Performance Report for Cooperative Agreement No: NA11SEC4810002
for the Period from September 1, 2015 to February 29, 2016
(Revised)

University of Maryland Eastern Shore

Living Marine Resources Cooperative Science Center

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Executive Summary

The mission of the Center is "*To develop exemplary academic and research collaborations that prepare a diverse student body for careers in marine and fisheries sciences".* Established in October, 2001, the LMRCSC was created as a cooperative agreement between NOAA Educational Partnership Program (NOAA EPP), the University of Maryland Eastern Shore (UMES), Delaware State University (DSU), Hampton University (HU), Savannah State University (SSU), the University of Miami (UM/RSMAS) and the University of Maryland Center of Marine Biotechnology now known as University of Maryland Center for Environmental Science Institute of Marine and Environmental Technology (UMCES-IMET). Oregon State University (OSU) was added to the consortium in 2011. UMES is the lead institution of the consortium.

The mission of the LMRCSC is accomplished by addressing the following goals:

Goal 1: Prepare the future workforce for marine and fisheries sciences
Goal 2: Strengthen collaborations across universities to enhance academic programs in marine and fisheries sciences
Goal 3: Develop an exemplary capacity for scientific collaborations among partner institutions in the fields of marine and fisheries sciences

The Center continues to be guided by two management tracks, A) Administrative and B) Programmatic. The Administrative component includes the Center Director, Program Manager, Executive Committee, Center Core Administration and the Board of Visitors, whereas the Programmatic component includes the Technical Advisory Board that reviews proposals submitted annually to the Center for funding.

To accomplish Goal 1, the Center recruited 18 new students, and provided direct financial support to 94 students (17 Ph.D., 36 M.S., 40 B.S.) who received training in NOAA core science disciplines during this reporting period. In addition, 22 undergraduate and graduate students, who did not receive direct support from the Center, benefited from center programs and infrastructure. 17 students graduated (9 BS, 4 MS, 4 Ph.D.) from the Center during this reporting period, and 8 students interned at NOAA labs/facilities (NOAA Sandy Hook NJ, NOAA Panama City Lab, NOAA SWFSC, NOAA AFSC Behavioral Ecology Laboratory) or labs of LMRCSC partner institutions. Among the recent graduates of the LMRCSC is Efe Oghenekaro, who is currently serving a Knauss Fellowship. Furthermore, the Center linked students to professional networks and employment opportunities in marine and fisheries science by providing support for them to attend scientific meetings such as the annual meeting of the American Fisheries Society. In order to maintain a pipeline of students into the marine sciences, the Center conducted several activities for grades K-12 which impacted 300 students.

To accomplish Goal 2, the Center used the Virtual Campus including the use of videoconferencing, Adobe Connect, Go-To-Meeting and Blackboard, for curriculum development and seminars and to offer courses to LMRCSC students. Seminars and several courses offered through the University of Maryland interactive video network (IVN) were made available to Center students during this reporting period. More than 43 NOAA scientific and administrative personnel were engaged in LMRCSC education and outreach, scientific research and administrative functions.

The LMRCSC continued its Seminar Series by featuring presentations by scientists. These seminars were made available to students and scientists at the Center and its partner institutions using Adobe Connect.

In support of Goal 3, twelve (12) projects received funding during this period. These collaborative projects address various aspects of NOAA's Next Generation Strategic Plan Goal (NGSG): "*Healthy Oceans - Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems*", and objectives: (1) Improved understanding of ecosystems to inform resource management decisions, (2) Recovered and sustained marine and coastal species, (3) Healthy habitats that sustain resilient and thriving marine resources and communities, and (4) Sustainable fisheries and safe seafood for healthy populations and vibrant communities. They also address some of the goals, objectives and priorities listed in NMFS 2007 Strategic Plan for Fisheries Research. Examples of research projects conducted by LMRCSC-funded scientists, students and NOAA collaborators include: The use of DNA barcoding technique to provide information on the diet and feeding of the commercially important Atlantic menhaden, Assessment of the performance of NOAA's montlake feed for production of Florida pompano under aquaculture conditions, and 3) the use of health and contaminant status of stranded marine mammals from coastal Maryland and the Chesapeake Bay to evaluate the role of disease and pollution on mid-Atlantic mammal mortality.

In the current reporting period, LMRCSC students and faculty made 68 presentations (oral and poster) at scientific meetings (41 of which were made by students), and published 29 articles in refereed journals and books, 7 of which were

authored or co-authored by students or graduates of LMRCSC. Through its research activities in living marine resources the Center is addressing NOAA Fisheries mission goal, to: "*protect, restore, and manage the use of coastal and ocean resources through an Ecosystem Approach to Management*".

A total of $1.3 million* was collectively awarded in grants to the LMRCSC institutions during this reporting period, which has directly impacted and will continue to have positive impacts on Center activities. These funds enhanced LMRCSC research through support of its faculty and students and by development/enhancement of infrastructure.

The foregoing indicate that the LMRCSC educational, research and outreach activities are addressing three of the five essential activities NOAA has identified as being important for the success of its mission: (i) "*developing, valuing, and sustaining a world-class workforce*", (ii) "*ensuring sound, state-of-the-art research*", and (iii) "*promoting environmental literacy*". Thus, the Center is making significant contributions to the training of a diverse body of students in NOAA related STEM disciplines that will help increase U.S. competitiveness in the global economy. The tables below summarize some of the LMRCSC accomplishments during this reporting period.

NOAA EPP Cooperative Science Centers (CSCs) Program's standardized Performance Measures:

- Number of students from underrepresented communities who were trained **(# =** 83**;** 21 **Ph.D.,** 27 **M.S.,** 35 **B.S.)** and graduated **(# =** 14**;** 4 **Ph.D.,** 2 **M.S.,** 8 **B.S.)** in NOAA-mission sciences in the past six months
- Number of students who were trained **(# =** 116**;** 25 **Ph.D.,** 38 **M.S.,** 52 **B.S)** and graduated **(# =** 17**;** 4 **Ph.D.,** 4 **M.S/PSM,** 9 **B.S.)** in NOAA-mission sciences in the past six months;
- Number of students who completed experiential opportunities at NOAA facilities **(# =** 8**);**
- Number of EPP funded students who were hired by NOAA **(# =** 2**)**, NOAA contractors **(# =** 1**)** and other environmental, natural resource, and science agencies at the Federal, State**(# =** 1**),** local and tribal levels, in academia**,** the private sector **(# =** 2**)**;
- Number of NOAA science and administrative personnel engaged in CSC Education and Outreach, Scientific Research, and Administrative functions **(# =** 43**)**
- Number of collaborative research projects undertaken between NOAA and MSI partners in support of NOAA operations **(# =** 12**);**
- Number of students **(# = 0)** and faculty **(# =** 2**)** who participated in and completed postdoctoral level research programs in support of the NOAA mission;
- Number of peer reviewed papers published in NOAA-mission sciences by scientists (faculty, postdoctoral fellows, and students) sponsored by NOAA EPP **(# =** 29**);**
- Funds leveraged with NOAA EPP funds (including student support) **(# = ~$** 1.28 **million);** and,
- Number of outreach participants engaged in NOAA mission relevant learning opportunities **(**1260**).**

Summary of LMRCSC Performance Measures of Success (Education and Outreach Programs) for 2014 - 2015

	Proposed in the Implementation Plan 12 months	Accomplished (Sept. 1, 2015 – Feb. 29, 2016); 6 months
Activities/Programs	**2015 – 2016**	**2015 – 2016**
# K-12 students participating in NOAA related science activities	1,000	400
# of students trained in NOAA related Sciences	90	116
# B.S. Students who graduate in NOAA core Sciences	24	9
# M.S. Students who graduate in NOAA core Sciences	11	4
# Ph.D. Students graduating in NOAA core Sciences	4	4
# of internships at NOAA/other labs.	33	8
# of Courses to be offered via Virtual Campus or online	5	10
Amount of leveraged funds ($) for education and outreach	500K	$865K
# of student presentations at conferences	80	41
# of NOAA/LMRCSC Fisheries Cruises	1	0
# of student co-authored publications	18	7
# of individuals impacted by outreach activities	>1,000	262

Summary of LMRCSC Performance Measures of Success (Research Programs)

	Proposed in the Implementation Plan 12 months	Accomplished (Sept. 1, 2015 – Feb. 29, 2016); 6 months
Activities	**2015 - 2016**	**2015 - 2016**
1. Science Meeting date	March	None this period
2. # of TAB Proposals funded	10 to 16	12
4. # of proposals funded (leveraged funding)	12	7
5. # of scientific presentations at conferences	120 (80*)	68(41*)
6. # of theses & dissertations produced	12	8
7. # of peer-reviewed publications	15*-30	29(7*)
8. Amount of leveraged funds ($)	$3 million	$1,276,641

**Number presented or co-authored by students (minimum)*

INTRODUCTION

The Living Marine Resources Cooperative Science Center (LMRCSC) was established in October 2001 as a cooperative agreement between NOAA Educational Partnership Program, the University of Maryland Eastern Shore (UMES), lead institution, Delaware State University (DSU), Hampton University (HU), Savannah State University (SSU), the University of Miami, Rosenstiel School of Marine and Atmospheric Sciences (UM/RSMAS) and the University of Maryland Biotechnology Institute Center of Marine Biotechnology (UMBI-COMB), now known as the University of Maryland Center for Environmental Science Institute of Marine and Environmental Technology (UMCES-IMET). With the addition of Oregon State University in 2011, the LMRCSC now has seven partner institutions. The mission of the Center is "***To develop exemplary academic and research collaborations that prepare a diverse student body for careers in marine and fisheries sciences***"**.**

The following are the goals and objectives of the LMRCSC:

Education Goal 1. Prepare the future workforce for marine and fisheries sciences

Objective 1.1: Recruit students from under-represented groups into marine and fisheries science disciplines

Objective 1.2: Increase retention and degree completion rates for students in marine and fisheries sciences programs

Objective 1.3: Assess the value-added outcomes of degree programs in marine and fisheries sciences at the partner institutions

Objective 1.4: Link students to professional networks and employment opportunities in marine and fisheries sciences

Education Goal 2. Strengthen collaborations across universities to enhance academic programs in marine and fisheries sciences

Objective 2.1: Use state-of-the-art, research-based curricula to provide students with the highest quality education in marine and fisheries sciences

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

Objective 2.3: Ensure that curricula of degree programs at partner institutions address current challenges and emergent needs within the profession

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

Objective 3.1: Integrate the Center's research agenda with NOAA Fisheries research priorities in four key thematic areas: quantitative fisheries, essential fish habitat, fisheries socioeconomics, and aquaculture.

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

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

SECTION I – STATUS OF AWARD TASKS (Goals and Objectives)

Summary

1. **Status of Goals/Objectives Accomplished as Defined in the Cooperative Science Center's Proposal:** This is provided below from page 15.

2. Status of Benchmarks due during the performance period: The LMRCSC is on track towards accomplishing the education and outreach, and research benchmarks in the implementation plan. The accomplishments during the 6 month reporting period have in some cases already exceeded the performance metrics proposed to be accomplished during a 12 month period. Of particular note is the fact that the number of students trained (116) and number of Ph.D. students graduated (4) during the 6 month reporting period exceed or equal the numbers proposed in the 12 month implementation plan.

3. Status of Special Award Conditions (if applicable) Due During the Performance Period:

Status Report on the LMRCSC Performance Improvement Plan: The LMRCSC has addressed most of the items proposed in the Performance Improvement Plan (PIP) document. The following are examples of components of the PIP that have been completed or are on-going.

Develop a Comprehensive Center-wide Assessment and Evaluation Plan *…..* **Completed**

LMRCSC Center-wide Communication Plan:

a. Hire a LMRCSC Communication & Outreach (C & O) Specialist (Milestone 1) … **Completed**
b. Hire a student assistant to work with LMRCSC C & O Specialist ….. **Completed**
c. Revise Center-wide Communication Plan (Milestone 2) …. **Completed**
d. Collect information and media to produce & disseminate an LMRCSC Newsletter to target audiences identified in Communication Plan (Milestone 3)…. **On-going**
e. Update LMRCSC website & websites of leveraged programs …. **On-going**
f. Produce & disseminate **reports/highlights** including Center-wide data on educational outcomes ….**On-going**

Assessment of the LMRCSC Center-wide Recruitment Plan

a. Develop a survey that will be administered to LMRCSC students to determine how they were recruited to the LMRCSC …. **Completed**
b. Prepare CSC wide recruitment brochure that will be used by all CSCs to recruit students for the centers … **Completed**
c. Collaborate with the newly hired UMES SANS student recruiter to enhance recruitment of students: need to create a LMRCSC student brochure …… **Completed**

Develop and Implement a LMRCSC Center-wide Data Management Plan

a. Design Electronic Center-wide Data Management Plan (Milestone 1) …. **Completed**

Enhance LMRCSC Center-wide cross-disciplinary collaboration and research

a. Identify center faculty with the appropriate expertise and schedule a conference call to discuss and acquaint them with the LMRCSC …. **Completed**
b. Invite the faculty to participate in the annual LMRCSC science meeting …. **On-going**
c. Develop collaborative cross-disciplinary research and/or training projects …. **On-going**

Provide LMRCSC Center-wide training on standardized NOAA mission-related technical and specialized computer skills

a. Implementation of center-wide core competencies
* Identify core competencies and develop additional training to fill in gaps (Milestone 1) ….. **Completed**
*Offer workshop on LMRCSC core competencies that addresses gaps (Milestone 2) …… **On-going**
* Standardized computer skills related to NOAA mission fields: offer a seminar on use of R in statistics (Milestone 3) ….. **On-going**

b. Effective use of internships at NOAA, summer & academic exchanges, or mentorship by NOAA professionals in the integration of students and faculty across NOAA LMRCSC partners …. **On-going**

Develop a LMRCSC Center-wide formal and structured professional and career development program

Professional and career development of undergraduates
*Revise the Student Development Plan for undergraduates …. **Completed**
*Offer the workshops/seminar series …… **On-going**
*Students complete the online Individual Student Development Form …. **On-going**

Continue implementation of the Individual Student Development form for graduate students and Post-docs. … **On-going**

Improving the Integration of Social Science into the LMRCSC

a. Increased social science faculty expertise in the Center …. **Completed**
*Hire a Resource Economist at LMRCSC-UMES ….. **Completed**
*Hire a Post-doc in area of Social Science (Environmental Policy) at LMRCSC-SSU …. **Completed**
*Increase the number of social scientists participating in the LMRCSC Science meetings …. **Completed**

b. increased collaboration with social scientists on appropriate Center research …. **Completed**

c. key societal attributes incorporated into some of the LMRCSC research publications, when there is an opportunity for the adoption of the research work by end-users or the opportunity to add a multidisciplinary dimension...**On-going**

4. Identification of the NOAA-mission Research and Report on the Impact of the Research on NOAA's Mission. In addition, provide the planned and actual duration and status of the research activity that is in support of NOAA's mission.

This is provided below under TAB funded projects from page 26 and Appendix V.

5. **Identification of All Collaborative Research Activities Undertaken During the Award Period:**
   This is provided below under TAB funded projects on page 26 and Appendix V.

6. **Report on the Administrative and Research Meetings Conducted in Support of Activities Under this Award:**
   Meetings conducted during this reporting period included weekly LMRCSC staff meeting at UMES, monthly meetings of the Executive Committee, the Science Committee, and conference calls by CSC Directors.

7. **Status of Recruitment (including students, staff and post-doctorates):** 15 students were recruited to the center (Table 1). Dr. Jolvan Morris (former LMRCSC postdoc) was hired as instructional faculty in the Department of Marine and Environmental Sciences in February.

8. **Status of Faculty/NOAA Staff Exchanges:**
   HU: We worked with Ronald B. Johnson, Michael Banks, and Bill Patterson in mentoring students.

   RSMAS: Dr. Babcock's project funded by the Florida RESTORE Act Centers of Excellence Program (FLRACEP) to improve the use of monitoring data in ecosystem models in the Gulf of Mexico is working closely with NOAA staff at the SEFSC. In January 2016, they held a meeting to start developing a comprehensive survey database to improve the spatial distribution of functional groups in the ecosystem models, which was attended (in person or online) by 14 NOAA scientists.

   SSU: Dr. Sue Ebanks and LMRCSC student Coral Thompson visited the NOAA NCCOS lab in Charleston for training in January.

   UMCES: Faculty had continued interaction with listed NOAA collaborators. Dr. Kevin Friedland is on Ammar Hanif's Ph.D. committee; Dr. Jose Rivera is on Jan Vicente's committee; Dr. Jim Sullivan is on David Marsan's committee; Dr. James Weinberg is on Shadaesha Green's committee.

9. **Progress on LMRCSC Student Development Plan (SDP) Implementation:** Students have been asked to complete student development plans in collaboration with their advisors. We are in the process of collecting those plans.
   HU: This period, students have been engaged in year-long research (see below), have been trained on effective oral and poster scientific communication, and have been participating in monthly journal discussions.

   UMCES: All students are required to develop individual development plans (IDP) with their mentors. This includes description of research project and submission of an annual plan for project goals, as well as goals for improving writing and oral skills. In addition, the mentors of LMRCSC-IMET graduate students are required to compile annual reports on their progress to include research strengths, performance needing improvement, skills needed to be improved or acquired, career development track.

   UMES: We have enacted Student Development Seminars to reinforce the priorities of the Student Development Plan. Seminars meet biweekly for undergraduate students and monthly for graduate students. Topics of these seminars have included various types of science communication, an introduction to Federal agencies with interactions with the Marine Sciences, and strategies for identifying and applying for internship opportunities.

Enhance Academic/Educational Development of students. This will help to prepare the students to acquire knowledge and technical skills to develop NOAA mission-related portfolios, particularly in marine and fisheries sciences.

a) **Offer rigorous courses in marine and fisheries science that include those considered essential for training fisheries scientists using the Centers virtual campus facility:** Several courses were offered to students at the center using the virtual campus facility (Tables 7a-b).

b) **Provide students with research experiences on Center campuses:** All LMRCSC students are expected to engage in research work at their home institutions during the academic year under the guidance of a faculty mentor

and/or during the summer in the form of internships. 5 students participated in internships at NOAA labs or in the labs of partner institutions (see Table 4). Additionally, several examples of research progress are listed here:

DSU: Graduate students participate in research at the aquaculture facility. The facility houses a small ocean acidification lab where **Keith Leonard** is doing his research. Undergraduate students **Chardonay Elliott** and **Chantell Gissendaner** did their own research projects on Blue Carbon in Delaware wetlands. Gissenmdaner completed a senior capstone project. **Nivette Perez-Perez** has done the majority of her research at the NOAA Sandy Hook Lab. During the winter, she continued her project by making monthly visits to the lab. She and **Eunice Handy** also helped Dr. Ozbay and Dr. Schott with the TAB project at UM-IMET.

HU: Larry Redd, Jr. is the Biology/MES graduate student continuing his research on the Effects of Temperature and Feed on Gastric Evacuation of Pompano and Comparison of Growth and Gastric Evacuation of Aquacultured Florida Pompano. **Natalia Lopez** and **Kenya Bynes** worked with Dr. Gibson on the Cryptic Diet of Doliolids. Natalia's thesis will be funded by this NSF project and she will be specifically investing the cryptic diet of salps. She has attended two cruises to begin her work. Kenya Bynes will conduct a seasonal assessment of zooplankton populations in the SAB and generate GIS maps to assess their seasonal patterns at the 40m isobaths**. Alexandra Salcedo**, **Niya Wilkins**, and **Michaella McFarland** worked with Dr. Rodriguez on the DNA Barcoding of Zooplankton in the Hampton Roads Area: A Biodiversity Assessment. They are conducting monthly cruises in 3 regions in the lower Chesapeake Bay, and identify zooplankton through microscopy and DNA analysis. **Jonathan Rogers**, **Christina Williams,** and **Kendall Chancellor**, received scholarship funding and did not participate in research during this period, but participated in lab meetings and journal discussions. These students will present their work at the HU's School of Science Research Symposium in March.

OSU: Chante Davis has completed analysis for chapter one of her dissertation. In Santa Cruz working with the Southwest Fisheries Science Center, she added a second molecular method for analysis of genetic data. This quarter she has drafted a manuscript that included this new data and added a co-author to the manuscript. This chapter is under adviser review and is in prep for publication. **Jessica Andrade** completed the ocean acidification experiments for her thesis and is currently collecting behavioral data from the videos of these trials. She is also in the process of writing up the methods section of her thesis. **Smit Vasquez Cabellero** has continued working on the research titled "West Coast Salmon Fishermen Spatial Behavior" which corresponds to the core essay of his job market paper He has created the first set of preliminary results and expects to present the final results in the upcoming EPP 8th Biennial Education and Science Forum. **Marisa Litz** submitted a manuscript to the journal Experimental Biology of Fishes based on a chapter of her dissertation. She also advanced to PhD candidacy by successfully passing oral PhD qualifying exam Fall 2015.

RSMAS: In addition to work on their theses and dissertation research, RSMAS LMRCSC students were encouraged to participate in NOAA cruises.

c) **Organize seminars for faculty and students:** The LMRCSC has established a center-wide seminar series that is attended by center scientists and students. Presentations at these seminars have been by scientists from the center and other institutions. Graduate students, particularly those supported by NSF CREST-CISCEP Center, leveraged with LMRCSC funds, have also given presentations of their research work to faculty and students. Seminars given during this reporting period are listed in Table 8.

Enhance Professional/Career Development of students.

a) **Train students to develop skills to teach, to co-mentor, to give and to receive feedback:**
Graduate students are actively engaged in teaching and mentoring undergraduates that work in partnership with them in their laboratories. The primary source of training in this activity comes from faculty direction and feedback on these activities. Additional instruction was provided through:
DSU: Graduate students at DSU usually have undergraduate students helping them with their projects. In this way they are developing skills to teach and train less experienced students and to co-mentor them. Examples include the pairing of **Keith Leonard** with **Chardonay Elliott** and **Erika Mendoza**. In turn, more experienced, senior undergraduate students like Chardonay train young undergrads such as Erika Mendoza and Jackie Miller.

HU: Natalia Lopez and **Alexandra Salcedo** are in preparation to teach and train the Marine Science campers this July.

b) **Create opportunities for students to teach, co-learn and mentor other students:** LMRCSC graduate students, particularly at UMES, are encouraged to teach at least one semester long lab session before they complete their degrees. Undergraduate students are required to attend tutorial sessions to serve as tutors to other students and/or to receive tutoring from other students. The LMRCSC **has multiple levels of mentoring** such that during the summer and academic year, high school and undergraduate students working in LMRCSC faculty research labs are co-mentored by graduate students, and high school students receive mentoring from undergraduate students.

DSU: Keith Leonard mentored **Chardonay Elliott** and; **Nivette Perez-Perez** mentored **Chardonay Elliott** and **Aicha Toure**. **Nivette Perez-Perez** helped with a DSU Fishing Derby seafood. (DSU students are not formally required to teach a course.) Students also assist with a climate change course.

HU: HU has instituted a Fall retreat for all students in the department, where the students are assigned mentors and mentees, gain training in team building, and learn science communication skills.

OSU: LMRCSC students at OSU participated in peer-review throughout the reporting period. **Munguia, Litz, and Andrade** each led a 2-week module during Winter Quarter 2016 that was focused on their research. In Week 1, they provided background readings relevant to their research area for the group (graduate students, one faculty member (Miller), and one NOAA scientist (Hurst), led a 1.5 hour discussion. In Week 2, they outlined their graduate research approach and solicited feedback from the group. Additionally, whenever a student is preparing for a presentation, they solicit and receive feedback from their peers during one or more practice talks. **Jessica Andrade** provided a laboratory tour and introduction to her research on ocean acidification effects on flatfish to an aquatic veterinarian class that is part of an Oregon Sea Grant and Oregon Coast Community College program. **Smit Vasquez-Cabellero** participated in a graduate student panel sponsored by OSU's Minorities in Agriculture, Natural Resources, and Related Science. **Chante Davis** delivered a lecture: Early Fish, Late Fish, or Spring Fish, Fall Fish. Hartnell College, Salinas, CA. September 25, 2015. During the SACNAS National Conference held during October 29-31, Washington DC., Smit served as judge for the Undergraduate Poster session on the field of Social Science.
Smit also taught (as a professor of record) Principles of Microeconomics class (EC 201) at Southern Oregon University. The class had 43 undergraduate students. **Marisa Litz** was a student speaker at the "Louis Stokes Alliance for Minority Participation Academy", Corvallis, OR, Sep 22, 2015

RSMAS: At RSMAS, Ph.D. student **Karlisa Callwood** taught a National Association for Interpretation (NAI) Certified Interpretive Guide Training Class. Dates: October 26 – December 21, 2015. She was also a guest lecturer in ECS 111 (Ecosystem Science), October 13, 2015, Title: Introduction to Fisheries Science.

SSU: Jasmine Pinto and **Owen Clower** shared boat time on the R/V Robinson this winter for their research projects. While Owen was using the Van Veen grab for his sampling and Jasmine was monitoring oyster reefs, each trained the other in the technique. Several students in the MS program have projects that require many persons in the field. LMRCSC Fellow **Emma Schultz** has worked with M.S. student **Sarah Webb** in the flatfish surveys, as has LMRCSC graduate student **Chelsea Parrish**. Most co-learning and mentoring activities happen within faculty labs, but cross department pairings do occur (as indicated above). Students who are supported by both GK12 and the LMRCSC take a course on curriculum development and implementation and use these skills 10 hours per week in local public school classrooms. Marine Science Outreach Coordinator Victoria Young developed an Ocean Ambassadors program that trains students to offer educational programs for K12 students who visit the campus. Ocean Ambassadors are also deployed to area events and schools.

UMCES: All graduate students engage in peer mentoring of other graduate students in their seminar courses and provide input on other students' proposal defense and thesis defense seminars. In addition, graduate students co-mentor undergraduate interns and have the opportunity to teach in the SciTech programs for middle and high school students and their teachers.

UMES: Chelsea Richardson and **Detbra Rosales** participated in the Teaching Assistant Training Workshop, which provided essential tools to help perform tasks as Graduate Assistants with competence and in compliance with University policies and procedures. Kristen Lycett attended the SREB Institute on Teaching and Mentoring in Crystal City, VA.

c) **Enhance student's skills in writing grant proposals and completing application forms for scholarships and fellowships:** All graduate students in the LMRCSC write research proposals that are submitted to, and approved by the advisory committee before they can complete their degrees. Graduate students at the center are also required to take a Scientific Communications course or its equivalent that includes developing and writing a grant proposal.

DSU: Graduate student **Nivette Perez-Perez** and **Hillary Dean** wrote thesis proposals; **Keith Leonard** is currently writing his thesis proposal. **Thaddeus Lehman** and **Chantell Gissendaner** are doing research for senior capstone projects this semester. They will write a short 'thesis'.

HU: LMRCSC funded students at HU are required to submit a monthly written summary of their research progress to the PD and to their research mentor. Students are required to keep detailed lab notebooks for lab meetings, and students are required to lead a journal discussion and all participants must submit a written summary of the journal article. Students are also strongly encouraged to applying for additional funding to support their research. For example, **Larry Redd Jr** wrote a compelling NOAA Knauss Fellowship application last year and is now a Knauss Fellow. He also co-wrote sections on the TAB report that funded his research and he successfully submitted his thesis and is in the process of writing a journal article from his thesis work. **Kenya Bynes** submitted a winning application to the VA Space Grant Consortium for 1st year funding, and is currently waiting to receive news on VSGC research award.

SSU: Students refine this skill in the Technical Writing course which is offered every fall. Coral Thompson also wrote a successful TAB proposal entitled, "Training protocol development for determining polycyclic aromatic hydrocarbons in shrimp and sediment from variably human-impacted areas within Southeast Georgia, USA." M.S. proposals for fall-admitted students are due the first Monday in May. None were defended during this reporting period.

UMCES: All IMET LMRCSC students participate in Maryland's Alliance for Graduate Education and the Professoriate (PROMISE AGEP, https://promiseagep.wordpress.com). This system-wide NSF funded program supports the academic and professional development of graduate students and postdoctoral fellows from all backgrounds and in all fields. The primary goals of PROMISE are to increase the numbers and diversity of underrepresented Ph.D.s who will become professors and to increase contributions to the STEM enterprise through impactful mentoring, community building, and professional development. PROMISE offers seminars, workshops, and programs that inspire thesis and dissertation completion, motivation to persist in the graduate program, and preparation for STEM careers. For graduate students, PROMISE provides: Dissertation House, Wednesday Success Seminars (Topics include: Finances, Leadership, Research & the IRB, Writing & Publishing, Grantsmanship). The PROMISE Summer Success Institute (SSI) brings together new/incoming graduate students and those graduate students (both Master's and Ph.D. level) continuing in their programs providing motivational encouragement from faculty and staff of color, alumni, and special guests.

UMES: Student Development Seminars held at UMES addressed several topics relevant to this section. Undergraduate and Graduate Students were introduced to the missions of several federal agencies to better understand the types of projects that will serve those missions. Undergraduate students were also provided instruction on strategies for locating internship opportunities and writing effective personal statements for applications.

d) Enable students to identify career opportunities and to develop interviewing and networking skills:
DSU: Nivette Perez-Perez attended the 2016 Ocean Sciences conferences and developed networking skills. She found a number of new young scientists/friends/future collaborators.

HU: All students in the MES department at HU must visit the Career Counseling Center, on campus, to receive information and training on resume building, interview skills, and portfolio building. This activity is a requirement for the class on Porfolio development taught by Dr. Gibson. LMRCSC students, Bynes, Wilkins, Rogers, and Salcedo all participated in the ASLOMP, and participated mentoring and networking activities at the ASLO conference.

OSU: Chante Davis is serving on the search committee for the Executive Director of the Marine Studies Initiative at OSU.

RSMAS: RSMAS graduate students receive e-mail notification of job opportunities, as well as opportunities for training and networking.

SSU: The Georgia Environmental Conference is a unique scientific meeting in that it brings practitioners from the state of Georgia together to discuss environmental issues that impact the state across professional areas: industry, government, and academic. Their student development program is geared towards networking with student attendees to identify and support new talent. Dr. Hoskins serves on the steering committee for this conference and took Sanya Compton, Chelsea Parrish, Emma Schultz, and Keya Jackson to the meeting on Jekyll Island August 16-18, 2015. Most MSCI students (M.S. and B.S.) take Introduction to Geographic Information Systems as a higher level elective. Each November, students who are in the course or who have used GIS in their research present their work on GIS Day, a GIS poster session and training conference. There, professionals in geography talk with students about careers and assess their work.

UMCES: The Institute of Marine and Environmental Technology's Ratcliffe Environmental Entrepreneurship (REEF) program provides numerous opportunities for LMRCSC students to develop their interviewing, networking and verbal communication skills during their monthly short courses and at events. The program helps students effectively communicate their research as well as their long term goals. Through this program, LMRCSC Graduate Student David Marsan has successfully completed an internship with the FDA. In addition, IMET graduate students participate in the many courses and workshops provided by PROMISE, University System of Maryland's NSF funded Alliance for Graduate Education and the Professoriate (AGEP) program such as AGEP's annual "Career Paths for Graduate Students" which provides the opportunity for students to learn about career possibilities and to network with employers of their interest.

UMES: LMRCSC Communications Specialist Anne Dudley routinely distributes job opportunities to the appropriate level of students. Ms. Dudley also led a discussion on the use of social media and networks in professional settings during the Student Development Seminar.

e) Create opportunities for students to develop collaborative leadership skills and to have leadership experiences:

HU: Graduate students at HU are leading the efforts for HU students to participate in the LMRCSC Center-wide seminar series. Students are also responsible for facilitating the Fall Departmental retreat. They are responsible for creating the agenda, organize activities, and mentor the incoming freshmen.

OSU: Chante Davis participated in the National Ocean Science Bowl as a moderator. **Jessica Andrade** continues to serve as treasurer of the Hatfield Student Organization (HSO).

RSMAS: Ph.D. student **LaTreese Denson** has been organizing the RSMAS component of the LMRCSC seminar series.

UMCES: IMET students assist in planning of events, including the UMCES Convocation and MEES Colloquium, participate in the Entrepreneurs Program, self-govern through an active Graduate Student Association. Student representatives participate at Faculty Meetings, at UMCES Senate and Graduate Council Meetings, and have representation on the UMCES Presidential Scholarship Review**.**

f) **Create opportunities for students to enhance their written and oral communication skills especially as it relates to translating discipline-based concepts, methods and practices in ways that experts from other fields will find understandable:** Several activities and programs have been held at the LMRCSC institutions to enhance students' oral and written communications skills, including LMRCSC sponsored seminars, symposia, conferences, and workshops. Written communication is enhanced through preparation of scientific reports as part of research experiences of undergraduates and writing of proposals. Students wrote research abstracts and made oral and poster presentations at scientific meetings. LMRCSC graduate students are also required to prepare and submit a manuscript to a journal before completing their degree programs.

DSU: All graduate students all DSU are required to write a thesis proposal and then defend the proposal to their committee members. This helps students discover their communication limitations and build a more solid foundation in their scientific communications.

HU: The department facilitated a poster and oral communication workshop for the students presenting at ASLO. Students also lead journal club discussion and graduate students participated in outreach activities to the general public.

SSU: In October, Drs. Hoskins and Morris took 8 students on a writing retreat to Sapelo Island (GA). While the activity was open to all graduate students (and a few undergraduates), only women accepted the offer. The retreat was organized as a Women's writing retreat. Structured time was used to address issues related to writing obstacles, the role of writing in a professional career, and career challenges unique to women. Unstructured time was used for writing, peer review/feedback, and self-observation.

UMCES: At IMET, students participate in journal clubs, seminar courses and attend scientific meetings. In addition, they have opportunities through the REEF program to meet with and explain their work to entrepreneurs and members of the business community.

UMES: The Student Success Seminars included practice with writing abstracts as well as elevator pitches in order to better distill research into brief statements of importance for a variety of audiences.

g) **Create opportunities for students to learn budget management:** Budget developments and critiques are components of the Scientific Communications course that graduate students are required to take before completing their degrees. This course is taught at UMES in the fall. Graduate students are also encouraged to submit TAB proposals and manage their own budgets. Many students not supported by TAB projects are also asked to manage supply budgets for their projects.

DSU: Keith Leonard has been given a supply budget. He orders his own supplies and tracks his spending.

OSU: Students, such as **Jessica Andrade**, manage their own budgets when then receive an OSU Mamie Markham Award (~$9,000). This provides them with budget management experience.

SSU: Coral Thompson has been assigned subaward for her TAB and administers it herself with modest oversight by Drs. Ebanks and Hoskins.

UMCES: At IMET, through the REEF program, graduate students take accountancy modules and learn how to apply for industrial/agency partnership funds. IMET students are also encouraged to apply for their own funding through graduate and postdoctoral fellowships and the TAB projects all of which provide budget management experiences.

h) **Create opportunities for students to participate in NOAA's mission and LMRCSC research-related seminars:** LMRCSC students participated in LMRCSC's seminar series, which is made available online via Adobe Connect. The LMRCSC seminar series is student-driven and student-run. With some guidance from Dr. Hoskins, the students

produced 4 seminars during this period (Table 8). Opportunities to participate in other partner or NOAA sponsored seminars are communicated to students as they become available.

HU: LMRCSC students participate in the monthly journal club meetings where each student must lead a journal discussion. Lopez and Salcedo presented in the Fall, and Bynes, Wilkins and Rogers will present in the spring.

RSMAS: In the Spring of 2016, Dr. Babcock began organizing a weekly Fishery Science Seminar at RSMAS to give students more exposure to current work in fisheries science. Speakers to date have included SEFSC scientists Dr. Jeff Isely, Dr. Shannon Cass-Calay, Dr. John Walter, as well as faculty from UM and Florida International University.

UMCES: IMET students participate in the LMRCSC student seminar series, which is made available online via Adobe Connect. Opportunities to participate in NOAA sponsored seminars are communicated to students as they become available. Additionally, IMET holds a weekly seminar series that all students and faculty are highly encouraged to attend.

i) **Encourage students to participate in summer internships at NOAA labs and labs at LMRCSC partner institutions:** Internship opportunities available at NOAA labs, LMRCSC and at various agencies, particularly USFWS were made available to students. Table 4 contains a list of students who participated in internships during this period.

j) **Encourage students to make oral and/or poster presentations at professional meetings**: Several LMRCSC students made presentations at scientific meetings during this reporting period. A listing of their oral and poster presentations are listed in Appendix IV.

k) **Provide opportunities for students to develop skills related to conflict and stress management**:

UMCES: At IMET graduate students are trained in conflict resolution management provided through the REEF program.

UMES: Undergraduate students in the Student Development Seminar attended a seminar on stress management provided by Campus Counseling Services that took place prior to final exams.

l) **Guide students to develop professional profile on an established professional social networking site to document NOAA mission-relevant STEM career progress:** Students were encouraged to create accounts on linkedin.com. We are working to compile a list of student and alumni profiles.

UMCES: IMET students are encouraged to join Research Gate and/or Linked in. IMET's Associate Director, Dr. Nick Hammond, IMET's Assistant Director, provides guidance on professional behavior and how to maintain an appropriate web presence

UMES: LMRCSC Communications Specialist Anne Dudley led a discussion on the use of social media and networks in professional settings during the Student Development Seminar.

m) **Create opportunities for students to network:** Social interactions and development of LMRCSC students occurred during this period through the LMRCSC Facebook page and the Graduate Student Association at UMES. LMRCSC students are supported to attend professional meetings, do field studies with other organizations, and participate in the University of Maryland System PROMISE program, http://promiseagep.wordpress.com.

1. Status of Goals/Objectives Accomplished as Defined in the LMRCSC's Proposal

For the period of **September 1, 2015 to February 29, 2016**, the following tasks were accomplished in support of the goals and objectives of the LMRCSC:

Education Goal 1: Prepare the future workforce for marine and fisheries sciences

The **NOAA Education Strategic Plan (2009-2029)** assigns a high level of importance to the goal of developing a future workforce that reflects the diversity of the U.S. Collectively, the LMRCSC partner institutions offer a full range of degrees (bachelors, masters, and Ph.D.) in marine and fisheries sciences.

Objective 1.1: Recruit students from under-represented groups into marine and fisheries science disciplines - Our recruitment efforts advance specific workforce development outcomes identified in the NOAA Education Strategic Plan.

Activities and Accomplishments: - **Recruitment into Marine Science Programs**: 18 students were recruited into the LMRCSC (Table 1).

Table 1. Students recruited into LMRCSC from September 1, 2015 to February 29, 2016

First Name	Last Name	Academic Institution	Degree Program	Expected Graduation Date
Erika	Mendoza*	DSU	B.S.	19-May
Jackilyn	Miller*	DSU	B.S.	18-May
Jasmine	Smalls*	DSU	M.S.	18-May
Kendall	Chancellor*	HU	BS	May-18
Jonathan	Rogers*	HU	BS	May-18
Niya	Wilkins*	HU	BS	May-18
Christina	Williams*	HU	BS	May-17
Natalia	Lopez*	HU	MS	May-17
Alexandra	Salcedo*	HU	MS	Dec-16
Angela	Munguia	OSU	M.S.	Dec. 2017
Caren	Barcelo	OSU	Ph.D.	Dec. 2016
Vanessa	Foster	SSU	B.S.	16-May
Seth	Klepal	SSU	B.S.	17-May
Danyelle	Stroud	SSU	B.S.	16-May
Rachel	Banks	UMCES	Ph.D.	May '21
Paul	Montalvo*	UMES	M.S.	17-May
Andre	Price*	UMES	M.S.	17-May
Cy'anna	Scott*	UMES	M.S.	17-May

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Objective 1.2: Increase retention and degree completion rates for students in marine and fisheries sciences programs: Direct financial support is one key element in retaining students. But the LMRCSC also engages in instructional and student support practices that have been shown to increase retention rates. LMRCSC students are also highly involved in peer networks, on campus and across the nation, including regular involvement in national meetings of the American Fisheries Society.

Activities and Accomplishments: Students who received financial support from September 1, 2015 to February 29, 2016 are listed in Table 2. Those who graduated during this reporting period are presented in Table 3.

Table 2. Students who received direct support during the funding period (September 1, 2015 to February 29, 2016).

	First Name	Last Name	Academic Institution	Degree	Type	Amount
1	Chardonay	Elliott*	DSU	B.S.	Stipend/Travel	$1,126
2	Chantell	Gissendaner*	DSU	B.S.	Stipend	$782
3	Aicha	Toure*	DSU	B.S.	Tuition	$3,296
4	Hillary	Dean*	DSU	M.S.	Stipend/tuition	$3,071
5	Eunice	Handy*	DSU	M.S.	Stipend/travel	$4,300
6	Symone	Johnson*	DSU	M.S.	Stipend	$4,686
7	Keith	Leonard	DSU	M.S.	Stipend/tuition	$14,146
8	Nivette	Perez-Perez*	DSU	M.S.	Stipend/tuition/travel	$11,352
9	Matthew	Stone	DSU	M.S.	Travel	$373
10	Kenya	Bynes*	HU	B.S	Scholarship	$3,166
11	Michaella	McFarland*	HU	B.S	Stipend	$2,166
12	Kendall	Chancellor*	HU	BS	Stipend	$500
13	Jonathan	Rogers*	HU	BS	Scholarship	$500
14	Niya	Wilkins*	HU	BS	Scholarship	$2,166
15	Christina	Williams*	HU	BS	Scholarship	$500
16	Natalia	Lopez*	HU	M.S.	Tuition (Fall/Spring)	$9,716
17	Larry	Redd Jr*	HU	M.S.	Stipend/Tuition (Fall)	$11,858
18	Alexandra	Salcedo*	HU	M.S.	Stipend/Tuition (Fall/Spring)	$18,716
19	James	Akau*	OSU	A.S.	stipend	$28,200
20	Jessica	Andrade*	OSU	M.S.	Stipend/tuition	$26,200
21	Angie	Munguia*	OSU	M.S.	Stipend/tuition	$25,000
22	Caren	Barcelo*	OSU	Ph.D	Stipend/tuition	$12,000
23	Smit	Vasquez Cabellero*	OSU	Ph.D	Stipend/tuition	$28,200
24	Rachel	Fujimoto*	RSMAS	M.P.S.	Stipend/insurance	$2,015
25	Chiara	Pacini*	RSMAS	M.S.	Stipend/insurance	$12,950
26	LaTreese	Denson*	RSMAS	Ph.D.	Stipend/tuition/insurance	$16,650
27	Owen	Clower	SSU	B.S.	Stipend	$1,140
28	Vanessa	Foster*	SSU	B.S.	Stipend	$1,920
29	Kalub	Holt*	SSU	B.S.	Stipend	$1,520
30	Seth	Klepal	SSU	B.S.	Stipend	$760
31	Shaneese	Mackey*	SSU	B.S.	Stipend/Travel	$2,333
32	Jasmine	Pinto*	SSU	B.S.	Stipend	$1,520
33	Danyelle	Stroud*	SSU	B.S.	Stipend	$1,440
34	LaGina	Frazier*	SSU	M.S.	Travel	$53
35	Jennifer	Gut	SSU	M.S.	Stipend	$2,500
36	Keya	Jackson*	SSU	M.S.	Travel	$53
37	Chelsea	Parrish	SSU	M.S.	Travel	$450
38	Rachel	Randall	SSU	M.S.	Travel	$53
39	Jordan	Rutland*	SSU	M.S.	Stipend/Tuition	$10,532
40	Emma	Shultz	SSU	M.S.	Stipend/Tuition	$12,545
41	Tiffany	Taubenheim*	SSU	M.S.	Stipend/Travel	$1,720

42	Jessica	Thompson	SSU	M.S.	Travel	$53
43	Coral	Thompson*	SSU	M.S.	Travel	$199
44	Candice	Amo-Adade*	UMCES	B.S.	Stipend	$1,658
45	Shanai	Brown*	UMCES	B.S.	Travel	$134
46	LaTaijah	Crawford*	UMCES	B.S.	Travel	$134
47	Madison	Dahle	UMCES	B.S.	Travel	$14
48	JB-Bakruddin	Muhammad*	UMCES	B.S.	Travel	$14
49	Chiamaka	Nnah*	UMCES	B.S.	Travel	$1,219
50	Jennifer	Riling	UMCES	B.S.	Travel	$14
51	Brianna	Roberts*	UMCES	B.S.	Travel	$14
52	Minyan	Watson-Faulkner*	UMCES	B.S.	Travel	$14
53	Rachel	Banks*	UMCES	Ph.D.	Stipend/Tuition/Travel	$29,346
54	Erica	Dasi	UMCES	Ph.D.	Stipend/Travel	$2,907
55	Kathleen	Gillespie*	UMCES	Ph.D.	Stipend	$2,139
56	Shadaesha	Green*	UMCES	Ph.D.	Travel	$746
57	Eunice	Handy*	UMCES	Ph.D.	Stipend	$2,476
58	Ammar	Hanif*	UMCES	Ph.D.	Stipend/Tuition/Travel	$25,571
59	David	Marsan*	UMCES	Ph.D.	Stipend/Tuition/Travel	$5,943
60	Leah	Maurer	UMCES	Ph.D.	Travel	$743
61	Nivette	Perez-Perez	UMCES	Ph.D.	Travel	$600
62	Jan	Vicente*	UMCES	Ph.D.	Travel	$94
63	Lavell	Allen*	UMES	B.S.	Travel	$161
64	Mariah	Dennis*	UMES	B.S.	Travel	$20
65	Sedona	Dorsett*	UMES	B.S.	Salary	$4,181
66	Wyntin	Goodman*	UMES	B.S.	Tuition	$3,813
67	Cloee	Grainger*	UMES	B.S.	Stipend	$723
68	Cassandra	Harris*	UMES	B.S.	Travel	$500
69	Hunter	Howard*	UMES	B.S.	Stipend, Tuition	$4,170
70	Marcus	Hughes*	UMES	B.S.	Tuition	$3,813
71	Mario	McGhee*	UMES	B.S.	Salary, Tuition	$4,235
72	Chiamaka	Nnah*	UMES	B.S.	Salary, Tuition, Travel	$7,453
73	Isabel	Obando*	UMES	B.S.	Travel	$902
74	Courtney	Rhoades	UMES	B.S.	Salary, Travel	$1,316
75	Ciara	Schnyder*	UMES	B.S.	Tuition	$3,813
76	Marci-Ann	Smith*	UMES	B.S.	Salary, Tuition	$4,527
77	Samih	Taylor	UMES	B.S.	Salary, Travel	$4,980
78	Abdalhafiz	Ahemedaltayb*	UMES	M.S.	Stipend	$8,951
79	Wilmellie	Cruz-Marrero*	UMES	M.S.	Stipend, Fringe, Tuition, Travel	$15,493
80	Mason	King	UMES	M.S.	Travel	$20
81	Paul	Montavalo*	UMES	M.S.	Stipend	$2,410
82	Noelle	Olsen*	UMES	M.S.	Stipend, Fringe, Tuition, Travel	$14,849
83	Audy	Peoples*	UMES	M.S.	Stipend, Fringe, Tuition, Travel	$11,850
84	Andre	Price*	UMES	M.S.	Stipend	$1,377
85	Chelsea	Richardson*	UMES	M.S.	Stipend, Tuition	$10,179
86	Jorge	Rodriguez*	UMES	M.S.	Stipend, Fringe, Tuition, Travel	$14,658

87	Detbra	Rosales*	UMES	M.S.	Travel	$859
88	Cyana	Scott*	UMES	M.S.	Stipend, Tuition	$8,839
89	Justin	Wilson *	UMES	M.S.	Stipend, Fringe, Tuition, Travel	$16,498
90	Laura	Almodovar-Acevedo*	UMES	Ph.D.	Stipend, Fringe, Tuition, Travel	$13,278
91	Kristen	Lycett*	UMES	Ph.D.	Travel	$203
92	Stephanie	Martinez-Rivera*	UMES	Ph.D.	Stipend, Fringe, Tuition, Travel	$20,145
93	Cara	Schweitzer	UMES	Ph.D.	Stipend, Tuition, Travel;	$13,015
94	Daniel	Sweeney	UMES	PSM	Tuition	$989
Total						**$554,426**

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Table 3. Students who graduated from September 1, 2015 to February 29, 2016.

First Name	Last Name	Academic Institution	Degree	Date	Post-Graduation Information
Chantell	Gissendaner*	DSU	B.S.	Dec. 15	Applying for Ph.D. program NC State
Prosper	Ikpeama*	DSU	B.S.	Dec. 15	Johnson Matthey Pharmaceuticals
Gloria	Akpabla*	Morgan State U	B.S.	15-Dec	Medical School, China
Rachel	Fujimoto*	RSMAS	M.P.S.	15-Dec	Fishery technician, State of Washington
Kris	Drummond*	SSU	B.S.	15-Dec	working
Sayda	Guerra*	SSU	B.S.	15-Dec	working
Kalub	Holt*	SSU	B.S.	15-Dec	working
Shaneese	Mackey*	SSU	B.S.	15-Dec	Applying to M.S. program at SSU
Mikhail	Musarra	SSU	B.S.	15-Dec	working
James	White*	SSU	B.S.	15-Dec	Looking for a graduate program /working
Sanya	Compton*	SSU	M.S.	15-Dec	Applying to Ph.D. at Univ. of West Indies
Michael	Scaboo	SSU	M.S.	15-Dec	In Ph.D. program at Univ. Delaware
Mason	King	UMES	M.S.	Dec. 15	
Tedra	Booker*	UMES	Ph.D.	Dec. 15	
Ejiroghene	Mayor*	UMES	Ph.D.	Dec. 15	
Efe	Oghenekaro*	UMES	Ph.D.	Dec. 15	Knauss Fellowship
Fred	Oseji*	UMES	Ph.D.	Dec. 15	

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Retention and degree completion rates are higher in academic programs that engage students in collaborative research with faculty members. Projects funded by LMRCSC involve both undergraduate and graduate students as active research participants. Students work as research collaborators with faculty and scientists at NOAA facilities. During the academic year, students participate in research projects at their home institutions. Table 4 shows 5 students who worked at NOAA labs or LMRCSC partner institution labs.

Table 4. Students who worked at NOAA labs or LMRCSC partner institution labs (September 1, 2015 to Feb. 29, 2016)

First Name	Last Name	Institution	Degree	Facility	Time Period	Activity or Title of Research Project
Hillary	Dean	DSU	M.S.	Panama City	Ongoing	Sturgeon
Eunice	Handy	DSU	M.S.	IMET		
Nivette	Perez-Perez	DSU	M.S.	Sandy Hook	Ongoing	Red Deep Sea Crabs
Eunice	Handy*	DSU	Ph.D.	IMET	Oct-Dec	Investigation of the mud crab *Panopeus herbstii* as a reservoir of a virus lethal to blue crab, *Callinectes sapidus*
Nivette	Perez-Perez*	DSU	Ph.D.	IMET	Oct, Nov	Searching the coastal bay food web for reservoirs of a virus lethal to blue crab,
Jessica	Andrade	OSU	M.S.	AFSC Behavioral Ecology Lab, Newport, OR	Fall 2015 & Winter 2016	Flatfish behavioral responses to predatory threat under elevated carbon dioxide concentrations
Chante	Davis	OSU	Ph.D.	SWFSC	Fall 2015	A landscape genetic approach to understanding adaptation of Chinook in the Siletz river using candidate loci associated with timing of reproductive events
Coral	Thompson	SSU	M.S.	CCHEBR Charleston	Jan 2016 (1wk)	Developing a training protocol for determining polycyclic aromatic hydrocarbons in shrimp and sediment from variably human-impacted areas in southeast Georgia

Twenty-two (22) undergraduate and graduate students, who did not receive direct support from the LMRCSC during this reporting period, benefited from the programs offered by the Center and/or infrastructure established by the LMRCSC during this reporting period. Names of the students are listed in Table 5.

Table 5. Students who did not receive direct support but benefited from the program offered or infrastructure established by the LMRCSC.

	First Name	Last Name	Institution	Degree
1	Andrew	Kluge	DSU	B.S.
2	Katie	Ommanney	DSU	B.S.
3	Valin	Booker*	HU	B.S.
4	Kyle	Farrington*	HU	B.S.
5	Chante	Davis*	OSU	Ph.D.
6	Marisa	Litz*	OSU	Ph.D.

7	Matt	Nuttall	RSMAS	Ph.D.
8	Halie	O'Farrell*	RSMAS	Ph.D.
9	Holly	Perryman	RSMAS	Ph.D.
10	Bruce	Pohlot	RSMAS	Ph.D.
11	Sanya	Compton	SSU	M.S.
12	Gloria	Akpabla*	UMCES	B.S.
13	Anya	Bird*	UMCES	B.S.
14	Sean	Brockington*	UMCES	B.S.
15	Andrea	Santos E Almeida*	UMCES	B.S.
16	Samuel	Lebarty*	UMES	B.S.
17	Chiebuka	Nwachukwu*	UMES	B.S.
18	Uche	Onuchukwu*	UMES	B.S.
19	Mohammed	Saleh*	UMES	B.S.
20	Thomas	Miller	UMES	M.S.
21	Rebecca	Peters	UMES	Ph.D.
22	Baruch	Volkis	UMES	Ph.D.

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Examples of How Students Benefitted from the LMRCSC: Research advisors of some of the students are also LMRCSC supported faculty. LMRCSC supported faculty are involved in teaching and advising PSM and NSF CREST-CISCEP students. Some of the students also use instrumentation, software, and supplies as well as facilities provided by the LMRCSC, or participate in workshops paid for and organized by the LMRCSC.

Career Development Assistance: Many students participated a variety of different career development activities during this period. Details of some of the activities are listed in Table 6.

Table 6: Participation in career development activities including workshops and other training opportunities

Name	workshop
Nivette Perez-Perez	DSU Fishing Derby Outreach
HU students	Oral and poster presentation workshop
Matt Nuttall	Writing workshop
Detbra Rosales and Chelsea Richardson	Teaching Assistant Workshop
SSU students	Women's Writing Retreat (Sapelo Island)
Rachel Banks*	NSF GRFP fellowship application workshop "Funding Your Graduate Education"
Rachel Banks*	PROMISE AGEP Research Symposium and Professional Development Conference
Shadaesha Green* Recipient of the PROMISE programs Outstanding Poster Presentation	PROMISE AGEP Research Symposium and Professional Development Conference.
Ammar Hanif*	Winter Dissertation House
Kathleen Gillespie*	PROMISE AGEP Research Symposium and Professional Development Conference
Kathleen Gillespie*	PROF-it: Professors-in-Training "Preparing Future Faculty" PROMISE: (AGEP)

Leah Maurer	REEF modules on interviewing and networking skills; identifying entrepreneurship opportunities; writing a business plan; perfecting the perfect pitch for both scientific and business presentations; crafting a budget; patents and trademarks pertinent to academic research; conflict resolution
David Marsan*	REEF modules on interviewing and networking skills; identifying entrepreneurship opportunities; writing a business plan; perfecting the perfect pitch for both scientific and business presentations; crafting a budget; patents and trademarks pertinent to academic research; conflict resolution

Build strong peer networks through student collaboration:
DSU: Keith Leonard, Nivette Perez-Perez and Matthew Stone collaborated on a video project in which they interviewed NOAA's Matthew Poach.

HU: Team building and peer mentoring workshops at VA Aquarium, as a part of our annual recruitment and retention student retreat.

UMCES: Students participated in the Student Government Association and PROMISE Program.

UMES: During Student Development Seminars, students have received instruction on giving and receiving constructive criticism in order to help one another with communications tasks.

Continually assess student performance and progress toward degree completion:

- **LMRCSC Exit Evaluation:** No exit evaluations were received during this period.
- **LMRCSC Cruise Evaluation**: No cruise took place during this period.
- **Evaluation Forms for interns and mentors**: No internship evaluation forms were received during this period.

Objective 1.3: Assess the value-added outcomes of degree programs in marine and fisheries sciences at the partner institutions: Involvement in scientific research, participation in internships at NOAA facilities, and engagement with the "essential curriculum" for marine and fisheries sciences have prepared LMRCSC graduates to enter the scientific and environmental management workforce. Participation in LMRCSC activities adds significant value to students' educational experiences, and prepares them to make important contributions to the scientific profession.

Activities and Accomplishments: The following are examples of what the Center did during the current reporting period to link students to professional networks and employment opportunities in marine and fisheries sciences. Students attended various scientific meetings. Their presentations are listed in Appendix IV.

Monitoring student progress: LMRCSC utilizes the online Student Tracker database as prescribed by NOAA for tracking student progress and outcomes. The Center maintains a series of online evaluation forms for the LMRCSC program overall, which graduating students are requested to submit, and for specific recurring activities such as the LMRCSC research cruise. We are also in the process of implementing the Student Development Plan, which students complete in collaboration with their advisors each semester in order to help track their progress.

Post-Graduate Tracking: Efforts are on-going to provide up-to-date graduate tracking information.

Scholarship: The following students received awards or scholarships during this reporting period:
Nivette Perez-Perez (DSU) received the Graduate Research and Training Scholarship Program (GRTSP).
Symone Johnson (DSU) received the Knauss Fellowship and started her fellowship in February. She is an Education Policy Fellow with NOAA Office of Education.
Kenya Bynes (HU) received the NOAA EPP Scholarship and the VSGC scholarship.
Michaella McFarland (HU) received the NOAA EPP Scholarship.
Larry Redd, Jr. (HU) received the Knauss Fellowship.
Rachel Banks (UMCES): MEES enhancement award, $5,000

David Marsan (UMCES): 1-year REEF fellowship, covering stipend, medical insurance and tuition, IMET
Leah Maurer (UMCES): 1-year REEF fellowship, covering stipend, medical insurance and tuition, IMET
Shaedaesha Green (UMCES): NSF LSAMP fellowship
Jan Vicente (UMCES): Nancy Foster fellowship

Objective 1.4: Link students to professional networks and employment opportunities in marine and fisheries sciences

Activities and Accomplishments: The following are examples of what the Center did during the current reporting period to link students to professional networks and employment opportunities in marine and fisheries sciences.

Students at all partner institutions were encouraged to become members of professional organizations including the National Shellfisheries Association, American Fisheries Society, American Indian Science and Engineering Society, American Society of Agronomy, and Association for the Sciences of Limnology and Oceanography.

HU: Students travelled to the OSM where they participated in student development workshops. Dr. Gibson worked with Malik Breland, graduate 2015, in applying for a NMFS observer position in the NWFSC. He was hired February 2016.

UMCES: Shadaesha Green was funded to attend 109th National Shellfish Association, Las Vegas, NV February 22-26. Leah Maurer was funded to attend 109th National Shellfish Association, Las Vegas, NV February 22-26. MEES 698T

Other Activities

Special achievement

- Ben Cuker continues to support LMRCSC students in the ASLO-MP

Education Goal 2: Strengthen collaborations across universities to enhance academic programs in marine and fisheries sciences

Activities and Accomplishments:

***Center Faculty and Staff Positions*:**

- Dr. Horodysky, Assistant Professor, now on tenure track , Fish Physiology, advisor for MS student
- Dr. Aurea Rodriquez, Marine and Environmental Science
- Research Assistant Professor, Zooplankton Genetics is now mentoring students
- Dr. Indu Sharma, Biology, has become an integral part of our LMRCSC, by advising students and building collaborations with Brad Stevens, Sook Chung, Rose Jagus, and the VT Aquaculture facility on the emerging collaborative work between institutions on the study of Deep Sea Red Crab, and is serving as a committee member for Natalia Lopez

Objective 2.1: Use state-of-the-art, research-based curricula to provide students with the highest quality education in marine and fisheries sciences

Activities and Accomplishments: ***Leveraging significant intellectual capital at partner institutions to advance educational programs and inform curriculum development*:**
Through the LMRCSC collaboration, students have access to a broader range of curricular and research experiences. They have opportunities to take courses and engage in research with faculty at other LMRCSC partner institutions, and with NOAA scientists who serve as adjunct faculty, thesis or dissertation committee members, and professional mentors. CSC Directors had several conference calls during the reporting period during which potential collaborative research and educational programs were discussed and developed. To ensure that students and faculty are informed about current research within LMRCSC, the Center uses Adobe Connect to make its Seminar Series available to students and faculty at all partners via the web.

Ensuring that curricula delivered at each partner institution are highly coordinated with the "essential curriculum" for marine and fisheries sciences, as identified by NOAA-NMFS: Extensive collaboration between LMRCSC faculty and NOAA scientists ensures that curriculum development is informed by the current challenges and emergent needs in the marine and fisheries sciences. This level of collaboration extends to having NOAA scientists teach courses with LMRCSC faculty, and serve on dissertation committees. Internship experiences at NOAA laboratories and field research also ensure that students participate in a curriculum that is highly aligned with the needs of NOAA-NMFS.

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

Activities and Accomplishments: The Virtual Campus was used to provide courses to students through videoconferencing and in an online format, hold student committee meetings, Executive Committee meetings, and thesis and dissertation defenses. Five (5) courses were offered in 2015 IVN, Go-to-Meeting, Adobe-Connect or Blackboard.

University of Maryland Interactive Video Network (IVN) courses:

Table 7a. Course Offered at the LMRCSC during Fall Semester 2015

Course number	Course Title	Instructor	Students (online)
MEES 641	Survey Sampling for Natural Resources	B. G. Stevens	7 at UMES, 1 at UMD-CP
MEES 606	Molecular Biology for Environmental Scientists	Allen Place & Rose Jagus	Detbra Rosales (UMES), Bernadette Ezeabikwa (UMES), Kristen Lycett (UMES)

Table 7b. Course Offered at the LMRCSC during Spring Semester 2016

Course number	Course Title	Instructor	Students (online)
MEES 640	Introduction to Environmental and Resource Economics	Chi, Yeong Nain	Michele Traver (UMES)
MEES 608N	Current Topics in Fisheries: Crustacean Biology and Fisheries	B. Stevens	S. Green, L. Maurer, J. Fisher
MBE716	Bayesian statistics for marine scientists	Babcock, E.A. RSMAS joint in person/online course	Noelle Olson (UMES), Rebecca Peters (UMES), plus 2 students from VIMS, and 8 in-person students at RSMAS

Seminars: Seminars presented to students and faculty are presented in Table 8.

Table 8. LMRCSC Seminar Series (September 1, 2015 to February 29, 2016)

Date	Presenter	Title
5-Feb-16	Bruce Pohlot	A Scientific Report on Billfish Research at The Rosenstiel School of Marine and Atmospheric Science
Nov. 12, 2015	Larry Redd, Jr.	Gastric Evacuation and Growth of Juvenile Florida Pompano
Nov. 20, 2015	Cara Schweitzer	Effects of Fishing Traps on Essential Fish Habitat in the Mid-Atlantic Bight

Feb. 17, 2016	Justin Wilson	Age Determination of Red Deep-Sea Crab (*Chaceon quinquedens*) by Growth Ring Analysis
Feb. 17, 2016	Stephanie Martinez-Rivera	Reproductive Biology of the Red Deep-Sea Crab (*Chaceon quinquedens*) in the Mid-Atlantic Bight

Objective 2.3: Ensure that curricula of degree programs at partner institutions address current challenges and emergent needs within the profession

***Engage undergraduate and graduate students in cutting-edge research experiences in marine and fisheries sciences, including learning experiences at NOAA facilities with NOAA mentors*:** One of the defining characteristics of the student academic experience at LMRCSC is extensive participation in scientific research. Undergraduate and graduate students work alongside faculty as collaborators on a range of research projects related to NOAA-NMFS priorities. Many of the projects involve student research at NOAA facilities under the guidance of NOAA mentors. Four (4) students worked at NOAA labs and other agencies during this reporting period (Table 4).

Research Goal 3: Develop an exemplary capacity for scientific collaborations among partner institutions in the fields of marine and fisheries sciences -

The Center's research is grouped into the four key thematic areas, associated with NOAA's research priorities. This research agenda is implemented collaboratively among faculty and students across the seven partnering institutions. LMRCSC research undergoes a rigorous scientific review process. Each year, LMRCSC convenes a Technical Advisory Board (TAB) to guide the Center in its research agenda. The TAB reviews and provides recommendations on the Center's research plan, and ensures that LMRCSC research is of high quality and aligned with NOAA-NMFS research priorities. Each year, LMRCSC issues a Request for Proposal (RFP) within the Center institutions, which seeks proposals for research projects that will be funded by the Center. Proposals are evaluated by the TAB, based on scientific merit, congruence with NOAA-NMFS research priorities, and level of involvement of students in the proposed research. An average of 12 research projects is selected for funding each year.

Activities and Accomplishments:
Eleven (11) projects were funded in 2015-2016 and twelve were funded in 2014-2015 (Table 9a,b).

Table 9a. Funded TAB Projects for the Period of 2015 - 2016

	PI	Title
16-01	Torres, L. (OSU); Cox, T. (SSU); Brodeur, R. (NOAA)	Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change: California sea lions and their pelagic prey off Oregon and Washington
16-02	Heppell, S. (OSU); Horodysky, A. (HU); Crawford, M. (UMES); Garza, J.C. (NOAA)	Settlement and recruitment in the genus *Sebastes*: Which Oregon estuaries serve as nursery areas for these commercially and recreationally important species?
16-03	Stevens, B. (UMES); Chung, S. (IMET); Place, A. (IMET); Sharma, I. (HU); Long, C. (NOAA); McBride, R. (NOAA); Poach, M. (NOAA)	Improving management of deep-sea red crabs (*Chaceon quinquedens*) Year 3: Reproductive biology, maturity, and age estimation
16-04	Sylvia, G. (OSU); Caballero, S.V. (OSU); Gong, T. (UMES); Lawson, P. (NOAA)	Spatial mixed-stock bioeconomic model for the West Coast Salmon Fishery
16-05	Hanif, A. (IMET); Jagus, R. (IMET); Place, A. (IMET); Stevens, B. (UMES); Friedland, K. (NOAA)	Ontogenic changes in the diet and microbiome of Atlantic menhaden using DNA barcoding
16-06	Pitula, J. (UMES); Uphoff, J. (MD DNR); Gonsalves, L. (NOAA)	RNA-DNA Ratios as Indicators of Ecosystem Health; metrics to determine the impact of land-use on fish habitat
16-07	Stevens, B. (UMES); Horodysky, A. (HU); Pitula, J. (UMES); Townsend, C. (Industry)	Bycatch and discard mortality for the commercial black sea bass trap fishery: Assessment of behavioral and physiological predictors of mortality
16-08	Place, A. (IMET); Horodysky, A. (HU); Brill, R. (HU)	Effects of low taurine diet on visual function in aquacultured cobia, *Rachycentron canadum*

16-09	Thompson, C. (SSU); Ebanks, S.C. (SSU); Ishaque, A. (UMES); DeLorenzo, M. (NOAA)	Training protocol development for determining polycyclic aromatic hydrocarbons in shrimp and sediment from variably human-impacted areas within Southeast Georgia, USA
16-10	Chi, Y.N. (UMES); May, E.B. (UMES); Gardner, W.D. (UMES); Lovell, S. (NOAA)	The Economic Impact of Offshore Fishing Tournaments in Ocean City, Maryland
16-11	Crawford, M. (UMES); Driscoll, C. (MD DNR); Horodysky, A. (HU); Gonsalves, L. (NOAA)	Analysis of Stranding Demographics and Heavy Metal Contaminants in Marine Mammals from Coastal Maryland

Table 9b. Funded TAB Projects for the Period of 2014 - 2015

Project No.	PI Name	Title	Theme
15-01	Michael Banks (OSU)	Microsatellite Markers Isolation (EST-SSR's) for Association Tests of Reproductive Phenotypes (GnRH, FSH and LH) in the Context of Environmental Variability for Chinook Salmon.	AC
15-02	Jennifer Guit (SSU)	Potential Impacts of the Savannah Harbor Expansion Project (SHEP) on the temporal and spatial patterns of fish assemblages near the mouth of the Savannah River, Georgia	EFH
15-03	Ammar Hanif (UMCES/IMET)	Analyzing diets of Atlantic menhaden using metabarcoding	EFH
15-04	Andrij Horodysky (HU)	Comparison of NOAA Montlake meal and Otohime feed performance in aquacultured pompano: feed ration, feed frequency, feed conversion ratio, and feed efficiency.	AC
15-05	Andrea Johnson (UMES)	RNA-DNA Ratios as Indicators of Ecosystem Health; metrics to determine the impact of land-use on fish habitat	EFH
15-06	Andrea Johnson (UMES)	Analysis of Stranding Demographics and Contaminants in Marine Mammals from Coastal Maryland and the Chesapeake Bay	QF
15-07	Jessica Miller (OSU)	Ocean acidification effects on ecology of juvenile northern rock sole	EFH
15-08	Jolvan Morris (Savannah State U.)	Place Attachment and Traditional Ecological Knowledge in the Sea Islands: A Case Study of Endangered Culture	FSE
15-09	Eric Schott (UMCES/IMET)	Searching the coastal bay food web for reservoirs of a virus lethal to blue crab *Callinectes sapidus*	EFH
15-10	Bradley Stevens (UMES)	Improving management of deep-sea red crabs, *Chaceon quinquedens*, Year 2: Reproductive biology, maturity, and age estimation	QF
15-11	Bradley Stevens (UMES)	Augmenting the Black Sea Bass, *Centropristis striata*, Stock Assessment, Year 3: Assessing the importance of fixed and fluid estuarine habitats	EFH
15-12	Leigh Torres (OSU)	Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change: California sea lions and their pelagic prey off Oregon and Washington	QF

LMRCSC TAB Project Summaries

Summaries of the LMRCSC TAB funded projects are presented below.

Project Year: 2015

Project #: 15-01

Project Title: Microsatellite Markers Isolation (EST-SSR's) for Association Tests of Reproductive Phenotypes (GnRH, FSH and LH) in the Context of Environmental Variability for Chinook Salmon.

PI Name: Michael Banks (OSU)
NOAA Collaborator: Peter Lawson (NOAA/NWFSC)
Other Collaborators: Andrij Horodysky (Hampton Univ.)

Research Students: Chante Davis (PhD Student, OSU)
Thematic Area: Quantitative Fisheries Funding: $49,094
Start Date: September 2014 End Date: August 2015

Abstract:

Chinook salmon is a culturally important and economically valuable fish. This anadromous and semelparous fish expresses diverse life histories that are characterized by the season of their return migration (called a "run") to spawning habitat. Prior research identified four spatially distinct subpopulations: 'Drift Creek', 'Spring', 'Fall', and 'Summer'. We plan to better resolve temporal population substructure by developing genetic markers that are linked to the regulation of gamete maturation. Traditionally, Spring run Chinook salmon migrate farther upriver with gonads that are less mature than the later Fall run. The timing of gamete maturation is synchronous with the arrival of fish on spawning habitat. The main hormone responsible for gamete maturation is Gonadotropin-releasing Hormone (GnRH). Our development of functional candidate markers that are associated with GnRH regulation may resolve temporal population substructure among the spatially separated subpopulations and enable future application for identifying environmental variables that contribute to population genetic structure.

Project #: 15-02

Project Title: Potential Impacts of the Savannah Harbor Expansion Project (SHEP) on the temporal and spatial patterns of fish assemblages near the mouth of the Savannah River

PI Name: Jennifer Guit (SSU)
NOAA Collaborator: John Manderson (NOAA/NEFSC)
Other Collaborators: Andrea Johnson (UMES)
Research Students: Jennifer Guit (MS Student, Savannah State U.)
Thematic Area: Essential Fish Habitat Funding: $51,863
Start Date: September 2014 End Date: August 2015

Abstract:

Over half of the commercial Atlantic catches are species that are dependent upon estuaries at some point during their life cycles. The recently approved Savannah Harbor Expansion Project will result in the deepening of the Savannah River shipping channel. Outcomes may be increased salt water intrusion and lower dissolved oxygen levels, which could negatively impact fishes of commercial and recreational importance that utilize the Savannah River estuary. The objectives of this proposal are to: 1) Determine the temporal and spatial patterns of fish assemblages near the mouth of the Savannah River before and after the deepening; 2) Determine fish health through gonadal histology; and 3) Publish a K- 12 activity geared toward the effects of anthropogenic impacts on the marine environment.

Project #: 15-03

Project Title: Analyzing diets of Atlantic menhaden using metabarcoding

PI Name: Ammar Hanif (UMCES/IMET)
NOAA Collaborator: Kevin Friedland (NOAA/NEFSC)
Other Collaborators: Al Place (UMCES/IMET); Bradley Stevens (UMES)
Research Students: Ammar Hanif (PhD Student, UMCES/IMET)
Thematic Area: Essential Fish Habitat Funding: $43,628
Start Date: September 2014 End Date: August 2015

Abstract:

Atlantic menhaden is a key forage species that serves as a trophic link between the plankton and predator fishes and birds. Identification of food organisms is difficult because the prey organisms are small and fairly easily digested such that traditional microscopic identification of stomach contents is somewhat limited potentially excluding insights into the predator-prey interactions of these forage fishes. As a result the understanding of larger scale processes such as food web interactions and energy flow through an ecosystem can be biased. This project is to develop and verify molecular techniques, based on cox1 DNA, as a tool to identify species in stomach contents of these fish and to compare them with those found in plankton. Existing molecular databases (National Center for Biotechnology Information and Barcode of Life) will be utilized for identification of

gut and plankton species. Identification by barcoding will also be verified by traditional microscopic methods.

Project #: 15-04

Project Title: Comparison of NOAA Montlake meal and Otohime feed performance in aquacultured pompano: feed ration, feed frequency, feed conversion ratio, and feed efficiency.

PI Name: Andrij Horodysky (Hampton Univ)
NOAA Collaborator: Ronald Johnson (NOAA/NWFSC)
Other Collaborators: Deidre Gibson (Hampton Univ); Michael Schwarz (VA Tech)
Research Students: Larry Redd, Jr. (MS Student, Hampton U.)
Thematic Area: Aquaculture Funding: $48,759
Start Date: September 2014 End Date: August 2015

Abstract:

As the demand for Florida pompano continue to increase aquaculture practices must be refined to optimize growth to satisfy a growing market. This project investigated the gastric evacuation of aquacultured juvenile Florida pompano fed three different diets at three temperatures to direct production of young life stages. Juvenile pompano were fed diets of frozen mysid shrimp, NOAA Montlake meal, and Otohime EP2 fish pellets at 20°C, 25°C, and 30°C. During the experiment, three fish were randomly sampled from the total population every 60 min and euthanized in MS-222 solution. Fish were then weighed (g), measured (SL), and frozen immediately for a period of 24-48h prior to dissections. The stomach and its contents were then emptied, patted dry, and weighed. A pilot gastric evacuation study was conducted January 21, 2014 using commercial Otohime EP2 fish meal; results indicated gastric evacuation was completed with an 11-12h time period after initial feed. A follow-up pretrial study was then conducted testing commercial EP2 fish meal to frozen mysid on March 12, 2014. Results from the March study indicated that juvenile pompano fed the frozen mysid diet completed gastric evacuation within a 6h time period. However, juvenile pompano fed Otohime EP2 fish pellets completed gastric evacuation at the 10h time period. Due to different growth rates according to diet, pompano fed NOAA Montlake and Otohime EP2 pellets have had gastric evacuation experiments conducted at 30°C, 25°C, and 20°C thus far. Results have indicated that the Otohime EP2 diet leads to faster gastric evacuation of juvenile pompano at 30°C, 25°C, and 20°C; however, anecdotal observations indicated that pompano fed NOAA Montlake diet on a higher average body weight and size compared to pompano fed the Otohime EP2 diet. Results from this study indicate that 30°C is an optimum temperature for pompano evacuation independent of the diet tested. If funded, an additional growth study will be conducted to formally compare the growth rates of juvenile pompano fed Otohime EP2 compared to NOAA Montlake meal.

Project #: 15-05

Project Title: RNA-DNA Ratios as Indicators of Ecosystem Health; metrics to determine the impact of land-use on fish habitat

PI Name: Andrea Johnson (UMES)
NOAA Collaborator: Lonnie Gonsalves (NOAA/NOS-Oxford)
Other Collaborators: James Uphoff (MD-DNR)
Research Students: Derek Burton (MS Student, UMES)
Thematic Area: Essential Fish Habitat Funding: $27,500
Start Date: September 2014 End Date: August 2015

Abstract:

Land development within the Chesapeake Bay watershed induces a suite of environmental stressors that negatively impact fish habitat and aquatic animal health. These effects degrade the ability of bay tributaries to serve as valuable nursery habitats for larval and juvenile fish which impacts fisheries production. The proposed study seeks to utilize RNA:DNA ratios as a bioindicator of larval and juvenile fish condition as a metric of fish habitat quality. The impact of variable land use patterns on fish habitat will be examined to further illustrate potential trade-offs between development on land and protection of habitats that provide a major socioeconomic and ecological contribution to coastal communities.

Project #: 15-06

Project Title: Analysis of Stranding Demographics and Contaminants in Marine Mammals from Coastal Maryland and the Chesapeake Bay

PI Name: Andrea Johnson (UMES)
NOAA Collaborator: Lonnie Gonsalves (NOAA/NOS-Oxford)
Other Collaborators: Cindy Driscoll (MD-DNR)
Research Students: Audy Peoples (MS Student, UMES)
Thematic Area: Quantitative Fisheries Funding: $19,500
Start Date: September 2014 End Date: August 2015

Abstract:

Contaminants and disease pose a serious risk to marine mammal health. The Marine Mammal Stranding Network offers a unique opportunity to examine the marine mammal health through the necropsy of stranded animals. Scientists from the Maryland Department of Natural Resources have compiled a long-term data set monitoring contaminant levels, observed incidence of disease, and overall health. This study will provide a robust analysis of this long-term data set that will examine the extent of contaminant exposure in marine mammals, the demographics of strandings, and the role of contaminants and disease in exacerbating stranding frequency. This information will be used to further guide analysis of the likely health impacts of chemical contaminants on marine mammal health. The proposed study intends to further the understanding of how humans impact the health and sustainability of marine mammal populations.

Project #: 15-07

Project Title: Ocean acidification effects on ecology of juvenile northern rock sole

PI Name: Jessica Miller (OSU)
NOAA Collaborator: Thomas Hurst (NOAA/AFSC)
Other Collaborators: Carla Curran (SSU)
Research Students:
Thematic Area: Essential Fish Habitat Funding: $37,469
Start Date: September 2014 End Date: August 2015

Abstract:

Research on the effects of ocean acidification (OA) on marine resource species has focused on the physiological effects on growth and development. However, recent research suggests that for many fish species, the primary action pathway of this aspect of climate change is the disruption of sensory and behavioral responses critical for survival. Specifically, several studies have found diminished behavioral sensitivity to predation cues at high CO2. We will describe the responses of juvenile northern rock sole to visual and olfactory predation cues and determine the extent to which elevated CO2 levels alter these intrinsic behavioral responses. This work will significantly improve our understanding of the diversity of impacts of OA to the productivity of critical marine fishery species.

Project #: 15-08

Project Title: Place Attachment and Traditional Ecological Knowledge in the Sea Islands: A Case Study of Endangered Culture

PI Name: Jolvan Morris (Savannah State Univ.)
NOAA Collaborator: Patricia Clay (NOAA/SERO)
Other Collaborators: Dionne Hoskins (SSU); Michael Jepson (NOAA/SERO)
Research Students:
Thematic Area: Fisheries Socio-Economics Funding: $9,760
Start Date: September 2014 End Date: August 2015

Abstract:

For centuries, Gullah-Geechee communities along the coastal Sea Islands of South Carolina and Georgia maintained their own way of life through a thriving economy based on ecology without compromising the natural environment. Proximity to the sea fostered an early tradition of seafood harvesting, ranging from cast netting to small-scale commercial shrimp boats (Blount, 2007). Harris Neck is a Sea Island community of cultural and ecological significance in the region. While place attachment has been researched extensively in the social and behavioral sciences, little research has been conducted on historic communities of color. The objective of this project is to quantify place attachment and describe traditional ecological knowledge between Gullah-Geechee communities in the Sea Islands.

Project #: 15-09

Project Title: Searching the coastal bay food web for reservoirs of a virus lethal to blue crab *Callinectes sapidus*

PI Name: Eric Schott (UMCES/IMET)
NOAA Collaborator: Linda Stehlick (NOAA/NEFSC)
Other Collaborators: Gulnihal Ozbay (Delaware State Univ.); Joe Pitula (UMES)
Research Students: Kristen Lycett (Ph.D. student, UMES); Matthew Stone (MS student, DESU).

Thematic Area: Essential Fish Habitat Funding: $40,086
Start Date: September 2014 End Date: August 2015

Abstract:

Blue crabs are a key link between benthic and pelagic food webs and support a commercial harvest of over $180 million. Fluctuations in abundance are not well understood, and there is an increasing appreciation for the potential role of disease in natural mortality. The 2013 Chesapeake Bay Stock Assessment Committee listed scarce information on disease-related mortality as a critical data gap. Our studies have shown that prevalence of a virus lethal to blue crab (RLV) can be as high as 78%, with an average of 20% across the Chesapeake and the Northeast. RLV can be transmitted to blue crabs by consumption of infected conspecifics. To investigate the possibility that other crustacean species may be a reservoir for RLV, students will look for RLV in green crabs, grass shrimp, and other crustaceans in the coastal bays of MD, DE, and NJ. Crustaceans and corresponding environmental data will be collected from coastal bays by students from UMES and DSU in the spring and summer of 2015. Samples will be analyzed for RLV using qPCR methodology at IMET. Students will investigate the potential for other species to serve as hosts to RLV by conducting controlled infections. Preliminary studies demonstrated the ability to transmit RLV to green crabs (*Carcinus maenas*) by injection. This finding will be reconfirmed, and extended by an attempt to transmit the virus by feeding. Improved understanding of disease-related mortality of blue crab will be valuable demonstration to NOAA's efforts to understand natural mortality of other fishery species.

Project #: 15-10

Project Title: Improving management of deep-sea red crabs *Chaceon quinquedens*, Year 2: Reproductive biology, maturity, and age estimation

PI Name: Bradley Stevens (UMES)
NOAA Collaborator: Chris Long (NOAA/AFSC), Matt Poach (NOAA/NEFSC), Rich McBride (NOAA/NEFSC)
Other Collaborators: J. Sook Chung (UMCES/IMET)
Research Students: Stephanie Martinez-Rivera (MS Student, UMES); Justin Wilson (MS Student, UMES); Shadaesha Green (MS Student, UMCES/IMET); Nivette Perez-Perez (MS Student, DSU)

Thematic Area: Quantitative Fisheries Funding: $59,784
Start Date: September 2014 End Date: August 2015

Abstract:

Deep sea red crabs support a small but valuable federally-managed fishery along the US Atlantic coast, but lack of information about their biology, abundance, growth, age, or reproduction prohibits adequate management. Preliminary data collected during LMRCSC cruises aboard NOAA Research Vessels in 2011-2013 indicates that female red crabs have a biennial reproductive cycle, and size of sexual maturity (SM50) of about 61 mm CL but male SM50 could not be determined. In 2013, students began verifying this information by histological analysis of gonad tissues. In 2014-15 we conducted sampling from

the commercial fishery to determine seasonality of reproduction, fecundity, and age analysis. Samples from previous cruises were processed to estimate size of oocytes and spermatophores. Eyestalks and gastric mills were prepared to determine age of crabs. This information is critical for management and conservation of red crab populations.

Project #: 15-11

Project Title: Augmenting the Black Sea Bass, *Centropristis striata*, Stock Assessment, Year 3: Assessing the importance of fixed and fluid estuarine habitats

PI Name: Bradley Stevens (UMES)
NOAA Collaborator: Howard Townsend (NOAA/NOS/CBO)
Other Collaborators:
Research Students: Laura Almodovar-Acevedo (MS Student, UMES)
Thematic Area: Essential Fish Habitat Funding:
Start Date: September 2014 End Date: August 2015

Abstract:

Black sea bass (BSB, *Centropristis striata*) support important commercial and recreational fisheries in the Mid Atlantic Bight. Adults live offshore, but juveniles depend on reef and hard bottom habitats in estuaries in the summer and early fall. We hypothesize that BSB recruitment is associated with the availability of oyster reefs in the Chesapeake, and annual variability in temperature, precipitation and salinity. In Year 1, we began developing a habitat suitability model to determine preferred habitats of BSB in the Chesapeake, and test the model by sampling a variety of known and unknown habitats. In Year 3 we wish to expand the range of sampling and determine when sonic tagged fish leave Chesapeake Bay. This proposal addresses two of the LMRCSC research themes including "Quantitative Fisheries" and "Essential Fish Habitat", as well as several NOAA Strategic Goals.

Project #: 15-12

Project Title: Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change: California sea lions and their pelagic prey off Oregon and Washington

PI Name: Leigh Torres (OSU)
NOAA Collaborator: Rich Brodeur (NOAA/NWFSC)
Other Collaborators: Tara Cox (SSU); Bryan Wright (OR DFW)
Research Students: Caren Barcelo (Ph.D. Student, OSU)
Thematic Area: Quantitative Fisheries Funding: $45,478
Start Date: September 2014 End Date: August 2015

Abstract:

Although distributional responses of marine predator populations to temporal and environmental variability have been demonstrated, these studies did not account for predator-prey relationships and therefore lacked an element of realism. This project will generate species distribution models of California sea lions and their prey items off the Oregon and Washington coasts to (1) describe and compare habitat use patterns, (2) predict distribution patterns under various temporal and climate change scenarios, and (3) evaluate the ecological and management implications of overlap or mismatch between predator and prey. This collaboration involves four agencies and two universities, aims to train under-represented students in spatial analysis, oceanographic, and science communication skills, and will deliver novel results to assist ecosystem based management.

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

Activities and Accomplishments:

- Monthly meetings and discussions of the LMRCSC Research Committee were held during this reporting period. CSC-CSC joint research projects were discussed and the LMRCSC annual Science meeting is being planned for May.
- Several collaborative research projects between scientists at LMRCSC MSIs and scientists at Research Intensive institutions (RSMAS, IMET, OSU) are on-going.

Leverage multiple sources of funding to support the Center's research agenda:
Activities and Accomplishments:

- Leveraged funds during this reporting period totaled $1,193,641 (Appendices II and III)

NOAA LMRCSC Scientific and Educational cruise aboard the NOAA Ship Delaware II
No LMRCSC research cruise was conducted in this period.

SCHOLARLY PRODUCTIVITY

In the current reporting period, LMRCSC students and faculty made 68 presentations at scientific meetings, and published 29 articles in refereed journals (Appendix IV).

Grantsmanship: A total of $1,276,641 (Appendix II and III) was collectively awarded to the LMRCSC partner institutions during the current reporting period which directly or indirectly impacted Center activities. Of the total amount of funds awarded to LMRCSC, $181,576 came from NOAA, whereas $1,095,065 was obtained from other agencies. The funds provided by these agencies were used to support faculty and students and develop/enhance infrastructure.

SECTION II – EDUCATION AND OUTREACH ACTIVITIES

1. **How many students and faculty were recruited to participate in academic programs, training, workshops, conferences or seminars?** 15 students were recruited to the center during this period.

2. **What are the new education programs (degree certificate programs, etc**.)? In 2015, RSMAS re-organized its departments, and developed several new Ph.D. programs. The new Department of Marine Ecosystems and Society now has a Ph.D. program, which will accept students studying fisheries, marine resource economics, marine policy, etc. The Department of Marine Biology and Ecology retains the Ph.D. program that was formerly called Marine Biology and Fisheries. UMCES is now accredited and able to confer MEES M.S. and Ph.D. degrees directly.

3. **Students receiving direct and indirect support from the LMRCSC. 116** students were supported. Of those, 94 were supported directly while 22 were supported indirectly.

4. **What outreach activities (e.g. workshops, conferences, seminars) have the Cooperative Science Center coordinated as part of the project?**
HU: Students attended an Oral and Poster Presentation Workshop in order to prepare for the ASLO Ocean Sciences Meeting.

UMCES: Chung: met with Baltimore Polytechnic 9th grade: Nov. 4th

Chung: met with Young Women Scientists. Nov. 12

Gillespie: Tues & Thursday mornings, teaching lab modules in SciTech to middle & high school students

Gillespie: volunteer instructor in Biotechnology for Baltimore City Community College

*Hanif: Working with Towson State University Scitech program teachers and administrators on teaching modules for middle and high school students

Jagus: visited Kennessaw State University to meet with their undergraduate and masters students about LMRCSC undergraduate internships and graduate programs, attended Student's Monthly Saturday informal talks with students from Emory University & Georgia Polytech, October, 2015.

Jagus/Hill: hosted Morgan State Biology Club students to give tour of IMET and discuss opportunities for summer internships and graduate studies. February 2016.

*Maurer: participated in IMET's Ask a Scientist Booth, Inner Harbor, September 2015

*Maurer: participated in Junior Achievement Day at Pikesville High School

*Maurer: participated in George Washington Elementary School Chesapeake Bay Day

Schott: semester-long internship for Baltimore Polytechnic student, *Faith Webster, Fall * Spring semesters.

UMES: Students participated in the Student Development Seminar, which focused on supporting the goals of the Student Development Plan, including scientific communication and applying for internships.

K-12 Education and Outreach Programs:

- **Hampton University Kayak Camp:** The LMRCSC is in the process of planning three summer camps for Summer 2016 for students ranging in age from 9-18 through one of its partner institutions, the Department of Marine and Environmental Science at Hampton University, and the Chesapeake Experience. "The residents of the Hampton Roads spend time enjoying the vast waterways in our area, but know very little about the ecology of their community. These camps provide opportunities for students to learn about the ecology, the biodiversity, and the environmental problems that plague the Chesapeake Bay watershed", remarks Dr. Deidre Gibson, project director of the HU-LMRCSC. "These camps also provide students an opportunity to learn about the research at Hampton University and to enjoy our Home by the Sea.
- **Research Experiences for Undergraduates in Marine and Estuarine Sciences:** The LMRCSC is a site of an REU program funded by NSF, and with additional support from the LMRCSC. Planning is underway to hose 11 students in Summer 2016. They will participate in various activities such as research, seminars, workshops, and field trips. The critical mass of scientists with expertise in NOAA related sciences recruited and supported by the NOAA LMRCSC made it possible to establish in 2010 at UMES this REU site. Some students (e.g. Nivette Perez, MS student at DSU) have enrolled in graduate programs at LMRCSC institutions after participating in the internship program.
- **Geosciences Bridge Program**: The LMRCSC worked collaboratively with other NOAA Cooperative Science Centers, CSCs (NCAS, CREST and ECSC) and established a summer geosciences bridge program at UMES. We are in the process of planning and reviewing applications to host 9-13 students. They will be exposed to the various areas of geosciences via hands-on activities and field trips. In addition, they will take a college level math class as well as freshman orientation class.
- **Regional National Ocean Sciences Bowl** competition hosted at SSU on February 6, 2016.
- **Website:** The LMRCSC web site (www.umes.edu/lmrcsc) is undergoing substantial renovations by Anne Dudley, Communications Specialist. The site highlights linkage with NOAA and Center accomplishments and makes them more accessible to the user. The site includes biographical information for faculty and graduate students at each Center partner institution. Each of the LMRCSC partner institutions also has its own website that is directly linked to the LMRCSC main web page. We expect the new site to go live this spring.

  Facebook: LMRCSC Technical Monitor Jeanine Cody created an LMRCSC page on Facebook which went live on July 20, 2009. It provides students and others a forum to network and discuss marine and fisheries issues, job and funding opportunities, current events in marine science, etc. Four hundred seventy-three (473) individuals, including many students, have signed up as 'fans' of the site. Partner institutions also maintain Facebook pages. At SSU, daily posts are made by the outreach coordinator.

SECTION III – SUCCESS STORIES (SCIENTIFIC AND STUDENT ACCOMPLISHMENTS)

1. What specific contributions have the projects made to the Center, NOAA and partners?
The LMRCSC educational, research and outreach activities have resulted in several contributions during this reporting period. 116 students from B.S. to doctoral levels were trained in NOAA core sciences. 17 students graduated (4 Ph.D., 4 M.S., 9 B.S). 12 projects funded through the TAB for 2014-2015 are being completed, and $ 1,276,641 in external funding is supporting Center-related activities.

2. How many students participated in Center projects or activities? 116 students participated in the Center projects. The names of some of the students, their research projects and presentations they made during this reporting period are presented in Appendix IV. 400 K-12 students participated in the Center educational and outreach activities.

3. What specific benefits were accrued to students, faculty members and the institution(s) by participating in the program? Students benefited from their participation in the projects through hands-on research experience, completion of theses in partial fulfillment of their degree requirements, stipend, and travel awards to conferences. Besides, some students secured employment after completion of their degree programs, or received scholarships for graduate studies.
Students are:

- gaining year-long research experience
- attending specific workshops
- traveling to local and international conferences

Faculty are:

- receiving funding to mentor LMRCSC students and are getting talented student researchers in their labs
- receiving funds for research supplies
- creating and maintaining research collaborations with Center partners and outside partners
- traveling to local and international conferences and workshops

Partner institutions are:

- receiving Indirect Cost funds from this grant
- receiving enhanced research facilities
- receiving trained students that are prepared for graduate school or the workforce
- benefiting from faculty collaboration across schools and departments
- receiving the benefit of potential recruitment from the LMRCSC Marine Science Summer Camp

Students who Received Scholarships for Graduate Degree Programs as a Result of their Work at the Center:
Larry Redd Jr is currently a NOAA Knauss Fellow
Malik Breland is currently a NMFS Observer

Students who Received Employment as a Result of their Work at the Center:

At the end of her year as a Knauss fellow, former graduate, Dr. Jeanette Davis has accepted a one-year contract at NOAA-NMFS in Silver Spring.

Chelsea Parrish was selected for the NOAA Corps.

SSU Marine Science alumnus and former NSF GK-12 fellow, Brandon Coleman, is working in Silver Spring, MD for Advanced Resource Technologies, Inc (ARTI). ARTI is a NOAA contractor.

Students who received Training at NOAA Laboratories or at Center Institutions: 5 students conducted research at NOAA labs (Table 4).

4. To what extent have the projects or activities enhanced and improved outreach, education, training and NOAA related research at the institutions? Students supported under the LMRCSC have access to tools and training they would not have were it not for the LMRCSC. 22 students at the Center institutions who were not directly funded by the LMRCSC

benefitted from the infrastructure and equipment made available to the institutions by the LMRCSC. The LMRCSC has secured leveraged funding (~$1.3 million) that has enabled the Center institutions to recruit and support more students than they would otherwise be able to support.

LMRCSC activities and infrastructure have created a model upon which other outreach and training programs have been built. Other marine science outreach programs at SSU feed into the Coast Camp. SSU Coast Camp has become the testing ground for K12 modules. Faculty have been able to apply for other base funding for research fellowships because of the prior funding provided by the LMRCSC. Finally, travel and research funding from the LMRCSC that allowed students to travel to NOAA labs helped publicize the quality of LMRCSC faculty and students, thereby improving our collaborative and recruitment success.

5. Did students participate in experiential research at, site visits to, or seminars at/with NOAA laboratories and/or facilities? Yes, names of student participants are in Table 4.

6. In what specific NOAA science, service or stewardship activities (e.g. NOAA research cruises; weather forecast modeling, etc.) were students involved?

This period, students were involved in research in the following areas;

- Marine Biotechnology: Red Crab study
- Aquaculture/Fisheries
- Marine science related engineering
- Fisheries Modeling
- Oyster reef monitoring

7. What significant impact(s) does the LMRCSC research, education and outreach, and administrative functions have university-wide, for the local community, and at the local, state, regional or national level?

- **University-wide**- The LMRCSC has provided infrastructure for research conferences at SSU via faculty, student research, and poster boards. It has also provided the fellowship mentoring model and the postdoctoral fellow development model. RSMAS students who are supported by the LMRCSC serve as Teaching Assistants for at least one semester, thus supporting graduate and undergraduate education. Students are active in campus activities.
- **Local Community & Region- HU's leveraged NOAA Sea Grant program supports the Newport News, Moton Community Center, Aquaponics systems for the food desert community.**
- **National-** LMRCSC students have travelled nationally to conduct research and to present the results of that research to national labs and conferences. The LMRCSC is increasing the number of students especially those belonging to underrepresented minority groups who are trained in NOAA related science disciplines, thereby positively impacting the future workforce. Marisa Litz gave a presentation to the NOAA Science Advisory Board on NOAA Education Partnership Program with Minority Serving Institutions Cooperative Science Centers: Graduate Research and Training Scholarship Program. Newport, OR. Jan 12, 2016.

SECTION IV – REVISIONS TO TASKS AS DESCRIBED IN GRANT AWARD AMENDMENTS AND THE IMPACT TO THE AWARD: There were no amendments to the award.

APPENDICES

Appendix I: Partial List of NOAA NMFS Scientists Who Collaborated with LMRCSC Scientists and Students during this reporting period (September 1, 2015 – February 29, 2016)

NOAA Scientists	NOAA Lab	Role at the LMRCSC
Bill Peterson	NOAA NWFSC, Newport, Oregon	Adjunct faculty, committee member
Burton Shank	NEFSC	Grad student advisory Committee Member, TAB Participant
Chris Long	Kodiak Lab, AFSC	Grad student advisory Committee Member, TAB Participant
Dan Holland	NOAA NQFSC	Committee member
Enric Cortes	SEFSC, Panama City	Ph.D. committee
Eric Anderson	NOAA SWFSC	GRTSP mentor
Howard Townsend	Coop Oxford Lab (NOS)	Grad student advisory Committee Member, TAB Participant, taught course
Jeff Isely	SEFSC	Seminar speaker
John Walter	SEFSC	Collaborator, seminar speaker
Karyl Brewster-Geisz	D.C.	Student committee member
Laurie Weitkamp	NOAA NWFSC, Newport, Oregon	Adjunct faculty, committee member
Linda Shtelik	JJ Howard	TAB collaborator
Martha Nizinski	NOAA Systematics Lab, Smithsonian Inst.	Grad student advisory Committee Member
Matthew Poach	Sandy Hook, NEFSC	Grad student advisory Committee Member, TAB Participant
Michael Banks	OSU/Hatfield	Collaborator on TAB/ EPP Student mentor
Michael Schirripa	SEFSC	Ph.D. committee
Peter Lawson	NOAA NWFSC	Committee member
Ric Broduer	NOAA NWFSC, Newport, Oregon	Adjunct faculty, GRTSP mentor
Richard McBride	NEFSC	Grad student advisory Committee Member
Ronald B. Johnson	NWFSC	Collaborator on TAB
Shannon Cass-Calay	SEFSC	Seminar speaker
Skyler Sagarese	SEFSC	Collaborator
Thomas Hurst	NOAA AFSC, Newport, OR	Adjunct faculty, committee member, mentor
Vince Guida	Sandy Hook, NEFSC	Grad student advisory Committee Member, TAB Participant

Appendix II. Current leveraged funding from NOAA to LMRCSC institutions

	Funding Agency	Title of Project	Start/End Date	Amount	Current 6 month period
Chante Davis	EPP	A landscape genetic approach to understanding adaptation of Chinook in the Siletz river using candidate loci associated with timing of reproductive events	6/1/15-5/31/16	GRTSP	$32,000
Marisa Litz	EPP	Development of a bioenergetics model to evaluate the effects of climate change on juvenile Chinook salmon growth	4/1/2015-3/31/16	GRTSP	$32,000
Cuker, B	NOAA MD Sea Grant	ASLOMP Supplement	10/1/15-2/28/16	$3,000	$3,000
B. Stevens, R. Appeldoorn (U.PR)	NOAA-SK	Camera sled survey of Queen Conchs in Puerto Rico	9/1/2015-8/30/2017	$358,305	$89,576
B. Stevens, R. Lipcius (VIMS)	NOAA-BREP	Impact of black sea bass traps on habitat	2/14/2016-1/15/17	$103,235	$25,000
Total					$181,576

Appendix III. Current leveraged funding to LMRCSC institutions from sources and agencies other than NOAA (*Students)

Author	Funding Agency	Title of Project	Start/End Date	Amount	Current 6 month period
Andrade, Jessica	Maimie Markham Scholarship	Flatfish behavioral responses to predatory threat under elevated carbon dioxide concentrations	6/1/15-5/31/17	$9,000	$4,000
Miller, Jessica	Bonneville Power Administration	Columbia River basin juvenile salmonids: survival and growth in the Columbia River plume and northern California Current: early marine residence	01/01/2016-12/31/16	$25,000	$12,000
Ozbay (DSU) McIntosh (DSU)	National Science Foundation	CCEP-II: MADE-CLEAR Maryland- Delaware Climate Change Education, Assessment, and Research	08/01/2012-07/30/2017	$300,000	$30,000
McIntosh	National Science Foundation	Bridge to Doctorate funding for Jasmine Smalls	08/01/2015-07/31/2017	$110,000	$25,000
Cuker, B	NSF	Multicultural Diversity in the Aquatic Sciences	8/1/13-7/31/18	$900,000	$180K
Gibson, D.	NSF	Cryptic Diet of the Doliolid…	2/1/15-1/31/18	$200K	$75K

Gibson, D.	NSF	Partnership in Research and Education in Materials (PREMP)	9/1/15-8/31/20	$3M	$600K
Paulinus Chigbu; Co-PIs: Ali B. Ishaque; Michael Abazinge; Reza Khanbilvardi; Vernon Morris; Erik Zettler	NSF	GP-IMPACT	9/1/15 to 8/31/18	$500,000.00	$83,000
B. Stevens	ACFHP	Hab in the MAB: Characteristics of black sea bass habitats	4/1/2016-12/31/18	$216,394	$36,065
Total					$1,095,065

Appendix IV: Presentations and Publications

Oral Presentations (*Students **Appendix IV: Presentations and Publications**

Oral Presentations (*Students)

DSU: 2 Presentations, 1 student presenter

Reckenbeil*, B.,Ozbay, G., Ewart, J. (2016). Using shoreline riprap to stock Eastern oysters (*Crassostrea virginica*). Presented at the World Aquaculture Conference, Las Vegas, NV, February 2016.

McIntosh, D., Schott, E., Schreier, H., Blank, G. (2016). Identification and isolation of novel probiotic bacteria for use in marine aquaculture. Presented at the World Aquaculture Conference, Las Vegas, NV, February 2016.

HU: 1 presentations, 1 student presenter

Rogers*, J., Cordoba, G., Nieves, M., Barber, P., Fong, P., Sura, S. (2016) Nutrients, high light, and shallow depths favor the expansion of the brown macroalgae *Turbinaria ornata* in the coral reefs of Mo'orea, French Polynesia. Presented at the Ocean Sciences Meeting (OSM), New Orleans, LA, February 2016.

OSU: 6 presentations, 4 student presenter

Litz, M.N.C.* (2016). What can we learn about the feeding ecology of juvenile salmon using an integrated biochemical approach? LMRCSC Seminar Series, Newport, OR. March 4, 2016.

Barceló, C*, C Coleman, B Wright, R Brown, J Adams, LT Balance, R Brodeur, LG Torres (2015). Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change. 21st Biennial Conference on the Biology of Marine Mammals: Bridging the Past and the Future, San Francisco, CA. December 13-18, 2015

Rose, G.*, Bottom, D., Whitman, L., and Miller, J. A. (2016). Describing juvenile life histories of the McKenzie River spring Chinook salmon spawning population using otolith microchemistry. Oregon Chapter American Fisheries Society Meeting, Seaside, OR.

Fedewa, E.*, Hurst, T. P., and Miller, J. A. (2016). Interannual variation in pre- and post-settlement processes of northern rock sole (*Lepidopsetta polyxystra*) in relation to temperature variability in the Gulf of Alaska. Alaska Marine Science Symposium. Anchorage, AK.

Carlton, J.T., Chapman, J.W., Geller, J.B., Miller, J.A., and Ruiz, G. (2016). The invasion process model and the transoceanic dispersal of coastal marine organisms by Japanese tsunami marine debris. 9th International

Miller, J.A. 2016. Causes and consequences of variation in salmonid migratory behavior. Oregon Chapter American Fisheries Society Meeting, Seaside, OR.

RSMAS: 1 presentations, 1 student presenters

Callwood, K.* 2015. Condos and Connectivity: Developing an Interdisciplinary Approach to Guide Caribbean Spiny Lobster (*Panulirus argus*) Fisheries Management within The Bahamas, 68th GCFI Conference, November 9-13, 2015

SSU: 0 Presentations, 0 student presenters

UMES: 6 Presentations, 3 student presenters

Chi, Yeong Nain. (2015). Modeling Trip-Related Expenditure of U.S. Saltwater Recreational Fishing. Accepted to present at the 2015 Annual Meeting of the Southern Economic Association, New Orleans, Louisiana, November 2015.

Goslee, P. (2016). Plunging into Maryland's coastal bays. Presented at the National Professional Development (NAPDS) Conference, Arlington, Virginia March 2016.

Schweitzer, C*. and Stevens, B.G. (2015). Trap Fishing Impacts on Benthic Live-Bottom Habitat within the Black Sea Bass Fishery in the Mid-Atlantic Bight. Presented at the American Fisheries Society (AFS) conference, Portland, OR, August 2015.

Sexton MS and Chigbu P. (2015). Peer mentoring as a method of developing communication skills among early undergraduate REU interns. CERF 2015. Portland OR.

S. Martinez-Romero*, and Stevens, B.G. (2016). Reproductive biology of the red deep-sea crab (*Chaceon quinquedens)* in the Mid-Atlantic Bight. National Shellfisheries Association 108th Annual Meeting, Las Vegas, NV, March 2016.

J. Wilson* and Stevens, B.G. (2016). Age determination of red deep-sea crab (*Chaceon quinquedens)* by growth ring analysis. National Shellfisheries Association 108th Annual Meeting, Las Vegas, NV, March 2016.

UMCES: 16 Presentations, 4 student presenters

Ahn, IS and Chung, S. (2016). Ontogenic expression of crustacean female sex hormone and its functional role in developing female specific-sex characteristics in the blue crab, *Callinectes sapidus*. 109th NSA, Las Vegas, NV February 22-26.

Green*, S and Chung, S. (2016). Crustacean hyperglycemic hormone of the red deepsea crab, *Chaceon quinquedens*: Identification and its potential role as a reproductive regulator. 109th NSA, Las Vegas, NV February 22-26.

Haq, S, Bachvaroff, T. R., Williams, E., Goodlett, D. R., and Place, A. R. 2015 One Pathway, Two Products: A polyketide synthase pathway in dinoflagellates results in both toxin and fatty acid production. 8th Symposium on Harmful Algae in the US, Long Beach, CA, November 15-19, (Poster and Speed Talk Presentation)

Hill, R T (2016). Bacterial symbionts in marine sponges: Key players in nutrient cycling in coral reef ecosystems. South African Society for Microbiology Biennial Conference. Invited Plenary. Durban, South Africa. January, 2016.

Hill, R. T. (2016). Bacterial symbionts in marine sponges: Key players in nutrient cycling in coral reef ecosystems. South African Society for Microbiology Biennial Conference. Invited Plenary. Durban, South Africa. January, 2016.

Jagus, R. (2015). Expansion of eIF4E and 4E-BP family members with radiation of the teleosts. MRC Centre for Reproductive Health, University of Edinburgh, September, 2015.

Jagus, R. (2015). It's all about translation. Department of Biology & Physics, Kennesaw University. October 2015.

Jagus, R, Liu, CL, *Watson, A, & Place, AR (2016). Adaptation of a fish liver cell line (ZFL) to a taurine free medium. World Aquaculture Society Meeting, Las Vegas, NV February 22-26.

Jones, G, Bachvaroff, T, Place, AR, and Jagus, R. 2015. Phylogeny and function—identification of the prototypical eIF4E translation initiation factor in dinoflagellates. 8th Symposium on Harmful Algae in the US. Long Beach, CA November 15-19.

Khoei, F. H., Watson, A., Place, A. R, Connolly, J. and Ghosh, U. (2015). The effect of sediment AC amendment on pelagic and benthic exposures to fish. CPRC-SETAC, Salt Lake City, Utah November 1-5. Oral Presentation

Maurer*, L and J. Chung, S. (2016). The influence of prey density and dietary supplementation on the larval development of the blue crab, *Callinectes sapidus*. 109th NSA, Las Vegas, NV February 22-26.

Schott, ES. (2016). "The role of disease in mortality of aquatic invertebrates: an abundance of blue crab virus" Stony Brook University, School of Ocean and Atmospheric Sciences. March 11, 2016.

Vicente*, J. (2015). Caribbean wide sponge epizooism reveals two new species of *Plakinidae* (Porifera: Homoscleromorpha), one new species of *Haliclona* (Demospongiae: Haplosclerida: Chalinidae) and the polymorphic nature of *Xestospongia deweerdtae* MEES Colloquium, October 30, 2015.

Wazniak, C., McCollough, C, Dawson, C, Deeds, J, Place, A. R., and Wolny, J. (2015). Occurrence of *Dinophysis* and Associated DSP Toxins in Maryland. 8th Symposium on Harmful Algae in the US. Long Beach, CA November 15-19, (Oral Presentation)

Place, A. R, and Ramos-Franco, J. (2015). Characterization of pores in black lipid membranes made by karlotoxin 2 (kmtx2) from *Karlodinium veneficum* (Dinophyceae) 8th Symposium on Harmful Algae in the US. Long Beach, California, November 15-19, (Oral Presentation)

Thao, YT, Hill, RT, Linh, TN, Si, VC. (2015). Collaborative research in isolation and selection of microalgal strains in Vietnam having suitable characteristics for edible oil production at large scale. 9th Vietnam-U.S. Joint Committee Meeting on Scientific and Technological Cooperation (JCM9). Ho Chi Minh City, Vietnam.

Poster Presentations (*Students)

DSU: 1 posters, 1 student presentations

Elliott*, C., Perez-Perez*, N., Gonsalves, L., Lamb, M.,Smith, S. (2016) Stable Isotope Signatures Suggest Different Feeding Strategies for Atlantic and Gulf Menhaden. Presented at the 2016 Ocean Sciences Meeting, New Orleans, LA, Feb. 2016.

HU: 5 posters, 5 student presenters

Bynes, K* (2016). Models for U.S. Fish Stock Assessment. Presented at the Ocean Sciences Meeting (OSM), New Orleans, LA, February 2016.

Shaifer*, J., (2016) Early Life-Stage Responses of a Eurythemal Estuarine Fish, Mummichog (*Fundulus hetereoclitus*) to Fixed and Fluctuating Thermal Regimes. Presented at the Ocean Sciences Meeting (OSM), New Orleans, LA, February 2016.

Williams*, C., Degregori, S., Barber, P., Sura, S. Fong, P., (2016). Herbivory and competition limit the expansion of the macroalga *Turbinaria ornata* to shallow zones on a fringing reef in the South Pacific. Presented at the Ocean Sciences Meeting (OSM), New Orleans, LA, February 2016.

Salcedo-Bauzá*, A., Rodríguez, A., Gibson, D., (2016). DNA Barcoding of Zooplankton in the Hampton Roads Area: A Biodiversity Assessment Hampton University. Presented at the Ocean Sciences Meeting (OSM), New Orleans, LA, February 2016.

Wilkins*, N., Rodríguez, A., (2016). DNA Barcoding of Ichthyoplankton in Hampton Roads Bay Estuary Hampton University. Presented at the Ocean Sciences Meeting (OSM), New Orleans, LA, February 2016.

0SU: 5 posters, 2 student presenters

Litz, M.N.C.*, Miller, J.A, Copeman, L.A., and Hurst, T.J. (2016). Effects of dietary fatty acids on juvenile salmon growth, biochemistry, and aerobic performance: a laboratory rearing experiment. 2016 Ocean Sciences Meeting, New Orleans, LA. February, 2016.

Akau, J. Miller, J. A., and MacKenzie, R. A. (2015) A twenty-year comparison of post-larval goby abundance on Hawaii Island. Coastal and Estuarine Research Federation Meeting, Portland, OR, November 2015.

Andrade, J.F.*, Hurst, T.P., Miller, J.A. (2016). Identifying flatfish behavioral responses to predation cues to inform corresponding ocean acidification experiments. 19th Western Groundfish Conference, Newport, OR. February, 2016.

Miller, J.A., Carlton, J.T., Chapman, J.W., Geller, J.B., Ruiz, G. (2016). The mussel *Mytilus galloprovincialis* on Japanese Tsunami Marine Debris: a potential model species to characterize a novel transport vector. 9th International Conference on Marine Bioinvasions, Sydney, Australia.

Miller, J.A., Peterson, W.T., Copeman, L A., Morgan, C. A., and *Litz, M.C.N. (2015) Seasonal variation in the biochemical ecology of lower trophic levels in the Northern California Current. Coastal and Estuarine Research Federation, Portland, OR.

RSMAS: 0 poster, 0 student presenters

SSU: 0 posters, 0 student presenters

UMES: 15 posters, 12 student presenters

Abass, R.*, Richardson, C.*, Ngoka, I.*, Karim, S.*, Jesien, R., Ishaque, A. (2015). Chemical Analysis and Estrogenic Activity Profiles of Contaminants of Emerging Concern (CECs) in Maryland Coastal Bays. 12th international symposium on Recent Advances in Environmental Health Research, Jackson, MS. 09/12-17/2015

Rosales, D*, and Pitula, J (2015) "Molecular Techniques in Detecting Harmful Dinoflagellates In the Maryland Coastal Bays". 6th Annual Regional Research Symposium April 21 2015. Poster presentation.

Rosales, D*, Wolny, Jennifer, and Pitula, J (2015) "Detection of Harmful Dinoflagellates in the Maryland Coastals Bays Filter Feeder ". 8th HAB symposium Nov 18 2015. Poster presentation

Schweitzer, C.*, Stevens, B. (2015). Trap Fishing Impacts on Benthic Live-Bottom Habitat within the Black Sea Bass Fishery in the Mid-Atlantic Bight. Presented at International Conference on Biodiversity, Ecology and Conservation of Marine Ecosystems (BeCoME), Hong Kong, China, June 2015.

Schweitzer, C*., Stevens, B. (2015). Trap Fishing Impacts on Benthic Live-Bottom Habitat within the Black Sea Bass Fishery in the Mid-Atlantic Bight. Presented at the UMES research symposium. 2015

Schweitzer, C*., Stevens, B. Disturbance of Essential Fish Habitat by Commercial Passive Fishing Gear in the Delaware, Maryland, and Virginia region of the Mid-Atlantic Bight. Presented at the Association for the Sciences of Limnology and Oceanography (ASLO), New Orleans, LA Feb. 2016

Rhoades, Courtney A.*, Maurice Crawford, Cindy P. Driscoll, and Amanda L. Weschler. 2016. An Analysis of Sea Turtle Demographics along Maryland Shores (1990-2015). 2016 Ocean Sciences Meeting, New Orleans, LA

Horruitiner*, C., A.J. Nicastro*, D. Lundgren, S. Sinclair, M. Crawford, M. Palace, M. Wik, J.E. Johnson and R.K. Varner. Examining the role of aquatic vegetation in methane production in a shallow high latitude lake in Abisko, Sweden. American Geophysical Union, San Francisco, CA, December 2015

L. Almodóvar-Acevedo*, M. Hasan, H. Townsend, and B. G. Stevens. Assessing available habitat for Black Sea Bass in the Chesapeake Bay through a Habitat Suitability Model. MEES Colloquium October 2015 – Annapolis, MD (Poster)

Chigbu, P., Malagon, H. and Doctor, S. (2016). Depth, salinity and temperature variability in the Maryland Coastal Lagoons. ASLO/Ocean Sciences meeting in New Orleans, LA; Feb. 22-26, 2016.

Morales-Núñez, A.G. and Chigbu, P. (2015). Range extension of the invasive isopod *Ianiropsis serricaudis* Gurjanova, 1936 in Maryland Coastal Bays, USA. CERF 2015 Conference, Portland, OR, November 9 -13, 2015.

Morales-Núñez, A.G. and Chigbu, P. (2016). Moving Northward? First Record of *Spilocuma watlingi* (Crustacea: Cumacea: Bodotriidae) in Mid-Atlantic Region, Maryland Coastal Bays, USA. ASLO/Ocean Sciences meeting, New Orleans, LA; Feb. 22-26, 2016

Mayor*, E.D. and Chigbu, P. (2016). Distribution of mysid species in relation to environmental factors in Maryland Coastal Bays. ASLO/Ocean Sciences meeting in New Orleans, LA; Feb. 22-26, 2016.

Peters, R.* and Chigbu, P. (2015). Spatial and temporal distribution of juvenile Black Sea Bass in the Maryland Coastal Bays. 145th American Fisheries Society (AFS) Annual Meeting, Portland, OR, August 2015.

Peters, R.* and Chigbu, P. (2016). Temporal trends in juvenile and young-of-the-year black sea bass, *Centropristis striata*, in the Maryland Coastal Bays ASLO/Ocean Sciences meeting, New Orleans, LA; Feb. 22-26, 2016

UMCES: 10 posters,7 student presenters

Banks*, R & Bachvaroff, TS (2015) Genetic identification of a toxic dinoflagellate, *Karlodinium veneficum*. MEES Colloquium, October 30, 2015.

Green*, S., Chung, J.S., Stevens, B. Understanding the reproductive endocrinology of the deep-sea red crab, *Chaceon quinquedens:* identification of reproductive regulators and vitellogenin. MEES Colloquium October 30, 2015.

Gillespie*, K & Jagus, R. (2015) Origins and evolution of eIF4E family members in zebrafish. EMBO Conference: Protein synthesis and translational control. Heidelberg, Germany, Sep. 2015.

Hanif*, A. Nature's ultimate environmental sampler: an analysis of Gulf Menhaden (*Brevoortia patronus*) stomach contents using molecular signatures. MEES Colloquium, October 30, 2015.

Lee Y, Feng J, Liu J and Li Y. (2015) Characterization of a phospholipid: diacylglycerol acyltransferase (PDAT) from an oleaginous marine microalga *Nannochloropsis oceanica* IMET1. Algae Biomass Summit, 9/29/2015 to 10/2/2015, Washington, District of Columbia, USA.

Liu, CL, Kai, Y, Dasi, E, *Watson, A, Chi, SC, Place, AR & Jagus, R. (2016) Monitoring fish eIF2α phosphorylation state in response to nutrient limitation in zebrafish and cobia. World Aquaculture Society Meeting, Las Vegas, NV February 22-26.

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Publications (*Students)

DSU: 0 publications, 0 student co-authors

HU: 4 publication, 0 student co-authors

Cuker, B. E., & Bugyi, G. (2016). The Fundamentals of Water and Natural Waters. In A. McKeown, & G. Bugyi (Eds.) Impact of Water Pollution on Human Health and Environmental Sustainability (pp. 1-28). Hershey, PA. doi:10.4018/978-1-4666-9559-7.ch001

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Horodysky AZ, SJ Cooke, JE Graves & RW Brill. (In press) Fisheries conservation on the high seas: linking conservation physiology and fisheries ecology for the management of large pelagic fishes. *Conservation Physiology*. *4(1)*:cov059

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OSU: 5 publications, 3 student co-authors

Fedewa*, E. J., Miller, J. A., Hurst, T. P. (2015). Pre-settlement processes of northern rock sole (*Lepidopsetta polyxystra*) in relation to interannual variability in the Gulf of Alaska. Journal of Sea Research. http://dx.doi.org/10.1016/j.seares.2015.11.008

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Marin Jarrin*, J. R. Teel, D. J., and Miller, J. A. (2016). Stock-specific movement and distribution of juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in sandy beach surf zones of Oregon and Washington, USA. Estuaries and Coasts. DOI 10.1007/s12237-015-0037-1

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RSMAS: 0 publications, 0 student co-authors

SSU: 0 publications, 0 student co-authors

UMES: 2 publications, 1 student co-authors

Morales-Núñez A.G., and Chigbu, P. (2016). A new species of *Apolochus* Hoover & Bousfield, 2001 (Crustacea: Amphipoda: Amphilochidae) from Maryland Coastal Bays (MCBs), USA. *ZooKeys* (In Press).

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UMCES-IMET: 18 publications, 3 student co-authors

Adolf, JE, Bachvaroff, TR, Deeds, JR, Place, AR (2015). Ichthyotoxic *Karlodinium veneficum* (Ballantine) J Larsen in the Upper Swan River Estuary (Western Australia): Ecological conditions leading to a fish kill. Harmful Algae 48:83-93.

Bachvaroff, TR, Williams, EP, Jagus, R, and Place, AR (2015). A noncryptic noncanonical multi-module PKS/NRPS found in dinoflagellates. Proceedings of the 16th International Conference on Harmful Algae, Cawthron Institute, Nelson, New Zealand and the International Society for the Study of Harmful Algae (ISSHA) A. Lincoln MacKenzie [Ed], 101-104.

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Dorantes-Aranda, JJ, Seger, A, Mardones, JL, Place, AR, and Hallegraeff, G. (2015). Improvements to the RTgill-W1 fish gill assay for ichthyotoxins: A comparison of the potency of different toxin fractions and extracts tested with different microplate materials. Proceedings of the 16th International Conference on Harmful Algae, Cawthron Institute, Nelson, New Zealand and the International Society for the Study of Harmful Algae (ISSHA) A. Lincoln MacKenzie [Ed], 202-205.

Fadaei, H, *Watson, A, Place, AR, Connoly, J. and Ghosh, U. (2015) Effect of PCB Bioavailability Changes in Sediments on Bioaccumulation in Fish. Environ. Sci. Technol., 2015, 49 (20), pp 12405–12413 DOI: 10.1021/acs.est.5b03107.

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Murray, SA, Kohli, G, Farrell, H, Spier, ZB, Place, AR, and Ruzyck, J, (2015). A fish kill caused by a bloom of *Amphidinium carterae* in a coastal lagoon in Sydney, Australia. Harmful Algae 49, 19-28.

Pie HV, Schott EJ, Mitchelmore, CL (2015) Investigating physiological, cellular and molecular effects in juvenile blue crab, *Callinectus sapidus*, exposed to field-collected sediments contaminated by oil from the Deepwater Horizon Incident. Sci Total Environ. 532, 528-539.

Seger, A, Dorantes-Aranda, JJ, Müller, M, Park, T-G, Place, AR and Hallegraeff, G. (2015). Mitigating fish-killing algal blooms: clay revisited to remove ichthyotoxins. Proceedings of the 16th International Conference on Harmful Algae, Cawthron Institute, Nelson, New Zealand and the International Society for the Study of Harmful Algae (ISSHA) A. Lincoln MacKenzie [Ed], 214-217.

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Van Dolah, E. R, Paolisso, M, Sellner, K, and Place, AR (2015). Employing a socio-ecological systems approach to engage HAB stakeholders. Aquatic Ecology (In Press)

Vicente*, J.; Silbiger, N.J.; Beckley, B.; Hill R.T. (2015). Impact of high pCO2 and warmer temperatures on the process of silica biomineralization in the sponge *Mycale grandis*. ICES-Journal of Marine Science: Journal du Conseil, fsv235.

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Zhou, C., Place, A. R, Yan, X., Zu, J., Luo, Q., Williams, E. and Jiang, Y. (2015). Interactions between *Karlodinium veneficum* and *Prorocentrum donghaiense* from the East China Sea. Harmful Algae 49, 50-57.

Appendix V: Reports on TAB funded projects (2014-2015)

Project Number: 15-01
Project Title: Microsatellite Markers Isolation (EST-SSR's) for Association Tests of Reproductive Phenotypes (GnRH, FSH and LH) in the Context of Environmental Variability for Chinook Salmon.

Project Abstract: We attempted to identify novel markers linked to functional genes that control and regulate reproductive hormone production. Previously, we identified four spatially distinct subpopulations that spawn in Siletz River, OR: Drift Creek, Spring, Summer and Fall. However, there is evidence of temporal structure that remains unresolved using neutral microsatellites. Functional candidate markers, as compared to neutral markers, provide alternate inference to further resolve fine-scale temporal substructure. "Spring run" Chinook salmon migrate farther upriver with gonads that are less mature than later "fall run" fish that typically spawn lower in the river. Regulation of gamete maturation must be synchronous with the arrival of fish on spawning habitat. Therefore, the potential for subpopulations to be identified by genetic markers that are linked to the regulation of gamete maturation inspired development of novel microsatellites. We continue to develop additional reproductive hormone related functional markers (including Gonadotropin-releasing Hormone) to better resolve temporal substructure.

Thematic Area Addressed: Quantitative Fisheries
Funding: $49,094
Lead Scientist(s): Michael Banks (OSU)
NOAA Collaborator(s): Peter Lawson (NOAA/NWFSC)
LMRCSC Collaborator(s): Andrij Horodysky (Hampton University)
LMRCSC Research Student(s): Chante Davis (PhD)
Start Date: 1 Sept 2014 **End Date:** 31 August 2015

Results of project to date: We attempted to identify novel markers linked to functional genes that control and regulate reproductive hormone production. We scanned and tested several hundred putative genes for microsatellites. Using two separate techniques, an R code as well as manual searches, we searched for tetra- , tri- and di-nucleotides within gene sequences. During the first year we determined 30 primer pairs that resulted in 7 possible microsatellites. These were not polymorphic among closely related sub-populations within our system. During the second year, a more manual search using online tools didn't result in many microsatellites that were convincing candidates for differentiating our sub-populations. We regret that a new approach may be necessary to build this type of gene-linked microsatellite. There is hope through a new annotated genome that has recently become available. We are hopeful that this may provide a link between the short sequences we're using to search for microsatellites and the DNA nucleotides that are directly up- and downstream of our sequence of interest, but this method has not begun yet.

Presentations at regional, national, or international meetings:
Davis, C. D. and M.A. Banks. Resolving temporal substructure of Chinook salmon (*Oncorhynchus tshawytscha*) of the Siletz River in Oregon. Association for the Sciences of Limnology and Oceanography, Granada Spain, February 22 – 27, 2015.

How will results be incorporated into NOAA Fisheries operations? This project is the first step within the context of a larger project, which will enable NOAA to meet its mission of healthy oceans, by using genetic tools to explore how environmental variation may affect population structure and the resiliency of a fish to changing environments. Management of wild Chinook depends on many factors including individual fitness, adaptability, and resilience of the species to changing environments. This first step was to characterize the genetic diversity and population structure within the river using a novel set of microsatellite markers and a previously described set of microsatellite markers. Once we describe the genetic diversity we will investigate how connectivity of subpopulations influences the genetic structure of Chinook populations by integrating concepts derived from river ecology and population genetics. This approach will enhance our ability to understand and predict how salmon populations will respond when the landscape changes. Specifically, the integration of genetic and spatial environmental data through riverscape genetics will help managers understand the genetic consequences of climate change, fragmentation, and connectivity on salmon population structure.

The research will be useful to NOAA Fishery Service Technical Recovery Teams (TRT), tasked with writing recovery plans for Salmon ESUs. Results from this type of analysis would provide answers that are needed to design

recovery plans and inform on the long-term persistence of ESUs. Persistence of salmon ESUs depends on connectivity of populations. Therefore, it is important to accurately identify all populations (or subpopulations) and understand how they interact (connectivity) in time and space.

How will results be incorporated into LMRCSC research and curriculum? We were able to host a visit from Assistant professor Dr. Aurea Rodriguez and undergraduate student Kenya Bynes, both from Hampton University to our OSU lab at the Hatfield Marine Science Center for one week in June 2015. Kenya was able to work in the Marine Fisheries Genetics lab where she received individual mentoring and experience in DNA extraction, amplification and sequencing of two mitochondrial genes from 18 different krill sampled from the Newport Hydrographic line. Kenya, Aurea and Michael Banks also met with NOAA Senior Scientists from the Northwest Fisheries Science Center as well as OSU Research Associate Adelaide Rhodes from the Center for Genome Research and Bioinformatics. Both meetings were to discuss and comprise an ongoing research project for the next and following summer that Kenya is interested in undertaking. This project is further detailed in our recent submission to the NOAA LMRCSC TAB program.

Project Number: 15-02
Project Title: Potential Impacts of the Savannah Harbor Expansion Project (SHEP) on the temporal and spatial patterns of fish assemblages near the mouth of the Savannah River, Georgia

Project Abstract: Evaluating the effects of anthropogenic activities is dependent upon data collection prior to impact, though funds are rarely allocated to conduct a long-term assessment before a critical need arises. The Savannah Harbor Expansion Project is one such activity that includes dredging of the Savannah River. It may potentially change physical conditions of the estuary thereby altering fish assemblages. The purpose of the present study was to characterize pre-impact fish assemblages along a salinity gradient near the mouth of the river and determine which abiotic factors most influence them. One site within the mouth of the Savannah River and 2 sites immediately outside the river mouth were sampled monthly for 2 yrs using both a beam trawl and seine net. Salinity, temperature, dissolved oxygen, and sediment grain size were assessed. All four factors had a significant effect on fish assemblages obtained by both gear types. A total of 3,943 fishes representing ≥ 55 species formed 3 statistically distinct fish assemblages and at least 3 seasonal assemblages. Only 24 species (43.6%) were collected by both gear types indicating the importance of using multiple gear types to assess fish assemblages. The fish assemblages near the mouth of the Savannah River may be altered or may shift given the predicted increase in salinity and/or the possible changes in sediment composition from channel dredging. Understanding the abiotic factors that most influence spatial and seasonal fish distributions prior to dredging will be invaluable in predicting how organisms will be impacted by similar public projects elsewhere.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Jennifer A. Güt, Savannah State University
NOAA Collaborator(s): Dr. John Manderson, Sandy Hook
LMRCSC Collaborator(s):
LMRCSC Research Student(s): James White and Chelsea Caldwell, SSU
Start Date: 1 Sept 2014 **End Date:** 31 August 2015

Results of project to date: The lead scientist submitted a manuscript entitled, “Assessment of Fish Assemblages Before Dredging of the Shipping Channel near the Mouth of the Savannah River in Coastal Georgia” to Estuaries and Coasts and is currently working on reviewer comments.

A K-12 activity entitled, “Hear Ye, Hear Ye: Town hall discussion of human-induced impacts on the ecosystem,” was submitted to *Current: the Journal of Marine Education*.

Presentations at regional, national, or international meetings:
Coastal and Estuarine Research Federation: Spring 2015 in Portland, OR. Oral presentation of thesis and grant data entitled, “Fish assemblages near the mouth of the Savannah River, Georgia before a channel dredging project”.

How will results be incorporated into NOAA Fisheries operations? Characterizing fish assemblages near the mouth of the Savannah River will be valuable for determining how fishes within the area, some of which are of commercial value, will

be impacted by the Savannah Harbor Expansion Project. This research will contribute to the Strategic Plan of the National Centers for Coastal Ocean Science (NOAA/NCCOS) as one of its fundamental principles is to conduct the anticipatory science necessary to manage potential impacts of stressors (such as dredging) on estuarine ecosystems. Dr. John Manderson assisted with providing feedback on sampling protocol and statistical analyses to help ensure that the results from the project may be helpful with fisheries management.

How will results be incorporated into LMRCSC research and curriculum? Anticipated tangible products that have resulted from this research include a master's thesis, a manuscript submitted to a peer-reviewed journal, a published K-12 activity submitted to a peer-reviewed education journal, and 2 presentations at scientific conferences. In the K-12 activity, students learn to explore the scientific process and focus on the final step of the method, which is the communication of results. Through the framework of a town hall meeting, students will explore the environmental and economic impact of an anthropogenic activity.

Project Number: 15-03
Project Title: Diet and feeding of menhaden using DNA barcoding

Project Abstract: Menhaden (*Brevortia* spp.) diets derive from filtration of the water column, consuming phytoplankton and zooplankton. Identification of food organisms is difficult because the prey organisms are small and fairly easily digested such that traditional microscopic identification of stomach contents is somewhat limited and may not provide the clearest insights into the predator-prey interactions of these forage fishes. When digestion is well advanced, traditional approaches cannot identify any prey, potentially excluding important information. This project will utilize the molecular technique of barcoding to provide an unambiguous forensic tool to identify stomach contents of menhaden, using the mitochondrial gene coding for cytochrome oxidase 1, Cox1, and conserved regions of the 18S ribosomal gene, as recommended by the Commission on the BarCode of Life (CBOL). DNA barcoding is a technique that uses a short standardized DNA region to identify species. Identification by barcoding will be verified by traditional microscopic methods. The data will provide useful information on the feeding ecology of menhaden as well as an improved understanding of food web dynamics.

Thematic Area Addressed: Quantitative Fisheries
Lead Scientist(s): Ammar Hanif, UMCES-IMET
NOAA Collaborator(s): Kevin Friedland, NOAA-NMFS
LMRCSC Collaborator(s): Dr. Bradley Stevens, UMES
LMRCSC Research Student(s): Ammar Hanif, MS
Start Date: September 2015 **End Date:** March 2016

Results of project to date: Upon completion of the 16S sequencing results to look at the microbiome and photosynthetic prey items we sought to look further in the diets of menhaden by using a different barcode targeting eukaryotic organisms. This will allow us to identify various prey items as well as look into the composition of the detrital material that makes up most of the gut material. Unlike prokaryotes, less emphasis has been placed on finding a universal DNA barcode for eukaryotes until recently. Given that the diet of menhaden consists mainly of phytoplankton and zooplankton, a suitable barcode needed to be developed in order to detect these groups. After a literature search we decided to use a primer set targeting the V4-V5 region of the 18S rRNA gene as described in Hugerth *et al.* 2014. This primer set was chosen, as we believe that it will provide the taxonomic resolution needed in order to determine diet items. We successfully tested these primers with several of the Gulf menhaden samples. Out of 20 of the samples submitted for Illumina high-throughput sequencing, 18 were successful. The results from this sequencing show that the phytoplankton groups Alveolata and Stramenopiles dominate the low salinity samples. The most common from these groups at the genus level was *Gyrodinium* and *Thalassiosirales* respectively. In contrast to the low salinity samples, the group Metazoa dominated the high salinity samples. The most common Metazoa was from the genus *Copepoda.* Other eukaryotic signatures found belonged to the groups Mollusca, Nematoda, and Ascomycota. Furthermore, there were several groups from Viridiplantae, which include several freshwater algae. This result along with the 16S results indicates that there may be a distinction in the diet and microbiome associated with salinity. Several diversity metrics show a similar pattern, as with the 16S data in the low salinity samples are more diverse than high salinity samples. The only difference in this case is that all the diversity metrics agree even though there is a clear dominance of metazoans in the high salinity samples. The groups Stramenopiles, Alveolata, Chloroplastida, and Cryptomonadales enrich the low salinity samples. Though copepods were the dominant metazoans the

molecular signatures of several popular freshwater aquarium fish, bivalves, and worm-like organisms were also found in the stomach. These organisms should not be looked at as diet items but are more likely evidence to show that organisms can be found in usual places using their molecular signatures. Looking at the beta diversity metric Unifrac and visualized by principal component analysis, we see that most of the distance was due to the difference in salinity. This evidence, along with the evidence of several salinity specific organisms being present, shows that the diet of menhaden along with the microbial community can change with salinity. These results also show that diets can shift within the same year class.

Given that menhaden are filter feeders, they are constantly sampling the microbial environment. The amount of detrital material found in their stomachs shows that menhaden do not distinguish between detrital and prey items. Therefore, it has been postulated that the menhaden stomach microbiome will reflect that of the water column despite the fact that some organisms are too small to be filtered via their gill rakers. This may come as a result of bacteria aggregating on appropriately sized debris. By using bioinformatics and molecular techniques we were able to look for bacterial indicators of aquatic and ecosystem health, such as pathogens and fecal bacteria. During the summer, Marcus Hughes, an undergraduate student from the University of Maryland Eastern Shore, analyzed a total of 20 archived Atlantic menhaden samples collected from the Choptank and Patuxent Rivers, which feed into the Chesapeake Bay for fecal bacteria, in an attempt to understand ecosystem health. After overcoming PCR inhibition in his samples, he used microbial source tracking to amplify a fecal bacterium from the genus *Bacteroides. Bacteroides* are among the most widely used groups for determining human fecal pollution in marine systems. He used a generic primer set to determine the presence of *Bacteroides*. He then used a human-specific primer set to determine if human specific *Bacteroides* was present. All samples showed positive results for the presence of *Bacteroides* using the generic primers. However, only 2 samples from each river system produced positive results when using the human specific primers. The results from this can show that menhaden can be used as indicators of ecosystem health and possibly become a part of management decisions.

How will results be incorporated into NOAA Fisheries operations? Although most forage fish species are not federally managed, many of their predators are. Multiple programs within NOAA/NMFS actively monitor forage fish and study their ecological interactions. The NWFSC is conducting studies of forage fish as integral components of the nearshore ecosystem. According to their website, climate conditions affect forage fish production which literally feeds into pelagic fish production. The work proposed here will provide a snap shot of menhaden prey that can be compared to future prey analyses as climate conditions change. This work will also help to inform the predictions of feed efficiency and prey selectivity based on menhaden gill raker functional morphological studies by Dr. Friedland's lab at NEFSC (Naragansett, Rhode Island). Our findings will help provide a better understanding of menhaden diets and food web dynamics.

How will results be incorporated into LMRCSC research and curriculum? The results of this project can be used to allow for further collaboration between other LMRCSC research faculty and students, and will inspire similar studies to be done on other environmental systems. Furthermore, the results can give ideas to other students and faculty on how to use molecular techniques such as barcoding and bioinformatics in other applications.

Project Number: 15-04

Project Title: Comparison of NOAA Montlake meal and Otohime feed performance in aquacultured pompano: feed ration, feed frequency, feed conversion ratio, and feed efficiency

Project Abstract: Fish protein from the aquaculture industry has been valuable to feeding an ever increasing world population. Traditional methods for culturing many fishes, including Florida Pompano, have involved the use of fishmeal based feeds. This project investigated the growth of aquacultured juvenile Florida pompano fed two diet types at two feeding frequencies at a feed ration of 5% bw/d. Juvenile pompano were assigned diets of NOAA Montlake meal and Otohime EP2 fish pellets with each diet having three replicate tanks for each feeding frequency. Florida pompano (initial weight 6.31 g/fish) were randomly assigned to one of twelve experimental tanks at a stocking density of 30 fish per tank and hand fed six days per week, two and four times daily at 5% bw/d. Fish were then group weighed every seven days to adjust feeding rate to account for weight gain. At the end of the study, fish fed two times daily, Otohime EP2 encountered higher weight gain than fish fed Montlake meal; however, fish fed the Montlake diet four times daily had a higher weight gain than fish fed Otohime EP2. These data suggest that although Otohime EP2 may allow for larger growth at a lower feeding frequency, the Montlake diet may be equal to or better than the fishmeal based Otohime diet from a sustainability perspective.

Thematic Area Addressed: Aquaculture
Lead Scientist(s): Andrij Horodysky, Hampton University
NOAA Collaborator(s): Ronald Johnson, NOAA NWFSC
LMRCSC Collaborator(s): Deidre Gibson, Hampton University
LMRCSC Research Student(s): Larry Redd, Jr (**MS**)
Start Date: 1 February 2015 **End Date:** 31 August 2015

Results of project to date: The experimental population of pompano (1000 individuals) were ordered from Troutlodge in late February and delivered in early March. Fish arrived weighing (mean= 0.2 g) and were immediately stocked in three 300L tanks. Fish were fed Otohime C2 and C3 larval feeds three times daily during the "grow-out" phase for two months until fish reached the start size of six grams. Following a one-week acclimation to the recirculating aquaculture system, fish were sorted by weight and randomly distributed to the 12 aquaria (30 fish per tank, average initial weight 6.31 g/fish). Aquaria were then randomly assigned one of the two dietary treatments (Montlake or Otohime EP2) and one of the two feeding frequencies. Water temperatures were maintained at 28±2 ^{o}C and salinity held at 20 ppt. Fish were fed 5% body weight throughout the nine week period of the study. Diets were hand fed four times (08.00, 12.30, 15.30, and 18.00 h) and twice daily (08.00 and 18.00 h). Fish were group weighed by tank every seven days to adjust feeding rate to account for weight gain. Upon termination of study, weight gain, feed conversion ratio, and specific growth rate were determined for both dietary treatments and feeding frequencies.

All datasets for functions of diet and weight gain were entered into R. Two base models were used, and model selection was accomplished via Akaike information criterion to determine parameter estimates providing the line of best fit for each diet and temperature (lower AIC value=better fit). Results indicated that the exponential model fit the data best for weight gain for the Montlake and Otohime diet when compared to the linear model.

Overall mean weight gain of fish fed the Otohime diet two (1188.3 g) and four (1015.7 g) times daily was not significantly greater than fish fed the Montlake diet two (1004.0 g) and four (1093.0 g) times daily. Specific growth rates (SGR %/d) for fish fed the Otohime diet two (3.1) and four (2.9) times daily were comparable to that of fish fed the Montlake diet two (2.9) and four (3.0) times daily. Feed conversion ratios (FCR) for fish fed the Otohime diet two (1.3) and four (1.3) were not significantly different than fish fed the Montlake diet two (1.3) and four (1.3) times daily. Survival was greater than 95% in all treatment groups. A two way ANOVA performed on weight gain indicated there was no significant difference between diet and feeding frequency. However, the interaction effect (P=0.008) between diet and feed frequency indicated a significant feed* frequency interaction. For specific growth rate (SGR) there was no significant difference between diet and feeding frequency; however, the interaction effect (P=0.006) between diet and feed frequency indicated a significant feed*frequency interaction. Moreover, feed conversion ratios (FCR) for Montlake meal and Otohime EP2 were not significantly affected by diet and feed frequency; however, the interaction effect (P=0.01) indicated a significant feed*frequency interaction.

Additionally, graduate student Larry Redd, Jr. successfully defended this research in conjunction with another LMRCSC funded project "Effects of Feed Type and Temperature on the Gastric Evacuation of Aquacultured Juvenile Florida Pompano." Mr. Redd currently is a working for the Highly Migratory Species (HMS) Management division for NOAA fisheries as part of the Knauss Fellowship Class 2016.

Presentations at regional, national, or international meetings: This project was presented at the 2015 American Fisheries Society Meeting in Portland, Oregon in August. A manuscript is in preparation.

How will results be incorporated into NOAA Fisheries operations? We worked with Dr. Ronald Johnson, Acting Program Manager, Environmental and Fisheries Sciences division, NOAA NWFSC. The results from this study provided the first data on the performance of NOAA's Montlake feed on aquacultured Florida pompano, a rapidly growing candidate species for aquaculture. There is great potential for the refinement of the feed through this work. Lastly, the development of protocols for feed type and feeding frequencies may serve as standards for culture of pompano, and may be used to inform/develop feeding protocols to optimize growth for the species in recirculating aquaculture systems.

How will results be incorporated into LMRCSC research and curriculum? Dr. Horodysky used the data from this project in his departmental elective Ichthyology lecture (Spring 2016) and will do so in future semesters of his departmental required Biometry course (Spring semesters).

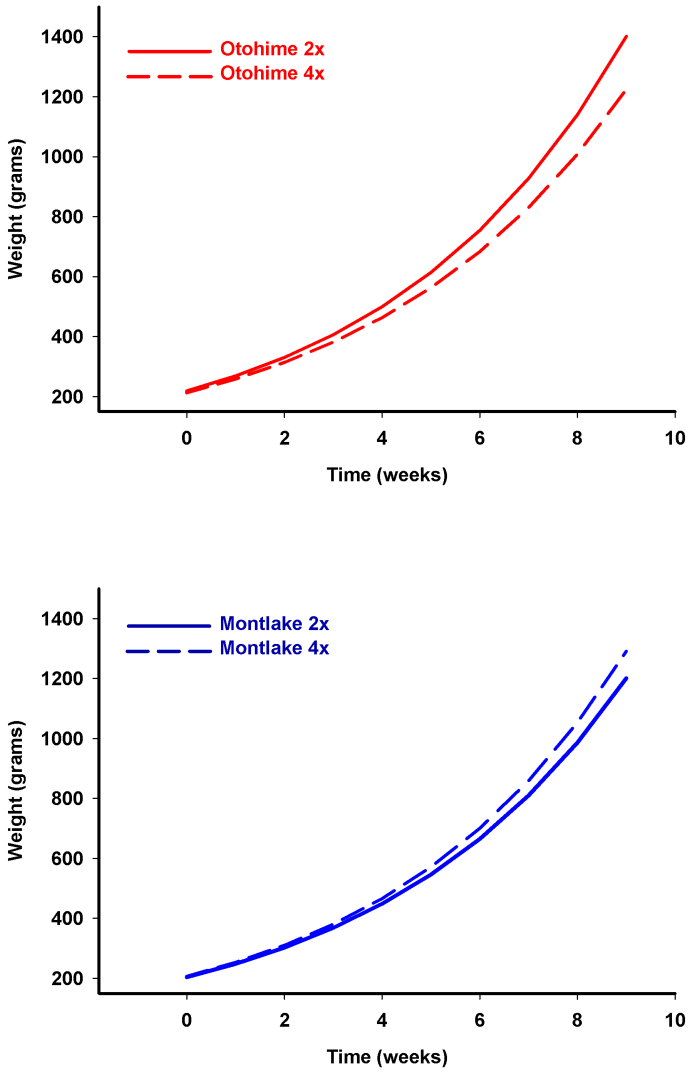


Figure 1. Tank biomass for Florida Pompano fed Otohime and Montlake diets. Best fit line for fish fed Otohime twice daily is represented by the solid red line. Best fit line for fish fed Otohime four times daily is represented by the dashed red line. Best fit line for fish fed Montlake twice daily is represented by the solid blue line. Best fit line for fish fed Montlake four times daily is represented by the dashed blue line. Lines of best fit for both diets are exponential models chosen by Akaike Information Criterion (AIC).

Project Number: 15-05

Project Title: RNA-DNA Ratios as Indicators of Ecosystem Health; metrics to determine the impact of land-use on fish habitat

Project Abstract: Land development within the Chesapeake Bay watershed induces a suite of environmental stressors that negatively impact fish habitat and aquatic animal health. These effects degrade the ability of bay tributaries to serve as valuable nursery habitats for larval and juvenile fish which impacts fisheries production. The proposed study seeks to utilize RNA:DNA ratios as a bioindicator of larval and juvenile fish condition as a metric of fish habitat quality. The impact of variable land use patterns on fish habitat will be examined to further illustrate potential trade-offs between development on land and protection of habitats that provide a major socioeconomic and ecological contribution to coastal communities.

Thematic Area Addressed: Essential Fish Habitats
Lead Scientist(s): Joseph Pitula, UMES (assumed lead from Andrea Johnson who is on leave of absence from UMES)

NOAA Collaborator(s): Lonnie Gonsalves, NOAA Cooperative Laboratory, Oxford, MD
Other Federal Partner(s): James Uphoff, MD Department of Natural Resources
LMRCSC Collaborator(s):
LMRCSC Research Student(s): Derek Burton and Paul Montalvo (MS, UMES)
Start Date: 1 Sept 2014 **End Date:** 31 December 2016

Results of project to date: This project is a two year project. In year one we demonstrated that, as expected, there is an impact of land use on ecosystem health. Conditions are favorable in the natural, pristine environment (Nanjemoy Creek) compared to the suburban environment (Mattawoman). The means used to draw this conclusion was by using juvenile fish development, as based on RNA:DNA ratios and DNA/mg of sample, as the sentinels of ecosystem health. 623 yellow perch larvae, collected between March –May of 2014, were analyzed.

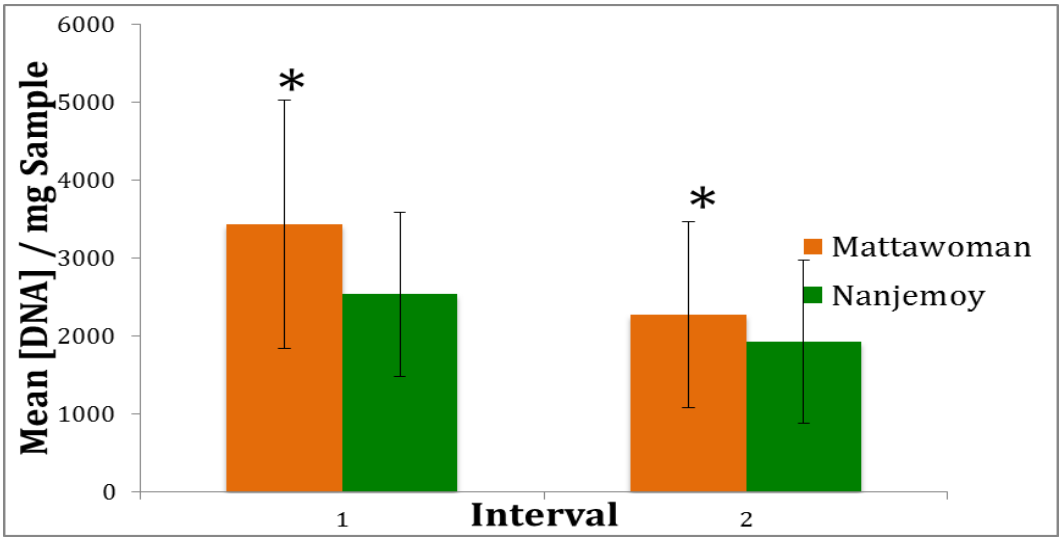


Figure1 shows that the DNA/mg of sample is significantly higher in the Mattawoman creek; indicating conditions are not as good compared to the Nanjemoy. ANCOVA test shows that there is a significant difference between the two rivers ($p<0.001$)

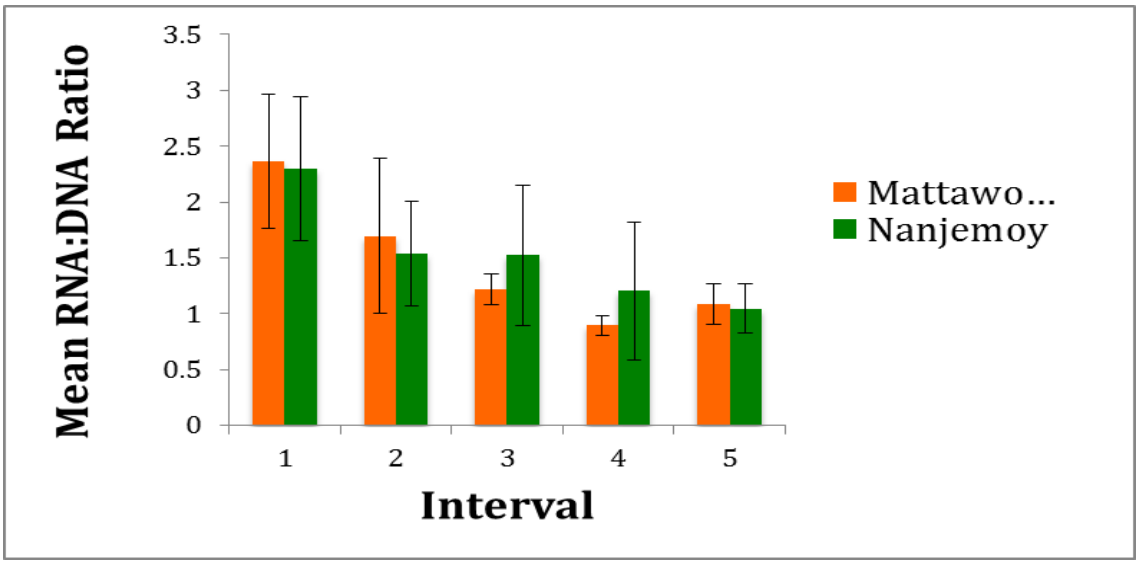
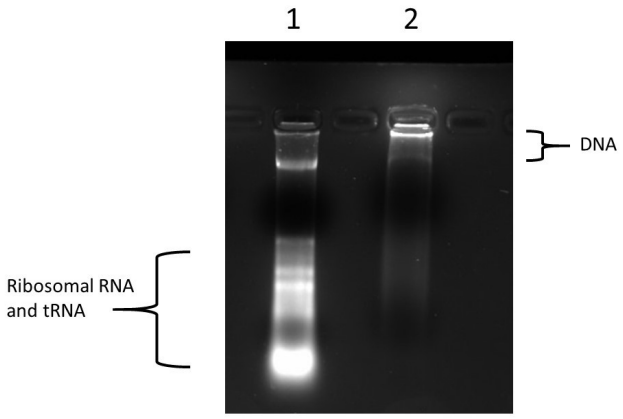


Figure 2 shows the average RNA:DNA ratio for each river based on Interval Dates. This representation shows no significant difference between each river.



Lane 1: Total Nucleic Acids
Lane 2: Post RNAse treatment

The plan for future work is to repeat these assessments, although the study site will shift to the Choptank River Estuary, due to a NOAA emphasis on oyster restoration. This work will commence in April.

In January of 2016, Paul Montalvo (MEES Graduate Student) joined the laboratory. He will be conducting the studies this spring and summer. Preparatory to that work, we analyzed the protocol to ensure high quality preparations, to increase our confidence in the approach. Shown above is a representative gel of total DNA and RNA isolation from one yellow perch larvae, followed by the remaining DNA material after RNAse treatment. Based upon our experience, the approach was shown to be reliable, as the major RNA species were intact and easily visible. This also suggests that mRNA preps will be reliable means to assess gene expression of various growth markers (aim 2). Paul has gone on to initiate the cloning of the myostatin gene in yellow perch, our first target as an alternative gene marker.

Presentations at regional, national, or international meetings: Results will be presented at the 2016 NOAA EPP Meeting

How will results be incorporated into NOAA Fisheries operations? We will use the approaches described here and apply them to a study ongoing in Choptank River. This is part of a larger initiative by NOAA to understand the dynamics of the Choptank River, as there is currently an oyster restoration project occurring there. This site was chosen because of moderate salinities that favor good reproduction and also do not promote diseases (such as Dermo) that are favored in higher salinities.

How will results be incorporated into LMRCSC research and curriculum? The results will be a test case for how a degraded ecosystem impacts larval development of yellow perch, and its impact on growth rates. Indirectly, this provides a snapshot of the ecosystem, and how other species may also be affected. It can be presented both in MEES seminar courses and in Fish Ecology courses.

Project Number: 15-06
Project Title: Analysis of Stranding Demographics and Inorganic Contaminants in Marine Mammals from Coastal Maryland and the Chesapeake Bay

Project Abstract: We are examining the trends in bottlenose dolphin (*Tursiops truncates*) strandings, contaminant loads and the potential cytotoxic effects of contaminants. Since 1990, there have been a total of 442 marine mammals stranded. Before 2013 there was a maximum of 30 strandings per year, however in 2013, there was a record number of 81 marine mammal strandings; of which 72 were bottlenose dolphins. This increase was during an Unusual Mortality Event (UME). We found that the bottlenose dolphin strands more frequently than any other marine mammal in Maryland waters and that most strandings occurred between the spring and fall.

We collected tissues from these animals and analyzed them for inorganic contaminants such as mercury (Hg) and selenium (Se). In the livers we found that there was an average of 4.54 µg/g Hg and 4.58 µg/g Se whereas in the kidneys we found

an average of 39.56 µg/g Hg and 20.74 µg/g Se. Other studies have determined that an Hg level over 100 µg/g will cause liver damage; four of our samples exceeded this level. To understand the effects that these contaminants have on dolphin health we plan to conduct cytotoxicity tests using Hg, Se and mercuric selenide (HgSe) on blood cells of the bottlenose dolphin. Both determining demographic trends and identifying the extent of contaminants, are key components in developing successful management strategies for marine mammal populations and helping NOAA Fisheries to meet its mandates under the Marine Mammal Protection Act and other laws.

Thematic Area Addressed: Quantitative Fisheries
Lead Scientist(s): Maurice Crawford and Cindy Driscoll
NOAA Collaborator(s): Lonnie Gonsalves
LMRCSC Collaborator(s):
LMRCSC Research Student(s): Audy Peoples and Courtney Rhodes
Start Date: 1 Sept 2013 **End Date:** 31 December 2016

Results of project to date: Audy Peoples travelled to Charleston, SC over the winter session of 2015-2016 to conduct research and train with equipment at the Hollings Marine Laboratory (HML). There he completed the inorganic comtaminant analysis on 44 marine mammal tissues from both Maryland and South Carolina samples using the inductively coupled plasma mass spectromerty (ICP-MS). We are waiting to receive results from this work.

We used teeth to age several of the bottlenose dolphins used in the study. Six bottlenose dolphin teeth were aged using a sectioning technique. Their ages ranged from 0 to 20 years of age. Ages: dolphin 14TTR04 (232.5 cm in length aged at 20), 15TTR04 (212 cm aged at 6), 13TTR109 (214 cm aged at 3.5), 13TTR106 (167 cm aged at 1), 13TTR92 (137 cm aged at 0.4), and 14TTR11 (124 cm) showed no growth layer so was aged at 0.

Presentations at regional, national, or international meetings: Audy Peoples presented results at the Annual Marine Estuarine Environmental Science (MEES) Colloquium in Annapolis, MD in October 2015. Courtney Rhodes presented results of the project at the 2016 Ocean Sciences Meeting in New Orleans, LA. Audy Peoples plans to attend the Society of Environmental Toxicology and Chemistry North America meeting in Orlando, FL in November 2016.

How will results be incorporated into NOAA Fisheries operations? The NOAA Office of Protected Resources, operating under the Marine Mammal Protection Act and the Endangered Species Act, leads national efforts in NOAA Fisheries to construct sound ecosystem-based management practices to protect marine mammals. Much of this effort has been conducted through state partnerships such as the Maryland Marine Mammal and Sea Turtle Stranding Program administered through the Maryland Department of Natural Resources Fish and Wildlife Health Program (DNR). Since 1990, DNR has monitored stranding events on the Maryland coast and in the Chesapeake Bay. Stranding researchers use marine mammal health and contaminants data to elucidate the role of disease and pollution on Mid-Atlantic marine mammal mortality. Stranding response efforts by DNR, and this project in particular, will assist NOAA in meeting its mandates under the Marine Mammal Protection and the Endangered Species Acts.

How will results be incorporated into LMRCSC research and curriculum? Results of this project were discussed in Environmental Science (ENVS 101) and will also be covered in Conservation Biology (BIOL 404). Audy Peoples completed courses in Principles of Geographic Information Systems (AGNR 483) and Marine Ecotoxicology (ENVS 603) during the fall semester of 2015.

Project Number: 15-07
Project Title: Ocean Acidification Effects on Ecology of Juvenile Northern Rock Sole

Project Abstract: The direct and indirect effects of ocean acidification have become a growing concern, particularly in high latitude regions where the levels and rate of increase in oceanic CO_2 are expected to be the highest. Studies with marine fishes suggest that elevated CO_2 levels interfere with the GABA-A receptor, inducing changes in a variety of behaviors. However, to date there have been no studies examining OA behavioral effects in any flatfish species. In laboratory experiments, we first examined the effects of multiple predation cues (predator odor, “alarm cues” from injured conspecifics,

and sight of a predator) on speckled sand dab activity and foraging under ambient CO_2 conditions. Of these, fish were most responsive to the alarm cues from damaged conspecifics. We then, examined the effects of elevated CO_2 levels on activity level and foraging behavior in the presence and absence of alarm cues. CO_2 treatments reflected present-day CO_2 levels (~400µatm) and those predicted to occur over the next 150 years (~1,200µatm and ~1,400µatm). This work will compliment studies of the direct physiological effects of OA on the growth and survival of egg and larval stages and improve our understanding of how the effects of OA will be manifest in complex ecosystems.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Dr. Jessica Miller, Oregon State University
NOAA Collaborator(s): Dr. Thomas Hurst, Alaska Fisheries Science Center
LMRCSC Collaborator(s): Dr. M. Carla Curran, Savannah State University
LMRCSC Research Student(s): Jessica Andrade (MS)
Start Date: 1 Sept 2015 **End Date:** 31 August 2016

Results of project to date: Due to issues with the availability of rock sole specimens for this work, we switched to an ecologically similar, locally abundant species, speckled sand dab. We first examined the responses of juvenile speckled sand dab to several indicators of predator threat including scent of the predator, chemical alarm cues, and direct visual exposure to a predatory fish. Interestingly, the strongest response observed was to the chemical alarm cues. However, unlike many other species, speckled sand dab increased activity and were still willing to forage after they were exposed to alarm cues from injured conspecifics, suggesting that this cue might actually function as a foraging cue for this species.

We also completed construction of an automated ocean acidification system in the lab for rearing flatfish and conducting experiments. The system, similar to one used in previous experiments with walleye pollock, includes an automated CO_2-injection system based on continuous pH measurements.

Led by M.S. student, Jessica Andrade, we performed a series of experiments examining the effects of elevated CO_2 levels on the activity patterns and foraging behavior of juvenile sand dab. Fish were acclimated to elevated CO_2 levels for 3 weeks, then tested with a standardized series of foraging opportunities interspersed with exposure to the predator threat cues. The experiments were completed in early 2016 and analysis of video footage is currently underway.

An undergraduate intern from Savannah State University, Kamilya Daniels participated in experiments for 10 weeks over the summer. In addition to assisting with flatfish experiments with graduate student Jessica Andrade, Daniels performed her own experiments with PI Thomas Hurst, examining the effects of elevated CO_2 levels on phototaxis in larval Pacific cod. Having, now graduated from Savannah State Univ., Daniels will be entering OSU's graduate certificate program in Fisheries Management.

Presentations at regional, national, or international meetings:

Andrade, J.F.*, Hurst, T.P., Miller, J.A. (2015). Flatfish behavioral responses to predatory threat under elevated carbon dioxide concentrations. Markham Marine Science Research Symposium, Newport, OR. June 25, 2015.

Andrade, J.F.*, Hurst, T.P., Miller, J.A. (2015). Identifying flatfish behavioral responses to predation cues to inform ocean acidification experiments. American Fisheries Society Annual Meeting, Portland, OR. August 16-20, 2015.

Hurst, T.P. (2015). Evaluating the effects of ocean acidification: from Alaskan organisms to Alaskan communities. Hatfield Marine Science Center, Newport, OR. December 2015.

How will results be incorporated into NOAA Fisheries operations? The results from this work will be directly incorporated into broader efforts of NOAA to identify and evaluate the magnitude of OA-induced effects on fisheries and marine ecosystems. A recent evaluation of the risks of OA to Alaskan communities did not consider the potential impacts of sensory/behavioral effects on population productivity (Mathis et al. 2014). If these effects are shown to be significant in flatfishes, they will be included in subsequent refinements of these semi-quantitative risk assessments as well as quantitative models of ecosystem responses (e.g. Busch et al. 2013).

How will results be incorporated into LMRCSC research and curriculum? This project involves a graduate student from OSU and included an undergraduate intern from SSU in Summer 2015. A visit by Dr. Carla Curran of SSU to the AFSC and OSU labs was instrumental in identifying areas of future collaboration between institutions.

In addition this project stimulated the development of a graduate seminar course on relevant aspects of fish physiology and behavior for OSU students, including two LMRCSC students. This will serve as a model for engaging NOAA researchers in the curriculum of LMRCSC programs.

Project Number: 15-08
Project Title: Place Attachment and Traditional Ecological Knowledge in the Sea Islands: A Case Study of Endangered Culture

Project Abstract: The objective of this project was to quantify place attachment and describe traditional ecological knowledge between Gullah-Geechee communities in the Sea Islands. In the last six months, the research team at Savannah State University transcribed data from a Summer research initiative hosted by the Gullah Geechee Sustainability Think Tank to connect researchers with the fishermen and women of the Gullah Geechee Nation through focus groups, interviews and cultural tours in several east coast communities from North Carolina to Florida. Data from these events were analyzed and synthesized as part of a manuscript to be submitted to *Local Environment: The International Journal of Justice and Sustainability.*

Thematic Area Addressed: Fishery Socio-Economics
Lead Scientist(s): Jolvan Morris (NOAA LMRCSC Postdoctoral Fellow, SSU)
NOAA Collaborator(s): Patricia Clay (Anthropologist, NOAA NEFSC), Michael Jepson (Social Scientist, NOAA SERO)
LMRCSC Collaborator(s): Dionne Hoskins (NOAA, SSU),
LMRCSC Research Student(s): Keya Jackson (MS-student, SSU)
Start Date: November 2014 **End Date:** January 2016

Results of project to date: The objectives of this project were to 1) quantify degrees of **attachment** to Harris Neck and other Gullah-Geechee Sea Island ecological-environmental and sociocultural places (e.g. Sapelo Island); 2) describe the practices and roles of fishing using an alternative *way of knowing* through Gullah-Geechee **traditional ecological knowledge**; 3) map place attachment and the **sea/landscape** values associated with the Sea Islands; and 4) expound upon the NOAA African American Fishermen Oral History Project (Hoskins, Abbott-Jamison, and Jepson, 2010).Three general research methods were proposed to accomplish the aforementioned objectives: 1) literature review; 2) survey; and 3) oral history interviews.

The literature review of materials relevant to Gullah-Geechee fishing communities was completed. Preparation of a manuscript renamed "Expanding Social Theories of Resilience: Social-Ecosystems, Cultural Systems, and Power in Historic African American Fishing Communities in Georgia" was also completed. The paper employs a sociocultural system perspective to interpret community-based activities in response to socioeconomic fishery crises in two African American communities: Pin Point and Harris Neck, Georgia. The search for references related to this manuscript greatly contributed to the body of literature necessary to accomplish some of the research objectives. This manuscript is currently in review and will be submitted to *Local Environment: The International Journal of Justice and Sustainability*.

In June 2015 research team members at Savannah State University took part in a research initiative hosted by the Gullah Geechee Sustainability Think Tank to connect researchers with the fishermen and women of the Gullah Geechee Nation through focus groups, interviews and cultural tours in several east coast communities from North Carolina to Florida. During this field work, twenty-eight surveys were collected between the four focus groups. Focus groups were digitally recorded. These data were transcribed so that thematic analysis could be conducted.

Presentations at regional, national, or international meetings:

- J. Morris. Coastal Cultures Conference: De Wata and We-Gullah/Geechee Sustainability (2015) in Beaufort, South Carolina: The African American Fishermen Oral History Project.
- J. Morris. NOAA EPP 7th Biennial Education and Science Forum (2014) in Princess Anne, Maryland: Identity, Place, and Traditional Knowledge in African-American Fishing Communities. Presenter: Jolvan Morris

How will results be incorporated into NOAA Fisheries operations? In accordance with the standing NOAA African American Fishermen Oral History Project, this project is relevant to NOAA Fisheries Service's Fisheries Social Impact Analysis and environmental justice analyses of fishing communities in the South Atlantic Region. This initiative contributed to the sociocultural data available on local populations who participate or have participated in marine fisheries in the past.

Since oral traditions and knowledge in the Gullah-Geechee community is typically passed orally, the available social and cultural information on this population's current and past involvement in marine fisheries is scarce.

Part of the current National Marine Fisheries Service mission objective solicits research that will examine the effects of changes in fishery resource availability on coastal fishing communities. These include changes in resource distribution, community vulnerability, community solidarity, ethnic and class diversity, and other factors which may affect community resilience (NMFS, 2010). Data collected over the course of the project shed light on trends and thematic areas related to the impacts of climate change on Sea Island communities. The impacts of pollution and coastal development on target (commercial and recreational) fish species were also emergent themes as this work progressed. Transcript data from the summer 2015 focus groups highlighted the need and desire for stakeholders in the Sea Island communities to be engaged in policy and decision-making processes impacting their communities.

How will results be incorporated into LMRCSC research and curriculum? Over the course of this research initiative instruction qualitative research methods were incorporated into the graduate level course curriculum for the LMRCSC and SSU Marine Science program through case-studies in undergraduate and graduate level Marine Conservation Biology classes. In Spring 2015, graduate students in the Environmental Risk Communications learned how to effectively communicate and engage with diverse stakeholder groups. The Gullah-Geechee fishing communities on which this research is focused were part of course discussion; more specifically LMRCSC research in these communities was used to highlight the importance of culturally competent research processes. During Summer 2015, this research was incorporated into the high school component of Coast Camp at SSU. High school students engaged in activities and research directly related to the socio-economic issues discussed in the results of the overall project. Outcomes of high school, undergraduate, and graduate level involvement in this research have included oral presentations, poster presentations, and written work. This research was used as part of a platform upon which funding was awarded for a curriculum development project called "Collaborate to Heighten Awareness, Rejuvenate, and Train: *CHART*ing a course to bring Environmental Justice on the coast." The results of this work have been scaffolded to curricula for two new courses at SSU that focus on coastal communities, risk management, and environmental justice. Both courses will be available to SSU students in Fall 2016.

Project #: 15-09
Project Title: Searching the coastal bay food web for reservoirs of a virus lethal to blue crab *Callinectes sapidus*

Project Abstract: Blue crabs are a key link between benthic and pelagic food webs and support a commercial harvest worth over $180 million. Our previous studies showed that prevalence of a virus lethal to blue crab (RLV, also called CsRV1) can be as high as 78%, with an average of 20% across the Chesapeake and the Northeast. CsRV1 can be transmitted to blue crabs by consumption of infected conspecifics. To investigate the possibility that other crustacean species may be a reservoir for CsRV1, students looked for CsRV1 in other crustaceans in the coastal bays of MD, DE, and NJ. Crustaceans and corresponding environmental data were collected from coastal bays by students from UMES and DSU in June and July of 2015. Samples were analyzed at IMET for CsRV1genomic RNA using an RT-qPCR method. The presence of CsRV1 was confirmed in blue crabs, but it was not detected in other crustacean species. Students investigated the potential for other species to serve as hosts to CsRV1by conducting controlled infections in xanthid and Asian shore crabs (*Hemigrapsus sanguineus*). Xanthid crabs acquired infections and died, while the Asian shore crabs acquired light infections and showed no mortality in 2 weeks. In November, DSU students analyzed over 100 mud crabs for the presence of CsRV1. A better understanding of disease-related mortality of blue crab will be valuable to NOAA's efforts to understand natural mortality in this and other fishery species.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Eric Schott (UMCES/IMET)
NOAA Collaborator(s): Linda Stehlik (NOAA/NEFSC)
LMRCSC Collaborator(s): Gulnihal Ozbay (Delaware State Univ.); Joe Pitula (UMES)
LMRCSC Research Student(s): Kristen Lycett (PhD student, UMES); Matthew Stone (MS student, DSU), Chiamaka Nnah (UG, UMES); LaTaijah Crawford (UF, DSU), Nivette Perez-Perez (DSU), Eunice Handy (DSU).
Start Date: 1 Sept 2014 **End Date:** 31 August 2015, with no cost extension until 31 Dec 2015.

Results of project to date: All of the student research activities have been completed. Undergraduates went on three field collections in June and July 2015, to the DE NERR, MD Coastal Bay, and the Sandy Hook NJ, estuary. At Sandy Hook/JJ Howard NOAA lab, students met with NOAA collaborator L. Stehlik and others (including Vince Guida, Coastal Ecology branch chief) to discuss their project looking for the CsRV1 virus in potential blue crab prey. Over 100 crustaceans were dissected, RNA extracted, and tested for CsRV1 by Rt-qPCR. The virus was confirmed to be present in blue crabs, but was not detected in xanthid crabs, sand shrimp, or Asian shore crab. Efforts were undertaken to collect more xanthids from the DE NERR (by DSU students in the fall). Two students from DSU spent a month at the Schott lab (IMET) to conduct RNA extractions and PCR to detect the virus. Of more than 100 crabs analyzed, just two showed evidence of faint infections. These two faint infections need to be confirmed by re-extraction from the archived frozen crabs.

For field trips, we have many partners to thank, including Steve Doctor of MD DNR, Mike Mensinger of DE NERR and Liza Baskin of the MAST School in Sandy Hook NJ.

The second objective, to test the ability of CsRV1 to cause infections in other crustacean species, was completed. Injections of CsRV1 into xanthid crabs (n=6) and Asian shore crabs (*Hemigrapsus sanguineus*; n=7) were conducted. All of the xanthid crabs acquired infections, and four died. Viral loads in injected crabs ranged from approximately 1 thousand to 1 billion genome copies per milligram muscle tissue. In *Hemigrapsus*, crabs also acquired infections, but none died and virus loads ranged from ten to 1 million copies per milligram tissue. The discovery that CsRV1 has the potential to infect and kill xanthid crabs may add a whole new layer of complexity to understanding the dynamics of the virus in the blue crab.

Presentations at regional, national, or international meetings:

Blue Crab Symposium. Carrie Weedon Science Center, Galesville, MD. 19 April 2015. "Mortality and disease in blue crabs". E. Schott

67th Interstate Shellfish Seminar. Ocean City, MD. April 16, 2015. "Identifying viruses in soft shell crab operations". E. Schott

40th Annual Eastern Fish Health Workshop. Charleston, SC. March 2-6, 2015. "Spatially and temporally variable prevalence of a virus fatal to the blue crab, *Callinectes sapidus*". E. Schott

World Aquaculture Society meeting. Fortaleza, Brazil. November 16-20, 2015. "A lethal virus of the Blue Crab *Callinectes sapidus* may be present throughout its trans-hemispheric range". E. Schott.

How will results be incorporated into NOAA Fisheries operations? Although blue crabs are not a federally managed species, they are fished in more than a dozen states. Interactions of with state and federal scientists in MD, DE, CT, and MA demonstrate how relevant this research is to the management of blue crabs, which support a >$160 million fishery in the US. It is reasonable to expect that in the Northeast, with the growing recreational and commercial harvest of blue crabs, supply and disease issues will arise. In the spring of 2011 we were contacted to help investigate the cause of a blue crab die-off in CT. This underscores the relevance of the proposed survey to multi-state crab health monitoring.

How will results be incorporated into LMRCSC research and curriculum? Findings are being incorporated into Dr. Schott's seminar course in the spring of 2016, offered to MEES students in the University of MD system (including LMRCSC students at UMES and IMET): "Diseases in Chesapeake Bay Fisheries" MEES 608C.

Project Number: 15-10

Project Title: Improving management of deep-sea red crabs (*Chaceon quinquedens* Year 2: Reproductive biology, maturity, and age estimation

Project Abstract: Deep sea red crabs support a small but valuable federally-managed fishery along the US Atlantic coast, but lack of information about their biology, abundance, growth, age, or reproduction prohibits adequate management. Preliminary samples were collected during LMRCSC cruises aboard NOAA Research Vessels during 2011-2013. In 2014-15 we conducted sampling from the commercial fishery to determine seasonality of reproduction, fecundity, and age analysis. Samples from previous cruises were processed to estimate size of oocytes and spermatophores. Oocytes from crabs in different stages of development show distinct size frequencies that can be used to help identify development stages. SM50 has been estimated for females based on ovary and external conditions, but cannot be estimated for males due to lack of allometric changes indicative of maturity. Gastric mills were prepared to determine age of crabs, and preliminary estimates range from 4 to 11 years. Larval cultivation studies indicated that growth was faster at 15 C, but survival was better at 9 C,

although no larvae survived to the megalopa stage. A full-length cDNA sequence encoding the CHH sequence for red crabs was cloned and radioimmunoassay (RIA) was used to determine ecdysteroid levels obtained from hemolymph samples of 55 crabs.

Thematic Area Addressed: Quantitative Fisheries
Lead Scientist(s): Bradley Stevens (UMES)
NOAA Collaborator(s): Chris Long, NMFS Kodiak Fisheries Laboratory; Rich McBride, NEFSC, Woods Hole, MA; Matthew Poach, NEFSC JJ Howard Lab, Sandy Hook, NJ
LMRCSC Collaborator(s): J. Sook Chung (UMCES-IMET)
LMRCSC Research Student(s): Stephanie Martinez-Rivera (PhD, UMES), Justin Wilson (MS, UMES), Shadaesha Green (UG, Hampton); Nivette Perez-Perez (MS, DESU).
Start Date: 1 Sept 2014 **End Date:** 31 August 2015

Results of project to date:

Background: During three previous NOAA-sponsored LMRCSC cruises in 2011, 2012, and 2013, red crabs were captured and sampled from four sites in the Mid-Atlantic Bight. During those trips we measured >2500 crabs and collected gonads from 245 crabs. Additional sampling was conducted in 2014 and 2015 to address three primary goals: 1) determine seasonality of reproduction, fecundity, and size at 50% sexual maturity (SM_{50}) for male and female red crabs; 2) determine if hard structures can be used to estimate age and growth of crabs, and 3) characterize the physiological regulators of reproduction in red crabs.

Sampling: Red crab samples were collected in July 2015 during one 5 d trip aboard a commercial vessel (the Hannah Boden), from The Atlantic Red Crab Company, and again in February 2016 from the processing plant. Insurance problems and weather have prevented sampling as often as we had hoped. Tissue samples collected were ovary, testes, vas deferens, hepatopancreas, midgut, eyestalks, stomach, muscle, and blood. Crabs were measured and sexed, and gross morphology was recorded including the presence, size and color of ovaries and external eggs.

This Project has a number of different components as listed below:

Size and Sexual Maturity: During the past year Stephanie Martinez worked with the samples (*n*) of 2011 (*n*=168), 2012 (*n*=78), 2013 (*n*=77), 2014 (*n*=199), and 2015 (*n*=90). Currently, we have collected 617 gonad, 89 egg, and 91 spermatheca samples. Histological and image analysis are used to determine gonad development stages. Image analysis of 2011 samples are almost completed. Estimates of SM50 for female red crabs from 2012-2013 were calculated by non-linear logistic regression, and variance was estimated by bootstrapping. Preliminary results showed that the SM50 for females ranges between 81-90 mm in carapace width (CW). For 2012 and 2013 samples, we observed different gonad development stages in crabs from different season, which were collected in January and July, respectively. The gross morphology of the samples and the gonad conditions of 2012 and 2013 samples suggest that red crabs have a biennial reproductive cycle.

Age Estimation: During the past year we continued our work on age determination of red deep-sea crab based upon methods developed by Kilada et al. (2012). Over 100 gastric mill samples collected from research cruises were placed in epoxy, sectioned and mounted on slides. These sections were viewed and photographed using a dissecting stereoscopic microscope for the zygocardiac sections and by compound microscope for the mesocardiac sections. Photographs taken were then enhanced with Adobe Photoshop software. Growth Rings were counted as paired dark and light rings in the endocuticle of the sectioned samples. Age estimates for 31 samples analyzed to date (67 to 144 mm CW) ranged from 4 to 11 counts of paired light and dark rings in the sectioned samples. These data will be used to construct growth rates for this species.

Endocrinology: The objective of this goal is to characterize the physiology and biochemistry of red crabs in order to determine their seasonal reproductive patterns, and endocrine regulation of reproduction. Since the last report, deep-sea red crab tissue samples collected during the summers of 2013 and 2014 have been processed by Shadaesha Green (Ph.D. student) at IMET. The reproductive strategy of crustaceans is closely related to their life history and requires precise regulation of neuroendocrine and non-neuroendocrine related compounds. The main objective of this research is to elucidate the potential role that putative reproductive regulators have on female *C. quinquedens* reproductive strategy. Specific aims for this project are to: (1) identify reproductive regulators, (2) establish a relationship(s) between reproductive

regulators and ovarian development/vitellogenesis, and (3) examine genetic differentiation among red crab populations inhabiting in Atlantic Ocean and Gulf of Mexico.

Identification of Reproductive Regulators: The crustacean hyperglycemic hormone (CHH) and the molt-inhibiting hormone (MIH) are two key crustacean neuropeptides being investigated to gain a better understanding of their functionality during reproductive cycles.

- Isolation of total RNA from ovary, hepatopancreas, and eyestalk tissues (n= 148) was completed and reverse transcribed into complementary DNA (cDNA), which will be used for gene expression analysis.
- Total RNA was also used to generate 5' and 3' RACE cDNAs for isolating the full-length cDNA sequences of putative reproductive regulators.
    - A full-length cDNA sequence encoding the CHH sequence was cloned.
    - A partial isolation of the cDNA sequence encoding the molt-inhibiting hormone (*ChqMIH*) was isolated.
- Sinus glands dissected from the eyestalk ganglia were used for CHH neuropeptide identification using a reverse phase-high performance liquid chromatography (RP-HPLC).
    - Two peaks (1 and 2) representing the minor and major forms of *C. quinquedens* CHH were identified using dot blot assay with anti *Carcinus* CHH serum. The presence of molt-inhibiting hormone was determined with *C. sapidus* MIH antisera.
- A radioimmunoassay (RIA) was used to determine ecdysteroid levels obtained from 25 µl hemolymph samples (n=55) that were collected over the course of the aforementioned sampling period.
    - This information is being used to coordinate molt stage with ovarian development and will ultimately help us to understand the life history tradeoffs of reproduction and somatic growth in this crab.

Establishing a Relationship(s) between Reproductive reguators and Ovarian development /Vitellogenesis:

Ovarian stage (1-5) was determined for all sampled females based on Haefner (1977). A partial isolation of the cDNA sequence corresponding to the highly conserved lipoprotein N-terminal domain (317 amino acids) of vitellogenin (*ChqVtG*) was made. In order to establish a relationship between reproductive regulators and vitellogenesis gene expression of ChqCHH, ChqMIH, and ChqVtG were measured. In addition to this, the total RNAs isolated from Red crab hepatopancreas at ovarian stage 1 and 3 were sequenced on the HiSeq platform for differential expression analysis.

Examining Population dynamics and differentiation: In order to generate efficient microsatellite markers, genomic DNAs that were isolated from male (n=4) and female (n=2) Red crabs from the Mid-Atlantic bight collected during the July 2015 sampling onboard the commercial F/V Hannah Boden were sent for MiSeq analysis at the UT Austin Genomic Sequencing and Analysis Facility (GSAF). Microsatellite markers are being currently developed. Once good markers are identified, they will be used to study the population genetics of the species, by determining the genetic distribution among red crabs in three different geographic locations (Gulf of Mexico, Mid-Atlantic bight, Northwest Atlantic). In order to collect red crabs many efforts have been made to find a point of contact in the Gulf of Mexico region, however, to date we have been unable to do so.

Larval Biology: Live red crabs were taken to the NOAA J.J. Howard Laboratory at Sandy Hook, where Delaware State graduate student Nivette Perez-Perez began hatching the larvae and raising them to determine feeding and temperature conditions required for larval survival. Complete hatch timing was observed for a single crab at daily intervals, and at 4-hr intervals over 3 d. Larvae were raised in flow-through containers (60 per treatment) at two temperatures (9°C and 15°C), with 5 diet treatments (no feeding, diatoms only, rotifers only, and diatoms or rotifers plus Artemia after reaching zoea stage III). Larvae exhibited faster development at 15°C than at 9°C, but mortality rate was greater at 9°C than 15°C. Larvae in unfed and algae diets survived longer at 9°C than those held at 15°C, and growth rate and survival were both highest on the rotifer diet at both temperatures. In 2015, we were unable to obtain additional crabs with late-stage eggs for hatching, due to delayed and canceled fishing trips.

Other Projects: We also collected midgut samples for Dr. Indu Sharma of Hampton University, who is examining them to determine the microbiomes present within the red crab digestive system. Leg muscle samples were collected for Dr. Chuck Jagoe of FAMU who will analyze them for the presence of heavy metals and other contaminants.

Presentations at regional, national, or international meetings:

S. Martinez-Romero, and B. G. Stevens. Reproductive biology of the red deep-sea crab (*Chaceon quinquedens)* in the Mid-Atlantic Bight. National Shellfisheries Association 108th Annual Meeting, Las Vegas, NV, March 2016.

J. Wilson and B. G. Stevens. Age determination of red deep-sea crab (*Chaceon quinquedens)* by growth ring analysis. National Shellfisheries Association 108th Annual Meeting, Las Vegas, NV, March 2016.

S. Green, J-S. Chung, and B. G. Stevens. Understanding the molecular mechanisms of reproductive biology of the snow crab, *Chionocetes opilio*, and the red deep-sea crab *Chaceon quinquedens.* National Shellfisheries Association 107th Annual Meeting, Monterey, CA, 26 March 2015.

How will results be incorporated into NOAA Fisheries operations? The federally-managed fishery for red crabs is conducted using industry-agreed size and catch limits, but little is known about their biology, abundance, growth, age, or reproduction. We are determining basic information on life history, reproduction, age, growth, and maturity that will lead to improved management of the red crab population and fishery based on biological benchmarks. This information will be invaluable for setting goals for sustainable management of this marine resource.

How will results be incorporated into LMRCSC research and curriculum? Three graduate students and one undergraduate student have been trained in anatomy and dissection protocols for deep-sea red crabs and histological preparation. Results of this research were incorporated into a class proposed for Spring 2015 by Dr. J. Sook Chung 'Comparative and Molecular Endocrinology MEES 698M. Methods for determining size at maturity were incorporated into "Biostatistics with R" taught by B. Stevens in fall 2014.

Project Number: 15-11
Project Title:
Augmenting the Black Sea Bass, *Centropristis striata*, Stock Assessment, Year 3: Assessing the importance of fixed and fluid estuarine habitats

Project Abstract: Estuarine habitats, such as the Chesapeake Bay, serve as an important nursery ground for the federally managed black sea bass (*Centropristis striata*). Available habitats vary every year and are influenced by factors such as rainfall and estuarine mixing. To explore this area of Essential Fish Habitat we are conducting a comprehensive study that incorporates ecosystem modeling, bioenergetics and field sampling. We developed a Habitat Suitability Model (HSM) in order to examine how available habitat for juvenile black sea bass fluctuates. Since *C. striata* prefer bottom structures, benthic habitat data was overlaid with the model output to evaluate the best sites. Reefs around Tangier Sound and Pocomoke Sound showed consistent suitable habitat. Suitable habitat increased from May to October, with July and August having the most variability, and October having the highest percent of suitable habitat. In an abundance survey on Tangier Sound, black sea bass were encountered from August to November, with September having the highest abundance. They were also most abundant on oyster reefs than on sand bottom and rock bottom. Hydroacoustic tags were inserted on 50 fish, and 9 tags have been detected by the array of receivers at the mouth of the bay. Understanding the factors that influence available estuarine habitat for juvenile *C. striata* will provide us more information that can be used to understand recruitment and identify essential fish habitat more accurately, which is vital for maintaining a sustainable commercial and recreational fishery.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Brad Stevens, LMRCSC
NOAA Collaborator(s): Howard Townsend, NOAA Chesapeake Bay Office – Cooperative Oxford Lab
LMRCSC Collaborator(s):
LMRCSC Research Student(s): Laura Almodóvar-Acevedo, PhD
Start Date: 1 Sept 2015 **End Date: 3**1 December 2016

Results of project to date: A Habitat Suitability Model (HSI) for black sea bass juveniles in the Chesapeake Bay was developed. The variability of the amount of areas with suitable and optimal habitat was evaluated by year and month. Results show that October has the highest percent of suitable habitat for black sea bass.

We evaluated 9 years between 1991 and 2004 and found that 1999 had the highest number of reefs that were suitable for black sea bass, and 2003 and 2004 the lowest. According to our model the amount of reefs available increase as we move towards October. July and August are the months that present the most variability. Years with lower river flow seem to have a higher number reefs that are suitable for black sea bass. Reefs that were consistently suitable for black sea bass were identified. This information can be used to determine specific ecosystem services of certain areas and can be considered when determining where to put restoration and conservation efforts.

We conducted our own survey with traps. We set baited traps in areas with oyster reefs, areas with rock reefs and areas with bare sand every month starting in April to observe the presence and abundance of black sea bass. Everything that was caught was measured. We observed black sea bass from August to November, with September having the highest abundance. Most of the black sea bass were caught over oyster reefs.

Hydroacoustic tags were inserted on 50 fish. There is an array of receivers at the mouth of the bay which will help us determine when the black sea bass leave the bay. The tag numbers have been sent to the U.S. Navy (who are in charge of the receivers) and they will let us know when they detect a tag. As of December 31, 2015, nine separate tagged fish have been detected by the receiver array, with most detections occurring during November. However, 7 of the nine fish were detected repeatedly, whereas two that were detected only once might have been false signals.

Some of the fish caught were brought back to the lab to be part of a bioenergetics experiment. We want to measure the effect of different temperatures on the active and standard metabolic rates of juvenile black sea bass through respirometry. We consulted with Dr. Richard Brill and Dr. Andrij Horodysky who have experience with these types of experiments on fish and designed an experimental protocol. We obtained the equipment. The results of this will help us optimize the temperature suitability index of our HSI model.

Laura Almodovar-Acevedo was accepted into the NOAA-EPP Graduate Research Training and Scholarship Program for 2016. Her admission was partially based on the results of this work and her cooperation with Dr. Howard Townsend at the NOAA Cooperative Oxford Laboratory. She will continue work on this project, particularly the fish respirometry research, as a visiting student at the NOAA Oxford Laboratory.

Presentations at regional, national, or international meetings:
A presentation by L. Almodóvar-Acevedo, M. Hasan, H. Townsend, and **B. G. Stevens**, titled "Assessing available habitat for Black Sea Bass in the Chesapeake Bay through a Habitat Suitability Model" was given at three separate meetings, incorporating updates:

- ASLO Meeting, Granada, Spain, February 2015.
- American Fisheries Society 145th Annual Meeting, Portland OR, 20 August, 2015
- University of Maryland MEES Colloquium, October 2015 – Annapolis, MD (**Poster)**

How will results be incorporated into NOAA Fisheries operations? This project is related to various strategic plan objectives in NOAA's long-term goal of maintaining Healthy Oceans, as described by the NOAA Fisheries Strategic Science Plan for 2013-2018. The results will help meet a strategic goal of "Understanding ecosystems and phenomena", and facilitate moving forward to an ecosystem-based approach to resource management. My research supports both Theme 2 (Understand, forecast, and mitigate effects of environmental change) and Theme 3 (Describe and assess the role of habitats in ensuring healthy marine ecosystems) of the Northeast Fishery Center Strategic Research Plan. The work also expands on NOAA's Science and Technology Enterprise by being part of an integrated modeling system. The HSM model of the Chesapeake Bay can be used as a base for understanding how climate change could affect black sea bass in the future. By giving new and important information about a fished species this study also supports the objective of having sustainable fisheries and ensure a safe and healthy supply of food (Theme 3) for healthy populations and vibrant communities. In order to have effective management and regulations we need to know more about what affects the populations and individuals of each species. In addition to meeting NOAA goals, my research fits within both the "Essential Fish Habitat" and "Quantitative Fisheries" research themes of the Living Marine Resources Cooperative Science Center.

How will results be incorporated into LMRCSC research and curriculum? Data and results will be presented during classes such as "Survey Sampling" taught by B. Stevens.

Project Number: 15-12
Project Title: Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change: California sea lions and their pelagic prey off Oregon and Washington

Project Abstract: Impacts of environmental change on the distribution of marine predators are typically assessed in isolation from aspects of community ecology, such as predator and prey relationships. This focus on individual species rather than community ecology limits our potential to understand, anticipate and respond to changes in ocean ecosystems. Our research uses species distribution models (SDM) to integrate habitat, predator (California sea lions; CSL) and prey species (Pacific sardine, Northern anchovy, Pacific herring). We aim to (1) describe and compare habitat use patterns, (2) predict distribution patterns under various temporal and climate change scenarios, and (3) evaluate the ecological and management implications of overlap or mismatch between predator and prey. Our work to date suggests that during warm years (e.g., *El Niño*), there is higher potential overlap between CSL and forage fish, particularly Pacific sardine and Northern anchovy. Lower prey occurrence and overlap was predicted by our models during colder years (*La Niña*). These modeling results reveal the dynamic nature of predator and prey in their response to habitat variability, and indicate that CSL must be capable of prey switching depending on conditions. Such distributional changes may incur energetic, ecological, reproductive, and population impacts to CSL and other marine predators that rely on these forage fish. The warm years examined here may reflect future environmental conditions expected based on climate change scenarios as the ocean warms generally. Our results can help managers understand and anticipate ecosystem-level response to climate change by integrating habitat, prey and predators.

Thematic Area Addressed: Quantitative Fisheries
Lead Scientist(s): Leigh Torres, Oregon State University (OSU)
NOAA Collaborator(s): Richard Brodeur, NWFSC, NMFS, Newport, OR
LMRCSC Collaborator(s): Tara Cox, Savannah State University (SSU)
LMRCSC Research Student(s): Caren Barcelo, Oregon State University, PhD., Cheyenne Coleman, Savannah State University (SSU), UG
Start Date: 1 Sept 2015 **End Date:** 31 February 2016

Results of project to date: California sea lion (CSL) satellite tracking data from 25 males were implemented as presence data in our species distribution models (SDM). These animals were captured in the Columbia River between April and June in 2005 and 2007 and fitted with PTT transmitters. The tracking data were filtered using the Freitas et al. (2008) algorithm to remove erroneous points. Additionally, all locations 'up river' and within 15 km of haulout locations were removed from the dataset. For our binomial (presence-absence) SDM, we generated 10x the number of real data locations for each individual-month combination. To distribute these in a realistic and un-biased manner, pseudo- absence data were randomly distributed outside a 4 km buffer of all real locations, but within a broader polygon built around the first point buffered by the total distance travelled by the individual in that month.

The fish (or prey) SDMs were built using presence-absence data of Pacific sardine, Northern anchovy, or Pacific herring obtained from NOAA's BPA pelagic fish trawls (n=498) conducted annually since 1998. We used data sampled in May and June between the years of 2003 and 2011 to match the temporal period of the CSL tracking data.

Presence and absence locations from the CSL and prey datasets were sampled for the following remotely sensed oceanographic data at a 4 km resolution: ETOPO bathymetry, MODIS-Aqua sea surface temperature (SST), chlorophyll *a* (CHL), and Frontal Probability (8-day composites).

We constructed negative binomial Generalized Additive Models (GAMs) using the mgcv package in R to characterize the relationship between the presence and absence data for CSL and the three prey species. CSL models were constructed using a mixed effects framework with each tracked individual as the mixed effect. Full SDMs included month and year as factors, as well as Latitude (φ) and Longitude (λ). Model selection was done by minimizing AICc and UBRE. While full models included all four predictor variables, spatial predictions of CSL and the prey species were generated using SDMs including only SST and CHL. SDMs were used to generate hind-casted spatial predictions of prey and predator distribution patterns onto monthly composite SST and CHL during various contrasting years (2005, 2008, 2010, 2014). We validated the full and prediction models by randomly withholding 10% of data, and using these data to calculate AUC, sensitivity and specificity. We also calculated the species overlap between CSL and each prey species by multiplying the predicted probabilities of species occurrence, i.e.

$$\mathbf{P}\text{overlap}(\varphi, \lambda),yr = \mathbf{P}\text{CSL}(\varphi, \lambda),yr * \mathbf{P}\text{FISH}(\varphi, \lambda),yr$$

Examination of the SST data revealed that 2005 and 2014 were 'warm' years in Northeastern Pacific in the spring and early summer, while 2008 and 2010 were 'cold' years (Fig. 1). During cold years, the predicted probability of CSL occurrence centered around the Columbia River. In contrast, during warm years CSL were predicted to be more broadly distributed along coast. The distribution of Pacific sardine was predicted to center around the Columbia River in all years, but during warm years they were predicted to have greater occurrence and distributed more continuously along the Oregon/Washington coasts. During warm years, northern anchovy had a much higher probability of occurrence within the study region than during cold years, and were distributed along much of the coast and offshore. The distribution of Pacific herring was predicted along the whole coast during all years, but with higher occurrence predicted in 2014. Predicted overlap between CSL and their prey species was greatest with Pacific sardine and Northern anchovy during warm years. During cold years, predicted overlap was restricted to the region near the Columbia River plume. Little overlap was predicted between CSL and Pacific herring.

Our work to date suggests that during warm years (e.g., *El Niño*), there is higher potential overlap between CSL and forage fish, particularly Pacific sardine and Northern anchovy. Lower prey occurrence and overlap is predicted by our models during colder years (*La Niña*). These results suggest that CSL must be capable of prey switching between different environmental regimes. While CSLs may adapt their distribution to that of their prey, such changes may incur energetic, ecological, reproductive, and population impacts to CSLs, and economic and social costs to human interactions. The warm years examined here may reflect future environmental conditions expected based on climate change scenarios as the ocean warms generally. Furthermore, other top marine predators feed on these forage fish in this region, such as seabirds and other pinniped species, making the results of this study potentially relevant to understanding the adaptability of many marine species to the combined impacts of habitat and prey distribution change.

We acknowledge several caveats in our study including the use of CSL tracking data only, with no observation data that is concurrent with the fish sampling data. Additionally, only adult male CSL are represented in tracking data, but males dominate the CSL population in the region. Furthermore, salmonids are an important prey item of CSL in the region but were not analyzed in this study. While we recognize these study caveats, our exercise demonstrates the utility of SDMs to integrate diverse datasets and compare habitat and distribution patterns.

Our next steps include:

- Implement outputs from an Earth System Model (ESM 2 MOM) developed at the Geophysical Fluid Dynamics Laboratory of NOAA in SDM predictions to assess the probability of occurrence and spatial overlap for predator and prey species in this region under various climate change scenarios.
- Utilize an expanded set of CSL fish prey items.
- Develop an interactive display at the OSU visitor center to disseminate results about integrative impacts of climate change on ecosystems.
- Publish current and future results in a peer reviewed journal.

Presentations at regional, national, or international meetings:

Caren Barceló, Lorenzo Ciannelli, Cheyenne Coleman, Josh Adams, Bryan Wright, Richard D. Brodeur, Leigh Torres. *Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change.* 21st Biennial Society for Marine Mammalogy Conference, San Francisco, CA, December 2015.

How will results be incorporated into NOAA Fisheries operations? The NMFS West Coast centers are currently implementing an Integrated Ecosystem Analysis (IEA) of the California Current ecosystem. One of the key components of the IEA is to develop habitat suitability maps of the major forage species and their avian and mammalian predators. Therefore, the information derived from our analyses will be incorporated into future IEA reports and be used directly in the management of these important forage species and their predators. Furthermore, the impacts of climate change on the predator-prey dynamics of CSLs is a focal component listed in NOAA's California Current Integrated Ecosystem Assessment that will contribute to marine spatial planning. Additionally, this project contributes to NOAA's mandate to manage protected resources. Although California sea lions are not threatened, results from this project will improve our understanding of how threatened marine predators in the region, such as killer whales and albatross, may respond to climate effects on their prey populations.

How will results be incorporated into LMRCSC research and curriculum? Dr. Torres leads the Geospatial Ecology of Marine Megafauna Lab (GEMM Lab: http://mmi.oregonstate.edu/gemm-lab) at Oregon State University (OSU) and Dr. Cox teaches an undergraduate GIS course at Savanah State University (SSU). The data analysis and results from this project will be incorporated into lectures by both Dr. Torres to graduate level students at OSU and Dr. Cox at SSU. In addition, Dr. Cox will incorporate the data into interactive, hands-on laboratory exercises in undergraduate and graduate GIS courses to increase the skill level of these students. These lectures will demonstrate the use and process of spatial data analysis and how to generate SDMs from various data types.