



**Performance Report for Cooperative Agreement No: NA06OAR4810163  
for the Period from March 1 to August 31, 2011**

**University of Maryland Eastern Shore**  
Living Marine Resources Cooperative Science Center

**Paulinus Chigbu, Ph.D. (Principal Investigator & Director, LMRSC)**  
**Bradley Stevens (Co-Principal Investigator & Distinguished Research Scientist)**  
University of Maryland Eastern Shore (Lead Institution)

**Stacy Smith, Ph.D. (Co-Principal Investigator)**  
Delaware State University

**Deidre Gibson, Ph.D. (Co-Principal Investigator)**  
Hampton University

**Dionne Hoskins, Ph.D. (Co-Principal Investigator)**  
Savannah State University

**Rosemary Jagus, Ph.D. (Co-Principal Investigator)**  
University of Maryland Center for Environmental Science, IMET (Since June 2010)

**David Die, Ph.D. (Co-Principal Investigator)**  
RSMAS/University of Miami

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## Executive Summary

The mission of the Living Marine Resources Cooperative Science Center (LMRCSC) is to conduct research congruent with the interests of NOAA Fisheries and to prepare students for careers in research, management, and public policy that support the sustainable harvest and conservation of our nation's living marine resources. 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 for Environmental Science Institute of Marine and Environmental Technology (UMCES-IMET). UMES is the lead institution.

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

**Goal 1: Enhance Marine Research and Academic Program Capacities of the Center MSIs**

**Goal 2: Enhance Research Programs in the Marine Sciences at Participating Institutions**

**Goal 3: Generate a Pool of Scholars Entering the Field of Marine Sciences and Fisheries**

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.

To accomplish Goal 1, the Center used the Virtual Campus for curriculum development and seminars and expanded it to include courses which were offered online between Center partners and to a NOAA NEFSC contractor and a NOAA employee located in Woods Hole, MA who are enrolled in the Professional Science Master's (PSM) degree program at UMES. Seminars and several courses offered through the University of Maryland interactive video network (IVN) were made available to Center students during this reporting period. NOAA scientists, including Dr. Howard Townsend (NOAA Cooperative Oxford Lab, MD), Dr. Larry Alade (NOAA NEFSC), and Jason Link (NOAA NEFSC) will teach a new course "**Ecosystem Modeling Applied to Fisheries**" at UMES in January 2012. The course was to be offered in summer 2011 but did not meet minimum enrollment requirements. Three courses (Multivariate Statistics, Stock Assessment, and Marine Population Dynamics) that are part of the "essential curriculum" recommended by NOAA Fisheries for training fisheries scientists were offered to students at the Center during spring semester. In addition, Fisheries Survey Sampling, Fish Ecology, and Risk and Decision Analysis are being offered this fall (2011). The Articulation Agreement document signed by all LMRCSC partners led to cross registration between partners for these courses. Five graduate students in the PSM program interned at NOAA Science labs in summer 2011.

In support of the programmatic component of the LMRCSC designed to accomplish Goal 2, twelve (12) collaborative projects were funded by the LMRCSC for 2010-2011 following the review of the proposals by the TAB and are currently underway. The on-going and future research projects at the Center are intended to meet the mission of NOAA Fisheries: "*Stewardship of living marine resources through science-based conservation and management and the promotion of healthy ecosystems*". The TAB and NOAA scientists' involvement also ensures that the LMRCSC has a strong linkage with the mission of NOAA: "*To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social and environmental needs*".

Highlights of the results obtained for some of the completed TAB projects are presented below. Additional information on the projects is presented on pages 11 to 26 of the report. The development of in-situ assessment and observation methods for black sea bass, a commercially important species, will allow for better understanding of the meaning of trap CPUE and how it relates to fish abundance, which will allow managers to interpret CPUE and landings data with greater accuracy. A major objective of NMFS is to develop alternate feeds for aquaculture. The study dealing with taurine as an ingredient in the development of fish free diets is helping to establish the minimum taurine requirement and its effects at different inclusion levels for many commercially important fish species. Taurine plays a major role in allowing the reduction and elimination of fishmeal from fish diets. Thus results from this study are useful for greatly enhancing the ability of the aquaculture industry to increase global fish production. Finally, the study on temperature preferences of Atlantic croaker under normoxic and hypoxic conditions has yield some preliminary data that are useful for evaluating the effects of anthropogenic stressors and habitat degradation on habitat use and residency of scianids.

In the current reporting period, LMRCS students and faculty made 52 presentations (oral and poster) at scientific meetings (33 of which were made by students), and published 13 articles in refereed journals, 5 of which were authored or co-authored by students or graduates of LMRCS. An additional 7 articles were accepted for publication or are in press. 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 \$2,591,029.14 was collectively awarded in grants to the LMRCS institutions during this reporting period, which has directly impacted and will continue to have positive impacts on Center activities. These funds enhanced LMRCS research through support of its faculty and students and by development/enhancement of infrastructure. Ten grant proposals totaling \$7,886,158.92 were submitted to funding agencies during the current reporting period.

In support of Goal 3, to generate a pool of scholars entering the field of marine science, 59 students (26 BS, 20 MS, 12 Ph.D students) were supported and received training in NOAA core sciences during this reporting period, and 15 students graduated (8 BS, 6 MS, 1 Ph.D.). Students participated fully and actively in faculty-directed research projects on their home campuses or at Center partners. Many received training directly at NOAA facilities. Students were also provided travel awards to conferences to present their research and network with their peers and with professional scientists.

In order to create a pipeline of students into the marine sciences, the Center conducted activities for students in grades K-12 which collectively impacted more than 1000 students. These included specific training and research experiences such as the Coast Camp for Youth at Savannah State University, CREST SEEL program at UMES, and the SciTech program at IMET in which 1000-2000 Baltimore area high school students participate annually, the Upward Bound Marine and Estuarine Science Program at UMES that reaches 25 high school students and activities in marine science conducted at local schools by LMRCS faculty and graduate students.

LMRCS educational, research and outreach activities are, therefore, 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”*. This table summarizes some of the LMRCS accomplishments during this reporting period.

### Summary of LMRCS Performance Measures of Success Relative to 2010-11 Implementation Plan

Activities	Proposed in the Implementation Plan (2010-11)	Accomplished (Mar. 1 – Aug. 31, 2011) 6 months
1. # of proposals funded by the Center after TAB reviews	12 (10 – 14)	12
2. # of proposals submitted to programs other than NOAA EPP	20	10
3. # of scientific presentations at conferences (including students')	35 (30 – 60)	52 (33*)
4. # of theses & dissertations produced	12	7
5. # of peer-reviewed publications/book chapters	18 (10 – 25)	13 (5*)
6. Amount of leveraged funds (\$)	\$1.3 million (500,000 to 1.5 million)	\$2,591,029.14
7. # K-12 students trained in NOAA related sciences	500	> 1000
8. # of B.S. students trained in NOAA related sciences	50	26
9. # of B.S. students graduated in NOAA core sciences	25	8
10. # of M.S. students graduated in NOAA core sciences	9	6
11. # of Ph.D. students graduated in NOAA core sciences	3	1
12. # of interns at NOAA/other labs.	10	20

**\*With students**

## INTRODUCTION

Established in October 2001, the Living Marine Resources Cooperative Science Center (LMRCSC) was created as a cooperative agreement between NOAA Educational Partnership Program, 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 for Environmental Science Institute of Marine and Environmental Technology (UMCES-IMET). UMES is the lead institution. The mission of the Center is to conduct research congruent with the interests of NOAA Fisheries and to prepare students for careers in research, management, and public policy that support the sustainable harvest and conservation of our nation's living marine resources.

The following are the goals and objectives of the LMRCSC:

### **Goal 1: Enhance Marine Research and Academic Program Capacities of Center MSIs**

**Goal 1 is accomplished through the following objective:**

***Objective 1:* Build upon Existing Academic and Organizational Infrastructure to Develop Strong Interactive Academic Programs in Marine Sciences**

### **Goal 2: Enhance Research Programs in the Marine Sciences at Participating Institutions**

**Goal 2 is accomplished through the following objectives:**

***Objective 1:* Continue Current and Develop New Research Programs Congruent with NOAA Fisheries Research Priorities**

***Objective 2:* Fully Integrate Research Programs with NOAA Fisheries to Ensure Long Term Funding and Programmatic Stability**

### **Goal 3: Generate a Pool of Scholars Entering the Field of Marine Sciences and Fisheries**

**Goal 3 is accomplished by the following objectives:**

***Objective 1:* Enhance Recruitment of Students from Underrepresented Groups into Marine Science Disciplines**

***Objective 2:* Strengthen Outreach & Education Programs to Students and the Public**

***Objective 3:* Develop Programs that Enhance the Practical Education of Undergraduate and Graduate Students in the Marine Sciences**

## **SECTION I – STATUS OF AWARD ACTIVITIES (Goals and Objectives)**

For the period **March 1 to August 31, 2011**, the following tasks were accomplished in support of the goals and objectives of the LMRCSC:

### **Goal 1: Enhance Marine Research and Academic Program Capacities of Center MSIs**

***Objective 1:* Build upon Existing Academic and Organizational Infrastructure to Develop Strong Interactive Academic Programs in Marine Sciences**

In the current reporting period, the Center institutions achieved this objective through:


- i. **Increased use of the Virtual Campus for a) curriculum development and b) meetings,**


ii. **Strengthening collaborations among center partners, and**


iii. **Strengthening administrative and programmatic components of the Center**

**i) Increased use of the Virtual Campus:** The Virtual Campus was used to provide courses to students, hold student committee meetings, Executive Committee meetings, and thesis and dissertation defenses. Details on these activities are shown below. The Virtual Campus concept was expanded during this reporting period to include not only courses offered through videoconferencing, but also in an online format. Three of the nine essential courses cited by NOAA NMFS as critical to training stock assessment scientists were offered online in Spring 2011 by LMRCSO researchers during the current reporting period and are listed below. Three others from this list are also being offered online this Fall 2011.

**ia) Academic Courses:**

 **Fish Stock Assessment (MEES 642):** This course was currently offered at UMES in Spring 2011, co-instructed by Dr. P. Chigbu, Dr. Larry Alade (NOAA NEFSC) and Dr. Albert Chi and delivered via Blackboard/Wimba. Jessica Blaylock, a contractor at the NOAA NEFSC and UMES Professional Science Master's (PSM) degree student, enrolled in this course online. Seven others at UMES took the course 'live'.

 **Multivariate Statistics (MEES 644):** This course was instructed by Dr. Albert Chi (UMES). In addition to Jessica Blaylock, who participated online, 5 other students enrolled in the class at UMES.

 **Marine Population Dynamics:** This course, instructed by Dr. David Die (RSMAS), was being offered live at the University of Miami and online (via GoToMeeting) to four PSM degree students at UMES

Several University System of Maryland MEES courses were offered in Spring 2011 to LMRCSO students and others at UMES. Courses offered or are currently being offered, and students who enrolled or are currently enrolled in them are shown in Tables 1 and 2, respectively. SSU, HU, RSMAS and DSU students were not enrolled in MEES courses for credit during the reporting period. The Center has developed an Articulation Agreement to make it possible for students at non-University System of Maryland institutions to enroll in the courses via IVN. The document has been signed by all LMRCSO partner institutions. Courses that are being offered online as part of the PSM degree program in quantitative fisheries and resource economics are presented in Table 3.

**Table 1. MEES Courses Offered in Spring Semester 2011 Using Interactive Video Network (IVN).**

Course number	Course Title	Instructor	Students
MEES698D	Advanced Population Dynamics	Wilberg	Dan Cullen (UMES) Shari Mullen (UMES) Belita Nguluwe (UMES) Heather Wolfer (UMES) Bhae-Jin Peemoeller (UMES)
MEES698M	Comparative Mol. Endocrinology	Chung	Jamila Payton (UMES) Tedra Booker (UMES)
MEES698E	Physiological Ecology of Animals	Rowe	Jamila Payton (UMES)
MEES698T	Environmental Statistics	Bi	Dan Cullen (UMES) Bhae Jin Peemoeller (UMES)
M698B	Biometry	Hilderbrand	Belita Nguluwe (UMES) Heather Wolfer (UMES)
MEES661	Physical Oceanography	Chao & Li	
M608X	Aquatic Readings Seminar	Morgan/AL	
MEES608P	Oil Pollution in Aquatic Environment	Mitchelmore	Shari Mullen (UMES) Courtney McGeachy (UMES) Belita Nguluwe (UMES) Efeturi Oghenekaro (UMES)

MEES608L	Marine Microbial Ecology Seminar	Chen & Hill	
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**Table 2. MEES Courses Offered in Fall Semester 2011 Using Interactive Video Network (IVN).**

Course Number	Course	Instructor	Students Enrolled
MEES 608B	Climate Change and Biosphere (Seminar)	Kilbourne	Dan Cullen Heather Wolfer
MEES 608K	Fluid Dynamics	Koch and Sanford	
MEES 610	Land Margins	Fisher	
MEES 682.	Fish Science & Management	Secor et al.	
MEES 698E	History of Ecology	Kangas	
MEES 698R	Stable Isotopes	Nelson and Cooper	
MEES 698X	Remote Sensing	Elmore	
MEES607	Quantitative Methods	Harris	
MEES608C	Diseases in the Chesapeake Bay	Schott	
MEES608D	Scientific Writing & Communications	Kennedy	Bhae Jin Peemoeller Whitney Dyson
MEES608L	Genomic Seminar	Hill & Chen	
MEES621	Biological Oceanography	Hood et al.	Belita Nguluwe
MEES698C	Cell and Molecular Biology	Place & Jagus	Bhae Jin Peemoeller
MEES698G	Microbial and Env.	Chen and Hill	
MEES698M	Practical Protein Chemistry	Ahmed	

**Table 3. Courses Offered Online during Fall Semester 2011**

Course number	Course Title	Instructor	Students (online)
AGSC 605	Agricultural Statistics	Harter-Dennis	Cornelius Chilaka (UMES/PSM) Evan Lindsay (UMES/PSM) Andrew Turner (UMES/PSM) Leonardo Matthews (UMES/PSM) Jeffrey Kipp (UMES/PSM) Kristen Lycett (UMES/CREST)
MEES688	Fishery Survey Sampling	Stevens	Andrea Stoneman (DSU) Jessica Blaylock (NOAA/UMES/PSM) Michele Traver (NOAA/UMES/PSM)
MEES688P/ORLD617	Personnel Development	Costello	Joseph Drummond (UMES/PSM) Cornelius Chilaka (UMES/PSM) Evan Lindsay (UMES/PSM) Leonardo Matthews (UMES/PSM) Andrew Turner (UMES/PSM) Jeffrey Kipp (UMES/PSM)
MEES 688	Fish Ecology	Chigbu & May	Jessica Blaylock (NOAA/UMES/PSM) Andrea Stoneman (DSU) Courtney McGeachy (UMES) Whitney Dyson (UMES)
MEES643	Risk and Decision Analysis	Ali	Jessica Blaylock (NOAA/PSM) Joseph Drummond (UMES/PSM) Evan Lindsay (UMES/PSM) Leonardo Matthews (UMES/PSM) Andrew Turner (UMES/PSM) Jeffrey Kipp (UMES/PSM)



The courses listed in Tables 1 to 3 above address various aspects of the study of living marine resources and their environments, hence, they were offered to students to strengthen their backgrounds in the LMRCSC thematic areas: Quantitative Fisheries, Essential Fish Habitat, and Aquaculture. LMRCSC students are not required to enroll in all the courses listed above, but instead they take only the course(s) that they need for graduation which are not offered at their home institutions.

Through the special topics and directed research courses SSU is able to readily avail its students of courses offered through the LMRCSC without going through the lengthy 4 tiered new course approval process at the university. This process often takes more than one semester. SSU is working on the recommendations for the unified curriculum and examining how such a program can fit in the University System of Georgia's structure. During this funding period, the Marine Science and Environmental Science Degree programs have been integrated into the Marine Science Degree curriculum.

#### Seminars

- The LMRCSC Seminar Series (Table 4) continued in this reporting period. The presentations were made available at all LMRCSC partners via the Virtual Campus. Three sessions (Table 5) have been scheduled for Fall 2011.

**Table 4. LMRCSC Seminar Series 2010-2011.**

DATE	SPEAKER	TITLE
April 15, 2011	Dr. Gulnihal Ozbay (DSU)	Investigation of Habitat Value of Floating Eastern Oyster ( <i>Crassostrea virginica</i> ) Aquaculture in Delaware's Inland Bays
May 13, 2011	Dr. Stacy Smith (DSU)	Drought, Reduced River Flow and Sea Level Rise: Climate Alteration of Carbon and Nitrogen Cycling in a West Florida Estuary and Its Impact on Fish Habitat

**Table 5. LMRCSC Seminar Series 2011-2012.**

DATE	SPEAKER	TITLE
October 7, 2011	Dr. Bradley Stevens (UMES)	Discovering the Kad'yak, Alaska's oldest known shipwreck
November 4, 2011	Dr. Andrij Horodysky (HU)	Sensory ecophysiology of mid-Atlantic fishes: towards a mechanistic understanding of form-function-environment relationships
December 2, 2011	Dr. Jessica Miller (OSU)	TBA

**ib) Executive Committee (EC) Meetings:** Because of budget reductions, EC meetings have been held via teleconference rather than by the Virtual Campus. Teleconferences were held monthly from March to August, 2011.

**ic) Student meetings:** No student meetings were held using the Virtual Campus during the reporting period.

**ii) Strengthening collaborations among center partners:** A strong collaboration is continuing between HU and UMES as a result of a funded TAB project (see TAB reports). HU and UMES students spent 10 weeks at the VIMS Eastern Shore Laboratory in Wachapreague, VA, investigating the Sensory ecology of tautog: ecophysiological auditory and visual performance measures, and Temperature preferences of Atlantic croaker under hypoxic and normoxic conditions.

**iii. Strengthening administrative and programmatic components of the Center:** The Center continued to be guided by two management tracks, A) Administrative and B) Programmatic.

**A. The Administrative component includes the Center Director, Program Manager, Executive Committee, Center Core Administration and the Board of Visitors.**

**Center Director and Staff:** There were no changes in Center staff during this reporting period.

**Executive Committee (EC):** The EC consists of the Distinguished Research Scientist (DRS), Project Directors from each Center institution and Center Director; Dr. Chigbu serves as chair of the EC. The EC met via conference call monthly from March to August, 2011.

**Center Core Administration (CCA):** The CCA, consisting of UMES' Vice President for Academic Affairs, UMES' Vice President for Administrative Affairs, a representative from the office of the President, UMES' Dean of the School of Agriculture and Natural Sciences, Chair of Department of Natural Sciences, LMRCS Director, DRS, and Program Manager met on March 14, 2011. CCA members were briefed by Dr. Chigbu on Center accomplishments, challenges, and about the re-competition proposal for the CSCs.

**LMRCSC Board of Visitors (BOVs):** The BOV, consisting of the Presidents of the LMRCS partner institutions or their designees, last met at SSU on November 3, 2010. The next BOV meeting is scheduled for November 2, 2011 and will be hosted by University of Miami-RSMAS.

**Center Faculty and Staff Positions:** No changes in this reporting period.

**B. Programmatic:**

**Technical Advisory Board (TAB):** Twelve proposals recommended for funding for the 2010/11 project year (Table 6) are underway and will be completed by December 2011.

A revised Request for Proposals for the 2011-12 project year was circulated to all partners as well as to NOAA Fisheries personnel on August 30, 2011. Proposals are due at UMES by October 14, 2011.

The TAB comprises the following individuals:

- Dr. Kristy Wallmo (TAB Chair; NOAA Office of Science & Technology)
- Dr. Tom Noji (Director, J.J. Howard Marine Science Lab., Sandy Hook, NJ)
- Dr. Mike Rust (NOAA NWFSC, Seattle, WA)
- Dr. Ayeisha Brinson (NOAA NEFSC, Woods Hole, MA)
- Dr. Richard Brill (NOAA SEFSC, VIMS)
- Dr. James Berkson (NOAA SEFSC, Virginia Tech)
- Dr. Meka Laster (NOAA EPP Representative), as an observer

**Monitoring and Evaluation:** Online evaluation forms designed to assess LMRCS programs have been in place since 2005. Four updated online evaluation forms for: 1) graduates, 2) cruise participants, 3) student interns, and 4) internship mentors exist.

**LMRCSC Exit Evaluation:** A total of 20 undergraduate and graduate students from at least four LMRCS partners have completed and submitted the exit evaluation during their final semester. None were submitted during this reporting period.

**LMRCSC Cruise Evaluation:** An evaluation form aimed at assessing the students' experience aboard LMRCS research cruises is distributed to participants following each research cruise. More than 10 completed surveys have been received.

**Evaluation Forms for interns and mentors:** To date, 37 students have provided evaluations of their internship experiences at various NOAA facilities, LMRCS partners and other institutions, including six submitted during the current reporting period. Similarly, a total of 17 supervisors have provided evaluations of the LMRCS students who participated in internships in their labs, one during the current reporting period. The data provided are utilized by the Center to ensure the best possible internship experiences for both students and their supervisors.

**Goal 2: Enhance Research Programs in the Marine Sciences at Participating Institutions**

**Objective 1: Continue Current and Develop New Research Programs Congruent with NOAA Fisheries Research Priorities**

RSMAS graduate students and LMRCSC associated faculty funded by the LMRCSC continued their research work in the areas of essential fish habitat, aquaculture, and quantitative fisheries. The work in essential fish habitat is being conducted by graduate students Xaymara Serrano and Rolando Santos. Xaymara is working with Dr. Andrew Baker on impacts of climate change on coral reef communities. Her dissertation will be entitled "Population Genetics of Scleractinian Corals in the Tropical Western Atlantic (Caribbean). Dwight Ebanks continued his work on the effects of climate change and acidification on early life history of cobia. This project has both applications to aquaculture and essential fish habitat. *Quantitative fisheries* is the main area of research of the RSMAS P.I. who during this period focused on work to support the assessment of International Commission for the Conservation of Atlantic Tunas (ICCAT) and billfish species. Dr. Die has continued his work of technical support of the Center for Independent Experts that provides NMFS with independent peer review of science products.

The LMRCSC is fully integrated into the support structure of the B.S. and M.S. degree programs in Marine Science at Savannah State University. SSU has provided research vessels (3), teaching and research space (3 research labs, 4 faculty offices, one academic building with classrooms, a dry lab, and computer lab), and some technical (boat captain) and administrative (clerical) support. Because SSU already had some research capacity, the LMRCSC has been able to enhance the quality of instrumentation and technical needs.

Existing NOAA collaborations with NOAA's Gray's Reef National Marine Sanctuary continue through current projects to monitor utilization of the reef by commercially important species. This work is now being continued by new M.S. student, Noelle Hawthorne.

**TAB Approved Projects for 2010/11:** Twelve projects recommended for funding by the Technical Advisory Board are on-going and will be completed by December 31, 2011 (Table 6).

**Table 6. Projects approved by TAB for 2010/2011**

<b>Principal Investigators</b>	<b>Proposal Title</b>	<b>Amount Approved</b>
1. Joe Pitula (UMES), Feng Chen (IMET), Eric May (UMES), Courtney Schupp (NPS)	Correlation of biotic and abiotic factors in environmental presence of <i>Hematodinium</i>	\$28,842.00
2. Sook Chung (IMET), Joe Pitula (UMES), Gretchen Messick (NOAA)	Determining critical stages of <i>Hematodinium</i> infection and measuring environmental and physiological stress impact on infection	\$31,179.00
3. Brad Stevens (UMES), Beth Babcock (RSMAS), Gary Shepard (NOAA)	Development of in-situ assessment and observation methods for black sea bass	\$13,420.00
4. Adam Tulu (UMES-Student), Ali Ishaque (UMES), Rosemary Jagus (IMET), Chris Chambers (NOAA)	Development of molecular tools and methodologies to evaluate the effect of marine pollutants on Atlantic tomcod, <i>Microgadus tomcod</i>	\$27,002.00
5. Matt Ogburn (SSU), Dionne Hoskins (SSU), Howard Schnabolk (NOAA)	Evaluation of restored intertidal oyster reefs using lidar	\$22,060.00
6. Dionne Hoskins (SSU), Susan Abbott-Jamison (NOAA), Michael Jepson (NOAA)	Piecing together the historical role of African-Americans in Georgia's coastal fisheries using oral histories	\$7,600.00
7. Andrij Horodysky (HU), Andrea Johnson (HU), Richard Brill (NOAA)	Sensory ecology of tautog: ecophysiological auditory and visual performance measures	\$21,108.00
8. Al Place (IMET), Tom Rippen (UMES), James Morris (NOAA)	Taurine – the missing ingredient for development of fish free diets for aquaculture?	\$34,297.00

9. Andrea Johnson (UMES), Andrij Horodysky (HU), Richard Brill (NOAA)	Temperature preferences of Atlantic croaker under hypoxic and normoxic conditions	\$41,614.00
10. Carla Curran (SSU), Paul Pennington (NOAA)	The effect of structure on predation rates of parasitized and unparasitized grass shrimp	\$30,500.00
11. Eric Schott (IMET), Dennis McIntosh (DSU), Gretchen Messick (NOAA)	Tracking pathogens of blue crabs along a climatological and latitudinal gradient	\$41,217.00
12. Belita Nguluwe (UMES-Student), Andrea Johnson (UMES), Al Place (IMET), Anne Richards (NOAA)	Use of mitochondrial DNA markers to evaluate US Fishery management areas and effective population size of monkfish	\$9,000.00

## **TAB Project Reports**

### **Project Title: *Hematodinium* and Dinoflagellates in Coastal Bays**

**Investigators: Joseph Pitula, Feng Chen Co-PI**

**Scope of work:** To investigate the diversity and biogeographic distribution of blue crab pathogen *Hematodinium* spp. in the Maryland coastal waters, and to correlate this with dinoflagellate populations coincident in these waters.

**Project Description:** Although dinoflagellate pathogen *Hematodinium* has been detected in various samples associated with blue crab tissues, we know very little if and how the pathogen transmits between crabs via water or sediment. Very few studies have been conducted to detect *Hematodinium* in the free living stages. We applied PCR based technology to detect the *Hematodinium* spp. in the natural environments. Water and sediment samples have been collected for two years along the Maryland coastal waters (the Delmarva Bay). The goal is to detect the blue crab pathogen in the water samples and understand their genetic diversity and population dynamics using molecular tools such as the cloning and sequencing method or DGGE fingerprinting method.

**Thematic Area Addressed:** Essential Fish Habitat

**NOAA Collaborator(s):** Frank Morado, Ph.D, Fisheries Pathobiologist , NOAA NWFSC, Seattle, Washington

**LMRCSC Collaborator(s):** Dr. Joseph Pitula

**LMRCSC Research Student(s) trained:** Ihuoma Njoku (UMBC), Whitney Dyson (UMES)

**Start Date:** Jan 2011

**Planned End Date:** December 2011

**Planned and actual results of project:** Three sediment samples, that were positive based on PCR amplification with *Hematodinium* specific PCR primers, were used for further analysis. These primers targeted specifically on the ITS regions of blue crab *Hematodinium*. The PCR amplicons were cloned and about 30 clones were picked randomly from each clone libraries. More than 80 clones were sequenced and the phylogenetic analysis suggests that the vast majority of sequences belong to blue crab *Hematodinium*. Interestingly two sequences were affiliated with green crab *Hematodinium*, suggesting the presence of other genotypes of *Hematodinium* in the Delmarva Bay. In general, genetic diversity of blue crab *Hematodinium* is low. However, this result is dependent on the specificity of PCR primers. A new set of PCR primers which target broader *Hematodinium* spp. has been designed and are under testing now.

**How will results be incorporated into NOAA Fisheries operations?** The outcome of this data is predicted to lead to better management strategies related to *Hematodinium* disease in crustaceans.

**How will results be incorporated into LMRCSC research and curriculum?**

**Course Material:** Dr. Pitula is going to teach a genetics course for graduate students at UMES in 2012. The data can be incorporated into the curriculum as: genetic methods for identification purposes, and for comparative phylogenetic analysis.

**PCR-DGGE training to LMRCS students:** On June 1-3, 2011, a PCR-DGGE training workshop was held in Dr. Feng Chen's lab. Dr. Jinjun Kan, an expert on DGGE provided a lecture and laboratory demonstration to a group of 10 students. This short workshop was mainly set up to train the summer intern, Ihuoma Njoku, an undergraduate student from UMBC who was supported by LMRCS. In addition, Ammar Hanif and Whitney Dyson, the two other minority graduate students supported by LMRCS also participated the training.

**Outreach activities:** Dr. Chen devoted a significant amount of time for mentoring and training high school students, high school teacher, undergraduate and graduate students in the past 6 months. The technician and graduate students in Dr. Chen's lab provided tremendous help for training the interns. The Chen lab trained eight high school students and one high school teacher from spring to summer 2011. They are Bilal Moiz (Mount Hebron HS, Fall 2010-Spring 2011), Daniel Kevin (Howard HS, Fall 2010-Spring 2011), Autumn Cadogan (Baltimore Polytechnic Institute, Fall 2010-Spring 2011), Benjamin Lao (Wild Lake HS, Summer 2011), Nicole Rusconi (River Hill HS, Summer 2011), Robert Luo (Poolesville HS, Spring-present 2011), Kenneth Hepburn (Parkdale HS, Biology/Chemistry teacher, Summer 2011), Deja Duncan (Polytechnic Institute, Fall 2011-Spring 2012), and Tomas Richard (Howard County HS, Fall 2011-Spring 2012). These students learned how to perform basic research, deliver scientific reports and present their research to the public. Four of them are minority students. The high school teacher, Ken Hepburn was working on the *Hematodinium* project which is supported by LMRCS. Ken was able to update his knowledge on molecular biology which will be beneficial to many high school students.

**Project Title: Determining critical stages of *Hematodinium* sp. infection, and measuring environmental and physiological stress impact on infection of the blue crab, *Callinectes sapidus***

**Project Description:** Decapod crustaceans (blue, snow, and tanner crabs and lobster) experiencing environmental stress compromise their physiological capacity for survival, hence increasing molt- and life stage- dependent disease susceptibility (bacterial and parasitic infections and epizootic shell disease) and mortality. To understand the direct effects of stress on the animals' susceptibility to disease(s), we aim to identify critical stages to *Hematodinium* sp infection and to measure their stress responses, using hatchery raised naive blue crabs as a model organism. These data allow us to extrapolate stress-induced infection and mortality and to simulate the levels of environmental stress on animals for predicting possible future disease outbreaks and mortality in various coastal areas in the U.S.

**Thematic Area Addressed:** *Essential Fish Habitat, Aquaculture*

**Lead Scientist(s):** J. Sook Chung, UMCES@IMET

**NOAA Collaborator(s):** G. Messick, NOAA Oxford Lab

**LMRCS Collaborator(s):** J. Pitula, UMES

**LMRCS Research Student(s):** Z. Sankoh, Morgan State University, and Meagan Bratcher, UMES.

**Start Date:** Jan. 03, 2011

**How will results be incorporated into NOAA Fisheries operations?** The outcome of this project will allow us to extrapolate stress-induced infection and mortality and to simulate the levels of environmental stress on animals for predicting possible future disease outbreaks and mortality in various coastal areas in the U.S.

**How will results be incorporated into LMRCS research and curriculum?** Research training was provided to undergraduate intern Z. Sankoh, Morgan State University (Sept. 1-Dec. 17, 2010) and Meagan Bratcher, UMES (June 1-Aug 5). J. Sook Chung incorporated the findings of this research into MEES 698M: Comparative and Molecular Endocrinology, Spring 2011.

## **Project Title: Development of in-situ assessment and observation methods for black sea bass, *Centropristis striata***

**Project Description:** Black sea bass (*Centropristis striata*) (aka BSB) support an important commercial and recreational fishery in the Mid Atlantic Bight. Fish live offshore near the continental shelf edge during winter, migrate to inshore habitats in the spring for spawning, and return offshore in fall. Trawl surveys conducted by NOAA are not effective in sampling the heterogeneous inshore habitats, so there is no acceptable index of abundance for adult black sea bass. We propose to develop methods for surveying abundance of black sea bass in inshore waters using in-situ video technology. The goals of the study will be to understand how fish utilize habitat, and determine if we can assess abundance in a quantitative manner. This project has two sub-projects: 1) Build and test a video observation platform for assessing the abundance of BSB and relate abundance to habitat and other variables (Dan Cullen, PhD student); and 2) Observe, classify, and quantify behavior of fish relative to traps and other fish in order to determine the effect of behavior on trap catches (Courtney McGeachy, M.S. student).

**Thematic Area Addressed:** Quantitative Fisheries; Essential Fish Habitat

**Lead Scientist(s):** Bradley G. Stevens, UMES

**NOAA Collaborator(s):** Gary Shepherd, National Marine Fisheries Service, NEFSC, Woods Hole, MA.; Vincent Guida, NEFSC, J.J. Howard Research Laboratory, Sandy Hook, NJ

**LMRCSC Collaborator(s):** Elizabeth Babcock, University of Miami, RSMAS

**LMRCSC Research Student(s):** Dan Cullen (Ph.D Student, UMES); Courtney McGeachy (MS Student, UMES).

**Start Date:** 1 Jan 2011

**End Date:** 31 December 2011

### **Results of project:**

**Video Sampling** – Sampling occurred on 11 dates between 14 June and 4 August, 2011 at six sites off the Maryland coast near Ocean City, MD, between 25 and 35 m depth. Sampling was conducted on predominantly hard bottom substrates with aggregated natural and artificial reefs. Video surveys were conducted from the *F/V Andrew G* (chartered vessel) using two modified habitat traps (106.7 cm x 53.3 cm x 30.5 cm; 3.8 cm 12 gauge wire equipped 3 escape vents). Five GoPro® HD Hero (720p resolution, 170° angle of view; Woodman Labs, Inc., California) cameras were attached to a steel frame 38.1 cm above each trap. For Subproject 1 (Trap 1), one camera was placed on each side facing outward while another was positioned facing inward to record fish/trap interactions; sampling consisted of 60 minute continuous video and photos at 5 or 10 s intervals, using baited (squid) and unbaited deployments. For Subproject 2 (Trap 2), four cameras were faced inward to observe fish in traps, and one faced outward; deployments were continuous for up to 4 hr in order to avoid disturbing fish. Additional observations were made with 4-5 hr deployments of Trap 2 in a mesocosm (tank) at the NMFS J.J. Howard Lab in Sandy Hook, NJ, where light, temperature, and salinity were artificially controlled. During all deployments at sea, angling was conducted to capture fish around the traps. The total length of fish caught by hook-and-line and traps was measured to the nearest centimeter. Over 80 hr of video have been collected of which only a few have been examined to date.

**Subproject 1: Assessment of BSB abundance** – For this report, two videos (baited, unbaited) collected on 23 June were analyzed using the “Mean Count” method to estimate the average number of fish. Of the four outward facing cameras, these were chosen as having the best view of fish. Prior to analysis, a still frame was taken every 30 seconds for the first 30 minutes of video beginning at the point when the trap landed on the bottom. A random sample of thirty frames was chosen and the number of fish from all frames was used to calculate the Mean Count or average. The average number of fish for the baited sample ( $3.1 \pm 2.7$  95% CI) was greater than that of the unbaited sample ( $1.3 \pm 1.9$  fish). Overall, the Mean Count of fish was higher for the baited video though the substrate type in the camera view was different. The baited video view included low relief coral while that of the unbaited consisted primarily of sand. Future video analysis will incorporate a stratified random sampling design with strata defined by substrate type (sand/mud, shell) and/or the presence of structure (rock, low/high relief coral, artificial relief) in the field of view.

### **Subproject 2: Evaluation of BSB behavioral interactions in and around traps**

Video recordings were viewed and fish behavior classified into 5 categories (assuming that fish were counted multiple times): (1) approach, any individual entering the field of view of the camera; (2) entry, fish fully entering trap; (3) half-entry, fish that entered more than half a body length into the trap; (4) exit, fish leaving the trap through either

an entrance (kitchen) or one of the escape vents (parlor); and (5) catch, the number of BSB in the trap at time of haul. The videos were also viewed for general behavior such as, feeding (on bait), combat, swarming of the trap, etc. Over 40 hr of video were collected at sea, during which fish were caught by the trap, and over 24 hr of video were collected in the mesocosm, during which 5 fish were caught.

**How will results be incorporated into NOAA Fisheries operations?** We expect to achieve several goals with applicable results: 1) Observe and quantify fish behavior in and around traps to determine entry and exit rates, and how fish react to the presence of other fish. This information will allow better understanding of the meaning of trap CPUE and how it relates to fish abundance, which will allow managers to interpret CPUE and landings data with greater accuracy. 2) Develop useful indices of fish abundance based on in-situ video observations, and develop a model relating fish abundance to habitat, depth, temperature, trap CPUE and other variables. Such information will be useful to develop better indices of fish population abundance, and add to the available data base for stock management.

**How will results be incorporated into LMRCS research and curriculum?** We expect that one PhD dissertation and one MS Thesis will be based partially on the results of this research. In addition, we will involve one or more undergraduate students in the research project. Data collected during the project will also be used in the class "Survey Sampling" taught by Dr. Stevens for training students to analyze fish stock assessment data.

## **Project Title: Development of molecular tools and methodologies to evaluate the effects of marine pollutants in the Atlantic tomcod, *Microgadus tomcod***

**Project Description:** The Ishaque/Chambers laboratories have a project underway to assess the effects of polycyclic aromatic hydrocarbon (PAH) and polychlorinated biphenyl (PCB) contaminants in the estuarine species, *Microgadus tomcod*. As part of this larger body of work, the UMES graduate student, Adam Tulu, has collaborated with Dr. Rosemary Jagus of UMCES-IMET to develop molecular tools and methodologies to assess the effects of PAH and PCB on the transcript levels of cytochrome 1A1 (CYP1A1) and cytochrome CYP19A (CYP19A). Under Dr. Jagus' guidance, Mr. Tulu has been successful in purifying RNA from tomfish samples generated in Dr. Chambers' laboratory, in cloning the cDNA for CYP1A1 and generating and cloning a partial cDNA sequence for CYP19A. To finalize his graduate studies, Mr. Tulu proposes to: a) complete the cloning of cDNA for CYP19A; b) generate in vitro transcripts of CYP1A1 and CYP19A for standard curves; and c) evaluate CYP1A1 and CYP19A transcript levels in fish exposed to PAH, PCB, or both, using RT-qPCR. A summer undergraduate intern will be recruited to assist in the processing of the many samples in need of analysis. The data gathered will be analyzed in the context of data already accumulated in this project including histological, biochemical and morphological response to the toxins.

**Thematic Area Addressed:** *Quantitative Fisheries*

**Lead Scientist(s):** Adam Tulu, UMES; Dr. Rosemary Jagus, UMCES-IMET and Dr. Ali Ishaque, UMES

**NOAA Collaborator(s):** Dr. Chris Chambers, NOAA Fisheries Service (NMFS)

**LMRCS Research Student(s):** Adam Tulu, UMES

**Start Date:** 01/03/11

**Results of project:** 3' rapid amplification of cDNA ends (RACE)-PCR has been successfully applied to construct the full length cDNA sequence of CYP19a aromatase. *In vitro* transcripts of CYP1A1 and CYP19A have been generated for standard curves and conditions for RT-qPCR determination have been optimized. CYP1A1 and CYP19A transcript levels have been determined in fish exposed to PAH, PCB, or both, using RT-qPCR. The study has demonstrated that PCBs alone, but not PAHs, have a significant effect on hepatic CYP1A and ovarian CYP19A.

Furthermore, there is a significant interaction between the effects of PAH and PCB on ovarian CYP19A transcript levels, but not on hepatic CYP12A transcript levels.

**How will results be incorporated into NOAA Fisheries operations?** The research will provide unique information on the relatedness of bioindicators, including measures of adult reproductive performance, and it will explicitly analyze the interactions among contaminants. These results extend beyond local species and systems to studies with similar concerns in other marine and estuarine ecosystems. The work has also provided a useful tool to investigate tomcod aromatase, CYP19A.

**How will results be incorporated into LMRCSC research and curriculum?** This funding is supporting the research of Mr. Adam Tulu towards completion of his Ph.D. thesis. The funds were also used to support a summer undergraduate intern, Jordan Gomes.

## **Project Title: Evaluation of restored intertidal oyster reefs using lidar**

**Project Description:** Restoring Essential Fish Habitat (EFH) is a critical aspect of Ecosystem-Based Management, leading to the rebuilding and sustaining of healthy fish stocks in areas that have been heavily impacted by human activities. Habitat restoration projects using the eastern oyster *Crassostrea virginica* provide an exceptional model system for studying restoration outcomes because they are conducted across a wide geographic range and with a variety of materials and techniques. Efforts to restore oyster reefs have varied in their outcomes, but outcomes beyond the first year are rarely documented due to lack of funding for long-term monitoring. Oyster density and reef area are relatively straightforward to quantify, but such measures alone are insufficient to determine whether restoration projects provide similar ecosystem services to natural reefs. Restoration outcomes related to biological components of reef structure and food webs such as oyster growth, community development, and use by important fishery species can be particularly difficult to measure, with high variability among natural reefs preventing comparison between restored and natural reefs (e.g. Walters and Coen 2006). Assessment of improvements in water quality is advancing with the development of in situ measurements of phytoplankton uptake, but results differ depending on differences in oyster size and density relative to water flow and depth (Grizzle et al. 2006; Grizzle et al. 2008). Clear, quantifiable and inexpensive measures of restoration success are needed to evaluate the outcomes of oyster restoration projects. The purpose of this study was to develop rapid, inexpensive measures of intertidal oyster restoration success that could be assessed in the field or remotely using lidar.

**Thematic Area Addressed:** Essential Fisheries Habitat

**Lead Scientist(s):** Dr. Matthew Ogburn, SSU

**NOAA Collaborator(s):** Howard Schnabolk, NOAA Office of Habitat Conservation

**LMRCSC Collaborator(s):** Dr. Dionne Hoskins, NOAA Fisheries and SSU

**LMRCSC Research Student(s):** Eric Ransom, SSU (Undergrad); Tiffany Ward, SSU (Graduate)

**Other collaborators:** Dr. Jeb Byers, UGA; Daniel Harris, UGA Marine Extension;

Brian Corley, UGA Marine Extension; Gabe Gaddis, GA DNR

**Planned Start Date:** January 2011

**Planned End Date:** December 2011

**Actual Start Date:** January 2011

**Actual End Date:** TBA

### **Planned and actual results of project:**

**Methods:** To evaluate the vertical structure of natural intertidal oyster reefs, seven natural reefs and non-reef (control) areas were studied along the Wilmington River and other tributaries of Wassaw Sound in Chatham County, GA. These reefs were distributed along a salinity gradient in the Wilmington River estuary that varied from 35 to 20 at low tide. No natural oyster reefs occurred at lower salinities in this estuary. At each site, three transects each in reef and adjacent non-reef areas were established perpendicular to shore. Shoreline slope was determined from relative elevation measurements taken at 1 m intervals along each transect from the marsh surface to the water's edge at low



tide. Relative elevations was determined by placing a laser level on a PVC post at the marsh edge and measuring the distance from the laser beam to the sediment surface. Rugosity was measured at each 1 m interval using a modification of the chain-length method (Rogers et al 1983) by laying a 2-m chain parallel to shore so that it follows the vertical structure of the reef and measuring the actual horizontal distance covered. Rugosity was calculated using the equation  $R = 1 - d/l$ , where  $d$  is the horizontal distance covered by the chain and  $l$  is the length of the chain when fully extended (Aronson and Precht 1995). In the reef areas, seven additional rugosity measurements were made at the lower (approximately 0.5 m above low water) and upper (approximately 0.5 m below the edge of the marsh) reef resulting in a total of 10 rugosity measurements each on the lower and upper reef. Reef height was measured as the distance from the sediment surface to the tallest point along the chain used for rugosity measurements.

**Biological data:** Percent cover estimates and oyster and mussel density, oyster shell height, and oyster mortality measurements were recorded to compare reef structure with the presence and growth of oysters and other reef organisms. Percent cover estimates were made visually in 1 m<sup>2</sup> quadrats along each transect. Cover was estimated to the nearest 5% (due to the limited accuracy of visual estimates) for five dominant cover classes which were: 1) live oyster, 2) dead oyster shell, 3) barnacles, 4) sand/mud, and 5) *Spartina alterniflora*.

Oyster density, mortality, and size distribution were recorded on the upper and lower reef to provide additional biological data for comparison with vertical structure. Oyster density was recorded as the number of live oysters in three 0.25 m<sup>2</sup> quadrats placed randomly along the upper and lower reef of each site. The ribbed mussel (*Geukensia demissa*) and hard clam (*Mercenaria mercenaria*) were also counted. Percent mortality was estimated by counting the number of recently dead oysters (clean shell with pearly-white interior) and dividing by the sum of live and recently dead oysters. The size distribution of oysters was estimated by measuring the shell height of 30 randomly selected oysters within each quadrat.

**Remote sensing:** Lidar data collected in 2009 is currently being analyzed using LP360 in ESRI ArcGIS 10 to convert point measurements to 2-D creekside profiles (Stockdon et al. 2009) and estimate rugosity (Walker et al. 2009). Lidar data analysis was delayed until fall due to late release of the data by Chatham County and issues with setting up a new computer for analysis (purchased with non-TAB funds). Remote measurements of creekside profile and rugosity will be compared to field measurements to ground-truth the lidar data. A minimum of 10 additional sites each in high, moderate and low salinity regions will be assessed for creekside profile and rugosity at reef and non-reef areas. These measurements will be used to establish differences in vertical creekside structure among areas with and without fringing oyster reefs. Measurements of creekside profile and rugosity of natural reefs will serve as the standard against which oyster restoration projects are evaluated.

**Preliminary results:** Biological characteristics of oyster reefs differed between restored and natural reefs; however restored reefs appeared to become similar to natural reefs as they aged. Oyster density was on the whole significantly higher ( $p < 0.001$ ) in restored reefs (overall mean,  $\pm$  S.D.;  $281 \pm 203$  m<sup>-2</sup>) than in natural reefs ( $216 \pm 140$  m<sup>-2</sup>). Important differences were observed in the location of high oyster densities between natural and restored reefs. Natural reefs had significantly higher ( $p < 0.001$ ) densities of live oysters in the upper reef ( $329 \pm 82$  m<sup>-2</sup>) than in the lower reef ( $172 \pm 152$  m<sup>-2</sup>), whereas restored reefs (especially reefs in their first or second growing season) had low densities in the upper reef ( $156 \pm 119$  m<sup>-2</sup>) and very high densities in the lower reef ( $368 \pm 202$  m<sup>-2</sup>) including a mean density of 716 m<sup>-2</sup> on a shell bag reef in its third growing season. Percent mortality was 3-4% and did not vary among natural and restored reefs or upper and lower reef sections. Oyster size increased with restored reef age, with the size distribution approaching that of natural reefs within 3-8 years.

The physical characteristics of reefs measured in the field also differed among natural and restored reefs. Both the rugosity and height of vertical structures were significantly higher ( $p < 0.001$ ) for the upper section of natural reefs (overall mean  $\pm$  S.E.; rugosity =  $0.34 \pm 0.01$ , height =  $13.8 \pm 0.9$  cm) as compared to the lower section (rugosity =  $0.19 \pm 0.01$ , height =  $8.6 \pm 0.9$  cm). On restored reefs, rugosity and height were similar to natural reefs on lower sections of the reef (rugosity =  $0.22 \pm 0.01$ , height =  $16.3 \pm 0.8$  cm), but were often much lower on the upper reef (rugosity =  $0.16 \pm 0.01$ , height =  $12.03 \pm 0.9$  cm). Restored reef material affected the vertical structure, with one reef having the greatest rugosity and height of any reef, restored or natural, because it was constructed using ~0.5 m PVC pipes. Other restored reefs had lower profiles (especially those constructed with shell bags) which were sometimes mostly covered with sediment on the upper section of the reef. The tall height of the lower section of reefs restored using shell bags was largely due to the height of the wooden pallets and shell bags with which they were constructed. A three-year old reef constructed with bundles of oak branches and shell bag reefs >5 years old had values of oyster density, rugosity, and height that were most similar to natural reefs.

**Discussion:** Restored intertidal oyster reefs in Georgia largely appear to be undergoing successful development into functioning reefs that are similar to natural reefs. Restored reefs that are more than three years old appear to be similar to natural reefs in most biological and physical characteristics measured in the field. However, these older reefs were smaller than more recently restored reefs, and thus may not follow the same pattern of development. We will be conducting future long-term monitoring of several recently restored reefs to follow their development over time.

An interesting and unexpected aspect of reef development has been that recently restored reefs (<5 growing seasons) had the highest densities of live oysters in the lower reef, whereas natural reefs and older restored reefs had higher densities in the upper reef. Natural reefs also had higher rugosity and taller vertical structures in the densely colonized upper reef than the lower reef. Many restored reefs had the highest rugosity and greatest height at the lower reef. This appeared to be because wave energy prevented sedimentation from burying lower sections of restored reefs (especially shell bag reefs), whereas upper sections of some restored reefs were mostly covered in sediment after only a few months. However, it is not entirely clear yet from our data why restored and natural reefs differed in this way.

**Future Plans:** We are currently working to analyze the remotely-sensed lidar data. Once analysis of the lidar data is complete, we will perform statistical comparisons of the lidar and field data. We will be comparing both the field-collected and remotely-sensed reef structure data to the biological data to determine whether measures of physical structure can provide rapid estimates of biological parameters. We will also make comparisons between the different types of reef restoration materials used on the GA coast.

Additionally, we will be developing an educational module in fall 2011 for use in K-12 classrooms. The module will focus on the ecosystem services provided by oyster reefs and the importance of restoring reefs to the coastal ecosystem.

**How will results be incorporated into NOAA Fisheries operations?** This project addresses NOAA's targeted research area of Essential Fisheries Habitat. NOAA has funded a number of habitat improvement projects in GA that were evaluated in this project. We anticipate that the results will provide information on restoration design and best practices that will guide the planning and construction of future reefs. We also anticipate that the study will inform restoration monitoring programs by providing baseline data on natural reefs against which to measure restoration outcomes, as well as an assessment of the utility of Lidar for making such assessments.

**How will results be incorporated into LMRCSC research and curriculum?** This research has provided a summer internship for an undergraduate student, Mr. Ransom. He is continuing to analyze the data he collected over the summer and write up his results as part of his senior research thesis class. We will fund the graduate student, Ms. Ward, this fall to help with additional data analysis and synthesis.

In addition, the project is part of a partnership between SSU and NOAA's Office of Habitat Conservation to conduct long-term monitoring of oyster restoration projects. This project allowed us to set up several long-term monitoring sites and collect the initial data. Our initial oyster monitoring in fall 2010 (prior to the receipt of this award) was conducted by a graduate research methods course taught by Dr. Ogburn. We anticipate continuing this monitoring effort with participation from this and other SSU classes.

## **Project Title: Sensory ecology of tautog: ecophysiological auditory and visual performance measures**

**Project Description:** The ecophysiological abilities of coastal fishes to cope with environmental variability and anthropogenic stressors have received little attention. We therefore seek mechanistic insights into the influence of biotic and abiotic processes on the auditory and visual systems of tautog as a companion project to our earlier study of the sensory systems of black sea bass. We will evaluate these ecophysiological performance measures as assays of essential fish habitat, predator-prey interactions, and anthropogenic stressors. This proposal responds directly to research priorities delineated in the LMRCSC RFP, and directly supports the mission of NOAA-Fisheries, and provides research experience for undergraduate students.

**Thematic Area Addressed:** Essential Fish Habitat

**Lead Scientist(s):** Dr. Andrij Z. Horodysky, HU

**NOAA Collaborator(s):** Dr. Richard Brill, NMFS-NEFSC

**LMRCSC Collaborator(s):** Dr. Andrea K. Johnson, UMES

**LMRCSC Research Student(s):** Elizabeth Seagroves, HU undergraduate; Krysten Rybyzyske, UMES undergraduate

**Start Date:** 01/11

**End Date:** 12/11

### **Planned and actual results of project:**

**Project Objectives and Achievements:** Tautog were obtained by hook and line and vented at the time of capture to avoid barotrauma. Two fish that exhibited exophthalmia at the time of capture expired before venting could be completed. Fish were transported by Dr. Horodysky to the VIMS Eastern Shore campus and maintained in temperature controlled, filtered, sterilized, and oxygenated recirculating 1000 L aquaria maintained at 32 ppt and 16 °C. Tanks were assayed 1-5 times daily for temperature, salinity, oxygen, and ammonia levels.

#### A) AUDITORY ECOPHYSIOLOGY

1. Characterize the frequency sensitivity and pressure and particle motion thresholds of Tautog, and 2) Using auditory thresholds, calculate theoretical auditory ranges as a function of depth.

- Auditory brainstem response experiments were conducted for nine tautog (530-1310 g), resulting in six complete datasets. For each fish, experiments included stimuli from (i) a speaker that presented both pressure and particle motion components of sound (range: 100-2000 Hz), and (ii) a vibration mini-shaker that presented predominantly particle motion (range: 100-1000 Hz). The large nuchal hump and extremely tough skin of tautog presented issues for proper placement of fine wire electrodes, and their copious mucus made the recording of auditory evoked potentials very challenging (mucus causes reference and recording electrodes to short to each other, damping the recorded signal). These issues were overcome via the use of implanted stainless steel needle electrodes and by adjusting the duration of stimulus presentation and increasing the number of recorded signal averages by an order of magnitude, which unavoidably lengthened the duration of experiments. Tautog demonstrated auditory brainstem responses from 100-600 Hz when stimulated with the shaker apparatus and 100-1200 Hz when stimulated by the speaker; in both cases, the species exhibited greatest sensitivity to low frequency stimuli (200-300 Hz). At all frequencies, tautog exhibited fairly high thresholds to speaker stimuli, demonstrating poorer auditory performance than black sea bass (Horodysky et al., unpublished data) or other coastal fishes surveyed with the same technique (Horodysky et al., 2008a; Horodysky, in preparation). These results suggest that tautog survey the auditory scene of the temperate reef environment at low frequencies, and that sensitivity to faint sounds and to higher frequencies (e.g., high frequency invertebrate stridulation noises) may not provide a selective advantage to the species.

#### B) VISUAL ECOPHYSIOLOGY

3. Characterize the luminous (intensity) sensitivity, flicker fusion frequency (speed of vision), and chromatic (color) sensitivity of tautog.

- We used whole-animal corneal electroretinography (ERG) to examine potential circadian changes in the response of tautog (*Tautoga onitis*) visual systems to light stimuli varying in wavelength (spectral sensitivity), intensity (luminous sensitivity), and temporal properties (flicker fusion frequency, FFF). Experiments were conducted for nine individuals (1140-2250 g), resulting in nine complete datasets. Tautog demonstrated fairly high and diel-invariant sensitivity to dim light (dynamic range of 2.2 log cd m<sup>-2</sup>) and moderate speeds of vision (FFF<sub>day</sub> 38 Hz; FFF<sub>night</sub> 34 Hz), consistent with patterns observed in other deeper-dwelling and temperate reef-associated fishes with which they co-occur. The eyes of tautog are comparatively more sensitive and slower than those of most shallow-dwelling coastal sciaenids (Horodysky et al., 2008b) and epipelagic coastal piscivores (Horodysky et al., 2010). Tautog exhibited broad spectral sensitivities from 400-560 nm, with peak sensitivity circa 490 nm (blue-green wavelengths). Rhodopsin templates fitted to the photopic spectral sensitivity data via maximum likelihood suggest the presence of a two cone pigments: one centered in short blue wavelengths (464 nm) and another at

longer green wavelengths (525 nm). These results are consistent with seasonal migration patterns from the shallow green-yellow coastal waters in cooler months to the deeper blue-green coastal waters during spawning in warmer months, and correlate well to results from other coastal fishes (Horodysky et al., 2008; 2010). Collectively the visual systems of tautog and other temperate reef fishes thus correlate well with the photoclimate and light niches they inhabit.

4. Provide intensity thresholds for the lower and upper limits of visual function
  - The dynamic range (5-95% of maximum intensity response) of tautog was  $2.2 \log \text{ cd m}^{-2}$ , indicating a lower (5%) threshold of  $-1 \log \text{ cd m}^{-2}$ . The upper threshold resides between  $1-2 \log \text{ cd m}^{-2}$ . It was beyond the scope of this study to measure the minimum intensity above threshold that causes retinal damage, or to measure the scope and permanence of that damage with increasing intensity above the upper threshold.
5. Determine whether visual and auditory responses of tautog are correlated with gender (male, female, and intersex) and gonadal development.
  - On the basis of macroscopic gonadal assessment, there is no evidence that visual functions differs among sexes. Histological assessment of gonadal development is ongoing at UMES.
6. Provide recommendations to aquaculture and management agencies involved with habitat issues and production of tautog in the mid-Atlantic region.
  - Although the role of audition in the ecology of tautog is not well understood, their nearly exclusive sensitivity to low frequency sounds suggests that low frequency noise pollution associated with marine construction and the operation of offshore wind farms and oil platforms may present particular challenges to the species. Tautog are presently overfished, and overfishing is occurring. Given these concerns, we recommend that future work investigates the potential sublethal effects of high background noise conditions on potential losses in yield due to stress, growth performance, and/or fecundity.
  - Tautog visual systems are well adapted for foraging during daylight hours in coastal waters of the mid Atlantic. Increased turbidity due to eutrophication, development/runoff, or siltation-producing activities such as coastal and marine construction present likely impediments to foraging and/or reproduction in the species. Visual ecophysiology experiments and husbandry experience through this project suggest that tautog culture operations strongly consider (i) shading holding/grow tanks from mid-day light intensities and (ii) providing refugia within holding or grow tanks for tautog to inhabit. Attempts to feed tautog pelleted or freeze-dried food were repeatedly unsuccessful – live bivalves elicited the strongest feeding responses in captivity.

**How will results be incorporated into NOAA Fisheries operations?** The overall goals of this project are to provide sensory data relevant to the habitat use and resiliency, to anthropogenic stressors and habitat degradation of a managed fisheries resource consistent with the missions of LMRCS and NOAA-Fisheries. Such data form baselines to better quantify potential impacts of habitat changes on spatial and temporal use of nursery habitats. This project builds upon previous studies on fish sensory ecology in the Mid-Atlantic region that have been published in the scientific literature. The results of this study will be reported to local, state, and federal constituents as well as at national scientific meetings.

**How will results be incorporated into LMRCS research and curriculum?** Data from this project will be included in lectures in Dr. Johnson's Fish Physiology Course and Dr. Horodysky's Ichthyology course. Drs. Horodysky, Johnson, and Brill are building a comparative database of sensory function in temperate reef-associated fauna that remain highly susceptible to overfishing due to their typically slow growth, complex life-history and reproductive habits, and high exploitation rates due to the ease of location of reef habitats where these species aggregate. Other threats to these fauna include marine construction and development of oil-drilling and wind farm operations proposed along the Mid-Atlantic seaboard.

**Project Title: Taurine – the missing ingredient for development of fish free diets for aquaculture?**

**Project Description:** Develop and evaluate commercially viable husbandry technologies for new candidate species in both near-shore, offshore, and land-based aquaculture systems. (NMFS Objective 4.5) and b.) Develop alternative feeds for aquaculture (NMFS Objective 4.4).

**Thematic Area Addressed:** Aquaculture

**Lead Scientist(s):** Dr. Allen R. Place, University of Maryland Center for Environmental Science, Institute of Marine and Environmental Technology

**NOAA Collaborator(s):** James A. Morris, Jr. NOAA, NOS, NCCOS, Center for Coastal Fisheries and Habitat Research, Beaufort, North Carolina, 28516, USA

**LMRCSC Collaborator(s):** Thomas E. Rippen, Seafood Technology Specialist, UMES, Princess Anne, MD 21853

**LMRCSC Research Student(s):** An LMRCSC summer intern was hired for the summer of 2011

**Start Date** 1/1/2011

**Results of project:** So far on this project we have completed taste testing of both gilthead sea bream, *Sparus aurata*, and Striped Bass, *Morone saxatilis*. The taste testing panel examined whether differences could be determined between fish raised on fishmeal based diets and those raised on plant protein based diets. The tests for each species were conducted separately, so comparisons between the species were not conducted, only within each species between the diet types. The results of the taste testing showed that the panel members could not tell a difference in taste with either species between the diet types, an encouraging result meaning that raising fish on plant proteins does not negatively affect their taste when compared to fish raised on more traditional, fishmeal based diets. There were however differences in the shear force of both fresh and cooked fillets for each species with the fillets from fish raised on plant proteins consistently requiring less force to shear, which corresponded to a higher water content of those fillets (Table 7).

**Table 7.** Peak shear force required to shear fillets from gilthead sea bream and striped bass, both cooked and fresh, raised on fishmeal or plant protein based diets.

Species	Diet	Fresh/Cooked	Peak Shear Force (g)
Gilthead Sea Bream	Fishmeal	Fresh	11,641.0
Gilthead Sea Bream	Plant Protein	Fresh	10,819.5
Gilthead Sea Bream	Fishmeal	Cooked	19,297.6
Gilthead Sea Bream	Plant Protein	Cooked	7,294.8
Striped Bass	Fishmeal	Fresh	17,299.2
Striped Bass	Plant Protein	Fresh	12,922.5
Striped Bass	Fishmeal	Cooked	45,532.0
Striped Bass	Plant Protein	Cooked	22,689.4

**Leveraged funding:** We are currently in the process of extending this work with Mike Rust and Ron Johnson (NOAA) with sable fish. Also, there is potential for getting some extra funding working with Shin Kwon Kim from Korea and the Soy industry to support our work if we can put together a joint project which would include IMET, NOAA and Shin Kwon's lab.

**How will results be incorporated into NOAA Fisheries operations?** Results of this work are helping to establish the minimum taurine requirement and its effects at different inclusion levels for several commercially important species in aquaculture. We believe that taurine plays a major role in allowing the reduction and elimination of fishmeal as the aquaculture industry seeks fishmeal replacements from more sustainable, plant protein based sources. Aiding the ability to reduce fishmeal and possibly fish oil through taurine inclusion and the use of sustainable

products will greatly enhance the ability of the aquaculture industry to increase global production to meet the ever increasing global demand for high quality, safe seafood. Organoleptic testing of fillets from fish raised on fish product free diets is a necessity in this process to ensure customer acceptability.

**How will results be incorporated into LMRCSC research and curriculum?** This project is 25 % support and graduate training to Aaron Watson and provided training to a summer undergraduate intern. Vanessa Richards, the LMRCSC intern on this project for the summer of 2011 gained experience in bomb calorimetry, lipid extraction and fatty acid methyl ester quantification, RNA extraction, reverse transcription and PCR techniques, and a great deal of experience in animal husbandry. This will hopefully help her a great deal as she is a pre-vet biology major at DSU.

## **Project Title: Temperature preferences of Atlantic croaker under hypoxic and normoxic conditions**

**Project Description:** Atlantic croaker (*Micropogonias undulatus*), an economically and ecologically important demersal species common in Chesapeake Bay, was used as a model species to assess the mechanistic influence of normoxic and hypoxic conditions on temperature preference and movements using a custom videography behavioral preference system. The results of this study complement currently funded work (NSF-CREST) that assesses croaker movement in Chesapeake Bay via telemetry. Our intent is to provide a model approach which can be applied to other fish species. Coupled with habitat mapping of the Chesapeake Bay, we provide important information on how essential fish habitat (EFH) is affected by increases in the spatial extent and duration of seasonal hypoxia in Chesapeake Bay.

**Thematic Area Addressed:** Essential Fish Habitat

**Lead Scientist(s):** Dr. Andrea K. Johnson, UMES

**NOAA Collaborator(s):** Dr. Richard Brill, NMFS-NEFSC

**LMRCSC Collaborator(s):** Dr. Andrij Z. Horodysky, HU

**LMRCSC Research Student(s):** Elizabeth Seagroves, HU undergraduate; Krysten Rybyzyske, UMES undergraduate

**Start Date:** 01/11

**End Date:** 12/11

### **Planned and actual results of project:**

**Project Objectives and Achievements:** Atlantic croaker were obtained from commercial fishing contacts and transported to the VIMS Eastern Shore Laboratory. Fish were maintained in temperature controlled, filtered, sterilized, and oxygenated recirculating 1000 L aquaria maintained at 18 ppt and 25°C. Tanks were assayed 1-5 times daily for temperature, salinity, oxygen, and ammonia levels.

At the time of a trial, a single croaker was removed from the holding tank and implanted with a small plastic sample identifying tag (Hallprint Ltd) that was affixed with high gain reflective tape. Each fish was then transferred to a ~ 50L behavioral Shuttlebox tank maintained at normoxia at 22-24°C and 18 ppt salinity that was illuminated with a single white 23W fluorescent bulb. The system consists of two round chambers (39 cm in diameter) connected by a short (10 x 6 mm) raceway and includes two recirculation pumps, four dosage pumps (for inflow from warm and cold baths), two temperature mixing towers, a CCD video camera, and two temperature probes to monitor temperature continuously. Custom ShuttleSoft software (Loligo Systems) tracked the movements of the animal throughout the Shuttlebox tank sections and controlled temperature accordingly. Changes in temperature were controlled by a DAQ instrument that regulates the activity of sets of pumps, depending on the position of the fish. Passage of the fish into the warmer side of the tank prompted the dosage pumps to increase the temperature in both tanks; the reverse occurred if the fish swam into the low temperature tank. A 2°C temperature difference was constantly maintained between the two circular tank sections, regardless of the direction of change. Oxygen saturation was monitored via a galvanic oxygen electrode which measured the content of water returning from the right hand (decreasing) circular section. Custom data acquisition software (DasyLab) controlled the addition of oxygen or nitrogen to the system to attain the desired experimental setpoint. Experiments were conducted for 24 hrs each at normoxia (> 90% O<sub>2</sub> saturation), moderate hypoxia (50% O<sub>2</sub> saturation), and severe hypoxia (25% O<sub>2</sub> saturation). Full normoxia-hypoxia

protocol data were obtained for eight croaker; normoxia-only data were collected for an additional three croaker to establish baseline behavior. At the conclusion of each Shuttlebox experiment, all fish were euthanized and blood, liver, and gonad tissues were sampled from seven individuals for histological and biochemical assays.

1. Determine the temperature preference of Atlantic croaker under normoxic conditions and two levels of hypoxic exposure.

- Atlantic croaker used in these experiments were fairly small (192-236 mm TL, 84-145g), approaching sexual maturity (Gonadosomatic index: 0.29-1.02). Croaker exhibited fairly broad time-at-temperature distributions at normoxia (range 13-32°C); selected temperatures generally decreased with oxygen content. At normoxia, croaker exhibited a broad affinity for temperatures ranging from 19-25%. At 50% oxygen saturation, fish exhibited a bimodal affinity pattern for 19°C and 23-24°C, which may be indicative of fish moving between the 'warm' and 'cold' sections of the experimental tank sections searching for more optimal oxygen conditions. It is worth noting that the temperature distribution of croaker at 50% oxygen saturation was constrained relative to normoxia-croaker spent less time at the extremes of the temperature distribution. At 25% saturation, croaker decreased general activity levels in the Shuttlebox tank, strongly preferring cold water (mode: 16°C). These results are consistent with general inferences into croaker physiology, as 25% oxygen saturation levels roughly correspond to the inflection point between aerobic metabolism and anaerobic debt (R. Brill, J. Peyton, and A. Johnson, personal observation). Minimized activity and selection of colder water are common mechanisms fishes use to endure hypoxia (Schurman et al., 1991). Statistical analyses of the complex autocorrelated behavioral data are underway. We are investigating mechanisms to model the within-individual autocorrelation and covariance in using both frequentist and information theoretic approaches.

2. Evaluate the effects of temperature and hypoxia treatment on Atlantic croaker general health.

- Based on size ranges, gonadosomatic index (GSI), and macroscopic assessment of gonad stage, croaker in these experiments were late juveniles and early adults approaching sexual maturity (GSI: 0.29-1.02). Splenosomatic index (SSI) ranged from 0.05-0.07, and hepatosomatic index (HSI) ranged from 0.4-1.0. Histological analyses of these tissues and microscopic analysis of blood cell counts are on-going.

3. Integrate observed physiological and behavioral responses determined in laboratory (this project) to telemetered field movements (horizontal and vertical; NSF-CREST-funded research), and to changes in water quality and other environmental variables measured in the field.

- On the basis of this initial investigation of croaker behavioral thermoregulation, and to codify laboratory-field integration, we wish to expand the project in 2012 as part of Dr. Johnson's UMES graduate student's doctoral dissertation (H. Wolfer). The use of a larger Shuttlebox tank will allow behavioral experiments to be conducted on the larger size class of adult croaker that are being tracked in the NSF-CREST project. Additionally, adjustments to videography via infrared illumination, rather than the white-light illumination we used, will allow the future assessment of potential diel differences in thermoregulation. These combined modifications would improve mechanistic insights into croaker behavioral thermoregulation and allow stronger integration between laboratory and field inferences.

4. Provide recommendations to management agencies involved with habitat issues in the mid-Atlantic region.

- This project provides preliminary insights relevant to the habitat use and resiliency to anthropogenic stressors and habitat degradation of Atlantic croaker consistent with the missions of LMRCS and NOAA-Fisheries. Results of this project will be made available to state, regional, and federal fisheries and management agencies.

**How will results be incorporated into NOAA Fisheries operations?** This project provided preliminary insights relevant to the habitat use and resiliency to anthropogenic stressors and habitat degradation of a managed fisheries resource consistent with the missions of LMRCS and NOAA-Fisheries. Such data form baselines to better quantify potential impacts of habitat changes on spatial and temporal use of nursery habitats. This project provides a critical laboratory behavioral link to codify leveraged laboratory and field research (NSF-CREST). The results of this project support an ecosystem-based approach to the ecophysiology of fisheries resources that use coastal mid-Atlantic waters.

**How will results be incorporated into LMRCSC research and curriculum?** Data from this project will be included in lectures in Dr. Johnson's Fish Physiology Course and Dr. Horodysky's Ichthyology course. Drs. Horodysky, Johnson, and Brill wish to build a comparative database of ecophysiological function in benthic fisheries resources.

## **Project Title: Tracking pathogens of blue crabs (*Callinectes sapidus*) along a climatological and latitudinal gradient**

**Project Description:** In collaboration with the DE NERR staff and a DSU graduate student, trawling will be conducted in the lower St. Jones River and nearby DE Bay NERR in June and October. Graduate student Ammar Hanif is overseeing subsequent crab sample processing and pathogen analyses with Dr. Schott. A summer undergraduate intern from a minority serving institution will also participate in sample collections (June-July) in the DE NERR. Additional crabs will be collected by partners in NJ, CT, and MA, and shipped to IMET for pathogen analyses. DNA and RNA will be extracted from crab samples (Schott, Hanif, Torres) and subjected to PCR analyses for the pathogens, *Hematodinium* sp. and blue crab reovirus. Prevalence of each pathogen will be calculated. These will be the first assessments of these two diseases in the Northeast. A specific objective of the project is to establish relationships with partners throughout the Northeast to allow the long term monitoring of blue crab health. The goal is to 1) establish sampling and shipping protocols, and 2) have these new collaborations continue and improve, with the result that the consortium of partners will be in a position to apply for funding from other external sources to continue blue crab diseases monitoring beyond the term of the LMRCSC grant. One additional benefit of the multi-partner collaboration is the exposure this will provide to graduate and undergraduate LMRCSC students.

**Thematic Area Addressed:** Quantitative Fisheries, Essential Fish Habitat

**Lead Scientist(s):** Eric J Schott, UMCES-IMET

**NOAA Collaborator(s):** Gretchen Messick, NOAA NCCOS Cooperative Oxford Lab, Ron Goldberg, NOAA NMFS Milford Lab

**LMRCSC Collaborator(s):** Dennis McIntosh, DSU

**LMRCSC Research Student(s):** Ammar Hanif (graduate student, Univ of MD), Laura Torres (summer intern, UTPA).

**Start Date:** Jan 1, 2011

### **Scope of work:**

1. Determine the early and late season *Hematodinium* sp. and RLV prevalence in blue crabs within the DE NERR. [Schott and McIntosh]
2. Measure *Hematodinium* sp. and RLV prevalence in blue crabs of mixed age/size classes along a climatic and latitude gradient from DE Bay to southern Massachusetts. This entails coordinating the collection and shipment of crabs from partners within MA Division of Marine Fisheries (B. Estrella), NOAA Milford Lab (R. Goldberg), NJ NERR (P. Jivoff, Rider University), and the DE NERR (R. Scarborough). [Schott]
3. Establish a process and network to conduct long term crab disease monitoring in the region, to enable correlations between disease, crab abundance, and climate change. [Schott and McIntosh]

**Planned and actual results of project:** The project will measure prevalence of the protozoan parasite, *Hematodinium* sp. and the viral pathogen, RLV, in blue crabs from DE Bay to Southern Massachusetts. This will establish the first data on these two diseases of blue crab in this geographic region. As the regional climate warms, blue crab populations may increase, as may the pathogens that afflict crabs. With the exception of DE Bay, the majority of crab sampling is occurring this month, and pathogen analyses will not be completed until November. Early season crabs were trawled from the DE Bay NERR by graduate student Ammar Hanif and summer intern Laura Torres (from Univ. of Texas, Pan American). Hanif and Torres analyzed over 50 crabs for pathogens, finding no prevalence of either in the June-July samples.



In late August, an opportunity arose to capture blue crabs in a salt pond of Long Island, adding a 5th location to the regional survey. These salt ponds are unusual, closed, settings, in which crabs are recruited in the early summer when the ponds are opened to the sea for several weeks. After the barrier to the sea rebuilds, there is no transport of blue crabs to or from the sea. Presumably, crab pathogens also do not enter after the closure. Analysis of these crabs is underway.

In the Northeast, with the decline of the lobster harvests, and the possible expansion of blue crab populations, there is a growing interest in the health and abundance of blue crabs. As a result of our partnership with NOAA Milford lab, we were asked to analyze crabs from a mass mortality that occurred in Long Island Sound in May and June. We did not find evidence that either pathogen was at work; we also understand that the deaths could be explained by sudden changes in temperature and salinity.

Correlations of disease prevalence with latitude and water temperatures will be investigated, and will be more meaningful if extended over a 3-5 year period. Developing preliminary data to apply for external support for a multi-year prevalence survey is an objective. Aside from developing a baseline or establishing whether these two lethal pathogens of blue crab are present in the NE, these analyses will address the question of whether crab pathogens will expand into Northern waters along with the host species. We have a suggestion from 2008-2009 data that both RLV and *Hematodinium* sp. are undetected in the northernmost range, in Southern MA.

**How will results be incorporated into NOAA Fisheries operations?** Blue crabs are not a federally managed species. However, interactions with state and federal scientists in MD, DE, CT, and MA reveal 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, a growing recreational and commercial harvest of blue crabs is on the horizon, especially if lobster harvests remain at historically low levels.

**How will results be incorporated into LMRCS research and curriculum?** Results will be used to support applications for external funding from NOAA and state agencies to continue the monitoring of blue crab health throughout the Northeast.

## **DE-11-01 NOAA LMRCS Scientific and Educational cruise aboard the NOAA Ship Delaware II**

### ***Executive Summary and Highlights***

A nine day cruise was conducted during January, 2011 for the purposes of training students in the NOAA Living Marine Resources Cooperative Science Center (LMRCS) in fisheries science, including learning field sampling procedures, and in support of projects being conducted by faculty and graduate students in the LMRCS program. Scientific objectives included:

- 1) An examination of latitudinal variation in habitat and fish assemblages,
- 2) Investigating spatio-temporal patterns in demersal-megabenthic habitats on the shelf and slope around Hudson Canyon, and
- 3) Exploration on the continental slope to define depth limits of monkfish distribution in the vicinities of Hudson and Norfolk Canyons.

Despite shortening of the 12-day cruise plan due to bad weather, objectives were met satisfactorily. In pursuit of the latitudinal variations projects, 10 fixed stations between northern New Jersey and northern North Carolina were sampled with CTD, beam trawl, and samples were taken of bottom sediments and plankton. Nine were also sampled with the 36' Yankee otter trawl. Ten fixed stations were sampled with CTD and beam trawl for the Hudson Canyon study, and six deepwater trawls were made at depths between 346 and 673 m: beyond depths sampled by the NEFSC groundfish survey. Among the highlights of the cruise were the following:

### Training:

- One NOAA/NMFS scientist, two LMRCSC faculty members, and nine students participated in the cruise, and at least two additional faculty and their students who were not actually aboard will be utilizing data and samples obtained on this cruise.

### Habitat Observations:

- Associations are beginning to appear between newly-mapped deepwater hard bottom patches and their benthic fauna and **monkfish habitat** in Hudson Canyon.
- A pattern is emerging on the Hudson Canyon shelf and slope in which a background of resident species appear consistently in particular habitats year-to-year while others, largely seasonal migrants, do not appear to make use of those habitats in a consistent manner, even in the same season. Data of all types from this and other cruises is being assembled into a **habitat model** to try to understand factors governing the distribution of resource stocks around this canyon.
- Dense patches of **deepwater corals** (the solitary cup coral *Dasmosmilia lymani*) and **sponges** continue to persist around the rim of Hudson Canyon. These data are currently being incorporated into **habitat suitability models** for these structural species and **habitat maps** for the canyon.
- **Juvenile black sea bass habitat** was again encountered in the gravelly rim of Hudson Canyon

### Ecosystem Assessment:

- A method continues to be developed by which **to assess year-to-year changes in biota shelf-wide** based on a combination of sampling methods taken on a grid of fixed, geographically widespread sites on the mid-Atlantic shelf (the Latitudinal Transects). This includes a **near-synoptic assessment of hydrological climate** that drives migratory patterns in large part. Subject to further development and critical review, this could serve as the basis for a direct biological indicator of fisheries ecosystem state.
- For the third year (2008, 2009, 2011), substantial numbers of juvenile **southern white shrimp** were taken on the shelf off Virginia; their progression northward should be monitored both as a possible indicator of climate change and for its potential commercial importance.

### Resource Stocks:

- Catches of **spiny dogfish** during the Longitudinal Transect study were greater than in 2008 or 2009, and a larger percentage (81%) of females  $\geq 80$  cm total length. This suggests that this stock has recovered from depletion of reproductive potential noted in previous years. Mature male:mature female ratio was  $\sim 0.95:1$ .
- **Monkfish** were caught at depths ranging from 59 to 643 m in much larger numbers (153) than on any previous LMRCSC cruise. All were caught with the deepwater flat otter trawl and 2 m beam trawl nets; none were caught with the 36' rockhopper Yankee. Large deep trawl catches were associated with substantial catches of sessile anemones, suggesting association with hard bottoms. The largest beam trawl catch occurred in an area of uneven, presumably sandy bottom thought to be the result of Pleistocene iceberg scouring. This is not the first time that monkfish have been caught by us there. Individuals  $>50$  cm T.L. were found largely in Hudson Canyon; Norfolk Canyon catches consisted almost entirely of smaller individuals.
- High densities of **deep sea red crab** (approaching  $10^5$  individuals/km<sup>2</sup>) and **witch flounder** (up to  $\sim 3000$ /km<sup>2</sup>) were estimated from catches in both Norfolk and Hudson Canyon areas. All deepwater trawl catches were dominated by these two species. The highest abundances of red crabs were in the range of  $\sim 500$ -700 m, beyond the depth range of NEFSC survey trawls. As in 2009, adult-sized witch flounder were more common in Hudson than in Norfolk Canyon.
- Several species of **deepwater crustaceans** of possible fisheries value were caught, among them **Gamba prawns** and **royal red shrimp**.

**Deep sea red crab:** Dr. Stevens and students measured 788 of 7406 crabs captured (10.6% sample), including 283 male crabs (mean 81.2 mm CL) and 505 females (mean 74.2 mm CL). We also sampled gonads from 70 males (testes and vas deferentia) and 96 females (ovaries) for histological examination. Carapace width (CW) was also

measured on dissected crabs, showing that there is no difference in the CW:CL ratio between the sexes. Tissues taken for histology have been dehydrated, embedded, sectioned, and stained, but have not yet been analyzed. External morphology of females (eggs, egg remnants, and pleopod condition) was not a useful indicator of maturity, as the majority of crabs did not have external embryos, and the greatest proportion in any 10 mm category was only 49%, suggesting that red crabs have a reproductive cycle that is longer than one year and may be biennial or longer. Preliminary examination of gonad condition, however, indicates that the median size of sexual maturity (SM<sub>50</sub>) for females is about 61 mm CL. We suspect that male maturity may be lower, and even the smallest crabs we sampled (50 mm CL) appeared to be sexually mature, which may not be small enough to determine the lower size limit of maturity. Red crab are a federally managed fishery but is data-poor due to lack of basic biological information. The data we collected will help establish size at maturity, and we hope to expand this data into a full research project within the next year.

## SCHOLARLY PRODUCTIVITY

In the current reporting period, LMRCSC students and faculty made 52 presentations (24 oral and 28 poster) at scientific meetings, published 13 articles in refereed journals with another 7 in press or accepted. The articles presented and published are listed below.

### **Oral Presentations** (\*Students, Presenter in **bold**)

- Alvarez, J.V. and **J. Sook Chung** (2011). Identification of prophenoloxidase (PPO) genes of *Callinectes sapidus*: cloning of PPOs and a putative role in shell-hardening process. National Shellfisheries Association, Baltimore, March 28-April 1.
- Bowers, H., L. Carrion, **A. Hanif\***, G. Messick, O. Zmora, **E. Schott**. (2011). A reo-like virus associated with mortalities of blue crab, *Callinectes sapidus*: tools to improve soft shell aquaculture. Presented at the National Shellfisheries Association Meeting, Baltimore MD, March 21, 2011.
- Brady, M\***, Conn, P., Bailey, L., Shertzer, K., Fox, D. 2011. Understanding Population Dynamics of American Eel (*Anguilla rostrata*) through Mark-Recapture and Telemetry. Delaware State University Graduate Research Symposium, April 15. Dover, DE.
- Breece, M\***, Fox, D., Savoy, T. 2010. Coastal Movements and Marine Habitat Utilization of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) along the Eastern Seaboard of the North America. Delaware State University Graduate Research Symposium, April 15. Dover, DE.
- Feng, X., Williams, E. and **Place, A.R.** Success of genetic tag identification of hatchery reared blue crabs. National Shellfisheries Association in Baltimore, MD, March 2011.
- Janiak, C.\*** and McIntosh, D. 2011. Developing aquaculture methods for *Fundulus heteroclitus*: broodstock management and hatchery techniques. Association of Research Directors 16<sup>th</sup> Biennial Symposium, April 9-13. Atlanta, GA.
- Jagus, R.** Regulation of gene expression in the toxic dinoflagellate, *Karlodinium veneficum*. NOAA Northeast Fisheries Science Center, Sandy Hook.
- Janiak, C.\*** and McIntosh, D. 2011. Developing aquaculture methods for *Fundulus heteroclitus*. Delaware State University Graduate Research Symposium, April 15. Dover, DE.
- Katenta, A.\***, J. S. Pitula and J. S. Chung. Molecular cloning of eIF4E-1 in the hepatopancreas of female blue crab *Callinectes sapidus*. University of Maryland Eastern Shore University Wide Graduate Research Symposium. Princess Anne, MD. April 21, 2011.
- Moore, J\***, Fox, D., Wetherbee, B.M., McCandless, C.T. 2011. Interannual site fidelity and habitat utilization of sand tigers in Delaware Bay. Delaware State University Graduate Research Symposium, April 15. Dover, DE.
- Pagenkopp Lohan, K.M., Shields, J. D., Xiao, J., Miller, T. L., Small, H. J., **Place, A.R.**, and Reece, K.S. 2011 The frequency and distribution of genetic strains of *Hematodinium*, a parasitic dinoflagellate of the blue crab (*Callinectes sapidus*), along the Delmarva Peninsula, VA. National Shellfisheries Association in Baltimore, MD, March 2011.

- Pitula, J. (2011).** Biotic and Abiotic Factors in *Hematodinium* sp. transmission. Presented at the Eastern Fish Health Workshop, Charleston, SC, March 2011
- Reckenbeil, B.\*** and Ozbay, G. 2011. Oyster Gardening – Where in Delaware's Inland Bays to Focus Shoreline Oyster (*Crassostrea virginica*) Rehabilitation Efforts. . Association of Research Directors 16<sup>th</sup> Biennial Symposium, April 9-13, 2011. Atlanta, GA. Received **1<sup>st</sup> place oral presentation in the renewable resources, bioenergy and environmental stewardship category.**
- Reckenbeil, B.\*** and Ozbay, G. 2011. Preliminary Shoreline Habitat Assessment of Rip-raps Stocked with the Eastern Oyster (*Crassostrea virginica*) in Jefferson Creek, South Bethany Delaware. Delaware State University Graduate Research Symposium, April 15. Dover, DE.
- Smith, S. M. E., Morgan, D., Musset, B., Cherny, V. V., **Place, A. R.**, Hastings, J. W. and DeCoursey, T. E. 2011. A Novel Voltage Gate Proton Channel in a Dinoflagellate. Biophysical Society, Baltimore, MD.
- Sook Chung, J.** and N. Zmora (2011). Multifunctionality of CHH neuropeptide family in molting and reproduction of the blue crab, *Callinectes sapidus*. National Shellfisheries Association, Baltimore, March 28-April 1
- Sook Chung, J.** and R. Overstreet (2011). Physiological and endocrinological responses of *Callinectes sapidus* to *Loxothylacus* infection. National Shellfisheries Association, Baltimore, March 28-April 1
- Streater, C.\*** E. Williams and A. Place. Identification of a Voltage-gated Proton Channel Gene in *Karlodinium Veneficum*. University of Maryland Eastern Shore University Wide Graduate Research Symposium. Princess Anne, MD. April 21, 2011
- Techa, S and **J. Sook Chung** (2011) . Molt control: Expression profiles of ecdysteroid receptor complex (*EcR-RXR*) and molt-inhibiting hormone of the blue crabs, *Callinectes sapidus*. National Shellfisheries Association, Baltimore, March 28-April 1
- Thongda, W. and **J. Sook Chung** (2011). An ovarian vitellogenin gene of the blue crab, *Callinectes sapidus*: isolation and its expression during ovarian development. American Fisheries Society Symposium, Eastern Shore, April 1.
- Thongda, W. and **J. Sook Chung** (2011). An ovarian vitellogenin gene of the blue crab, *Callinectes sapidus*: isolation and its expression during ovarian development. National Shellfisheries Association, Baltimore, March 28-April 1
- Tibbles, J., E. Williams, A. Place and **J. Sook Chung** (2011). Is a genetic variation responsible for the differential growth rate of animals obtained from a single brood of *Callinectes sapidus*? National Shellfisheries Association, Baltimore, March 28-April 1
- Watson, A. M.\*, and **Place, A. R.** 2011 Fatty acid profiles of cobia, *Rachycentron canadum*, and Gilthead Sea Bream, *Sparus aurata*, fed diets containing alternative lipid sources. World Aquaculture Society, March 3, 2011. New Orleans.
- Williams, E. and **Place, A.R.** Comparison of genetic diversity in different life stages of the blue crab (*Callinectes sapidus*) with mitochondrial and microsatellite markers. National Shellfisheries Association in Baltimore, MD, March 2011.

#### **Poster Presentations** (\*Students, Presenter in **bold**)

- Allman, A. and **Place, A.R.** The effect of cage size and ration on growth of the juvenile blue crab, *Callinectes sapidus* (Rathbun), in a recirculating system. National Shellfisheries Association in Baltimore, MD. (**Poster Presentation**).
- Allman, A. and **Place, A.R.** Fiber digestion in the juvenile blue crab, *Callinectes sapidus* Rathburn., National Shellfisheries Association in Baltimore, MD, March 2011. (**Poster Presentation**).
- Cannon, A.,\*** and Ozbay, G. 2011. Videography: Interviewing and Surveying of Oyster Gardeners . 4<sup>th</sup> Annual American Fisheries Society UMES Student Subunit. University of Maryland Eastern Shore, Berlin, MD. April 1. Tied for 1<sup>st</sup> place poster presentation

- Dyson, W.\***, Ammar Haniff\*, Eric J. Schott, Joseph Pitula: A PCR Based Assay for Detection of *Hematodinium* sp. in sediment and water from the Maryland Coastal Bays. AFS Tidewater Chapter Meeting. Gloucester Point, VA. March 10-12, 2011. Received 2<sup>nd</sup> place student poster award
- Davis, J.\*** & Hill, R. Bacterial symbionts of a marine invertebrate as sources of anticancer compounds. American Fisheries Symposium (AFS): UMES Student Sub-Unit 4<sup>th</sup> Annual Symposium, April 2011.
- Davis, J.\*** & Hill, R. Bacterial symbionts of a marine invertebrate as sources of anticancer compounds. American Fisheries Symposium (AFS): UMES Student Sub-Unit 4<sup>th</sup> Annual Symposium., April 2011.
- Feng, X., Williams, E. and **Place, A.R.** Heteroplasmy in the mitochondrial genome of the blue crab *Callinectes sapidus* demonstrated in multiple loci across generations. National Shellfisheries Association in Baltimore, MD, March 2011. (**Poster Presentation**).
- Gillespie, K\***, Choi, E, **Currie, A.E.**, and R. Jagus Poster at the American Fisheries Symposium (AFS): UMES Student Sub-Unit 4<sup>th</sup> Annual Symposium, Elucidating cDNA sequences of eIF4E family members 2A and 2B from zebrafish April 2011.
- Gardner, W.\*** Congener-Specific Analysis of PCB Accumulation in Chesapeake Bay Striped Bass (*Morone saxatilis*). NOAA Cooperative Science Center Directors Meeting and Symposium. Silver Spring, MD. March 23, 2011.
- Gardner, W.\*** Congener-Specific Analysis of PCB Accumulation in Chesapeake Bay Striped Bass (*Morone saxatilis*). University of Maryland Eastern Shore University Wide Graduate Research Symposium. Princess Anne, MD. April 21, 2011.
- Gonsalves, L.\*** Polyunsaturated fatty acids and resistance to mycobacteriosis in striped bass. NOAA Cooperative Science Center Directors Meeting and Symposium. Silver Spring, MD. March 23, 2011.
- Hanif, A.\*** Bowers, H., McIntosh, D., Dyson, W., Pitula, J. S., Jagus, R. and E. Schott. Using PCR to search for environmental evidence of *Hematodinium* sp., a lethal parasite of blue crab” National Shellfisheries Association Meeting, Baltimore MD, March 21, 2011.
- Hanif, A.\***, Ogburn, M., White, S., Bedu, P., and E. Schott: Using molecular methods to monitor pathogens in early life history of blue crabs (*Callinectes sapidus*),” American Fisheries Society-UMES subchapter. Paul S. Sarbanes Coastal Ecology Center, Assateague Island, MD. April 1, 2011. Received **Best presentation award**.
- Hanif, A.\*** “Using molecular methods to monitor pathogens in early life history of blue crabs (*Callinectes sapidus*)” NOAA Symposium, at NOAA Headquarters in Silver Spring MD, March 24, 2011.
- Hill, J., Masters, B. and **Place, A.R.** Multiple paternity in the blue crab (*Callinectes sapidus*) assessed with microsatellite markers. National Shellfisheries Association in Baltimore, MD.
- Janiak, C.\*** and McIntosh, D., 2011. Aerial egg incubation of the baitfish *Fundulus heteroclitus*. 4<sup>th</sup> Annual American Fisheries Society UMES Student Subunit. University of Maryland Eastern Shore, Berlin, MD. April 1.
- Peemoeller, B.J.\*** and B.G. Stevens. Improving conservation of New England whelks (*Busycotypus canaliculatus*): size at maturity. 4<sup>th</sup> AFS-UMES Student Subunit Aquatic and Fisheries Science Symposium. Berlin, MD. April 1, 2011.
- Lazarre, D.\*** Invasive Lionfish: Analysis of Sightings Records. NOAA Cooperative Science Center Directors Meeting and Symposium. Silver Spring, MD. March 23, 2011.
- Peemoeller, B.J.\*** and B.G. Stevens. Improving conservation of New England whelks (*Busycotypus canaliculatus*): size at maturity. AFS Tidewater Chapter Meeting. Gloucester Point, VA. March 10-12, 2011.
- Smith, S., Cherrier, J, Caffrey, J. **Sarkodee-Adoo, J.\*** 2011. Dissolved Inorganic Carbon Dynamics in Two Subtropical Estuaries: Apalachicola Bay, FL, and St. Joseph Bay, FL. 96<sup>th</sup> Ecological Society of America Conference, August 7-12. Austin, TX.
- Stoneman, A.\*** Kocovsky, P., Kraus, R., Lee, C., and Plumb, R. 2011. Diet, Age, and Reproduction of Trout-perch in the Western Basin of Lake Erie. International Association for Great Lakes Research 54<sup>th</sup> Conference, June 2011. Duluth, MN.
- Tibbels, J., Williams, E., **Place, A.R.** and **Chung, J.S.** Is a genetic variation responsible for the differential growth rate of animals obtained from a single brood of *Callinectes sapidus*? National Shellfisheries Association in Baltimore, MD, March 2011.
- Tikochinski, Y., Williams, E., and **Place, A.R.** Genetic variability of the Mediterranean Israeli coast population of the invading blue crab *Callinectes sapidus*. National Shellfisheries Association in Baltimore, MD.

- Tulu, A.\***, A. Ishaque, R. C. Chambers, and R. Jagus. Development of molecular tools, cDNA cloning, and sequence analysis of aromatase cytochrome P45019A in Atlantic tomcod, *Microgadus tomcod*. University of Maryland Eastern Shore University Wide Graduate Research Symposium. Princess Anne, MD. April 21, 2011
- Tulu, A.\***, Ishaque, A., Chambers, R. C., & Jagus, R. Development of molecular tools, cDNA cloning, and sequence analysis of aromatase Cytochrome P450 19a in Atlantic tomcod. 4<sup>th</sup> AFS-UMES Student Subunit Aquatic and Fisheries Science Symposium. Berlin, MD. April 1, 2011.
- Vicente, J.\***, Loh, T., Diaz, M. C., and R. W. Thacker, Larval settlement behavior of the Panamanian sponges *Xestospongia bocatorensis* and *Neopetrosia proxima* when exposed to different substrates. American Fisheries Symposium (AFS): UMES Student Sub-Unit 4<sup>th</sup> Annual Symposium. March 2011.
- Vicente, J.\***, Loh, T., Diaz, M. C., and R. W. Thacker, Larval settlement behavior of the Panamanian sponges *Xestospongia bocatorensis* and *Neopetrosia proxima* when exposed to different substrates. American Society of Microbiology Maryland Branch Meeting 05/2011.
- Watson, A.\***, and A. Place. March 2011. Fatty acid profiles of cobia, *Rachycentron canadum*, and gilthead sea bream, *Sparus aurata*, fed diets containing alternative lipid sources. Aquaculture America 2011. New Orleans, Louisiana.

### **Publications (\*Students)**

#### **Published**

- Bowen-Stevens, S., Cox, T.M., and M.C. Curran. 2011. What are Bottlenose Dolphins Doing on Land? an Activity Teaching the Scientific Method through the Unique Behavior of Strand Feeding. *The American Biology Teacher*. 73(7): 407–411.
- Chung JS, Manor R, Sagi A., 2011. Cloning of an insulin-like androgenic gland factor (IAG) from the blue crab, *Callinectes sapidus*: implications for eyestalk regulation of IAG expression. *Gen. Comp. Endocrinol.* 147: 201-213.
- Hearne, J.L. and Pitula JS. 2011. Identification of Two Spliced Leader RNA Transcripts from *Perkinsus marinus*. *J. Eukaryot. Microbiol.* 58:266-268.
- Horodysky, A.Z., R.W. Brill, P.G. Bushnell, J.A. Musick, and R.J. Latour. 2011. Comparative metabolic rates of common western North Atlantic sciaenid fishes. *J. Fish. Biol.* 79:235-255
- Johnson A.K., Bediako, B.\* , and E. Wirth. 2011. Metal concentrations in monkfish, *Lophius americanus* from the northeastern USA. *Environmental Monitoring and Assessment*. 177(1-4): 385-297.
- Montalvo N.F.\* , Hill R.T., 2011. Sponge-Associated Bacteria are Strictly Maintained in Two Closely-Related but Geographically Distant Sponge Hosts. *Appl. Environ. Microbiol.* Aug. Epub.
- Ozbay, G., Holloway, F. Hughes, J., Ukaegbu, O.\* and Dillard, C. (2010). Investigating Growth Responses, Survival, and Cellular Activities of Harmful Algal Species, *Karlodinium veneficum* and *Prorocentrum minimum* under Various Environmental Conditions: Students Harmful Algal Research Projects. *Journal of Environmental Monitoring & Restoration*. 6:178-192.
- Rittschof D, Darnell MZ, Darnell KM, Goldman M, Ogburn MB, McDowell R. 2010. Estimating relative abundance of the female blue crab spawning stock in North Carolina. In: GH Kruse, GL Eckert, RJ Foy, RN Lipcius, B Sainte-Marie, DL Stram, and D Woodby (eds.). *Biology and Management of Exploited Crab Populations under Climate Change*. Alaska Sea Grant, University of Alaska Fairbanks.
- Santos, R.O.\* , Lirman, D., and J.E. Serafy. 2011. Quantifying freshwater-induced fragmentation of submerged aquatic vegetation communities using a multi-scale landscape ecology approach. *Marine Ecology Progress Series*. 427: 233-246.
- Serrano, X.\* , Serafy, J. and M. Grosell, M. (2011). Osmoregulatory capabilities of the gray snapper, *Lutjanus griseus*: salinity challenges and field observations', *Marine and Freshwater Behaviour and Physiology*.
- Van Wagoner, R.M., Deeds, J.R., Tatters, A. O., Place, A.R., Tomas, C. R., and Wright, J.L.C. (2010) Structure and Relative Potency of Several Karlotoxins from *Karlodinium veneficum*. *J. Natural Products* 73(8): 1360–1365
- Weinbauer, M., F. Chen, S. Wilhelm. 2011. Virus mediated redistribution and partitioning of carbon in the global oceans. pp. 54-55. In: Jiao et al. (ed). *Microbial Carbon Pump in the Ocean*. *Science/AAAS*, Washington, DC.

Zhang, R. and F. Chen. 2011. The Largest Gene Engineering Factory - Microbial Gene Transfer in the Ocean. The 10,000 Scientific Challenges. Scientific Publisher, Inc. Beijing, China.

### **In Press or Accepted**

- Cai, W.W., H. Wang, F. Chen, T.L. Zheng. 2011. Bacteriophage influences the dynamics of toxic dinoflagellates by lysing algicidal bacteria. *Appl. Environ. Microbiol.* (Accepted).
- Huang, S., S.W. Wilhelm, H.R. Harvey, K. Taylor, N.Z. Jiao, and F. Chen. 2011. Novel lineages of *Prochlorococcus* and *Synechococcus* in the global oceans. *ISME J* (in press).
- Huang, S., K. Wang, N.Z. Jiao, and F. Chen. 2011. Genome sequences of four *Synechococcus* siphoviruses: a new insight into the diversity of marine cyanophage. *Environ. Microbiol.* (in press).
- Huang, S., Y.Y. Zhang, F. Chen, N.Z. Jiao. 2011. Complete genome sequence of a marine roseophage provides evidence into the evolution of gene transfer agent in alphaproteobacteria. *Virology Journal.* (in press).
- Jiao, N., G.J. Herndl, D.A. Hansell, R. Benner, G. Kattner, S.W. Wilhelm, D.L. Kirchman, M.G. Weinbauer, T.W. Luo, F. Chen, and F. Azam. 2011. The microbial carbon pump and the oceanic recalcitrant dissolved organic matter pool. *Nat. Rev. Microbiol.* (in press).
- Kan, J. T.E. Hanson, and F. Chen. 2011. Synchronicity between population structure and proteome profiles: A metaproteomic analysis of Chesapeake Bay bacterial communities. In: Frans J. de Bruijn (ed.). Handbook of Molecular Microbial Ecology I: Metagenomics and Complementary Approaches. (in press).
- Wang, K., K.E. Wommack, F. Chen. 2011. Inter-annual survey in the Chesapeake Bay: Abundance and distribution of *Synechococcus* and cyanophages. *Appl. Environ. Microbiol.* (in press).

### **Submitted**

- Aultman, T.\* and M.C. Curran. Move over! Studying flatfish travel patterns to profile fish behavior. The American Biology Teacher.
- Graves, J.E., A.Z. Horodysky, and D.W. Kerstetter. In review. Incorporating circle hooks into pelagic longline and recreational billfish fisheries: bottom-up versus top-down control. *Bull. Mar. Sci*
- Hammerschlag, Neil, Lazarre, Dominique M\*, Rumbold Darren, Wasno Robert, Hammerschlag-Peyer Caroline M and Slonim Curt. In Review. Summer movement patterns of tiger sharks satellite-tagged off the Gulf Coast of Florida. *Marine Ecology*
- Steven Saul,\* David Die, Elizabeth N. Brooks, Karen Burns. *Trans. Am. Fish. Soc.* (in review). An individual-based homing model of ontogenetic migration in coral reef fish using a biased random walk
- Sukkestad, K\*. and M.C. Curran. Noodling for mollusks: Who knew that some mussels were endangered? The American Biology Teacher.
- Kalinowsky, C.A.,\* M.C. Curran, and J. Smith. Fall 2010. Age and growth of the Cobia (Linnaeus 1776), in Port Royal Sound and adjacent waters of Beaufort County, South Carolina. *Fishery Bulletin.*
- Montalvo, N. F.\* and R. T. Hill. Bacterial speciation in the marine sponges *Xestospongia muta* and *Xestospongia testudinaria*. Submitted to *Applied and Environmental Microbiology*. (In revision).

### **Non-peer reviewed**

Janiak, C.\* (2011) Open house showcases DSU Aquaculture Research and Demonstration Facility. *Fish Farming News* .18(1):6-7.

Schott, E. Maryland Watermen's Gazette (August, 2011), What is Blue Crab Reovirus, and is it important? Written at the initiation of the editor, this article has generated inquiries and information from crab shedders.

### **Media coverage:**

- a) Baltimore Sun, January 24, 2011. "Scientists discover virus that is killing soft crabs"
- b) Bay Journal, March 2011. "Researchers discover viruses responsible for peeler crab deaths." Fisheries Information Service.
- c) World News, Jan 26, 2011. "Research could lower mortalities in harvested soft shell crabs"

**Grantsmanship:** A total of \$2,591,029.14 (Tables 8a and 8b) was collectively awarded to the LMRCS partner institutions during the current reporting period which directly or indirectly impacted Center activities. Among the stakeholders that provided the awards included the US Department of Agriculture, US Environmental Protection Agency, US Department of Education, National Science Foundation, US Department of Commerce through the National Marine Fisheries Service, Foundations, and the Departments of Natural Resources in each partnering institution's home state. Of the total amount of funds awarded to LMRCS, \$776,721.07 came from NOAA, whereas \$1,814,308.07 was obtained from other agencies.

The funds provided by these agencies impacted LMRCS research through support of its faculty and students and by development/enhancement of infrastructure. Ten proposals that total \$7,886,158.92 (Table 9) were submitted to various agencies during this reporting period.

**Table 8a. Current leveraged funding from NOAA to LMRCS institutions**

Author	Funding Agency	Title of Project	Start/End Date	Amount	Current 6 month period
Zohar, Y. (IMET)	NOAA	The blue crab <i>Callinectes sapidus</i> : an integrated research program of basic biology, hatchery technologies, and potential for replenishing stocks	12/01/06-11/30/11	\$4,095,099	\$409,509.90
Chen, Feng (UMCES-IMET)	NOAA	Metagenomic analysis of microalgae in the Chesapeake Bay	8/1/10-7/31/11	\$19,975	9987.5
Hill, Russell (UMCES-IMET)	NOAA	Metagenomic analysis of microalgae in the Chesapeake Bay	8/1/10-7/31/11	\$52,150	26075
Schott, E. (UMCES-IMET)	NOAA Sea Grant	Effects of toxic algae blooms on health and disease of blue crab: Defining thresholds for exposure	2/1/11-1/31/12	\$22,463	11231.5
Stevens, B.G.(UMES)	NOAA	Improving conservation of New England Whelks	2010-2012	\$75,688	12614.67
Hoskins, D. (SSU)	GA Sea Grant	Marine Resources Utilization in GA	2009-11	\$16,830	\$4,207.50
Gilligan, M. (SSU)	NOAA	Replacement of University's Major Marine Science Vessel	2010-11	\$449,550	\$224,775.00
Johnson, A.K (UMES) and R.A. Richards (NOAA)	NOAA NMFS- Monkfish Set Aside Program	Influence of temperature on the distribution and catch rates of monkfish, <i>Lophius americanus</i> .	5/1/11-4/30/12	\$ 79,899	\$39,949.50
Ozbay, G. (DSU)	NOAA ECSC	Benthic diatom assemblages as environmental indicators in Blackbird Watershed, Delaware	6/1/2008-5/2011	\$146,895	\$24,483
Place, A.R. (IMET)	NOAA	Metagenomic Analysis of Microalgae in the Chesapeake Bay	08/01/10-07/31/11	\$27,775	\$13,887.50
<b>TOTAL</b>					<b>\$776,721.07</b>

**Table 8b. Current leveraged funding to LMRCS institutions from sources and agencies other than NOAA (\*Students)**

Author	Funding Agency	Title of Project	Start/End Date	Amount	Current 6 month period
*Serrano, X. (RSMAS-Student)	McKnight Fellowship	Ecophysiology of corals	8/2008-7/2011	\$30,000	\$5,000.00
*Santos, R. (RSMAS-Student)	McKnight Fellowship	Multi-scale spatial variation of nearshore submerged aquatic vegetation seascapes at Biscayne National Park	8/2009-7/2012	\$30,000	\$5,000.00



Die, D.J. (RSMAS)	NTVI (*)	Center for independent experts	9/2007-8/2011	\$122,176	\$33,125.00
Chung, J.(COMB), Zmora, O.(COMB), & Sagi, A.	US-Israel BARD	Endocrine and Molecular Manipulations of the Crustacean Molt to Control Growth and Synchronize Ecdysis	2009-2011	\$150000	\$37,500.00
Jagus, R. (COMB)	NSF-MCB	Interferon-upregulated eIF2alpha kinases in fish	06/15/07-05/31/11	\$612,209	\$76,526.13
Schreier, H. (COMB) & Tal, Y.	US-Israel BARD.	Using a "Sulfide Loop" to control fish pathogens in marine recirculating aquaculture systems	2009-2011	\$150000	\$37,500.00
Schott, E. (UMCES-IMET)	Barbor FTD	Blue crab reo-like virus transmission study	3/25/11-3/35/12	\$12,568	\$6284
Schott, E. (UMCES-IMET)	FWRI	Impact of Hematodinium	9/1/10-8/31/11	\$3,975	\$1987.5
Frischer, M. (SKIO), Gibson, D.(HU) G. Paffenhöfer	NSF	Doliolid Blooms: What are the Driving Variables? Investigations of Trophic Interactions	1/1/09-12/21/12	\$75,688	\$12,614.67
Halverson, C., Gibson, D.(HU) and C. Witherspoon	NSF OCE ISE	Communicating Ocean Sciences to Informal Education Network (COSIEN)	10/1/10 – 9/1/12	\$32,281	\$8,070.25
Smith, S. (DSU), Ozbay, G. (DSU)	USDA-NRCS	The efficacy of heavy use area protection (HUAP) pads to decrease runoff of nonpoint source pollution into the Chesapeake Bay watershed.	8/1/2011-8/1/2012	\$99,435.92	\$49717.96
Ozbay, G. (DSU)	USDA-CBG	"Enhancing Geographic Information System Education and Delivery through Collaboration: Curricula Design, Faculty, Staff, and Student Training and Development, and Extension Services.	9/1/2010-8/30/2013	\$299,996	\$49,999.33
Ozbay, G. (DSU)	USDA-AFRI	Inactivation of enteric foodborne viruses in high risk foods by non-thermal Processing technologies.	2/1/2011-1/31/2016	\$2,000,000	\$200,000
Ozbay, G. (DSU)	USDA Evans-Allen program	Monitoring aquatic health and habitat value of oyster (Crassostrea virginica) gardening and restoration through community-based oyster enhancement efforts.	9/1/2010-8/31/2012	\$209,750	\$52,437.50
Ozbay, G. (DSU)	DuPont Clear into the future Env stewardship grant	Oyster restoration efforts at Delaware's inland bays	7/1/2010-6/30/2011	\$25,000	\$12,500
Ozbay, G. (DSU)	DSU Center for School Change	Diverse Pathways to Success: Women in the Sciences and Social Sciences, Part 2	1/1/2010-12/30/2011	\$750	\$375
Ozbay, G. (DSU)	NSF	Research Experience for Undergraduates Site: Undergraduate Research in Molecular Genetics & Genomics at DSU	5/2010-9/2012	\$250,000	\$62,500

Ozbay, G. (DSU)	USDA-NRI	Persistence of Enteric Viruses in Oysters ( <i>Crassostrea virginica</i> )	10/1/2008-9/30/2011	\$100,000	\$16,666.67
Ozbay, G. (DSU)	EPA	Mid-Atlantic Drinking Water Program: Drinking Water and Human Health. National Integrated Water Quality Program (NIWQP)	12/1/2009-11/30/2012	\$48,000	\$8,000
Ozbay, G. (DSU)	NSF SMILES	Monitoring Aquatic Health and Habitat Value of Oyster ( <i>Crassostrea virginica</i> ) Gardening and Restoration through Community Based Oyster Enhancement Efforts	TBD	\$10,000	10000
Ozbay, G. (DSU)	USDA-FSIS	Microbial and Chemical Contaminants in Processed Catfish for Food Safety.	09/25/09-09/24/11	\$555,550	\$138,887.50
Hoskins, D.(SSU)	COL	National Ocean Science Bowl (GA-SC) competition	2010-11	\$15,000	\$7,000.00
Hoskins, D. (SSU)	Ocean Leadership	Diversity Initiative	2010-11	\$10,000	\$5,000.00
Hintz, C. (SSU)	United Negro College Fund	Production of High Fidelity Lunar Stimulants for Exploration Risk Reduction and Systems Analysis Year 2	2009-11	\$66,000	\$16,500.00
Mayor Otis Johnson, Ph.D., Maria Procopio, Dionne Hoskins, and Horace Magwood, III	GA DNR	Sidewalk to the Sea Program	2009-11	\$191,580	\$47,895.00
Curran, C.(SSU)	USDOE	Training and research grant	2009-15	\$3,000,000	\$250,000.00
Gilligan, M.(SSU)	NSF	Research Experience for Undergraduates	2009-12	\$292,434	\$48,739.00
Pride, C.(SSU)	NSF	New GK12: Building Ocean Literacy in a Coastal Community Through Science	2009-14	\$2,214,884	\$221,488.40
P. Chigbu & J. Love (UMES)	NSF	University of Maryland Eastern Shore REU in Marine and Estuarine Science	6/1/09 – 5/31/12	\$231,521	\$38,586.83
P. Chigbu, J. Pitula, E. May, M. Mitra, & A. Johnson (UMES)	NSF	CREST Center for the Integrated Study of Coastal Ecosystem Processes and Dynamics	8/1/10 – 7/31/15	~\$5,000,000	~\$500,000
P. Chigbu, K. Wallmo (NOAA), J. Okoh, J. Keane-Dawes, S. Tubene (UMES)	NSF	Professional Science Master's degree in Quantitative Fisheries and Resource Economics	5/1/10 – 4/30/13	~\$700,000	\$116,666
E. May, A. Allen (UMES)	USDA Capacity Bldg Grant	Capacity Building Grants Program, Watershed Level Examination of Urea Use as Fertilizer and the Production of the Biotxin Domoic Acid	10/1/10 – 9/30/13	\$499,950	\$83,325.00
A. Allen, E. May (UMES)	USDA Capacity Bldg Grant	Development of A Subsurface Application Technology for Dry Poultry Litter to Protect Air and Water Quality	10/1/10 – 9/30/13	\$599,000	\$99,833.33
Gibson, D., Horodysky, A., Cuker, B.	NSF (HRD-HBCU-UP)	Targeted Infusion Project: Educational Partnership in Climate Change and Sustainability (EPICCS)	9/1/11 – 8/31/14	\$163,749	\$54583
<b>TOTAL</b>					<b>\$1,814,308.07</b>

**Table 9. Grants submitted by LMRCSC during this reporting period (March 1 to August 31, 2011)**

Author	Funding Agency	Title of Project	Amount
Smith (DSU), Ozbay (DSU)	USDA-NRCS	The efficacy of heavy use area protection (HUAP) pads to decrease runoff of nonpoint source pollution into the Chesapeake Bay watershed.	\$99,435.92
Gibson, D. (HU)	NIST Construction Grants program	Atmospheric and Coastal Sciences Research Building (ACSRB)	\$5,000,000
Chung, J.S. (IMET)	US EPA	Uptake and effects of dispersed oil droplets and emulsified oil by estuarine crust	\$139,393
Chung, J.S. (IMET)	GRI	LSU Research Consortium: Effects of oil droplets	\$393,824
Chung, J.S. (IMET)	NSF	Functional roles of a novel crustacean female sex hormone in sex differentiation and developing secondary sex features of crustaceans	\$635,507
Place, A.	NOAA	ECO HAB: Integrating cell and toxin cycles of karlodium veneficum with key environmental regulators: In situ studies of predictive determinants for bloom toxicity	\$74,375
Place, A.	NOAA	ECO HAB: Sorting the fatty acid chaff from the toxin wheat or is it all wheat? – Assigning dinoflagellate PKS genes to toxin synthesis.	\$434,608
Place, A.	BARD	Taurine: A potential key ingredient to reduce the dependence on fish meal in aquaculture	\$158,400
Place, A.	NIH	The chemistry and biology of the karlotoxins	\$392,488
Place, A.	NSF	Diversification along a salinity gradient: Genetic mechanisms and functional consequences	\$558,128
TOTAL			<b>\$7,886,158.92</b>

**Objective 2: Fully Integrate Research Programs with NOAA Fisheries to Ensure Long Term Funding and Programmatic Stability.** All research projects funded through the LMRCSC have substantial involvement by NOAA scientists. Details on these projects are included on pages 11 – 26 above.

## SECTION II – EDUCATION AND OUTREACH EFFORTS

LMRCSC Education and Outreach efforts are addressed through the following goal and objectives:

### **Goal 3: Generate a Pool of Scholars Entering the Field Of Marine Sciences and Fisheries**

The objectives which accomplish this goal include:

**Objective 1: Enhance Recruitment of Students From Underrepresented Groups into Marine Science Disciplines**

**Objective 2: Strengthen Outreach & Education Programs to students and the public**

**Objective 3: Develop Programs that Enhance the Practical Education of Undergraduate and Graduate students in the Marine Sciences**

**Objective 1: Enhance Recruitment of Students From Underrepresented Groups into Marine Science Disciplines**

Total student support for the current reporting period was \$394,367 or 18% of \$2,221,860 awarded to LMRCSC during 2010/11 (Table 10). Total student support for project year 2010-11 was \$883,027 (40%).

Twenty six (26) B.S., 20 M.S., and 12 Ph.D. students were supported during the current reporting period through fellowships, scholarships, stipends and travel awards. Students who received support during the current reporting period are shown in Table 11.

**Table 10. Student funding by LMRCSC institution**

	Budget	9/1/10- 2/28/11	3/1/11- 8/31/11	9/1/10- 2/28/11	3/1/11- 8/31/11	TOTAL
<b>UMES</b>	\$987,353	\$173,273	\$121,707	18%	12%	30%
<b>SSU</b>	\$316,828	\$79,741	\$43,693.90	25%	14%	39%
<b>RSMAS</b>	\$114,402	\$33,439	\$35,078.00	29%	31%	60%
<b>HU</b>	\$197,757	\$42,716	\$37,035	22%	19%	40%
<b>DSU</b>	\$229,794	\$38,000	\$53,268.55	17%	23%	40%
<b>IMET</b>	\$375,726	\$121,491	\$103,584	32%	28%	60%
<b>TOTAL</b>	\$2,221,860	\$488,660	\$394,367	22%	18%	40%

**Table 11. Students who received support during the funding period March 1 to August 31, 2011.**

First Name	Last Name	Academic Institution	Degree	Type	Amount
Tedra	Booker	UMES	Ph.D	Travel	\$30.00
Meagan	Bratcher	UMES	B.S.	Stipend, tuition, travel	\$6,316.09
Daniel	Cullen	UMES	Ph.D	Stipend, tuition, travel	\$12,505.76
Erica	Dasi	UMBC	B.S.	Stipend, tuition, travel	\$6,611.20
Whitney	Dyson	UMES	M.S.	Stipend, tuition, travel	\$8,170.67
Rehab	El Fadul	UMES	Ph.D	Travel	\$30.00
Eric	Evans	UMES	Ph.D	Stipend, tuition, travel	\$6,765.60
William	Gardner	UMES	Ph.D	Travel	\$546.81
Paula	Johnson	UMES	Ph.D	Stipend, tuition	\$6,158.35
Courtney	McGeachy	UMES	M.S.	Stipend, tuition	\$10,998.61
Belita	Nguluwe	UMES	M.S.	Stipend, tuition, travel	\$9,524.75
Jamila	Payton	UMES	M.S.	Stipend, tuition, travel	\$10,627.83
Jhamyllia	Rice	UMES	Ph.D	Stipend, tuition	\$10,028.12
Candace	Rodgers	UMES	M.S.	Stipend, tuition	\$10,115.42
Kristen	Rybyzynske	UMES	B.S.	Stipend, tuition	\$3,684.33
Cy'Anna	Scott	UMES	B.S.	Stipend	\$3,241.00
Emily	Tewes	UMES	M.S.	Tuition	\$2,650.00
Adam	Tulu	UMES	Ph.D	Stipend, tuition, travel	\$13,702.78
Indraneel	Deshpande	College of NJ	B.S.	MTA	\$ 96.00
Jordan	Gomes	UMBC	B.S.	Salary, Fringe, Parking	\$ 6,182.63
Seghen	Haile	UMBC	B.S.	Salary, Fringe, Parking, Lodging	\$ 7,225.73
Darbi	Jones	Umiami	B.S.	Salary, Fringe, Parking	\$ 5,476.73
Ihuoma	Njuku	UMBC	B.S.	Salary, Fringe, Parking, MTA	\$ 7,407.81
Vanessa	Richards	DSU	B.S.	Salary, Fringe, MTA, Lodging	\$ 7,196.73
Laura	Torres	UT PanAm	B.S.	Salary, Fringe, Parking, Lodging	\$ 9,043.77
Jeanette	Davis	UMCP	M.S.	Stipend	\$ 6,889.26

Erica	Dasi	UMBC	B.S.	Stipend	\$ 1,631.89
Kathleen	Gillespie	UMCP	M.S.	Salary, Fringe, tuition	\$ 17,190.62
Ammar	Hanif	UMCP	M.S.	Salary, Fringe, tuition	\$ 18,088.42
Belita	Nguluwe	UMCP	M.S.	MTA	\$ 64.00
Jamila	Payton	UMCP	M.S.	Travel	\$ 96.00
Jan Vicente	Raczkow	UMCP	Ph.D.	salary	\$ 13,884.54
Adam	Tulu	UMCP	Ph.D	Travel	\$ 96.00
Aaron	Watson	UMCP	Ph.D.	Salary, Fringe, Travel	\$ 3,014.04
Dwight	Ebanks	RSMAS	Ph.D	Stipend, Tuition	\$11,445.00
Dominique	Lazarre	RSMAS	Ph.D	Stipend, Travel, Tuition	\$16,152.00
Xaymarra	Serrano	RSMAS	Ph.D	Stipend, Travel	\$3,818.00
Rolando	Santos	RSMAS	Ph.D	Stipend	\$3,663.00
Kendyl	Crawford	HU	B.S.	Stipend/travel	\$7,658
Kayelyn	Simmons	HU	B.S.	Stipend	\$1,000
Symone	Johnson	HU	B.S.	Stipend/travel	\$1,909
Keya	Jackson	HU	B.S.	Stipend/travel	\$500
Daniel	Ingham	HU	B.S.	Stipend	\$1,000
Maryse	Leandre	HU	M.S.	Stipend/tuition/travel	\$16,938
Coleman	Ewell	HU	B.S.	Stipend	\$500
Camille	Ganus	HU	B.S.	Stipend	\$500
Elizabeth	Seagroves	HU	B.S	Stipend/travel	\$6,530
Joyah	Watkins	HU	B.S	Stipend	\$500
Marissa	Brady	DSU	M.S.	Stipend	\$7,258.80
Amy	Cannon	DSU	B.S.	Travel	\$30.00
Michael	Cinelli	DSU	M.S.	Stipend	\$699.17
Cory	Janiak	DSU	M.S.	Stipend/Tuition/Travel	\$13,725.12
Johnny	Moore	DSU	M.S.	Stipend	\$10,994.75
Brian	Reckenbeil	DSU	M.S.	Stipend	\$3,750.00
Andrea	Stoneman	DSU	M.S.	Stipend/Tuition/Travel	\$16,810.71
Dontrece	Smith	SSU	M.S.	Fellowship	\$8,935.04
Noelle	Hawthorne	SSU	M.S.	Fellowship	\$12,013.34
Tiffany	Ward	SSU	M.S.	Fellowship, Tuition	\$6,024.96
Rebecca	Hazleton	SSU	M.S.	Fellowship	\$2,424.96
Aaron	Huls	SSU	B.S	Stipend	\$1,800
Amarria	Phillips	SSU	B.S	Stipend, Travel	\$4,000
Nicole	Arkwright	SSU	B.S	Travel	\$446.39
Ana	Reyes	SSU	B.S	Stipend, Travel	\$4,449.21
David	Waldburg	SSU	B.S	Stipend	\$1,800
Bill	Gardner	SSU	HS	Stipend	\$1,800
TOTAL					\$394,366.94

**Recruitment into Marine Science Programs:** Recruitment has been facilitated through increased outreach of LMRCSC using the following modalities: 1) LMRCSC web site, 2) LMRCSC newsletters and brochures, 3) Participation in meetings of AFS, ASLO, ERF and other organizations which provide wide exposure, 4) Visits to universities/colleges and personal contact, and 5) Internships at Center partner institutions. Contact between Center students and faculty at events such as the LMRCSC Student Weekend and ASLO has led to increased interest among students in pursuing advanced degrees within the Center. In addition, the LMRCSC's reputation nationwide has resulted in an increase in applications to Center partners. The students who graduated at the LMRCSC institutions are in Table 12, whereas those who interned at NOAA or at LMRCSC partner institutions are in Tables 13 and 14.

- ✈ Program Manager Todd Christenson has taken an increased role in recruitment for LMRCSC program and typically attends the annual meetings of American Fisheries Society, American Society of Limnology and Oceanography, Hispanic Engineering, Science, and Technology, and Society for the Advancement of Chicanos and Native Americans in Science. This has raised the profile of LMRCSC and led to increased interest in and applications to the LMRCSC institutions. Furthermore, participation in these events has helped the Center to establish a rapport with prospective students, which is ultimately critical to recruitment efforts.
- ✈ Todd Christenson gave a presentation on the LMRCSC to the NOAA Undergraduate Scholars on the final day of the internship (Aug 5, 2011) at NOAA Headquarters in Silver Spring, MD.
- ✈ The presence of the REU programs at both UMES and SSU directed by Drs. P. Chigbu and M. Gilligan, respectively provide excellent recruiting opportunities for LMRCSC. For example, participation in the UMES REU has led to matriculation of two students at UMES during this reporting period.
  - T'Keyah Hines, a participant in the 2011 REU has entered UMES as a freshman for fall, 2011.
  - James Lewis, a 2010 REU participant is currently an Advanced Special Status student at UMES, completing prerequisite courses for entrance to the MEES program for January, 2012.
- ✈ Drs. Dionne Hoskins and Matthew Ogburn hosted three interns (Michael Knowles, Lynnece King and Amarria Phillips) from the EDGE program during summer 2011 at SSU
- ✈ Dr. Jagus and Dr. Hill have fostered a constructive relationship with the new Director of the University Honors program at Morgan State University. They have hosted more visits from the Morgan Biology Club and have provided undergraduate semester internships to Ziane Sankoh. Dr. Jagus has also formed a partnership with Dr. John Trant, Dean of the College of Science and Mathematics at the University of Texas Pan American (UTPA); recruitment visit is planned this Fall 2011. Dr. Jagus gave recruitment talk at Hampton University, April 4, 2011. Dr. Sook Chung and Dr. Keiko Sate provided a tour of IMET's marine recirculating aquaculture facility to a group of summer interns, in the NSF REU and NSF CREST Center, and their faculty mentors (P. Chigbu and A. Johnson) July, 2011

**Table 12. Number of students who graduated from March 1, 2011 to August 31, 2011**

First Name	Last Name	Academic Institution	Degree	Date
Bashiru	Balogun	UMES	Ph.D	05/2011
Kayelyn	Simmons	HU	B.S.	05/2011
Nicholas	Clemons	UMES	M.S.	12/2010
Sabrina	Bowen	SSU	M.S.	05/2011
Robin	Perttree	SSU	M.S.	05/2011
Tyler	Greer Thompson	SSU	M.S.	05/2011
Donna	McDowell	SSU	M.S.	05/2011

Courtney	Jones	SSU	B.S.	05/2011
Tiffany	Ward	SSU	B.S.	05/2011
Simone	Kilgore	SSU	B.S.	05/2011
Anna	Campbell	SSU	B.S.	05/2011
Shamgan	Perkins	SSU	B.S.	05/2011
Sara	Pluff	SSU	B.S.	05/2011
Michelle	Sherman	SSU	B.S.	05/2011

**Table 13. Students who worked at NOAA labs or LMRCSC partners (March 1 to August 31, 2011).**

First Name	Last Name	Academic Institution	Degree	Facility	Time period
William	Gardner	UMES	Ph.D	NEFSC, Sandy Hook Lab	October, 2009 to present
Adam	Tulu	UMES	Ph.D	UMCES-IMET	Jan 2-30, 2011
Jamila	Payton	UMES	M.S.	UMCES-IMET	Jan 9-13, 2011
Camren	Brown	HU	B.S.	SSU	June 1 to Aug 5, 2011
Camille	Gaynus	HU	B.S.	UMES	June 1 to Aug 5, 2011
Belita	Nguluwe	UMES	M.S.	UMCES-IMET	July 1-31, 2011
Malik	Breland	HU	B.S.	UMES	June 1 to Aug 5, 2011
Courtney	McGeachy	UMES	M.S.	NEFSC, Sandy Hook Lab	Aug 18-26, 2011
Dan	Cullen	UMES	Ph.D	NOAA Woods Hole Lab	August 11, 2011
Cy'anna	Scott	UMES	B.S.	AFSC, Seattle, WA	June 1 to Aug 5, 2011
Coleman	Ewell	HU	B.S.	NOAA HQ, Silver Spring, MD	June 1 to Aug 5, 2011
Kate	Fleming	DSU	M.S.	NMFS lab-Panama City, FL	Jan 2010 to present.
Jeffrey	Kipp	UMES	PSM	NOAA Beaufort, NC lab	June 1 to Aug 5, 2011
Leo	Matthews	UMES	PSM	NOAA NERO, Gloucester, MA	June 1 to Aug 5, 2011
Evan	Lindsay	UMES	PSM	NOAA Woods Hole Lab	July 1 to Aug 26, 2011
Andrew	Turner	UMES	PSM	NOAA Chesapeake Bay Office	June 1 to Aug 5, 2011
Jessica	Blaylock	UMES	PSM	NOAA Woods Hole Lab	June 1 to Aug 5, 2011
Shari	Mullen	UMES	MEES	NOAA AFSC (NOAA GSP)	
Lonnie	Gonsalves	UMES	MEES	NOAA COL, MD (NOAA GSP)	
Noelle	Hawthorne	SSU	M.S.	Grays Reef NMS	

**Table 14. Internships by students in UMES Professional Science Masters program**

First Name	Last Name	Internship Assignment	Project Title	Mentor(s)
Jeffrey	Kipp	NOAA NMFS, Beaufort, NC	Simulated surplus production assessment of golden tilefish ( <i>Lopholatilus chamaeleonticeps</i> ) in the south Atlantic	Dr. Kate Andrews, Research Mathematical Statistician
Leo	Matthews	NOAA Northeast Regional Office, Gloucester, MA	Sector Management; Environmental assessment	Dr. Mark Brady

Evan	Lindsay	NOAA NMFS, NEFSC, Woods Hole, MA	Fecundity of goosfish, <i>Lophius americanus</i> , in the northeast United States	Dr. Richard S. McBride, Branch Chief, NEFSC Population Biology Branch & Dr. Andrea K. Johnson (UMES)
Andrew	Turner	NOAA Chesapeake Bay Office, Annapolis, MD	Evaluating Management Strategies to Mitigate the Effect of Increasing Blue Catfish, <i>Ictalurus furcatus</i> , Populations in Chesapeake Bay Tributaries	Dr. Howard Townsend & Dr. Bruce Vogt
Jessica	Blaylock	NOAA NMFS, NEFSC, Woods Hole, MA	Assessing the performance of New England groundfish stock assessment projections to be used for updated management catch advice	Dr. Elizabeth Brooks

**Objective 2: Strengthen Outreach & Education Programs to students and the public**


**Accomplishments** – In this reporting period, LMRCS faculty worked on a wide range of projects, strengthening outreach and education programs to students and the public. This, in turn, resulted in additional grant awards (Table 8a&b), proposals that have been submitted to an agency for funding (Table 9) and collaborative projects, which are summarized below.

**K-12 Education:** In this reporting period, LMRCS offered the following activities for K-12 students.

**SSU Coast Camp for Youth:** During this reporting period, LMRCS offered its month-long summer marine science camp to 107 youth at SSU. The SSU Coast Camp, coordinated by Dr. Dionne Hoskins, is designed to teach students how to be better stewards of the marine environment using NOAA’s 7 ocean literacy principles. Students are divided into 4 classes: lower elementary (7-8 years), higher elementary (9-10 years), middle school (11-13 years), and high school (14-18 years). Each class is taught by 3-4 counselors. By serving a broad age group and being affordable, the SSU Coast Camp offers strong, accessible science instruction and long term exposure to marine science for a diverse audience of youth. The pre- and post-test scores of Coast Camp participants are presented in Table 15.

**Table 15: Mean pre- and post-test scores of Coast Camp participants 2007-2011.**

Year	Pre	Post	%Improvement	Significance ( $\alpha=0.05$ )	
				Within YR	By YR
2007	74.78±3.25	81.88±2.71	4.82±2.43	0.013	A
2008	70.37±3.15	82.19±2.39	12.04±4.01	<0.001	A
2009	61.83±2.73	73.14±2.66	11.31±2.61	<0.001	B
2010	61.43±2.41	69.84±2.87	8.41± 2.78	0.004	B
2011	57.40±2.72	66.67±2.64	7.92 + 2.51	<0.001	B


 **CREST Student Enrichment and Experiential Learning (SEEL):** LMRCS faculty hosted and mentored 7 high school students from Worcester, Wicomico and Somerset county public schools for 7 weeks during summer of 2011 (Table 16). Students conducted research along side their mentors, LMRCS graduate students and REU undergraduates and produced posters and Powerpoint presentations of their results. These were presented at a joint symposium of the REU interns and CREST SEEL students on August 5, 2011.


**Table 16: CREST SEEL High School Interns (Summer 2011)**


First Name	Last Name	School	Mentor	Project
Elishaddai	Ephrem	Parkside High School	Andrea Johnson	Assessment of the physiological effects of hypoxia and environmental contaminants on Atlantic Croaker





Cody	Holland	Wicomico High School	Yan Waguespack/Madhumi Mitra	Understanding the dynamics of phytoplankton and macroalgae species including harmful algal blooms (HABs)
De'vonte	Joynes	Wicomico High School	Joseph Pitula	Evaluation of the effects of environmental factors on blue crab ( <i>Callinectes sapidus</i> ) and its relation to infection by <i>Hematodinium</i> sp.
Mark	Waguespack	Bennett High School	Nianhong Chen/Eric May	Spectroscopic Analysis of Phytoplankton Pigments in Maryland Coastal Bay Water
David	Sproul	Washington High School	Paulinus Chigbu	Understanding the dynamics of zooplankton community structure and their driving mechanisms
Kaitlynn	Young	Crisfield High School	Eric May	The effects of land use and climate variability on water quality including nutrient dynamics
Ria	Mandan	Parkside High School	Andrea Johnson	Assessment of the physiological effects of hypoxia and environmental contaminants on Atlantic Croaker


 **Teacher Development Workshop:** UMES offered a workshop for K-12 teachers from July 11-22, 2011, designed to provide hands on lessons in lab and field research in marine and environmental science which can be infused into existing K-12 science curricula. The workshop offered 3 graduate credits (ENVS 612) for successful completion. Though 7 teachers originally expressed strong interest, only one (Patricia Benner, Crisfield High School) participated. Ms. Benner conducted research under the guidance of Drs. Paulinus Chigbu, Andrea Johnson and other UMES faculty and produced a lesson plan for use in the classroom.

 **Upward Bound Marine and Estuarine Science Program:** This program offers lessons in marine science and coastal ecology to 20 – 25 students in grades 10-12 from Somerset, Worcester and Wicomico Counties, MD. The program draws on the expertise of UMES-LMRCSC faculty and staff as well as MD Coastal Bays Program, National Park Service and MD Department of Natural Resources at the UMES Paul S. Sarbanes Coastal Ecology Laboratory. In the past, the program has been conducted for 6 sessions during the summer and on four selected Saturdays (4 sessions) during the academic year. The 2010-11 academic year sessions focused on “Protecting, Restoring, and Sustaining Green Infrastructure”

 LMRCSC graduate Nick Clemons, a National Park Service employee, led or participated in sessions during the summer or academic year. Todd Christenson (UMES) and Dr. Andrea Johnson (UMES) continued to serve on the planning committee.

 David Die (LMRCSC Project Director, RSMAS) continued to collaborate with the R.J. Dunlap Conservation Program at the University of Miami in their outreach and educational program with high school students.

 Summer Microbiology and Research Training Program (SMaRT): IMET offered an intensive 10 day course for graduate and undergraduate students from June 22 – July 1, 2011 focusing on training in microbiology and molecular and microbial ecology. Students were instructed in isolation of microbes from sponges, identification of isolates by 16S ribosomal RNA gene (rDNA) sequencing, extraction of total DNA from sponges and in PCR on this DNA to amplify microbial genes. A major focus was the detection of signaling compounds from microbes. Microscopy and fluorescence *in situ* hybridization were also covered. IMET doctoral student Naomi Montalvo served as an instructor.

 Out of her role as UMCES-IMET LMRCSC Director, Dr. Jagus coordinates many outreach activities including the placement of high school interns from Baltimore City and Howard County in faculty labs at IMET.


- 🐟 Ammar Hanif (M.S. IMET) volunteers in teaching practical microbiology and molecular biology tools to 7<sup>th</sup>-9<sup>th</sup> students at the Baltimore Islamic Community School; and is also a volunteer instructor in Towson State University SciTech module: Marine Natural Products Laboratory.
- 🐟 Dr. Eric Schott (IMET) volunteers with 3<sup>rd</sup>, - 5<sup>th</sup> grade students at a Roland Park, Elementary School #233 in Baltimore. He supplies blue crabs and presents crab behavior and environmental challenges for crabs.

### **American Fisheries Society:**

- 🐟 Students from LMRCS and the UMES AFS Student Subunit organized the **4th Annual Fisheries and Aquatic Sciences Symposium** at UMES on April 1, 2011. This event served as a venue for LMRCS students to present their research. Dr. Dennis Hansford (NOAA Office of Science and Technology) was the lunch-time keynote speaker. Students from UMES-IMET and DSU, as well as UMES, attended and presented their research.
- 🐟 LMRCS student Lonnie Gonsalves has been nominated for President-elect of the AFS Equal Opportunity Section. If confirmed he will assume the two-year post in 2012.
- 🐟 UMES-PSM student and NOAA contractor Michele Traver continues to serve as Chair for the AFS Equal Opportunity Section's Mentoring for Professional Diversity award committee.
- 🐟 The AFS UMES Student Subunit contributed funds to support the Equal Opportunity Section student travel award.

### **Outreach**

- 🐟 DRS Dr. Brad Stevens serves on the editorial committee for the Journal of Shellfish Research.
- 🐟 LMRCS Director, P. Chigbu has been appointed to serve as a Technical Advisor to the Advisory Committee to the U.S. National Section to International Committee for the Conservation of Atlantic Tunas (ICCAT).
- 🐟 The LMRCS has recently used its infrastructure and SSU's facilities to become host of the Georgia-South Carolina Regional Competition of the National Ocean Science Bowl. LMRCS staff (Drs. Hoskins and Ogburn) are co-regional coordinators and produced the 2011 bowl with a \$25,000 subsidy (\$15k for a Diversity Initiative) from the Consortium for Ocean Leadership.
- 🐟 HU's LMRCS and Marine Science Club students organized the Teen Environmental Conference for Middle, High and HU College students in the City of Hampton. This event was leveraged by Dr. Gibson's NSF COSIA grant in Partnership with the VA Aquarium. The results of this event were presented at the AFS meeting in Seattle, WA on September 4-8, 2011.
- 🐟 Dr. Stacy Smith volunteered and participated in the annual Delaware Bay Horseshoe Crab Spawning Survey, conducted by the Delaware National Estuarine Research Reserve. Overharvesting of horseshoe crabs depleted the population, but spawning surveys from recent years show their numbers are rebounding.
- 🐟 Dr. Eric Schott serves as board member of Blue Water Baltimore, a 501c3 organization that works to revitalize Baltimore's streams and harbor, and thence the Chesapeake Bay and is a member of the Scientific and Technical Advisory Committee. Dr. Schott also serves on the Maryland Oyster Advisory Commission, appointed by Governor O'Malley. This body advises the Maryland Department of Natural Resources on oyster management in the state. Dr. Schott also serves on the Maryland Sea Grant Ecosystem Based Fisheries Management Blue Crab team.

 **Aaron Watson** (M.S. IMET) was interviewed and filmed for a documentary on the current state of the oceans and aquaculture sustainability. The resulting documentary, *Oceans: Turning the Tide*, video, 26:40, created for national broadcast by LinkTV, San Francisco, was aired September 2011.

- **Newsletter:** The Center publishes a newsletter, *The Living Sea*, to highlight Center research and educational activities. No issues were produced during the current reporting period.
- **Website:** A major redesign of LMRCS C web site ([www.umes.edu/lmrcsc](http://www.umes.edu/lmrcsc)) intended to make the site more comprehensive and centralized was initiated during this reporting period with completion anticipated by December 2011. The new site will highlight Center accomplishments and make them more accessible to the user, and will be modified to include information on faculty and students at all partners. Each of the LMRCS C partner institutions also has its own website that is directly linked to the LMRCS C main web page. The web sites for the respective institutions are: DSU (<http://cars.desu.edu/aqua-sci/index.htm>); SSU (<http://www.ssufisheries.com/>); HU (<http://www.hamptonu.edu/academics/schools/science/marine/>); UMCS-IMET (<http://www.umces.edu/imet>) and RSMAS ([http://cufer.rsmas.miami.edu/index.php?page\\_id=31](http://cufer.rsmas.miami.edu/index.php?page_id=31)).
- **Facebook:** LMRCS C Technical Monitor Jeanine Cody created an LMRCS C 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, funding and identify job opportunities, current events in marine science, etc. Two hundred forty-eight (248) individuals, including many students, have signed up as 'fans' of the site. The site is co-managed by Jeanine Cody and Todd Christenson.

### **Objective 3: Develop Programs that Enhance the Practical Education of Undergraduate and Graduate Students in the Marine Sciences:**

#### **Workshops/Seminars:**

- The LMRCS C Seminar Series continued during this reporting period (see Tables 4 & 5). Dr. Matthew Ogburn (SSU) and Dr. Gulni Ozbay (DSU) presented their seminars, respectively on March 11 and April 15, 2011.

#### **Cruises:**

- Doctoral student Jan Vicente (IMET) participated in a scientific cruise onboard R/V Walton Smith from 07/14/11-08/01/11. He conducted a time series study of nitrogen fixing gene expression in the sponges *Ircinia strobilina* and *Mycale laxissima*. Core samples of *Xestospongia muta* were also collected.
- HU masters student Maryse Leandre completed a research cruise in summer 2011.

#### **Internships:**

Ten (10) week summer internships were given at IMET from June 1-August 5, 2011. Ten (10) students were chosen out of an applicant pool of almost 30. In addition to orientation and safety training, a field trip to NAIB, special seminars, and workshops on applying to graduate school, the students participated in inquiry based research projects listed below:

- 1) Oluwakemi Adewuyi, Morgan State U: Novel parasite entry mechanisms in the eastern oyster *Crassostrea virginica*. Mentor, Gerado Vasta.
- 2) Megan Bratcher, UMES: Determination of the ontogenic variation in salinity tolerance of the blue crab, *Callinectes sapidus*. Mentor, J. Sook Chung.
- 3) Erica Dasi, UMBC: Optimization of expression of recombinant zebrafish PKR. Mentor, Rose Jagus.
- 4) Indraneel Deshpande, NJCC: Optimization of algal growth. Mentor, Allen Place
- 5) Jordan Gomes, HCCC: Quantification of zebrafish eIF4E 1A, 1B, 1C. Mentor, Rose Jagus.

- 6) Seghen Haile, UMBC: Construction of an Oyster Larvae Probiotic Bacterium that Expresses Green Fluorescent Protein to Study Host-Bacterial Interactions. Mentor, Hal Schreier
- 7) Darbi Jones, U Miami: Development of expression vectors for use in *Perkinsus marinus*. Mentor, Jose-Antonio Robledo.
- 8) Ihuoma Njoku, UMBC: Detection and Diversity of Blue crab *Hematodinium* sp. in the Coastal Sediment. Mentor, Feng Chen.
- 9) Vanessa Richards, DSU: Development of fish free diets for aquaculture. Mentor, Allen Place.
- 10) Laura Torres, UTPA: Detection and prevalence of two pathogens, Reo-like Virus(RLV) and *Hematodinium.sp*, in wild populations of *Callinectes sapidus* in the North East Region of the United States. Mentor, Eric Schott.

### SECTION III – SUCCESS STORIES

- Dr. Brad Stevens (DRS) has established a histology laboratory at the UMES Paul Sarbanes Coastal Ecology Center. This lab has enhanced the Center's capacity to conduct life history studies of fish.
- LMRCSC's Professional Science Masters program in Quantitative Fisheries and Resource Economics accepted several additional students for Fall, 2011 including Michele Traver (NOAA Employee, Population Dynamics branch, Woods Hole, MA),
- During the summer of 2011, students in the PSM program worked for 8-12 weeks at NOAA facilities in order to fulfill the internship requirement of the program (Table14 above).
- In order to accommodate the two NOAA employees in the PSM program, online versions of several quantitative fisheries courses were developed and offered during the Spring 2011 semester: 1) Stock Assessment, co-taught by Dr. Chigbu and Dr. Albert Chi (UMES) and Dr. Larry Alade (NOAA NEFSC). 2) Multivariate Statistics, taught by Dr. Albert Chi (UMES), and 3) Marine Population Dynamics, taught by Dr. David Die (RSMAS). The Stock Assessment and Multivariate Statistics courses are being offered in real time using Blackboard and Wimba. GoToMeeting is used to offer the Marine Population Dynamics course. Three additional classes from the list of nine essential courses for fisheries are being offered online in Fall Semester, 2011 (Fish Ecology, Fisheries Survey Sampling, and Risk and Decision Analysis). The development of these courses is a significant step toward a full online program which can ultimately be made available nationwide.
- Under Dr. Gibson's leadership, Hampton University continues to integrate into the LMRCSC's research and education plan. Students have benefited from the linkage with her DREAMS and COSEE programs. Dr. Andrij Horodsky continues to mentor students, and worked with HU and UMES students on his funded TAB project this summer. He is now offering an Ichthyology course, which has already become a big hit with students in the Marine Science and Biology departments. HU student, Kendyl Crawford has used her skills gained from LMRCSC to assist Dr. Daniel Pauly (Professor, University of British Columbia, Canada) in his program the Sea Around Us. She spent this summer assessing fisheries data from small Pacific Islands.

#### 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. Fifty-nine (59) students from B.S. to doctoral levels were supported and trained in NOAA core sciences. Six MS students graduated. Twelve projects funded through the TAB are underway for 2010-11; \$2,591,029.14 in external funding is supporting Center-related activities.
- The Center's doctoral graduates, Larry Alade, Ayeisha Brinson and Jose Reyes-Tomassini, all NMFS employees, are continuing to collaborate with the Center particularly in teaching courses in support of its mission.

- Noelle Hawthorne's (M.S., SSU) work is helping to refine how GRNMS estimates utilization of Gray's Reef by commercially important migratory species. Tiffany Ward's (B.S., SSU) (with Eric Ransom) work on natural and artificial oyster reefs is allowing us to provide important data to the restoration center on the comparative value of restored oyster reefs.

**2. How many students participated in Center projects or activities?** Fifty-nine (59) 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 the section on "scholarly productivity" on pages 26 through 30. More than 1000 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. Some of the students' awards and benefits are mentioned below:

***Student Awards:***

Aaron Watson (M.S., UMCES- IMET) won the 2011 M.P. Mulvihill Aquaculture Scholarship and also awards for his poster presentations at the following conferences

- \* Best Student presentation from the United States Aquaculture Society
- \* Best Student presentation from the Sea Grant Association

IMET graduate student, **Ammar Hanif**, won the prize for best oral presentation at UMES Student Sub-Unit 4<sup>th</sup> Annual Symposium, April, 2011.

Whitney Dyson (M.S. UMES) won 2<sup>nd</sup> place for her poster at the American Fisheries Society Tidewater Chapter meeting in March, 2011.

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

- Bashiru Balogun (Ph.D, UMES) received a Post-Doctoral position in the Department of Agriculture at UMES following his graduation in May 2011.
- Nicholas Clemons (M.S., UMES) was offered a permanent (FTE) position as Ranger II with the National Park Service in Spring, 2011. He will officially graduate in December, 2011.

***Students who Received Scholarships for Graduate Degree Programs as a Result of their Work at the Center:***

Xaymara Serrano and Rolando Santos continued to receive support during this period from the McKnight Fellowship to support their PhD work.

***Students who received Training at NOAA Laboratories or at Center Institutions***

a) William Gardner has been conducting research in collaboration with Dr. Ashok Deshpande at the NOAA J.J. Howard Marine Science Lab at Sandy Hook continuously from April, 2009 to the present. William is analyzing the PCB content of Atlantic coast and Chesapeake Bay striped bass. He will complete this research project in December, 2011 and is expected to graduate in May, 2012.

b) Courtney McGeachy worked with Dr. Beth Phelan at the NOAA J.J. Howard Marine Science Lab at Sandy Hook, NJ from Aug 18-26, 2011. She examined behavioral ecology of black sea bass in and around traps using *in situ* video monitoring.

c) Dan Cullen (Ph.D, UMES) worked with Dr. Anne Richards in summer 2011 conducting analysis of monkfish distribution and temperature data.

d) Adam Tulu is collaborating with Dr. Rosemary Jagus. He conducted portions of his doctoral research on the effects of marine pollutants in the Atlantic tomcod, *Microgadus tomcod* at the IMET facility in Baltimore from June 1 to August 30, 2011.

e) Jamila Payton (M.S. UMES) worked at UMCES-IMET (June 1 to August 30, 2011) under the supervision of Dr. Rose Jagus. Jamila's research examines the physiological effects of hypoxia on Atlantic croaker in the Chesapeake Bay.

f) Belita Nguluwe (M.S., UMES) analyzed DNA samples from monkfish collected in the Northern and Southern management areas under the supervision of Dr. Al Place at UMCES-IMET from July 1 to July 31, 2011.

g) Kristen Rybyzyske (B.S. UMES), Elizabeth Seagroves (B.S. HU) and Symone Johnson (B.S. HU) worked with Drs. Richard Brill (NOAA) and Andrij Horodysky (HU) at the Virginia Institute of Marine Science Eastern Shore Laboratory at Wachapreague, VA. The students participated in all phases of collaborative projects being conducted by HU and UMES on sensory ecology of black sea bass and the effects of hypoxia on the behavior of Atlantic croaker.

h) 10 students participating in the Research Experiences for Undergraduates in marine and estuarine science program at UMES during summer, 2011, visited UMCES-IMET on July 25, 2011. They were given a tour of the aquaculture laboratory by Drs. Sook Chung and Keiko Saito.

#### **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 LMRCS have access to tools and training they would not have were it not for the LMRCS. Several students at the Center institutions who are not directly funded by the LMRCS are benefiting from the infrastructure and equipment made available to the institutions by the LMRCS. Moreover, the LMRCS has resulted in leveraged funding that has enabled the Center institutions to recruit and support more students than they would otherwise be able to support.

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