with the presence of heatwaves in the Gulf of Alaska. Pre-heatwave cool years (2006-2013) overlapped very little in prey community composition with heatwave years (2014-2016, 2019). Years between the two heatwaves (2017- 2018), included shared prey species from both heatwave years and years prior to heatwaves. These shared characteristics suggest that diet composition of juvenile Pacific Cod may return to a pre-heatwave community composition if the system were allowed to recover without additional

thermal disturbances. During the marine heatwave events, juvenile Pacific Cod fed on larger polychaete worms and crangonid shrimps compared to their pre-heatwave diet of small copepods and gammarid amphipods. Juvenile Pacific Cod were larger during heatwave conditions, and this trend towards larger prey in warm years may be linked to their larger size and mouth gape width. We have analyzed ~50% of all otoliths in this project and anticipate completing otolith analyses by June 2021. Preliminary results suggest that juvenile Pacific Cod may be growing more quickly under heatwave conditions. We have collected stable isotope data for use in determining Pacific Cod trophic position through time, but have not yet analyzed this data. We anticipate completing this data analysis by summer 2021. I am also transitioning from a MS to a PhD, with anticipated graduation in summer 2024.

Relevance to NOAA

Living marine resources such as Pacific Cod are critical for Alaska's commercial, subsistence, and recreational fishing industries and represent an important economic and nutritional resource at both a regional and national scale. This TAB project complements and expands ongoing Pacific Cod research within the NOAA Alaska Fisheries Science Center, including efforts to identify overwintering processes during the first year of life and the validation of an individual-based transport model for Pacific Cod. Quantifying trends in Pacific Cod growth and foraging within essential nursery habitat can illuminate changes in a nursery's ability to support a stenothermic species like Pacific Cod and lead to more effective precautionary management for long-term sustainability. For example, the North Pacific Fisheries Management Council sets an annual specific total catch for Gulf of Alaska Pacific Cod based on population- and ecosystem-level risk metrics. Growth patterns, condition, and diet composition of juveniles settling in coastal nurseries can be important metrics that indicate changes in the population and inform management decisions. Metrics such as these were used to help inform the 2020 closure of the fishery in response to unprecedented low biomass. In addition, climate-mediated declines in Pacific Cod have important ecosystem implications, with effects cascading up the food web to top predators such as salmon, marine mammals, and sea birds. The Kodiak Island beach seine time series is identified as a valuable dataset for the "ecosystem indicators" section of NOAA AFSC's Assessment of the Pacific Cod stock in the Gulf of Alaska because it is the only dataset for nursery-age Gulf of Alaska Pacific Cod that spans multiple thermal regimes and includes data from the 2014-2016 and 2019 marine heatwaves. Trends from these archived specimens can illustrate climate-mediated shifts in growth and production of juvenile Pacific Cod and aide in recovery efforts for the species.

Broader Impacts

Stakeholders, fishermen, and related industry participants in Southeast Alaska are directly impacted by declines in Pacific Cod. To connect with other Pacific Cod scientists, I will work with Dr. Ben Laurel to help organize and participate in events connected to the Alaska Marine Science Symposium in Anchorage, with the purpose of connecting Pacific Cod scientists and stakeholders across the region to discuss current and future Pacific Cod research and potential collaborations. The first of these meetings was successfully implemented at the 2020 Alaska Marine Science Symposium and included a virtual follow-up meeting in February 2021.

Presentations or Publications

Blaisdell, J., Thalmann, H.L., Klajbor, W., Zhang, Y., Miller, J.A., Laurel, B.J., & Kavanaugh, M.T. (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. https://doi.org/10.3389/fmars.2021.656088

Thalmann, HL, B Laurel, and JA Miller. Catching the Heatwave: Juvenile Pacific Cod diet composition and growth in response to anomalous warming in Gulf of Alaska nursery habitats. 2022 Alaska Marine Science Symposium. Virtual Meeting. January 2022. (Best Student Oral Presentation).

Thalmann, HL, B Laurel, and JA Miller. Too hot to handle: Effects of recent marine heatwaves on juvenile Pacific Cod foraging, growth, and trophic position in Gulf of Alaska nursery habitats. NOAA LMRCSC Graduate Student Seminar Series. Virtual Meeting. January 2022.

Thalmann, HL, B Laurel, and JA Miller. Juvenile Pacific Cod diet composition and trophic shifts in response to anomalous warming in the Gulf of Alaska. Coastal Cod Symposium. Virtual Meeting. November 2021.

*Marshall, K, *K Osborne, HL Thalmann, BJ Laurel, and JA Miller. Diet composition and size distribution of juvenile Pacific Cod in response to thermal variability. 2021 Research Advances in Fisheries, Wildlife, and Ecology Virtual Symposium. Virtual Meeting. May 2021. (Best Mentor/Mentee Poster Award).

Thalmann, HL, B Laurel, and JA Miller. Too hot to handle: effects of thermal variability on juvenile Pacific Cod foraging and growth. 2021 Kodiak Area Marine Science Symposium. Virtual Meeting. April 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

Project Number 19-07
Title: Population structure and growth of lane snapper, a data limited species
Thematic Research Area SASI: Stock Assessment Support and Information

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 - Rosenstiel School of Marine and Atmospheric Science
Co-PI:
Name: Dr. Elizabeth Babcock
Institution: University of Miami - Rosenstiel School of Marine and Atmospheric Science
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

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

Results to Date:
I have received the ages for a set of fish collected from the SEAMAP cruise that took place in Fall 2021. I am working with their office to collect the ages from a second cruise that took place in Summer 2021. I have also received a number of samples from a NOAA employee located in La Marque, TX. This will allow examination of multiple life stages and fish collected throughout a large portion of the species range. Samples collected from North Carolina have been inventoried and are ready for processing.

The results below were presented in Savannah Clax's final presentation. Florida samples were from a subset of samples collected from southwest Florida to east Texas from January 2015 to October 2017 by United States federal sampling programs. These samples were collected from both commercial and recreational fisheries. Samples from Belize were collected from May to June 2019 from commercial fisheries. Fork length and weight were collected from all samples before otoliths were removed and prepared for ageing.

After processing otoliths, it was determined that the Florida samples contained larger and older fish than the samples collected in Belize. The largest fish from the Florida samples was 495 mm in FL and the largest in Belize was 322 mm in FL. There was a greater range of sizes among the Florida samples as seen in the length frequency figures below (Figure 1 and 2). The lack of larger fish in the Belize sample made it difficult to calculate growth parameters covering the entire size range of the species. The lack of larger fish collected during sampling may indicate the presence of overfishing in the Belizean lane snapper fishery. As a result, more efforts have been made to conduct additional sampling in Belize to retrieve additional fish larger than 35 cm in FL.

The oldest fish reported from the Florida samples was 13 years of age, whereas the oldest fish collected from Belize was just under 5. The growth parameters are displayed in the table below (Table 1). The t_0 values are closer in value at -2.15 and -2.39 and this is due to the lack of young of the year samples from both locations. The L_∞ value is much higher for the Florida samples, and this is due to the larger sizes and greater range of sizes collected. The L_∞ value for Belize is 232.21. This value is much lower than the Florida samples due to the smaller fish collected from this area. The lack of size and age diversity also impacted the K value for Belize. K represents the exponential rate of approach to asymptotic size. The lack of large fish in the Belize resulted in the higher K value of .852 for these samples. The Florida samples had a K value of 0.257. This is due to the larger sample size, larger range of sizes, and larger max size in the samples, causing the exponential rate to asymptotic size to be slower.

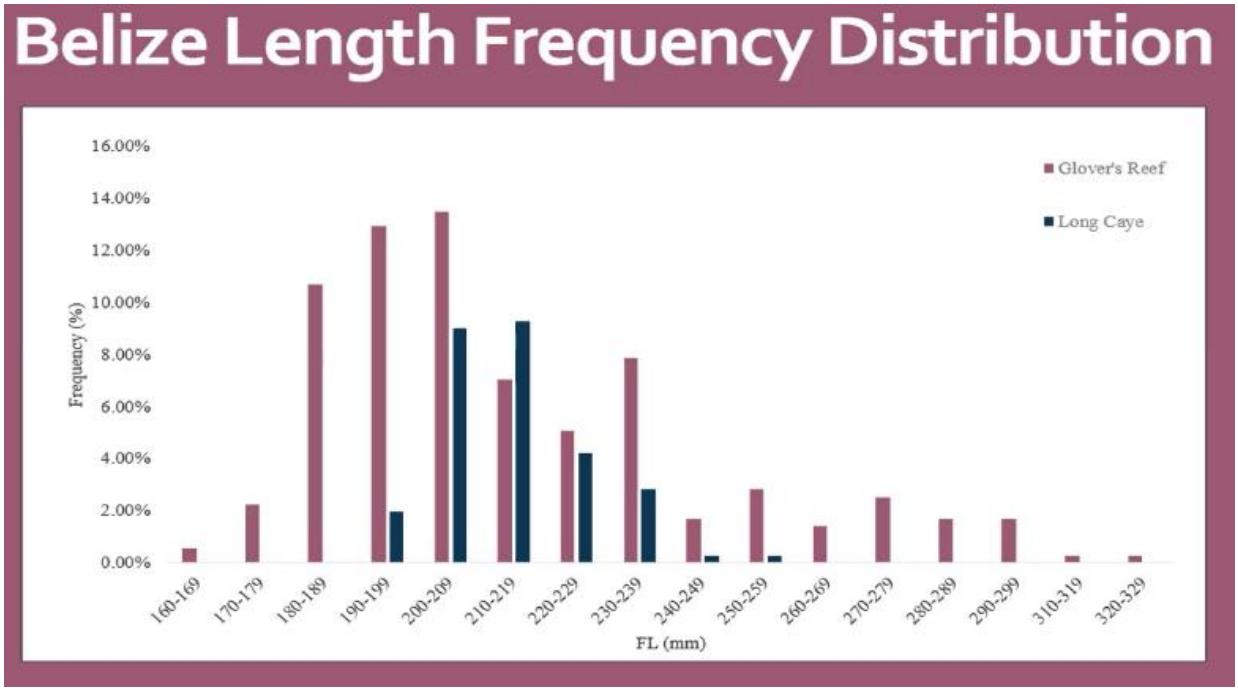

Figure 1. Length Frequency Distribution of Lane Snapper in Belize

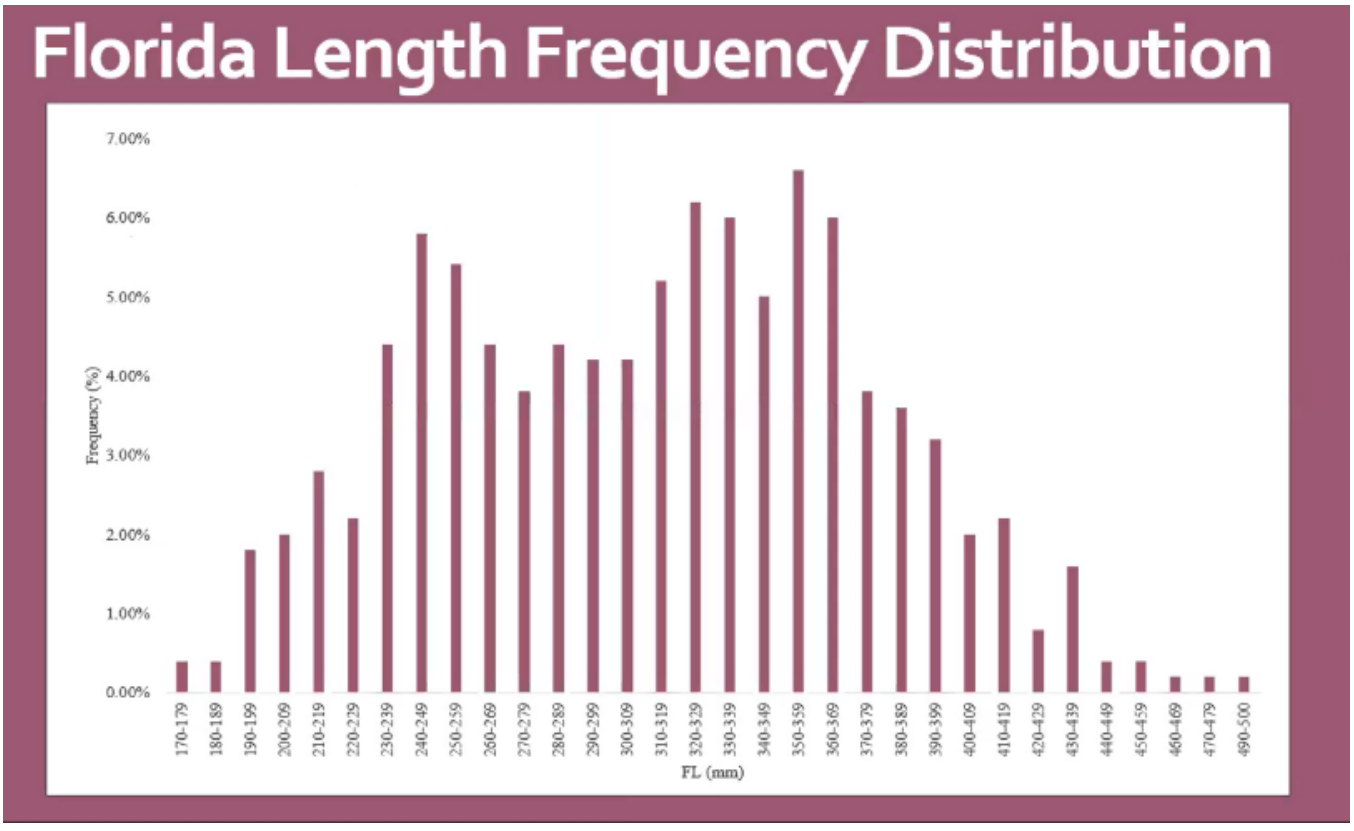

Figure 2. Length Frequency Distribution of Lane Snapper in Belize

Table 1. Population Parameters of Lane Snapper

Belize	Florida
L∞:232.21	L∞:397.05
K:0.852	K:0.257
To:-2.39	To:-2.15

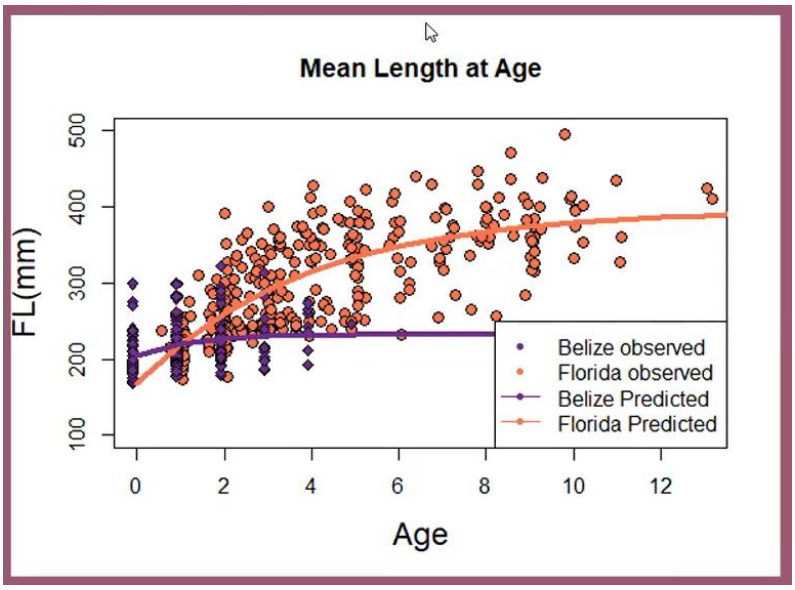

Figure 3. Length-Age Relationships of Lane Snapper

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

Presentations or Publications: None to date

Performance Measure: 3.4a1: Fish Stock Sustainability Index (FSSI) (cumulative)

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

NOAA RD Linkage: C4c: Develop integrated models that take advantage of synoptic data at various scales, to inform ecosystem-based management

Next Gen Priorities: Improved understanding of ecosystems to inform resource management decisions

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

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

Abstract: The green microalga *Haematococcus pluvialis* produces an antioxidant pigment, astaxanthin, which is widely used in salmon aquaculture as a feed additive. The 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 the 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: (NEFSC)	**Name**: Dr. Gary Wikfors	**Lab/Facility**: Milford Lab
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, 2022

Results to Date: Four rounds of a two-step cultivation experiment 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 to achieve 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 the 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 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.

In multiple repeats of this experiment, 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 2-4 days out of the 6 total days. The mutant strain generally begins reaching higher cell density than the wild type by Day 3 of heterotrophic growth. The mutant K achieves a final cell density of between 2.52 x 10^5 to 2.78 x 10^5 cells mL^{-1}, and the wild type achieves a final cell density of between 1.92 x 10^5 to 2.61 x 10^5 cells mL^{-1} (

Figure *2*A). Optical density data corroborated this trend (

Figure *2*B). These results also coincided with faster acetate consumption, and consequently a higher acetate consumption rate demonstrated by the mutant K in comparison with the wild type (

Figure *2*C-D). Wild type and mutant samples harvested at 0, 24, and 48 hours of heterotrophy have been sent to DeltaOmics for proteomic and phosphoproteomic analysis to investigate differential protein and phosphoprotein expression of the acetate metabolism biosynthesis pathway between the strains.

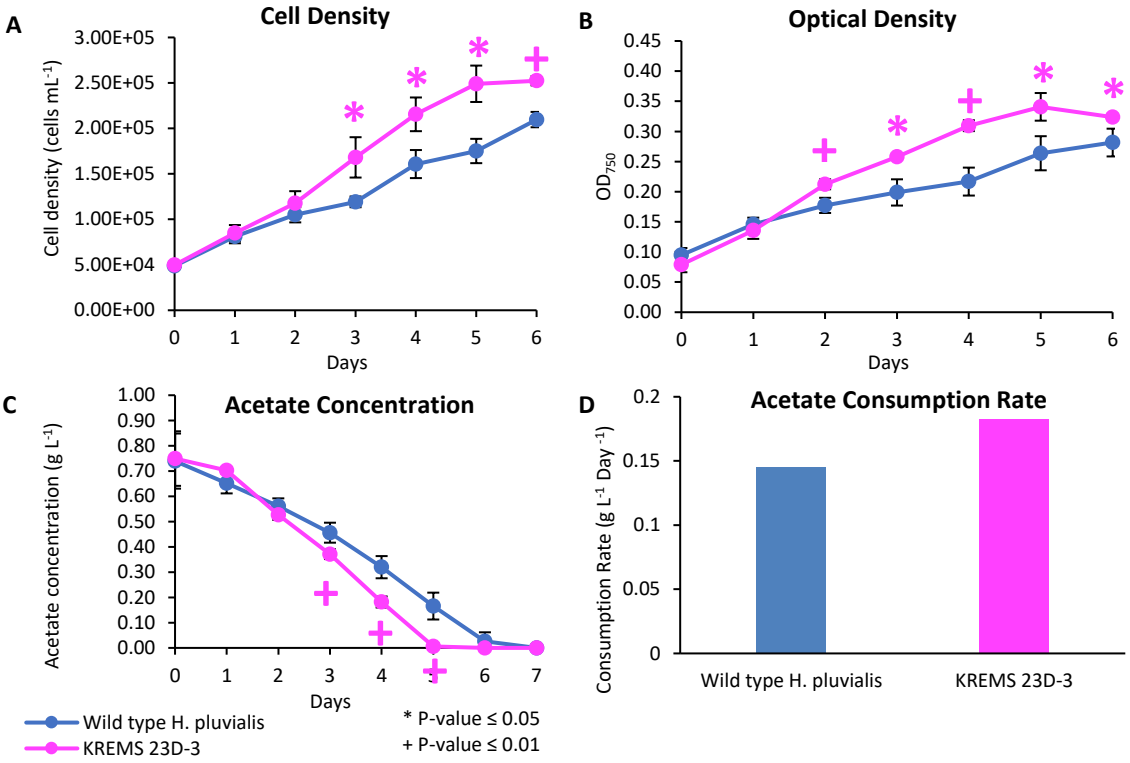

Figure 2: Enhanced mutant heterotrophic growth and acetate consumption rate.
A) Mutant K began to achieve higher cell densities than the wild-type starting on Day 3 of heterotrophic growth and continued to achieve higher cell densities with statistical significance through the rest of the growth period. B) Optical density data corroborates cell density data. C) Mutant K began to deplete the acetate in the growth media to a greater extent starting on Day 3, completely depleting the medium of acetate by Day 5. The wild-type did not deplete acetate until Day 6. D) The acetate consumption rate is calculated as a linear trend between Days 2-4 when the R^2 value was closest to 1 (best fit to linear trendline). Here, the rate (g L^{-1} Day^{-1}) is represented by a bar graph.

Another round of this experiment will be conducted including an additional mutant candidate strain, JWHIB 27-38, which has been generated by heavy ion bombardment mutagenesis. Additionally in this repeat, the cell density of all strains will be adjusted to the same starting level before high light induction to remove cell density as a variable at the start of high light induction. Cell density adjustment will be achieved by increasing the volume of cultures with supernatant from a spare culture.

Finally, the transcriptomic analysis will also be conducted on harvested samples to corroborate proteomic and phosphoproteomic data. Harvested biomass samples for RNA-Seq were snap-

frozen in liquid nitrogen for 60 seconds and stored at -80°C until later processing. RNA will be extracted using a combination TRIzol followed by Qiagen Plant RNeasy Mini Kit protocol. RNA quality and quantity can be assessed using a 2100 Bioanalyzer and measuring OD260/280 and OD260/230 ratios using a Nanodrop 2000c spectrophotometer. At least 1000 ng of RNA, extracted from approximately 20 mL of culture, will be used for cDNA library construction. The Scotty web tool will be used to determine the number of replicates needed, the sequencing depth, and whether or not paired-end reads are necessary for the cheapest but most powerful RNA-Seq experiment. This will also determine the most appropriate sequencing platform to use, which will in turn determine the most appropriate cDNA library preparation approach.

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 the development of rational engineering strategies for improved astaxanthin production in the algae and aquaculture industry. A 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. The 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 the 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 Ph.D. 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: Data from this project will be presented as a poster at The Tenth Biennial NOAA EPP/MSI Education and Science Forum at Florida A&M University on April 6-April 8.

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

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 SASI: Stock 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 Dr. Eric Schott **Institution**: UMCES/IMET
Co-PI: Dr. Bradley Stevens **Institution**: UMES
NOAA Partner: Original partner was B. Vogt **Lab/Facility**: NCBO
Other Partner(s): Gretchen Messick at NOAA Oxford, Jorge Bauzá-Ortega, San Juan Bay Estuary Program
Graduate Student: Olivia Pares **Undergraduate Student:** TBD

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

Results to Date:
***Callinectes* life history:**

We looked at the abundance and reproductive activity of *Callinectes* sp. in the Torrecillas Lagoon. *Callinectes sapidus* was the most abundant crab in October 2020 (n=34) and January 2021 (n=26). However, in April (n= 35), July (n=33), and October 2021 (n= 31), *C. bocourti* was the most abundant crab in the lagoon (**Figure 1**). Overall, a total of 97 *C. sapidus* crabs were collected. Of those, 83 were female with a mean carapace width of 120 mm (**Table 1**). Fourteen males were collected with a mean carapace width of 108 mm. A total of 139 *C. bocourti* crabs were collected. Of those, 113 were female with a mean carapace width of 101 mm. A total of 26 males were collected with a mean carapace width of 108 mm. The third most abundant *Callinectes* species was *Callinectes similis*, with 47 crabs collected throughout the study. Of those, 29 were female with a mean carapace width of 92 mm and a total of 18 males with a mean carapace width of 111 mm.

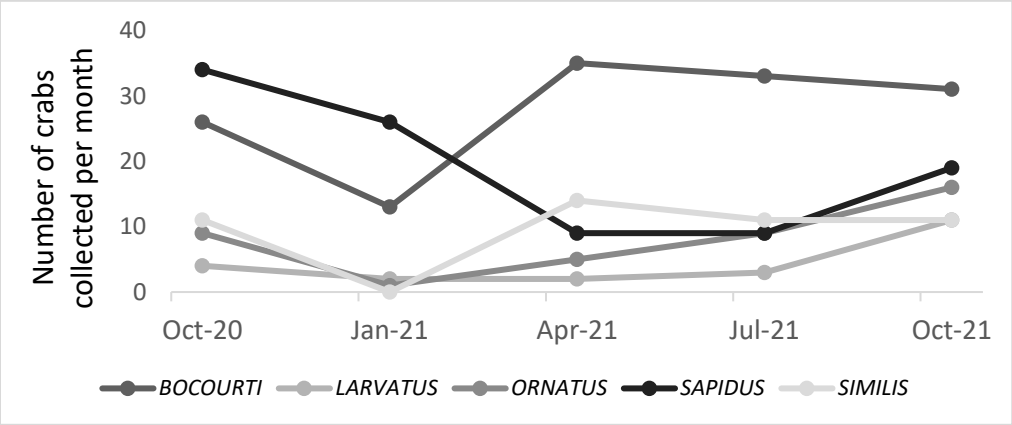

Figure 1. Number of *Callinectes* sp. collected per month.

The sex ratio of *C. sapidus* in October 2020, January 2021, and October 2021 was significantly skewed towards females ($p<0.05$). When abundance was low in April and July 2021, the sex ratio was closer to the 1:1 ratio. The sex ratio of *C. bocourti* in October 2020, April, July, and October 2021 was significantly skewed towards females ($p<0.05$). In January 2021, the sex ratio was closer to a 1:1 ratio between males and females. Mature female *C. sapidus* demonstrated spawning peaks in October, with 13-14% ovigerous females. In January, when the abundance of

Table 1. Summary of the mean carapace width of male and female *Callinectes* sp. and total species collected.

Species	n	Male	Female	Mean CW± SE- Males	Mean CW± SE
Callinectes sapidus	97	14	83	108 ± 7.6	120 ± 1.23
Callinectes bocourti	139	26	113	108 ± 1.6	101 ± 0.82
Callinectes similis	47	18	29	111 ± 2.4	92 ± 2.1
Callinectes ornatus	40	2	38	97 ± 10	102 ± 1.65
Callinectes exasperatus	5	3	2	104 ± 0.64	117 ± 17.7
Callinectes larvatus	22	18	4	101 ± 1.86	75 ± 7.18

CW: Carapace width, SE: Standard Error, n: Sample size

C. sapidus was high, only 4% of the mature females were ovigerous. Mature female *C. bocourti* spawning peaked in October and April with 20-30% ovigerous females. There was a gap in spawning in July with 0% ovigerous females.

Callinectes spp. disease ecology:

Using PCR assays specific for infectious agents, all crabs were assessed for the presence of the virus CsRV1 and the protozoan parasite *Hematodinium perezi. The* presence of CsRV1 was not found in any of the crabs. *Hematodinium* sp. was present in *C. sapidus, C. bocourti, C. similis*, *C. ornatus*, and *C. larvatus.* The overall prevalence of *Hematodinium* sp. was highest in *C. sapidus* with 40%, followed by *C. similis (27%), C. bocourti (23%), C. ornatus (21%),* and *C. larvatus (16%).* The prevalence of *Hematodinium* sp. and abundance of *C. sapidus* was highest in October 2020 and January 2021. The percent of infection of *Hematodinium* sp. in *C. sapidus* and the quantity of the species declined in April compared to the other months (Figure 2). *Hematodinium* sp. was not present in *C. sapidus* in July, and in October of the following year, the prevalence was at 12%. The prevalence of *Hematodinium* sp. in *C. bocourti* was 35% in October 2020, with 25 individuals sampled. In January 2021, the prevalence of *Hematodinium* sp. increased to 64%, while the abundance of *C. bocourti* reached its lowest at 11 individuals sampled. In the following months, the quantity of *C. bocourti* remained at over 20 individuals while the prevalence of

Hematodinium sp. continued to decline each month.

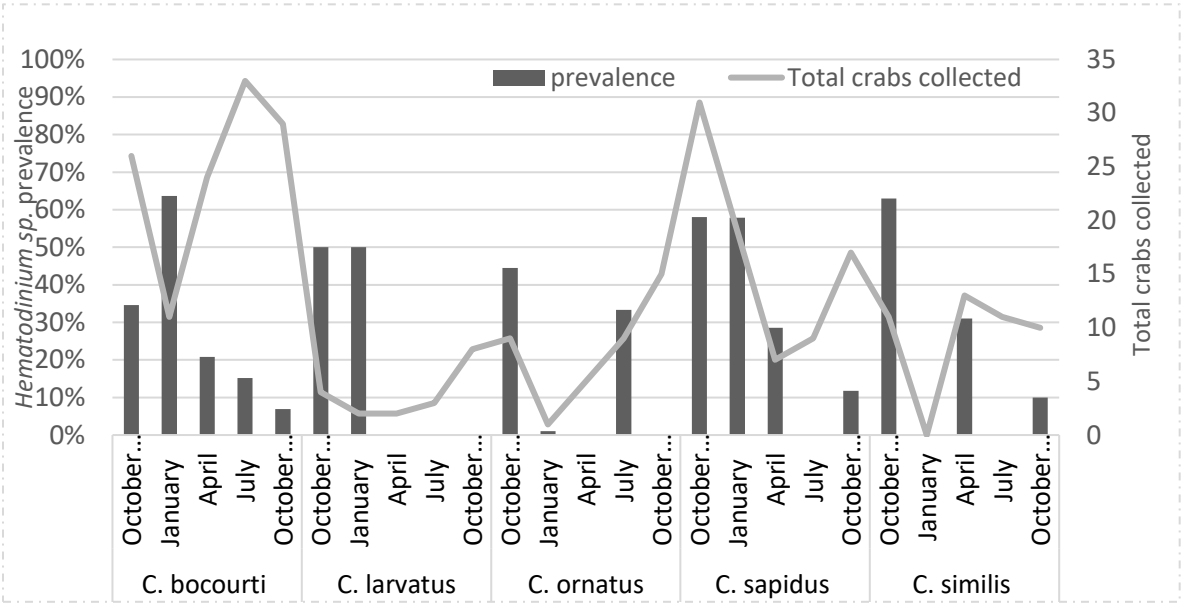

Figure 2. Prevalence of *Hematodinium* sp. in all *Callinectes* spp. hosts, and number of *Callinectes* spp. collected per month.

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 fishers, which may shift effort to/from other critical fisheries of spiny lobster and conch as those species become more or less abundant.
Broader Impacts: Communications with managers in PR DNR, ISAMR (a program of The Park School Baltimore), students at San Juan Schools, information exchanged with artisanal fishers of *Callinectes* spp.; information exchanged with a charter boat captain (Armando, at Magic Tarpon) who has come to trust Olivia Pares over the five trips that she made on La Torrecillas estuary.

Presentations & Publications: (from Sept 2021 to Feb 28, 2022). None.
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

Project Number 20-06
Title: Investigating the effects of climate change on heat shock proteins and development in 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 on the drivers of these changes in bioenergetics and in gene expression during the early life history stages of this species. Our 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 Island.

Principal Investigator: Janelle Layton
Co-PI: Scott Heppell
NOAA Partner: Steve Gittings
Graduate Student: Janelle Layton

Institution: Oregon State University
Institution: Oregon State University
Lab/Facility: Silver Spring, MD
Undergraduate Student: NA

Start Date: 09/2020

End Date: 09/2022

Results to Date: Graduate student has successfully completed her research review. Research progress was delayed by 1 year because of covid restrictions. Sample collection has been completed during the months of January and February of 2022. Currently in the process of analyzing samples preserved in formalin and finalizing heat shock protein analysis procedures.

Relevance to NOAA: As stated in the request for proposals for this funding mechanism: "The LMRCSC will conduct research that supports effects of climate on the distribution and production of living marine resources, including reproduction, growth, mortality, diseases and contaminants, and sustainability." We will specifically 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 in tropical water. 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. Given that Nassau Grouper are part of the management portfolio of three different Fishery Management Councils (SAFMC, GFMC, CFMC), these results have a direct impact on a federally managed species.

Broader Impacts: The results of this study will help us evaluate the physiological response of early life stage Nassau Grouper to thermal stress both at the population and individual level. The individual variability could be extremely important, because if there is phenotypic variability in response, then it would directly argue for maintaining as large and diverse a genetic pool in the population as possible so that the species has the highest probability of success in adapting to a changing climate. Furthermore, this work will determine whether HSPs may be used as (1) a tool for better understanding morphological and physiological changes in the early life history of Nassau Grouper and (2) novel biomarkers for future climate change studies in marine organisms.

Presentations & Publications:
Janelle Layton, Scott Heppell, Alli Candelmo, Brice Semmens, Christy Semmens, Brian C. Stock, Lynn Waterhouse, Croy M. McCoy, and Bradley Johnson. Investigating the Impacts of Increasing Temperatures on Early Life History Stages of Nassau Grouper. American Fisheries Society 151st Annual Meeting. Baltimore, MD November 6-10, 2021 – Poster

Janelle Layton, Scott Heppell, Alli Candelmo, Brice Semmens, Christy Semmens, Brian C. Stock, Lynn Waterhouse, Croy M. McCoy, and Bradley Johnson. Investigating the Impacts of Increasing Temperatures on Early Life History Stages of Nassau Grouper. Submitted for presentation at the 2022 NOAA EPP Forum. Tallahassee, FL April 6-8, 2022 – Poster

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

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 posting 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: Imani Wilburn, University of Maryland Eastern Shore
Co-PI: Dr. Maurice Crawford, University of Maryland Eastern Shore (UMES)
NOAA Partner: Dr. Ashok Deshpande, NEFSC: Northeast Fishery Science Center
Other Partner: Dr. Kausik Das, The University of Maryland Eastern Shore
Students: Imani Wilburn (MS, UMES)
Keywords: Fisheries; Microplastics
Start Date: 6/1/2020 **End Date:** 12/31/2021

Results to Date: I have been able to collect almost 800 fish that currently need to be processed, both from the Northern bays and the Southern bays. I was also able to collect fish from the Delaware Inland Bays that have 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 have been excluded from the study. The data I am prepared to report on are in the tables below.

Total Number of Fish Collected

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 goalof NOAA's resilient coastal communities because of my efforts to develop a method to removemicroplastics from water.

Broader Impacts

Plastics and microplastics have serious impacts on wildlife, but little is known about how it 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 begun ingesting microplastics, directly and indirectly, but the possible health effects are still not clear. Widespread presence of microplastics in fish could discourage customers from purchasing fish and negatively affect the industry. Overall, the issue of microplastics is not very 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 its 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 theCovid19 pandemic, no K-12 activities have taken place at this time.

Presentations or Publications: None to date

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

Project Number 20-11

Title: Estimating the effective population size and historical demography of leopard seals (*Hydrurga leptonyx*) in the Antarctic Peninsula

Thematic Research Area: Ecosystem change and prediction

Abstract:

The leopard seal (*Hydrurga leptonyx*) is an apex marine predator in the Antarctic ecosystem with a determinant role in ecosystem functioning through top-down control of other mesopredator prey. Recently, summer leopard seal sightings have steadily increased in the Northern Antarctic Peninsula (NAP), where they predate Antarctic fur seal (*Arctocephalus gazella*) pups at high rates, partially contributing to this species population collapse in the NAP. Leopard seal abundance is difficult to estimate directly because observational surveys are costly and hold a high degree of uncertainty. Therefore, population trends are largely unknown. In this study, we used molecular genetic methods to estimate the effective population size (N_E) and historical demography of leopard seals. We sequenced a 405-base pair (bp) fragment of the mitochondrial DNA (mtDNA) control region of 90 seals sampled at the NAP by the US Antarctic Marine Living Resources Program (US

AMLR) during the austral summers of 2008 – 2019. Our genetic diversity assessment revealed moderate to high nucleotide and haplotype diversity relative to other Antarctic ice seals (π= 0.013; Hd= 0.96). We estimated a theta value (Θ = 0.039), which resulted in a large N_E > 500,000 individuals. Our analyses also rejected the null hypothesis of constant population size (Fu F*s* = –14.76) with a demographic expansion around 35,000 years before present (YBP; τ = 3.64). This timing of expansion contrasts the pattern of Pleistocene population increase estimated to have occurred earlier in the Pleistocene for other Antarctic ice seals. Our study provides valuable baseline population estimates for a poorly known apex predator in one of the most rapidly warming regions of the planet.

Principal Investigator: Dr. Carolina Bonin
Co-PI: Dr. Eric Lewallen
NOAA Partner: Dr. Douglas Krause
Graduate Student: Arona Bender
Institution: Hampton University
Institution: Hampton University
Lab/Facility: NOAA SWFSC AERD
Undergraduate Student: Kathryn Cruz

Start Date: 01/13/2020 **End Date:** 05/08/2022

Results to Date:

We successfully obtained mtDNA control region sequences from 90 leopard seals (405-bp fragments). The number of different haplotypes was 34, with 16 (47.1%) represented by one individual. A TCS haplotype network was used to visualize the relationships among the unique mtDNA haplotypes. Haplotypes at the opposite edges of the network were separated by more than 23 mutational steps apart. In addition, the network reveals a split of haplotypes into two main haplogroups (haplogroups A and B), and the absence of intermediate haplotypes (Fig 1). These findings are suggestive a large population with individual leopard seals likely coming to NAP from divergent locations around the Antarctic continent.

The estimate of haplotype diversity was large (0.96) and approaching 1.0, and nucleotide diversity was 0.013 (Table 1). Using the parameter theta (Θ = 0.039) and a mutation rate (μ) for the mitochondrial control region for pinnipeds of 7.5×10^{-8} substitutions/site/year, the effective female population size was estimated at 260,000. Assuming a 1:1 sex ratio, the total effective population size obtained was 520,000 (Table 2). Neutrality tests were run yielding a significant negative Fu *Fs* value (P < 0.01), which is indicative of population expansion. Mismatch distribution estimates were not different significantly from a unimodal mean pairwise difference distribution suggesting leopard seals past sudden abundance increase (Fig 2). The peak of the unimodal distribution (τ) was 3.77, and a low Harpending's raggedness value of 0.008 (P = 0.69) corroborating our findings of past population expansion (Table 3). The reconstruction of the historical demography of female effective population size over time was conducted within a Bayesian framework. The pattern revealed was one of a gradual increase in abundance followed by a recent sudden increase around 35,000 years ago (Fig 3). This period coincides with an epoch of intense glaciation.

Table 1: Standard genetic indices of leopard seals. Number of specimen (N), number of haplotypes (h), number of singleton haplotypes and percentage of singletons (n singletons; percentage), haplotype diversity (Hd), nucleotide diversity (π).

Genetic parameter	Value
N	90
h	34
n singletons (percentage)	16 (47.1%)
Hd	0.96
π	0.013

Table 2: Effective population size of leopard seals. Estimations of theta (Θ) with lower and upper bounds (95% CI), female effective population size (N_{EF}), and effective population size (N_E) with lower and upper bounds estimated from Θ.

Index	Value	Lower bounds	Upper bounds
Θ	0.039	0.027	0.053
N_{EF}	260,000	180,000	353,333
N_E	520,000	360,000	706,666

Table 3: Analysis testing for recent population expansion of leopard seals. The distribution of pairwise haplotype differences (mismatch distribution) for recent population expansion in leopard seals. Fu's test of selective neutrality (Fu *Fs*), sum of squared deviations and significance (SSD), Harpending's raggedness index and significance, and peak of pairwise distribution (τ).

Index	Value	P-value
Fu *Fs*	-14.76	(0.00)
SSD (Mismatch)	0.003	(0.58)
Raggedness	0.008	(0.69)
τ	3.77	–

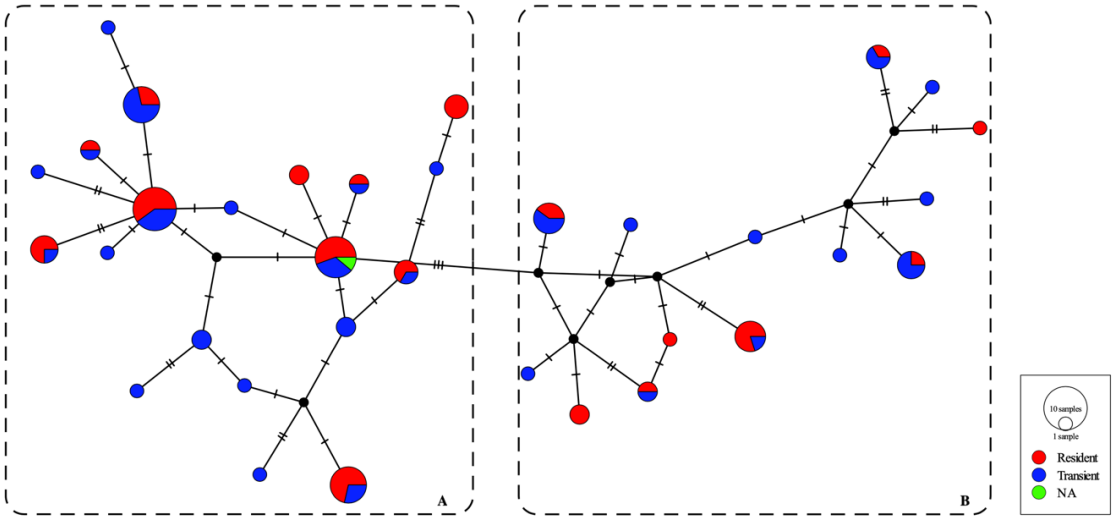

Fig. 1. Mitochondrial DNA haplotype network. A TCS haplotype network of the 34 leopard seal haplotypes color-coded according to their residence status. Circle size is proportional to the haplotype frequency with red indicating resident samples and blue transient. Each dashed line corresponds to a mutational step. Network reconstruction was split into two haplogroups A and B.

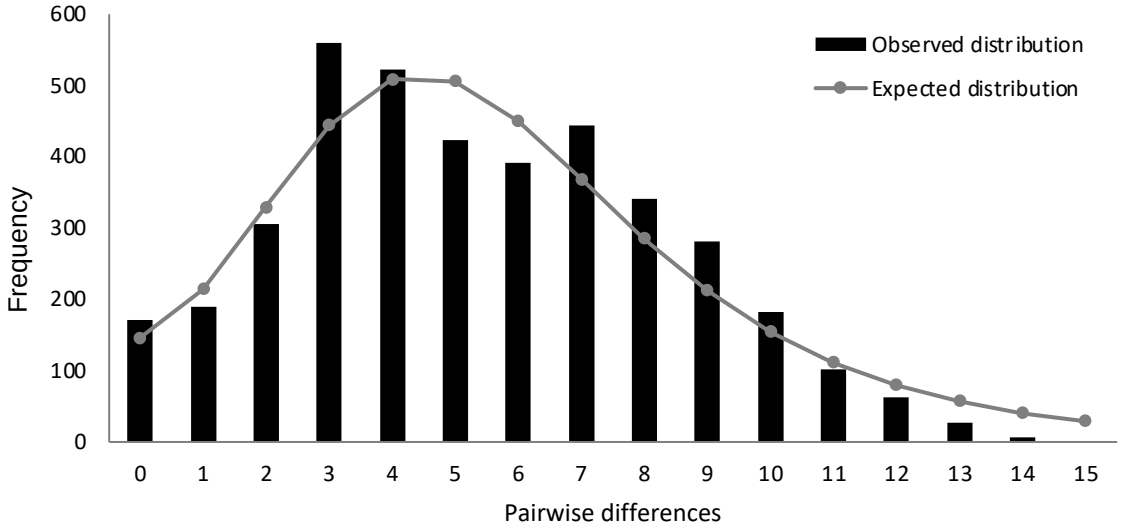

Fig. 2. Distribution of pairwise nucleotide differences for leopard seal. Bars indicate observed distribution of pairwise differences, while the grey line shows the expected distribution modeled for sudden population growth. Note the conformance of observed data to the sudden growth model distribution.

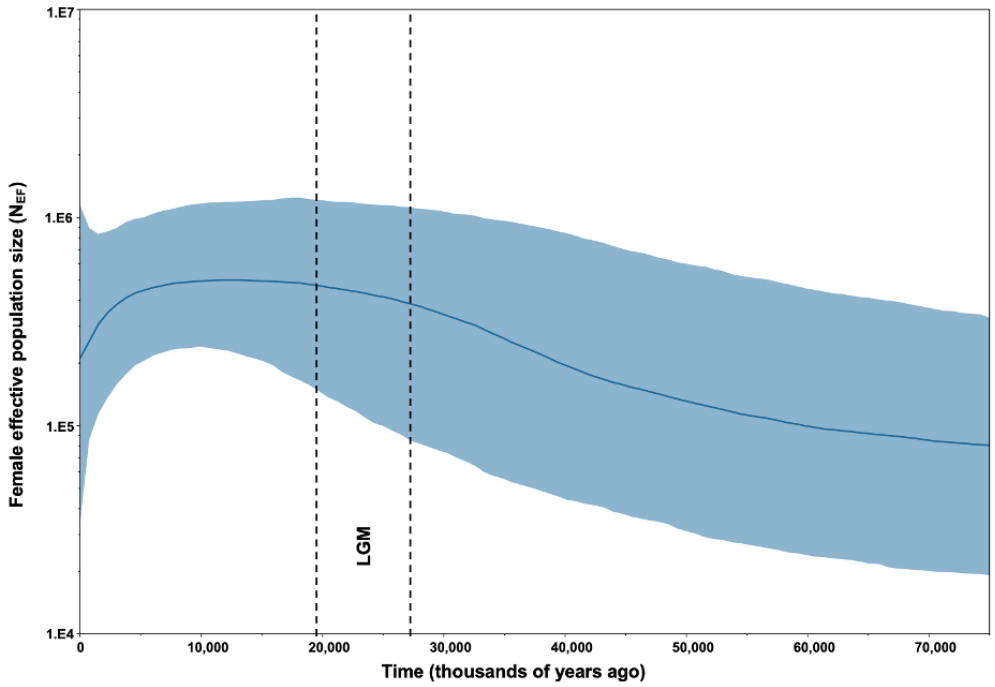

Fig. 3. Population trajectory of leopard seals over the last 75,000 years. Bayesian skyline plot showing $N_{EF}T$ ($N_{EF=}$ effective female population size; T= time indicated in thousands of years ago) changes through time in *H. leptonyx* population. The blue line illustrates the median estimate, and the blue color block represents the 95% highest posterior density.

Relevance to NOAA: This research will provide valuable genetic data and population abundance information on leopard seals, who are known to exert top-down control in other key Antarctic species, which can serve as a foundation for scientists to determine future scenarios in one of the most rapidly warming areas in the globe.

Broader Impacts: NOAA ALMR provides fundamental data to support the ecosystem-based management approach for Antarctic Living Resources and this project fits into their goal of fulfilling their mission, which is established by Federal Mandates and the Antarctic Treaty.

Presentations & Publications:
Bender, A.N., Krause, D., Goebel, M., Lewallen, E., Bonin, C. 2022. Genetic approaches to monitor effects of climate change on leopard seals in the Antarctic Peninsula. NOAA EPP/MSI Forum, Florida A&M University, Tallahassee, FL, April 2022. Oral Presentation (*Future)

Bender, A.N., Krause, D., Goebel, M., Lewallen, E., Bonin, C. 2022. Estimating the effective population size and historical demography of leopard seals (*Hydrurga leptonyx*) in the Antarctic Peninsula. Presented at the Ocean Sciences Virtual Meeting, February 2022. Oral Presentation

Bender, A.N., Krause, D. 2021. Initial analysis of the foraging tactics and social behavior of Antarctic fur seals (*Arctocephalus gazella*) from animal-borne HD video footage. Presented at Antarctic Ecosystem Research Department Science Friday Meeting, August 2021. Oral Presentation

Bender, A.N., Lewallen, C. 2021. Estimating effective population size and historical demography of leopard seals (*Hydruga leptonyx*) in the Antarctic Peninsula. Presented at Hampton University School of Science 25th Annual Virtual Research Symposium, April 2021. Oral Presentation

Bender, A.N., Lewallen, C. 2020. Genetic approaches for monitoring the effects of climate change on Leopard Seals *(Hydrurga leptonyx*) in the Antarctic Peninsula. Presented at the NOAA LMRCSC Graduate Seminar Series Virtual Meeting, December 2020. Oral Presentation

Bonin, C., Lewallen E., Barreto, F., **Bender, A.,** Cruz, K., Krause, D., Goebel., M. Genetic approaches for monitoring the effects of climate change on leopard seals in the Antarctic Peninsula. NOAA EPP Virtual Meeting, April 2020.

Project Number 21-01
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 the 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: Tunde Adebola **Institution**: Hampton University
Co-PI: Eric Lewallen **Institution**: Hampton University

NOAA Partner: Howard Townsend **Lab/Facility**: Oxford, Maryland
Graduate Student: Noah Tait **Undergraduate Student:**

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

Results to Date:
We were able to successfully recruit a graduate student, Mr. Noah Tait, in the spring semester of 2022. Noah will be presenting preliminary work that is based on our TAB research grant at the EPP Forum and HU School of Science Symposium this spring. He is also conducting research through the NERTO program in the summer under the guidance of Dr. Howard Townsend. We began preliminary code construction for an AI plugin last summer 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.

Relevance to NOAA: We propose the use of cutting-edge technologies that will be at the intersection of ecological, behavioral, and social science with the potential of improving our understanding of how human behaviors impact 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 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 research centers including the RASMAS program at the University of Miami, and with researchers across the US and beyond as this project grows and improves over time.

Presentations & Publications:
Noah will present preliminary work on the model we are developing during the EPP Forum in Florida and at the HU School of Science Symposium next week.

Project Number 21-02
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) to provide 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 v. 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. Dave Secor **Institution**: UMCES/IMET
Co-PI: Name: Dr. Rose Jagus **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

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 abundancies 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.

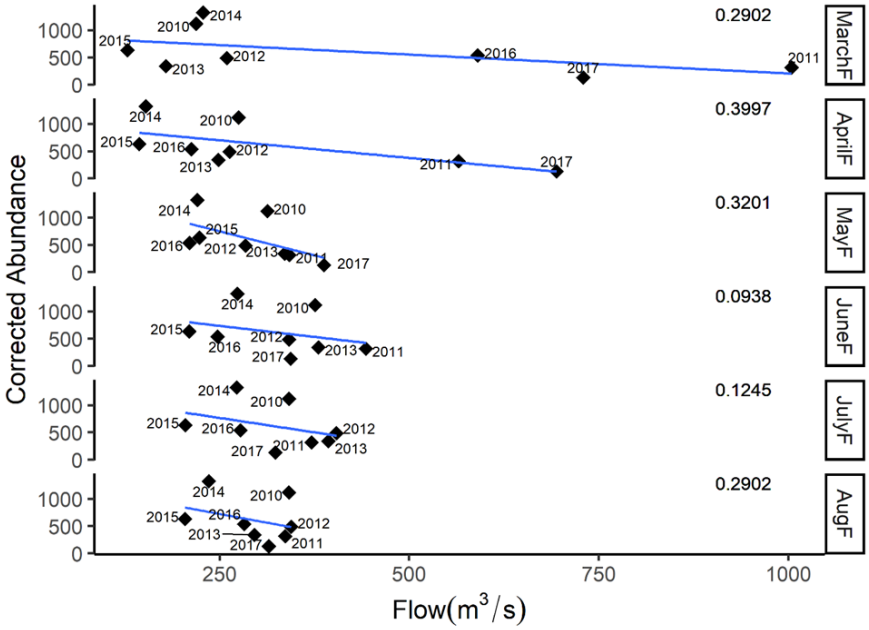

Figure 2. Scatter plot showing the relationship between average monthly flow and annual abundance from 2010 to 2017. R-squared values each month are represented in the top right of each graph.

Experimental pond trials to assess limitations in the ability to distinguish sturgeon and gar targets from ARIS images were conducted on March 28, 2022 at the UMCES Horn Point Laboratory (Figure 3). Eight individual Atlantic sturgeon and longnose gar were placed in floating pens and imaged by the ARIS at two distances: 4 m and 8 m. During each treatment, fish were imaged for 3 five minutes to document swimming style and the morphological details of acoustic images. After imaging, each fish was assigned a unique number and measured for total length. LMRCSC Fellow Coleman will analyze these videos and record differences in swimming styles, morphological features, and length estimates from ARIS to reduce the uncertainty in the identity of acoustic targets less than 1.2 m.

Figure 3. Trials to evaluate species identification and length estimation using ARIS camera system.

Floating pen within pond held individual sturgeon and gar.

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

Coleman, N.C. and Dudley, P.N. (2021). Using DIDSON to estimate green sturgeon abundance in the Sacramento River. Oral Presentation at the Interagency Ecological Program, Sturgeon Project Work Team Biannual Meeting. August 6th, Santa Cruz, California.

Coleman, N.C., Lankowicz, K.M., O'Brien, M.H.P., Secor, D.H. (2021) Using Adaptive Resolution Imaging Sonar (ARIS) to estimate the fall spawning run of Atlantic sturgeon in the Nanticoke River-Marshyhope Creek. Poster Presented at American Fisheries Society 151st Annual Meeting. November 6-10, Baltimore, Maryland.

Coleman, N.C., Lankowicz, K.M., O'Brien, M.H.P., Secor, D.H. (2022) Using Adaptive Resolution Imaging Sonar (ARIS) to estimate the fall spawning run of Atlantic sturgeon in the Nanticoke River-Marshyhope Creek. Oral Presentation at American Fisheries Society Tidewater Division. March 24-26. Nag's head, North Carolina.

Appendix III: Leveraged funds

Source	Type	Start date - end date	Total amount	Current 6 month period	PI	Project title	Contribution to Center
DE EPSCOR	Grant	2019-2024	5.8M	$5,000	Cherese Winstead	EPSCOR	Funding for student travel.
NSF-HRD	Grant	09/01/19-08/31/22	$400,000	$10,000	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 Gibson, and student internships.
NSF	Grant	8/1/18-7/31/22	$741,820	$150,000	Cuker and Lewallen	Multicultural Diversity in the Aquatic Sciences	Funds are used to support students to ASLO conference.
NSF-OCE	Grant	5/1/21-4/30/26	60,500	$0.00	Gibson	Cold Tongue Mixing	Funds will be used to support student travel for research in Ghana summer 2023.
NSF-BIO-IOS	Grant	8/1/2019 - 7/31/2024	700,000	$10,000	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	8/1/2020-7/31/2023	$299,999	$5,000	Lewallen	Epigenomic adaptations of dolphin skin	Research topics and supplies provided for

							LMRCSC funded student
NSF GRFP	Fellowship	Fall 2023-Fall 2026	$153,000		Janelle Layton		Will support her to PhD
Bonnevile Power Administration	Grant	2019-2023	$35,000	$25,000	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	$55,000	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
Shark Conservation Fund via Dalhousie University	Grant	7/1/2021-6/30/2025	$82,500	$16,500	Elizabeth Babcock	Unlocking the global shark meat trade	Provides partial salary support for E. Babcock
CIMAS	Grant	Sept 2021-Aug 2022	$98,396	$24,599	Elizabeth Babcock	Bycatch estimation project	Funding supports one MS student and partial salary support for E. Babcock
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

NOAA Ocean Acidification Program	Grant	Oct. 2021-Sept. 2024	$182,305.7	$30,384	J. Leo, J. Doerr, C. Hintz, D. Hoskins-Brown, M. 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	$16,422	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			K. Cobb, J. Gambill, P. Omunga, M. McClain	Harnessing sea level sensors as tools for advancing climate justice in coastal Georgia communities	Partial salary for Young, program support
Anonymous Donor	Award	01/01/21-12/31/21	$20,000	$20,000	R. Jagus	Contribution to the IMET Summer Internship program	Funding supports IMET Summer Internship, 2021
Bunting Foundation	Award	01/01/21-12/31/21	$50,000	$50,000	R. Jagus	Contribution to the IMET Summer Internship program	Funding supports IMET Summer Internship, 2021
Charles & Lois Miller Foundation	Grant	2/1/21 - 1/31/22	$10,000	$10,000	Russell Hill	Contribution to the IMET Summer Internship program	Funding supports IMET Summer Internship, 2021
Department of Energy	Grant	09/2020 – 09/2023	$3,000,000	$500,000	Li, Chen, Hill	A Highly Efficient Microalgae-Based Carbon Sequestration System to Reduce CO2 Emissions from Power	Research activity involves REU students from URM

						Plant Flue Gases	
Jim and Patty Rouse Foundation	Grant	4/15/21 - 5/15/25	$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	8/7/19 - 6/30/22	$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	05/2021-04/2022	$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
Ratcliffe Foundation	Grant	7/1/14 - 6/30/23	$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

NSF	Grant	9/1/2016 –8/31/22	$5,000,000		P. Chigbu; M. Sexton; A. Ishaque; S. Parveen; M. Xia	CREST Center for the Integrated Study of Coastal Ecosystem Processes and Dynamics	Funds support PIs salaries, students, research
NSF	Grant	2/23/2021 -2/22/24	$323,985	$54,000	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	$5,278	P. Chigbu	Student Airborne Science Activation for MSI (SaSa) for training students in remote sensing	Funds support student training
Stephenson Pope Babcock Foundation	Grant	1/1/20 - 12/31/21	$8,000	$2,896	Feng Chen	Microbial communities on microplastic particles in marine environments	Funds support IMET outreach and interns

Appendix IV: LMRCSC External Evaluation: Year 6 Mid-Year Report

LMRCSC Year Six Mid-Year Report
March 15, 2022

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 was submitted with the project proposal for review and approval by NOAA EPP. During year five, there were substantial impacts to the LMRCSC due to the SARS-COVID Emergency Response conditions which have been

implemented across the nation. These were described in the annual report for year five submitted in early fall 2021. These responses included shifting of face-to-face activities to online communications methods, and numerous program planning and implementation complications which affected student research, access to laboratories and other research settings, and program participation and travel. Due to these responses, NOAA EPP issued a one year, no-cost extension to the LMRCSC to continue and finalize planned activities for the project period.

This current report is the mid-year, abbreviated summary of continued evaluation efforts in this sixth year. As in previous years, the first half of the year included collection of impact assessments from undergraduate and graduate students. In addition, a revised workshop focused on student data skills, i.e., the Data Carpentry workshop, was implemented in fall 2021, to include both internal and external impact survey data collection from participants. These data are summarized for this mid-term report below.

Undergraduate Student Impact Survey

A group of six undergraduate students representing Hampton University, Savannah State University, and the University of Maryland-Eastern Shore, completed a mid-year survey to identify perceptions of the program and potential impacts on their educational and career trajectories. Five indicated they are pursuing degrees in Marine and Environmental Sciences or (one) Environmental Sciences. Each has remained confirmed in their selection of college major—which is atypical as the normal pathway for undergraduates is to exhibit regular changes of major.

Item five on the survey asked students for their career goals. Two indicated research, two indicated work as environmental lawyers, one each in environmental consulting and resource management. The students' motivation for careers in science (item six) seemed highly related to environmental and global stewardship issues. Respondents perceive a value-laden focus to science careers. Interestingly, even though they are undergraduates, four of the six describe research or field experiences (item eight) in which they have participated under the funding or auspices of the LMRCSC. This is a stronger response from undergraduates and suggests a growing refinement and expertise in the education programs for LMRCSC and particularly in the communications efforts to link, in the minds of students, their college experiences with LMRCSC as an umbrella entity.

Items nine and ten solicited descriptions of any professional mentors which the students/respondents had. Three of the five respondents to this item noted undergraduate professors as fulfilling this professional role for them. This is a valuable observation from a programmatic standpoint. LMRCSC leadership may wish to consider whether there is sufficient outreach to the undergraduate faculty members at the respective institutions about the need for student mentoring, with orientation on the LMRCSC and opportunities connected to it, as well as further professional opportunities through LMRCSC for the faculty members themselves.

Finally, in this pool of questions, item eleven revealed that four of the six respondents had received LMRCSC orientation and information from faculty members or program representatives at their home institutions. This observation addresses the question of administrative effectiveness of the LMRCSC and suggests that communications and program orientation, recruitment, and onboarding of students is occurring and embedded down into the institutional faculty level.

Items twelve through seventeen sought to identify pre- or co-collegiate/co-curricular activities related to science among the responding pool. These have been found in related research in science career pipeline issues to have some relationship with students choosing or persisting in the STEM employment pipeline. While this response pool was small, interesting observations in response data include little family background for STEM careers for these students, but some evidence of involvement in other STEM related activities beyond the LMRCSC project. There was evidence of family encouragement for STEM careers from parents and grandparents. One individual participated in an REU program.

Item eighteen reflects that these respondents believe there are strong employment possibilities for STEM careers which they are pursuing.

Item twenty asked respondents to identify other potential activities of interest which could be offered by the LMRCSC. Among the activities suggested were visits to other LMRCSC institutions,

additional workshops for statistics, policy or justice issues, and scuba diving or other research opportunities. The respondents perceived (item twenty-one) that these additional activities would supplement their knowledge and also have important social affects by linking students with other LMRCSC participants and institutions.

Item twenty-three asked respondents how their knowledge of NOAA had changed over the recent year. This item is related to one of the mission objectives of the LMRCSC for communication of NOAA mission and research objectives to students in the LMRCSC. Three of the respondents answered this item and provided detailed information. One had served as a NOAA/EPP fellow over the previous year. One specified that a workshop offered by LMRCSC provided NOAA information. A final respondent simply noted affirmatively that his/her knowledge of NOAA had increased without specifying a source of this knowledge.

Items twenty-four through twenty-six solicited additional information specific to the LMRCSC more broadly. Four of the six respondents reported little interaction with other LMRCSC institutions. All six of the respondents reported high to medium knowledge of LMRCSC as a NOAA EPP network—a strong response and further evidence of effective administrative/communications efforts in the LMRCSC. And finally, all six reported high levels of interest in continuing involvement with LMRCSC through a potential alumni organization in the future.

The remaining items, twenty-seven through thirty-two, suggest that these respondents continue to have some concerns about support structures for transitioning to graduate school, even though all six report a high level of interest in doing so. Some of their concerns relate to preparing for the GRE and identifying and transitioning to graduate schools and programs. There is evidence in these questions that many of these respondents are already interacting with graduate students and obtaining some input from program leadership and faculty at their institutions.

Graduate Student Impact Survey

A larger response pool—eighteen individuals—was obtained from the graduate students for the mid-term cycle of survey collection. It may be that this far into the program, the graduate students have grown more accustomed to receiving these information requests from the evaluation team, or simply may be more mature in viewing this as a professional responsibility and reality in the workplace. There was wide distribution of the respondents across the LMRCSC, with each of the institutions having representation in the response pool (there may have been some misinterpretation of the “home school” question, so some individuals may have pointed back to an undergraduate home school as alumni. Thirteen of the respondents are seeking MS degrees, and five are seeking Ph.D. degrees. The primary content disciplines for all of these students are marine related, suggesting strong success in the recruitment processes for LMRCSC, and a strong NOAA-aligned academic and research focus. None of the respondents have changed their focus while working within the LMRCSC. All reported undergraduate preparation in related disciplines including marine science, biology, environmental science or oceanography. One outlier is an individual respondent out of nutritional sciences tied to an agricultural orientation. Each of the respondents (item six) identified future career orientations pertaining to the professoriate or research positions, either for a university or a government agency. Three respondents specifically named NOAA as a future opportunity for employment, although most of the other responses align with NOAA mission science.

Item seven asked respondents to describe how and when they began considering a career in science. Again, this type of background information can be useful in formulating an effective recruitment plan. The largest cluster of responses (n=6) pointed back to childhood, followed by high school (3) or middle school (2) as the time when perceptions of science careers or desires for science careers began to form. This is a critical observation, as there remains some institutional perception, particularly in the federal science agencies, that targeting career recruitment education and outreach below the undergraduate level is not a valuable use of funds. For this group of graduate students pursuing STEM careers, those decisions formed in childhood and adolescence were crystalizing and powerful.

Item eight asked respondents *why* they wanted to pursue a career in science, seeking to ascertain motivation. The most interesting and powerful cluster to emerge from these response data using content analysis were the ideas of *meaning and passion*. Although the specific vocabulary differed—terms such as love, passion, joy, happiness, fun and related terms—the emergent motivation was very similar. Students perceived an affective, positive response when thinking about a STEM career. Several used the terms meaningful or fulfilling. These ideas are thoroughly consistent with adult learning principles, where adult and young adult students pursue life goals through an attachment of personal fulfillment and meaning to the pursuit. Again, this observation may be useful in planning education programs for these young adults and as an additional theoretical framework (adult learning theory) to describe the important work of the LMRSC.

Items nine through thirteen prompted very rich and lengthy narrative responses from these graduate students which described a wide range of research and/or field experiences in which they had participated as a result of LMRCSC. Clearly, this reflects that LMRCSC is aligned with and supporting NOAA Mission Science concerns in the opportunities that it is providing to its graduate students. The respondents also described powerful mentorship experiences which they had had, many of which came through LMRCSC personnel or undergraduate or graduate course faculty. Several respondents mentioned their NERTO mentors. And LMRCSC personnel, Dr. Chigbu, Dr. Dionne Hoskins-Brown, Dr. Rose Jagus, Dr. Liz Babcock and Dr. Victoria Young were mentioned specifically as valued and valuable career mentors. As a final note, it seems clear from the responses that these graduate students indeed view the NERTO assignment as an authentic and valuable research experience which has supported them professionally. Finally, thirteen of seventeen responses had received orientation to LMRCSC formally from someone at their home institution, with four additional respondents stating that they were unsure whether they had received orientation or not. Again, a positive reflection for the administrative functions of communication.

Items fourteen and fifteen sought to identify whether these graduate students had a "track record" of participation in STEM related activities from high school forward through college. The responses were rich and inspiring. The data reflect a veritable "who's who" of the national or regional, federally funded opportunities. Responses listed the EPP MSI scholarship, NOSB, the McNair Scholar program, NSF STEM Fellow programs, and REU programs. There is support for concluding that this holistic community of scaffolded STEM experiences are functioning as somewhat of an incubation system for emerging young science scholars. This complex-systems view of the formal and informal connections among these background supports for LMRCSC students certainly has contributed to these students current "moment" and should likely be researched or evaluated as contributory factors in the LMRCSC program.

Items sixteen and seventeen reveal an interesting divergent observation. While most respondents (15/18) remain in communication with key high school teachers or undergraduate faculty members, the inverse (3/18) describes these student's family members employment in STEM fields. As observed in other research, teachers at the secondary and post-secondary level can be valuable vectors for career pipeline development of young adults, even in the absence of parental support for these STEM disciplines.

Given this previous observation, item eighteen does demonstrate that parents who are not employed in STEM areas do value STEM careers for their children. Many of these graduate student respondents describe how parents encouraged their passion and interest in science. This encouragement was viewed as very important and memorable by these respondents.

Item nineteen asked respondents to gauge their employability in their chosen career aspirations. Fifteen of eighteen rated this as Very or Moderately employable over the next ten years. Previous concerns expressed by earlier students were absent in these ratings.

The next set of interesting data to emerge in the survey was in item twenty-one. Respondents identified the most engaging or significant LMRCSC activity from the past year. Several respondents listed the Data Carpentry Workshop, a significant and positive improvement in responses to data workshops or courses from previous years. Further, and again a notable positive observation, several

respondents used the term “cohort” or “cohort experience.” In earlier years, it was difficult to ascertain whether the concept for cohort relationships was being adequately “pushed down” into the awareness of students, even though it was very much a goal of the LMRCSC leadership. Refinements to workshops and orientation (which these survey data demonstrate is happening) may have contributed, or likely contributed, to this emergence of the cohort language in the survey data. These experience responses demonstrate positive administrative oversight, growth and improvement in the program, and positive impact on the students.

Item twenty-two asked respondents to explain why the previously mentioned experience was perceived as valuable. This question elicited rich and detailed responses. Several explained how the cohort experience workshop enhanced valued work skills. This comment was made about the data workshop as well. Several described the social interactions with other students, and also the ability to meet potential mentors. Given the context of Covid response that drove this experience online last year, it was interesting to observe from several comments that the experience helped them navigate and manage the “covid era.”

Item twenty-three asked respondents to name and describe the most beneficial university course which they had taken in the past year. The intent of this question was, again, to identify the integration of LMRCSC experiences and opportunities for students with NOAA Mission Science. The courses identified by the respondents indeed demonstrated this. Courses listed included Coastal Pollution, Environmental Law, Population Dynamics, Ocean Law, and Marine Ecotoxicology among others. Fourteen of the eighteen responses were from science or science policy areas which clearly matched NOAA concerns. Interestingly, other courses mentioned—Technical Writing, Programming in R, and Skills for Team Science—overlapped the professional work skills that are also objectives for the LMRCSC and NOAA EPP.

Item twenty-four drilled explicitly into enhanced student understanding of NOAA Mission Science and Fisheries Science from this past year’s experiences. Students described a number of examples of how they had grown professionally, and the full response data set it powerful. Example quotes include:

- *My knowledge NOAA mission science has been enhanced by attending conferences and seminar series that described what role different scientists played in the NOAA mission.*
- *I have been very lucky to meet NOAA scientists and to learn more about the various areas they work in at the Gulf of Maine Research Institute this summer.*
- *Becoming a NOAA EPP/MSI Graduate Fellow helped me understand how my role as a NOAA supported student contributes to NOAA’s mission and also ways that I can enhance my contributions to NOAA’s mission and fisheries science.*
- *I actually recently had a meeting with Dr. Sexton that increased my knowledge on the mission statement and NOAA as a whole. Making sure to include MSI after EPP, how to address myself properly, and other important things to know were discussed. This year that knowledge was greatly enhanced.*

Items twenty-five and twenty-six were rating questions which reflected, as in earlier years, a perception that there was low to medium interaction with students and professors at other LMRCSC institutions (other than their home school), but a medium to high level of knowledge about the LMRSC as a NOAA EPP overall. In the former case, that response pattern is not unusual and is a function of a “home school advantage” for connections and networking. In the latter case, this seems to reflect a positive growth in the LMRCSC administrative, and communications functions this past year.

As with the undergraduate students, item twenty-seven indicates a strong interest in participating in a future potential Alumni Association for the LMRCSC. Item twenty-eight continued last year’s concern about Covid responses and revealed some concerns about a loss of work time on research, the loss of hands-on experience due to social distancing, and the compression of time for those students where they are attempting to maintain a completion calendar or schedule to finish schooling. Item twenty-nine solicited descriptions of changes at their home universities required by Covid. Again, these descriptions

validate the responses to the prior item by revealing that the most likely mitigation efforts for Covid did indeed isolate students, eliminate interpersonal contact and limit use of labs and research capability. The final item, seeking ideas for additional supports and resources, did not reveal strong clusters of similar items that would inform practice, but the evaluators encourage the leadership at LMRCSC to review these raw data responses regardless. Two respondents did suggest a common idea of writing support for theses and dissertations which might be discussed at a leadership monthly meeting.

Data Carpentry Workshop Survey

As noted in the graduate student survey responses above, there was a very positive receptivity to the Data Carpentry Workshop in fall 2021 that carried over into the general survey for the fall semester. The evaluators did develop a short survey specifically for this workshop and include it at the end of the workshop for students to garner additional, program specific information about this LMRCSC opportunity.

Item one asked respondents how many credit hours in statistics or data management they had taken prior to this course. Four respondents indicated from 1-3 hours. Five respondents indicated from 4-6 hours, and two respondents indicated over six hours. One respondent had not taken statistics or data management coursework at all prior to this workshop. This response pattern suggests a widely divergent preparation for the student group.

Item two asked how respondents perceived the course would support or had supported their NERTO or TAB projects. Each of the twelve respondents perceived a benefit and use for the content of this course—which is a significant, positive improvement from earlier iterations of the data course and reflects significant work by the LMRCSC team to create a course that accommodated the widely divergent background preparation noted above. This is a commendable accomplishment. Item three suggests that only three of the twelve perceived the course moved too quickly (these were the students with the least background preparation via credit hours in related studies). All twelve respondents (item four) asserted that the workshop would be useful for their future career and eight respondents added open comments to expand on this. Select responses included:

- *I did not know much about any statistical tests before this workshop, it was very interesting to learn about more complex functions;*
- *Being able to use R will help with data analysis and the ability to find career opportunities;*
- *I have been hearing about R and needed an introduction but didn't know where to start on my own, so this was very valuable.*

Interestingly, item five on the survey revealed that only four of the twelve respondents perceived that the course fostered their developing relationships with other students. It is likely that the instructional modality (online) and the intensity of the content and study was not orientated to social development as was the Cohort Experience course. This is not viewed as a deficiency by the students, however. The overall rating of the course (item six) did not reflect a single negative evaluation: nine respondents rated the course as excellent and three rated it at the mid-point of the scale or as okay.

The remaining items explored the various content elements of the course and student perceptions of the value and importance of these. Item seven suggested that the data visualization skills were a strong and valuable part of the course. Item eight revealed nine of the twelve respondents perceived the sequencing of materials was appropriate and came at an appropriate moment in their academic program. The negative responses were from students who had a stronger background in statistics, and likely perceived that they were already past the difficult stage of concept development in this area. And finally, item nine records that nine of the twelve perceived that the online instructional modality was extremely or somewhat effective, with only three perceiving that it was not. One respondent qualified his/her negative rating by suggesting that the negative only applied to the course section on R, and that the other materials were very effective online. The final item (ten) solicited areas for improving this experience, and the largest cluster related to the intensity of the schedule, with suggestions that perhaps it could be disseminated over a longer time frame. Nevertheless, the evaluators discount this suggestion as it is a

typical response to an intense experience, and there is no other evidence that student performance was negatively affected by the pace of instruction.

There are select, additional response data from this Data Carpentry workshop which will be reviewed holistically and included as necessary in the summer 2022, final annual report of the LMRCSC sixth year activities for this extension year. Initial review of these does not reveal any differing responses than those contained above or in the previous graduate fall survey.

Additional Evaluator Efforts (visit to SSU, participation in meetings, discussions on new evaluation plan for new funding)

As final summary of evaluator efforts this first half of the extension year, the following work effort was undertaken to maintain momentum in holistic evaluation of the LMRCSC. First, Dr. Tina Bishop visited Savannah State University and had an update conversation with Dr. Victoria Young, the LMRCSC Education Coordinator, to continue monitoring of program implementation. Second, the evaluation team regularly participated in the monthly LMRCSC Executive Committee video conference call, and on select Education Committee meetings to report formative information to the team for immediate review, and to continue to monitor project implementation. And finally, this second Covid response year has continued to foster the use of threaded email discussions and information sharing, and the evaluation team monitors and participates in these communication efforts as part of the overall administrative and communications plan.

Report Conclusions

It was a given that, with a second year of Covid emergency responses ongoing at the LMRCSC partner institutions, there was a possibility of program disruption. Nevertheless, the evaluation efforts for the first half of this no-cost-extension year reveal that the team has substantively adapted its project to the use of distancing and technologically mediated communications and work methods. Students, faculty, and team members demonstrate success in key project elements relying on these communication technologies.

Further, there is evidence that the opportunities to strengthen the LMRCSC which were identified by the external panel review have been or are being addressed. A substantively revised data course was implemented to wide acclaim by the students. Students perceive they are part of a cohort of graduate and undergraduate learners that relates to the LMRCSC as an overarching Center of which they are a part, and in which they have professional peers and colleagues across the various institutions. This should only benefit and strengthen the recruitment of undergraduate to graduate students in years to come. And finally, these revisions and others suggest a highly functioning administrative culture for the LMRCSC. The leadership team is capable of affecting positive change and program enhancement and growth as data inform their work. This is a strong finding for this midpoint in this year's effort.

Appendix V: Performance Metrics from Implementation Plan

Education Performance Metrics:

	2021/22	
Activities/Programs	**Proposed (12 months)**	**Accomplished (9/1/2021-2/28/22)**
# Students trained in NOAA related	56 (42*)	55(50*)
# B.S. Students who graduate in NOAA	6 (4*)	1(1*)
# M.S. Students who graduate in NOAA	11 (9*)	1(1*)
# Ph.D. Students graduating in NOAA	1*	1(1*)
# of internships (e.g. NERTO) at NOAA facilities	12	9
# of URM students in development activities that will lead them to attain degrees and/oremployment	12*	50
# of EPP-funded graduates who participate in andcomplete agency mission-related postdoc. Level programs	2	0
Amount of leveraged funds ($) for education andtraining	500K	$843K
# of student presentations at conferences (average)	20	9
# of student co-authored publications	10	5

Research Performance Metrics:

Activities	**2021/22**	
	Proposed (12 months)	**Accomplished (9/1/2021/28/2022)**
Science Meeting date	June	None during this period
# of collaborative research projects (TAB Proposals) funded	6 to 10	None during this period
# of new & continuing proposals funded (leveraged funding)	12	29
# of scientific presentations at conferences	50 (15*-90)	9(9*)
# of theses & dissertations produced	12	1
# of peer-reviewed publications	10*-30 (25)	9(5*)
Amount of leveraged funds ($)	$3 million	$1.03 Million
of NOAA scientists serving as mentors and advisors for student research each year	>20	42
# of intra-institutional partnerships in support of	Average	

NOAA's mission	of 4	21
# of times LMRCSC publications have been cited	Will be documented	1062 (155 from directly funded papers)

Administrative Performance Metrics:

	2021/22	
Activities	**Proposed (12 months)**	**Accomplished(9/1/21-2/28/22)**
Submission of monthly invoices to UMES	Monthly	Average time between invoices = 3.46 months
Successful execution of sub-awards (<60 days of receiving award notification from NOAA EPP)	October or earlier	N/A during no-cost extension period
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
Holding of LMRCSC Science meetings at NOAA facilities	Summer	Not during this period
Funding of collaborative research projects via TAB review process	Spring	N/A during no-cost extension period
Submission of semi-annual reports	Every 6 months	Every 6 months
Submission of student tracker data	Every 6 months	Sept. 2020
Executive Committee meetings	Monthly	Monthly
Updating of the LMRCSC Website	Weekly	Weekly
Meeting of the LMRCSC Education/Outreach Committee	Once every four months	Oct. 2021, Feb. 2022
# of featured articles in print or digital media per year referencing LMRCSC	At least 50	17

LMRCSC Budget (Amount Received, Spent and Remaining), Years 1 to 5

LMRCSC - Financial Summary

		Grant Amount	Student Support	Student Prof. Development	Non-Student
	Amount Received	$ 2,975,000.00	$ 1,490,898.27	$ 150,000.00	$ 1,334,101.73
Year 1	Amount Spent	$ 2,525,579.53	$ 1,290,064.26	$ 51,218.00	$ 1,184,297.27
	Balance	**$ 449,420.47**	**$ 200,834.01**	**$ 98,782.00**	**$ 149,804.46**
	Amount Received	$ 3,000,000.00	$ 1,497,733.50	$ 150,000.00	$ 1,352,266.50
Year 2	Amount Spent	$ 2,821,804.93	$ 1,547,568.03	$ 27,193.00	$ 1,247,043.90
	Balance	$ 178,195.07	$ (49,834.53)	$ 122,807.00	$ 105,222.60
	Amount Received	$ 3,415,000.00	$ 1,758,688.38	$ 150,000.00	$ 1,506,311.62
Year 3	Amount Spent	$ 2,500,929.05	$ 1,045,154.03	$ 79,750.00	$ 1,376,025.02
	Balance	**$ 914,070.95**	**$ 713,534.35**	**$ 70,250.00**	**$ 130,286.60**
	Amount Received	$ 3,368,841.00	$ 1,600,870.02	$ 150,000.00	$ 1,617,970.98
Year 4	Amount Spent	$ 2,294,237.02	$ 840,287.95	$ -	$ 1,453,949.07
	Balance	**$ 1,074,603.98**	**$ 760,582.07**	**$ 150,000.00**	**$ 164,021.91**
	Amount Received	$ 2,741,159.00	$ 1,420,817.05	$ 150,000.00	$ 1,170,341.95
Year 5	Amount Spent	$ 1,702,114.06	$ 531,772.11	$ -	$ 1,170,341.95
	Balance	**$ 1,039,044.94**	**$ 889,044.94**	**$ 150,000.00**	**$ -**
	Amount Received	$ 907,969.00	$ 463,453.71	$ -	$ 444,515.29
Year 5-1	Amount Spent	$ 212,365.71	$ 1,826.23		$ 210,539.48
	Balance	**$ 695,603.29**	**$ 461,627.48**	**$ -**	**$ 233,975.81**
	Amount Received	$ 800,000.00	$ 412,029.57	$ -	$ 387,970.43
Year 5-2	Amount Spent	$ 387,970.43	$ -	$ -	$ 387,970.43
	Balance	**$ 412,029.57**	**$ 412,029.57**	**$ -**	**$ -**

	Amount Received	$ 17,207,969.00	$ 8,644,490.50	$ 750,000.00	$ 7,813,478.50
Totals	Amount Spent	$ 12,445,000.73	$ 5,256,672.61	$ 158,161.00	$ 7,030,167.12
	Balance	**$ 4,762,968.27**	**$ 3,387,817.89**	**$ 591,839.00**	**$ 783,311.38**