Performance Report for Cooperative Agreement No: NA06OAR4810163
for the Period from September 1, 2010 to February 28, 2011

University of Maryland Eastern Shore
Living Marine Resources Cooperative Science Center

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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 located in Woods Hole, MA who is 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. The LMRCSC partner institutions have signed the Articulation Agreement document which makes it possible for students at one institution to take courses offered at another Center institution. Four NOAA scientists, including Dr. Howard Townsend (NOAA Cooperative Oxford Lab, MD) will teach a new course "**Ecosystem Modeling Applied to Fisheries**" at UMES in July 2011. 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 are being offered to students at the Center this spring semester. Five graduate students in the PSM program will intern at NOAA Science labs in summer 2011. Internship placements for four of the students have been finalized.

In support of the programmatic component of the LMRCSC designed to accomplish Goal 2, ten projects approved for 2009/10 were completed by December 31, 2010. Twelve (12) collaborative projects were funded by the LMRCSC for 2010-2011 following the review of the proposals by the TAB. 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 10 to 24 of the report. Through the use of acoustic telemetry and mark-recapture techniques, the project on American eel has generated data that are being used to estimate size-specific population parameters (e.g. mortality rates). Estimation of basic life history parameters of important marine fish species is a major priority of NOAA Fisheries. NMFS is also interested in understanding the impacts of global climate change on fish stocks. Results of the project dealing with the physiological effects of increasing CO_2 concentrations on pre-fertilization and larval stages of cobia suggest that elevated CO_2 levels might impact the respiration rates of fish eggs. Finally, the project on the use of DNA markers to evaluate US fishery management areas and effective population size of monkfish, *Lophius americanus*, has demonstrated the existence of three genetic groups of monkfish which show no spatial correlation to the management areas. This suggests that there is no geographic isolation among the three genetic groups and that the monkfish population may not be a unit stock. This has important management implications.

The 10 day LMRCSC winter research cruise was used to train students in fisheries and marine sciences, including field sampling procedures, and to support projects conducted by faculty and graduate students. Three

scientific objectives were addressed: (1) an examination of the 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) deepwater exploration on the continental slope to define depth limits of monkfish distribution in the vicinities of Hudson and Norfolk Canyons.

In the current reporting period, LMRCSC students and faculty made 84 presentations (oral and poster) at scientific meetings (50 of which were made by students), and published 13 articles in refereed journals, 6 of which were authored or co-authored by students or graduates of LMRCSC. An additional 4 articles (2 of which have LMRCSC students or recent graduates as co-authors) 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 $3,134,017 was collectively awarded in grants to the LMRCSC institutions during this reporting period, which has directly impacted and will continue to have positive impacts on Center activities. These funds enhanced LMRCSC research through support of its faculty and students and by development/enhancement of infrastructure. Eight grant proposals totaling $2,745,092 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, 56 students (20 BS, 22 MS, 14 Ph.D students) were supported and received training in NOAA core sciences during this reporting period, and 4 students graduated (2 BS, 2 MS). Students participated fully and actively in faculty-directed research projects on their home campus 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 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 LMRCSC faculty and graduate students.

LMRCSC 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 LMRCSC accomplishments during this reporting period.

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

Activities	Proposed in the Implementation Plan (2010-11)	Accomplished (Sept. 1 – Feb. 28, 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	8
3. # of scientific presentations at conferences (including students')	35 (30 – 60)	84 (50*)
4. # of theses & dissertations produced	12	2
5. # of peer-reviewed publications/book chapters	18 (10 – 25)	13 (6*)
6. Amount of leveraged funds ($)	$1.3 million (500,000 to 1.5 million)	$3,134,016.86
7. # K-12 students trained in NOAA related sciences	500	> 1000
8. # of B.S. students trained in NOAA related sciences	50	20
9. # of B.S. students graduated in NOAA core sciences	25	2
10. # of M.S. students graduated in NOAA core sciences	9	2
11. # of Ph.D. students graduated in NOAA core sciences	3	0
12. # of interns at NOAA/other labs.	10	4

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 **September 1, 2010 to February 28, 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 are being offered online by LMRCSC researchers during the current reporting period and are listed below:

ia) Academic Courses:

- **Fish Stock Assessment (MEES 642)**: This course is currently offered at UMES in Spring 2011, co-instructed by Dr. 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, is enrolled in this course online. Seven others at UMES take the course 'live'.

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

- **Marine Population Dynamics:** This course, instructed by Dr. David Die (RSMAS), is being offered live at University of Miami and online (via GoToMeeting) to four PSM degree students at UMES (as MEES 688).

Several University System of Maryland MEES courses were offered in Fall 2010 and Spring 2011 to LMRCSC students and others at UMES. Courses offered and students who 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 LMRCSC partner institutions.

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	Physiol ogical Ecol ogy 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	

Table 2. MEES Courses Offered in Fall Semester 2010 Using Interactive Video Network (IVN).

Course Number	Course	Instructor	Students Enrolled
MEES 698E	Ecosystem Restoration	Kaushal	
MEES 626	Env. Geochemistry I	Schijf	
MEES 698I	Chesapeake Bay Health	Mitchelmore	
MEES698C	Molecular Biology	Place & Jagus	Belita Nguluwe (MS, UMES), Rehab El Fadul (PhD, UMES)
MEES608L	Genomic Seminar	Hill & Chen	
MEES 682.	Fish Science & Management	Secor et al.	2 students
MEES 608P	Env. Pollution Seminar	Mitchelmore & Rowe	
MEES621	Biological Oceanography	Hood et al.	Belita Nguluwe (M.S. UMES) Whitney Dyson (M.S./Ph.D UMES) Bhae Jin Peemoeller (M.S. UMES) Efeturi Oghenekaro (M.S. UMES) Ejiro Mayor (M.S. UMES)
MEES698G	Marine Geology	Palinkas	Shari Mullen (PhD, UMES)
MEES607	Quantitative Methods	Sanford	Jan Vicente Rozckow (IMET, PhD),
MEES608D	Scientific Writing & Communications	Kennedy	
MEES608C	Diseases in the Chesapeake Bay	Schott	2 students

The courses listed in Tables 1 and 2 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.

Survey Sampling: Dr. Brad Stevens taught a graduate level course in survey sampling during Fall semester 2010, which commenced on August 27. This course was used to provide students information on methods of estimating abundance and other parameters of fish, shellfish, and wildlife populations. Students learned theory and techniques for different sampling strategies including random, stratified, systematic, cluster, adaptive, and ratio estimators, as well as procedures for estimating error rates and sample size for each method. Problems and examples were based on fisheries survey data, with emphasis on trawls, dredges, or video surveys, and were analyzed using Microsoft Excel or R. Eleven students, mostly from LMRCSC at UMES, enrolled in the course which was offered via the Virtual Campus. No student from other LMRCSC institutions enrolled in the course.

Seminars

- The LMRCSC Seminar Series (Table 3) continued in this reporting period. The presentations were made available at all LMRCSC partners via the Virtual Campus.

Table 3. LMRCSC Seminar Series 2010-2011.

DATE	SPEAKER	TITLE	No of Participants
September 10, 2010	Dr. Al Place (UMBI-COMB)	*Callinectes sapidus*, a resilient genome evolving in highly variable environment	UMES: 20 IMET: 10
October 8, 2010	Dr. Joseph Pitula (UMES)	Correlation of biotic and abiotic factors in environmental presence of *Hematodinium* sp.	UMES: 19
October 22, 2010	Dr. Dionne Hoskins (SSU)	Marsh-edge use by estuarine nekton in coastal Georgia	UMES: 7 SSU: 8 IMET: 6
February 11, 2011	Dr. Elizabeth Babcock (RSMAS)	Using Data from Marine Reserves to Inform Fishery Management: Examples from California	UMES: 9 HU: 7

		and Belize	IMET: 7
March 11, 2011	Dr. Matthew Ogburn (SSU)	Towards Ecosystem based management for blue crabs	UMES: 11 SSU: 20 IMET: 8
April 15, 2011	Dr. Gulnihal Ozbay (DSU)	Investigation of Habitat Value of Floating Eastern Oyster (*Crassostrea virginica*) 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	

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 September 2010 to February 2011.

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

ii) Strengthening collaborations among center partners: New HU Research Assistant Professor (Dr. Andrij Horodysky) established linkage with Dr. Andrea Johnson (UMES) and Dr. Richard Brill (NOAA) which led to a successful project examining the sensory ecology of black sea bass. This project provided internship experience for Kendyl Crawford (HU) and Joe'ella Caddle (UMES) at the VIMS Eastern Shore laboratory in Wachapreague, VA in summer 2010. Drs. Horodysky and Johnson developed two proposals, including a renewal of the sensory ecology project, which were submitted to the TAB on September 24, 2010.

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 September 2010 to February 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, LMRCSC 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 LMRCSC partner institutions or their designees, last met at SSU on November 3, 2010. The next BOV meeting is scheduled for November 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):** Ten proposals recommended for funding for the 2009/10 project year (Table 4) were completed in December 2010. The 2010/11 LMRCSC Request for Proposals (RFP) was distributed to researchers at all LMRCSC partner institutions on July 12, 2010 with 13 proposals submitted to Program Manager

Todd Christenson on September 24, 2010. The proposals were reviewed by the TAB after which 12 projects (Table 5) were funded by the Center.
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 LMRCSC 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 LMRCSC partners have completed and submitted the exit evaluation during their final semester.
LMRCSC Cruise Evaluation: An evaluation form aimed at assessing the students' experience aboard LMRCSC research cruises is distributed to participants following each research cruise. More than 10 completed surveys have been received including two in the current reporting period.
Evaluation Forms for interns and mentors: To date, 31 students have provided evaluations of their internship experiences at various NOAA facilities, LMRCSC partners and other institutions. Similarly, 16 supervisors have provided evaluations of the LMRCSC students who participated in internships in their labs. 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 was conducted by graduate students Xaymara Serrano and Rolando Santos. Xaymara is working with Dr. Andrew Baker on impacts of climate change in 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 participated in ICCAT SCRCS in September 2010. Dr. Die also continued his work of technical support of the Center for Independent Experts that provides NMFS with independent peer review of science products.

TAB Approved Projects for 2009/10: Ten projects recommended for funding by the Technical Advisory Board were completed by December 31, 2010 (Table 4)

Table 4. Projects supported by LMRCSC for the 2009/2010 project year.

Proposal Title	Collaborators	Total Approved
1.Correlation of biotic and abiotic factors in environmental presence of *Hematodinium*	Joseph Pitula (UMES), Eric May (UMES), Feng Chen (COMB), Eric Schott (COMB), Frank Morado (NOAA), Carl Zimmerman (NPS)	$36,536.00
2. Effect of coded wire tags and *Probopyrus pandalicola* on the susceptibility of grass shrimp to predation in mesocosms-Year 2	Carla Curran (SSU), Paul Pennington (NOAA)	$48,898.00
3. Estimation of survival, emigration and fishing mortality rates for American eel through telemetry and mark-recapture-Year 2	Dewayne Fox (DSU), Larissa Bailey (USGS) Paul Conn (NOAA), Kyle Shertzer (NOAA)	$39,393.00

4. Influence of predicted aqueous hypercapnia on cobia pre-fertilization and larval stages	Dwight Ebanks (RSMAS), Dan Benetti (RSMAS) Nelson Ehrhardt (RSMAS), Rose Jagus (COMB)	$27,351.00
5. Measuring environmental and physiological stress and its impact on infection in blue crab by *Hematodinium*	J. Sook Chung (COMB), Joseph Pitula (UMES) Gretchen Messick (NOAA)	$35,835.00
6. Molecular tracking of pathogens in early life history of blue crabs	Eric Schott (COMB), Matthew Ogburn (SSU), Susan White (NOAA)	$40,454.00
7. Reproductive and immunological health assessment of Atlantic croaker exposed to hypoxia in Chesapeake Bay	Andrea Johnson (UMES), Yonathan Zohar (COMB), Richard Brill (NOAA)	$24,880.00
8. Sensory ecology of juvenile and adult black sea bass	Andrij Horodysky (HU), Andrea Johnson (UMES) Richard Brill (NOAA)	$33,159.00
9. Understanding the interaction of probiotic and pathogenic bacteria in oyster larvae culture	Harold Schreier (COMB), Eric Schott (COMB) Dennis McIntosh (DSU), Gary Wikfors (NOAA)	$39,715.00
10. Use of DNA markers to evaluate US fishery mgmt areas and effective pop. size of monkfish	Andrea Johnson (UMES), Allen Place (COMB) Anne Richards (NOAA)	$23,174.00

1.Correlation of biotic and abiotic factors in environmental presence of *Hematodinium*

Joseph Pitula (UMES), Eric May (UMES), Feng Chen (COMB), Eric Schott (COMB), Frank Morado (NOAA), Carl Zimmerman (NPS)

Project Description: The blue crab (*Callinectes sapidus*) fishery is of critical importance to the economics of the Chesapeake Bay region. Stressing these populations is infection by the dinoflagellate parasite *Hematodinium* sp. Detection of free-living *Hematodinium* sp. from environmental samples will be important to understand how crabs may acquire infection, and what stages within both the host and the parasite life cycle influence infectivity. Using the most specific molecular technology available, this collaboration between UMES, IMET and the National Park Service (NPS) will investigate potential reservoirs of blue crab disease in Atlantic coastal bays. Our goal will be to correlate environmental and biological parameters that favor the presence of putative free-living life history stages of *Hematodinium* sp.

Beginning in April of 2010, graduate student Whitney Dyson performed monthly environmental sampling of sites within the Maryland Coastal Bays, collecting both sediment samples and water samples enriched for various plankton species. The sites chosen were centered in Chincoteague Bay of the Maryland Coastal Bays, as part of a collaborative effort with the National Park Service. Our goal was to discover whether we could observe *Hematodinium* sp. in environmental sites, as it is unclear whether this dinoflagellate exists for a portion of its life cycle within the environment, or only in the blue crab which it parasitizes.

Based upon our preliminary observations we have detected *Hematodinium* sp., using a standard PCR-based assay, from sites within the entire Bay region, with only sites 6, 12, 16, and 17 showing no signals. Sampling was performed monthly at each site, except for September of 2010. A total of 302 sites were analyzed, and 34 (11%) were positive for a signal either in water or sediment samples. A relatively equal distribution between water (55%) and sediment (45%) was observed.

Two points of interest emerged from our analysis. First, 3 locations may be potential "hotspots" where parasite prevalence is concentrated. We observed that:

- sites 1,2, and 18 (Sinepuxent Bay) had 8/34 or 24% of all detections
- sites 3 and 4 (Trappe Creek/Newport Bay) had 5/34 or 15% of all detections
- site 10 (Sinnickson VA) had 6/34 or 18 % of all detections

Collectively these 3 locations represent 57% of all detections. Particular emphasis on these locations will be the focus of our 2011 survey, and will include both dinoflagellate population determinations and blue crab infection rates.

Another important observation was that detection of potential environmental reservoirs occurred in April and May. This is about two months prior to when blue crabs begin to display heavy infections, and thus would be very unlikely to have been derived from a disease-related sporulation event, which is common in the host parasite interaction. The biological relevance of this early-season detection will be explored in greater detail. An important

new collaborator has been added to the group since the grant was submitted. Rick Cawthorn, an expert in protistan biology and advanced microscopic techniques, from the Atlantic College of Veterinary medicine in Prince Edwards Island Canada, will be assisting in the determination of the viability of environmental detection of parasite.

Students who worked on this project included Whitney Dyson, a graduate student in the LMRCSC program. She was responsible for collection of sediment and water samples, and DNA extraction from them. In addition, she has performed the PCR analysis, which is on-going. In the summer of 2011 we will be recruiting an NSF-funded Research Experience for Undergraduates student, and an undergraduate student associated with an NSF-funded CREST program, to assist in our studies.

In our study of dinoflagellate populations a DGGE method, whereby a population is screened by a gel that resolves slight differences in PCR products from a mix of RNAs, will be preformed this summer under the guidance of Dr. Feng Chen at IMET. Samantha Chukwura, a UMES undergraduate, preformed this version of the analysis during a summer internship in the laboratory of Feng Chen at IMET.

No papers were submitted as a result of this work, although we anticipate a manuscript to be submitted near the end of this year. However, Ms. Dyson's work from last year and this year was incorporated into a talk that the PI (Joseph Pitula, UMES) presented recently at the 2011 Eastern Fish Health Workshop in Charleston, SC. In addition, Ms. Dyson has presented this work in poster format at the following meetings/conferences: a) the 4th Aquatic and Fisheries Science Symposium April 1, 2011 UMES, Paul Sarbanes Center and b) the 25th Anniversary meeting of the Tidewater Chapter of AFS at VIMS on March 10-12. Ms. Dyson presented a poster titled "A PCR-based assay for detection of *Hematodinium* sp. in Sediment and Water from the Maryland Coastal Bays" by WE Dyson, E. Schott, A. Hanif, and J. S. Pitula, for which she received the 2nd Place Poster award and an honorarium of $100.

2. Project Title: The Effect of Coded Wire Tags on the Growth of the Grass Shrimp *Palaemonetes pugio* in Mesocosms. Year II.

Project Description: As grass shrimp are an important food source for many commercially important species, their density can play an important role in determining habitat quality, which can be determined indirectly by assessing growth rates (Curran and Able 2002), and therefore whether areas could be essential fish habitats. The objectives are to: determine the growth rate of isopod-parasitized and unparasitized grass shrimp *Palaemonetes pugio* in mesocosms at the NOAA lab in Charleston, SC and add this information to the model constructed on the impact of this sexually castrating parasite; and determine predation rates on grass shrimp by a fish predator. Results will be disseminated to local schools through the funded participants, including a teacher-intern who will design a K-12 activity for publication.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Dr. Mary Carla Curran and Dr. Paul Pennington
NOAA Collaborator(s): Paul Pennington
LMRCSC Collaborator(s): Dr. Dionne Hoskins (NOAA Fisheries/Savannah State University)
LMRCSC Research Student(s): Jakelin John (graduate student, SSU, 2010), Krystle Ludwig (graduate student, SSU, 2009-2010), Michael Partridge, (graduate student, SSU, 2009-2010), Chris Williamson (undergraduate student, SSU, 2009-2010), Joe LaBarre (undergraduate student, SSU, 2009-2010), Michele Sherman (undergraduate student, SSU, 2009-2011), Leona Gerido (teacher-intern, 2010), Jamie McCullers (undergraduate summer 2010-spring 2011)
Planned Start Date: Fall 2008
Planned End Date: Sept 2010
Actual Start Date: 1 Oct 2009
Actual End Date: 30 Sept 2010

Planned and actual results of project: The objectives of this proposal were to: determine the effect of coded wire tags on growth rates of the grass shrimp *Palaemonetes pugio*; determine the growth rate of tagged grass shrimp in mesocosms at the NOAA laboratory in Ft. Johnson, SC; and determine whether the fish predator *Fundulus heteroclitus* prefers parasitized or unparasitized grass shrimp. In addition, it will be determined whether the growth rate of bopyrid-parasitized individuals is different than unparasitized individuals. In year II, the questions of whether

gravid shrimp could reproduce (year II) and whether structure (*Spartina alterniflora*) affected predation were assessed.

In year I, it was determined that tagged unparasitized grass shrimp growth (in length) was higher than tagged parasitized grass shrimp for all 3 mesocosms ($p<0.0001$). It was also determined that *Fundulus heteroclitus* significantly ate more tagged parasitized shrimp than any other treatment. Unparasitized grass shrimp averaged (±SD) percent survival was the highest (41.00±14.38%) while tagged parasitized grass shrimp average (±SD) percent survival was the lowest (17.00±5.03). There was a significant difference ($p=0.0199$) in survival of grass shrimp type when the control mesocosm of each trial was included. The experiment was repeated in year II, but with the addition of *S. alterniflora* to see if structure affected predation, but these results are inconclusive at this point. The experiment will be repeated in summer 2011.

In year II, it was found that ~59% of the unparasitized females became gravid in the control mesocosm. Only 1 of the parasitized females became gravid and this individual had lost its parasite. Approximately 51% of the females that had their parasites removed before the experiment became gravid. This indicates that the effect of the parasite on reproduction can be reversed if the parasite is lost, which can occur during molting.

Undergraduate Joe LaBarre conducted a small study to determine whether parasitized grass shrimp are more susceptible to predation by *Fundulus heteroclitus*. He found that shrimp behavior is more important than whether the shrimp was parasitized by *Probopyrus pandalicola*, but has found that the fish preferred parasitized shrimp 59% of the time. However, the most striking finding is that the most active shrimp was consumed first 98% of the time, regardless of parasite presence. Undergraduate Michele Sherman conducted a project on the effect of the parasite on starvation in grass shrimp and found that parasitized shrimp survived approximately 5 fewer days than unparasitized shrimp. In year II, she is finalizing her study on whether temperature affects the impact of the parasite. To date, it appears that the parasite has more of an impact at higher temperature, but the experiment is being repeated this semester.

Monthly monitoring for shrimp densities and parasite prevalence in Georgia is continuing. In 2009, Tracey Modeste (thesis funded in part by LMRCSC) found that the prevalence of the bopyrid was 4.3% at Country Club Creek and 1.5% at Moon River. The highest egg loss due to sterilization was 335 eggs/m^3. Parasitic sterilization, causing a loss of 21% of mean egg production may reduce the number of eggs available by as much as 45%, which may lead to a decline of this important prey item.

Undergraduate Jamie McCullars has continued the density monitoring at Country Club Creek and Moon River. He had noted the same general trends we have seen in the past: higher density and gravidity of shrimp in warmer months.

The results of this project include: two master's theses:

Ludwig (Dec 2009) "The effects of coded wire tags and the isopod parasite *Probopyrus pandalicola* on the growth and predation of daggerblade grass shrimp *Palaemonetes pugio* Holthuis (1949)"

Partridge (May 2010) "Behavioral effects of the parasite *Probopyrus pandalicola* on the swimming endurance and toxicity of fipronil to the daggerblade grass shrimp *Palaemonetes pugio,* and integrating shrimp density data into a K-12 activity.

Data from the above projects have been used as the background for Dr. Curran's role as PI/Co-PI in the following 3 funded proposals: Collaborative: NSF New GK12: Building Ocean Literacy in a Coastal Community through Science Education and Estuarine Monitoring; NSF OEDG Collaborative Research: Enhancing Diversity in Geoscience Education through Coastal Research in a Port City (EDGE); and Department of Education Title VII Coastal Ocean and Underwater Research to Advance Graduate Education (COURAGE).

How will results be incorporated into NOAA Fisheries operations? Results from this research are relevant to the management, conservation, and protection of living marine resources, all of which are part of the NOAA mission. It was determined that grass shrimp, an important food resource for many commercially important species, can be affected by parasites. In particular, growth is reduced in parasitized individuals. In addition, this isopod prevents the shrimp from reproducing, which in turn can affect shrimp populations and thereby impact habitat quality. Furthermore, a relatively novel technique (coded wire tags) was used to tag a small species. Although this technique

has been used on larger species, this study has shown that the tag can be used on smaller individuals, is retained, and does not affect shrimp growth.

How will results be incorporated into LMRCSC research and curriculum? Dr. Curran's teacher-intern is incorporating her findings into K-12 curricula, as have past LMRCSC teacher interns. Dr. Curran is incorporating her field experience into her classroom teachings (Fish Ecology, Fisheries Oceanography, Marine Ecology, and Technical Writing) and both she and her students have spoken at local schools.

3. Estimation of survival, emigration and fishing mortality rates for American eel through telemetry and mark-recapture-Year 2

Project Description:

American eels (*Anguilla rostrata*) have supported an important fishery in the mid-Atlantic since colonial times and continue to do so today. Nevertheless, concerns among fisheries managers are growing as a result of perceived declines in landings and recruitment indices throughout the range of American eels. Although American eels have been the focus of intensive fishery, continuous data is lacking. Through this project a hybrid model is being developed to generate survival, mortality and emigration probabilities from coupling both mark-recapture and telemetry data. Previously, a multistate model was used to generate probabilities of recovery, capture, and size-specific movements (Cairns 2009). By adding the telemetry component to the mark-recapture study previous hypotheses will be addressed (e.g. does harvest rate influence detection probability and/or transition probability between strata). Combining these sources of data will provide managers with more precise parameter estimates thereby allowing for better management decisions regarding the conservation of the species. This project is currently providing invaluable training for a graduate student in the areas of quantitative fisheries and essential fish habitat.

Thematic Area Addressed: Quantitative Fisheries and Essential Fish Habitat
Lead Scientist(s): Dr. Dewayne Fox (DSU)
NOAA Collaborator(s): Drs. Paul Conn and Kyle Shertzer, NOAA Fisheries, Beaufort, NC
LMRCSC Collaborator(s): N/A
LMRCSC Research Student(s): Marissa Brady (DSU)
External collaborators: Dr. Larissa Bailey, Colorado State University
Industry collaborators: Ed and Sharon Farrall, and Mike Stanski
Planned Start Date: April 2008
Planned End Date: December 2010
Actual Start Date: May 2009
Actual End Date: December 2010

Planned and actual results of project:

To date, monthly mark-recapture census of American eel for 2010 have been completed from April-September, two months are remaining (October and November). All PIT tags purchased through the TAB funding were deployed in the field as of August 2010. The biotelemetry portion began in March with the re-deployment of Receivers (N=7) and weekly tracking began shortly thereafter in the St. Jones River, DE. Starting in May, 60 transmitters (30 V9-2L and 30 V8-4L) (Figure 1) were deployed for the second field season of the biotelemetry component. The addition of smaller transmitters (V8-4L) will give us the opportunity to assess other size class movements in the river. Three additional receivers were deployed near the mouth of the St. Jones River, DE in July to assess seasonal movement out of the river in the fall.

This project builds upon a 5 year program which is unique in its partnership with commercial harvesters and the application of both standard and novel statistical methods designed for capture-recapture studies. From June 2009-July 2010, a total of 128,781 detections of telemetered American eel were collected and 39/41 telemetered individuals were successfully relocated using manual tracking, passive tracking and mark-recapture methods. For the 2010

telemetered individuals (N=60), through September 2010 a total of 18,572 detections were collected and 52/60 telemetered individuals were successfully relocated using manual tracking, passive tracking and mark-recapture methods. Manual tracking has occurred weekly through the navigable portions of the St. Jones River.

How will results be incorporated into NOAA Fisheries operations?

The overall goals of this project are to provide information useful for the successful management of American eel fisheries. Results of the mark-recapture component of this work were presented to the ICES Subcommittee on American eels in Saline Waters in March, 2009 and at the September 2009 ASMFC American eel Stock Assessment Committee meeting. The graduate student on the project presented preliminary data for the 2009 field season at the 2009 NOAA EPP Forum at Howard University in Washington, DC. The results of the current study will help refine mortality estimates (both natural and fishing) for future eel stock assessments. NMFS and the ASMFC will benefit from the results of this project through direct estimation of size specific population parameters for eel. The approach of fishery independent and fishery dependent sampling employed in this study allows us to gain valuable insights on the population ecology of American eel.

How will results be incorporated into LMRCSC research and curriculum?

The proposed work is directly relevant to the LMRCSC, NMFS, and the ASMFC. The study addresses two targeted research themes (quantitative fisheries and essential fish habitat) outlined by the LMRCSC and NMFS by utilizing combined biotelemetry and mark-recapture methodologies to estimate important population parameters. These topics were presented to LMRCSC students/faculty/staff through formalized class lectures (e.g. DSU course on Fisheries Management and UM-RSMAS course on Marine Population Dynamics). This project is the M.S. thesis research for Marissa Brady, who is expected to graduate in May, 2011.

4. Project Title: Influence of predicted aqueous hypercapnia on cobia, *Rachycentron canadum*, pre-fertilization and larval stages of development

Project Description: Increased atmospheric CO_2 has decreased oceanic pH by 0.1 (pre-industrial through 2005) with a continued projected decrease up to 0.35 by 2100 (IPCC 2007). Studies of the effects of hypercapnia on marine teleosts are sparse but warranted due to anticipated changes. The goal of this research is to assess the impact of projected increases in CO_2 on the recruitment of the widely distributed and aquacultured cobia, *Rachycentron canadum,* by determining physiological impacts on gametes under reproductively relevant conditions. Sperm respiratory rates, motility, and the impact on egg and larval development will be accessed. Findings will provide the basis for further physiological and reproductive studies and aid in forecasting the response in fish stocks to global climate change.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Dwight Ebanks, Daniel Benetti, Nelson Ehrhardt, and Rosemary Jagus
NOAA Collaborator(s): None
LMRCSC Collaborator(s): Dr. Rosemary Jagus, Associate Professor; UMCES IMET
LMRCSC Research Student(s): Dwight Ebanks (RSMAS)
Industry collaborators: Dr. Chris Langdon
Planned Start Date: January 2010
Planned End Date: December 2010

Actual Start Date: December 2009
Actual End Date: TBD

Planned and actual results of project: Respiration experiments on cobia spermatozoa, fertilized eggs, and yolk-sac larvae have been conducted to evaluate potential impacts of forecasted aqueous hypercapnia and the concurrent decrease in pH. These initial experiments have shown differences in respiration rates for spermatozoa, eggs , and yolk-sac larvae in control (380 ppm CO_2) compared to high CO_2 concentrations (800 ppm), however a consistent

trend has not been observed. The data have not been statistically analyzed because additional experiments need to be conducted to determine if a trend will emerge. Respiration rates of spermatozoa (n=30708) and yolk-sac larvae (n=6) increased when exposed to the high concentration of CO_2 (800 ppm). However, the respiration rates of fertilized eggs (n=15) decreased at the high CO_2 concentration. A decreased respiration rate was expected in the high CO_2 concentration treatment; however, this was not observed for both the spermatozoa and yolk-sac larvae. Currently, cobia brood stocks are being given a period of rest after an extended 2010 spawning season that ended in November. Experiments are expected to resume in March/April as the cobia brood stock enter their natural spawning season.

How will results be incorporated into NOAA Fisheries operations? This study will help to identify the sensitivity and potential impact of increased global atmospheric CO_2 to the pre-fertilization, embryo, and larval stages of a near ubiquitous marine teleost. Findings will provide information that is lacking (Ishimatsu et al. 2008), but essential to understanding potential impacts to recruitment for fish populations. These studies will also directly support NOAA's Ecosystem Approach to Management by addressing the Identification and Application of Physiological Performance Measures for Determining Habitat Capacity for Sustaining Fish Populations (Area C) under Essential Fish Habitat in the LMRCSC 2009 RFP. This project also aids NMFS in the research area of Impact of Anthropogenic Factors and Environmental Changes on Fish Populations (NMFS 2007). This will be achieved by addressing "… the effects of long-term changes in the ocean climate on living marine resources," which "… helps assess the true impact of human induced factors." Additionally, Dr. Margaret Miller, the Ocean Acidification liaison at the NOAA Southeast Fisheries Science Center, will provide advice in developing the project.

How will results be incorporated into LMRCSC research and curriculum? LMRCSC objectives benefit by the collaboration between RSMAS and COMB and the training of a minority Ph.D. student. These results were orally presented in a 2011 departmental student seminar.

5. Measuring environmental and physiological stress and its impact on infection in blue crab by *Hematodinium*

Project Description:
The growth of blue crab is seasonal and requires molting process. A high mortality of blue crab (*Callinectes sapidus*) caused *Hematodinium* sp. infection is known to be associated with the life- and molt stage and specific, stressful environmental conditions. Physiological (health) parameters of the host blue crab depend on the molt cycle, implying that the infection of this parasite is closely linked to a particular molt stage and extreme stressful environmental conditions.
Thematic Area Addressed: Quantitative Fisheries, Essential Fish Habitat
Lead Scientist(s): Dr. J. Sook Chung, UMCES-IMET
LMRCSC Collaborator(s): Joseph Pitula, UMES
NOAA Collaborator(s): Gretchen Messick, Cooperative Oxford Lab
LMRCSC Research Students: One graduate student and three summer interns
Whitney Dyson, UMES
Anna Katenta, UMES;
Eric Walker Jr: Virginia Wesleyan College
Zianab Sankoh, Morgan State University

Start Date: January, 2010
Planned End Date: December, 2010

Planned and actual results of project:
Identifying a critical molt stage of blue crab in *Hematodinium* sp. infection: The mode of *Hematodinium* sp. infection in the blue crab has not been identified yet. In light of finding molt-stage dependent infection related mortality and a strong cannibalistic behavior in this species, we hypothesized that ingestion by cannibalism may be the mode of infection. We conducted an ingestion experiment by feeding a piece of meat of infected crabs (provided

by G. Messick) to adult males at two different molt stages: intermolt and early postmolt. We examined the hemolymph to identify the presence of *Hematodinium* and monitored for the first 7 days after feeding for the changes in the physiological parameters of the hemolymph that are typically known for energy metabolism and stress indicator in this host species. Our preliminary results revealed that susceptibility and mortality caused by *Hematodinium* are indeed a molt-stage specific phenomenon. All animals (n=4) at early post molt (1-2 days after molt) that were fed once with a piece of tissue (~2-3 g) of an infected animal were dead within three weeks after feeding. By contrast, those at intermolt or early premolt stages were still alive after three weeks (n=4).

Host physiological parameters were analyzed in respect to the high mortality noted in early post molt stages, in order to determine if the *Hematodinium* infection influenced these host parameters. The test group fed with infected animals exhibited significantly elevated glucose level at Day 8, compared to prior two sampling points and those of controls. Our data clearly demonstrate that the infection changes physiological parameters and causes physiological stress in the host. Although it is preliminary, our data signify that non-reducing disaccharide, trehalose may play a significant role in physiological adaptation in response to infection and environmental perturbation. The analysis of timing and level of infection using quantitative PCR (qPCR) analysis is in progress.

6. Project Title: Molecular tracking of pathogens in early life history of blue crabs (*Callinectes sapidus*)

Project Description: Although diseases have the potential to significantly affect blue crab populations, there have been few studies on the impact of diseases on overall mortality, especially in early life history. The protozoan parasite, *Hematodinium*, is a significant blue crab pathogen in Atlantic coastal bays, especially in GA. We have also discovered that a reo-like virus is associated with much of the mortality in soft-shell crabs operations from DE to FL, including GA. PCR-based assays for specific diseases can allow large numbers of individuals to be assessed, and permit testing of very small life stages. Using specific PCR assays designed for *Hematodinium* and blue crab reovirus, we have begun to assess disease prevalence in post-settlement crabs in the salt marshes near Savannah, GA, and are preparing to assess megalopae stage larvae in the late summer and fall.

Thematic Area Addressed: Quantitative Fisheries, Essential Fish Habitat
Lead Scientist(s): Eric J Schott, UMCES-IMET
NOAA Collaborator(s): Susan White, NCCOS, Hollings Marine Lab
LMRCSC Collaborator(s): Matthew Ogburn, Savannah State University
LMRCSC Research Student(s): Ammar Hanif (graduate student, Univ of MD), Peter Bedu (summer intern, DSU).
Industry collaborators:

Planned Start Date: Dec. 1, 2009
Planned End Date: Nov. 30, 2010

Actual Start Date: May 1, 2010
Actual End Date: Dec 31, 2010

Planned and actual results of project: Sampling for megalopae was attempted monthy by Dr. Ogburn from May to Sept. 2010. Blue crab megalopae were obtained only in Sept. Megalopae and juvenile crab collections were made by Dr. Ogburn and Mr. Hanif in May 2010. In July 2010, Dr. Ogburn led Mr. Hanif and Mr. Bedu in sampling for juveniles. June 7 through August 7 2010, Mr. Bedu and Mr. Hanif extracted RNA and DNA from all crabs (n=58) collected in June-July and conducted PCR assays for the parasite, *Hematodinium* sp. and for the blue crab reovirus (RLV). No *Hematodinium* sp. DNA was detected in any of the crabs. Three of the crabs, all collected in July, were positive for the reovirus, using the Rt-PCR assay. Mr. Hanif and Dr. Schott are currently testing the efficacy of DNA and RNA extractions from crab larvae, using hatchery-reared zoea obtained in the IMET aquaculture research center. These methods will be used to analyze crab larvae obtained by Dr. Ogburn in the Savannah area in October-November (when larvae are more abundant than in summer months).

How will results be incorporated into NOAA Fisheries operations? Understanding the role of disease during early life history in blue crabs could provide insights that can be applied to other species more directly managed by NOAA fisheries, such as tanner and snow crabs, which are also host to *Hematodinium* spp. As a link in the food web, blue crab abundance can also have effects (as predator or prey) on populations of fish or shellfish that are state and federally managed.

How will results be incorporated into LMRCSC research and curriculum? Information on blue crab health and disease was included in a graduate level seminar course ("Diseases in the Chesapeake Bay") offered by E.J. Schott through the MEES program at the University of MD. This project was also the subject of a seminar delivered by Dr. Schott to the LMRCSC consortium (via IVN) on April 16, 2010, "Building a molecular toolbox to study blue crab diseases".

7). Project Title: Reproductive and immunological health assessment of Atlantic croaker exposed to hypoxia in Chesapeake Bay

Project Description: Determine the effects of hypoxia exposure on reproductive, endocrine and general health functions of croaker under controlled laboratory conditions and to compare these biomarker responses in croaker collected from hypoxic and reference sites in the Chesapeake Bay.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Andrea K. Johnson (UMES)
NOAA Collaborator(s): Richard Brill (VIMS)
LMRCSC Collaborator(s): Yonathan Zohar, IMET (COMB)
LMRCSC Research Student(s): Jamila-Dawn Payton (M.S. Student, UMES)
Industry collaborators: Local Maryland fishermen

Planned Start Date: January 2010
Planned End Date: December 2010
Actual Start Date: January 2010
Actual End Date: December 2010

Planned and actual results of project: Laboratory studies were conducted from May to July, 2010. Atlantic croaker were collected by hook-and-line in the Chesapeake Bay in June and July, transported to UMES, and acclimated for 2 weeks in 1600L circular tanks (closed-system). Fish were kept at a seasonally adjusted photoperiod and fed a commercial diet once daily to satiation. Salinity was maintained at 13 g/L (± 0.5) and temperature at 27°C; conditions similar to those measured in the mainstem and tributaries of the Chesapeake during the summer. After acclimation, 32 fish were randomly assigned among 4 800L treatment tanks a control (normoxic; n = 8 fish/tank) or experimental (hypoxic; n = 8 fish per tank) 48 hours prior to initiation of 24hr hypoxia exposure experiments and 26 fish were randomly assigned among 4 tanks 2 control tanks (normoxic; n = 5 and n = 6) and 2 experimental tanks (hypoxic; n = 5 and n = 6) for the 96 hr and 168 hr exposure experiments, respectively. The normoxic tanks were kept at a DO concentration of 5.4 - 6 mg/L, and 73 – 84% saturation for the duration of the experiment. Fish in the hypoxia treatment tanks were exposed to 1.3 – 2.5 mg/L DO, and 18 – 33% saturation during the exposure times. During the experiments fish were sampled at 24, 96, 168 hr to validate physiological conditions under normal and hypoxic DO. General health was measured at every time period, while reproductive response were measured after a week (168 hr) when gonads were more developed. All procedures were conducted under the approval of the UMES Institutional Animal Care and Use Committee (IACUC).

Blood, spleen, brains and gonads were sampled for 24, 96, and 168 hr to determine any effects of hypoxia on croaker physiological general health. Each fish was humanely euthanized, total length, body weight, liver, spleen, and gonad weight measured and tissue samples (liver, heart, gonad, kidney, and spleen) were collected for histopathology. The packed cell volume (PCV or hematocrit), plasma proteins, enzymes and electrolytes from blood and plasma were used as indicators of general health function and condition.

Spleenosomatic index (SSI) is a measure of spleen size relative to total body weight of the individual. This index gives an insight to how much energy has gone into producing red blood cells (RBC). A larger SSI may indicate a higher storage of RBC instead of circulation in the blood stream. One-way ANOVA showed no significant difference in SSI among time or exposure to hypoxia, however graphically, 24 and 168 hr exposure to hypoxia showed reduced SSI compared to normoxic controls. This was not the same in the 96hr exposure. PCV was not significantly different at any time period, but hypoxic fish graphically stayed elevated throughout all time exposures. Fish were captured and handled the same way before sacrificing, so it is assumed there were no immediate effects due to handling.

The reduction of oxygen when a fish is exposed to hypoxia may also activate glycolysis as a means of ATP production. During glycolysis, liver glycogen reserves are used and phosphotases catalyze NADPH to make ATP instead of using O_2. Reductions in the individual heposomatic index (HSI) and increases in plasma phosphorus would be indicators of reduced aerobic metabolism and increased anaerobic metabolism due to reduced oxygen availability. Because these were effects that only occur after longer time in hypoxia the 24hr were not included in the analysis. Although, there was no significant difference between the means, HSI was smaller at both time periods in hypoxia exposed fish. Plasma phosphorus was higher in the hypoxic fish at 96 hr, but this was not significantly different from the other time periods.

Gonadosomatic index (GSI) was measured and used as determinant of gonadal and reproductive development in fish exposed at the 168 hr period. There were no significant differences between males and females so all fish were combined for analysis. Although the means were not significantly different GSI of hypoxic fish at 168hr looked reduced compared to the normoxic controls. Gonadotropin releasing hormone (GnRH-I) has been cloned and will be measured in the brain and gonad of 96 and 168 hr exposed fish using quantitative real-time RT-PCR to measure neuroendocrine reproductive function.

How will results be incorporated into LMRCSC research and curriculum? This study is aimed at assessing the "state of health" and "fitness" of fish exposed to sublethal hypoxia by various physiological indicators. It will provide information for determining how well fish species adjust to altered ecosystems. Results should be applicable to other model fish species and coastal ecosystems.

8. Project Title: Sensory ecology of juvenile and adult black sea bass: 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 juvenile and adult 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 priority areas delineated in the LMRSCS RFP, and directly supports the mission of NOAA-Fisheries. This project will provide research experience for undergraduate students on topics including black sea bass life history and aquaculture, sensory ecology, and quantitative analyses.

Thematic Area Addressed*: Essential Fish Habitat/Aquaculture*

Lead Scientist(s): Dr. Andrij Z. Horodysky (Hampton University).
NOAA Collaborator(s)*:* Dr. Richard W. Brill (NOAA, NEFSC Woods Hole, MA and VIMS)
LMRCSC Collaborator(s)*:* Dr. Andrea Johnson, University of Maryland Eastern Shore
LMRCSC Research Student(s)*:* Ms. Joe'Ella Caddle (UMES); Ms. Kendyl Crawley-Crawford (Hampton University)
Planned Start Date*:* 1 Jan 2010
Planned End Date*:* 31 Dec 2010

Planned results: This project will:
1. Characterize the frequency sensitivity and pressure and particle motion thresholds of black sea bass juveniles and adults.
2. Using auditory thresholds, calculate theoretical auditory ranges as a function of depth.

3. Characterize the luminous (intensity) sensitivity, flicker fusion frequency (speed of vision), and chromatic (color) sensitivity of juvenile and adult black sea bass.
4. Provide intensity thresholds for the lower and upper limits of visual function
5. Determine whether visual and auditory responses of black sea bass are correlated with gender (male, female, and intersex) and gonadal development.
6. Provide recommendations to aquaculture and management agencies involved with habitat issues and production of black sea bass in the mid-Atlantic region.

***Results to date**:* Drs. Johnson, Horodysky, and Brill recruited two students for this project, Ms. Joe'Ella Caddle (BS, UMES 2010) and Ms. Kendyl Crawley-Crawford (Junior, HU). The students, Dr. Horodysky, and Dr. Brill lived in residence at the VIMS Eastern Shore Laboratory in Wachapreague, VA during the summer, and Dr. Johnson commuted during several vision and hearing experiments. Research was therefore conducted via live-in immersive experience, with the students getting a broad spectrum of experience on this project and others. Skills learned by the students to date on this project include: experience using several types of fishing gear; capture, transport, and identification of marine fishes; animal husbandry and water quality analyses in flow-through (open) and recirulating (closed) systems, electrophysiological techniques (auditory brainstem response and electroretinography), and electrophysiological data analysis. Value-added skills outside of this project learned by the students during their immersion internship experience included: bivalve aquaculture and husbandry, collection and blood sampling of elasmobranchs, familiarity with methods to assess crustacean metabolic rate under hypoxia, team building exercises.

Juvenile black sea bass were obtained via trawl gear and fish traps; adults were obtained by hook and line and from a commercial fisherman operating in Virginia waters. Fish were transported to the VIMS Eastern Shore campus in Wachapreague, VA and maintained in flow-through (juvenile) or temperature controlled, filtered, and oxygenated recirulating 1000 L aquaria (adults). Subjects were fed dried krill and live grass shrimp, and were starved 48 hrs prior to experiments to ensure gastric evacuation. At the time of a trial, each fish was removed from holding tanks during daylight hours, sedated with an intramuscular (IM) dose of ketamine hydrochloride (30 mg kg-1), and immobilized with an IM injection of the neuromuscular blocking drug gallamine triethiodide (Flaxedil; 10 mg kg-1). At the conclusion of each experiment, each fish was euthanized humanely via a massive IM dose of sodium pentobarbital (~300 mg kg-1) and dissected. Measurements of total length (TL, mm), body weight (g) and gonad weight (g) were taken and gonad samples collected for histopathology.

Sound in water is composed of two physically linked components, propagating scalar pressure waves and directional particle motion, which differ in the pathways through which they reach the inner ears of fishes. The otoliths of all fishes are biological accelerometers that directly detect the vector particle motion components of sound as a result of inertial differences between sensory epithelia and otoliths. Additionally, the pressure component of sound may be detected indirectly by some fishes via accessory anatomical structures that transform sound pressure waves into particle displacements.

Few studies have examined hearing thresholds with respect to pressure and particle motion sensitivity, especially throughout development. We therefore performed auditory brainstem response experiments using a hydrophone and geophone to assess ontogenetic changes in the responses to particle motion and pressure components of sound in juvenile and adult black sea bass. Auditory abilities of black sea bass were assessed via auditory brainstem response (ABR) experiments, which are non-invasive recordings of the neural activity in the eighth cranial nerve and brainstem in response to synchronized acoustic stimuli. Experiments were conducted for 7 juveniles and 4 adults. Juvenile and adult fish demonstrated responses from 100-2,000 Hz, consistent with the interpretation that black sea bass are hearing generalist fishes presumably more sensitive to the (vector) particle motion components of sound. Thresholds did not vary significantly with ontogeny as evidenced by strongly overlapping confidence intervals, and both juveniles and adults demonstrated lower (i.e. more sensitive) thresholds at lower frequencies. Ongoing work includes the calculation and expression of thresholds re: 1uPa (pressure) and 1 cm s-1 (particle motion) and calculation of the theoretical auditory ranges as a function of depth, using the pressure thresholds of juveniles and adults. By virtue of their structure-associated ecological habits and their greater sensitivity to low frequency sounds, black sea bass are susceptible to anthropogenic noise pollution resulting from marine construction, offshore drilling, and the creation and operation of offshore wind farms. Future research avenues for additional leveraged funding may include the effects of marine noise on the structure and function of black sea bass auditory systems, including thresholds for damage of the otic system.

The visual function of black sea bass was investigated via whole-animal corneal electroretinography (ERG). Separate experiments assessed the range of luminous sensitivity, the speed of vision, and the range of wavelength (color) sensitivity of black sea bass visual systems. High quality ERG data were obtained from 7 juveniles, 10 adult males, and 9 adult females. Juveniles exhibited strongly diel-variant luminous sensitivity, with significantly better sensitivity to dim light at night than during the day. Adults exhibited less marked increases in nocturnal luminous sensitivity, however, adults were ~100 times more sensitive to dim light during the day than juveniles. Adults also experienced slower vision than juveniles, consistent with the former's selection of deeper coastal habitats. Black sea bass demonstrated strong sex-specific differences in chromatic (color) sensitivity. Male sea bass exhibited comparatively stronger responses to short wavelength (blue) stimuli during daylight hours than females, suggesting that the blue nuptual coloration of nuccal crests in dominant males may serve more of a role in agonistic male-male signaling than in mate attraction. This is an interesting hypothesis for potential future behavioral experimentation. Future research avenues for additional leveraged funding may include the effects of increasing turbidity and hypoxia on the structure and function of black sea bass visual systems, including threshold distances for communication and/or sex-specific catchability in gears reflecting various wavelengths.

Ongoing work for both vision and hearing datasets includes histological processing of gonad samples and statistical analyses. Electrophysiological recordings are non-independent within subjects, therefore ABR and ERG data will be analyzed using two-way repeated measures ANOVAs. Covariance structures that best describe within-individual correlations will be selected via Akaike's Information Criterion (AIC) in an Information Theoretic approach. For vision experiments, additional analyses to be conducted include rhodopsin template fitting, developed/coded by A.Z. Horodysky in R. The program comparatively fits pigment templates (such as those of Singarajah and Harosi (1992)) to ERG spectral sensitivity data via maximum likelihood and selects among templates via Information Theoretic methods.

***Notable achievements**:* This project resulted in both an oral and poster presentation at the 2011 ASLO Aquatic Sciences Meeting in San Juan, Puerto Rico. Citations for the presentations are given below. Ms. Kendyl Crawley Crawford was awarded an *Outstanding Student Presentation Award* for her oral presentation on the vision portion of this project. This is a highly honorary award, particularly for an undergraduate presenting amidst hundreds of undergraduate and graduate students in an international conference of ~ 2,000 attendees. Ms. Crawford has submitted an extended abstract to present the vision component and be considered for a student award at the 2011 national meeting of the American Fisheries Society in Seattle, WA.

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 LMRCSC 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. Drs. Horodysky and Rich McBride (NOAA Fisheries - NEFSC) had a conversation in spring 2011 about this project; Dr. McBride was provided with K. Crawford's extended AFS abstract.

How will results be incorporated into LMRCSC research and curriculum? Data from this project were included in lectures in Dr. Johnson's Fish Physiology Course and Dr. Horodysky's Ichthyology course. Drs. Horodysky, Johnson, and Brill recently received funding for a companion 2011 TAB proposal to assess vision and hearing in tautog (*Tautoga onitis*), with the goal of 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.

9. Project Title: Understanding the interaction of probiotic and pathogenic bacteria in oyster larvae hatchery culture.

Project Description: The focus of the project was to use gene-specific molecular tools to quantify the concentration of probiotic and pathogen bacteria present during the course of infection. Results from these studies will allow us to determine how long they are maintained by the oyster larvae as well as provide insight into where they may act.
Thematic Area Addressed: Aquaculture
Lead Scientist(s): Dr. Hal Schreier (UMBC-IMET), Dr. Eric Schott (UMCES-IMET)
NOAA Collaborator(s): Dr. Gary Wikfors and Ms. Diane Kapareiko, NEFSC, Milford, CT
LMRCSC Collaborator(s): Dr. Dennis McIntosh, Delaware State University
LMRCSC Research Student(s): Ms. Oluchi Ukaegbu, Delaware State University
Start Date: June, 2010
End Date: December, 2010

Planned and actual results of project: As part of ongoing studies on improving shellfish aquaculture, the Milford Lab isolated several bacteria from digestive glands of eastern oysters or bay scallops that have inhibitory effects against known shellfish-pathogen bacterial B183. The characterization of one strain, OY15, was the focus of the 2009 TAB-funded project, which found that the strain was related to *Vibrio parahemolyticus*, produced extracellular amylase, lipase and metalloproteases, which likely contributed to its ability to act as a probiotic. Furthermore, while strain OY15 was found to have little influence on larval or culture water bacterial communities (as determined by 16S rRNA bacterial diversity analyses), it was hypothesized that its role as a probiotic was likely a result of direct interactions with the oyster itself, which is consistent with results from previous hemocyte and immunosuppression studies.

The focus of the study was to begin understanding the spatial and temporal relationships for OY15 and B183 by applying quantitative assays that enumerated both strains from different treatments. This approach required the development of molecular tools to allow for a quantitative measure of OY15 and B183 DNA sequences. Initially, we focused on characterizing the 16S-23S rRNA gene sequences from both strains in order to identify sequences from the intergenic regions that could be used to develop gene specific probes. Using oligonucleotide primers designed for 16S and 23S rRNA gene sequences, four unique 16S-23S rRNA intergenic sequences (IGSs) were isolated from strain B183 and three were identified from OY15. These sequences were characterized by phylogenetic analyses and alignments were used to design species-specific primers for quantitative polymerase chain reaction (qPCR) assays. Determining primer applicability for qPCR assays was done using total DNA extracted from *C. virginica* larvae (starting with two-day old cultures) treated with either B183 (10^5 CFU/ml @ days 2, 3, and 4), OY15 (10^3 CFU/ml @ days 2, 3, and 4), both bacteria, or no bacterial treatments. While we sought conditions for amplifying IGS regions by PCR that could clearly distinguish DNA from B183 and OY15, a small level of cross reactivity was encountered, which was not acceptable for the high sensitivity of qPCR protocols. Thus, it was necessary to identify another set of genes that could be targeted for the application of the qPCR technology.

After carrying out a literature search, we turned our attention to two genes—*toxR* and *dnaJ*—that were shown to be effective in identifying and quantifying different *Vibrio* sp. in environmental samples. Since we previously showed that *toxR* could not be amplified from B183, we used primers developed by Takahashi *et al*. [J. Microbiol. Methods 61:77-85 (2005)] to clone this gene from OY15. Sequence analysis showed that the OY15 *toxR* gene had high sequence similarity to *toxR* from *V. alginolyticus* and *V. parahaemolyticus*, which was consistent with our previous 16S rRNA gene analysis (noted above). Using the approach described by Pollock *et al.* [Appl. Env. Microbiol. 76:5282-5286 (2010)], we cloned *dnaJ* from B183. Sequence analysis indicated that the B183 *dnaJ* gene had high sequence similarity to *dnaJ* from *V. coralliilyticus* and *V. neptunius*. Both primer sets were found to be specific for their own targets and no cross reactivity was detected under the PCR conditions used for amplification. Taqman primers based on both *dnaJ* and *toxR* sequences were developed and qPCR experiments were done using DNA prepared from treated and untreated oyster larvae cultures. Our preliminary results have indicated that this approach has yielded information about the numbers of B183 and OY15 in each treatment; evaluating these results is presently in progress.

The successful identification of species-specific probes places us in an excellent position to determine OY15 and B183 prevalence and location, which are the focus of continuing studies. The 2010 research included a trip

to Milford by Oluchi Ukaegbu, who worked with Dr. Wikfors and Ms. Kapareiko to collect samples of oyster larvae exposed to B183 and OY15. Ms. Ukaegbu returned to IMET where she has continued to work towards quantifying the populations of these two bacteria.

How will results be incorporated into NOAA Fisheries operations? Oyster restoration in the Chesapeake Bay and elsewhere is a NMFS priority. With natural spat falls limiting recruitment in many areas, hatchery technology is relied upon to support both aquaculture and ecological restorations. Our studies will provide additional understanding into probiotic bacterial mechanisms and will set the foundation to develop strategies for inhibiting pathogenic bacterial activity in oyster larval culture. The studies will also allow us to determine the next set of questions that need to be addressed in order to gain additional insight into these processes, which we hope to carry out in the next funding period.

How will results be incorporated into LMRCSC research and curriculum? The project was instrumental in providing a Delaware State University student, Ms. Oluchi Ukaegbu, enhanced training in oyster spawning and aquaculture technology and in modern microbial molecular ecology techniques, approaches that are not readily available in standard lab classes. The project also provided a foundation for continued collaboration between the Milford Lab, Delaware State and IMET scientists.

10. Project Title: The use of DNA markers to evaluate US fishery management areas and effective population size of monkfish, *Lophius americanus*

Project Description: The American monkfish (*Lophius americanus*) supports one of the most lucrative fisheries in the northwest Atlantic Ocean. Despite a paucity of life history, genetic or behavioral data, monkfish management in the US divides the species range into Northern and Southern Management Areas (NMA and SMA). However, little is known of stock structure, an understanding of which is critically important to population assessment. The purpose of this study was to elucidate genetic differences between the two monkfish management areas. Monkfish (males, n =188; females, n= 153) were collected seasonally (winter-spring, fall) with gill and trawl nets from Cape Cod, MA to Cape Hatteras, NC during the 2009 to 2011 NOAA Living Marine Resources Cooperative Science Center research cruise, 2009 NEFSC Cooperative Monkfish survey, and 2010 NEFSC annual trawl survey. Preliminary studies revealed three major genetic clades that were spatially distributed and not associated with management areas. This study will provide critical information necessary for improving the management of this important commercial fishery.

Thematic Area Addressed: Essential Fish Habitat
Lead Scientist(s): Andrea Johnson (UMES)
NOAA Collaborator(s): Anne Richards, NOAA, Northeast Fisheries Science Center, Woods Hole
LMRCSC Collaborator(s): Dr Allen Place (UMCES IMET)
LMRCSC Research Student(s): Belita Nguluwe, graduate (UMES)
Industry collaborators: Research vessel: Delaware II, Fishing vessel: Mary K and the Endurance
Planned Start Date: January 2011
Planned End Date: December 2011

Actual Start Date: June 2009
Actual End Date:

Planned and actual results of project: Monkfish (*Lophius americanus*) samples (n=311) have been processed and in the winter of 2011 additional samples (n=22) were collected during the NOAA LMRCSC research cruise for genetic analysis. During the NOAA LMRCSC research cruise monkfish were caught in Norfolk (n =10) and Hudson (n =12) canyon; these samples are in the process of being analyzed. Monkfish samples collected in 2009 and 2010 were analyzed using mtDNA and rRNA primers which were identified as cytochrome oxidase I (*COX-I*) and *12S* respectively; primers were designed using the Primer3 program. The sequences were obtained from NCBI gene bank. The *COX-I* primer yielded fairly desirable gel bands as well as allele peaks and was used as a marker to determine if there were identifiable genetic groups that were related to one another and the management areas. The

12S rRNA was used to check polymerase chain reaction (PCR) reliability for both the 2009 and 2010 monkfish samples.

Methods: The American monkfish study area includes U.S. waters of the northwest Atlantic Ocean ranging from the Gulf of Maine and Georges Banks south through the Mid-Atlantic region to Cape Hatteras, North Carolina. Monkfish (males, n =188; females, n= 153) were collected seasonally (winter-spring, fall) with gill and trawl nets from Cape Cod, MA to Cape Hatteras, NC during the 2009, 2010 and 2011 NOAA LMRCSC research cruise, 2009 NEFSC Cooperative Monkfish survey, and 2010 NEFSC annual trawl survey). Liver and fin clips were collected for genetic analysis and stored in 2mL nunc tubes with 95% ethanol or in RNALater, a salt solution used to preserve samples for RNA analysis. A DNA extraction and amplification protocol adapted by Dr. Place's lab (UMCES-IMET) was used to process collected monkfish samples.

Preliminary results showed three genetic groups but no spatial correlation to the management areas, suggesting no geographic isolation among the three groups. A 594bp region of mtDNA was yielded from mtDNA sequenced PCR products, which was then aligned and curated on Sequencher. CLC workbench was used to generate a phylogenetic tree and bootstraps were assigned to estimate precision.

In the summer of 2010 additional samples were collected (n=113) and extracted (n=21) and a 635bp region of COX-I was yielded from PCR products which was then aligned (n=105) using CLUSTALW and visually curetted on Sequence scanner v1.0. MEGA 4.0 was used to generate a phylogenetic tree. The 2009 (n=219) samples were included in phylogenetic tree (n =84).

Conclusions: Three genetic groups were observed which consisted of L.a. I, L.a. II and L.a III. The non-spatial correlation of the groups suggests that the examined monkfish population may not be a unit stock. Genetic assortment does not correspond to either management area, implying that the monkfish in US waters are not geographically isolated. Two outliers were observed in the phylogenetic tree which may be an indication of the presence of another species of monkfish (*Lophius gastrophysus*) that is primarily distributed south of Cape Hatteras, NC.

The 2009 and 2010 samples Neighbor-Joining (NJ) derived tree exhibited three major clades but the individuals did not correspond to those in 2009 clades. The 2009 and 2010 samples were run with 12S rRNA to test PCR reliability and species verification. Samples (n = 78) that did not yield PCR products collected in 2009 (n = 67) and 2010 (n =11) were re-extracted and amplified with *COX-I* primer. Successfully amplified PCR products (n = 37) will be used for genetic analysis.

Future Plans: For 2011, juvenile monkfish (n = 28) are to be processed for species identification. The samples are intended to be used for species veracity for collected adult monkfish that did not amplify with *Lophius americanus* specific primers. In addition to species verification, mapping of the observed clades will be performed to determine spatial distribution. Genetic data analysis will be conducted to examine the population genetics and haplotypes of the clades found within the management areas.

How will results be incorporated into NOAA Fisheries operations? This proposal addresses the RFP's targeted research area of Essential Fish Habitat. This project will provide managers with a biological test of the current management boundary set between monkfish stocks and provide estimates of genetic population size for this heavily exploited commercial resource. These data will be considered in context with previous and ongoing UMES monkfish life history studies and annual ecological and oceanographic variables. Results will be published in a report to the LMRCSC, submitted to a peer-reviewed journal and presented at scientific conferences.

How will results be incorporated into LMRCSC research and curriculum? This research will provide data for partial fulfillment of the requirements of the MEES MS Program for a UMES graduate student (Belita Nguluwe). Belita Nguluwe presented preliminary results (Genetic Discrimination of Monkfish Population in Northwest Atlantic using COX-I gene) at 2011 American Society of Limnology and Oceanography (ASLO) Aquatic Sciences meeting in San Juan, Puerto Rico.

Table 5. Projects approved by TAB for 2010/2011

Principal Investigators	Proposal Title	Amount Approved
1. Joe Pitula (UMES), Feng Chen (IMET), Eric May (UMES), Courtney Schupp (NPS)	Correlation of biotic and abiotic factors in environmental presence of *Hematodinium*	$28,842.00
2. Sook Chung (IMET), Joe Pitula (UMES), Gretchen Messick (NOAA)	Determining critical stages of *Hematodinium* 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, *Microgadus tomcod*	$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

1. Correlation of biotic and abiotic factors in environmental presence of *Hematodinium*

Joe Pitula (UMES), Feng Chen (IMET), Eric May (UMES), Courtney Schupp (NPS)

This project is a continuation of the project that was funded in 2009/2010. A description of an updated result of the project has already been given on pages 10 and 11 above.

2) 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 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.
Thematic Area Addressed*:* *Quantitative Fisheries /Aquaculture*
Lead Scientist(s): J. Sook Chung, UMCES-IMET
NOAA Collaborator(s)*:* G. Messick, NOAA Oxford Lab

LMRCSC Collaborator(s)*:* J. Pitula, UMES
LMRCSC Research Student(s)*:* Z. Sankoh, Morgan State University
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 LMRCSC research and curriculum? Training was provided to undergraduate intern Z. Sankoh, Morgan State University (Sept. 1-Dec. 17, 2010). J. Sook Chung is incorporating the findings of this research into MEES 698M: Comparative and Molecular Endocrinology, Spring 2011.

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

Project Description: Black sea bass (*Centropristis striata*) 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. In Year 1, we plan to build and test a video observation platform and observe fish in traps. In Year 2, we will refine techniques for assessment and develop standard video sampling procedures.

Thematic Area Addressed: Quantitative Fisheries; Essential Fish Habitat
Lead Scientist(s): Bradley G. Stevens (UMES)
NOAA Collaborator(s): Gary Shepherd, Vincent Guida, NEFSC

LMRCSC Collaborator(s): Elizabeth Babcock (RSMAS)

LMRCSC Research Student(s): Dan Cullen (Ph.D, UMES)
Start Date: 1 Jan 2011 **End Date:** 31 December 2011

Planned and actual results of project: In February 2011 we began interviewing commercial fishermen for this project, then selected Chet Townsend who co-owns two vessels, including the 50 ft F/V "Andrew J", berthed in Ocean City MD. After inspecting their vessel to see how it met our needs, we borrowed two commercial Black sea bass traps from them in order to begin modifications for camera mounting. We also settled on a design for a small camera sled, and have contracted with a commercial welder to build the sled. We began purchasing small items, including Go-Pro HD cameras, a Panasonic Tough-book computer, and navigational software. We are still negotiating purchase of a Deep-sea Power and Light (DSPL) multi-sea cam with associated lights and cables, pending resolution of power requirements and availability. We hope to have all equipment in hand and ready to work by 23 May, 2011. In addition, we added an MS student, Ms. Courtney McGeachy, who will undertake the task of observing fish behavior in traps, with a goal of determining entry times and rates, and exit rates; we are hoping she can also make some controlled observations of Black sea bass behavior in the large tank at the Sandy Hook lab later in the summer.

Due to budget limitations we had to eliminate side-scan sonar rental and 3 days of sea time, leaving only 8 days for the project. However, we may be receiving additional funds from the State of MD for a habitat assessment project, some of which can be used to help test the camera sled, thus freeing up more of our sea time for actual work.

How will results be incorporated into NOAA Fisheries operations? We expect to achieve several goals with applicable results: 1) Fish behavior in traps: estimate arrival times, entry rates and exit rates; these will allow better

understanding of the meaning of trap CPUE, how it relates to fish abundance, and the natural progression of catch rates over time. This will allow managers to interpret CPUE and landings data with greater accuracy. 2) Video-based assessment: we hope to determine if video-based estimates are feasible, and if they are correlated with habitat and trap catches; if so, they can be used as a quantitative measure of abundance, and add to the available data base for stock management.

How will results be incorporated into LMRCSC research and curriculum? We expect that one Ph.D dissertation and one M.S Thesis will be based partially on the results of this research. 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.

4) 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); Dr. Ali Ishaque (UMES)
NOAA Collaborator(s): Dr. Chris Chambers (NOAA Fisheries Service)
LMRCSC Collaborator(s): None
LMRCSC Research Student(s): Adam Tulu (UMES)***Start Date:*** 01/03/11

Results of project*:* 5' and 3' rapid amplification of cDNA ends (RACE)-PCR has been successfully applied to construct the full length cDNA sequence of CYP19a aromatase.

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.

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 will also be used to support a summer undergraduate intern.

7) 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 LMRSCS RFP, and directly supports the mission of NOAA-Fisheries, and provides research experience for undergraduate students.

Thematic Area Addressed: Essential Fish Habitat/Aquaculture
Lead Scientist(s): Dr. Andrij Z. Horodysky, HU
NOAA Collaborator(s): Dr. Richard W. Brill, NOAA, NEFSC, Woods Hole, MA and VIMS
LMRCSC Collaborator(s): Dr. Andrea Johnson, UMES
LMRCSC Research Student(s): TBA, UMES; Ms. Elizabeth Seagroves, Hampton University
Planned Start Date: 1 Jan 2011
Planned End Date: 31 Dec 2011

Planned results: This project will:
1. Characterize the frequency sensitivity and pressure and particle motion thresholds of tautog.
2. Using auditory thresholds, calculate theoretical auditory ranges as a function of depth.
3. Characterize the luminous (intensity) sensitivity, flicker fusion frequency (speed of vision), and chromatic (color) sensitivity of tautog.
3. Provide intensity thresholds for the lower and upper limits of visual function
4. Determine whether visual and auditory responses of tautog are correlated with gender and gonadal development.
5. Provide recommendations to aquaculture and management agencies involved with habitat issues and fisheries production of tautog in the mid-Atlantic region

Results to date: Drs. Johnson, Horodysky, and Brill are recruiting two students for this project. Ms. Elizabeth Seagroves (Junior, HU) has accepted the offer to participate in this research. Dr. Johnson is still evaluating candidates for the UMES summer undergraduate research position.

Tautog will be obtained via fish traps operated by a commercial fisherman operating in Virginia waters and by hook and line. Fish will be transported to the VIMS Eastern Shore campus in Wachapreague, VA and maintained in flow through (juvenile) or temperature controlled, filtered, and oxygenated recirulating 1000 L aquaria (adults). Subjects will be fed dried krill and live grass shrimp, and will be starved 48 hrs prior to experiments to ensure gastric evacuation. At the time of a trial, each fish will be removed from holding tanks during daylight hours, sedated with an intramuscular (IM) dose of ketamine hydrochloride (30 mg kg-1), and immobilized with an IM injection of the neuromuscular blocking drug gallamine triethiodide (Flaxedil; 10 mg kg-1). At the conclusion of each experiment, each fish will be euthanized humanely via a massive IM dose of sodium pentobarbital (~300 mg kg-1) and dissected. Measurements of total length (TL, mm), body weight (g) and gonad weight (g) will be taken and gonad samples collected for histopathology.

Accomplishments to date:
- HU intern (Elizabeth Seagroves, Junior) has been selected.
- Equipment and supplies are being purchased (Feb. - present)
- All hands research meeting will be held on 03/24/11 in Wachapreague
- Planning of fish transport and experimental logistics will be from March to June
- Fish to be collected in April-May 2011
- Experiments will begin 1 June 2011

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 LMRCSC 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. The results will be reported to local, state, and federal constituents as well as at national scientific meetings.

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 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.

8) 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, UMCES - IMET
NOAA Collaborator(s): James A. Morris, Jr. NOAA, NOS, NCCOS, Beaufort, North Carolina
LMRCSC Collaborator(s): Thomas E. Rippen, Seafood Technology Specialist, UMES, Princess Anne, MD
LMRCSC Research Student(s): An LMRCSC summer intern will be hired for the summer of 2011
Start Date 1/1/2011

Results of project: A sensory discrimination ballot has been developed for use with a taste panel at UMES. A triangle test will be used to determine if panelists are able to distinguish flesh from fish grown on the two diets. Procedures for cooking will be standardized to assure uniformity of cooking for samples presented to panelists. In addition to determining if sensory differences exist, panelists will be asked to rate the intensity of the difference and to attribute it to appearance, odor, flavor and/or texture. UMES IRB approval was sought and given for the sensory protocol.
Aaron Watson has been awarded the 2011 Mulvihill Scholarship (World Aquaculture Society).
Seminars given by the PI to NOAA members
September, 2010, NMFS, Beaufort Laboratory: Scrabbled Modules, Spliced Leaders And Cap Dependent Translational Control - Dinoflagellates Break All The Eukaryotic Paradigms.
October 2, 2010: NMFS, Beaufort Laboratory: Saving our Fisheries - Development of a Fish-Free Diet for Aquaculture

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 providing training to Aaron Watson and will provide training to a summer undergraduate intern.

9. 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, will be 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 will complement currently funded work (NSF-CREST) that assesses croaker movement in Chesapeake Bay via telemetry. The intent is to provide a model approach which can be applied to other fish species. Coupled with habitat mapping of the Chesapeake Bay, we will provide important information on how essential fish habitat is affected by increases in the spatial extent and duration of seasonal hypoxia in Chesapeake Bay.

Thematic Area Addressed*:* Essential Fish Habitat, Aquaculture

Lead Scientist(s): Dr. Andrea Johnson (University of Maryland Eastern Shore)
NOAA Collaborator(s)*:* Dr. Richard W. Brill (NOAA, NEFSC, Woods Hole, MA and VIMS)
LMRCSC Collaborator(s)*:* Dr. Andrij Z. Horodysky (Hampton University).
LMRCSC Research Student(s)*:* TBA, UMES; Ms. Elizabeth Seagroves (Hampton University)

Planned Start Date: 1 Jan 2011
Planned End Date: 31 Dec 2011

Planned results: This project will:
1. Determine the temperature preference of Atlantic croaker under normoxic conditions and two levels of hypoxic exposure.
2. Evaluate the effects of temperature and hypoxia treatment on Atlantic croaker general health
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
4. Provide recommendations to management agencies involved with habitat issues in the mid-Atlantic region.

Drs. Johnson, Horodysky, and Brill are recruiting two students for this project. Ms Elizabeth Seagroves (Junior, HU) has accepted the offer to participate in this research. Dr. Johnson is still evaluating candidates for the UMES summer undergraduate research position. The students, Dr. Horodysky, and Dr. Brill will live in residence at the VIMS Eastern Shore Laboratory in Wachapreague, VA during the summer, and Dr. Johnson will commute during several vision and hearing experiments. Research will therefore be conducted via live-in immersive experience, with the students getting a broad spectrum of experience on this project and others.

Atlantic croaker will be obtained from a commercial fisherman operating in Maryland and Virginia waters and by hook and line. Fish will be transported to the VIMS Eastern Shore campus in Wachapreague, VA and maintained in flow-through (juvenile) or temperature controlled, filtered, and oxygenated recirculating 1000 L aquaria (adults). Subjects will be fed dried krill and live grass shrimp, and will be starved 48 hrs prior to experiments to ensure gastric evacuation. At the conclusion of each experiment, each fish will be euthanized humanely via a massive IM dose of sodium pentobarbital (~300 mg kg-1) and dissected. Measurements of total length (TL, mm), body weight (g) and gonad weight (g) will be taken and gonad samples collected for histopathology.

Experiments will be conducted for 15 Atlantic croaker. At the time of a trial, a fish will be removed by Dr. Horodysky from holding tanks during daylight hours and allowed to acclimate to a Loligo Systems Shuttlebox behavioral tank for 24 hrs. Advanced electronic shuttleboxes that produce a horizontal gradient controlled by the spatial movements of the organism have been used in several temperature preference (Neill et al., 1972; Reynolds and Casterlin, 1978; Schurmann et al., 1991; Mortensen et al. 2007) as well as salinity preference studies (Serrano et al., 2010). The system consists of two round chambers connected by a tube and includes two recirculation pumps, four dosage pumps (for warm and cold inflow), two temperature mixing towers, a CCD video camera, two temperature probes to monitor temperature continuously. Shuttlebox experiments are driven by behavioral movements of individual fish as monitored via video software and custom data acquisition software; changes in temperature are controlled by a DAQ instrument that regulates the activity of sets of pumps, depending on the position of the fish and the difference in temperature between the two tanks (Schurmann et al., 1991; Serrano et al., 2010). Passage of the fish into the warmer side of the tank prompts the dosage pumps to increase the temperature in both tanks; the reverse occurs if the fish swims into the low temperature tank. When the fish remains stationary in the

connecting tube, all pumps are turned off and temperature is maintained at a constant value until the fish moves again into one of the experimental tanks (Serrano et al. 2010).

***Temperature preference under hypoxia experiments**:* Croaker will be introduced into the shuttlebox containing air-saturated water at 27°C. The light/dark cycle will follow the same as in the holding tank (ambient). Each fish will be allowed an overnight period of acclimation to the shuttlebox. After the acclimation period, each subject will be allowed to thermoregulate for 1 day at each of the following oxygen concentrations: normoxia (6.5 mg/L), moderate hypoxia (3.0 mg/L), and severe hypoxia (1.4 gl/L). The shift in oxygen concentrations will be made 1 h before the simulated dusk, with the new PO2 established in < 1 h. The oxygen concentration will be measured with an acid-base analyzer and oxygen electrode. Since the electrode is temperature-sensitive, the measurements of oxygen concentration cannot be made directly in the chambers (where the temperature fluctuated); O2 concentration will thus be measured in a cuvette at 25 °C, with a constant flow of water maintained past the electrode by a roller pump. The desired oxygen concentration will be maintained by a computer-controlled system that triggers the addition of pure N2 or air into the recirculating water to maintain the desired assay concentration (following Schurmann et al. 1991).

Evaluating the effects of temperature and hypoxia treatment on Atlantic croaker general health: To determine the impact of the stressors on the fish's general health (i.e., temperature and hypoxia), blood samples will be analyzed for electrolytes, plasma chemistry and hematological changes. In addition, histology samples will be collected at the end of the experiments to evaluate the general health of the wild-caught croaker. Sample processing and data analyses for this experimental objective will be conducted by the UMES graduate and undergraduate students under the direction of Dr. Andrea Johnson at UMES.

Indicators of overall health and tissue damage: Organosomatic Indices: Hepato-somatic index (HSI) will be used as an indicator of exposure to environmental stressors, as nearly all cells of the liver are affected by toxic agents. Spleno-somatic index (SSI) will be used as an indicator of environmental conditions, disease and/or immune functional response. Splenic dysfunction due to adverse environmental conditions has been observed in teleosts exposed to contaminants. Hepatosomatic indices and SSIs will be calculated as 100 X (organ weight (mg)/ body weight mg) . Gonadosomatic index (GSI) will be used as an index of gonadal growth from the formula: gonad weight/(body weight-gonad weight) X 100. Histopathologic analysis of gill, heart, liver, spleen and anterior kidney will be used to determine tissue damage and general health of these wild-caught fish. Gonad samples will be collected for histology to determine sex and gonadal development of croaker. Samples will be fixed in 10% NBF, routinely processed, embedded in paraffin, sectioned at 5 µm and stained with hematoxylin and eosin (H&E).

Indicators of Physiological Condition: Blood smears for differential leukocyte counts and whole blood samples will be analyzed in Dr. Johnson's Fish Health lab at UMES. The packed cell volume (PCV or hematocrit), plasma proteins, plasma chemistries and electrolytes will be used as indicators of disease, immune function and physiological condition. These health indicators have been widely studied and applied to both laboratory and field studies. Smears will be stained with Wright-Giemsa stain (Volu-Sol, Inc., Salt Lake City, UT) and 100 leukocytes on each slide will be identified. The packed cell volume will be determined by reading the packed cell percentages using microhematocrit tubes. Plasma total solids will be measured with a refractometer (Leica Microsystems). Indicators of organ and/or muscle damage include: creatine kinase (CK), aspartate aminotransferase (AST) and lactate dehydrogenase (LDH). Glucose, phosphorus, calcium, total protein, albumin, globulin, AST, CK and LDH will be measured with an automated chemical analyzer (Analyst II, Hemagen Diagnostics). Electrolytes (sodium, potassium and chloride) will be measured using the EasyVet NaKCl analyzer (Hemagen Diagnostics).

Results to date: Winter 2011

- HU intern was selected (Elizabeth Seagroves, Junior). UMES interview process is ongoing
- Budgets are being loaded (Feb-March)
- Equipment and supplies are being purchased (Feb-present)
- All hands research meeting will be on 03/24/2011 in Wachapreague
- Planning of fish transport and experimental logistics will be from March to June
- Fish will be collected in April-May 2011
- Experiments will begin 1 June 2011

How will results be incorporated into NOAA Fisheries operations? The overall goals of this project are to provide data relevant to the habitat use and resiliency to anthropogenic stressors and habitat degradation of a managed fisheries resource consistent with the missions of the LMRCSC 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 will be combined with data from studies of black sea bass to 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

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

Project Description: The effect of climate change is expected to raise the temperature of southern New England waters by up to 4.5 ˚C in this century, resulting in water conditions more like the current mid-Atlantic region. This may result in northward expansion of fish species as well as their pathogens. DE Bay is the northern limit for commercial harvest of blue crab, though substantial populations extend to MA and support a recreational fishery. Using molecular assays, we will assess the prevalence of two fatal pathogens of blue crab, a reovirus and a protozoan parasite, in the northern range from DE Bay to the south shore of MA. This student project can serve as a template for long-term studies of the effects of climate change and latitude on blue crab disease prevalence in the Northeast.
Thematic Area Addressed: Quantitative Fisheries, Essential Fish Habitat
Lead Scientist(s): Eric J Schott, UMCES-IMET
NOAA Collaborator(s): Gretchen Messick, NCCOS, Oxford Lab
LMRCSC Collaborator(s): Dennis McIntosh, Delaware State University
LMRCSC Research Student(s): Ammar Hanif (M.S. student, Univ of MD); Summer intern to be determined.
Other collaborators: Robert Scarborough, Delaware NERR**,** Ron Goldberg, NOAA-NMFS Milford Lab., Paul Jivoff , Rider University, at NJ NERR, Bruce Estrella, Massachusetts Division of Marine Fisheries

Planned Start Date: Dec. 1, 2010
Planned End Date: Nov. 30, 2011

Actual Start Date: Feb. 1, 2011
Actual End Date:

Planned and actual results of project: The bulk of this project will commence in June with the first samples of crabs in the DE NERR. As of February, commitments to collect crabs in Northeast states have been established and reconfirmed. Dr. Schott has communicated with each of the partners in four states, to coordinate harvest and shipment of blue crabs from DE, NJ, CT, and MA. Details of harvesting and shipping methods were reviewed.

In February, Mr. Hanif, Dr. Schott, and Dr. McIntosh met with Bob Scarborough, at the DE National Estuarine Research Reserve, to have a tour of the field sampling sites and main station at the DE NERR. Mr. Hanif conferred with staff at the NERR on plans to conduct multi-species surveys at the time that he trawls for crabs in June and October.

Dr. Schott and Dr. McIntosh have circulated a flyer to attract quality undergraduate summer interns to apply for the paid position working at IMET from June to August. Applicants from DSU will be evaluated along with applicants from a number of other institutions.

The number of crabs expected to be analyzed in this project is from 250 to 400. The analyses include extraction of RNA and DNA, and conducting rt-PCR and qPCR.. To reduce the cost and time required for rt-PCR, Dr. Schott has recently verified that a new commercial product (Applied Biosystems TaqMan 1 step virus master mix), is effective for detection of the reolike virus. Mr. Hanif has become very proficient in DNA and RNA extractions, and

with this rapid RT-PCR assay reagent we are confident in our ability to process in a timely manner all the crabs we receive.

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

How will results be incorporated into NOAA Fisheries operations? This project will provide unique data on disease prevalence in blue crab from DE to MA. The data generated will help to develop concepts about the ramifications of climate change on diseases affecting a fishery valued in the tens of millions of dollars.

How will results be incorporated into LMRCSC research and curriculum? Information on blue crab health and disease is included in a graduate level seminar course ("Diseases in the Chesapeake Bay") offered by E.J. Schotts through the MEES program at the University of MD.

Ammar Hanif will be presenting his poster "Using molecular methods to monitor pathogens in early life history of blue crabs (*Callinectes sapidus*)" at the NOAA Symposium, at NOAA Headquarters in Silver Spring MD, on March 24, 2011.

12. Project Title: The use of DNA markers to evaluate US fishery management areas and effective population size of monkfish, *Lophius americanus.*

Belita Nguluwe (UMES-Student), Andrea Johnson (UMES), Al Place (IMET), Anne Richards (NOAA)

This project is a continuation of the project that was funded in 2009/2010. A description of an updated result of the project has already been given on pages 22 to 24 above.

SCHOLARLY PRODUCTIVITY

In the current reporting period, LMRCSC students and faculty made 33 presentations (19 oral and 14 poster) at scientific meetings, published 6 articles in refereed journals with another 10 in press. The articles presented and published are listed below.

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

Baptist, C., Laber, C., Smalley, G. W. and **Place, A. R.** 2011 The Influence of Irradiance on Growth, Feeding, and Toxin Production in the Mixotrophic Dinoflagellate *Karlodinium veneficum*. 2011 ASLO Aquatic Sciences Meeting in San Juan, Puerto Rico from 13-18 February.

Bowers, H. A., Lee Carrion, **Ammar Hanif***, Gretchen A. Messick, Oded Zmora, Eric J. Schott: A Fatal Reovirus Associated with Mortalities of Blue Crab *Callinectes sapidus* in Aquaculture and Soft-shell Production Facilities, World Aquaculture Society, IMBC. Qingdao, China Oct. 2010.

Brady, M*, Conn, P., Bailey, L., Shertzer, K., Fox, D. 2010. Combining mark-recapture and telemetry to understand American eel population dynamics. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA, September 12-16, 2010.

Breece, M*., Fox, D., Savoy, T. 2010. Coastal movements of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the New York Bight. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Brown, L.M., Savoy, T.F., Manderson, J.A., and D. A. Fox. The Atlantic cooperative telemetry network: A collaborative approach to telemetry data exchange in the eastern U.S. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Cinelli, M*. and D. McIntosh. 2011. Thermal tolerance of the Weakfish *Cynoscion regalis*. Aquaculture America 2011. New Orleans, LA, USA.

Crawford, K.* Ontogeny of Auditory and visual Ecophysiology in Back Sea Bass. American Society of Limnology and Oceanography Annual Meeting. San Juan, PR. February 12-16, 2011. (***Outstanding student oral presentation awardee***).

Crawford, K.* Sensory Ecology of Black Sea Bass. DREAMS Seminar Series. November 22, 2010. Hampton University

Cullen, D.W.*, Richards, R.A., and A.K. Johnson. The influence of temperature on the distribution of monkfish (*Lophius americanus* V.). 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Curran, C., Ebanks, S.*, Yozzo, K., Modeste, T., Partridge, M. How does the bopyrid parasite *Probopyrus pandalicola* affect the density and behavior of the daggerblade grass shrimp *Palaemonetes pugio*? SEERS, St. Augustine, FL (Nov 2010)

Curran, C., Solow, A. and M. Allen. Long-term patterns in use of an intertidal salt marsh basin by flatfishes in South Carolina, USA. American Fisheries Society Pittsburgh, PA (Sept 2010) best undergraduate oral presentation

Curran, C. Does temperature play a role in long-term patterns? Use of an intertidal salt marsh basin by flatfishes in South Carolina. Flatfish Biology Conference, Westport, CT (Dec 2010)

Curran, M.C., Solow, A.R., Allen, D.M. Long term patterns in use of an intertidal salt marsh basin by flatfishes in South Carolina, USA. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Curran, M. C., Aultman, T. V.; Hoover, K. M.; Gerido, L.; Sukkestad, K. E. Developing K-12 activities as part of broader impacts: how to use university research to address ocean literacy. American Society of Limnology and Oceanography Annual Meeting. San Juan, PR. February 12-16, 2011.

Davis, J.*, R. Pittiglio, M. T. Hamann and R. T. Hill**.** 2010. Bacterial symbionts of a marine invertebrate as sources of anti-cancer compounds. International Marine Biotechnology Conference, Qingdao, China. 8th-12th October 2010.

Fleming, K*., Fox, D., Nunley, J.M., Parauka, F.M. 2010. Who pays the price of progress: Gulf sturgeon habitat utilization and residency in Choctawhatchee Bay, FL. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010.

Gonsalves, L. C*. Minority recruitment, educations, and community oureach: graduate students to the rescue. American Society of Limnology and Oceanography Annual Meeting. San Juan, PR. February 12-16, 2011.

Green, S.* All about my COSEE and REU Experience. DREAMS Seminar Series. November 22, 2010. Hampton University

Hanif, **A**.*, Holly Bowers, Joseph Pitula, Gretchen Messick, Whitney E. Dyson*, Eric Schott: Development and testing of a molecular assay to search for environmental reservoirs of a lethal parasite effecting blue crab fisheries, 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Hill, R.T. 2010. Marine invertebrates and their associated microbes as a resource for drug discovery (KEYNOTE). International Marine Biotechnology Conference, Qingdao, China. 8th-12th October 2010.

Hintz, C. Based studies of formation trace element incorporation into biogenic calcite, Invited seminar, Oak Ridge National Labs, Oak Ridge Tennessee (Fall 2010)

Hoover, K.*, Curran C, Seasonal use of a shallow estuarine creek by flatfishes. SEERS, St. Augustine, FL (Nov 2010)

Horodysky, A. Z., Brill, R.W., Warrant, E.J., Musick, J.A., and R.J. Latour. Visual ecology of benthic and pelagic piscivores in coastal mid-Atlantic waters. Implications for predator-prey dynamics. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Hoskins, D. Tales of Landings and Legacies: African Americans in Georgia's Coastal Fisheries. LMRCSC Seminar (Oct 2010)

Hoskins, D. Estuarine Ecology and Land Use. Institute for Georgia Environmental Leadership, Sapelo Island (Sept 2010)

Hoskins, D. L.; Bounds, J.: The Chatham County resource protection commission: a model of innovation in land conservation. American Society of Limnology and Oceanography Annual Meeting. San Juan, PR. February 12-16, 2011.

Jackson, K.* Re-burrowing of Blue Mudshrimp. DREAMS Seminar Series. October, 25, 2010. Hampton University

John, J.*, Curran, C., Pennington, P. The effects of the isopod parasite *Probopyrus pandalicola* on the gravidity of the daggerblade grass shrimp *Palaemonetes pugio* SEERS, St. Augustine, FL (Nov 2010)

Leandre, M.* Microbial Decomposition of Doliolids. DREAMS Seminar Series. November 1, 2010. Hampton University

McIntosh, D. and R. Lynch. 2011. A low-cost, tank-based prototype hatchery to produce saltwater baitfish. Aquaculture America 2011 Book of Abstracts, New Orleans, LA, USA. **Invited.**

Moore, J.E*., Fox, D., Wetherbee, B.M., McCandless, C.T. 2010. Interannual site fidelity and habitat utilization of sand tigers in Delaware Bay. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Murphy, M. E*.; Hoskins, D.; Hall, J. M.: Unlocking the history of African Americans in coastal Georgia coastal fisheries. ASLO, San Juan, Puerto Rico (Feb 2011)

Ozbay, G., Jackson, A. and Aini, T. 2010. Black Lip Pearl Oyster (*Pinctada margaritifera*) Spat Stocking Densities at CMI Arrak Oyster Hatchery in Majuro, Marshall Islands. International Conference for Shellfish Restoration, Charleston, South Carolina, USA, November 17-20, 2010 .

Pitula, J. & **S. Chung** (2011). Effects of Environmental Factors on Blue Crab, *Callinectes sapidus*, and its relation to infection by *Hematodinium* sp, UMES-NSF CREST workshop, Feb. 4th-5th, 2011, Eastern Shore.

Pitula, J. (2011). The Genetics of Marine Protozoan Parasites: from Basic Biology to Diagnostic Tool. Horn Point Laboratory Seminar Series, University of Maryland Center for Environmental Sciences, Cambridge, MD 01/2011.

Pitula, J. (2010). Biotic and abiotic factors in *Hematodinium* sp. Transmission. Bitter Crab Disease Workshop AVC Lobster Science Centre Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PEI Canada. 11/2010.

Pitula, J. (2010). Metabolism and gene expression studies in diverse protozoan parasites: evolutionary convergence and divergence. UMES Department of Natural Sciences Seminar Series 10/2010.

Place, A. R. 2010. LIPIDOMICS: Lipid Targeted Algal Toxins. 2010 Phycological Society of America Annual Meeting, Michigan State University, July 10-13.

Place, A. R. 2010. Karlotoxins - Their Structure, Mode of Action and Ecological Function 14th International Conference on Harmful Algae. Hersonissos, Crete-Greece, November 1-5.

Place, A. R. 2010. 5-Hydroxymethyluracil is synapomorphic to the Dinokaryotes only. 14th International Conference on Harmful Algae. Hersonissos, Crete-Greece, November 1-5. (**Poster Presentation)**

Reckenbeil, B.* and Ozbay, G. November 2010. Preliminary Study Investigating Shoreline Oyster (*Crassostrea virginica*) Reclamation in Delaware's Inland Bays. American Fisheries Socieity, Mid-Atlantic Chapter Meeting. November 19, 2010, Lewes, Delaware, USA.

Roche, S. A., Porter, N. M., **Place, A. R.** and Leblond, J. D. 2010. Sterol Biosynthesis in the Marine Dinoflagellates, *Karenia brevis* Piney Island and *Karlodinium veneficum* MD5. 14th International Conference on Harmful Algae. Hersonissos, Crete-Greece, November 1-5.

Santos, R. O.*; Lirman, D.: habitat suitability models for submerged aquatic vegetation (sav) in biscayne bay, Florida, USA. American Society of Limnology and Oceanography Annual Meeting. San Juan, PR. February 12-16, 2011.

Saul, S., Walters, J.F., and D.J. Die. Modeling the spatial distribution of commercially important reef fish on the west Florida shelf. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA**,** September 12-16, 2010**.**

Simmons, K.* Growth of larval fish in FL coral reefs. DREAMS Seminar Series. November 1, 2010. Hampton University

Seagroves, E.* HU Periwinkles Revisited. DREAMS Seminar Series. November 22, 2010. Hampton University

Walters, T. L., Pavel, C. A., Frazier, L. M., Thompson, M. E., Gibson, D. M., Paffenhöfer, G. A., Frischer, M. E., Molecular gut content profiling of Dolioletta gegenbauri in Southeastern subtropical continental shelf intrusion waters: What are they eating? ASLO, San Juan, Puerto Rico (Feb 2011)

Ward, T.*, The method of tethering affects predation on shrimp by red drum. ASLO, San Juan, Puerto Rico (Feb 2011)

Williams, A.* Using Google Earth to locate fishing vessels. DREAMS Seminar Series. October, 25, 2010. Hampton University

Poster Presentations

Caddle, J. A.* **Johnson, A. K**., Brill, R. W.; Crawford, K. C.*, Horodysky, A. Z.: Ontogeny of auditory and visual ecophysiology in black sea bass (*Centropristis striata*). American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Carroll, C.J.*, Fangman, S., McFall, G., Kendall, M.S., and M. Ogburn. Using acoustic telemetry to track snapper and grouper species in particular areas of Gray's Reef. 140th Annual Meeting of the American Fisheries Society, Pittsburg, PA 2010. September, 2010.

Choi, E., Joshi, B., Pecher, W., and **Jagus, R.,** Functional analysis of PKR from *Danio rerio* Cold Spring Harbor, Translational Control 2010.

Dyson, W.*, Ammar Hanif*, Eric J. Schott, Joseph Pitula: A PCR Based Assay for Detection of *Hematodinium* sp. in sediment and water from the Maryland Coastal Bays. 140th Annual Meeting of the American Fisheries Society, Pittsburg, PA 2010. September, 2010.

Dyson, W.*, Ammar Hanif*, Eric J. Schott, Joseph Pitula: A PCR Based Assay for Detection of *Hematodinium* sp. in sediment and water from the Maryland Coastal Bays. MEES Colloquium September 2010, UMES, MD.

Green, S.* Effects of Land Use Watershed Size and Soil Types on the Concentrations of N and P in Coastal Plain Streams. American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Hanif, A.*, Holly Bowers, Joseph Pitula, Gretchen Messick, Whitney E. Dyson*, Eric Schott: Development and testing of a molecular assay to search for environmental reservoirs of a lethal parasite effecting blue crab fisheries. MEES Colloquium September 2010, UMES, MD.

Horodysky, A., and K. Crawford*. Ontogeny of Auditory and visual Ecophysiology in Back Sea Bass. American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Jackson, K.* Size Dependent Burrowing Competence of the N. American Blue Mud Shrimp. American Society of Limnology and Oceanography Annual Meeting. San Juan, PR. February 12-16, 2011.

Johnson, S.* Preserving Endangered Species: Pesticide Management. American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Kapareiko, D., G. H. Wikfors, J. H. Alix, E. Schott, H. J. Schreier, D. McIntosh, J. M. Rash and **O. Ukaegbu**.* Analysis of spatial and temporal interactions of a probiotic bacterium and a shellfish larvae pathogen during hatchery larviculture of eastern oysters (*Crassostrea virginica*). 31st Milford Aquaculture Seminar, February 7-11, 2011.

Katenta, A.* Sex-dependent expression of an unusual eIF4E family member in the blue crab, *Callinectes sapidus*. Annual Biomedical Research Conference for Minority Students, Nov 10th-13th, 2010, Charlotte, NC.

Leandre, M. Y,*; Gibson, D. M.; Kirchman, D. L.; Frischer, M. E.; Thompson, M. E. Population dynamics of the bacterial community during tunicate decomposition. American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Lewis, J. R.*, Johnson, A. K. Effects of acute hypoxia on the Atlantic croaker. American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Lidie, K., **Jagus, R.,** Darzynkiewics, E., Stepinski, J., and **Place, A. R.** 2010. Identification of Eukaryotic Translation Initiation Factor 4E Family members with Distinctive Cap Binding Properties in Dinoflagellates. Cold Spring Harbor, Translational Control 2010.

Maynard, A.*, Porter, J., Reckenbeil, B. and Ozbay, G. Revitalizing Habitat and Community: Restoration of Habitat Integrity and Population Productivity of Delaware's Inland Bays Oysters (*Crassostrea virginica*). Delaware State University Presidential Inauguration Event, Dover, Delaware, USA, September 16, 2010.

McGeachy, C. T*. effects of ocean outfalls on coral reef ecosystems. American Society of Limnology and Oceanography Aquatic Sciences Meeting. San Juan, PR. February 12-16, 2011.

Nguluwe, B.*, Johnson, A. K. Williams, E., Carlin, J., Richards, A., and **Place, A. R.** 2011 Stock Discrimination of American monkfish in Northwest Atlantic Using Mitochonrial DNA. 140th American Fisheries Society, Pittsburgh, PA, September 2010.

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Grantsmanship: A total of $3,134,016.86 (Tables 6a and 6b) was collectively awarded to the LMRCSC 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 LMRCSC, $837,031.25 came from NOAA, whereas $2,296,985.61 was obtained from other agencies.

The funds provided by these agencies impacted LMRCSC research through support of its faculty and students and by development/enhancement of infrastructure. Eight proposals that total $2,745,092 (Table 7) were submitted to various agencies during this reporting period.

Table 6a. Current leveraged funding from NOAA to LMRCSC institutions

Author	Funding Agency	Title of Project	Start/End Date	Amount	Current 6 month period
Zohar, Y. (IMET)	NOAA	The blue crab *Callinectes sapidus*: 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
Stevens, B.G.(UMES)	NOAA	Improving conservation of New England Whelks	2010-2012	$75,688	$9,461.00
Watkins, M. and D. Hoskins (SSU)	NOAA EPP/MSI EEP	Habitat Restoration and Monitoring Using GIS Technology: A Student Training Program	10/1/05-11/1/10	$492,958	$49,295.80
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, *Lophius americanus*.	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

Place, A.R. (IMET)	MD Sea Grant	The torage effect, biodiversity and recruitment pathways for the Chesapeake striped bass	2/01/09-01/31/11	$198,834	$49,708.50
Schott, E. (IMET)	MD Sea Grant	Support for the International Marine Biotechnology Conference 2010, in Quingdao, China	08/31/10-01/31/11	$10,000	$5,000.00
David J. Die	NOAA NMFS (*)	Habitat of shallow water groupers	7/2001-6/2011	$ 135,071	$6,753.55
TOTAL					**$837,031.25**

Table 6b. Current leveraged funding to LMRCSC institutions from sources and agencies other than NOAA (*Students)

Author	Funding Agency	Title of Project	Start/End Date	Amount	Current 6 month period
*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
David J. Die	NTVI (*)	Integrated Ocean Observing System Products for Integrated Ecosystem Assessments.	5/2009 2/2011	$90,000	$22,500
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
Place, A.R. (COMB)	MD DNR	Efficient assessment of Chesapeake Bay HABs with rapid toxin screening	10/01/09-09/30/10.	$30,000	$15,000.00
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
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
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	$250,000

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 (*Crassostrea virginica)*	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)	USGS Water Research Grant	Oyster Restoration Efforts at Delaware Inland Bays: U*tilizing rip-rap as a substrate for oysters*	6/1/2010-2/28/2011	$3,500	$1,750
Ozbay, G. (DSU)	NSF SMILES	Monitoring Aquatic Health and Habitat Value of Oyster (*Crassostrea virginica*) 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
Gilligan, M.(SSU)	NSF	Bridge to Research in Marine Sciences: a summer Research Experiences for Undergraduates to NSF	2009-14	$292,434	
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 Biotoxin 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
Schott, E. (IMET)	NSF	Support for the International Marine Biotechnology Conference 2010, in Quingdao, China	08/31/10-01/31/11	$12,000	$6,000
TOTAL					**$2,296,985.61**

Table 7. Grants submitted by LMRCSC during this reporting period (September 1, 2010 to February 28, 2011)

Author	Funding Agency	Title of Project	Amount
Gibson, D. (HU), Murray, L. (UMCES)	NOAA Environmental Literacy Program	Teacher Enhancement Program: Partnerships in Science	$148,993
Gibson, D. (HU) and Cornell University	National Science Foundation (MRI)	Development of a Robust Autonomous Open-Source Profiling System for Monitoring Aquatic Environments	$95,500
Gibson, D. (HU), VIMS, ECSU	NSF HBCU-UP TIP	Education Partnership in Climate Change and Sustainability (EPiCCS)	$300,000
Chung, J.S. (IMET)	North Pacific Review Board	North Pacific Research Board: Identification of a non-lethal, specific biomarker for evaluating the exact reproductive stages of size-related sexual maturity in male *Chionoecetes opilio*	$182,997
Jagus, R., and Place, A. (IMET)	NIH	Translational regulation by eIF2alpha phosphorylation in toxic dinoflagellates	$413,875
Jagus, R., and Place, A. (IMET)	NSF	Regulation of Dinoflagellate mRNA Recruitment via eIF4E variants and post-translational modification	$757,931
Schott, E. and Jagus, R.,(IMET)	NOAA	Investigation of disease dynamics among sympatric native and invasive crustaceans: tracking a protozoan disease in blue, green and Asian shore crabs	$60,200
Dan Rittschof, Zack Darnell, Matthew Ogburn, Pablo Munguia, Tom Schultz, Dionne Hoskins	NSF	Comparative Analysis of Estuarine Ecosystems	$785,596
TOTAL			$2,745,092

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. Detail on these projects is included on pages 10 – 33 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 $488,659 or 22% of $2,221,860 awarded to LMRCSC during 2010/11 (Table 8).

Twenty (20) B.S., 22 M.S., and 14 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 9.

Table 8. Student funding by LMRCSC institution (for 6 month period)

Institution	Funding to students	Budget	%
UMES	$173,273	$987,353	18%
SSU	$79,741	$316,828	25%
RSMAS	$33,439	$114,402	29%
HU	$42,716	$197,757	22%
DSU	$38,000	$229,794	17%
IMET	$121,491	$375,726	32%
TOTAL	$488,660	$2,221,860	22%

Table 9. Students who received support during the funding period September 1, 2010 to February 28, 2011.

First Name	Last Name	Academic Institution	Degree	Type	Amount
Daniel	Cullen	UMES	Ph.D	Stipend, tuition, travel	$15,023.42
Whitney	Dyson	UMES	M.S./Ph.D	Stipend, tuition, travel	$16,736.34
Rehab	El Fadul	UMES	Ph.D	Travel	$590.82
Eric	Evans	UMES	Ph.D	Stipend, tuition, travel	$21,252.58
William	Gardner	UMES	Ph.D	Travel	$117.00
Paula	Johnson	UMES	Ph.D	Stipend, tuition	$11,080.26
Courtney	McGeachy	UMES	M.S.	Stipend, tuition	$14,014.46
Belita	Nguluwe	UMES	M.S.	Stipend, tuition, travel	$17,752.49
Jamila	Payton	UMES	M.S.	Stipend, tuition, travel	$17,136.12
Jhamyllia	Rice	UMES	Ph.D	Stipend, tuition	$11,770.73
Candace	Rodgers	UMES	M.S.	Stipend, tuition	$14,398.31
Cy'Anna	Scott	UMES	B.S.	Stipend, tuition	$3,312.50
Adam	Tulu	UMES	Ph.D	Stipend, tuition, travel	$13,450.27
Oshin	Wilson	UMES	M.S.	Stipend	$16,637.53
Dwight	Ebanks	RSMAS	Ph.D	Stipend	$15,515.00
Dominique	Lazarre	RSMAS	Ph.D	Travel	$977.60
Xayamara	Serrano	RSMAS	Ph.D	Stipend	$8,525.51

Rolando	Santos	RSMAS	Ph.D	Stipend	$8,420.50
Alyssa	Currie	UMCP	B.S.	Salary, Fringe	$ 906.61
Erica	Dasi	UMBC	B.S.	Salary, Fringe, MTA	$ 2,471.45
Jeanette	Davis	IMET	Ph.D	Salary, Fringe, travel,tuition	$ 19,034.42
Kathleen	Gillespie	IMET	Ph.D	Salary, Fringe, travel, tuition	$ 25,718.12
Ammar	Hanif	IMET	M.S.	Salary, Fringe, travel, tuition	$ 27,856.38
Zianeb	Sankoh	MSU	B.S.	Salary, Fringe,ARCLab	$ 7,286.18
Oluchi	Ukaegbu	DSU	B.S.	Salary, Fringe,Travel,MTA,	$ 16,688.01
Jan	Vicente	IMET	Ph.D	Salary, Fringe, travel, tuition	$ 21,529.66
Kendyl	Crawford	HU	B.S.	Stipend	$5,500
Camren	Brown	HU	B.S.	Stipend	$1,500
Brittany	Carmon	HU	B.S.	Stipend	$1,750
Kayelyn	Simmons	HU	B.S.	Stipend	$3,500
Coleman	Ewell	HU	B.S.	Stipend	$1,750
Symone	Johnson	HU	B.S.	Stipend	$1,500
Keya	Jackson	HU	B.S.	Stipend	$3,000
Shadaesha	Green	HU	B.S.	Stipend	$1,750
Maryse	Leandre	HU	M.S.	Stipend/Tuition/Travel	$17,216
Elizabeth	Seagroves	HU	B.S.	Stipend	$2,250
Joyah	Watkins	HU	B.S.	Stipend	$1,500
Daniel	Ingman	HU	B.S.	Stipend	$1,250
Camile	Gaynus	HU	B.S.	Stipend	$250
Marissa	Brady	DSU	M.S.	Stipend/travel	$11,164.20
Michael	Cinelli	DSU	M.S.	Travel	$515.00
Cory	Janiak	DSU	M.S.	Stipend/Tuition/Travel	$15,340.00
Johnny	Moore	DSU	M.S.	Stipend/Travel	$10,980.75
Benjamin	Maher	SSU	M.S.	stipend	75
Michael	Partridge	SSU	M.S.	travel	500
Joseph	Labarre	SSU	B.S.	stipend	999.6
Amarria	Phillips	SSU	B.S.	stipend, travel	1028.42
Dana	Davis	SSU	M.S.	stipend	1800
David	Waldburg	SSU	B.S.	stipend, travel	4000
Catherine	Carroll	SSU	M.S.	stipend, travel, tuition	6666.14
Jakelin	John	SSU	M.S.	stipend	6666.14
Marvin	Mace	SSU	M.S.	stipend	7500
Mark	Wagner	SSU	M.S.	stipend	7500
Dontrece	Smith	SSU	M.S.	stipend	9006.14
Krystle	Ludwig	SSU	M.S.	stipend/scholarship/travel	12000
Jeremy	Mitschler	SSU	M.S.	Stipend	9999.99
Robin	Perrtree	SSU	M.S.	stipend	12000
TOTAL					$488,659.65

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 recruited into the LMRCSC

during this reporting period are presented in Table 10, students who graduated are in Table 11, whereas those who interned at NOAA or at LMRCSC partner institutions are in Table 12.

- Program Manager Todd Christenson has taken an increased role in recruitment for LMRCSC program and has actively recruited students at the American Fisheries Society national meeting, September 12-16, 2010, Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) conference in September 29-October 1, 2010, Spelman College Undergraduate Research Fair October 27, 2010, and the American Society of Limnology and Oceanography national meeting. Feb 12-16, 2011. He has since been in contact with many students at various stages of their academic careers, several of whom have applied to graduate degree programs within LMRCSC. He also established a connection at SACNAS with faculty from California State University at Monterey Bay, who have helped recruit several undergraduate students to the UMES REU program for 2011.

- Todd Christenson also gave a presentation on the LMRCSC to students from both Spelman and Morehouse Colleges on October 28, 2010 and discussed the LMRCSC program with faculty members Drs. Duane Jackson and Rahmelle Thompson. One of Dr. Jackson's students is exploring graduate opportunities at UMES following her graduation.
- Todd Christenson utilized the Virtual Campus on December 6, 2010 to discuss graduate and undergraduate opportunities at LMRCSC with 15 students from Dr. Gibson's freshman class at Hampton University as well as several graduate students.
- Dr. Ogburn has recruited three students this semester for undergraduate and graduate research on LMRCSC projects. One student, Ana Reyes, is from a traditionally underrepresented group, and will work on oyster restoration during the spring semester and summer.
- Drs. Curran and Hoskins recruited students from the Hampton ASLO Multicultural Program and served as program mentors.
- Drs. Ogburn and Curran met with students at the fall South Eastern Estuarine Research Society (SEERS) meeting.
- The LMRCSC had a table at the SSU Grad Recruitment Fair (11 Nov10) and the Tybee Water Fair to increase water conservation awareness (29 Jan11).
- Dr. Hoskins has recruited a PSLSAMP student (Jaron Frost) and an Ernest Hollings (Jovian Smith) student to work in her lab.
- Drs. Hoskins and Ogburn hosted EDGE interns this fall (Michael Knowles and Terry Anderson).
- One Hampton University student has been accepted into the SSU REU program for summer 2011.
- Two Hampton University students have been accepted into the UMES REU program for summer 2011.

Table 10. Students recruited into the LMRCSC program from September 1, 2010 to February 28, 2011

First Name	Last Name	Academic Institution	Degree
Amy	Burgess	UMES	Ph.D
Alexandra	Sutton	UMES	Ph.D
Emily	Tewes	UMES	M.S./Ph.D
Kristen	Lycett	UMES	M.S./Ph.D
Camren	Brown	HU	B.S.
Brittany	Carmon	HU	B.S.
Coleman	Ewell	HU	B.S.
Shadaesha	Green	HU	B.S.
Elizabeth	Seagroves	HU	B.S.
Joyah	Watkins	HU	B.S.
Daniel	Ingman	HU	B.S.
Camile	Gaynus	HU	B.S.
Andrea	Stoneman	DSU	M.S.
Tyisha	Hundley	DSU	B.S.
Whitney	Wood	DSU	B.S.

Table 11. Number of students who graduated from September 1, 2010 to February 28, 2011

First Name	Last Name	Academic Institution	Degree	Date
Catherine	Carroll	SSU	M.S.	12/2010
Mark	Wagner	SSU	M.S.	12/2010
Garth	Marchant	SSU	B.S.	12/2010
Sheena	Corning	SSU	B.S.	12/2010

Table 12. Students who worked at NOAA labs or LMRCSC partners (Sept. 1, 2010 to Feb. 28, 2011).

First Name	Last Name	Academic Institution	Degree	Facility	Time period
Gardner	William	UMES	Ph.D	NEFSC, Sandy Hook Lab	October, 2010 to present
Tulu	Adam	UMES	Ph.D	UMCES-IMET	Jan 2-30, 2011
Kate	Fleming	DSU	M.S.	NMFS lab-Panama City, FL	Jan 2010 to present.
Payton	Jamila	UMES	M.S.	UMCES-IMET	Jan 9-13, 2011

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

Accomplishments – In this reporting period, LMRCSC 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 6a&b), proposals that have been submitted to an agency for funding (Table 7) and collaborative projects, which are summarized below.

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

- ***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. LMRCSC students and AFS-UMES Student Subunit members Jamila Payton, Belita Nguluwe, Shari Mullen, Dan Cullen, along with Leonardo Matthews, Evan Lindsay and Jeffrey Kipp from the Professional Science Masters program designed and led a session on water quality and treatment on November 20, 2011. The 2010-11 academic year sessions focused on "Protecting, Restoring, and Sustaining Green Infrastructure"
- David Die (LMRCSC Project Director, RSMAS) continued to collaborate with the RJ. Dunlap Conservation Program at the University of Miami in their outreach and educational program with high school students.
- LMRCSC student Nick Clemons, a National Park Service employee, led or participated in sessions during the summer or academic year (Table 13). Todd Christenson (UMES) and Dr. Andrea Johnson (UMES) continued to serve on the planning committee.

Table 13. Upward Bound Marine and Estuarine Science Program Sessions

Date	Theme	Leaders
October 30, 2010		Carrie Samis (MCBP), Angela Baldwin (MDNR) Nick Clemons (LMRCSC/NPS)
November 20, 2010	Water quality and treatment	LMRCSC Students: Jamila Payton, Dan Cullen , Belita Nguluwe, Shari Mullen, PSM Students: Jeffrey Kipp, Leonardo Matthews, Evan Lindsay
January 20, 2011		
May 14, 2011	Herp Search	Nick Clemons (LMRCSC/NPS), Jim Rapp (DLITE) Carrie Samis (MCBP)

Outreach

- LMRCSC Distinguished Research Scientist Dr. Brad Stevens is a crew member aboard the skipjack Nathan. On September 20, 2010, the crew of the Nathan hosted Secretary of Agriculture Tom Vilsack for a cruise on the Chesapeake Bay during which Dr. Stevens discussed with the Secretary the conservation of the Bay and its resources.
- On September 18, 2010, Todd Christenson and Dr. Brad Stevens led a group of approximately 20 students from UMES and Salisbury University on a coastal cleanup held in conjunction with national Coast Day at Assateague Island. Following the cleanup, Todd joined local agencies such as the Salisbury Zoo, MD Coastal Bays Program, MD Department of Natural Resources and National Park Service at an outreach event at Assateague State Park, where he discussed LMRCSC research initiatives and displayed specimens from the Centers biological collection.
- Dr. Eric Schott (IMET) serves as board member of Blue Water Baltimore, a 501c3 organization that works to revitalize Baltimore's streams and harbor, and 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.
- Dr. Russell Hill (IMET) served as a panelist in the Public Forum on "Emerging Opportunities in Biotechnology" organized by the Center for Biotechnology Education, The Johns Hopkins University, 18th November, 2010.
- The Seaing is Believing Art and Essay Contest (~100 entries) at SSU continued during this reporting period.
- The LMRCSC is also working with the Savannah Ocean Exchange, an internal initiate being hosted in Savannah that encourages global leaders to disseminate working solutions to ocean-related problems. www.savannahoceanexchange.com.
- Drs. Carol Pride, Dionne Hoskins, and Carla Curran were each invited to present their diversity work as panelists at the COSEE SE Invitational Workshop for Broadening Participation held at SSU, December 9-10, 2010.
- Dr. Matt Ogburn has a blue crab blog: http://bluecrabblog.blogspot.com/2011/03/towards-ecosystem-based-management-of.html.
- Dr. Carla Curran has a podcast on "Science and the Sea," a 2-minute radio program that airs on about 180 radio stations in 38 states and several other places overseas. The link can be found at: http://coseenow.net/podcast/.
- Dr. Sue Ebanks and Mr. Greg Hunter attended the 2nd Annual Student Success Expo on February 12, 2011 to raise awareness about the Center.
- The regional Ocean Sciences Bowl brought over 80 high school students (16 teams) from South Carolina and Georgia to SSU on February 7th.

Community Service: LMRCSC students, faculty and staff contributed more than 150 hours community service to the following activities listed in Table 14.

Table 14. Community Service Activities and outreach activities at LMRCSC

Location	Activity	Institution	# of Participants
Upward Bound Marine and Estuarine Science Program	Water quality and treatment		
Coastal Cleanup		UMES	20
Coast Day	Outreach activity	UMES	100
SSU	Recruitment	SSU	200

SKIO	BOB FLO Seminar	SSU	30
Johnson High School	Outreach Activity	SSU	120
Johnson High School	NOSB	SSU	6
Gadsden Elementary	Family Science Night	SSU	150
Derenne Middle School	Science Olympiad Practice	SSU	20
Largo Tibet Elementary	Career Fair	SSU	60
Frank Callen Boys and Girls Club (Kaeton Homes)	Outreach Activity	SSU	60
SCCPSS	Savannah Science Seminar	SSU	30
Southwest Elementary	Math & Science Night	SSU	400
Derenne Middle School	Family Science Night	SSU	150
SCCPSS	Savannah Science Seminar	SSU	30
Calvary Day School	NOSB	SSU	2
Shuman Elementary	Math & Science Night	SSU	200
Chatham County Student Expo	Outreach & Recruitment	SSU	1000
Ocean Awareness Day (SkIO)	Outreach Activity	SSU	10
SSU (Youth for a Cleaner Environment)	Outreach Activity	SSU	25
May Howard Elementary School	Science Night	SSU	80-100

- **Newsletter**: The Center publishes a newsletter, *The Living Sea,* to highlight Center research and educational activities. The Spring 2011 issue is nearly complete and will be released in April, 2011. All issues of this newsletter are available for download in PDF format from the Center's web site (http://www.umes.edu/lmrcsc). DSU also produces a quarterly newsletter that highlights activities occurring at DSU in the areas of Fisheries, Aquaculture, and Natural Resources.
- **Website**: A redesigned LMRCSC web site (www.umes.edu/lmrcsc) was completed and launched on October 28, 2008. The new site is more user-friendly, more efficient in its layout and scalable to accommodate new needs and functions as they arise. Each of the LMRCSC partner institutions also has its own website that is directly linked to the LMRCSC 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/); UMCES-IMET (http://www.umces.edu/imet) and RSMAS (http://cufer.rsmas.miami.edu/index.php?page_id=31).
- **Facebook**: LMRCSC Technical Monitor Jeanine Cody created an LMRCSC page on Facebook which went live on July 20, 2009. It provides students and others a forum to network and discuss marine and fisheries issues, funding and identify job opportunities, current events in marine science, etc. One hundred ninety nine (199) 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:

- Dr. Andrij Horodysky (HU) visited UMES on November 5-8, 2010 to present two seminars entitled, respectively "Sensory biology of fishes I: Electroreception, mechanoreception, olfaction, gustation, and audition" and "Sensory biology of fishes II: Vision". He also conducted a workshop on November 5 on the use of Adobe Illustrator for scientific illustration.

Research Cruises

- LMRCSC conducted its seventh consecutive annual winter cruise from January 10-21, 2011 aboard the R/V Delaware II. Dr. Vince Guida from the NOAA J.J. Howard Marine Science Lab served as Chief Scientist. LMRCSC DRS Dr. Brad Stevens and DSU Project Director Dr. Stacy Smith served as watch chiefs. Students who participated in the cruise are shown in Table 15. Significant findings from the cruise, excerpted from the cruise report, are shown below. The complete cruise report can be found in Appendix I.

  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, which were met despite inclement weather conditions.

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 trawl sampling program continues, in order 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 ≥ 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 ~ 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^2) and witch flounder (up to ~3000/km^2) 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 ~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.

Table 15: Students who participated in the LMRCSC winter cruise

First Name	Last Name	Degree	Institution	Vessel	Date
Eric	Evans	Ph.D	UMES	Delaware II	Jan 10-21, 2011
Rehab	El Fadul	Ph.D	UMES	Delaware II	Jan 10-21, 2011
Daniel	Cullen	Ph.D	UMES	Delaware II	Jan 10-21, 2011
Cy'anna	Scott	B.S.	UMES	Delaware II	Jan 10-21, 2011
Maryse	Leandre	M.S.	HU	Delaware II	Jan 10-21, 2011
Evan	Lindsay	M.S.	UMES	Delaware II	Jan 10-21, 2011
Jeffrey	Kipp	M.S.	UMES	Delaware II	Jan 10-21, 2011
Bhae-Jin	Peemoeller	M.S.	UMES	Delaware II	Jan 10-21, 2011

SECTION III – SUCCESS STORIES

- LMRCSC's Professional Science Masters program in Quantitative Fisheries and Resource Economics accepted its first cohort of four students in Fall, 2010. During the summer of 2011, these students will work for 6 weeks at NOAA facilities in order to fulfill the internship requirement of the program. One NOAA contractor (Jessica Blaylock, Pop Dynamics Branch) from the Woods Hole laboratory enrolled in this program in Spring 2011. Another NOAA Woods Hole lab employee (Michelle Traver, Pop Dynamics Branch) has been accepted and will matriculate in Fall 2011.
- 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. The development of these courses is a significant step toward a full online program which can ultimately be made available nationwide. LMRCSC students Eric Evans and Courtney McGeachy are also enrolled in the Stock Assessment course, and Whitney Dyson is enrolled in Multivariate Statistics.
- Xaymara Serrano (PhD, RSMAS) served as the chair of the Marine Sciences panel for the 2011 Florida Education Fund Mid-Year Research and Writing Conference in Tampa, FL from February 25-27, 2011.
- Adam Tulu, Eric Evans, Jhamyllia Rice (UMES), and Dominique Lazarre (RSMAS) applied to the NOAA Graduate Sciences Program for 2011. Dominique Lazarre and Dan Cullen (UMES) applied for the Nancy Foster scholarship. Courtney McGeachy (UMES) applied for the EPA STAR fellowship.

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-six (56) students from B.S. to doctoral level were supported and trained in NOAA core sciences. Two MS students graduated. Ten projects funded through the TAB for 2009/10 are now complete with an additional 12 projects underway for 2010-11; $3,134,016.86 in external funding is supporting Center-related activities.
- The Center's recent doctoral graduates, Larry Alade, Ayeisha Brinson and Jose Reyes-Tomassini, all NMFS employees, are continuing to collaborate with the Center in support of its mission.

2. How many students participated in Center projects or activities? Fifty-six (56) 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 32 through 38. 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:

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

- Sue Chaplin Ebanks, who received her M.S. degree from SSU as an LMRCSC student, recently graduated with her Ph.D from University of Miami (ECSC), and joined the faculty of Savannah State University.
- Catherine Carroll (SSU) was hired as a research technician under a Title VII sponsored program with Dr. Carla Curran based on the work she did in her LMRCSC-funded M.S. thesis.
- Kasim Ortiz has been offered a NOAA STEP appointment at the University of South Carolina. He is working on an M.S./Ph.D. in Marine Spatial Planning in the Geography department.

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.
b) Kate Fleming (DSU) continued her work on sturgeon at the NOAA NMFS lab in Panama City, FL, which commenced in January, 2010.
c) 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 January 2-30, 2011.
d) Jamila Payton (M.S. UMES) worked at UMCES-IMET (January 9-13, 2011) under the supervision of Dr. Rose Jagus. Jamila's research examines the physiological effects of hypoxia on Atlantic croaker in the Chesapeake Bay.

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

5. Did students participate in site visits to NOAA laboratories and/or facilities? No site visits were conducted during this reporting period.

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

Appendix I: Other Projects in Support of Undergraduate or Graduate Involvement in Research

11 March 2011

CRUISE RESULTS
NOAA Ship Delaware II
DE-11-01 NOAA LMRCSC SCIENTIFIC AND EDUCATIONAL CRUISE

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 (LMRCSC) in fisheries science, including learning field sampling procedures, and in support of projects being conducted by faculty and graduate students in the LMRCSC 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 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 ≥ 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 ~ 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^2) and **witch flounder** (up to ~3000/km^2) 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 ~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.**

Cruise Period and Area of Operations

This cruise was conducted from January 11 through 19, 2010 with designated stations (Figure 1) located in coastal and shelf off northern New Jersey (northern most site) to Oregon Inlet, North Carolina (southern most site). Weather restricted sampling to sites only as far south as Norfolk Canyon, off Virginia.

Cruise Goals and Objectives

The purpose of this cruise was to provide scientific personnel of the NOAA Living Marine Resources Cooperative Science Center (NOAA/LMRCSC) the opportunity to conduct a series of studies and to provide experience to graduate and undergraduate students who are engaged in academic programs in the marine sciences. Twenty-six stations were surveyed using 36' Yankee, Beam trawls, and Deepwater Flat Net (Tables 1-3). Three studies were conducted during the course of this cruise. The studies were as follows: 1) Examination of latitudinal variation in habitat and fish assemblages; and 2) Hudson Canyon sampling, and 3) Deepwater exploration to define depth limits of monkfish distribution in the vicinities of Hudson and Norfolk Canyons and assess monkfish, deep sea red crab, and witch flounder numbers there. The results of this cruise also provided experience and insight into the planning and onboard management of multi-sampling and multi-project cruises, in anticipation of more inclusive kinds of cruise programs that will be demanded in support of Ecosystem-Based Fisheries Management.

Site Selection

Stations for DE11-01 (Figure 1) were chosen based on study requirements and consultation with scientists at the National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC). Station names remained the same as on previous LMRCSC (latitudinal transect stations) and Benthic Habitat cruises (Hudson Canyon beam trawl stations). Deepwater monkfish stations in the vicinity of Hudson and Norfolk Canyons were designated with "HC" and "NC" numbers according to a scheme devised by Drs. Anne Richards and Andrea Johnson for monkfish trawls. Station HCX in Hudson Canyon was added in order to explore a region of that canyon that has recently been mapped acoustically in ultra-high resolution during a recent Habitat Mapping cruise (HB09-04). Not all stations originally planned were able to be sampled during the cruise. Despite inclement weather 67% of the Latitudinal stations and all of the Hudson Canyon beam trawl stations were sampled, although no 36Y otter trawl was performed at one of the Latitudinal stations sampled. Uneven topography and long, straight trawl tracks, particularly in the Norfolk Canyon Transect area, prevented the tight control of trawl depth specified by the original 12 depth plan. Precise trawl locations were chosen for relatively flat contours at approximately the specified depth range by the bridge watch based on sonar reconnaissance.

Procedures

At the Latitudinal Transect (LT) sites, a CTD, Van Veen Grab, paired bongo plankton nets, a 2m beam trawl, and a 36 foot Yankee (36Y) otter trawls (rock hopper) were deployed. Trawl nets were deployed from the stern trawl A-frame using both trawl winches (36Y) or only the port trawl winch (2m BT). Standard 1" trawl wires were used for all trawl gear. The 2m BT was deployed for a 15 minute tow at ~2 kt., and the 36Y was towed at ~3.8 kt. for 20 min. so as to minimize the possibility of obtaining unmanageably large catches of spiny dogfish. 36Y trawls were limited to daylight deployments, as performed in 2008. Sampling with 2 m beam trawls, CTD-bongo plankton nets, and Van Veen grab was performed at whatever time the ship arrived on station. An effort was made to minimize switching out of 36Y otter and 2 m beam

trawls whenever possible by alternating which trawl was done first at a station. The CTD, Van Veen Grab, and plankton bongo nets were deployed from the forward starboard A-frame using the ship's hydrographic winch. Here, too, first deployments alternated between the Van Veen and CTD-bongo rigs to avoid the need for two changes per station.

Hudson Canyon beam trawl sampling consisted of CTDs deployed prior to individual trawl, followed by a 15 minute tow at ~2 kt. approximately along a specified depth contour with a 2 meter beam trawl (2m BT). Deepwater trawls were made at 3 kt. with a 36' flat net equipped with deepwater head rope floats. All deepwater tows were 30 minute in length. Deep trawls were preceded by CTDs.

All trawl catches were processed during the cruise. Catches were sorted to the lowest practicable taxon (LPT), which for most specimens was species. All taxa were enumerated and weighed by LPT. Size distributions were recorded for all fishes, sea scallops, squid, and crab and lobster species of fisheries interest. Large samples were enumerated and sized by extrapolation from subsamples. Biological specimens of doubtful identity were photographed and preserved in 10% buffered formalin for subsequent identification. Reference specimen representing fish species not previously encountered were retained for the Reference Collection of the LMRCSC.

Van Veen grabs were performed by lowering the apparatus to the bottom, and once closed raising it and removing one sample of approximately 1 kg in weight. Samples were placed in Ziploc® freezer bags and transferred to the -20°C freezer for storage during the cruise. The paired bongo nets were lowered in conjunction with the CTD. Once retrieved, nets were washed down with sea water, and the replicate samples remaining in the cod end collectors transferred to individual 1 L glass jars, diluted with filtered sea water to approximately 700 mL, to which was added ~70 mL full strength borate-buffered formalin.

Data recorded for monkfish captured (by all methods) included total length, sex and maturity, gut content identity, and weights of total body, liver, and gut contents. Samples of ovary were take for histology, samples of fin and liver for genetics, and samples of muscle and liver for stable isotope analysis, as requested by Anne Richards and Andrea Johnson. Data for deep sea red crab captured in deepwater flat net trawls included metrics and gonad samples for histology were taken for later analysis by LMRCSC Distinguished Scientist Brad Stevens.

Results

Disclaimer: Results presented here represent a very preliminary overview of observations and data collection during cruise DE-09-01. Additional quality assurance examination needs to be applied to raw data and no attempt has been made to apply rigorous statistical tests to any existing quantitative data regarding any hypotheses. The following detailed presentation is meant only to provide the reader a general idea of the nature of the raw data available and its utility toward meeting the stated objectives of the cruise.

Project Summaries: Of the projects initiated during the cruise, all were completed to the satisfaction of the investigator. The results from each of these are as follows.

1. Marine Fish Diversity along Latitudinal Gradients of the Mid-Atlantic Bight – During the sampling, the 36' Yankee otter trawl, two meter beam trawl, CTD, paired bongo nets, and Van Veen grab sampler

were deployed at nine stations representing four longitudinal transects as summarized in Figure 1a. Catches are summarized in Tables 1 and 4. Catches with the 36Y net were heavily dominated by spiny dogfish and longfin squid at most stations. Summer flounder, northern searobin, and margined sea star were also important in terms of occurrence. To this list beam trawl catches add a number of species (e.g. monkfish, gulfstream flounder) and expand the distribution (increase the occurrence) of a number of others (e.g. red hake, spotted hake, northern sea robin). Fig. 2 compares the taxa richness of catches from the 36Y and 2m beam trawls for the last three years, demonstrating the utility of a multiple-method sampling strategy for purposes of ecological assessment. Beam trawl catches approximately double the number of species caught in addition to adding to the distribution of some species.

2. Hudson Canyon Sampling – Results of beam trawl sampling in the Hudson Canyon area (Fig. 1a,b) are provided in Tables 2 and 5. This data is part of an ongoing data set used by NMFS for the Hudson Canyon and is currently being incorporated into a habitat mapping effort for Hudson Canyon. A large catch of juvenile monkfish was made at station PR31, where mapping by USGS and subsequently by NEFSC (Fig. 3) detected an irregular bottom with linear scour marks, presumably left by icebergs during the Pleistocene low sea level stand. This is not the first time monkfish have been caught in numbers by us here. It is suspected that the peculiar character of the microtopography at this site may attract or foster the survival of young monkfish.

3. Deepwater Monkfish Transects – Deepwater flat net catches in the Norfolk Canyon and Hudson Canyon Monkfish Transects (Fig. 1b) are summarized in Tables 3 and 6. Catches were very heavily dominated by deep sea red crabs, and all also included witch flounder. Unlike previous years, large catches of monkfish were also made in deepwater tows in both Hudson and Norfolk Canyons.

Detailed Observations

Habitat Notes

Monkfish (*Lophius americanus*) and **Deep Sea Red Crabs** (*Chaeceon quinquidens*) are a major resource species that are sought in deepwater habitats in east coast canyons. For the first time, a trawl station (HCX) was planned to overlap the ultra-high resolution multibeam sonar data of the canyon thalweg (bottom channel) collected by the NIUST *Eagle Ray* AUV aboard Habitat Mapping cruise HB09-04 and processed into a detailed bathymetric and backscatter maps in FY10-11 thanks to funding from the NOAA Coral Reefs program. This was suspected to be the location of as yet uncharacterized hard bottom communities based on small patches of hard bottom (i.e. high acoustic backscatter values) of unknown character amid a large expanse of soft bottom (low backscatter) at about 500 m depth in the thalweg. While the trawl actually fell just outside the mapped area, we were able to capture some fauna that we believe may characterize both the hard and soft bottom in that area and a piece of the substrate that may be responsible for the patches of anomalously high backscatter values. As with all other deepwater trawls, the catch was dominated by deep sea red crabs and witch flounder with typically associated species (marlin spike grenadier, red hake, offshore hake, thorny skate). It also contained a large number of unidentified attached anemones, gooseneck barnacles, and sea spiders, thought to be hard-bottom associates. This and other deepwater stations where anemones were found (HC2, NC3, NC10) also yielded large catches of decapods shrimp (several species) and large numbers monkfish. A relationship is suspected between hard bottom patches, their fauna, and monkfish. Those stations whose catches lacked

anemones (HC4, HC6) coincidentally also lacked monkfish. A lump of semilithified (hard) and heavily burrowed clay also came up with the trawl at HCX (Fig. 5). This may be the source of the high backscatter patches observed from our mapping effort and the hard bottom fauna in this trawl.

Black Sea Bass (*Centropristis striata*) are well-known to seek structured habitats such as rocks and wrecks during their seasonal inshore residence. The preferred habitat of this fish during their offshore (winter) period is less clear, particularly for juveniles. On this cruise it was noted that at the two trawls in which this fish was caught are areas of well-characterized gravel to clay outcrop bottoms along the eastern rim of Hudson Canyon (stations UV01 and UV02). As in previous years, it appears that these hard bottom habitats, relatively rare on the outer shelf, may play a role as overwintering habitat for young black sea bass.

Habitats dominated by **Splitting Cup Corals** (*Dasmosmilia lymani*) were again encountered at Hudson Canyon southwest rim station WX4 based upon catches of these corals in beam trawls. As they were first seen at this station since 2004 and detected on subsequent cruises in 2007, 2008, 2009, and 2010, they appear to persist as a habitat feature for at least 7 years. There is no known previous data for this deep sea hard coral on growth or lifespan. **Sponge-dominated habitats** were again detected in catches from stations UV01 and UV02 on the northeast rim. Specimens of corals and sponges were taken for laboratory examination.

Ecosystem Measures

As in previous years, the observation was made that parallel sampling with more than one type of sampling gear gives a far better of community composition (e.g. Fig. 2) and habitat character than dependence upon data from any single sort of gear, no matter how efficient. The fact that an identical multi-method sampling regime was conducted at the same locations for four successive years (2008-2011) in pursuit of the Latitudinal Survey opens the possibility of combining data from the various sites to make year-to-year comparisons of ecosystem over a wide geographical area. Unfortunately, the third year (2010) adds data for only one of five transects to that comparison. Patterns remain to be analyzed.

Juvenile white shrimp (*Litopenaeus setiferus*), caught at inshore LT6 stations in 2008 and 2009, but not 2010, were again present in January, 2011. No report has been found of the presence of this south Atlantic Bight-Gulf of Mexico species off Virginia during winter. This species bears watching as a harbinger of climatic change.

Oceanography

Water column profiles for this cruise are compared with those for 2009 and 2010 in Fig. 5. Bottom water temperatures were generally cooler on the shelf than in 2009 and showed a strong seaward gradient. Outer shelf temperatures were slightly warmer. As in the past, Hudson Canyon again demonstrated at least three layers of water masses and complex distribution of temperatures. Since 36Y operations were conducted only during daylight hours, and opportunity presented itself during the early morning hours of Jan. 17th to conduct a series of hourly CTDs at Station LT6-1 off the mouth of Chesapeake Bay for the purpose of detecting tidal changes in the water column. Six such profiles were made (Fig. 6). While the temperature range was small (~0.5º C), the profiles demonstrate a clear transition from stratified to fully mixed during this short period of a little less than half a tidal cycle, suggesting a dynamic frontal system.

Stocks of Interest

1. Monkfish

Table 7 shows monkfish catches from all beam trawl and deepwater trawl tows. In addition to beam trawl tows from PR31, large numbers of monkfish were caught in deep tows at sites HC2 and HCX (379-565 m depth) and NC3 and NC10 (346-641 m depth), but none were caught at two deepest sites sampled in Hudson Canyon: HC4 and HC6 (469-673 m). Large monkfish were caught primarily in Hudson Canyon (Fig. 7)

2. Spiny Dogfish

In recent years there has been concern over the stock structure of the spiny dogfish (*Squalus acanthias*). Large (>80 cm TL), productive females had fallen to less than 5% of the catch in some surveys. Though our sampling was extremely limited, our samples consisted of about 42% large females (Table 8), suggesting a stock in good reproductive condition. Spiny dogfish were caught in a deep trawl at station HCX at depths approaching 500 m.

3. Deep Sea Red Crab

Deep sea red crab (*Chaceon quinquidens*) was the major catch species in all Deepwater Monkfish Transect catches (Table 4). As stock assessment is performed infrequently with this species, data on catch distribution from this cruise, while extremely limited, might be of some use. All catches were heavily dominated by females. Maximum densities occurred in Hudson Canyon stations HC4 and HC6 (469-673 m). A trawl at station HC8 was unsuccessful and was not repeated. Catches in Hudson Canyon were uniformly greater in 2011 than in 2009 (Fig. 8).

4. Witch Flounder

Witch flounder occurred in all deepwater trawls (Table 10), as they had in 2009, in densities comparable with those of the 2009 for Norfolk Canyon, but greater than in 2009 for Hudson Canyon (Fig. 7). As in 2009, most Hudson Canyon witch flounder exceeded 22 cm in total length (adult size threshold), while Norfolk Canyon fish were smaller (Fig. 9).

5. Cephalopod Mollusks

Longfin squid (*Loligo pealeii*) were captures at all but one Latitudinal Transect station in Y36 tows and in one deepwater tow (Table 11). Most individuals were small: in the 5-7 cm mantle length range. Catches were comparable with those in 2009. No shortfin squid (*Illex illecebrosu*s) were caught. Beam trawls at four Latitudinal and two Hudson Canyon stations caught small numbers of bobtail squid (Sepiolidae, probably *Semirossia tenera*). Single specimens of the deepwater squid *Mastigoteuthis agassizi* were captured at stations HCX and NC3.

Data Management and Disposition of Data and Samples

Raw catch data from all trawls have been entered into a Windows Excel® spreadsheet database based on a data template employed for trawl data from Benthic Habitat cruises. Separate spreadsheets were used for each project. Another spreadsheet, also based on a Benthic Habitat cruise template, contains a log of all cruise sampling activities, including CTDs. These are retained by Chief Scientist Vince Guida at NEFSC J.J. Howard Laboratory for dissemination to principal investigators for all projects. The Chief Scientist has

also retained all ship's SCS files (including GPS, sonar, ADCP, and ship's weather and hydrographic sensor data) as provided by the ship's electronic technician, plus CTD files from the cruise for dissemination as requested. CTD files are also retained by the NEFSC Oceanography Branch.

For purposes of quality assurance, data catch will be independently verified by a second researcher within LMRCSC. Metadata for each spreadsheet will be created that will list the individuals who entered and checked the data. Data will be disseminated by the Chief Scientist to investigators for all projects.

Collection data will be transformed into a website with digital images of representative specimens. Digital images from the cruise have been posted to the LMRCSC website and included on quarterly reports. All digital files are managed by Mr. Todd Christenson, LMRCSC Program Manager. Sediment and plankton samples taken with Van Veen and bongo nets respectively have also been retained for analysis by LMRCSC. Samples of monkfish tissues and detailed monkfish data collected on this cruise have been distributed to Anne Richards of NEFSC Woods Hole Laboratory and Andrea Johnson of University of Maryland Eastern Shore. Samples of deep sea red crab tissue and detailed data for that species have been retained by Brad Stevens of UMES.

Preserved invertebrate specimens have been retained for identification by the Chief Scientist at NEFSC J.J. Howard Laboratory. Digital images of specimens taken by the Chief Scientist are also retained by him at J.J. Howard Laboratory. Requested whole frozen specimens of cephalopod mollusks have been distributed to Lisa Hendrickson of NEFSC Woods Hole Laboratory.

Data and results from all studies will either be reproduced through peer-reviewed publications, society meetings, public forums, or website postings. In addition to faculty and research associates, approximately 5 graduate students and 1 undergraduate student may utilize the data for augmenting or developing their own research. In most cases, the data will provide foundation for larger research studies that are currently conducted or soon will be conducted at the UMES LMRCSC.

Scientific Personnel

Name	Title	Organization
Vincent Guida	Chief Scientist	NEFSC, J.J. Howard Lab
Bradley Stevens*	Faculty	LMRCSC (UMES)
Stacy Smith*	Faculty	LMRCSC (Delaware State Univ.)
Martina Pierdomenico	Student Intern	NEFSC, J.J. Howard Lab (U. Rome)
Daniel Cullen	Student	LMRCSC (UMES)
Rehab El Fadul	Student	LMRCSC (UMES)
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Eric Evans	Student	LMRCSC (UMES)
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Table 1. Summary of trawl events and catches from the 2011 Latitudinal Survey.

			Ship's GPS (start)						Temp (deg C)		Total Catch		No. Taxa/Tow		
Trawl No.	Station	Trawl Type	Lat	Lon	bottom swept (m^2)	Date	Time (UTC)	Depth (m)	Surf	Bott	Wt (kg)	No. Indiv.	Total	Fish	Invert
1	LT1-1	2m BT	3953.36	7346.11	1,794	1/12	10:18	33.0	--	5.8	3.7	1919	18	5	13
3	LT2-1	2m BT	3904.49	7354.11	1,811	1/13	0:00	41.7	6.9	6.2	17.5	3393	16	2	14
4	LT2-2	2m BT	3905.43	7320.16	2,193	1/13	12:12	62.9	9.4	5.8	4.4	141	20	7	13
7	LT2-3	2m BT	3904.19	7254.21	1,889	1/13	19:33	85.2	11.5	12.5	1.0	70	8	4	4
22	LT4-3	2mBT	3811.65	7402.77	2,437	1/16	5:51	72.8	9.7	9.2	1.7	121	17	6	11
23	LT4-2	2mBT	3811.23	7412.71	2,363	1/16	7:44	59.3	8.8	7.8	8.5	398	28	12	16
24	LT4-1	2m BT	3811.39	7432.72	1,815	1/16	10:22	38.5	5.5	5.5	3.0	458	21	6	15
28	LT6-3	2mBT	3659.45	7438.37	2,359	1/17	1:13	100.7	13.3	13.0	1.2	383	25	5	20
29	LT6-2	2mBT	3701.63	7502.57	2,167	1/17	4:14	45.0	8.0	7.3	1.3	418	16	7	9
30	LT6-1	2mBT	3701.72	7517.22	3,552	1/17	6:17	33.4	6.7	5.9	0.8	1232	13	4	9
2	LT2-1	Y36	3904.50	7354.01	22,990	1/12	21:08	41.5	7.0	6.2	169.8	423	12	6	6
5	LT2-2	Y36	3905.18	7320.72	22,694	1/13	13:19	61.9	9.3	5.8	841.1	2675	10	5	5
6	LT2-3	Y36	3905.12	7254.39	24,283	1/13	17:44	87.6	11.5	12.5	84.3	3717	14	9	5
25	LT4-1	Y36	3811.29	7432.80	25,730	1/16	12:28	36.9	5.5	5.5	801.2	432	14	7	7
26	LT4-2	Y36	3811.13	7413.34	23,632	1/16	14:56	58.4	7.4	7.8	1608.7	914	11	6	5
27	LT4-3	Y36	3811.10	7403.30	24,956	1/16	16:31	69.5	9.4	9.2	1455.7	1887	12	6	6
31	LT6-1	Y36	3701.65	7516.92	23,428	1/17	12:39	34.5	6.9	6.2	81.6	112	8	3	5
32	LT6-2	Y36	3701.78	7503.08	24,161	1/17	14:14	45.5	8.0	7.3	184.1	170	11	6	5
33	LT6-3	Y36	3700.45	7439.35	21,615	1/17	16:44	100.2	12.9	13.0	1784.4	876	9	4	5
TOTALS					235,869						7054.0	19739	87	30	57
Y36 mean					23,721						779	1,245	11	6	5
Y36 SD					1234.3						694.2	1254.5	2.0	1.7	0.7
2mBT mean					2,238						4.3	853	18	6	12
2mBT SD					525.37						5.2	1062.5	5.7	2.7	4.4

Table 2. Summary of trawl events and catches from the 2011 Hudson Canyon Survey.

			Ship's GPS (start)						Temp (deg C)		Total Catch		No. Taxa/Tow		
Trawl No.	Station	Trawl Type	Lat	Lon	bottom swept (m^2)	Date	Time (UTC)	Depth (m)	Surf	Bott	Wt (kg)	No. Indiv.	Total	Fish	Invert
7	UV02 #1	2mBT	3939.31	7224.96	2,215	1/14	1:12	104.0	11.2	12.6	1.6	232	21	7	14
8	UV02 #2	2mBT	3939.20	7225.01	1,948	1/14	2:15	110.2	11.1	12.6	8.6	643	25	9	16
9	WX4	2mBT	3934.81	7226.48	1,926	1/14	3:43	112.9	10.3	13.6	1.5	535	17	4	13
10	PR31	2mBT	3940.09	7219.87	2,545	1/14	5:31	114.8	11.2	12.0	2.2	782	22	6	16
11	WX2	2mBT	3939.12	7228.83	2,741	1/14	7:12	127.5	11.0	11.8	1.6	125	13	7	6
12	UV01	2mBT	3939.81	7226.67	3,037	1/14	8:26	97.6	11.1	12.2	1.2	141	15	6	9
13	IJ1	2mBT	3926.09	7224.25	1,782	1/14	11:06	130.0	11.2	14.4	2.7	1485	28	6	22
14	KL3	2mBT	3921.33	7221.04	3,389	1/14	13:40	153.2	14.0	14.1	1.3	476	18	4	14
15	KL5	2mBT	3919.78	7216.08	1,359	1/14	15:13	261.8	11.4	9.3	1.5	328	22	8	14
16	IJ5	2mBT	3922.05	7214.46	919	1/14	16:41	284.0	11.2	8.7	7.0	473	15	9	6
17	IJ3	2mBT	3924.53	7219.42	2,378	1/14	18:31	150.0	11.7	14.8	0.7	462	21	2	19
	TOTALS				24,239						30.0	5682	70	22	48
	mean				2,204						2.7	517	24	6	16
	SD				722.52						2.6	379.7	15.2	2.2	11.0

Table 3. Summary of trawl events and catches from the 2011 Deepwater (Monkfish) Survey.

			Ship's GPS (start)						Temp (deg C)		Total Catch		No. Taxa/Tow		
Trawl No.	Station	Trawl Type	Lat	Lon	bottom swept (m^2)	Date	Time (UTC)	Depth $(m)^1$	Surf	Bott	Wt (kg)	No. Indiv.	Total	Fish	Invert
20	HC2	flat otter	3929.25	7211.16	25,587	1/15	10:33	403.7	10.8	7.8	457.3	930	30	19	11
19	HC4	flat otter	3922.24	7210.54	26,871	1/15	2:11	558.5	11.0	7.3	496.8	2431	20	14	6
18	HC6	flat otter	3920.59	7208.63	26,585	1/14	22:33	631.7	12.5	5.5	462.7	2434	17	12	5
21	HCX	flat otter	3931.04	7222.90	27,441	1/15	14:10	499.4	10.5	6.4	478.0	2112	28	15	13
34	NC3	flat otter	3651.16	7437.15	22,572	1/17	21:46	580.8	14.7	5.1	271.8	1354	43	26	17
35	NC10	flat otter	3653.36	7437.53	24,833	1/18	1:03	363.4	14.4	9.0	165.2	832	30	15	15
	TOTALS				153,890						2331.8	10093	82	44	38
	mean				25,648						388.6	1682	36	17	15
	SD				1772.95						136.71	735.8	22.1	5.04	11.06

Table 4. Latitudinal Transect catch summary: most important species (accounting for >10% of total numbers or total weight or occurring in >50% of trawls).

	36Y Otter Trawls			2m Beam Trawls		
Taxon	% of indiv.	% of wt.	% of trawls	% of indiv.	% of wt.	% of trawls
spiny dogfish - *Squalus acanthias*	**30.9**	**97.2**	**100**	0.0	0.0	0
longfin squid - *Loligo pealii*	**60.9**	0.7	**89**	0.0	0.0	0
rock crabs - *Cancer* spp.	0.6	0.0	**78**	1.0	0.0	**60**
margined sea star - *Astropecten americanus*	1.6	0.0	**67**	3.8	0.0	**60**
summer flounder - *Paralichthyes dentatus*	0.1	0.2	**56**	0.1	5.8	30
Atlatnic mackerel - *Scomber scombrus*	1.4	0.3	**56**	0.0	0.0	0
butterfish - *Peprilus triacanthus*	1.4	0.1	**56**	0.0	0.0	0
sand dollar - *Echinarachnius parma*	1.4	0.0	33	**41.4**	0.2	**70**
sand shrimp - *Crangon septimspinosa*	0.0	0.0	0	**34.7**	0.0	**80**
monkfish - *Lophius americanus*	0.0	0.0	0	0.0	**13.7**	10
spotted hake - *Urophycis regia*	0.0	0.0	11	0.1	1.9	**50**
red hake - *Urophycis chuss*	0.0	0.0	11	0.4	1.1	**90**
northern searobin - *Prionotus carolinus*	0.1	0.0	22	0.5	0.9	**60**
Gulfstream flounder - *Citharichthys arctifrons*	0.0	0.0	0	1.2	0.3	**90**
side-gilled sea slug - *Pleurobranchaea* sp.	0.0	0.0	22	4.0	0.0	**70**
bristlebeak shrimp - *Dichelopandalus leptocerus*	0.0	0.0	11	2.7	0.0	**80**
Acadian hermit crab - *Pagurus acadianus*	0.0	0.0	0	0.5	0.0	**50**
common sea star - *Asterias forbesii*	0.1	0.0	33	0.4	0.0	**50**
Nemertea - unidentified	0.0	0.0	0	0.0	0.0	**50**
TOTALS	98.5	98.5	--	91.0	23.8	--

Table 5. Hudson Canyon beam trawl survey catch summary: most important species (accounting for >10% of total numbers or total weight or occurring in >50% of trawls).

	2m Beam Trawls		
Taxon	% of indiv.	% of wt.	% of trawls
margined sea star - *Astropecten americanus*	**33.3**	**15.9**	**91**
deepwater crangonid - *Pontophilus brevirostrus*	**18.9**	1.0	**100**
red hake - *Urophysis chuss*	1.4	**33.7**	45
demosponges unclass.	0.0	**11.1**	27
blackbelly rosefish - Helicolenus dactylopterus	1.5	3.3	**55**
gulfstream flounder - *Citharichthys arctifrons*	2.4	1.3	**100**
bristlebeak shrimp - *Dichelopandalus leptocerus*	6.9	1.2	**55**
squat lobster - *Munida iris iris*	7.0	0.5	**100**
Tonguefish unclass. - *Symphurus* sp.	0.7	0.4	**55**
silver hake - *Merluccius bilinearis*	0.1	0.4	**64**
unident. red shrimp	1.6	0.3	**64**
sand zoanthids - *Epizoanthus americanus*	3.9	0.3	**55**
side-gilled sea slug - *Pleurobranchaea* sp.	0.9	0.1	**64**
dividing star - *Stephanasterias albula*	0.8	0.0	**55**
TOTALS	79.4	69.7	--

Table 6. Deepwater otter trawl (monkfish) survey catch summary: most important species (accounting for >10% of total numbers or total weight or occurring in >50% of trawls).

	Deepwater 36' Flat Net		
Taxon	% of indiv.	% of wt.	% of trawls
deep sea red crab - *Chaceon quinquidens*	**73.4**	**70.9**	**100**
spiny dogfish - *Squalus acanthias*	2.0	**13.0**	**50**
monkfish - *Lophius americanus*	1.2	4.8	**67**
thorny skate - *Amblyraja radiata*	0.7	2.8	**67**
witch flounder - *Glyptocephalus cynoglossus*	2.6	1.4	**100**
red hake - *Urophysis chuss*	1.3	1.2	**83**
fixed anemones unclass.	2.1	0.8	**67**
white hake - *Urophycis tenuis*	0.4	0.6	**50**
offshore hake - *Merluccius albidus*	0.8	0.5	**83**
Jonah crab - *Cancer borealis*	0.4	0.5	**50**
blackbelly rosefish - *Helicolenus dactylopterus*	0.4	0.1	**83**
marlinspike - *Nezumia bairdi*	1.1	0.1	**83**
bristlemoutn - *Gonostoma elongatum*	0.2	0.0	**50**
red shrimp unclass.	1.5	0.0	**67**
decapod shrimp sp. 2 - unclass.	0.8	0.0	**50**
orange roughy - *Hoplostethus atlatnicus*	0.2	0.0	**67**
royal red shrimp - *Pleoticus robustus*	0.0	0.0	**50**
decapod shrimp sp. 1 - unclass.	0.2	0.0	**67**
slender snipe eel - *Nemichthys curvirostris*	0.1	0.0	**67**
cutthroat eel - *Synaptobranchus* sp.	0.1	0.0	**67**
fish unclass.	0.1	0.0	**50**
TOTALS	89.5	96.8	--

Table 7. Monkfish catches from 2 m beam trawl and deepwater flat otter trawl tows. None were caught in 36Y tows.

Station	Gear Type	Lat (ddmm.mm)	Lon (ddmm.mm)	Mean Depth (m)	Bottom T (deg C)	Monkfish raw catch	Catch weight (kg)	min-max TL (cm)	median TL (cm)
LT1-1	2mBT	3953.36	7346.11	33.0	5.8				
LT2-1	2mBT	3904.49	7354.11	41.7	6.2				
LT2-2	2mBT	3905.43	7320.16	62.9	5.8				
LT2-3	2mBT	3904.19	7254.21	85.2	12.5				
LT4-3	2mBT	3811.65	7402.77	72.8	9.2				
LT4-2	2mBT	3811.23	7412.71	59.3	7.8	2	4.77	53-54	53.5
LT4-1	2mBT	3811.39	7432.72	38.5	5.5				
LT6-3	2mBT	3659.45	7438.37	100.7	13.0				
LT6-2	2mBT	3701.63	7502.57	45.0	7.3				
LT6-1	2mBT	3701.72	7517.22	33.4	5.9				
UV02 #1	2mBT	3939.31	7224.96	104.0	12.6				
UV02 #2	2mBT	3939.2	7225.01	110.2	12.6				
WX4	2mBT	3934.81	7226.48	112.9	13.6				
PR31	2mBT	3940.09	7219.87	114.8	12.0	31	0.54	--	--
WX2	2mBT	3939.12	7228.83	127.5	11.8				
UV01	2mBT	3939.81	7226.67	97.6	12.2				
IJ1	2mBT	3926.09	7224.25	130.0	14.4				
KL3	2mBT	3921.33	7221.04	153.2	14.1				
KL5	2mBT	3919.78	7216.08	261.8	9.3				
IJ5	2mBT	3922.05	7214.46	284.0	8.7				
IJ3	2mBT	3924.53	7219.42	150.0	14.8				
HC2	Flat OT	3929.25	7211.16	403.7	7.8	32	40.16	25-77	53
HC4	Flat OT	3922.24	7210.54	558.5	7.3				
HC6	Flat OT	3920.59	7208.63	631.7	5.5				
HCX	Flat OT	3931.04	7222.9	499.4	6.4	13	17.70	24-63	26
NC3	Flat OT	3651.16	7437.15	580.8	5.1	24	12.00	25-43	29
NC10	Flat OT	3653.36	7437.53	363.4	9.0	51	42.00	24-71	31
Overall						153	117.17		

Table 8. Spiny dogfish catch during DE11-01.

Station	Lat (ddmm.mm)	Lon (ddmm.mm)	Mean Depth (m)	Bottom T (deg C)	Est. Total Catch	Est. m:f ratio	% of males ≥ 60 cm	% of females ≥ 80 cm	females ≥ 80 cm as % of total catch
HC2	3929.25	7211.16	403.7	7.8	149	48.67	100.0	0.0	0.0
HCX	3931.04	7222.9	499.4	6.4	50	24.00	100.0	100.0	4.0
LT2-1	3904.5	7354.01	41.5	6.2	191	0.08	100.0	72.7	67.4
LT2-2	3905.18	7320.72	61.9	5.8	529	57.78	100.0	11.1	0.2
LT2-3	3905.12	7254.39	87.6	12.5	9	1.25	100.0	100.0	44.4
LT4-1	3811.29	7432.8	36.9	5.5	304	0.04	100.0	74.1	70.9
LT4-2	3811.13	7413.34	58.4	7.8	626	0.09	100.0	80.0	73.1
LT4-3	3811.1	7403.3	69.5	9.2	968	24.47	100.0	85.7	3.4
LT6-1	3701.65	7516.92	34.5	6.2	35	0.06	100.0	51.5	48.6
LT6-2	3701.78	7503.08	45.5	7.3	83	0.04	100.0	69.6	67.1
LT6-3	3700.45	7439.35	100.2	13.0	711	0.07	100.0	91.5	85.3
Overall					3655	0.95	100.0	81.2	41.6

Table 9. Deep Sea Red Crab catches during DE11-01.

Station	Lat (ddmm.mm)	Lon (ddmm.mm)	Depth Range (m)	Bottom T (deg C)	Est. Total Catch	Est. M:F ratio	Est. Density (no./sq km)
HC2	3929.25	7211.16	379-443	7.8	449	0.08	17,548
HC4	3922.24	7210.54	469-653	7.3	2223	0.34	82,730
HC6	3920.59	7208.63	580-673	5.5	2315	0.37	87,078
HCX	3931.04	7222.90	425-565	6.4	1513	0.14	55,136
NC3	3651.16	7437.15	535-641	5.1	709	0.32	31,410
NC10	3653.36	7437.53	346-410	9.0	197	0.04	7,933
Overall					7406	0.27	

Table 10. Witch Flounder catch during DE11-01.

Station	Start Lat (ddmm.mm)	Start Lon (ddmm.mm)	Depth Range (m)	bottom swept (m^2)	Date (UTC)	Start Time (UTC)	Bottom T (deg C)	Total No. Caught	Total Wt. Caught (kg)	Est. Density per sq km
HC2	3929.25	7211.16	379-443	25,587	1/15	10:33	7.8	77	11.16	3009
HC4	3922.24	7210.54	469-653	26,871	1/15	2:11	7.3	21	2.86	782
HC6	3920.59	7208.63	580-673	26,585	1/14	22:33	5.5	29	3.42	1091
HCX	3931.04	7222.90	425-565	27,441	1/15	14:10	6.4	63	10.86	2296
NC3	3651.16	7437.15	535-641	22,572	1/17	21:46	5.1	61	2.80	2702
NC10	3653.36	7437.53	346-410	24,833	1/18	1:03	9.0	10	0.74	403
overall				153,890				261	31.84	

Table 11. Longfin Squid catch during DE11-01.

Station	Lat (ddmm.mm)	Lon (ddmm.mm)	Mean Depth (m)	Bottom T (deg C)	*Loligo* raw catch	Normalized catch (indiv/km^2)	min-max ML (cm)	median ML (cm)
LT2-1	3904.5	7354.01	41.5	6.2	2	87	13-14	13.5
LT2-2	3905.18	7320.72	61.9	5.8	2,071	91,256	3-9	5
LT2-3	3905.12	7254.39	87.6	12.5	3,567	146,890	2-9	5
LT4-1	3811.29	7432.8	36.9	5.5	1	39	--	--
LT4-2	3811.13	7413.34	58.4	7.8	225	9,521	5-12	7
LT4-3	3811.1	7403.3	69.5	9.2	879	35,222	--	--
LT6-1	3701.65	7516.92	34.5	6.2	0	<43	--	--
LT6-2	3701.78	7503.08	45.5	7.3	3	124	5-7	6
LT6-3	3700.45	7439.35	100.2	13.0	78	3,609	4-7	5
HC2	3929.25	7211.16	403.7	7.8	1	39	20	--
HC4	3922.24	7210.54	558.5	7.3	0	<37	--	--
HC6	3920.59	7208.63	631.7	5.5	0	<38	--	--
HCX	3931.04	7222.9	499.4	6.4	0	<36	--	--
NC3	3651.16	7437.15	580.8	5.1	0	<44	--	--
NC10	3653.36	7437.53	363.4	9.0	0	<40	--	--
Overall					6,827	18,583		

Figure 1a. Map of Northeast United States and Mid Atlantic Bight showing proposed sampling locations and cruise path. Dotted lines indicate cruise track. Numbered Latitudinal Transects (LT) and their individual stations occur throughout the range of the cruise, Solid green squares: stations visited during this cruise; Empty squares: stations not visited. Hudson Canyon (HudCan) beam trawl and deep trawl stations (red triangles) are clustered around that feature, off New Jersey. Norfolk Canyon (Norfolk) deep trawls are clustered around that feature, off Virginia.

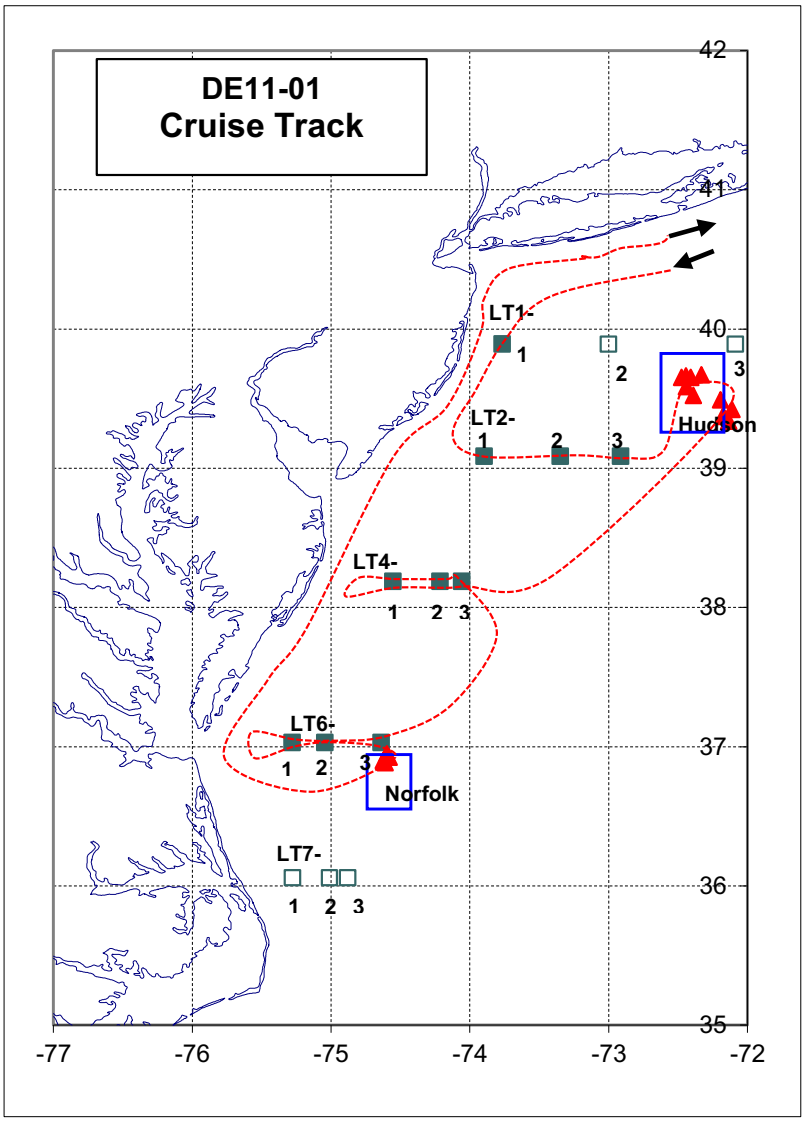


Figure 1b. Hudson Canyon sampling stations.

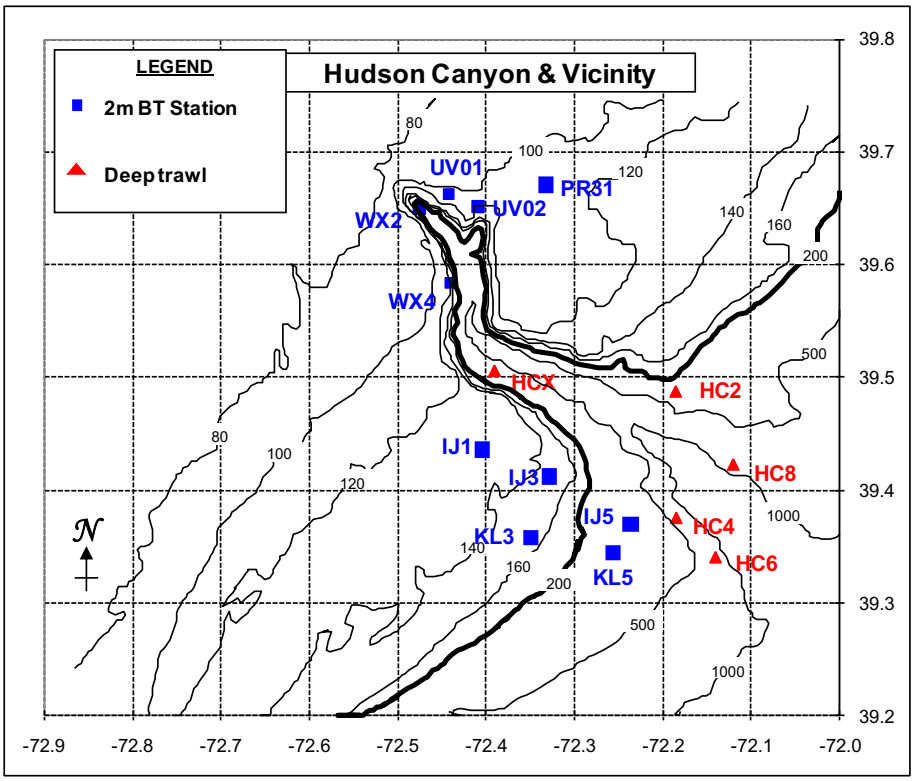


Figure 2. Diagrammatic comparison of composite catches by the 36Y and 2m beam trawl nets at the same stations during subsequent LMRCSC cruises: A. DE09-01, B. DE10-02, C. DE11-01.

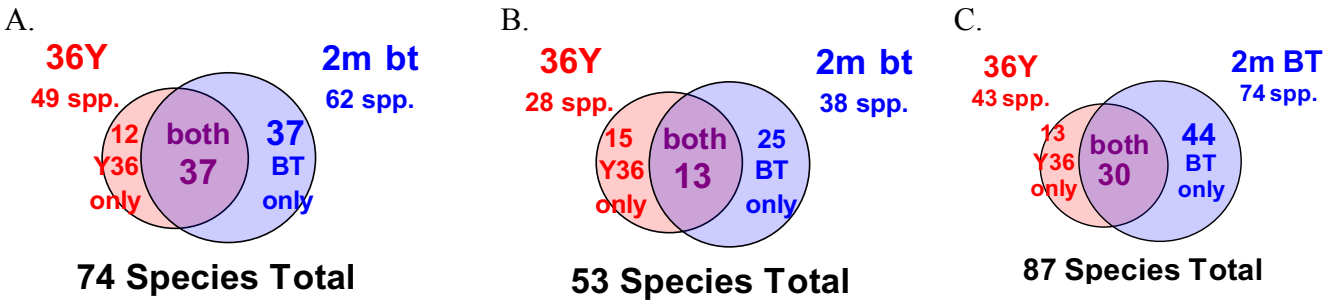


Figure 3. Single beam sonar interpolation surface at site PR31 mapped during Benthic Habitat cruise DE07-02.

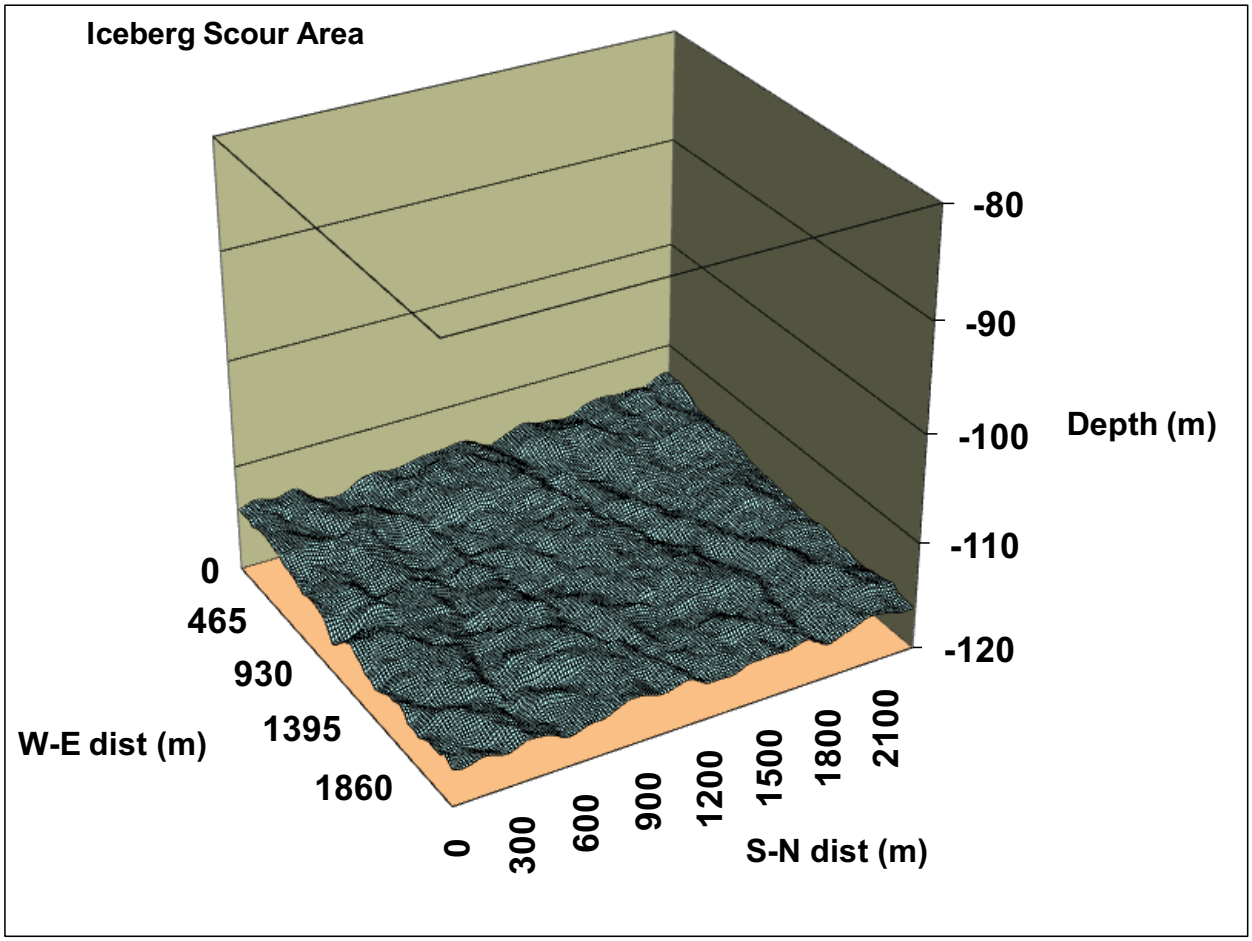
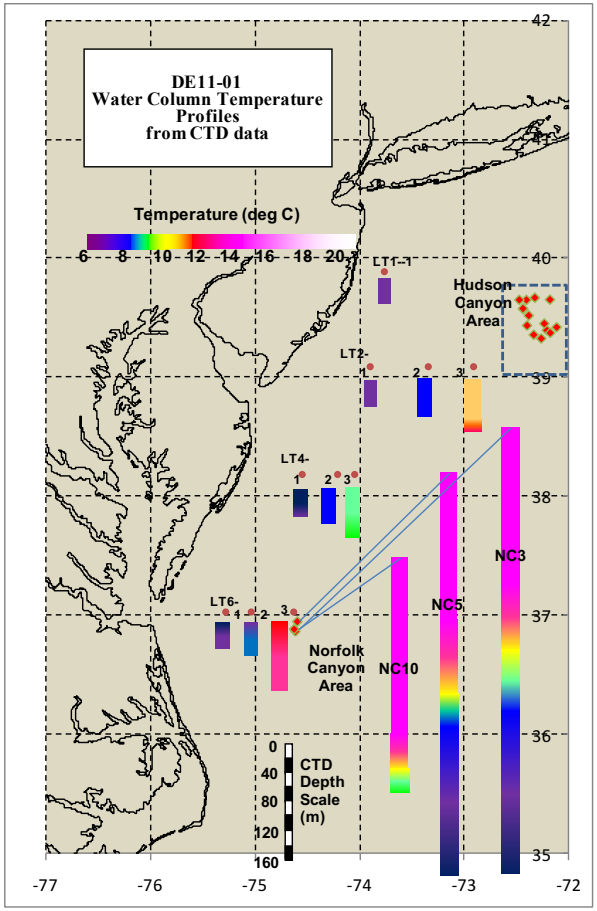


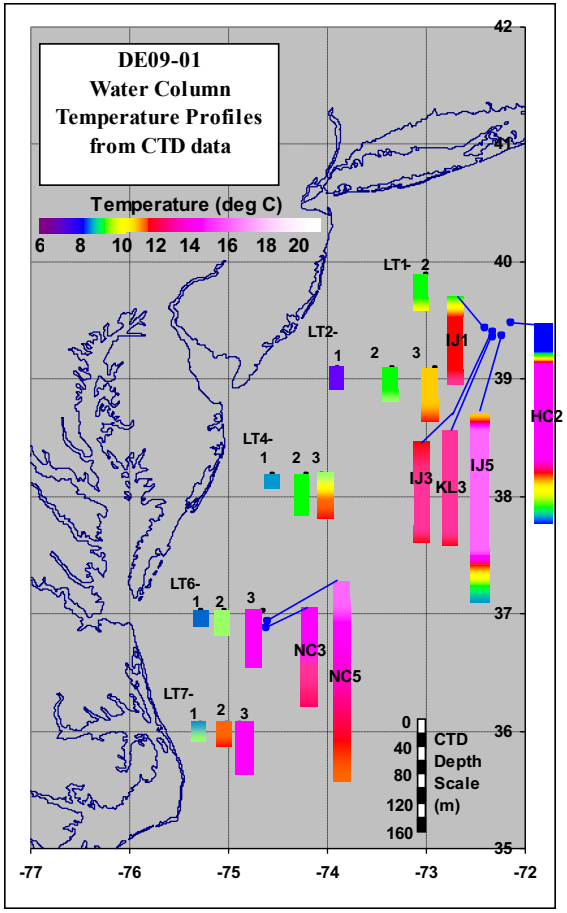
Figure 4. Lump of heavily burrowed, semilithified clay from deepwater otter trawl at station HCX.

Figure 5. Water column temperature profiles for A. January, 2011 (DE11-01), January, 2009 (DE09-01), and February-March, 2010 (DE10-02)

A.



B.



C.

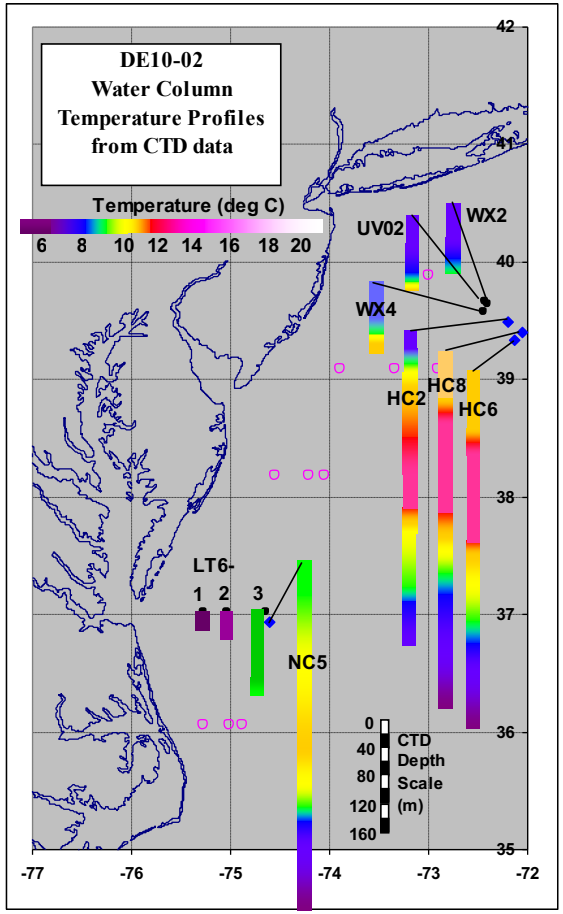


Figure 5D. Water column temperature profiles for January, 2011 (DE11-01): Hudson Canyon segment

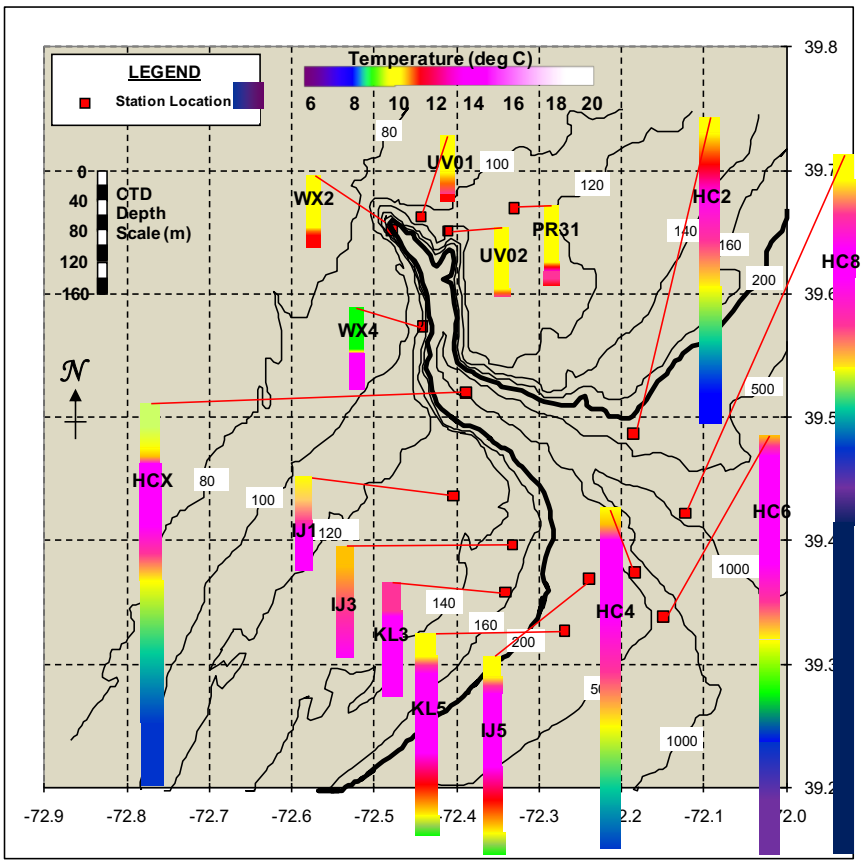


Figure 6. Virginia time series water column temperature profiles for Jan. 17th, 2011. Times are local (EST).

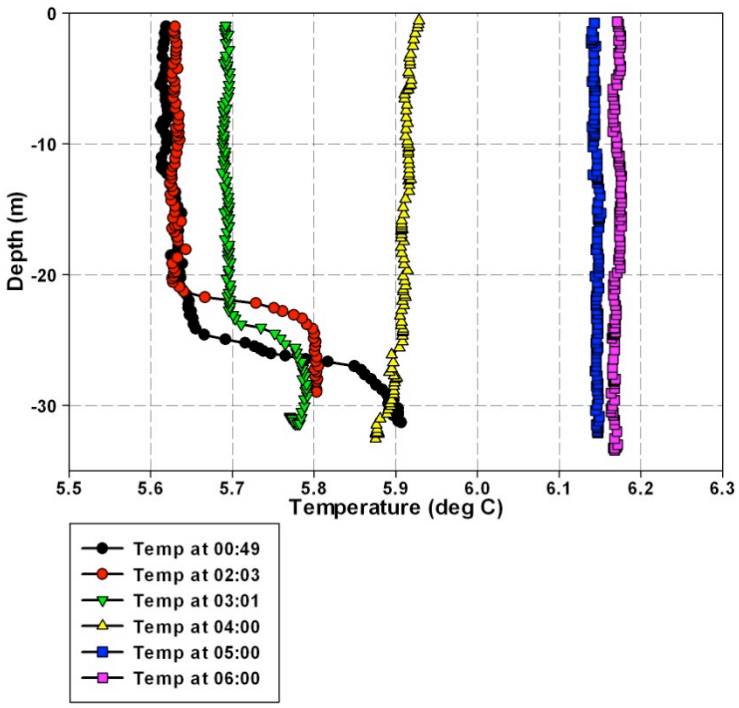


Figure 7. Size comparison of monkfish caught in deep tows from Norfolk and Hudson Canyons.

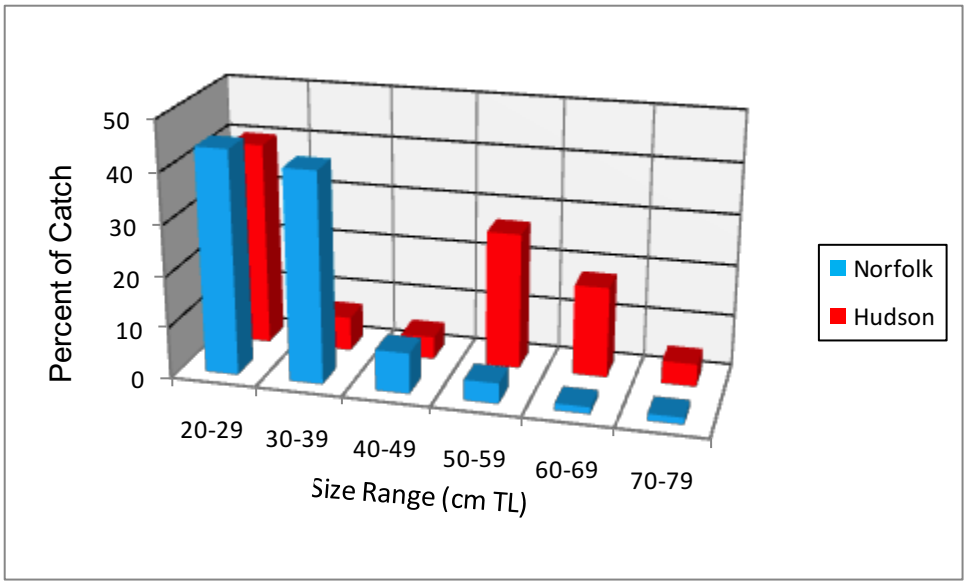


Figure 8. Distribution of Deep Sea Red Crab and witch flounder catches in 2011 as compared with 2009. Red lines and labels and darker shapes are 2011 trawl tracks and data, green lines and labels and lighter shapes are 2009 data. Station HCX is not shown.

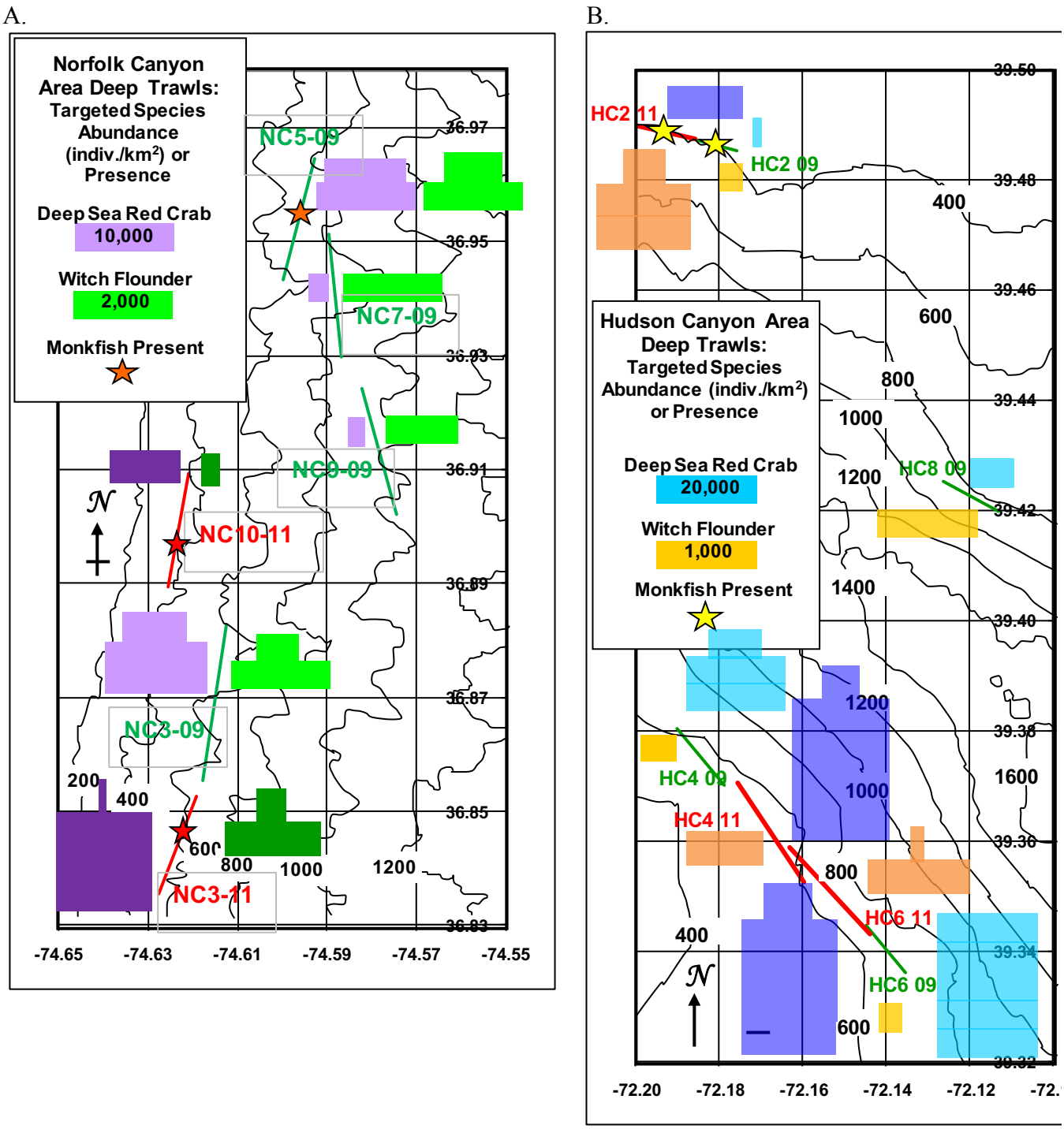


Figure 9. Size comparison of witch flounder caught in deep tows from Norfolk and Hudson Canyons.