CINAR

Cooperative Institute for the North Atlantic Region

Annual Progress Report

April 1, 2012 - March 31, 2013

Donald M. Anderson, Director

Submitted to:
National Oceanic and Atmospheric Administration
Ocean and Atmosphere Research (OAR)

Gulf of Maine Research Institute

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

University of Maryland CENTER FOR ENVIRONMENTAL SCIENCE

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WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CINAR

Annual Progress Report

Reporting Period: April 01, 2012 - March 31, 2013

Submitted by:

Donald M. Anderson, Director

Submitted to NOAA on 04/30/2013

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EXECUTIVE SUMMARY

CINAR began operation on July 1, 2009. WHOI is the lead institution in partnership with the University of Maryland Center for Environmental Science, Rutgers University, University of Maine and the Gulf of Maine Research Institute.

The geographic domain of CINAR is the U.S. northeast continental shelf from Cape Hatteras to Nova Scotia. Because of the importance of large-scale climate and biological connectivity in the North Atlantic, CINAR's geographic scope also includes basin and global-scale processes that affect the shelf ecosystem. The overall goal of CINAR is to engage NOAA and academic scientists in cutting-edge research that enables NOAA to make informed decisions about sustainable and beneficial management of the U.S. northeast continental shelf ecosystem.

Funding:

In its first year of operation, CINAR supported 11 projects for 9 investigators, totaling $3.6 million in funds. Year one funds were mainly through the NMFS line office ($3.5 million).

- In year two, funding increased significantly to a total of $11.4 million with $3.3 million from NMFS, $7.7 million from OAR, and $0.3 million from NOS.
- In year three, funding was nearly $10.4 million from OAR, $3 million from NMFS, and $1.7 million from NOS.
- In year four, Funding was lower this year, with $5.6 million from OAR, $2.7 million from NMFS, and $.03 million from NOS.

Postdoctoral Support

Currently, WHOI supports one 18-month CINAR Postdoctoral Scholar per year as part of its cost-sharing commitment. Given the funding source, these postdoctoral scholars are located at WHOI. We are pleased to include progress reports from Postdoctoral Scholar Robert Todd and Ke (Kevin) Chen as part of this year's CINAR progress report. It is of note that CINAR's first Postdoctoral Scholar, Joel Llopiz, has been appointed as an Assistant Scientist on the scientific staff of the Biology Department at WHOI.

Program Development

One of the goals of CINAR has been to make better use of the technical expertise available at the CINAR partner institutions. We thus formulated an "Innovation and Transformation" program and presented it to the leadership at the NEFSC. Titled "*Transformative research in ecosystem based management: a process of technology development, demonstration, and implementation,"* the program had the objective to foster the development and implementation of a broad range of innovative technologies that can dramatically alter or transform current policies and procedures in ecosystem management and quantitative fisheries science in the northeast region. NOAA's Cooperative Institutes have been established to augment the research and development capabilities of its line offices and centers, and CINAR is uniquely positioned to assist the NEFSC in this regard, given its diverse capabilities and skills in instrument and sensor development, imaging and data visualization, statistical analysis of complex datasets, numerical modeling of hydrographic and ecosystem processes, and social and human dimensions science. A cooperative program with CINAR can help the NEFSC move its regional fisheries and ecosystem management into new directions.

As a first step towards this long-term objective, funds were made available for one transformative technology that was selected by the NEFSC as being close to operational use. This was a project led by WHOI PI Scott Gallager, entitled "Manual and Automated Analysis of Stereo Images and Transitions of HabCAM Technology to NOAA Operations".

It is not clear whether this innovation and transformation program will continue given current budget pressures, but CINAR staff will continue to push for support, for individual projects, but perhaps for an annual, internal competition among partner institutions, with selections of successful projects made in direct consultation with NEFSC managers.

The recent appropriation to NOAA as a result of Superstorm Sandy gave CINAR an opportunity to demonstrate the value of a consortium CI as a source of innovative ideas to address pressing NOAA problems. In that case, the need was for projects that would enhance NOAA's abilities to respond to extreme weather events. The five CINAR partners worked closely together to formulate a rapid response observational and modeling program that fills an important gap in NOAA's predictive capabilities. Although only time will tell whether funding for such a program will be forthcoming, this was a worthwhile activity for the CINAR partners that demonstrated the power of consortium Cooperative Institutes – joint efforts to come up with solutions to pressing NOAA problems using the expertise and facilities of a range of investigators and institutions. We hope to have other opportunities to direct CINAR's expertise and facilities to other problems leading to enhanced research applications that are not tied to individual NOAA sponsors.

Earlier this year, CINAR sponsored a workshop organized around the historic temperature anomalies observed at the eastern edge of the Northeast Shelf Large Marine Ecosystem (NES LME). Temperatures in the region as much as 6 degrees warmer than historic levels were observed beginning in late 2011 and continuing through spring 2012. The workshop brought NOAA and CINAR scientists together with fishermen to discuss the current state of understanding regarding shelfbreak processes, impacts of the recent warming and the design of additional measurements that can be made to assess the ecosystem state more accurately. The primary goal of the workshop – to create new partnerships between academic scientists, representatives of the commercial fishing industry, and NMFS scientists - has been met. Workshop leaders are now finalizing a white paper addressing the science questions. This will be brought to the Consortium for Ocean Leadership to discuss whether this could be used to form a new National Ocean Partners Program (OPP). Discussions will also involve other possible funding options for future science activities, including NOAA, NSF, private foundations, etc.

Education and Outreach

We are pleased to report that many of our ideas for programs in education and outreach are coming to fruition.

2012 saw the first of our Teacher Workshops planned around CINAR themes. This will be an annual event, currently planned for WHOI, but eventually expanded to involve scientists from all CINAR partners in conjunction with their university or state education and outreach programs (e.g., Sea Grant). We have also launched our CINAR sponsored program in Minority Traineeships, providing one minority student per year to each partner institution to work with CINAR-sponsored PIs.

We have established a partnership between WHOI, the University of Massachusetts School for Marine Science and Technology (SMAST), and the NEFSC to address issues related to Massachusetts and regional fishing communities. Two components are included: 1) a series of rotating, competitive Fellow awards for WHOI scientists working in areas relevant to the central theme of quantitative fisheries science; and 2) faculty support at SMAST to conduct research and educational activities related to stock assessment and quantitative fisheries science. The primary goal of this program is to provide both the research tools and the trained personnel that are needed to help address the challenge NOAA and the Northeast Fisheries Science Center face in moving toward Integrated Ecosystem Assessments and Ecosystem Approaches to Management. With a purposefully strong local focus, this program demonstrates the willingness of the NEFSC to develop programs that support fishing communities like those in New Bedford and Gloucester. A progress report for this program is provided in this document, beginning on page 160.

CINAR ANNUAL RESEARCH HIGHLIGHTS

Paul Anderson – University of Maine
A US-Canada Science Symposium: the American Lobster in a Changing Ecosystem

Sponsored by CINAR and the University of Maine Sea Grant Program, this symposium provided the opportunity for scientists in this region, working on the American Lobster to convene and to promote the sharing of new findings. This was a very timely convergence of the science because of severe die-off of lobster in southern New England and the opportunity to look at the challenges and vulnerabilities of this species throughout the range from New England to Canada.

- The format of the symposium allowed for approximately 60 scientific presentations, as well as blocks of time for discussion. Manuscripts submitted for publication that pass peer review will be published in the *Canadian Journal of Fisheries and Aquatic Sciences*. A wrap-up session was held on the final day to synthesize a summary report that will highlight significant conclusions, information gaps and research needs. This document will help to connect research teams and institutions with the goal of enhancing networks and research collaboration. Maine Sea Grant's communications team will be involved in editing and producing a final document that will be made available electronically via the Internet.

Ke Chen – Woods Hole Oceanographic Institution
CINAR Postdoctoral Scholar

Ke has been working on the quite unusual warming in the spring of 2012 over the Mid-Atlantic Bight shelf in collaboration with his advisors, Glen Gawarkiewicz and Steve Lentz, as well as others at WHOI and elsewhere. The water temperature on the MAB continental shelf was anomalously warm in the first half of 2012, and had major impacts on the Northeast US coastal ecosystem and commercial fisheries. According to a NOAA Northeast Fishery Science Center ecosystem advisory, the spring bloom in 2012 started as early as February and phytoplankton biomass was higher than average. Atlantic Cod distribution had a northerly shift consistent with the response to the ecosystem warming. Starting with all available in-situ observations collected in this period, Ke aims to understand the spatial and temporal characteristics of the warming and its underlying dynamic processes.

- Systematic warm anomalies from Gulf of Maine to Cape Hatteras were found to be related to large scale atmospheric forcing.
- The warm anomalies extend from the ocean surface through the water column.
- Close correlation has been found between Jet Stream latitude and water temperature anomalies.
- Anomalous large net atmospheric heat flux in late 2011 and early 2012 inhibits heat loss of the ocean and decreases its cooling rate.

Di Jin - Woods Hole Oceanographic Institution
Vessel Safety and Fisheries Management

The objective of this project is to improve our understanding of the determinants of fishing vessel accidents and to improve safety in commercial fishing.

- Fishermen engage in more risky behavior as a result of increasing fisheries regulations, such as fishing in inclement weather, continuing to work despite crew fatigue, and extending the normal length of a fishing trip.

- Regulators should consider the unintended consequences of fisheries regulations on safety behaviors, and develop programs that account for the indirect impact of these regulations on overall safety in the industry.

Mike Purcell - Woods Hole Oceanographic Institution
Using Remus 100 Autonomous Underwater Vehicles to Conduct NEFSC Scallop Surveys

The aim of this project was to demonstrate the effectiveness of using lightweight autonomous underwater vehicles (AUVs) to conduct benthic habitat surveys. The overall effort has included engineering developments and at sea testing.

- Developments included a new 360-LED, low power lighting array and camera module for a REMUS 100 AUV. These components were installed on a REMUS 100 AUV already equipped with the following sensors: high frequency side scan sonar, acoustic Doppler current profiler, conductivity, temperature and depth sensors. The AUV was used to conduct scallop surveys on Stellwagen Bank in June, 2012. Ten missions were conducted over four days.
- Small, lightweight AUVs may be used to conduct multispecies benthic surveys which gather information on a variety of benthic organisms and habitat, as well as species-specific data. These surveys may be conducted quickly using multiple vehicles and with smaller ships, which will reduce costs. Additionally, they result in no physical disturbance of bottom habitats upon which fisheries resources depend.

Graham Sherwood – Gulf of Maine Research Institute
Inshore Gulf of Maine Herring Acoustic Survey

The goals of this project are to use acoustics to estimate abundance and biomass of herring in coastal waters of Maine and, combining results with those from the NMFS offshore survey, to generate a synoptic "snapshot" of the status of the Gulf of Maine herring complex.

- Acoustic backscattering data has been collected from a total of 4,200 miles of transects in coastal Maine waters to be used in estimates of herring abundance and distribution.
- Collaboration that has been fostered between GMRI and the lobster industry. Fishermen (10 lobstermen) were actively involved in every step of this project from the planning stages, through equipment installations and calibrations and data collection. Meetings were held to inform participants of project progress, solicit advice for continuation of the survey/sampling and securing funds for future survey work that makes use of their expertise, vessels and the acoustic equipment.
- Results of this study will inform management decisions that could contribute to maintaining a sustainable population of Atlantic herring in the Gulf of Maine. More

accurate estimates of herring abundance in the Gulf of Maine may contribute to more predictable bait supply for the Gulf of Maine lobster industry which relies heavily on this resource.

David W. Townsend – University of Maine
Nutrient Dynamics on the Northeast Continental Shelf: Sample Analysis

The accelerated melting of the Greenland ice sheet and the Arctic ice cap in recent decades appears to be influencing marine ecosystems far removed from the Arctic Ocean via changes in the circulation of the Labrador Sea and the Northwest Atlantic continental shelf and slope waters. This has resulted in an increased baroclinic transport of low salinity shelf waters to regions farther south. Consequently, we are seeing changes in the water properties and nutrient regime in the Gulf of Maine over the past several decades. In order to begin to monitor this apparent change in the ecosystem of the Northwest Atlantic continental shelf, this project involves analyzing nutrient samples collected on NOAA Northeast Fisheries Science Center Ecosystem Monitoring Program (EcoMon) cruises.

- Results continue to provide evidence of shelf waters becoming fresher and colder, with proportional changes in nitrate and silicate.
- This research is providing baseline data for future interpretations of climate change-induced alterations to the marine environment of the Northwest Atlantic continental shelf.
- Data have already provided evidence in support of earlier expressed concerns about far-field effects of Arctic melting.

Lisan Yu - Woods Hole Oceanographic Institution
Fifty-Year Analysis of Global Ocean Surface Heat Flux

The Objectively Analyzed air-sea Fluxes (OAFlux) project is a research and development project focusing on global air-sea heat, moisture, and momentum fluxes. The project is committed to produce high-quality, long-term, global ocean surface forcing datasets from the late 1950s to the present to serve the needs of the ocean and climate communities on characterization, attribution, modeling, and understanding of variability and long-term change in the atmosphere and the oceans.

- With the newly completed global analysis of ocean surface winds, the OAFlux project now provides climate records of global air-sea fluxes of heat, moisture, and momentum and serves the communities' need of multi-decade datasets with accuracy for research on global energy and water cycle.
- Global winds have been changing. Tropical trade winds have been strengthening and southern hemisphere westerlies are found to have shifted and intensified poleward.
- The rate of ocean evaporation has been trending downward since 2000, reversing the upward trend that dictated the decades of 1980s and 1990s.

INTRODUCTION

The Cooperative Institute for the North Atlantic Region (CINAR) is a regional CI that focuses on the U.S. northeast continental shelf (NES) large marine ecosystem (LME) that encompasses the shelf from Cape Hatteras to Nova Scotia - one of the world's most highly productive marine ecosystems. The structure and dynamics of the NES ecosystem are strongly influenced by local, regional, and basin-scale environmental forcings and by a range of human activities including fishing, the discharge of nutrients and other pollutants, and development along the coast. There is also a growing recognition of ecological impacts from climate change and ocean acidification.

CINAR is a consortium of five partner institutions that together span the geographic range of the NES and provide the required breadth, depth and quality of scientific expertise, instrumentation, models, and facilities to address many of NOAA's needs in the region. Partners include the University of Maryland Center for Environmental Science (UMCES), Rutgers University (RU), the Woods Hole Oceanographic Institution (WHOI), the University of Maine (UME), and the Gulf of Maine Research Institute (GMRI). The CINAR Program Office is located at WHOI.

1.1 Institute and Core Activities

1.2 CINAR Vision, Mission, Goals and Organization

Our vision for CINAR is as an essential component of the NOAA research and management capability in the northeast region, functioning as a mechanism that allows NOAA scientists to easily and rapidly obtain research assistance for ongoing projects, that contributes to the science planning process in NOAA, and that anticipates and responds to technical needs through the development of instruments, models, and approaches that contribute to management decisions.

CINAR's philosophy of operations focuses on research, transition of research to applications specific to NOAA's mission and goals, and a range of education and outreach activities to train new NOAA scientists, enhance knowledge and expertise of existing scientists, and communicate research results. Our overarching goal is to dramatically improve the predictive science that enables sound management, while concurrently informing the general public and stakeholders of the complexities and importance of ecosystem-based management of NES LME resources.

The mission of CINAR is engage NOAA and academic scientists in cutting-edge research that enables NOAA to make informed decisions about sustainable and beneficial management of the northwestern Atlantic shelf ecosystem.

Working within the geographic framework of the NES LME, the goals of CINAR are:

1) To establish CINAR as a leader in promoting "rational ocean stewardship" and serving as a model for development of similar ecosystem approaches to management in other regions;

2) To coordinate research, education and outreach with NOAA scientists in support of responsible stewardship of coastal and marine resources in the region;

3) To conduct research that identifies and evaluates linkages among productivity, fish and fisheries, pollution, climate change and ecosystem health;

4) To conduct research and develop decision-support tools for sustainable fisheries management;

5) To conduct research and develop tools to restore degraded habitats and support restoration and rebuilding of protected species to healthy population levels;

6) To improve integration and availability of ocean observations from global to local scales;

7) To provide mechanisms for transition of predictive/forecasting and monitoring tools into operational use for management;

8) To improve ability to distinguish shifts in marine resource status caused by human impact from those due to climate and other natural forcing; and,

9) To develop robust indicators of ecological health and socioeconomic benefits that can be utilized by resource managers.

CINAR Organization

CINAR is managed and administered through WHOI, Woods Hole, Massachusetts.
Donald M. Anderson, the CINAR Director, has overall management responsibility for CINAR providing leadership with NOAA and with the CINAR Council of Fellows. He is responsible for scientific leadership of CINAR and for ensuring maintenance and development of scientific programs and priorities. The CINAR Director has budgetary authority over Task 1 (administrative) activities and accountability for Task 2 and 3 activities, subject to review and advice of the Executive Board. The administrative structure of CINAR is shown in Figure 1.

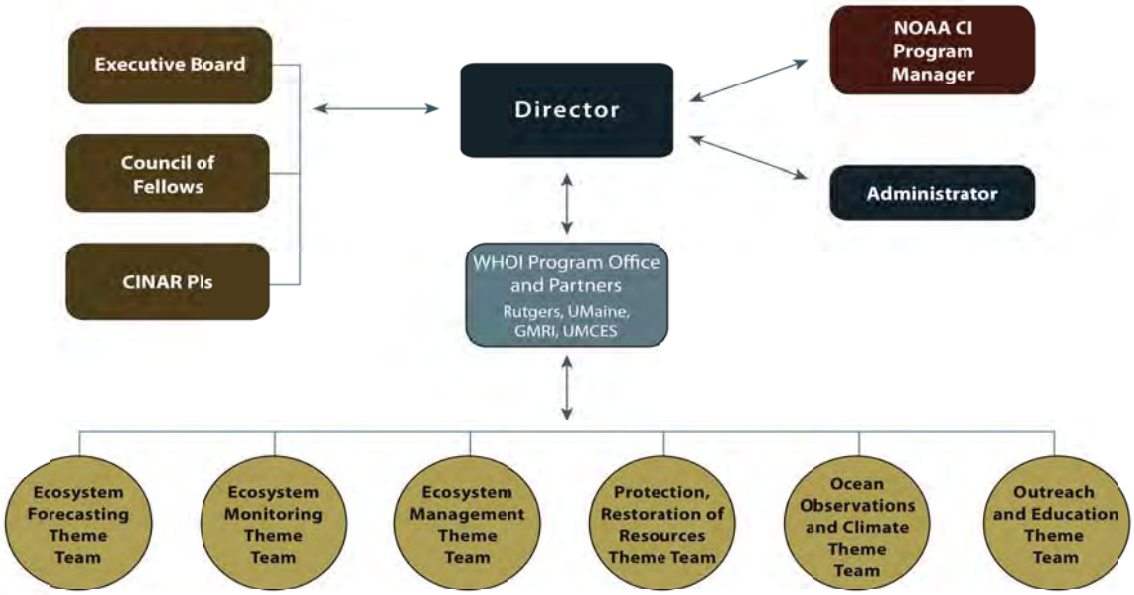


Figure 1. Organizational structure of CINAR

CINAR PIs

The CINAR PIs include Donald M. Anderson, *CINAR Director, Woods Hole Oceanographic Institution*; Oscar Schofield, *Professor, Institute of Marine and Coastal Science, Rutgers University*; Michael Roman, *Director, Horn Point Laboratory, University of Maryland Center for Environmental Science*; Fei Chi, *Director, School of Marine Sciences, University of Maine*; and John Annala, *Chief Scientific Officer, Gulf of Maine Research Institute*. The CINAR PIs meet frequently in person or via conference call to discuss issues and to ensure that partner institutions are updated on CINAR activities.

CINAR Executive Board

The Executive Board consisting of senior employees from NOAA, WHOI, and at least one of the other CINAR consortium members, provides a senior management linkage to NOAA to guide the programmatic priorities and policy directions of CINAR. Members of the Executive Board participate in annual meetings, and represent the views of their program or branch within NOAA so as to facilitate beneficial interactions between NOAA scientists and CINAR. The Executive Board includes representatives from NOAA line offices and goal teams that have research interests in the North Atlantic region.

The CINAR Executive Board members are:

William Karp, Chair	NMFS	NEFSC
Venkatachalam Ramaswamy		OAR Representative
Russell Callender	NOS	Representative
Krisa Arzayus		Climate Goal Team Representative
Ned Cyr	NMFS/OST	
Donald Anderson	CINAR	Director
John Annala	CINAR	PI, Gulf of Maine Research Institute
Leon Cammen		Director, National Sea Grant Program
Peyton Robertson	North	Atlantic Regional Team Representative
Laurence Madin	WHOI	Leadership
Philip Hoffman		OAR CI Program Director

CINAR Council of Fellows

Chaired by the CINAR Director, the Council of Fellows is the primary planning and consultative body of CINAR. Responsibilities include participating in conference calls and occasional in-person meetings and discussion of issues related to the administration and oversight of CINAR. NOAA Council members are expected to serve as a conduit for information in both directions between NOAA and CINAR, including the identification of research opportunities for the CINAR partners.

Membership includes: one senior representative from each CINAR partner institution (GMRI, RU, UMaine, and UMCES), the CINAR Director; a senior manager from the NEFSC; OAR Climate Program Manager (or designee); and NESDIS/NCDC representative. The OAR CI Program Manager will be a special advisor to the Council in an *ex officio* status.

The CINAR Council of Fellows members are:

Donald Anderson, Chair		CINAR Director
Oscar Schofield	CINAR	PI, Rutgers
Michael Roman	CINAR	PI, UMCES
Peter Jumars		CINAR PI, University of Maine
John Annala	CINAR	PI, Gulf of Maine Research Institute
Paulinus Chigbu		MSI Representative / UMCES
Fred Serchuk	NMFS/NEFSC	
Position to be filled		OAR/Climate Program Office
Ellen Mecray		NESDIS/NCDC
Philip Hoffman, *ex officio*		OAR CI Program Director

CINAR Theme Leaders

Includes individuals from the partner institutions with long-term and significant interactions with NOAA who will serve as representatives for their respective CINAR research theme. Each leader is supported by Theme Coordinators at each partner institution, each of whom represents a large group of participating investigators, as identified on the CINAR web site (www.cinar.org).

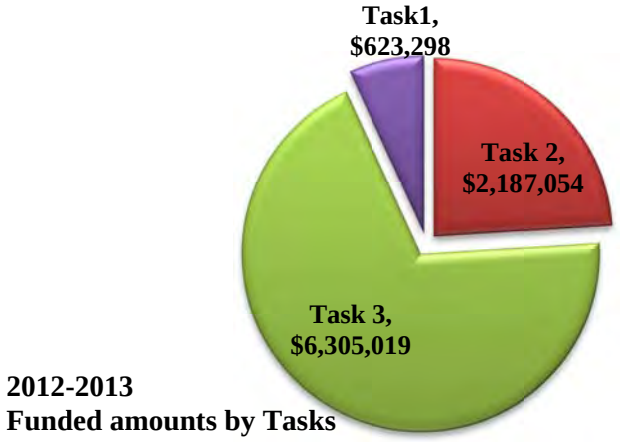
CINAR Research and Administrative staff

WHOI and the partner institutions provide the administrative staff for grants and contracts management, human resource management, systems administration, procurement, and all necessary support staff roles for CINAR activities. CINAR uses the services of researchers through an appropriate combination of tenured or tenure-track faculty in academic departments, and non-tenure track faculty. Each institution is responsible for appropriate oversight of faculty research activities. CINAR actively promotes undergraduate and graduate education through internships, cooperative experiences, graduate assistantships, and fellowships.

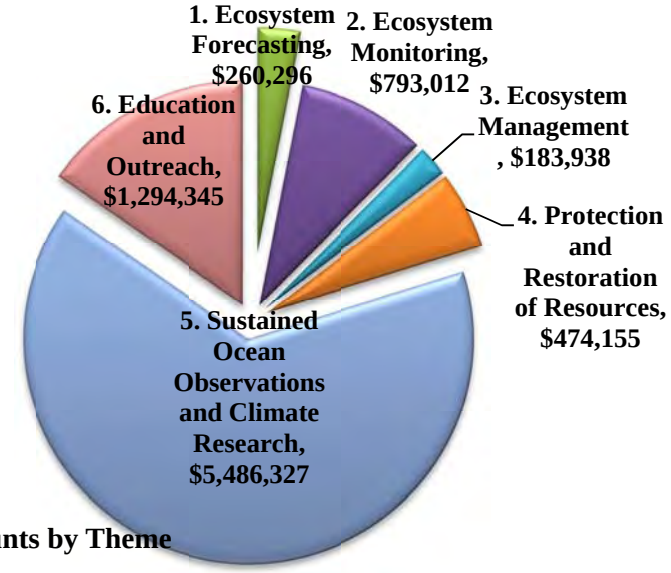
CINAR Program Office

Donald Anderson	CINAR Director
Judy Kleindinst	CINAR Administrator
Ann Stone	CINAR Administrative Professional

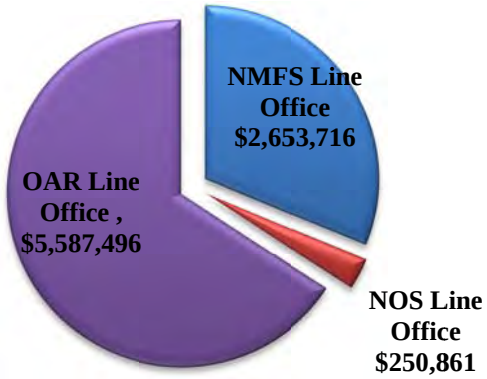
1.3 Distribution of NOAA Funding by Task, CINAR Themes and NOAA Line Office



2012-2013
Funded amounts by Tasks

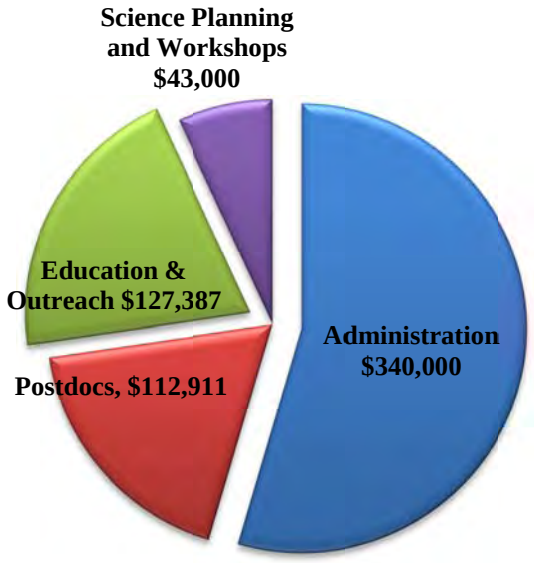


2012-2013
Funded amounts by Theme



2012-2013
Funded amounts by Line Office

1.4 Task I Activities with Distribution of Funding



Task I funding is provided by three sources – OAR, NMFS and WHOI (cost sharing). In year 4, we received $110,000 from OAR, $240,000 from NMFS and $283,298 from WHOI as cost-sharing to cover salary and related costs for part of CINAR Director Anderson's time and for a CINAR Postdoctoral Scholar

CINAR Five-Year Review

In addition to the "normal" administrative activities with running a consortium CI, this year, significant time was devoted to preparing for the CINAR Five-Year Review, held in September. Many CINAR investigators, students, postdoctoral investigators, and our CINAR Consortium PIs participated in the review by giving presentations or posters, meeting with the review panel and answering questions. We received a mark of "outstanding" from the review panel and the NOAA Science Advisory Board has accepted the report. We are pleased that CINAR will be renewed for another five years. Copies of the preparatory material given to the review committee is available on our website: http://www.cinar.org/page.do?pid=110136. During the coming year, we will work our Council of Fellows and Executive Board to address some of the recommendations from the review panel.

Data Management

The NSF funded Biological and Chemical Oceanography Data Management Office (BCO-DMO) recently finalized the bottle and underway data from the project, Investigations of *Alexandrium fundyense* dynamics in the Gulf of Maine, principal investigators Don Anderson, Dennis McGillicuddy and Bruce Keafer. These CINAR-relevant data are accessed via the following URLs:

Bottle Data:
http://osprey.bco-dmo.org/dataset.cfm?id=13715&flag=view

Underway Data:
http://osprey.bco-dmo.org/dataset.cfm?id=13716&flag=view

OC467 Event Log:
http://osprey.bco-dmo.org/dataset.cfm?id=13875&flag=view

Information about this project is available at:
http://osprey.bco-dmo.org/project.cfm?flag=view&id=126&sortby=project

BCO-DMO continues to make available the New England Fisheries Science Center (NEFSC) EcoMon data on the hydrography and biology of Gulf of Maine. These data can be accessed via the following URLs:

Hydrography:
http://osprey.bcodmo.org/dataset.cfm?id=13663&flag=view&return=deploy

EcoMon 10m2:
http://osprey.bcodmo.org/dataset.cfm?id=13683&flag=view

EcoMon 100m3:
http://osprey.bcodmo.org/dataset.cfm?id=13684&flag=view

Information about the NEFSC and these two projects are available at:
http://osprey.bcodmo.org/program.cfm?flag=view&id=22&sortby=program

Education and Outreach

Postdoctoral Scholar program. Through WHOI cost-sharing support for CINAR, each year we appoint an 18-month Postdoctoral Scholar. Postdocs are selected from a national competition at WHOI of very strong applicants in all fields of oceanography. The CINAR Director convenes an ad hoc committee each year of CINAR investigators from each scientific department at WHOI to review the top 25 applicants and make recommendations for which ones CINAR is interested in supporting. Currently we have two CINAR Postdoctoral Scholars - Robert Todd and Ke (Kevin) Chen. Their reports begin on page 19.

Our next Postdoctoral Scholar will be Sara Bender, University of Washington. Her report will be included in the next CINAR progress report.

Teacher's workshop. CINAR sponsored a teachers' workshop in August 2012, entitled "*Robotics, Vehicles, and Underwater Imaging*". CINAR Investigators Hanu Singh and Mike Purcell presented information and materials for middle and high school teachers from the Northeast region. CINAR will continue to sponsor at least one teachers' workshop per year on a topic related to its themes.

Undergraduate student training: During the summer of 2012, CINAR provided undergraduate summer intern funding at Rutgers. The summer intern program trained eight undergraduates and three Naval cadets in glider operations. In addition to the training, students also spent the summer working with scientists from NFMS. Specifically the CINAR undergraduates conducted an extensive analysis of existing data as part of their summer experience focused on using observatory data to assess ecosystem status of the Mid-Atlantic Bight. One of the student projects focused on using the historical data to document a shift in the timing of the Autumn shelf destratification, which has significant implications for the food web. Working with NMFS the student has been assessing the impact of these changes n butterfish habitat. Another CINAR student focused on NFMS surveys to sample the butterfish habitat using ocean observatory data. The students also presented posters at the CINAR Science Review held in September, 2012.

CINAR has instituted a Minority Traineeship program whereby one undergraduate minority traineeship at each partner institution will be offered each summer. Students have already been selected and appointed for summer 2013 – we will have a total of five minority trainees throughout the CINAR consortium. We will provide reports from these students in next year's progress report.

Outreach. CINAR recently became a sponsor of the Gulf of Maine Times (http://www.gulfofmaine.org/gomt/?page_id=519), produced by The Gulf of Maine Council Outreach Committee. The Gulf of Maine Council on the Marine Environment was established in 1989 by the governments of Nova Scotia, New Brunswick, Maine, New Hampshire and Massachusetts to foster cooperative actions within the Gulf watershed. Its mission is to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations. We are currently working with the editor to produce articles on CINAR funded projects. Its readership is approaching 100,000.

Mike DeLuca, Theme Leader for CINAR Education and Outreach, gave a presentation to the NOAA Education Council on February 20, 2013. He provided a general overview of the CINAR vision and mission, followed by an introduction to the major thematic areas of expertise, and technology/infrastructure available through CINAR. He also provided information on the education and outreach capacity of CINAR in greater detail including COSEE, research internships, workforce development, formal and informal science education programs, and partnership programs with the Sea Grant and NERRS communities. Discussion involved partnering opportunities including joint proposals, prospects for leveraging resources, the benefits of capitalizing on existing networks, access to advanced technology that can enrich Science, Technology, Engineering and Mathematics (STEM) education, and provided a few local examples of how science education programs can be a vehicle to engage the public in community-based stewardship programs. Mike is currently working with NOAA Office of Education staff to explore links between CINAR and the NOAA Educational Partnership Program.

CINAR Workshops / Seminars

CINAR sponsored or co-sponsored several workshops and seminars during the past year:

- Ecosystem Dynamics, Bio-Physical Interactions, and Biogeochemistry of the Northeastern Shelfbreak Workshop, January 2013 (CINAR sponsorship)
- Data Visualization to Support Ecosystem Based Management Workshop, February, 2013 (NART sponsorship; CINAR co-sponsorship).

- The following seminars were held at WHOI (WHOI Biology / CINAR co-sponsorship):
    - May 31, 2012 *Science for Right Whale Conservation: An Outsider's View*
        - Peter Corkeron, NOAA Northeast Fisheries Science Center

    - February 14, 2013 *Modeling seasonal cycle of dissolved oxygen in Chesapeake Bay: implications for hypoxia response to river flow and wind forcing*
        - Yun Li, Guest Investigator, Biology Department, WHOI; NOAA Postdoctoral Researcher, Northeast Fisheries Science Center

    - February 21, 2013 *Krill ecology in the Gulf of Maine region studied using acoustic techniques*
        - Gareth Lawson , Assistant Scientist, Biology Department, WHOI

2011 CINAR POST DOCTORAL SCHOLAR PROGRESS REPORT

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012-March 31, 2013

Post Doctoral Scholar: Robert Todd - Woods Hole Oceanographic Institution

Related NOAA Goal Plan:
Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme:
Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

Robert Todd completed his tenure as a CINAR postdoctoral scholar in November 2012. During this reporting period, he primarily studied exchange across the shelfbreak front in the Middle Atlantic Bight (MAB). In particular, he focused on using autonomous underwater glider observations to quantify horizontal scales of variability and the spatial extent of interleaving across the shelfbreak front; used glider observations of anticyclonic eddies interacting with the shelfbreak front to corroborate laboratory findings showing that stronger anticyclones carried larger amounts of shelf water farther offshore; and used in situ and remote sensing data to investigate an unusual diversion of the Gulf Stream's path during fall 2011 that brought it into direct contact with the upper continental slope south of New England
.

ACCOMPLISHMENTS

Three papers detailing the work were published during the reporting period: Todd et al. 2013 (J. Phys. Oceanog.), Gawarkiewicz et al. 2012 (Sci. Rep.), Cenedese et al. 2013 (J. Phys. Oceanog.). Todd also gave several seminars explaining these results and presented a poster at the CINAR 5-year review.

HIGHLIGHTS

• Horizontal spatial scales increase from ~10 km within the Middle Atlantic Bight shelfbreak front to ~30 km in the Slope Sea.
• Interleaving of shelf and slope waters creates horizontal thermohaline variability within ~50 km of the shelf break in the MAB.
• When anticyclones interact with a shelfbreak front, the volume of shelf water exported and the distance that shelf water is carried offshore both increase with increasing anticyclone strength.
• In fall 2011, a northeastward diversion of the Gulf Stream from its usual path brought unusual water properties and strong currents to the outer continental shelf and upper continental slope.

SOCIETAL BENEFITS

The Middle Atlantic Bight shelfbreak front is a region of high productivity that supports numerous commercial and recreational fisheries. Understanding exchange across the shelfbreak front is critical to understanding how this important ecosystem functions and how it may be susceptible to future climate change.

EDUCATION AND OUTREACH ACTIVITIES

• Departmental seminars at Scripps, CalPoly, MIT.
• Poster presentations at CINAR 5-year Review (WHOI) and 2012 MABPOM meeting (UConn)

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

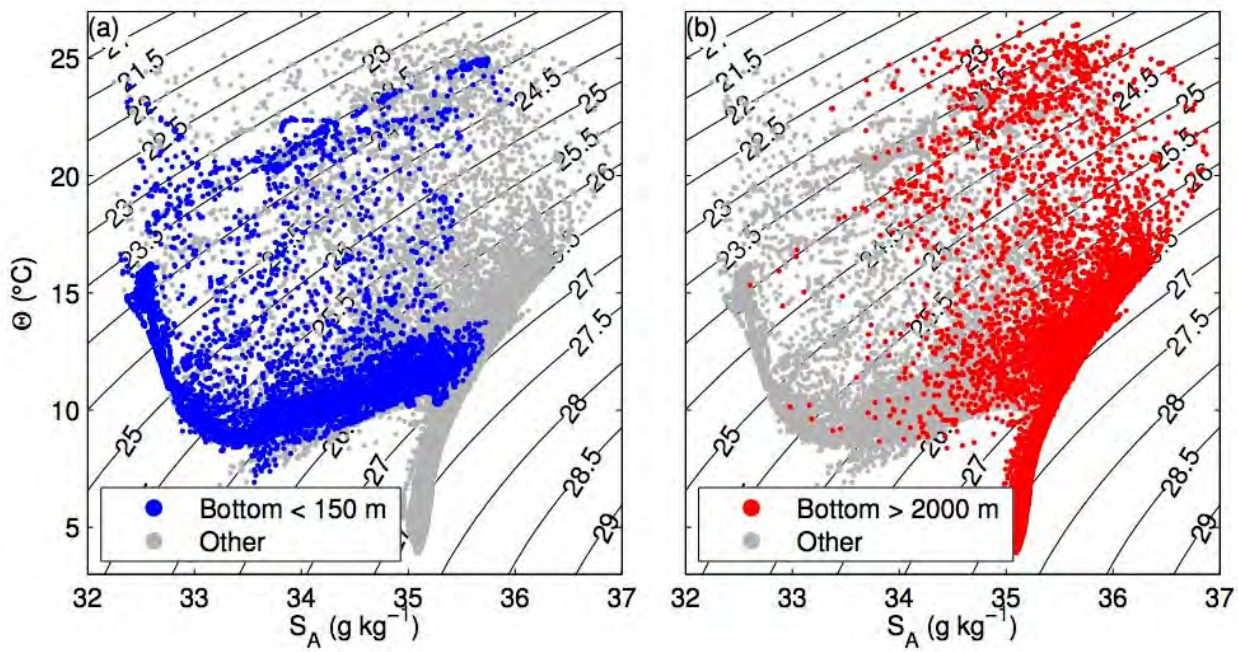


Figure 1: Temperature and salinity measurements during a 4-month glider deployment crisscrossing the shelf break in the Middle Atlantic Bight south of Cape Cod in summer 2007. Grey points in both panels show all data during the deployment. In (a), observations collected where the bottom was shallower than 150 m are shown blue. In (b), observations collected where the bottom was deeper than 2000 m are shown red. Waters over the shelf (blue) are primarily cool and fresh, but some warm salty waters from offshore are found shoreward of the shelf break. Waters over the continental rise (red) are generally warmer and saltier, but cool fresh shelf waters are found well offshore of the shelf break.

2012 CINAR POST DOCTORAL SCHOLAR PROGRESS REPORT

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012-March 31, 2013

Post Doctoral Scholar: Ke Chen - Woods Hole Oceanographic Institution

Related NOAA Goal Plan:
Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme:
Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

Ke Chen started his postdoctoral scholarship appointment at WHOI in November 2012. Ke previously received his PhD in Marine Science at North Carolina State University under the supervision of Ruoying He. Ke's PhD work mainly focus on the shelfbreak region in the Mid-Atlantic Bight. Utilizing state-of-art numerical modeling techniques, he investigated the circulation dynamics and biophysical processes at the Mid-Atlantic Bight (MAB) shelfbreak region.

As a CINAR postdoctoral scholar, Ke has been working on the quite unusual warming in the spring of 2012 over the Mid-Atlantic Bight shelf in collaboration with his advisors, Glen Gawarkiewicz and Steve Lentz, as well as others at WHOI and elsewhere. The water temperature on the MAB continental shelf was anomalously warm in the first half of 2012, and had major impacts on the Northeast US coastal ecosystem and commercial fisheries. According to a NOAA Northeast Fishery Science Center ecosystem advisory, the spring bloom in 2012 started as early as February and phytoplankton biomass was higher than average. Atlantic Cod distribution had a northerly shift consistent with the response to the ecosystem warming. Starting with all available in-situ observations collected in this period, Ke aims to understand the spatial and temporal characteristics of the warming and its underlying dynamic processes.

ACCOMPLISHMENTS

Based on 13 years of NDBC buoy data, Ke found that the surface temperature anomalies in 2012 compared to 2000-2010 show consistent timing and a systematic trend from Gulf of Maine to Cape Hatteras. On intra-seasonal time scales, anomalies are in phase from north to south. This indicates that this warming event is related to large scale atmospheric forcing. The surface anomalies actually start in late 2011 and continue to June, 2012 and show temperature anomalies as large as 6 °C near Cape Hatteras (Figure 1). Furthermore, analysis of XBT data collected off New Jersey (the Oleander line) in the first half of 2012 shows that the temperature anomalies extended through the entire water column. Heat budget calculations reveal that the surface air-sea fluxes balance the temperature changes in the water column. The temporal variability of the anomalies correlate well with the Jet Stream latitude, with lags of 3-6 days depending on the locations of the buoy, showing that the anomalies are related to fluctuations in the atmosphere. The larger net heat flux related to the anomalous Jet Stream latitude in late 2011 to early 2012 inhibits the heat loss from the ocean and causes a much slower cooling rate of ocean

temperature, particularly during late autumn and early winter. Strong intra-seasonal Jet Stream activities in the first half of 2012 then further increased the warm anomalies systematically.

HIGHLIGHTS

- Systematic warm anomalies from Gulf of Maine to Cape Hatteras were found to be related to large scale atmospheric forcing.
- The warm anomalies extend from the ocean surface through the water column.
- Close correlation has been found between Jet Stream latitude and water temperature anomalies.
- Anomalous large net atmospheric heat flux in late 2011 and early 2012 inhibits heat loss of the ocean and decreases its cooling rate.

SOCIETAL BENEFITS

Better understanding of the dynamic process of the 2012 warming is important for ecosystem monitoring and forecasting. By establishing a link between large scale Jet Stream variability and coastal ocean temperature change, this work also provides further insights into linkages between large scale atmospheric patterns and its direct impact on continental shelf temperatures.

EDUCATION AND OUTREACH ACTIVITIES

- CINAR Shelfbreak Ecosystem workshop
- Public Presentation- North River Watershed Association
- WHOI Physical Oceanography department seminar
- Invited talk at University of Massachusetts Dartmouth

CINAR RESEARCH SUMMARIES

The following pages provide research summaries of the 47 CINAR projects funded during the period April 01, 2012 through March 31, 2013. The projects are organized by theme.

Theme I. Ecosystem Forecasting

1. Donald Anderson, WHOI – *The Mid Atlantic Cold Pool and Stock Assessments: Developing Environmental Indices at the Range Limit of Species*

2. Robert Beardsley, WHOI- *Technical Services and Improvement of FVCOM for NOAA Modeling Activities*

3. Rubao Ji, WHOI- *Stratification Indices for Stock and Ecosystem Assessment from a Data Assimilative Circulation Model*

4. Timothy Shank ,WHOI- *Habitat Suitability Modeling for Deep-Sea Corals and Sponges in the Northeast and Mid-Atlantic Regions: Ground-truthing Potential Deep-sea Coral Areas*

5. David Townsend, UMaine- *Nutrient Dynamics on the NE Continental Shelf: Sample Analyses*

6. James Wilkin, Rutgers- *Sustaining Development of National Ocean Service Operational Forecast Systems Based on the Regional Ocean modeling System*

Theme II. Ecosystem Monitoring

1. Donald Anderson, WHOI – *Development of a Conceptual Framework for the Contribution of the Social Sciences (CSS) to Ecosystem-Based Fishery Management (EBFM)*

2. Andrew Bowen ,WHOI-*2012 ROV Jason Use for VENTS- NeMO*

3. Yong Chen ,UMaine- *A Preliminary Study to Develop an Abundance Index for Cusk from their Bycatch in the Gulf of Maine*

4. Yong Chen ,UMaine- *Development of a Sentinel Survey/Fishery in the Eastern Gulf of Maine*

5. Josh Kohut, Rutgers- *Evaluation of Broad and Fine Scale Models of Butterfish BIOMASS to by-Catch Reduction in the Longfin Inshore Squid Fishery in the Mid-Atlantic Bight*

6. Michael Purcell,WHOI- *Using Remus 100 Autonomous Underwater Vehicles to Conduct NEFSC Scallop Surveys*

7. Timothy Shank ,WHOI-*TowCam Exploration for Chemosynthetic Ecosystems at the Chile Triple junction*

8. Graham Sherwood, GMRI- *Inshore Gulf of Maine Herring Acoustic Survey*

9. Hanumant Singh, WHOI- *Development of Protocols and Tools to Assess Fish Populations and Habitats Using SeaBED AUV*

10. Hanumant Singh, WHOI- *Integrating a Forward looking Sonar on the SeaBED AUV*

11. Hanumant Singh, WHOI - *Real Time Imagery from an Autonomous Underwater Vehicle to Enhance Adaptive Mission Execution*

12. Hanumant Singh, WHOI- *Obstacle Avoidance For Reef Fish Stock Assessment*

13. Hanumant Singh, WHOI- *Systems Level Sensing and navigation Integration for the SeaBED AUV*

Theme III. Ecosystem Management

1. Paul Anderson, UMaine- *A US- Canada Science Symposium: The American Lobster in a changing Ecosystem*

2. John Annala, GMRI- *Workshop on Stock Structure of Atlantic Cod in the Gulf of Maine Region*

3. Steve Eayrs, GMRI- *Electronic Vessel Trip Reports*

4. Jessica Joyce, Dan Holland, GMRI- *Social Capital in the NE Ground Fish Industry*

5. Di Jin ,WHOI - *Vessel Safety and Fishery Management*

6. Dan McCorkle ,WHOI- *An Experimental Investigation of the Impact of Ocean Acidification on the Early Life Stages of Surfclams, and the Interactive Effects of Feeding*

7. Jen Sun ,GMRI- *Evolution of Groundfish Sectors Business Model*

Theme IV. Protection and Restoration of Resources

1. Mark Baumgartner ,WHOI- *Real Time Assessment of Baleen Whale Occurrence Using Moored Passive Acoustics*

2. Mark Baumgartner ,WHOI- *Characterizing North Atlantic Right Whale Habitat through Integration of Satellite Tagging, Acoustic, and Visual Survey Data*

3. Carrie Byron ,GMRI- *Migration of post Smolt Atlantic salmon in the Gulf of Maine and Gulf of Saint Lawrence*

4. Carrie Byron ,GMRI- *Evaluation of the importance of Predator and Prey Field and Ocean Circulation on Atlantic Salmon Growth and Survival in the Gulf of Maine*

5. James Gilbert, UMaine - *Estimation of Harbor Seal Numbers in New England*

6. Jonathan Labaree, GMRI – *Funding Sector Operations and Dockside Monitoring in Fishing Year 2011*

7. Michael Moore,WHOI- *Human Interaction Investigations in Marine Mammals*

8. Michael Moore, WHOI - *Marine Mammal Health and Entanglement Research*

9. John Stegeman,WHOI- *Analysis of CYP1A1 Expression in Cetacean Tissue Samples*

Theme V. Sustained Ocean Observations and Climate

1. Donald Anderson,WHOI - *Quarterly Climate Reports*

2. Donald Anderson,WHOI - *Bilateral Workshop*

3. Carin Ashjian,WHOI- *Bowhead Whale Feeding in the Western Beaufort Sea Oceanographic Conditions Whale Prey Distributions and Whale Feeding and Foraging Behavior*

4. Carin Ashjian,WHOI - *An Eye in the Ocean Exploration of High -Resolution Vertical Distributions of Plankton and Particles and Coincident Hydrography in the Western Chukchi Sea Using a Video Plankton Recorder*

5. Jessica Grebmeier, UMCES- *Pacific Artic Group (PAG) Secretariat Office*

6. W. Brechner Owens, WHOI- *WHOI Contribution ARGO Float Program (2012 -2013)*

7. Robert Weller and Albert Plueddeman,WHOI- *Ocean Climate Observations and Analyses (2012-2013)*

8. Lisan Yu,WHOI- *50 Year Analysis Global Ocean Surface Heat Flux*

Theme VI. Education and Outreach

1. Donald Anderson ,WHOI- *Research And Education In Quantitative Fisheries And Ecosystem Science*

2. Donald Anderson ,WHOI- *US National Office for Harmful Algal Blooms*

3. Alexa Dayton ,GMRI- *Marine Resource Education Program: Professional Training for Fisherman in the Northeast Region and a Forum for Dialogue among Fishermen, Scientists and Managers.*

4. Alexa Dayton ,GMRI- *Fisheries Science & Management Education for fishermen in the Southeast Fisheries Region*

THEME I. ECOSYSTEM FORECASTING

The Mid Atlantic Cold Pool and Stock Assessments: Developing Environmental Indices at the Range Limit of Species

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Donald Anderson- WHOI (Subaward to David Mountain, U. Arizona)

NOAA Program Manager – Jonathan Hare NMFS

Related NOAA Goal Plan – Goal 2: Climate Adaptation and Mitigation
CINAR Theme – Ecosystem Forecasting

PROJECT OVERVIEW

The goal of this project is to develop environmental indices that capture the influence of oceanographic conditions on the dynamics of resource species in the Mid-Atlantic Bight (MAB), with specific reference to the local yellowtail flounder population. The dominant oceanographic feature in the MAB is a cold band of water that occurs at depth on the outer shelf during the summer and fall and is a remnant of the previous winter's cooling as the shallower waters in the region warm with seasonal heating. This feature is called the cold-pool. Various studies have related inter-annual changes in MAB water temperature with changes in the distribution and recruitment of various local resource species including yellowtail founder. Indices of variation in the temperature, development and spatial extent of the cold-pool will be developed for comparison with analyses of the changes the yellowtail founder distribution and recruitment being conducted by researchers at the Northeast Fisheries Science Center. Specifically using historic hydrographic data, candidate indices will be developed for the cross-shelf extent and minimum temperature of the cold-pool in the fall along a number of sections across the MAB. Indices also will be developed for the mean and minimum temperature along the mid-line of the cold-pool. Identification of suitable environmental indices that exhibit predictive power for yellowtail flounder recruitment could aid fishery management interests in managing this important resource.

ACCOMPLISHMENTS

During 2012 all indices of average shelf water temperature, salinity and volume in the Middle Atlantic Bight (MAB) developed in the first year of this project were extended through 2011. Analysis of yellowtail flounder catch in relation to water temperature variability was presented to the Stock Assessment Workshop by the NOAA Program Manager for this project, J. Hare.

A temperature/salinity data set collected on glider transects was obtained from Rutgers University to compare with the indices developed in the project from ship-board measurements. There were 174 glider transects along a single track line across the MAB off New Jersey from 2003 to 2008. Only 15 transects had sufficient data and were sufficiently co-occurring with the ship-board measurements to allow comparison. On that limited basis a regression analysis indicated that the glider observations could account for about 50% of the variance in cold pool indices for temperature and salinity.

HIGHLIGHTS

- Variability in yellowtail founder catch was found to be significantly related to the environmental variability identified in this project.

SOCIETAL BENEFITS

Understanding of the environmental influence on yellowtail flounder stock abundance could contribute to better management of the species.

Technical Services and Improvement of FVCOM for NOAA Modeling Activities

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Robert Beardley- WHOI

NOAA Program Manager – Frank Aikman NOS

Related NOAA Goal Plan –
CINAR Theme – Ecosystem Forecasting

PROJECT OVERVIEW

The objectives of this project are to: 1) hold an FVCOM workshop at the NOAA Coast Survey Development Laboratory (CSDL) to update NOAA modelers on FVCOM and to address NOAA questions; 2) host CSDL modelers for technical consultation at UMASS as needed, 3) hold conference calls with CSDL modelers as needed; 4) support CSDL in applying FVCOM multi-domain nesting techniques; and 5) assist FVCOM code modification to support ecological application of FVCOM. The multi-domain nesting techniques are being developed for the US Northeast Coastal Ocean Forecast System (NECOFS) and the FVCOM offline biological models were used for the NECOFS region for the long-term simulation of ecological processes in the Gulf of Maine. FVCOM teams will provide the updated examples of techniques used for NECOFS to support the NOAA modeling activities.

ACCOMPLISHMENTS

The FVCOM development team has provided CSDL with various types of technical support. They include:

1) Providing a well-tested multi-domain nesting module and an example for the nesting setup that was used for the Gulf of Maine. In FVCOM version 3.1.6, we have developed a multi-domain nesting module that allow nesting FVCOM with any structured grid or unstructured grid models. We tested this module for nesting FVCOM with HYCOM, and provided CSDL the updated code of FVCOM version 3.1.6 with inclusion of an example of the nesting setup between FVCOM and HYCOM. We also helped train CSDL to understand how to nest FVCOM with other structured grid models.

2) Modifying the ecological module in FVCOM to include boundary forcing, and also provide the CSDL an offline-based ecological model. We have helped CSDL to debug the setup of their ecological model using FVCOM. To help them run the ecological model online and also offline, we modified the ecological module code and taught them how to use it. We also provided our set up for the NPZD model used for the New England coastal region as an example.

3) Holding regular conference calls with CSDL to help them solve technical issues in their application of FVCOM to build the coastal forecast system. The conference calls were very productive and helpful. CSDL collected all questions from the NOAA sides including all

institutions and labs that are using FVCOM, and then we provided answers following the list on the conference calls.
4) We have provided the dikes/groyne modules to CSDL and helped them to set up the coastal inundation system. We provided an example of the model setup with inclusion of dikes/groynes and helped them to solve various technical issues.

5) We have modified FVCOM input and output modules to meet the need for the NOAA 24/7 forecast operation. We have implemented the CODE 3.1 into FVCOM for the calculation of the surface heat flux and also flexible NetCDF output files to improve the model-data comparison.

6) We completed writing a new FVCOM version manual and will set up the workshop at CSDL in July, 2013. Based on our agreement, the workshop is for NOAA.

7) We have used the funds to improve the Northeast Coastal Ocean Forecast System (NECOFS), and successfully used this system to predict the February 8-9 blizzard that swept over the New England coast.

HIGHLIGHTS

With the support of the FVCOM development team, the NOAA CSDL has successfully developed a 24/7 operational forecast system for the Gulf of Mexico shelf and San Francisco Bay, and the NOAA Great Lake Lab has developed a high-resolution FVCOM system for Great Lakes (the first model system linking five lakes). The technologies used in these systems are from NECOFS in the CINAR region.

SOCIETAL BENEFITS

The forecast system has improved NOAA's forecasting capability of the coastal environment conditions that are critical for communities.

EDUCATION AND OUTREACH ACTIVITIES

We have hosted many scientists and graduate students at different institutions and universities from all over the world to learn FVCOM at the UMASSD FVCOM development team lab.

Stratification Indices for Stock and Ecosystem Assessment from a Data Assimilative Circulation Model

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Rubao Ji- WHOI

NOAA Program Manager – Jonathan Hare NMFS

Related NOAA Goal Plan –
CINAR Theme – Ecosystem Forecasting

PROJECT OVERVIEW

The goal of this project is to develop stratification indices for the Northeast U.S. shelf ecosystem based on the 33-year reanalysis product of a data assimilative circulation model. Our four main objectives are 1) *Evaluate reanalysis product*: Compare model-based reanalysis with additional independent observation data to evaluate and quantify model bias and uncertainty; 2) *Assess variability and scale*: Quantify spatial and temporal variability in stratification and define approximate scales for developing indices; 3) *Derive indices and build database*: Derive indices of stratification (magnitude, timing) and build a 33-year (1978-2010) database for the Northeast U.S. shelf ecosystem. 4) *Inform monitoring design*: Use an Observing System Simulation Experiment (OSSE) approach to evaluate optimal monitoring design for observing stratification, and use this information to improve NEFSC monitoring activities.

During the report year, we have completed the evaluation of the reanalysis product and an assessment of variability and scales (*Objectives 1* and *2*), and we have begun to build a stratification database and derive indices of stratification (*Objective 3*).

ACCOMPLISHMENTS

During the first six months of this project, we compared model-based estimates (generated by co-PI Chen's group at U. Mass. Dartmouth) with the NEFSC observations (37304 sites) from 1978 to 2010 regarding key variables of water temperature, salinity and stratification. The point-to-point comparison was conducted using bilinear interpolation and a nearest-neighbor algorithm to identify observations nearby in space and time, respectively. A number of metrics have been used to quantify and compare the magnitude and distribution of temperature, salinity and stratification from the model with observations. For stratification, these metrics included the surface-to-bottom density difference, the surface-to-50m density difference, the magnitude and depth of the peak stratification and potential energy anomalies (so-called Simpson Energy). The model performance across these criteria is consistently good, with correlation coefficient above 0.90 and model skill above 0.93, except for the maximum stratification (correlation coefficient and model skill are 0.40 and 0.52, respectively), which is sensitive to the vertical resolution and thus different between model and data. A small proportion (<0.5%) of the sites show moderate data-model mismatch. Those sites are located in the Middle Atlantic Bight (MAB) area during summertime where sharp density gradients develop with the formation of the underlying cold pool (Figure 1).

Building upon the high-skill of the reanalysis product, we have constructed a stratification climatology by averaging over the 33-years period at each grid point. We calculated the timing and magnitude from the climatology in terms of the following parameters: (1) timing of setup of stratification, (2) timing of maximum stratification, (3) timing of destratification, and (4) the magnitude of the maximum stratification. A similar analysis is being conducted by co-PI Fratantoni whereby harmonic curve fitting to observations is used to predict the annual cycle of stratification within individual Ecological Production Units (EPUs, defined by the NEFSC Ecosystem Assessment Program). The results are now being compared to determine whether a single stratification value for each EPU matches the scale of seasonal variability, or whether larger/smaller units need to be defined.

In addition, we have decomposed the total stratification into thermal and haline contributions, which allows us to distinguish underlying processes controlling the magnitude and timing of stratification in different regions (e.g. buoyancy control versus heat flux). We have conducted EOFs analyses on the model fields to examine interannual variations in stratification and quantify the dominant spatio-temporal patterns. Dominant principle components were compared with the changes of temperature and salinity at surface and 50m depth to examine the key controls. On the northern Northwest Atlantic Shelf, especially the Nova Scotian Shelf – Gulf of Maine region, interannual changes in surface salinity were found to be significantly modulated by alongshore wind stress.

HIGHLIGHTS

- The 33-year reanalysis product shows high performance in capturing the observed temporal and spatial variations of water temperature, salinity and stratification on the Northeast U.S. Shelf and in the Gulf of Maine.

- The degree of stratification is quantified via a number of criteria, across which the model performance is high over most of Northeast U.S. shelf.

- Seasonal variations in stratification are dominated by the seasonal cycle of temperature, while interannual variations appear to be controlled by changes in surface salinity.

SOCIETAL BENEFITS

This product will be used in NEFSC Ecosystem Assessment products, be available for stock assessments, and for the regional research community through the NEFSC website. These reanalysis indices will greatly contribute to NEFSC activities and provide an approach that can be replicated in other regions. The indices will also be provided to stock assessment (e.g., Atlantic surf clam, Atlantic herring) scientists in the NEFSC, initially through environmentally explicit stock recruitment relationships and by evaluating the effect of stratification on catchability of pelagic species.

EDUCATION AND OUTREACH ACTIVITIES

- Ji, R., 2013. Update talk on biological-physical coupled modeling on the Northwest Atlantic Shelf. ICES WGIPEM workshop (Served as Working Group co-chair). Paris, France.

- Ji, R., 2012. Basin Scale Modeling - Northwest Atlantic Effort. EURO-BASIN Program mid-term Workshop (Served as a Provocateur for the basin-scale modeling section). Lisbon, Portugal.

- Chen, C., 2013. Lecture: A Global-Regional-Estuarine Nested FVCOM System: A Unstructured-grid Ocean Model With Aim at Simulating the Multi-scale Oceanic Response to Climate Change, Lecture at Pan-American Advanced Studies Institution, Chile, January 3-15.

- Chen, C. and R. C. Beardsley, 2012. A Global-Regional-Estuarine Nested FVCOM System: A Unstructured-grid Ocean Model with Aim at Simulating the Multi-scale Oceanic Response to Climate Change. Frontiers in Computational Physics: Modeling the Earth System, Boulder, CO, USA. December 16-20. Oral presentation.

- Chen, C., 2012. A global-regional-estuarine nested FVCOM system: an unstructured-grid ocean model with aim at simulating the multi-scale oceanic response to climate change. Invited keynote talk at International Symposium on Climate Change and Human Activities: Coastal Consequences and Responses, Shanghai, China, October 28-31.

- Chen, C., 2012. Multi-Scale Ecosystem Processes-Lecture: Coastal Processes, Inha University, South Korea, October 20.

- Chen, C. and R. C. Beardsley, 2012. Status and continuous improvement of Northeast Coastal Ocean Forecast System (NECOFS), University of Rhode Island, RI.

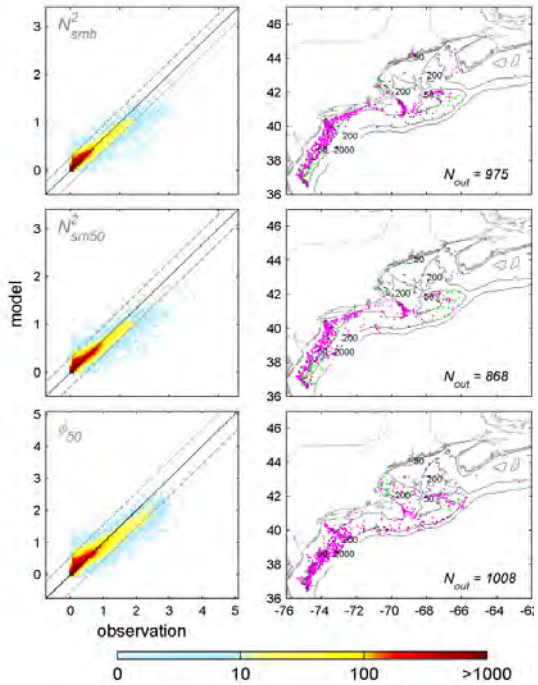
- Hare, J. and P. Fratantoni, NEFSC seminar, 2013. Why do we do bongo's and CTD's on the trawl survey, Feb. 28, Woods Hole, MA

- Results are planned to be presented in the FATE 2013 Science Meeting - June 2-6, 2013, Miami

PUBLICATIONS

We are preparing 1 manuscript on the link between the interannual variations of wind forcing and the surface salinity changes in the study region.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Jan-Mar
Apr-Jun
Jul-Sep

Figure 1. The comparison of vertical density stratification from FVCOM-GOM3 model results and NEFSC observations (ftp://ftp.nefsc.noaa.gov/pub/hydro/spool_hydro/yearly/). The unit of stratification is 10^{-3} s^{-2} for N^2 and 10^2 J m^{-3} for φ_{50}. A total of 37304 data points are compared.

Left column: The density of data points is calculated in 5×10^{-5} s^{-2} or 7.5 J m^{-3} bins and is shown in logarithmic scale in the colorbar. In each graph, the solid diagonal lines represent an exact match between model and data. The dashed lines represent 1 standard deviation of observations.

Right column: the geographic location of the data points that fall outside of diagonal area bounded by the dashed lines. Colors in the legend represent 4 seasons.

Habitat Suitability Modeling for Deep-Sea Corals and Sponges in the Northeast and Mid-Atlantic Regions: Ground-truthing Potential Deep-sea Coral Areas.

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Timothy Shank- WHOI

NOAA Program Manager – Martha Nizinski NMFS/NEFSC
Related NOAA Goal Plan –

CINAR Theme – Ecosystem Forecasting

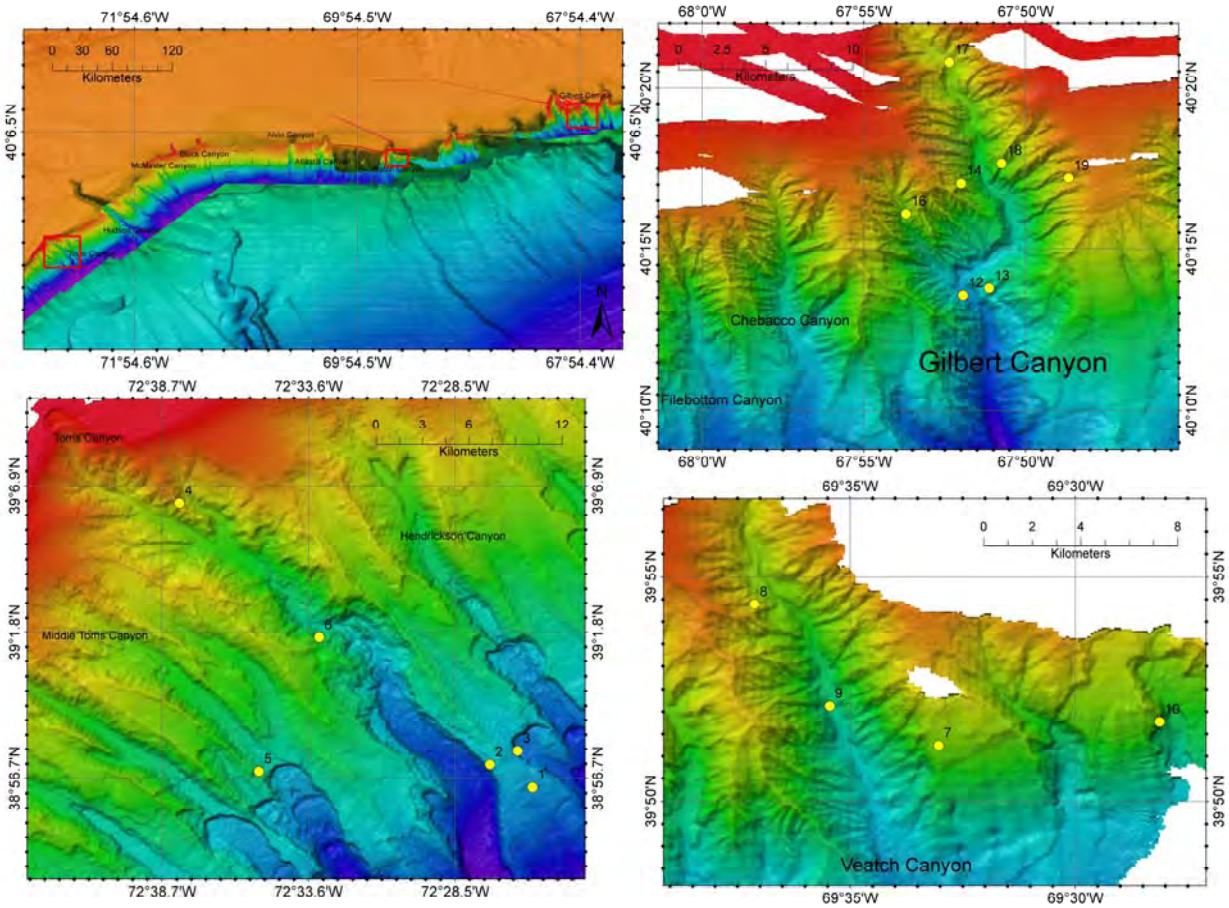
PROJECT OVERVIEW

The goal of our program was to locate, photographically document, and ground-truth known or suspected deep-sea coral habitats associated with deepwater canyons off the coast of the northeastern U.S following active seafloor mapping programs in this region. In particular, surveys of canyon areas were conducted using a towed camera system to: 1) characterize benthic (bottom) habitats; 2) identify areas where corals were present; ground-truth areas predicted to be coral hotspots based on data provided from a habitat suitability model; and 3) groundtruth recently-collected multibeam data and the potential accuracy of historical coral records, and 4) provide coral and sponge composition and distribution data for future ecosystem based management efforts.

ACCOMPLISHMENTS

High-quality multibeam data collected from recent ACUMEN mapping expeditions (conducted by NOAA Ships *Okeanos Explorer* and *Ferdinand Hassler*) were utilized to locate high-relief bottom features that appeared to be likely coral habitat in Toms Canyon complex (with tows in Toms, Middle Toms, and Henderickson Canyons), Veatch Canyon, and Gilbert Canyon. Utilizing a recently developed habitat suitability model to predict where corals were likely to occur based on conditions found in locations where corals were previously reported (e.g., steep to vertical slopes) and the WHOI Towed Camera System *TowCam,* 4 North Atlantic canyons were investigated between July 5-18, 2012 including Tom's Canyon (38° 56.3823 N, 72°25.7944 W at 1804m depth), Hendrickson Canyon (38°57.6673 N, 72°26.3203 W at 1705m depth), Veatch Canyon (39°51.234 N, 69°33.0397 W at 1262m depth), including canyon limbs extending west of Veatch Canyon and Gilbert Canyon (Latitude: 40°17.2029 N, Longitude: 67°48.5498 W, at 707m depth). A total of 17 *TowCam* lowerings were completed with more than 30,000 images obtained of these canyon systems in order to collect contemporary deep-sea coral and sponge distribution, abundance, and habitat data. Images were taken every 10-15 seconds at an altitude between 2-6 meters from the seafloor with a 16-megapixel camera. *TowCam* was equipped with two vertical lasers separated by 20 cm for scale and co-registered to a Seabird CTD sensor and altimeter to provide accurate depth and altitude for each image. Eleven suction samples were obtained from within Toms, Middle Toms, and Henderickson Canyons, as well as Veatch and Gilbert Canyons yielding canyon sediment fauna. A habitat suitability model was groundtruthed using various physical and biological data.

In each of these canyons (during 17 of 18 tows) we documented deep-water corals. Both Toms and Henderickson Canyon provided images of bubblegum corals, gorgonians, sea pens, and sponges. Veatch Canyon hosted paramuricid corals in high abundances as well as an abundance of a solitary hard coral (e.g., *Desmophyllum dianthus*) and a variety of sponges living on the steep canyon walls. Coral diversity, including antipatharian black corals, and abundance was high in the virtually unexplored Gilbert Canyon, an area the model predicted to be a coral hotspot.



HIGHLIGHTS

With the discovery of diverse deep-sea corals in each of the canyons surveyed, our knowledge of deep-sea coral diversity and distribution in the Northeast Atlantic US EEZ region increased exponentially. We qualitatively validated our deep-sea coral habitat suitability model; the model correctly predicted suitable coral habitat and identified hotspots of coral abundance and diversity (e.g., in Gilbert Canyon). Deep-sea coral habitat was correlated to high-resolution bathymetry maps through ground-truthing of bottom topography and imagery. Notably, antipatharians (black corals) were discovered for the first time in the Northeast Atlantic Canyon region.

SOCIETAL BENEFITS

The ability to locate and define the composition and distribution of vulnerable marine ecosystems, as well as validate (and further enhance) predictive ecosystem modeling is critical for a better management and conservation of living resources and their habitats.

EDUCATION AND OUTREACH BENEFITS

Our field program was communicated via the web as part of the five Atlantic Canyons Undersea Mapping Expeditions, in which scientists on three NOAA ships gathered baseline information, mapping priority frontier areas along the continental shelf and slope along the mid-Atlantic coast of the United States, from Virginia to Rhode Island.

http://oceanexplorer.noaa.gov/okeanos/explorations/acumen12/welcome.html. The efforts and training of undergraduates, guest investigators, and a Graduate Research Assistant were supported through this work.

PHOTOS

Bubblegum coral (likely *Paragorgia aborea*) ~140 cm, common in North Atlantic canyons, were observed with sponges living in cracks along the vertical wall of Hendrickson Canyon at 1705 meters depth.

Orange brisingid sea stars congregate on a sedimented outcrop at 1703m in Southwestern Toms Canyon.

Nutrient Dynamics on the NE Continental Shelf: Sample Analyses

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

David W. Townsend - UMaine

NOAA Program Manager – Jonathan Hare NMFS

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Forecasting

PROJECT OVERVIEW

The accelerated melting of the Greenland ice sheet and the Arctic ice cap in recent decades appears to be influencing marine ecosystems far removed from the Arctic Ocean via changes in the circulation of the Labrador Sea and the Northwest Atlantic continental shelf and slope waters. This has resulted in an increased baroclinic transport of low salinity shelf waters to regions farther south. Consequently, we are seeing changes in the water properties and nutrient regime in the Gulf of Maine over the past several decades. Retrospective analyses of hydrographic and nutrient data back to the 1960s have revealed that deep water layers in the Gulf (>100m) have become fresher and cooler, with lower nitrate but higher and more variable silicate concentrations over a period coincident with recent, rapid melting in the Arctic (Townsend et al. 2010). There is growing evidence that those changes in the nutrient regime may also be forcing changes in the structure of the planktonic ecosystem (McGillicuddy et al., 2011; Townsend et al., 2013).

In order to begin to monitor this apparent change in the ecosystem of the Northwest Atlantic continental shelf, we have been funded by CINAR to analyze samples collected as part of the ***NOAA Northeast Fishery Science Center's Ecosystem Monitoring Program*** (ECOMON Program) in collaboration with Dr. Jon Hare. The ECOMON Program conducts survey cruises approximately four times each year in shelf and slope waters of the Gulf of Maine – Georges Bank – Mid-Atlantic Bight. As part of their standard sampling, they perform a CTD cast at each station and, when possible (given constraints for water sample allocation) they collect water samples for nutrient analyses. Samples are filtered and frozen at sea and then delivered by overnight courier to the University of Maine where they are analyzed for nitrate plus nitrite, silicate, phosphate and ammonium using standard autoanalyzer techniques. Those data are delivered to NOAA following each cruise.

ACCOMPLISHMENTS:

As of this writing (April 8, 2013) have received and processed samples from 10 ECOMON cruises, summarized in Figure 1, which shows station locations for each cruise and the number of samples analyzed. Upon completion of our nutrient measurements we combine the resulting data with the CTD data and produce profiles of the hydrography and nutrient properties. We plan to continue to study – with our NOAA and Woods Hole Oceanographic Institution colleagues – the hydrographic and nutrient data collected on future ECOMON cruises, as the data density

becomes suitable for more in depth analysis. As with all of our nutrient data processed in our laboratory, we are incorporating them into our regional nutrient and hydrographic database (Rebuck et al., 2009).

HIGHLIGHTS

- Results continue to provide evidence of shelf waters becoming fresher and colder, with proportional changes in nitrate and silicate (e.g., Townsend et al., 2010) as reported in earlier progress reports.
- Our continued analyses of the nutrient samples collected on the ECOMON cruises will be extremely important in our interpretations of conditions of Paralytic Shellfish Poisoning (PSP) from *Alexandrium* populations.

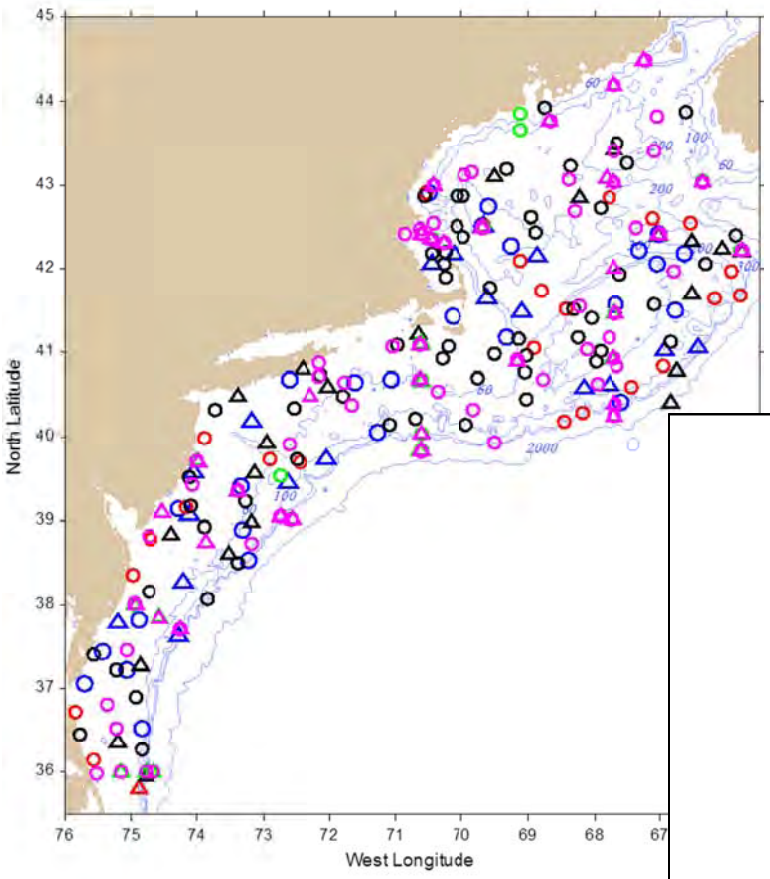
SOCIETAL BENEFITS

- This research is providing baseline data for future interpretations of climate change-induced alterations to the marine environment of the Northwest Atlantic continental shelf.

- Our data have already provided evidence in support of earlier expressed concerns about far-field effects of Arctic melting.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Station Map: NOAA ECOMON Surveys 2009 to 2012



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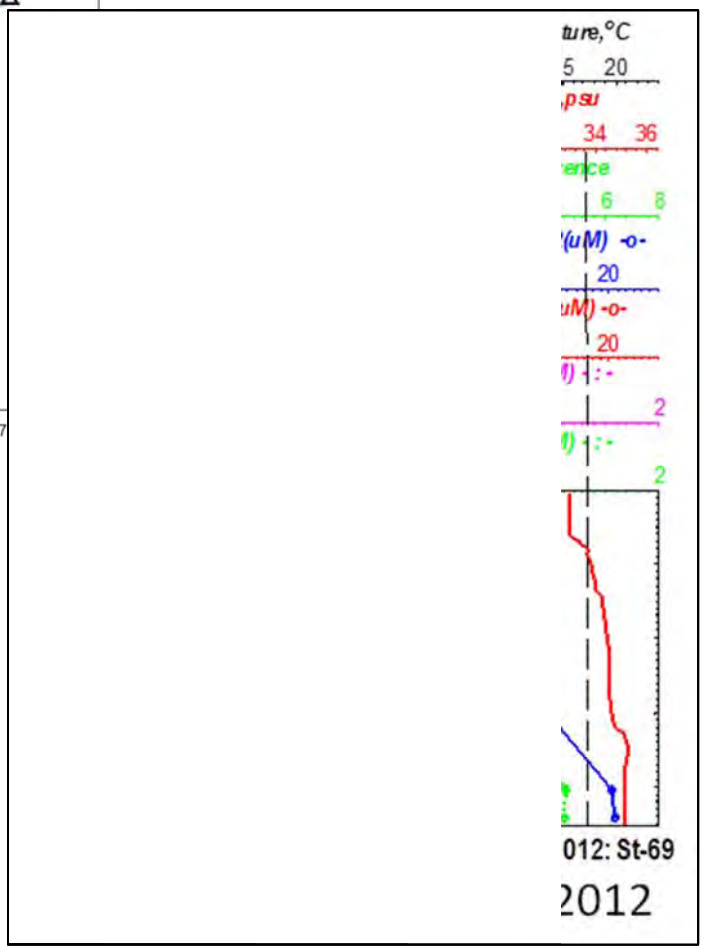

Insert: Hydrographic profiles in the Northeast Channel in the Fall of 2011 and 2012, showing a greater influx in 2012 of relatively fresh (salinity in red) and low nitrate (blue lines) shelf water at depths between ca. 50 and 160m.

Sustaining Development of National Ocean Service Operational Forecast Systems Based on the Regional Ocean modeling System

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

James Wilkins- Rutgers

NOAA Program Manager – Aijun Zhang-NOS

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Forecasting

PROJECT OVERVIEW

NOAA and NOS have the mission and mandate to provide guidance and information to support navigation and coastal needs. To support this mission, NOS is developing and implementing hydrodynamic model-based Operational Forecast Systems (OFS) for seaports, estuaries, the Great Lakes, and coastal waters. An OFS consists of the automated integration of real-time observations, hydrodynamic model forecasts, product dissemination, and continuous quality control and monitoring.

The Regional Ocean Modeling System (ROMS; www.myroms.org) is being used for three new OFSs under active development for the Chesapeake Bay (CBOFS), Delaware Bay (DBOFS), and Tampa Bay (TBOFS) to provide maritime community users with real-time operational products, which include nowcasts and short-term 1- to 2-day forecast guidance of water levels, currents, water temperature, and salinity. These parameters are fundamental physical variables for applications such as emergency response (e.g. oil spills; search and rescue) and ecological forecasting. ROMS will continue to be used for development of other NOS OFS in future.

The specific objectives of this project are to facilitate exchange of information between the ROMS developer group and the ROMS users at NOS so as to ensure that (i) NOS has access to and is aware of the most recent developments in the ROMS source code, (ii) NOS follows ROMS best practices, and (iii) NOS needs and recommendations for code modifications are conveyed to the developers and implemented in the community to make NOS user experience accessible to the broader ROMS user community.

ACCOMPLISHMENTS

Activities under this project will commence April 23/24 with a meeting of Rutgers and NOS scientists to identify project priorities and action items.

SOCIETAL BENEFITS

Improved quality in the model-based scientific information conveyed to maritime industry and resource managers operating in the Chesapeake, Delaware and Tampa Bay ports.

THEME II. ECOSYSTEM MONITORING

Development of a Conceptual Framework for the Contribution of the Social Sciences (CSS) to Ecosystem-Based Fishery Management (EBFM)

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Donald Anderson, Porter Hoagland - WHOI, Bonnie McKay GMRI

NOAA Program Manager – Matt McPherson NMFS, NEFSC+
Related NOAA Goal Plan – Climate Adaptation and Mitigation:An Informed Society Anticipating and Responding to Climate and its Impacts

CINAR Theme – Ecosystem Monitoring

PROJECT OVERVIEW:

This project comprises four pilot studies focusing on the ways in which the social sciences could contribute to the realization of EBFM. The funding will be used to support travel expenses for CINAR investigators to collaborate and for the convening of a project workshop. The PIs and collaborating investigators recognize the progress on the pilot studies will of necessity rely upon complementarities among ongoing research efforts funded through other sponsors. Some of these complementarities were discussed during a Human Dimensions Session at a recent NEFSC EcoAP Research Retreat. (December 2012).

ACCOMPLISHMENTS:

The four pilot studies eventually will be reported on, discussed, and improved at a workshop. Originally envisioned for the spring of 2013, the PIs have decided to postpone the convening of the workshop in order to continue progress on the four pilot studies. The pilot studies and their current status are as follows:

(1.) Spatial mapping to characterize the extent of overlap between EPUs (or other finer resolution ecological units) and human communities, especially those associated with individual ports or MARFIN-type regions. One hypothesis is that a greater degree of coherence between EPUs and such "communities at sea" might imply more successful management of the EPUs as common property resources. A second is that linking EPUs to specific communities (and local economies) might foster a greater sense of stewardship as well as opportunities for direct participation in environmental assessment or governance. Finally, the ability of qualitative assessments of fishing communities (e.g., port profiles and other extant data) to inform EBFM might be enhanced by linking them to specific habitats and territories within or continuous with specific EPUs. Kevin St. Martin (Rutgers) and Julia Olson (NEFSC) are continuing to work closely with Mike Fogarty and his colleagues at the NEFSC Ecosystems Assessment Program on understanding the relationships between EPUs and communities-at-sea and spatial resource dependencies.

(2.) Linking ecological food web models to regional economic impact models to understand both overall welfare and some of the distributional effects of alternative conservation and management measures, institutional arrangements, ecological relationships, or environmental changes. Current efforts in the northeast region involve both the use of input-output (IO) models to characterize the economic impacts of management measures and the development of more

complex computable general equilibrium (CGE) models that are capable of providing estimates of welfare effects (Jin *et al*. 2012). Work to date includes the publication of a paper on the viability of economic fisheries data for use in coastal and marine spatial planning in the Northeast Region (Jin *et al*. 2013) and presentation of the CGE approach to the modeling of EBFM at the International Institute for Fisheries Economics and Trade in Dar es Salaam, Tanzania (Hoagland and Jin 2012). This work also was recently presented at an MIT Sea Grant Stakeholder Forum on "Adapting to Change in Marine Systems" (April 2013). Di Jin (WHOI), Porter Hoagland (WHOI) and Eric Thunberg (NEFSC) are continuing to work on this pilot study.

(3.) Portfolio management to understand the decision-making behavior of individual or coherent groups of fishermen in multi-species fisheries in the face of uncertainties and given historical patterns of regulation. This behavior may be usefully modeled as a kind of "portfolio" management, through which fishermen hedge risks by harvest choices and by maintaining permits (even if unused during some periods). Moreover, fishermen may not be pure profit maximizers; their behaviors might be better characterized as risk-minimizing, satisficing, or seeking to perpetuate particular lifestyles. A portfolio modeling approach also could be implemented at the community (*i.e*., port or sector) scale. Preliminary modeling has been undertaken by Geret DePiper (NEFSC), data has been compiled, and a proposal for further funding of this effort is now under consideration at NMFS. Geret DePiper (NMFS), Di Jin (WHOI), and Porter Hoagland (WHOI) are continuing to work on this pilot study.

(4.) Characterizing vehicles (institutional processes and structures) for achieving co-management. Differences exist between the EBFM approaches now being taken by the Mid-Atlantic and the Northeast regional fishery management councils. The former is taking a more incremental approach, examining at the executive level the potential for implementing EBFM, while the latter is taking a more radical approach, involving the development of a EB fishery management plan, associated environmental impact statement, and ecological spatial modeling efforts. The Mid-Atlantic does not manage any overfished stocks, but the environmental conditions there are changing rapidly, likely impacting the distribution of stocks. The Northeast Council has recently implemented a sectoral catch share program for managing groundfish. Existing institutions and stakeholders in both regions may be reluctant to adopt EBFM approaches that are significantly different from the status quo. This "institutional inertia" may affect adversely the extent to which an EBF co-management can be achieved. Bonnie McCay (Rutgers) has published a review on recent work relating to shifts in fishing grounds as fishermen adapt to climate change (McCay 2012). Bonnie McCay (Rutgers) and Michael Paolisso (Maryland) are continuing to work on this pilot study.

Ongoing work on this project include:

- characterizing how the pilot studies might contribute to NEFSC research efforts on a multispecies-multifleet, length-based, spatial assessment model for the US northeast continental shelf, which is now under development by the NEFSC Ecosystems Assessment Program;
- identifying other CINAR social scientists who might collaborate on the pilot studies (and characterizing the nature of their collaborations);
- making further progress on the pilot studies and clarifying how the research efforts that constitute the pilot studies might contribute to EBFM;
- identifying dates for the workshop and holding the workshop; and
- continued development of products (peer-reviewed papers, technical reports, or other) that provides insights for the contribution of the social sciences to EBFM.

References

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2012 ROV Jason Use for VENTS- NeMO

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Andrew Bowen- WHOI

NOAA Program Manager – Dan Simon OAR/PMEL
Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Monitoring

PROJECT OVERVIEW

WHOI operates the NDSF, which includes the human-occupied Deep Submergence Vehicle (HOV) *Alvin*, Remotely Operated Vehicle (ROV) *Jason*, and the Autonomous Underwater Vehicle (AUV) *Sentry*. These facilities are funded by federal agencies such as the National Science Foundation (NSF), the Office of Naval Research (ONR) and National Oceanic & Atmospheric Administration (NOAA) on a daily rate basis, to provide deep sea capabilities for funded science programs sponsored by these agencies. R/V *Atlantis* served as the support vehicle for HOV *Alvin*. The ROV and AUV can be installed on other vessels suitable for their deployment. This "fly-away" capability provides scheduling flexibility to meet a much wider range of requirements for the scientific community.

Most NeMO cruises involve the use of JASON-II, ROPOS, or similar ROV for conducting dive operations, however the ALVIN manned submersible does also on occasion cover some of these requirements. Other cruise activities involving water column studies, seafloor mapping, and deployment/recovery of moorings and AUVs can also be accomplished on platforms not necessarily involving ROVs or manned submersible support.

ROV Jason was originally budgeted for 5 days at $19,999/day for operations onboard the R/V Thompson in support of Dr. David Butterfield's 2012 VENTS-NeMO Research Program. Operations actually took place on the R/V Langseth due to mechanical issues with the R/V Thompson. An additional day was added to Dr. David Butterfield's operations resulting in an additional charge day of $19,999. Due to the negotiated rate agreement we have in place, at the end of 2012 the actual day rate for ROV Jason was determined to be higher than projected and a rate increase was submitted as a supplement to the original award along with the additional operating day.

Original Request: $99,995 ($19,999 x 5 days)

Supplement: $31,999 ($19,999 x 1day plus rate increase of $2,000 x 6 days)
Total: $131,994

ACCOMPLISHMENTS

ROV *Jason* completed four dives (J2-660 to J2-663) in support of Dr. David Butterfield onboard the R/V *Langseth*:

Dive 1: Maggie cal at midwater (Tivey Twist), SCPR placement, place thermal blanket K,vent fluid sampling, dive length 20:03, dive depth 1544 meters
Dive 2: Maggie cal at midwater (Tivey Twist), vent fluid and bio sampling (Spansih Steps, Trevi, N3, Boca, Mushroom), dive length 28:29, dive depth 1535 meters

Dive 3: Offload data from CORK 1025C; optical comms testing, dive length 9:23, dive depth 2422 meters
Dive 4: Offload data from CORK 857D; optical comms testing, dive length 10:37, dive depth 2610 meters

HIGHLIGHTS

- The only cruise to make seafloor observations at Axial Seamount this year, providing a critical look at the hydrothermal system 16 months after the April 2011 eruption.
- Positioned Self-Calibrating Pressure Recorder (SCPR
- Tested the (SCPR) instrument with acoustic comms
- Made observations of hydrothermal activity along the 2011 eruption zone
- Collected samples
  Recovered and deployed temperature recorders
- Conducted a video survey and photomosaic

SOCIETAL BENEFITS

The impact on society derived from these oceanographic expeditions can be extensive, and includes technological advances to be achieved in sensing and imaging the deep ocean and seafloor, knowledge to be gained from historical climate records stored in the deep sea, and the effect of an open house tour of the manned and unmanned submersibles on a group of high school students. The general public, the U.S., and international scientific communities all benefit from the work done with the vehicles of the National Deep Submergence Facility.

EDUCATION AND OUTREACH ACTIVITIES

The cruise web site concept has been effective in reaching the classroom with near real-time images and two-way communications between the scientists and students in schools across the country. Several cruises in 2013 are planning to use this tool. Past examples of web sites of this nature are:

http://science.whoi.edu/DiveDiscover/

http://www.ocean.udel.edu/extreme2004/home.html

http://www.ridge2000.org/SEAS/

Several 2013 cruises will involve collaborative efforts involving the international community. The joining of scientific minds without regard for ethnicity or political background strengthens these expeditions and brings the world closer together.

A Preliminary Study to Develop an Abundance Index for Cusk from their Bycatch in the Gulf of Maine

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Yong Chen - UMaine

NOAA Program Manager – Earl Meredith NECRP, Narragansett, RI

Related NOAA Goal Plan – Healthy Ocean: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Monitoring

PROJECT OVERVIEW

The objective of this study is to develop an abundance index from the cusk bycatch data collected in the American lobster sea sampling program.

The Maine DMR has a sea sampling program to have onboard observers to collect lobster and bycatch data. The Maine DMR lobster sea sampling data provides evidence that cusk bycatch are more likely to be caught in the early spring or late fall, especially in the eastern region of the Gulf of Maine. Based on previous studies, we plan to include month, latitude, longitude, sediment, depth, bottom temperature, salinity, and fishing boat in the CPUE standardization. These variables are considered to influence the CPUE of cusk. Thus, it is necessary to standardize the CPUE of cusk derived from bycatch in the lobster fishery.

ACCOMPLISHMENTS

We have had all the cusk bycatch data collected in the sea sampling program of the lobster fishery identified, sorted, and organized. We are currently identifying key environmental variables and exploring various statistical models including GLM, GAM, and two-stage GLM/GAM models to fit the data to quantify the spatial distribution of critical habitat for cusk and to develop an annual standardized abundance index, which can be used to evaluate the temporal variability in the population abundance of cusk. We expect this work will be done in late April or early May.

HIGHLIGHTS

- Cusk are one of the groundfish species caught as bycatch in the American lobster trap fishery along the coast of Maine;

- The number of cusk caught as bycatch in the lobster fishery tends to vary with seasons, bottom types, and geographic locations of lobster traps, which makes the estimation of the total cusk bycatch difficult; and

- The nominal CPUE of cusk bycatch cannot be used directly to index the cusk abundance, and standardization is needed to remove the impact of the environmental variables on cusk catch rates.

SOCIETAL BENEFITS

The study can improve our understanding of tempo-spatial dynamics of cusk population in the Gulf of Maine, and provide critical information needed for the conservation of cusk that is defined as a "species of concern".

EDUCATION AND OUTREACH ACTIVITIES

An undergraduate student is involved in this project for her capstone research experience. She has submitted an abstract for the University of Maine undergraduate Student Research Exhibition.

Cushman, J. and Y. Chen. 2012. Spatio-temporal distribution of cusk bycatch in the Gulf of Maine lobster fishery. Oral presentation at the Canadian Conference for Fisheries Research (CCFFR), Moncton, NB.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Figure 1. Cusk and cod per 100 trap hauls observed by the Maine DMR lobster sea sampling program by month (2006-2011 data)

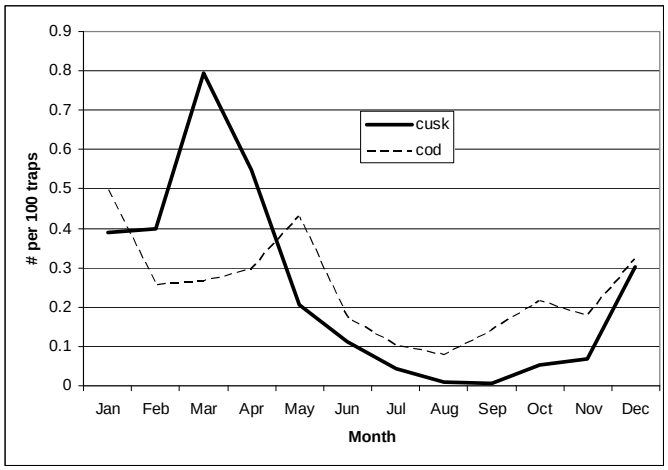


Figure 2. Cusk and cod per 100 trap hauls observed by the Maine DMR lobster sea sampling program by lobster zone (2006-2011 data).

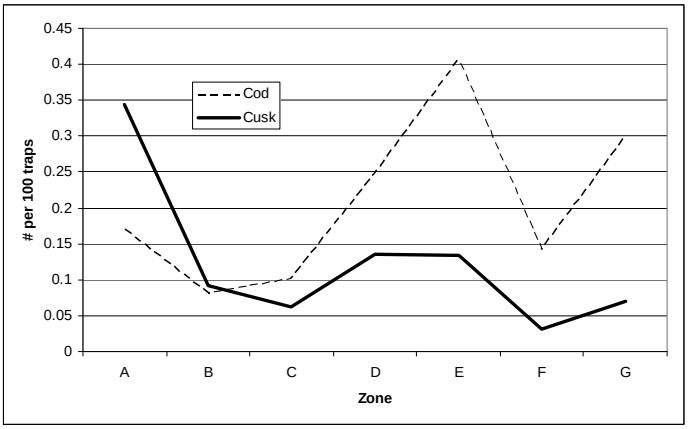
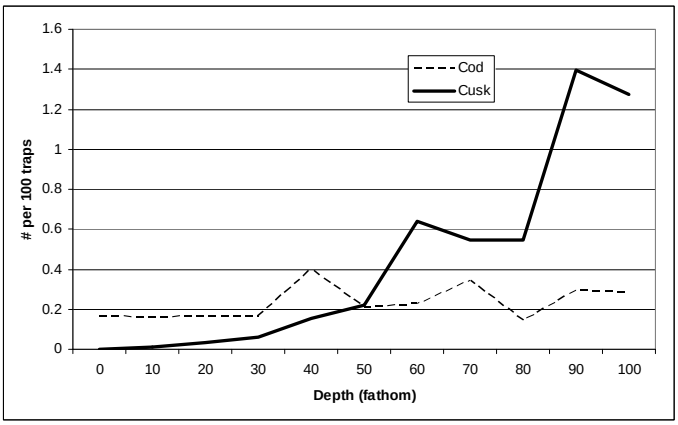


Figure 3. Cusk and cod per 100 trap hauls observed by the Maine DMR lobster sea sampling program by depth (2006-2011 data).



Development of a Sentinel Survey/Fishery in the Eastern Gulf of Maine

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Yong Chen- UMaine

NOAA Program Manager – John Hoey- NECRP- Narragansett, RI

Related NOAA Goal Plan – Goal 1: Healthy Ocean: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems
CINAR Theme – Ecosystem Monitoring

PROJECT OVERVIEW

The project objectives are to identify habitat associations for Gulf of Maine (GoM) and Gulf of Mexico (GoMex) golden tilefish, develop maps for lobster and tilefish in relation to various sediment and hydrographic factors, improve precision of CPUE estimates by including habitat in index standardization, and develop prior distributions for virgin biomass or recruitment (tilefish) for use in assessment models, leading to improved data quality and stock assessment. The project will compile sediment and hydrographic data for the two study regions and assemble the relevant survey and catch data sets for each species. A series of maps relating tilefish and lobster abundance will be created using habitat models. The results from the models will then be used to improve the estimation of CPUE by the selective incorporation of pertinent environmental data. For tilefish, burrow density information will be analyzed to help estimate a range of unfished spawning stock biomass.

ACCOMPLISHMENTS

Habitat associations for GOM American lobster and GoMex tilefish have been identified and compiled using likelihood-ratio based model selection algorithm. In both cases (and especially for tilefish) we had to account for high proportions of zeros in the data and so we used two-stage models that can better account for the overabundance of tows where the species of interest was not observed. We used two-stage generalized additive models for the lobster habitat analysis and two-stage, zero-altered and zero-inflated generalized linear models for the tilefish analysis. For American lobster the habitat variables we tested were bottom temperature, bottom salinity, latitude, longitude, depth, distance offshore, and 2 substrate features. For golden tilefish we tested depth, sediment, carbonate, organic carbon, shear stress, organic carbon, bottom roughness and critical shear stress. To identify the best model within each class, we used a likelihood ratio test-based model selection algorithm.

Generally, temperature, depth and distance offshore were the best descriptors of lobster spatial distribution. Salinity and sediment type were important, but only in certain cases (e.g. salinity was important in describing the distribution of juvenile males in spring). Prediction maps by season and maturity status are given in figure 1.

For golden tilefish, we had access to 2 types of data: bottom longline surveys and observed fishery trips. The models built using observer data generally performed better in diagnostic tests

and so those models were used for the analysis. Figure 2 gives the diagnostics for the different model forms and error distributions we tested. Based on model diagnostics along with a visual inspection of the resulting predictions (figure 3), we selected the zero-altered poisson as our final model.

To develop a standardized survey index for American lobster, we used variables important in describing both the distribution of American lobster in space (depth, temperature and salinity) and the survey (time of day, wave height and tow length). We found the trend of standardized index was similar to the non-standardized trend for both males and females (figure 4) although there were occasional differences in trend direction.

Especially with respect to potential short-term impacts of climate change, a solid understanding of the relationships between species and their environments is a critical baseline. The tilefish habitat model can also be used as a starting point for developing a lower bound for virgin biomass if some level of longline catchability is assumed. The standardization of survey catch-per-unit-effort offers a less biased description of temporal change in stock abundance. Both these project components can help improve the information used in stock assessment models.

PUBLICATIONS

For the habitat modeling of American lobsters we developed a likelihood-ratio based model selection algorithm for generalized additive models. A paper describing this methodology as applied to the American lobster study is in preparation and is titled *Species distribution models: time block selection, data length influences and model selection*. Also in preparation is a paper describing the spatial distribution of tilefish in the Gulf of Mexico and is based on the habitat modeling for that species.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

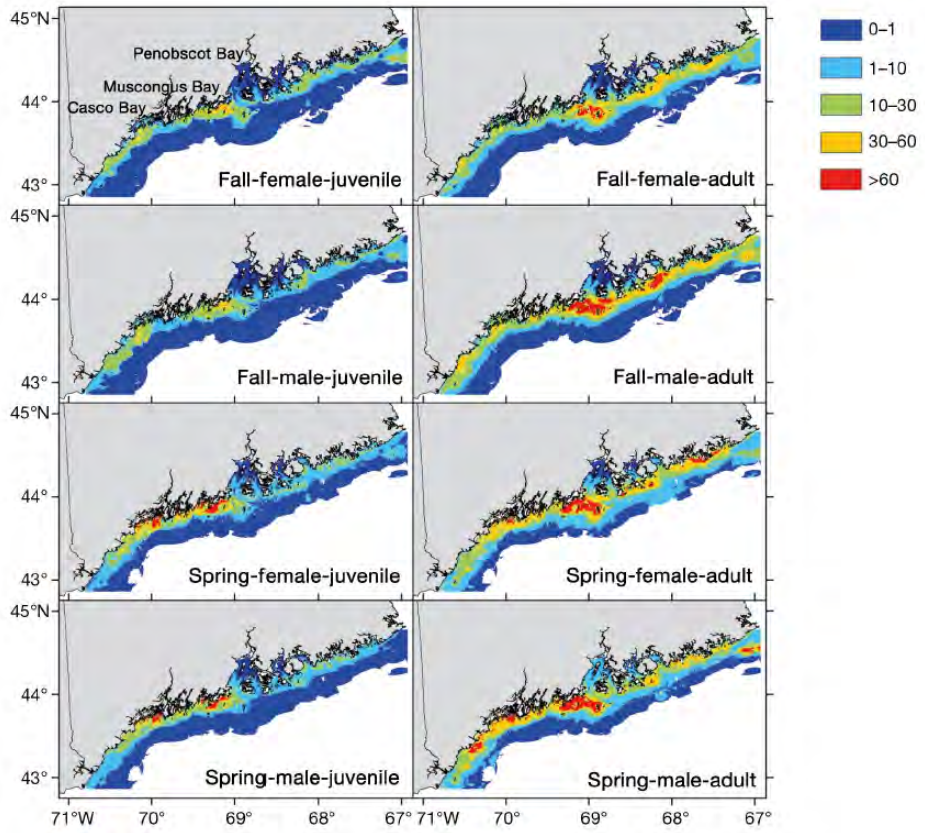


Figure 1: Predicted season-, size-, and sex-specific lobster density (per 792 m^2) distribution for 2006.

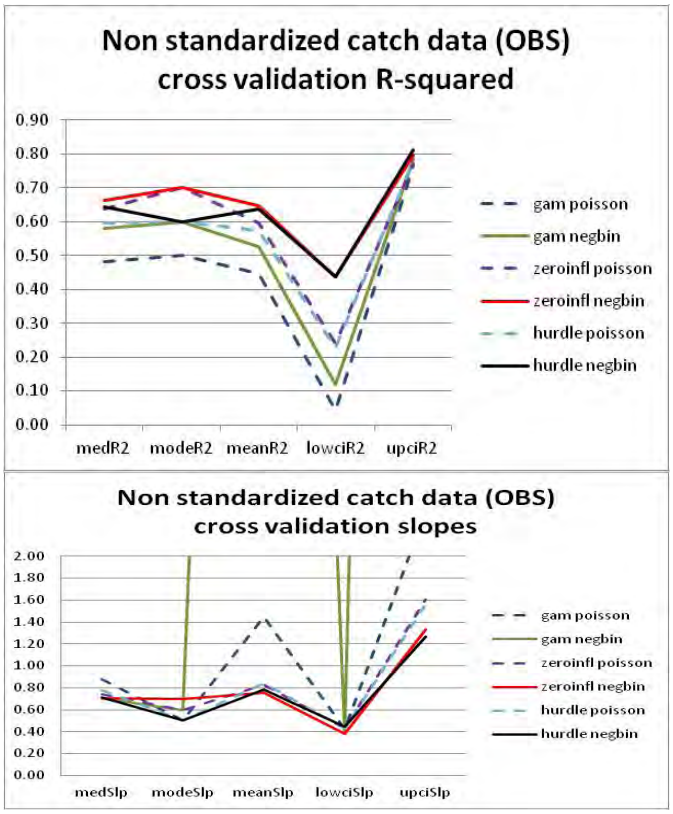


Figure 2: Diagnostics for tilefish habitat models based on observer data. The figures include the mean, median, mode, lower and upper CI bounds for 100 cross validation slope and R^2 for each model.

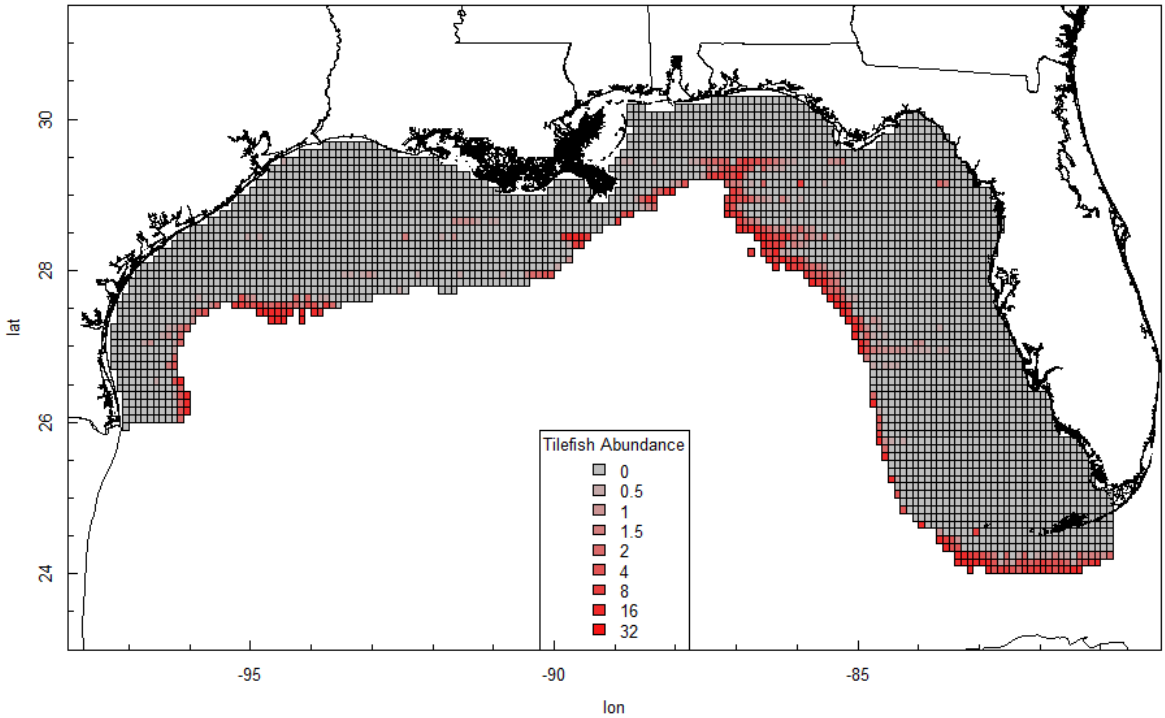


Figure 3: Tilefish predictions based on observer data using a zero altered poisson generalized linear model.

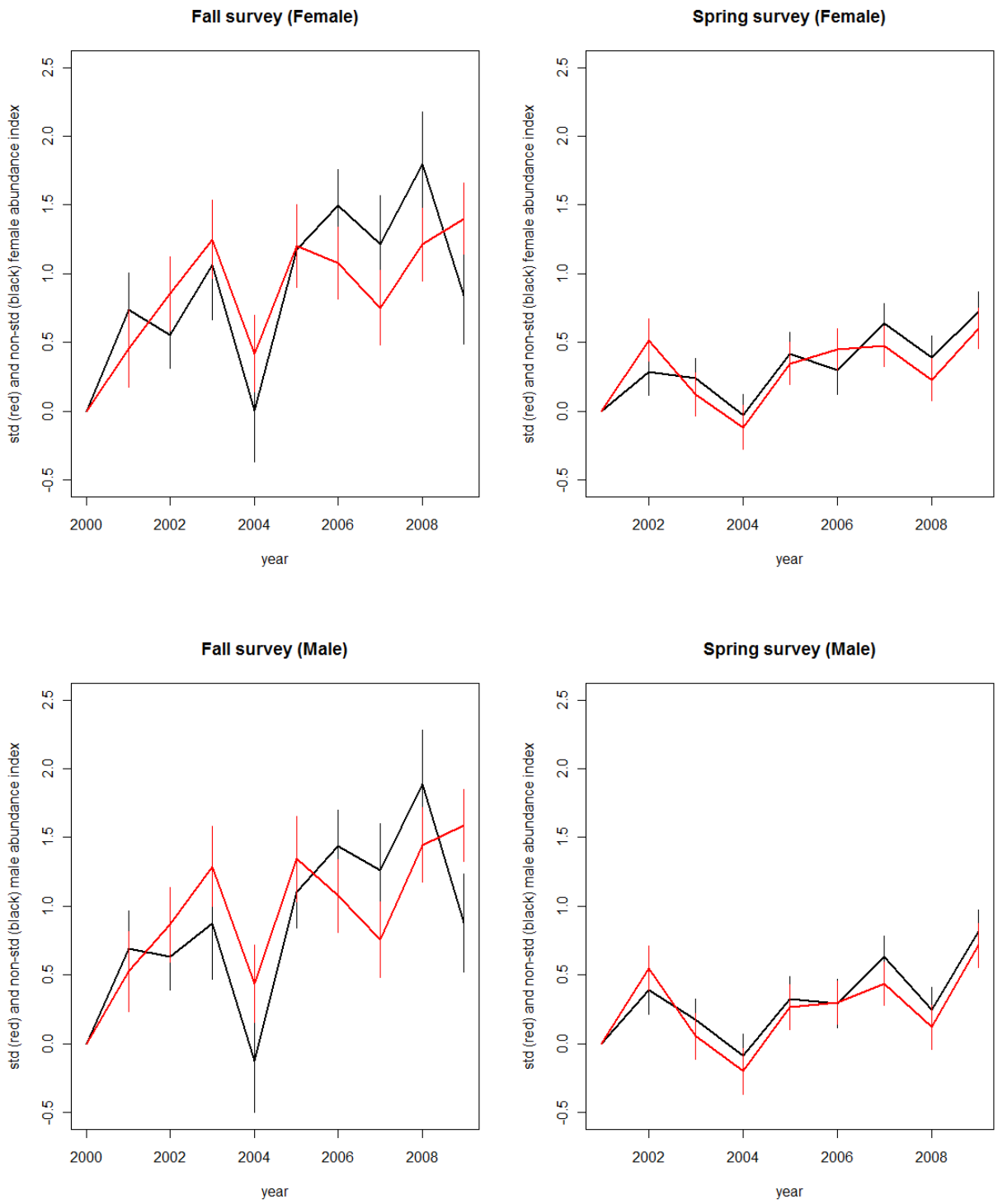


Figure 4: Standardized (red) and non standardized lobster survey abundance index by sex from 2000 to 2009. The bars indicate the standard error f

Evaluation of Broad and Fine Scale Models of Butterfish BIOMASS to by-Catch Reduction in the Longfin Inshore Squid Fishery in the Mid-Atlantic Bight

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Josh Kohut – Rutgers University

NOAA Program Manager – John Hoey - NMFS/NEFSC- Narragansett Lab

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Forecasting

PROJECT OVERVIEW

Through coordination between government and academic research institutions, fisheries management institutions, and commercial squid fishermen and we intend to evaluate existing auto-correlative and environmentally based models of butterfish biomass with an at sea trial and demonstrate the feasibility of employing real-time temperature data delivered automatically from industry boats.

Task 1: The habitat and auto-correlative models developed from a previous project will be evaluated over an 8-day at sea trial designed to quantify the effectiveness of these models to predict regions of high butterfish biomass at broad (habitat) and fine (auto-correlative) scales within the loligo fishing grounds concentrated near the shelf break during the winter trimester. The intent is to assess the skill of the model to predict regions that will minimize by-catch. Finer scale sampling will evaluate the output of the auto-correlative model.

Task 2: Building on relationships with the industry, we will enlist two to three larger vessels with high operating costs that will not be constrained to a scientific survey design to further test and refine the dynamic habitat and auto-correlative models, report by-catch biomass as well as near real time reporting of sub-surface temperature and hydroacoustic data, and document observed variables that impact decisions about how and why the fishers trawl at certain locations and times.

Task 3: Convene a 1-day workshop to bring together partners in the industry with project partners to define the expectations of the real-time reporting tasks. The purpose of the workshop will be to update the industry partners on the status of the models to be evaluated and introduce them to the temperature and real-time reporting tasks to be employed on their ships. The goals here will be to ensure that they are comfortable with the systems being deployed on their ships and are comfortable with the data sharing aspects of the work.

ACCOMPLISHMENTS

Our time from April 2012 – March 2013 was spent primarily on two general tasks, the analysis of our 8 day survey on the F/V Karen Elizabeth and the setup and completion of our ship-of-opportunity surveys conducted aboard the F/V Karen Elizabeth and the F/V Jason and Danielle.

8 Day Survey Analysis: Using this design we learned a huge amount about what we know about butterfish based upon analysis of data at broad scales, and what fishermen like Chris Roebuck know based on their time on the water fishing very precisely in areas where they think fish probably live. The work we are doing now is based on three of the most important lessons we learned:

1) Our models accurately captured butterfish responses to ocean features like temperature fronts and upwelling zones at spatial scales of 10s to 100s of kilometers. However, there were habitat features at finer spatial scales of centimeters to kilometers important to butterfish that we couldn't capture using the data we had available to us.

2) In contrast, fishermen have an extremely fine scale knowledge of associations of animals with ocean features we can't capture using traditional fishery independent surveys. By working together with the fishermen we can try to connect the broad scale patterns we see in our data and models over seasons and decades and the mechanisms the fishermen observe at fine spatial scales on a daily basis.

3) We also found during our experiment with Chris that some habitats inshore in shallow water and offshore in deep water are ecologically important to the animals but not accessible to the big ships used for regional fish surveys.

Ship-of-opportunity Surveys: The F/V Karen Elizabeth captained by Chris Roebuck out of Pt. Judith, Rhode Island and the F/V Jason and Danielle captained by Hank Lackner out of Montauk, New York participated in our ship-of-opportunity survey. The purpose of these surveys was to gather additional evaluation data based on the typical trips completed by the industry. Over these surveys we gathered bottom temperature data with Star-Oddi Centi temperature depth probes installed on the doors of their gear. In addition to this environmental data directly sampled we developed short surveys to get information on the decision-making the captains went though before setting their gear. For each tow the captains recorded information related to their anticipated catch based on environmental and experiential data. Following each tow the captains recorded the actual catch biomass. To date we have collected 80 surveys from the F/V Jason and Danielle. We will be collecting the remaining surveys from both the F/V Karen Elizabeth and F/V Jason and Danielle in the coming weeks to inform our final evaluation of the model.

HIGHLIGHTS

Designed the survey sheet for ship of opportunity surveys.

- Purchased temperature probes for 2 vessels participating in ship-of-opportunity surveys.
- Worked with two vessels to collect survey sheets and bottom temperature data for their trips completed in the winter 2013 offshore squid fishery.
- Continued frequent interactions with industry partner

SOCIETAL BENEFITS

This research has shown that incorporating the knowledge of fishermen can positively impact the results of scientific research. The at-sea evaluation of the butterfish model identified the scales over which the model can be applied. Over the Mid-Atlantic Bight Scale, the model did a good

job at identifying the preferred offshore butterfish habitats. The model did not however resolve the fine scales used by the fisherman within this coarser grid. The evaluation identified a role the model could play in guiding an industry based survey focused on small pelagic fish like butterfish, extending the coverage of the fishery-independent survey and sampling habitat regions not currently sufficiently sampled.

EDUCATION AND OUTREACH ACTIVITIES

Presentations:

- Kohut et al. Using ocean observing systems and local ecological knowledge to nowcast butterfish bycatch events in the Mid Atlantic Bight longfin squid fishery.
    - MARACOOS Annual Meeting, Baltimore, MD, November 2012
    - Oceans 2012 MTS/IEEE, Virginia Beach, VA, October 2012
- OpenOcean. Manderson et. al. Climate change, thermal habitat dynamics, habitat coverage bias & population dynamics in offshore forage species butterfish & longfin squid) central to the MAB food web. MAFMC Council Meeting, Hampton, VA, February 2013
- OpenOcean 2013 Manderson et al. A simple approach to packing space into time and a Thermal habitat indicator for ecosystem assessment. NART Data visualization workshop. Portsmouth, New Hampshire. February 5, 2013.
- Kohut et al. The power of partnership between science and the fishing industry in applied ecosystem science. WHOI-CINAR Shelfbreak Ecosystem Workshop, Warwick, RI, January 2013.
- Palamara et al. Putting the dynamics of the ocean into marine spatial planning: temporal variation in butterfish habitat. ASLO Aquatic Sciences Meeting, New Orleans, LA. Abstract ID 10576. February 2013**.**
- OpenOcean 2013 (*Manderson et al*). A simple approach to packing space into time and a
- thermal habitat indicator for ecosystem assessment. Working Group Meeting on the Northwest Altantic Regional Sea. Halifax, Nova Scotia. February 1, 2013
- OpenOcean 2013. (*Manderson et al*) Climate change, thermal habitat dynamics, habitat coverage bias & foodweb dynamics with special reference to butterfish. NEFSC Seminar Series Woods Hole Laboratory January, 24, 2013
- OpenOcean 2013. (*Manderson et al*) Climate change, thermal habitat dynamics, habitat coverage bias & population dynamics in offshore forage species (butterfish & longfin squid) central to the MAB food web. MAFMC Squid Summit, Riverhead Long Island January, 16, 2013.
- OpenOcean 2013. (*Manderson et al*) Insights into shelf break front dynamics, winter habitat, & keystone forage populations gained from collaborations with fishermen. CINAR Shelfbreak Workshop. Providence Rhode Island January, 08, 2013
- Manderson 2012: One academic ecologists view of how to get marine habitat ecology into the science informing ecosystem management. Session on Ecosystem science in Marine Resource Education Program. Baltimore, Maryland November, 27 2012
- Kohut J., Manderson J. 2012 Can we improve stock assessments by using dynamic habitat models and fishery-dependent surveys as a supplement to current fishery-independent surveys? F18: 2012 ICES Annual Science Conference, Bergen Norway September 17-21, 2012
- Manderson J.P. 2012. Does our habitat paradigm cross the land-sea boundary? Keynote address at 2nd National Habitat Assessment Workshop. Seattle, Washington September 5, 2012.

- Brown, Lori M., Thomas F. Savoy, John Manderson and Dewayne A. Fox. 2012 Using Networks to Enhance Telemetry Research In the Eastern United States: The Atlantic Cooperative Telemetry Network. AFS meeting. August . Minneapolis
- Manderson J. P. 2012 "Steps toward an operational seascape ecology in support of the management of sustainable ecosystems" 2nd International Symposium of the American Institute of Fishery Research Biologists on "The Relative Importance of Fishing and the Environment in the Regulation of Fish Population Abundance." June 26-28 2012, New Bedford MA. Invited talk and book chapter
- Manderson J.P. Kohut, J. Hoey, J., DiDomenico, G. 2012 "The butterfish smackdown": Steps towards the development of an operational seascape ecology in support of ecosystem co-management. World Fisheries Congress " Edinburgh Scotland 7th - 11th May 2012

Using Remus 100 Autonomous Underwater Vehicles to Conduct NEFSC Scallop Surveys

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Michael Purcell, Norman Farr - WHOI

NOAA Program Manager – JoanMoakley- NMFS

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems
CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

The aim of this project was to demonstrate the effectiveness of using lightweight autonomous underwater vehicles (AUVs) to conduct benthic habitat surveys. The overall effort has included engineering developments and at sea testing. The developments included a white-LED panel and color camera module. The new components were integrated on a REMUS 100 AUV. Tests were conducted near Woods Hole and then on Stellwagen Bank.

ACCOMPLISHMENTS

The accomplishments included the development of a new 360-LED, low power lighting array and camera module for a REMUS 100 AUV. These components were installed on a REMUS 100 AUV already equipped with the following sensors: high frequency side scan sonar, acoustic Doppler current profiler, conductivity, temperature and depth sensors. The AUV was used to conduct scallop surveys on Stellwagen Bank in June, 2012. Ten missions were conducted over four days.

HIGHLIGHTS

- Developed a new white-LED array to support color imaging from a small AUV
- Developed a new color camera module for a small AUV
- Demonstrated the usefulness of small AUVs in conducting benthic habitat studies during four days of scallop surveys on Stellwagen Bank on the R/V *Gloria Michelle*. Collected data included color imagery, 1800 kHz side scan sonar data and environmental properties.

SOCIETAL BENEFITS

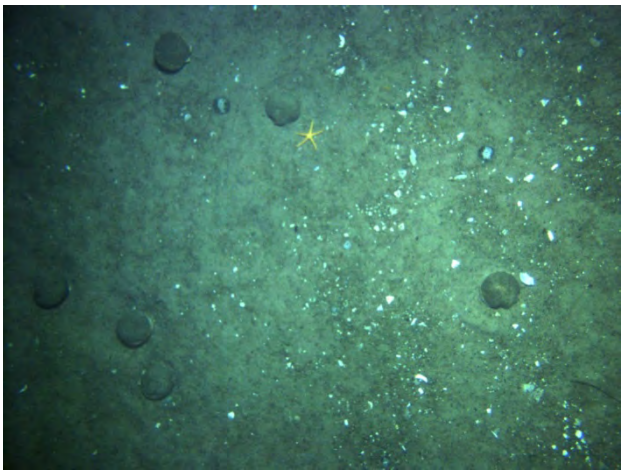
Small, lightweight AUVS may be used to conduct multispecies benthic surveys which gather information on a variety of benthic organisms and habitat, as well as species-specific data. These surveys may be conducted quickly using multiple vehicles and with smaller ships, which will reduce costs. Additionally, they result in no physical disturbance of bottom habitats upon which fisheries resources depend.

EDUCATION AND OUTREACH ACTIVITIES

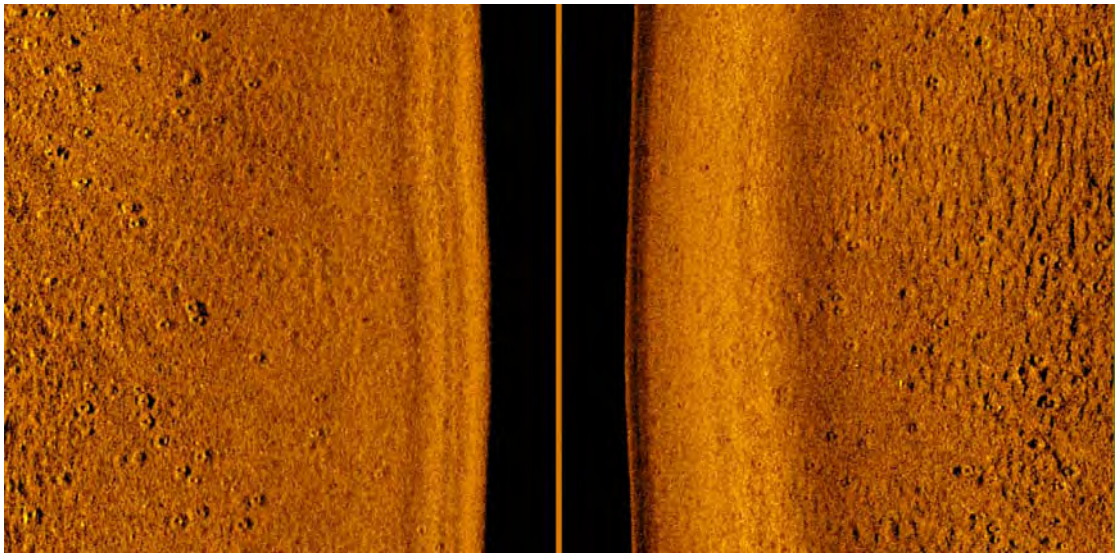
- Project overview presented in Sea Grant talk to teachers

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

REMUS 100 AUV with camera module and LED array on deck of R/V Gloria Michelle



Example image from REMUS 100 color camera (Prosilica GC 1380 C) at 3-meter altitude



Example 1800 kHZ side scan sonar image with scallop depressions

TowCam Exploration for Chemosynthetic Ecosystems at the Chile Triple Junction

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Timothy Shank- WHOI

NOAA Program Manager – John Hoey - NMFS/NEFSC- Narragansett Lab

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

This program completed the first systematic exploration for hydrothermal activity along the East Chile Rise in collaboration with U. California biologists studying cold seeps along the adjacent continental margin. The Chile Triple Junction (CTJ) is geologically unique, worldwide, as the only place on Earth where a section of mid-ocean ridge is being subducted beneath a continental margin. Accordingly, it is also one of the few places on Earth where submarine hydrothermal vents and ocean margin cold-seeps could be juxtaposed in close proximity. As such, the CTJ was a high priority for exploration throughout the Census of Marine Life decade, for those studying the biogeography and biodiversity of chemosynthetic fauna: it has the potential to reveal to what extent common chemosynthetic fauna might be able to colonize hydrothermal and cold-seep habitats, alike, as they disperse around the world's oceans. A necessary pre-requisite to any such study, however, is to establish whether any submarine vent activity exists close to the Chile Triple Junction. During the 2010 season, our team was able to map and search systematically for hydrothermal activity along the two ridge-segments closest to the CTJ and identify that there were water-column signals indicative of seafloor venting close to the Triple Junction. In Spring 2012 we returned to the area and established where these plume signals, which remained directly comparable to the 2010 data-set were at their strongest – at a location known to within <1km, immediately adjacent to the ridge-margin intersection.

Our proposed project had the following three key objectives:

1) Does intense seismic activity immediately north of the Chile Triple Junction - both in the young ocean crust being subducted, and in the over-riding plate - give rise to enhanced fluid flow? If so, does this enhanced flow, combined with the extremely steep thermal gradients that arise from subduction of young hot lithosphere, cause destabilisation of gas hydrate deposits and, consequently, extensive methane release to the overlying oceans?

2) Does the complex interplay between the trench and ridge-crest near the CTJ, clearly evident in widely varying ridge-morphologies, give rise to similarly varied styles of hydrothermal venting? Will we locate long-lived, tectonically-controlled vent-sites, previously considered unique to slow- and ultra-slow spreading ridges, and novel "hybrid" systems, with great economic potential, emplaced directly into the continental margin?

3) Do the fauna inhabiting chem osynthetic ecosystems in the SE Pacific Ocean represent a new biogeographic province? Are the faunal communities similar at all locations close to the CTJ, or are there differences between, for example, hydrothermal vent and cold-seep com munities that can be attributed to differing environm ental param eters such as substrate, tem perature, pressure?

ACCOMPLISHMENTS

A total of 3 *TowCam* lowerings and 1 AUV *Sentry* dive were completed, yielding close to 20,000 images taken of the Chile Triple Junction seafloor in order to study deep-sea faunal distribution, abundance, and habitat data. *Tow Cam* images were taken every 10-15 seconds at an altitude between 2-6 meters from the seafloor with a 16-megapixel camera. Each bottom image was visually screened and scored independently by at least two experienced scientists with identification of hard and soft corals, sponges, and fish. Presence/absence scoring was logged for each image using iview Medio Pro (ver. 3.1.3 Iview Multimedia Ltd) from which data catalogues indicating faunal occurrence were constructed. Text data files from each *TowCam* lowering were exported from the iView MediaPro catalog and merged with navigation files using the time-date stamp from the image file names. Faunal location data and associated habitat data were geo-referenced in ArcGIS and mapped.

Because AUV, CTD and Sentry operations were all conducted in parallel as the INSPIRE 2012 cruise progressed (4.5 days on station) our Sentry investigations were initiated with only a subset of the CTD data presented above being available. For example, CTD 03P results were only available after the final photo-survey AUV dive had been launched and the second TowCam deployment was underway. Accordingly, but knowing from CTD01T that our strongest plume anomalies were located closest to the Triple Junction, the Sentry AUV was deployed on dive 137 to map around the arc of the ridge-margin intersection between 46°15.6’ and 46°17.2’S. Our survey provided almost complete coverage of the southern arcuate section of the scarp including the break in slope at the base of the Chile margin and, to the West, adjacent regions of flat seafloor representing the axial rift-valley of the East Chile Rise. Preliminary analysis of this microbathymetry, while still on station, was sufficient to reveal a number of fields of mounds/hummocks. One particularly marked example was located close to 46°16.35’S, 75°47.75’W, just 200-300m NE from the location where our strongest CTD plume anomalies were detected but subsequent TowCam 03 survey revealed no hydrothermal activity or communities at the specific site targeted by this approach. As with the CTD-rosette operations, no Eh or optical backscatter anomalies were observed throughout our Sentry AUV oeprations during the INSPIRE 2012 cruise.

The primary methodology for biological investigations planned for the INSPIRE project was to conduct near-bottom photography from our deep-diving AUV *Sentry*. For the 2012 cruise we not only planned photographic surveys using the *Sentry* AUV but, to maximize scientific returns from the short period of station time available, we also deployed the *TowCam* deep tow vehicle for three photo-survey deployments (Fig.1).

During the first tow, the vehicle followed along the base of the arcuate ridge/margin intersection, to investigate the base of slope as a possible conduit for active fluid flow. While no active venting was observed, the trajectory followed the base of slop very closely at a depth of ~3824m and revealed soft sediments with frequent mound and burrow structures present and hosting abundant ophiuroids and holothurians with occasional echinoderms and, increasingly, xenophyophores. The abundances of burrows, asteroids and xenophyophres increased

significantly toward the base of the slope. TowCam deployment 02 began with a survey along the relatively flat terrain at the top of the scarp that defines the Ridge-Margin intersection at the Chipe Triple Junction. While a traverse down the scarp was also planned (Fig.1) most of the E-W and NW-SE components of this survey had to be conducted off-bottom to avoid interference with Sentry mapping in the same area such that the remainder of the observations from this dive were also conducted running SW-NE along every summit of the scarp. The seafloor at these depths (2500-2600m) also exhibited extensive soft sediment cover with abundant burrows. Fauna recognized from images during this survey included Acharax clams, urchins, holothurians and echinoid worms, fish, shrimp, asteroids, crinoids and xenophyophores. Our final TowCam deployment (TC03) coincided with Sentry dive 138 which also conducted near-bottom photographic surveys. While Sentry 138 was designed to target key target areas on the steep slopes revealed by the Sentry 137 multibeam survey the TC03 deployment was designed to pass directly over an area of rough hummocky terrain on the deep seafloor close to 46°16.35'S that was also revealed by the Sentry 137 microbathymetry and that also underlay, offset by ~250m to the north and east, the locus of our strongest measured CH4-rich hydrothermal plumes. This survey as for TC01 encountered extensive soft sediment cover with hummocks and burrows but no evidence for active venting in the mound area targeted. Continuing north, parallel to the base of scarp at these latitudes, the primary fauna observed were fish, holothurians, xenophyophores and ophiuroids. Also seen, but less abundant, were small translucent gastropods and echiuran worms together with urchins and a few crustaceans.

HIGHLIGHTS

- AUV *Sentry* and Tow-Cam deployments to this area revealed thick sediment cover of this southernmost section of the Each Chile Rise ridge-axis consistent with the hydrothermal plume data (strong, co-registered CH_4 and ^3He anomalies but no corresponding *in situ* Eh and optical backscatter sensor anomalies nor TDMn/TDFe anomalies in the water samples).

- From seafloor imaging (Sentry & TowCam) we can confirm that sediments at the CTJ host fauna in much higher abundances than would be expected from the same depth (~3000m) elsewhere along the Chile margin.

- The in-fauna collected from sediment cores closest to our suspected vent area show some analogies to cold seep fauna from the south and central Pacific – to a certain extent in the macrofauna but especially in their microbial communities.

SOCIETAL BENEFITS

This project was established to conduct the first systematic exploration of the geologically unique Chile Triple Junction, using state-of-the-art technology to search for, locate and photograph new hydrothermal vent, cold seep and novel "hybrid" systems. These were to be the first such sites located in this region of the Pacific and considered likely to host fauna previously unknown to science that might represent a completely new biogeographic province. Our aim was to undertake the first important steps toward establishing a natural laboratory in the SE Pacific to investigate complex interactions between the Solid Earth, Oceans and Life.

EDUCATION AND OUTREACH ACTIVITIES

Both of our field programs were very graciously hosted by NOAA's Ocean Explorer web-presence as follows:

INSPIRE 2010 = http://oceanexplorer.noaa.gov/explorations/10chile/welcome.html

NSPIRE 2012 = http://oceanexplorer.noaa.gov/explorations/12chile/welcome.html

Additional outreach activities included:

2010: A live multinational (US, Chile, UK & Spain) broadcast was conducted from the RV Melville, on station.

2012: PI German was a keynote at the Ocean Exploration soiree, AGU Ocean Sciences Meeting, Salt Lake City.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

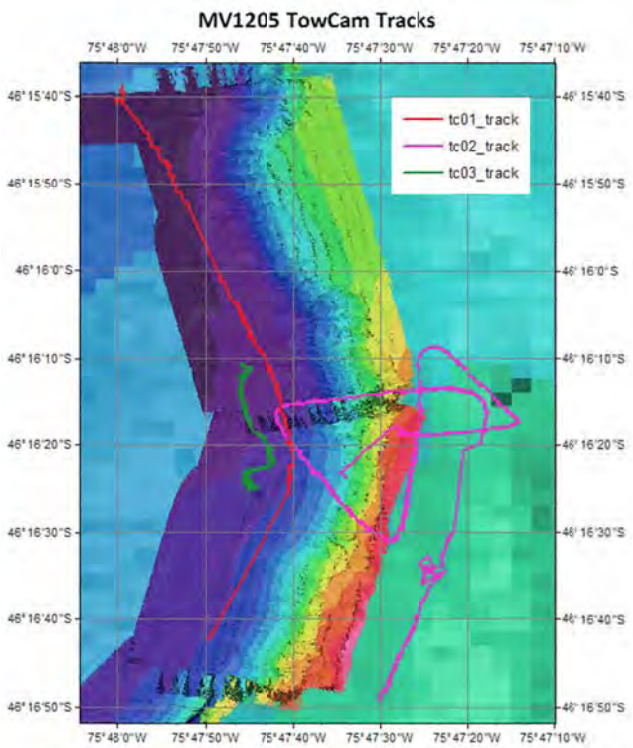


Fig. 1. Map showing TowCam tracks superimposed on microbathymetry data obtained during Sentry Dive 137.

Inshore Gulf of Maine Herring Acoustic Survey

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Graham Sherwood -GMRI

NOAA Program Manager – Michael Jech NMFS/NEFSC

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

The goals of this project are to 1) use acoustics to estimate abundance and biomass of herring in coastal waters of Maine (Area 1A), and 2) combine our results with results from the NMFS offshore survey to generate a synoptic "snapshot" of the status of the Gulf of Maine herring complex. We will use a spatially- and temporally-comprehensive survey design, coordinated with the NMFS offshore survey using comparable acoustic systems.

Our objectives are:

1. Document the spatial extent of the herring complex across a broad time frame when herring are known to aggregate, spawn, and migrate through coastal Maine waters (i.e., autumn).

2. Estimate abundance and biomass for inshore Gulf of Maine herring for comparison with stock assessment estimates (the entire complex) and assumed allocations of the entire complex to inshore and offshore components.

Funds from the Maine Technology Asset Fund (MTAF) were used to purchase equipment for conducting the surveys. This includes ten ES70 echosounders with 38- and 200-kHz single beam transducers outfitted on ten lobster boats with homeports distributed equidistant across the coast of Maine. MTAF funds were also used to purchase other infrastructure equipment such as an EK60 split-beam echosounder (38- and 200 kHz transducers), computers, Echoview software, data storage, and other associated equipment. Funds from this project have been used to cover operating costs for the survey, staffing, supplies, and maintenance, and represent required match for the MTAF award.

ACCOMPLISHMENTS

To date, we have collected over 4,200 miles of acoustic transect data (Figure 1). This equals 7 trips (average) per boat (from early September 2012 to early November 2012) times 60 miles per trip times 10 boats. The scope of this data collection effort is about an order of magnitude greater than most acoustic survey programs. Funds remain for each vessel to sample 3 more times in the fall of 2013. This will add an additional 1,800 miles of acoustic transect data to our analysis as well as another year of monitoring herring for inter-annual comparisons.

Data is still being analyzed. We are currently analyzing all acoustic data in Echoview software (Myriax ®). Echoview is the standard software for analyzing fisheries acoustics data. With MTAF funds, we have purchased a 5-year license and modules specific for the analysis of herring data (e.g., school detection). Using Echoview, we will estimate herring biomass in terms of Nautical Area Scattering Coefficient values (NASC). We will apply geostatistical techniques for analyzing spatial patterns in herring biomass and distribution. Multiple steps need to be completed before NASC values can be generated. These steps include bottom detection (to isolate the water column), bad ping removal (caused by air bubbles in rough seas for instance), noise removal (both electrical and mechanical noise) and school detection. Given the volume of data collected, we are still running through these protocols and have not yet reached the step to provide biomass estimates for this report. These analyses are forthcoming and will be included in subsequent reports.

Perhaps of equal value to the scientific objectives of this study is the collaboration that has been fostered between GMRI and the lobster industry. Fishermen (10 lobstermen) were actively involved in every step of this project from the planning stages, through equipment installations and calibrations and data collection. We convened a participants meeting in early 2012 to help launch this collaboration and will hold another similar meeting in spring 2013. This meeting will inform participants of project progress, solicit advice for continuation of the survey/sampling and securing funds for future survey work that makes use of their expertise, vessels and the acoustic equipment.

HIGHLIGHTS

- Acoustic backscattering data has been collected from a total of 4,200 miles of transects in coastal Maine waters (Area 1A for herring management) to be used in estimates of herring abundance and distribution.
- An additional 1,800 miles of transects will be sampled in 2013.
- Repeat sampling took place so that changes in distribution of herring could be tracked in addition to estimates of total biomass.
- Data analysis to produce estimates of biomass is ongoing.
- This project is supporting and will form the basis of a Master's thesis for a UMaine graduate student (Katie Wurtzell).

SOCIETAL BENEFITS

The intended purpose of this research is to provide current estimates of Atlantic herring abundance and biomass. Results of this study will inform management decisions that could contribute to maintaining a sustainable population of Atlantic herring in the Gulf of Maine. More accurate estimates of herring abundance in the Gulf of Maine may contribute to more predictable bait supply for the Gulf of Maine lobster industry which relies heavily on this resource.

EDUCATION AND OUTREACH ACTIVITIES

Poster presentations highlighting our survey objectives and industry collaboration were given at the CINAR review in Woods Hole (Sept 2012) and the '*American Lobster in a Changing Ecosystem*' symposium held in Portland (Nov 2012). This project is supporting a graduate

student at the University of Maine; Katie Wurtzell will examine spatial-temporal patterns in herring distribution as part of her MSc thesis.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

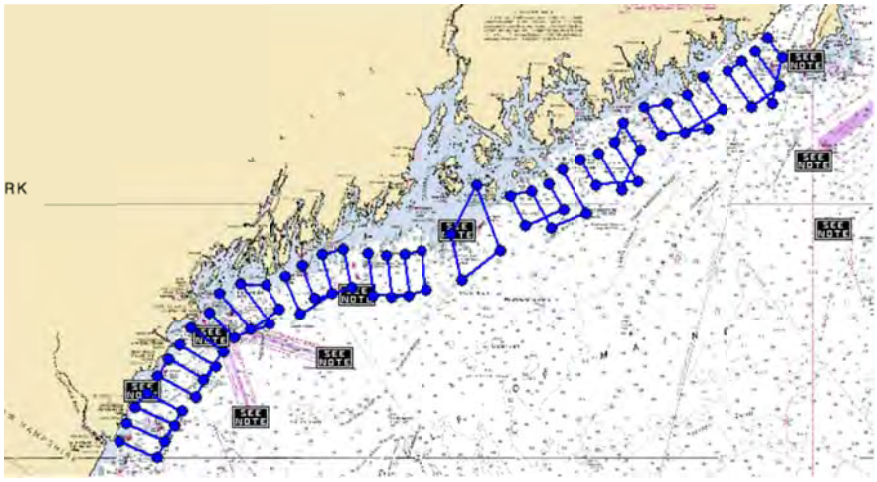


Figure 1. Chart showing location of acoustic transects sampled by 10 lobster vessels throughout Maine coastline (Area 1A). Each vessel (except one) collected acoustic data from four perpendicular (from shore) transects for a total of 38 transects distributed from York to Cutler, ME.

Development of Protocols and Tools to Assess Fish Populations and Habitats Using SeaBED AUV

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Hanumant Singh – WHOI

NOAA Program Manager – M. Elizabeth Clarke NMFS/NWFSC

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

Over the last few years our laboratory has built various tools and components are used to process and analyze the imagery associated with the AUV. These tools work well when used in isolation but there is a lot of potential for further enhancement of these tools if they could be used to complement each other. Thus this project has the following goals:

1. To extend our ability to count fish and classify habitat by using large scale mosaics as opposed to individual fish.

2. To extend our ability to construct automatic large area mosaics by utilizing the multibeam data to assist in the warping of the unstructured 3D terrain underwater.

3. To combine the forward-looking imagery associated with the BlueView Imaging sonar with the multibeam data.

4. To combine the forward-looking imagery with the forward-looking sonar and multibeam to examine fish avoidance and other phenomenon of interest

ACCOMPLISHMENTS

Our fundamental contribution has been in the use of graph-based techniques for the simultaneous fusion of the optical and acoustic imaging methodologies. This technique includes in its optimization the role of attitudinal offsets and other calibration methodologies that have so far always been treated independently of the sensors. These techniques can now be applied in a straightforward manner by technicians and other fisheries personnel without regard to the complexities of the underlying mathematical structures that has so far hampered the use of such techniques in the past.

HIGHLIGHTS

- Multisensor fusion of optical and acoustic imagery for large scale mapping across a variety of sensors

EDUCATION AND OUTREACH ACTIVITIES

Graduate student Clayton Kunz completed his doctoral dissertation (partially supported through this program) entitled "AUV Navigation and Mapping in Dynamic Unstructured Environments".

PUBLICATIONS

1. Kunz, C., Singh, H., "Map Building Fusing Acoustic and Visual Information using Autonomous Underwater Vehicles," *submitted to the International Journal of Robotics Research*.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

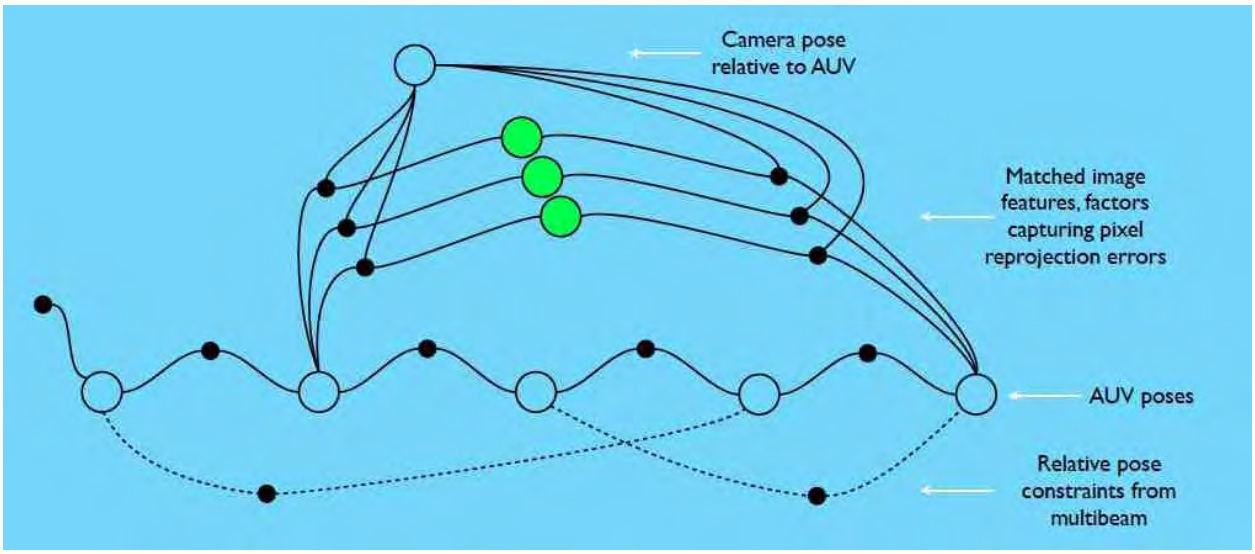


Figure 1: Graph-based techniques are now allowing us to provide a mathematical framework that allows us to combine optical and acoustic imagery into a consistent representation that respects the constraints associated with offsets and calibration data while presenting a simplified front end to the fisheries end-user community.

Integrating a Forward looking Sonar on the SeaBED AUV

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Hanumant Singh – WHOI

NOAA Program Manager – John Rooney NMFS/PIFSC

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

This project proposed the development and integration of the necessary hardware and software components to integrate the BlueView P900-130 high-resolution sonar to the SeaBED AUV, thereby enhancing its utility as a non-extractive, fisheries independent data collection tool. This development and integration includes the hardware necessary to mount and interface the BlueView Technologies sonar to the existing SeaBED AUV physical, power, and data collection platforms. The sonar itself was to be procured by PIFSC and made available for integration.

ACCOMPLISHMENTS

The Seabed AUV operated by NOAA's Pacific Island Fisheries Science Center has very successfully been used for video transect surveys. However, to address the limitation of low ambient light levels affecting video data collection and to strengthen the capability to identify and enumerate demersal fishes as well as to describe potential behavioral modifications, we had proposed to integrate a high-resolution imaging sonar into the SeaBED AUV's existing suite of sensors. Mounted horizontally and pointing forward of the AUV, the sonar imaging system serves to enhance sighting, quantification, and sizing of demersal fishes. As sonar is unaffected by low-light conditions, the proposed acoustic imaging system improves the SeaBED AUV's forward-looking video sensor range in light-limited conditions (e.g. depth > 100 m, low visibility, nighttime deployments). Furthermore, the video-like display of the high-resolution sonar data aids in determination of potential behavioral modifications of certain fish species, thereby enabling refinement of sampling design and AUV operation to minimize those behaviors. Used in conjunction with the optical imagery enabling species identification for fishes that are within range, these two tools should provide a synergistic and powerful combination for addressing the ASTWG themes of near-boundary assessments of living marine resources and remote species identification and enumeration. While the system has integrated on the AUV, NOAA researchers are now beginning to use it for its intended purpose and we are excited about the data this will generate.

HIGHLIGHTS

- A Blueview imaging system was successfully integrated on the NOAA AUV

SOCIETAL BENEFITS

The Blueview system is one more tool that can provide a better fisheries independent view for stock assessment.

Real Time Imagery from an Autonomous Underwater Vehicle to Enhance Adaptive Mission Execution

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Hanumant Singh – WHOI

NOAA Program Manager – M. Elizabeth Clarke NMFS/NWFSC

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

This effort was aimed at integrating the WHOI acoustic modems with co-processors and PSK coding. This will include the integration of both software and hardware and testing of systems. After integrating the hardware and software systems, the systems were to be tested during real missions in both the Western Pacific and West Coast to 1) obtain real-time imagery and 2) use information from imagery to remotely adjust the mission track.

ACCOMPLISHMENTS

The system was integrated as proposed. In addition, graduate student Christopher Murphy, who was working in this area (funded through this and other grants), defended his doctoral dissertation entitled "Progressively Communicating Rich Telemetry from AUVs via Relays". The results have also been submitted for publication in the Journal of Oceanic Engineering. Encoding and transmitting imagery at the extremely low data rates available on conventional modems is not possible with conventional (jpeg, jpeg2000) coding schemes. Our methodology utilizes a multi-step approach that initially classifies and segments the imagery into multiple classes, discretizes the space via an arithmetic coding scheme, and then reconstructs a texture-synthesized version on the surface.

HIGHLIGHTS

- Routine telemetry of underwater imagery from AUVs across the horizontal channel.

SOCIETAL BENEFITS

The ability to telemeter imagery across the horizontal channel allows us to really concentrate our efforts on obtaining the kind of survey that is optimal for the given circumstances which in turn greatly improves the efficacy of our stock assessment surveys.

EDUCATION AND OUTREACH ACTIVITIES

Contributed (in part) to the doctoral dissertation of Christopher Murphy

PUBLICATIONS

Murphy, C., Walls, J., Schneider, T., Eustice, R., Stojanovic, M., Singh, H., "CAPTURE: A Communications Architecture for Progressive Transmission via Underwater Relays with Eavesdropping," *accepted by the IEEE Journal of Oceanic Engineering*

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

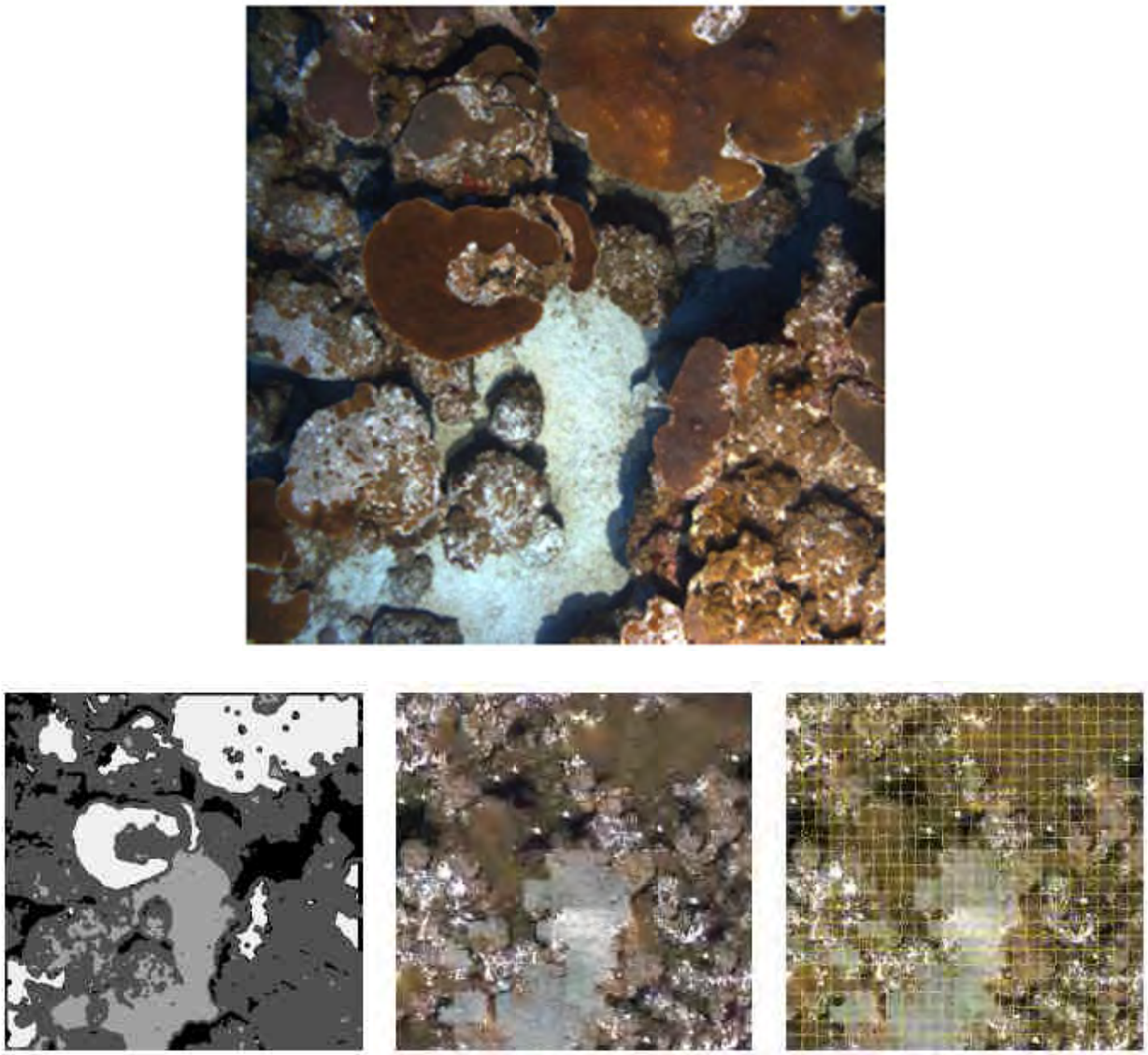


Figure 1. Original image (top) and intermediate stages of processing for very high level compression of underwater imagery for real-time transmission. Bottom row (left) segmented image (center) reconstructed based on texture synthesis and (right) tiles used for texture synthesis.

Obstacle Avoidance For Reef Fish Stock Assessment

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Hanumant Singh – WHOI

NOAA Program Manager – John Rooney NMFS/PIFSC

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

This work aims to improve the capabilities of the NOAA Seabed Autonomous Underwater Vehicle (AUV) to work in complex and rugged terrain associated with coral reefs to further the studies associated with reef fish stock assessment.

ACCOMPLISHMENTS

Our approach to obstacle avoidance and isobath following with the AUV, involved algorithmic development based on the existing blueview multibeam sonar, which is typically mounted facing forward forward-facing to look at fish in the path of the AUV. The blueview sonar has a 120 degree (horizontal) field of view, and a 20 degree vertical field of view and a reasonable range of tens of meters. By examining the returns and filtering out the fish we believe that we can detect and respond to obastacles in our path.

For isobath following, we could also use the blueview, though we would have to orient it more sideways (say 45 degrees forward) to get a better view of the terrain. As this was not considered acceptable for all the different deployment scenarios, we have acquired a pencil beam sonar that is pointed down and forward to provide coverage additional to that provided by a forward looking Blueview multibeam sonar. Merging these two capabilities into a coherent algorithmic framework is ongoing.

HIGHLIGHTS

This work is ongoing. The current iteration of algorithms is being tested on a research cruise on the NOAA ship R/V Oscar Sette. We expect to continue testing the algorithms later this summer.

SOCIETAL BENEFITS

The ability to utilize an AUV in the highly unstructured and rugged terrain on coral reefs will greatly improve our ability to to understand the complex interactions within these important ecosystems.

Systems Level Sensing and navigation Integration for the SeaBED AUV

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Hanumant Singh – WHOI

NOAA Program Manager – M. Elizabeth Clarke NMFS/NWFSC

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

This project aimed to introduce the use of long baseline navigation on the Seabed AUV to allow for precise and accurate repeat surveys of areas of interest on the seafloor. It also focused on taking the existing sensors on the AUV and providing a mechanism for pulling all the sonar and optical data into a consistent composite view.

ACCOMPLISHMENTS

This work is ongoing. During the course of this project, the AUV was lost at sea. A replacement AUV has been procured and has just come online. As of the writing of this document the new AUV is undergoing testing on the NOAA research vessel R/V Oscar Sette.

The process of integration of the long baseline capability is underway. We expect to further test these capabilities over the coming months. The algorithmic framework associated with systems level sensing is also well in place but further testing and refinement of these algorithms will take place over the next few months on the new AUV.

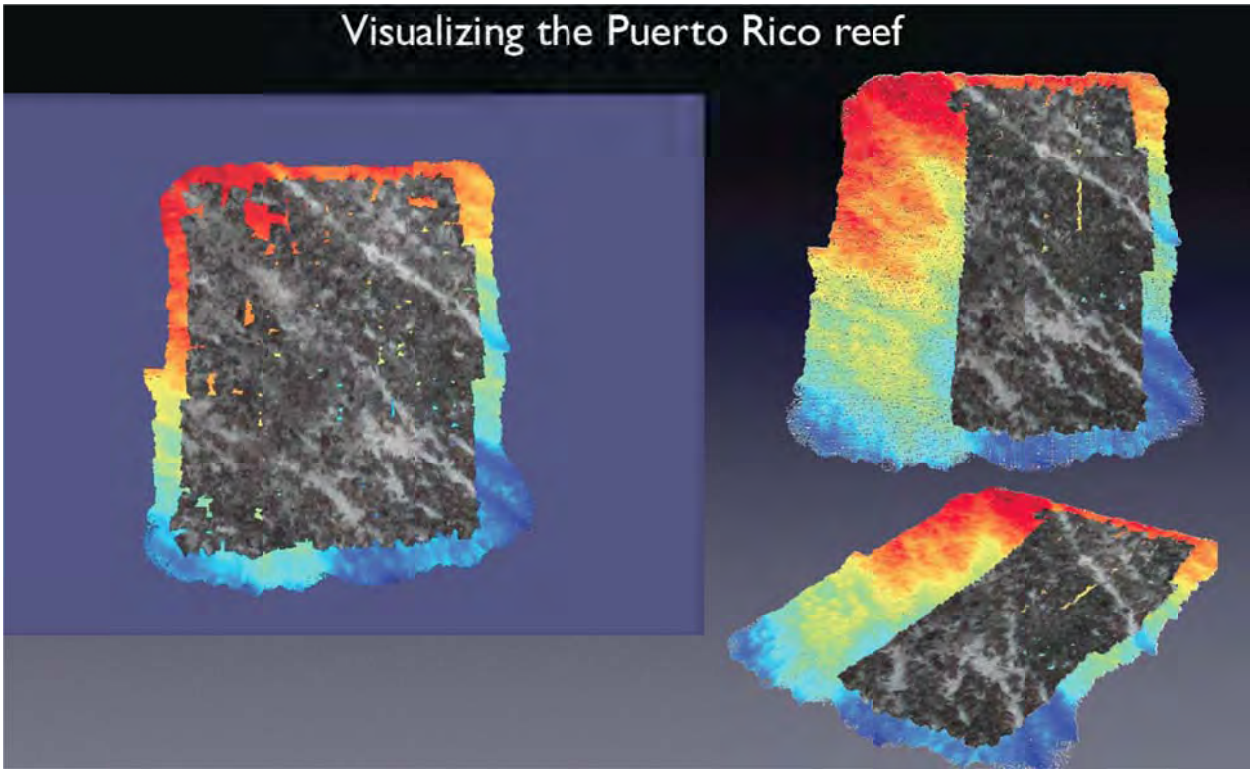
HIGHLIGHTS

This work will result in a new capability for looking precisely and accurately doing repeat surveys of the seafloor and for building multiscalar, multisensory maps of the environment.

SOCIETAL BENEFITS

This work should allow us to really examine our data in a new manner that should yield insights into fisheries stock assessment and habitat mapping.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



The amalgamation of long baseline navigation, multibeam sensing, and 3D image reconstruction allows us to build a composite view of the environment that includes accurate and precise fused representations that fully characterize the area being studied – this site is a coral reef in Puerto Rico that was damaged (and is recovering) from a ship grounding event.

THEME III ECOSYSTEM MANAGEMENT

A US- Canada Science Symposium: The American Lobster in a Changing Ecosystem

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Paul Anderson - UMaine

NOAA Program Manager – Russell Brown, NMFS- NEFSC

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

The *8th International Conference and Workshop on Lobster Biology and Management* recently held in Norway, while informative, was poorly attended by students of the American lobster, largely because of the cost. Major research initiatives are beginning to generate interesting results across the species' range. These include: shell disease research in southern New England; industry-supported hatchery-based enhancement efforts in the southern Gulf of St. Lawrence; studies of the ecology and economics of coupled human-natural systems in the Gulf of Maine; establishment of baseline health parameters and response to disease, as well as long-term studies tracking the molt cycle in Atlantic Canada; and, parallel studies of larval connectivity on both sides of the border. This symposium was held in Portland, Maine provided the opportunity for scientists in this regions, working on the American Lobster to convene and to promote the sharing of new findings and in-depth discussion.

Approach - The Meeting

Participation: 150 attendees by invitation; academic and government scientists, students, resource managers and industry members participating in research. The symposium included a series of plenary talks with invited speakers from throughout the region (Canada to Virginia) and a call for papers/posters. Leaders from various regions and elements of the lobster industry throughout the Northeast were also in attendance.

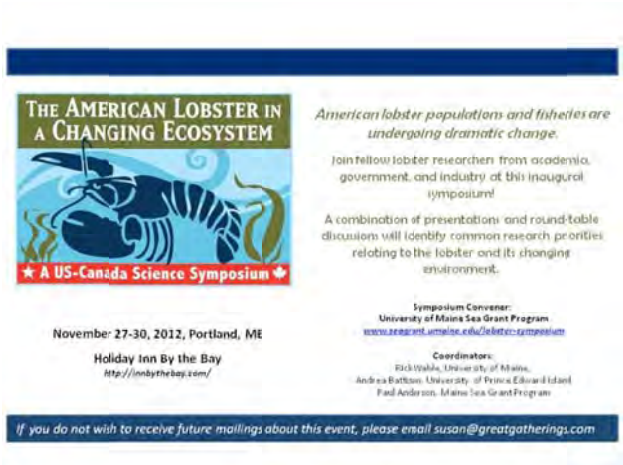
Sessions included a combination of invited and contributed presentations and interactive group discussions. Session Topics –

Trophic dynamics
Meta-population Dynamics & Connectivity
Anthropogenic Environmental Stressors
Coupled Human-Natural Systems & Ecosystem-based Management

The meeting was convened by the Maine Sea Grant College program and coordinated by Paul Anderson (Director), Dr. Rick Wahle (University of Maine), and Dr. Andrea Battison (University of PEI, Canada). An International steering committee helped to assist with all aspects of planning with sub-committees for logistics, fund-raising, and content.

The format of the symposium allowed for approximately 60 scientific presentations, as well as blocks of time for discussion. Manuscripts submitted for publication that pass peer review will be published in the *Canadian Journal of Fisheries and Aquatic Sciences* (CJFAS). A wrap-up session was held on the final day to synthesize a summary report that will highlight significant conclusions, information gaps and research needs. This document, along with the networking that will happen throughout the event will help to connect research teams and institutions with the goal of enhancing networks and research collaboration. Maine Sea Grant's communications team will be involved in editing and producing a final document that will be made available electronically via the Internet.

Design elements for the symposium were developed by Maine Sea Grant. (see below):



ACCOMPLISHMENTS

We had 150 attendees, four major symposium themes, four plenary talks by world experts in lobster science, 46 invited presentations, and 26 scientific posters. We also conducted facilitated round table discussions on each theme. We anticipate up to 20 of the presentations will be submitted for publication in the Canadian Journal of Fisheries and Aquatic Sciences and will be preparing a summary paper of the science highlights. Although the symposium evaluation results are still pending, the casual consensus has been that it was an extremely valuable event for networking within the science community and provides a point in time moving forward for future collaborative and interdisciplinary approaches to some lingering and emerging issues related to the long term sustainability of this important fishery in the region at a time of well-documented ecosystem change.

The event also garnered significant press from around the country and the region including newspapers, television, radio and the Web. Highlights of the symposium and some of these media links are available at Catherine Schmitt's blog site: http://www.seagrant.umaine.edu/blog/lobster-symposium-2.

Materials related to the event including the program with all abstracts is available on the symposium web site: http://www.seagrant.umaine.edu/lobster-symposium. Based upon the symposium evaluation, the Steering Committee will convene at least once more to discuss the likelihood of repeating the symposium in a few years, quite likely in Canada.

HIGHLIGHTS

- 150 scientists, students and policy makers from the United States and Canada participated in this 2-day meeting sharing the most current research findings about the American Lobster.
- Scientists were provided an excellent opportunity to connect with one another, compare research ideas and discuss collaborative approaches for future research to fill some of the most pressing information gaps about the American lobster.

- This was a very timely convergence of the science because of severe die-off of lobster in southern New England and the opportunity to look at the challenges and vulnerabilities of this species throughout the range from New England up into Canada. The American lobster is clearly one of several canaries in an all-too crowded "climate change coal mine".

SOCIETAL BENEFITS

The lobster fishery is profoundly important to the coastal communities in this region and it is critical that the science community is addressing key questions about the vulnerability and resiliency of this organism to a changing ecosystem. Easily the largest fishery in Maine, if this fishery were to suffer the fate of neighboring states to the south, there would be severe impact on the livelihood of thousands of fishermen and other related industries, which would, in turn have a devastating affect on the communities where they work.

EDUCATION AND OUTREACH ACTIVITIES

This conference had over 60 presentations and 30 posters. A complete list and abstracts are available at: http://www.seagrant.umaine.edu/files/LobsterSymposiumProgram.pdf

PUBLICATIONS

We anticipate up to 20 of the presentations will be submitted for publication in the Canadian Journal of Fisheries and Aquatic Sciences and will be preparing a summary paper of the science highlights.

Workshop on Stock Structure of Atlantic Cod in the Gulf of Maine Region

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

John Annala- GMRI

NOAA Program Manager – Russell Brown, NMFS NEFSC

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

A workshop on stock structure of Atlantic cod in the Gulf of Maine region was held on June 12 – 14, 2012 in Portsmouth, NH. The workshop is viewed as the first phase of a three-phase process.

The purpose of this workshop was as follows:

1. Review existing data, information, and results of analyses relevant to the stock structure of cod in the Scotian Shelf, Georges Bank, Gulf of Maine, and southern New England regions.
2. Based on these reviews, make recommendations on the most likely biological stock structure in these regions (including sub-stock structure if warranted), considering the current management units as a null hypothesis and other stock structure scenarios as alternative hypotheses.
3. Make recommendations for any future research required to evaluate the most likely biological stock structure developed in 2 above.
4. Provide advice on the alignment (or mis-alignment) of the current management unit boundaries vis-à-vis the most likely biological stock structure identified in 2 above.

Objectives:

1. Summarize the potential implications of defining inappropriate stock boundaries and ignoring sub-stock structure within stock units, as well as the potential advantages and disadvantages for both science and management of revising the status quo units.
2. Review tagging, genetic, life history, and other data on the current management units to estimate rates of mixing and, conversely, independence. This synthesis should include the Gulf of Maine, George's Bank, the Mid-Atlantic Bight, and the Scotian Shelf.
3. Synthesize those same tagging, genetic, life history, and other data to determine whether one or more alternative spatial configurations are more likely than the status quo.
4. Characterize the mechanisms that drive spatial finer scale dynamics of cod populations and the fishing fleet, including habitat status and distribution, behavioral diversity, oceanography, predator-prey dynamics, and other factors.
5. Evaluate key stock structure assumptions of assessment models, essentially testing the "null hypothesis" of the status quo stock configuration.
6. Provide advice on spatially-explicit management goals and strategies based on the synthesis of processes driving finer scale patterns, whether a new spatial configuration is adopted or not.

7. Provide advice on what information and data are required to analyze the advantages and disadvantages of either maintaining the status quo or adopting different spatial configurations through simulation modeling.
8. Determine the data gaps for 1 – 7 above and identify the future work required to address these gaps.

ACCOMPLISHMENTS

The workshop reached the following conclusions and recommendations:

Overall conclusions and recommendations on most likely stock structure and appropriate management units

The workshop agreed on the following statements on broad-scale stock structure:

1. Conceptualizing the most likely biological stock structure is essential for the next steps of evaluating alternative management units and whether they are more likely to achieve fishery objectives.
2. Any management unit boundary will be a simplification of a more complex ecosystem, but if the simplification sufficiently reflects reality, we can meet our fishery and conservation objectives (optimum yield, preventing overfishing, etc.).
3. All information from U.S. waters indicates that there are three genetic stocks: 1) Offshore - Eastern Georges Bank (with some connectivity with the Scotian Shelf); 2) Inshore - Northern, Spring-Spawning Complex; and 3) Inshore – Southern, Winter-Spawning Complex.
4. Information from more traditional stock identification information generally supports the genetic perspective (e.g., tagging, growth, larval dispersal).
5. Cod in the eastern Gulf of Maine appear to be distinct from other groups.

The Workshop agreed on the following statements on fine-scale stock structure:

1. Larval retention and multi-year fidelity to local spawning sites suggest fine-scale meta-population structure.
2. Some traditional spawning groups were depleted, and have not been re-colonized by more productive groups.
3. Depletion of historical spawning groups is most apparent in the eastern Gulf of Maine, the Mid-Atlantic, the 'Plymouth Grounds,' and recently Nantucket Shoals.

The Workshop agreed that all genetic information available from U.S. waters is not entirely congruent with current management unit boundaries. Many of the workshop participants felt that there was compelling evidence that the current management units need to be revised. However, the workshop did not reach any conclusions on what the most appropriate management units might be. This will require further data analysis and modeling in order to complete Phase I of the SSC recommended process.

Identify gaps in the data and analyses and recommend actions to address them

The gaps in the data and analyses were separated into two groups based on the timeframe in which they could be addressed – (1) short term (next 6 to 12 months); and (2) longer term (greater than 12 months).

Short term

1. Identify, collect, and analyse any further available key data and information required to complete Phase I and move to Phase II. Such data and analyses could include, but not be limited to, the following and should include data from the Scotian shelf and other appropriate Canadian waters:
    a. Any further existing genetic data
    b. Additional tagging data and estimation of movement rates from entire dataset
    c. Life history parameters
    d. Further consideration of larval dispersal from key spawning grounds, e.g. Georges Bank
    e. Further evaluation of the advantages and disadvantages of alternative management unit scenarios on stock status and yields from the cod stocks in the region (Gulf of Maine, Georges Bank, Mid-Atlantic bight, and Scotian Shelf).

Longer term

1. Stock composition analysis in Gulf of Maine fishery (e.g., using otolith cores)
2. Collection and analysis of further genetic data from key areas, e.g. Georges Bank, eastern Gulf of Maine (including archaeological data), and perhaps Canadian waters.

Recommended next steps

The workshop did not explicitly address and propose the next steps in the process. The Workshop Steering Committee subsequently discussed the next steps required to complete Phase I and lead up to Phase II of the recommended SSC process.

The Steering Committee recommends that an inclusive but focused Working Group meeting be held involving a small group of Canadian and US scientists to consider the results of the Workshop. This Working Group should be provided the short-term data and analyses identified as missing by the workshop. Using that information, as well as the conclusions from the workshop, the Working Group should determine the most appropriate representations of biological stock structure to complete Phase I of the process. The results from this Working Group meeting should be evaluated through an independent peer-review process. These peer-reviewed results should be used in Phase II of the process to make recommendations on the most appropriate management units.

HIGHLIGHTS

The workshop achieved the following:

1. Reviewed existing data, information, and results of analyses relevant to the stock structure of cod in the Scotian Shelf, Georges Bank, Gulf of Maine, and southern New England regions.
2. Made recommendations on the most likely broad-scale and fine-scale biological stock structure in these regions.

3. Identified gaps in the data and analyses and recommended actions to address them.
4. Provided initial views on the alignment (or mis-alignment) of the current management unit boundaries vis-à-vis the most likely biological stock structure.

SOCIETAL BENEFITS

The 2011 stock assessment for Gulf of Maine cod painted a much gloomier picture of stock status and indicated that the stock was overfished and overfishing was occurring triggering a substantial reduction in the cod quota in 2013. One of the major uncertainties identified in the 2011 stock assessment was the assumed stock structure for cod off the northeastern US and Atlantic Canada. One of the possible outcomes of using an incorrect stock structure in the assessment is that inappropriate quotas would be set thereby increasing the risk to both the stock and the industry.

EDUCATION AND OUTREACH ACTIVITIES

This workshop was open to all fisheries stakeholders and included an industry panel that provided their views on the issues discussed to the other workshop participants.

Electronic Vessel Trip Reports

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012-March 31, 2013

Steve Eayrs, GMRI

NOAA Program Manager –Joan Palmer, NMFS NEFSC

Related NOAA Goal Plan: Goal 1: Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme: – Ecosystem Management

PROJECT OVERVIEW

Our overall objective for this year was to continue to facilitate the uptake and use of electronic logbook software by fishermen and their transmission of electronic vessel trip reports (eVTRs). Following the 2011-2012 fishing year, in which 13 vessels were equipped with equipment to report VTRs electronically (and of which only 4 were actually using with any frequency or regularity) we have now expanded to having 32 vessels equipped of which 23 are currently active on a regular basis. While each fisherman generally has some initial complaints about the system, for the most part every active user quickly becomes comfortable with sending reports electronically after a brief period to gain system familiarity.

Of the 32 active vessels, 18 are from the Port Clyde Coastal Community Sector, 8 are from Northeast Fishery Sector (NEFS) 11, 2 are from NEFS 10, 2 are from the Northeast Coastal Communities Sector (NCCS), 1 is from NEFS 3, and 1 is from NEFS 12. Currently the largest obstacle to eVTR adoption is a lack of interest, preparedness, or desire to transmit VTR data electronically or to use the currently available software options. FLDRS, the eVTR software developed and released at no cost by the New England Fisheries Science Center (NEFSC), has been selected by the Port Clyde Sector, the Cape Cod Hook Sector, and willing participants within the NCCS sector as a usable program. All thirteen remaining sectors have been recommended different software and are either still considering its use or awaiting notification it is available in a regulatory-compliant version. This delay has led fishermen from several NEFS sectors to become frustrated, respond by independently deciding to adopt FLDRS, and seek our assistance to get them started.

Many fishermen, however, are still unwilling to commit to this project and we are therefore limited in our ability to provide hardware and software and training. While not all sector managers have explicitly stated that their fishermen cannot report electronically using FLDRS, they are not supportive of our efforts to provide this option to fishermen, particularly until they decide on their preferred software option. There are signs however that this is beginning to change. Specifically, a new software option is expected to be introduced shortly and used by one of the outstanding Sectors. Preliminary discussions with this sector suggest that GMRI will be formally requested to provide eVTR technical support to their fishermen, numbering just over 40 individuals. As a result of these delays the uptake of eVTR options has been slower than hoped or anticipated, however we are now starting to see greater movement and momentum.

ACCOMPLISHMENTS

We have set up 32 groundfishing vessels (up from 13 last year) with new eVTR software, of which 23 are currently reporting electronically using FLDRS (up from 4 last year). These vessels have collectively sent over 500 reports duirng the past year. As the start of the new fishing season approaches we are anticipating new active eVTR users.

Given the vagaries of the fishing industry, including arranging times to meet with captains, accessing and outfitting a vessel with eVTR software and hardware has been and remains a challenge. A good bit of time is spent just building and maintaining a relationship with captains and their respective sector manager, promoting the merits of eVTR and addressing their concerns prior to them agreeing on an installation. Arranging convenient times to complete an installation also remains a challenge.

We have completed numerous one-on-one meetings with fishermen and sector managers to assess their interest in reporting electronically and demonstrating how the software works, how they will be able to access the data, and what they can do with the data. We've highlighted to fishermen the benefits in getting timely information to sector managers and the NMFS, including having information that is largely error free and comprehensible. As particular issues have arisen from fishermen or sector managers we have worked closely with them and the NMFS to ensure that the issue was fully resolved.

Once a fisherman has agreed to an installation we arrange a time to down to the boat and install a laptop (if required), necessary software, and provide him one-on-one training in the use and operation of the laptop and software. We also provide detailed training guides including screenshots of the software during all stages of data entry. If a fisherman requires further support, has a problem, or the software needs an update/modification, we arrange to meet him at the dock and assist with those tasks. In the first year following an installation we have typically found it necessary to visit fishermen on their boats between 2 and 5 times, not including visits to update software.

HIGHLIGHTS

- Trained 32 fishermen in the use and operation of electronic logbook software to transmit logbook data electronically and outfitted their vessels with appropriate hardware and software
- Established GMRI as the point of contact with fishermen/sector managers/NMFS managers regarding eVTR issues and operation
- Maintained all 23 currently active boats using the current version of the software

SOCIETAL BENEFITS

This research is providing captains an opportunity to transmit their vessel trip report data electronically more simply and easily, at less cost and sooner compared to paper trip reports, thus they are able to spend more time focusing on fishing activity, boat operations, and safety.

- Following the installation of necessary hardware and software, and appropriate training, the transmission of eVTR data is more accurate and appropriate, and therefore lends itself to

timely and responsive analysis and utilization by Sector managers, NEFSC staff, and others with access to these data

EDUCATION AND OUTREACH ACTIVITIES

In early 2013 project staff from GMRI provided an oral presentation on the eVTR project at an annual meeting for fishermen in the Port Clyde Community Groundfish Sector, in Rockland, ME.

- In late 2012 Project staff from GMRI provided a poster presentation on the eVTR project at The Innovation in Fisheries Workshop in Portland, ME.
- Produced a GMRI project flyer that included a description of the eVTR project and contact details at the New Bedford Working Waterfront Festival (2012), the Innovation in fisheries workshop in Portland Maine (2012), and the Maine Fishermen's forum (2013).

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

GMRI project flyer promoting research project opportunities for the fishing industry including participation in the eVTR project was distributed.

Social Capital in the NE Ground Fish Industry

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012-March 31, 2013

Jessica Joyce, Dan Holland GMRI

NOAA Program Manager –Patricia Pinto da Silva- Social Science Branch NEFSC

Related NOAA Goal Plan: Goal 1: Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme: – Ecosystem Management

PROJECT OVERVIEW

The objective of this project is to review and compare stated goals and objectives of key federally managed fisheries around the US and in particular explore the social and economic goals embedded in each of their respective fishery management plans. Key fisheries were identified initially as those that involved the most participants and/or the greatest landing values. Selected fisheries were then cross checked with regional key informants to confirm that these would serve as relevant indicators of a region's goals and objectives. Key informants were identified by a snowball sampling method that originated from our own project team and included council staff, NOAA social scientists at each of the regional science centers, and other experts that might have knowledge about fisheries management plans within each region. Questions were asked that identified key fisheries as a fishery that was important to the region either socially, economically, or culturally- historically, while important amendments were any amendment that the expert thought was relevant or had a significant impact on the management of the fishery. For ease of access and interpretation the amendments included were limited to 3-7 for each fishery and were amendments that have been finally approved by the respective management councils. Regionally key fisheries ranged between two and three in most regions, but only included one shallow reef fish in the Caribbean.

Once these fisheries and their amendments were identified, the goals and objectives were identified in the text. Each goal and objective was then uploaded and coded using Atlas Ti, a qualitative data analysis software package. Each goal and objective was coded under four major categories: Biological, Economic, Social, and Other. Biological and economic were initially straightforward. 'Biological' included any element that discussed mortality, recruitment, or maintenance of the species, while 'Economic' included any element that discussed yield, capacity, or effort. 'Social' was more complex and included elements that discussed participants, while 'Other' included any element that discussed regulations or could not be appropriately binned in the other three categories. Finally hierarchical trees were created to illustrate the relationship between regions, plans and outcomes.

Note that the project described in this report for the period April 1, 2012 - March 30, 2013 does vary from the original Social Capital Survey project led by Dan Holland. Dan Holland resigned from GMRI almost two years ago, and the remaining project funds were utilized to conduct this separate, but related analysis of social and economic goals and objectives within regional fishery management plans.

ACCOMPLISHMENTS

- Analyzed goals and objectives from multiple amendments to 17 FMPs across all eight regional fishery management councils.

- Each goal and objective was coded into one of the four main categories, and then further refined to create sub-categories through an iterative process.
- Twenty-one hierarchical trees were created to illustrate the relationship between regions, plans and outcomes (see Figure 1 for an example of the New England Regional tree).

- Trends were analyzed within and between regional fishery management councils.

- A literature review was conducted to compare the project results with other similar studies, and to inform the project report and poster.

- A project poster has been drafted.

HIGHLIGHTS

- We mapped the goals and objectives for key fisheries in each of the eight fisheries management regions.

- We will be presenting the analysis in poster format at the 'Managing our Nations Fisheries' conference and the annual meeting of the Society for Conservation Biology. We hope to get feedback on how the analysis would be useful to each of the regional fisheries management councils, and will integrate this feedback into the report.

- The intent of this project is to help the councils consider how to improve their approach to defining goals and objectives so they are clear, salient, and more likely to be achieved.

- Next steps include drafting a paper and a manuscript.

SOCIETAL BENEFITS

The impetus for this project stems from a recommendation in the '*The Review of the New England Fishery Management Process*' report (Touchstone or Pate, April 2011). This project begins to address one recommendation to design a cost-effective performance management system to track the progress of decisions and capture lessons learned and best practices. Through this project, which NMFS plans to advance a nationwide process for defining and evaluating FMP goals and objectives, the public will benefit from a step towards more effective and consistent fisheries management.

EDUCATION AND OUTREACH ACTIVITIES

A poster will be presented at the 'Managing Our Nations Fisheries' Conference in May 2013 and the Society for Conservation Biology annual meeting in July 2013.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

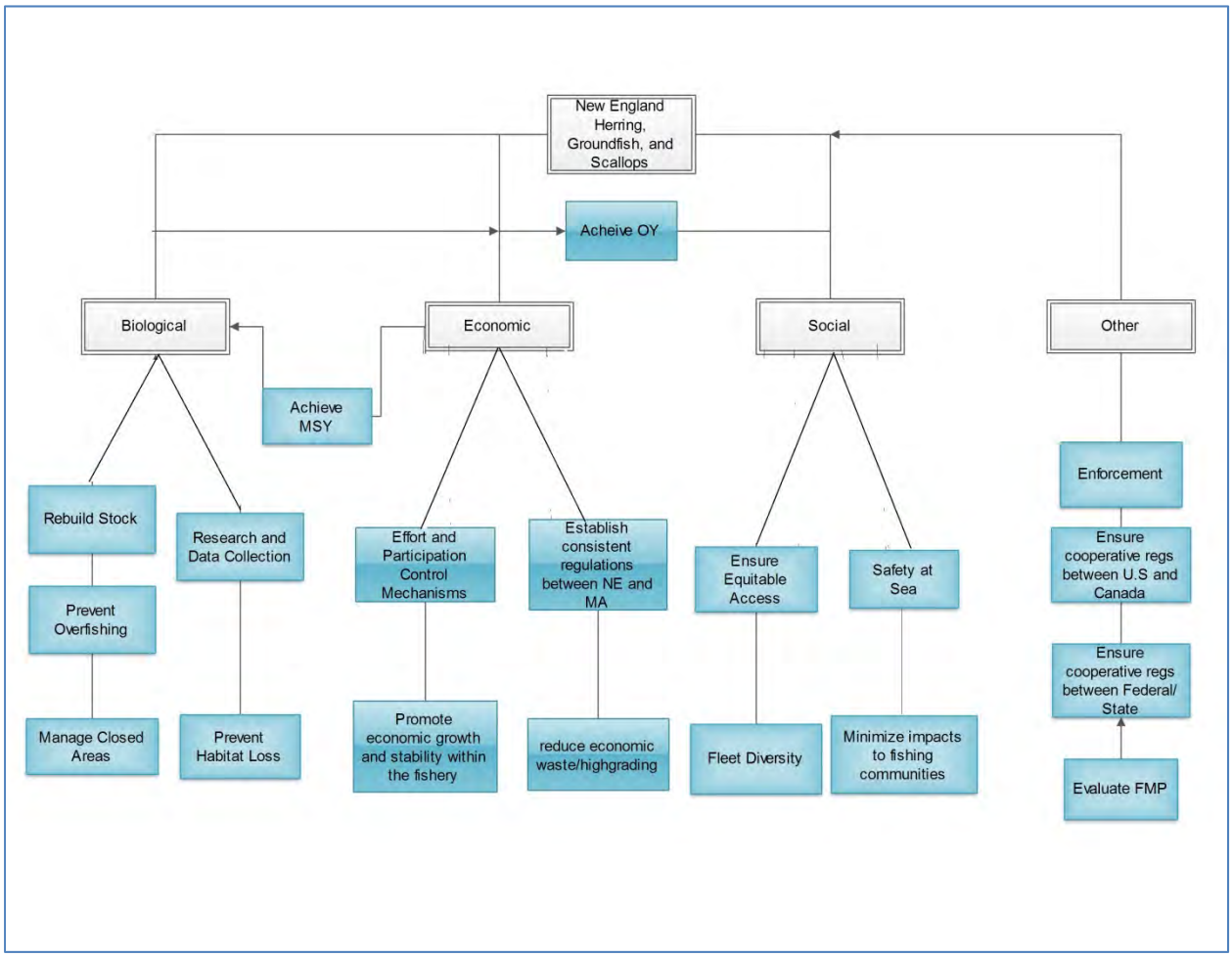


Figure 1. Hierarchical tree depicting the combined goals and objectives of three New England fishery management plans: Herring, Groundfish, and Scallops.

Vessel Safety and Fishery Management

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012-March 31, 2013

Di Jin- WHOI

NOAA Program Manager - Chad Demarest NMFS/NEFSC

Related NOAA Goal Plan Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme: – Ecosystem Management

PROJECT OVERVIEW

The objectives of the project are to improve our understanding of the determinants of fishing vessel accidents and to improve safety in commercial fishing. This is a one-year project (August 1, 2011 to July 31, 2012), and we have completed all major research tasks and a final project report.

ACCOMPLISHMENTS

The study consists of two main parts. The first part of the study examined the determinants of fishing vessel damage severity and crew injury severity. Detailed data of individual fishing vessel accidents for the 8-year time period 2001-2008 that were investigated by the U.S. Coast Guard were used to estimate the two accident severity equations. The equations were estimated utilizing the ordered probit model.

The estimation results suggest that fishing vessel damage severity is positively associated with several types of accidents (e.g., loss of stability, abandonment, and sinking), daytime wind speed, vessel age, and distance to shore. Vessel damage severity is negatively associated with daytime sea level pressure and vessel size. If the accident vessel is abandoned, the probability of a total loss increases by 0.6912.

Crew injury severity is positively associated with loss of stability and sinking. If a fishing vessel lost its stability resulting from an accident, its marginal probability of incurring fatal injury is higher by 0.3191. The injury severity is negatively related to material failure and summer season. Unlike in the case of vessel damages, the direct effects of weather variables (wind and sea level pressure) on crew injury severity are not statistically significant.

The second part of the study involves a survey of fishing vessel safety and risk taking behaviors. Approximately 100 commercial fishermen were administered the survey during two safety training sessions in New Bedford, MA to assess their level of safety preparedness, risk preferences, and the impact of fisheries regulations on safety behaviors.

Preliminary results of the survey reveal that more than half of the surveyed fishermen had never participated in any organized marine-related safety training. The fishermen displayed risk-loving personalities and, not surprisingly, tended to trivialize their occupational risks. The fishermen consistently undervalued their occupational risks and rated their own fishing activities as less risky than the occupation as a whole. This is despite the fact that nearly half reported to have been in a fishing-related accident and/or were injured on the job.

The survey provided strong evidence to suggest that fishermen engage in more risky behavior as a result of increasing fisheries regulations, such as fishing in inclement weather, continuing to work despite crew fatigue, and extending the normal length of a fishing trip. A quarter of the surveyed fishermen also blamed the financial pressures from regulations as a reason for not maintaining safety equipment on their vessels.

HIGHLIGHTS

- Fishing vessel damage severity is positively associated with several tapes of accidents (e.g., loss of stability, abandonment, and sinking), daytime wind speed, vessel age, and distance to shore.

- Crew injury severity is positively associated with loss of vessel stability, sinking, sea level pressure, and distance to shore.

- The fishermen displayed risk-loving personalities and tended to trivialize their occupational risks.

- Fishermen engage in more risky behavior as a result of increasing fisheries regulations, such as fishing in inclement weather, continuing to work despite crew fatigue, and extending the normal length of a fishing trip.

SOCIETAL BENEFITS

Commercial fishing is a dangerous occupation, and accidents are bound to happen given the operational environment within which fishing is conducted. NOAA Fisheries consider vessel safety as a key performance measure, yet relatively little research has been conducted to evaluate changes in accident rates or risk taking. Results of the study help managers to understand the determinants of fishing vessel accidents and to improve regulations affecting safety in commercial fishing.

EDUCATION AND OUTREACH ACTIVITIES

- Approximately 100 commercial fishermen were administered a survey during two safety training sessions in New Bedford, MA to assess their level of safety preparedness, risk preferences, and the impact of fisheries regulations on safety behaviors.

- There is a large deficit in marine-related safety training in New England commercial fishermen. More widespread safety training in the industry is necessary.

- Fishermen tend to trivialize their occupational risks. For these reasons, they may be unlikely to participate in safety-related training voluntarily, and mandatory safety education may be necessary to ensure participation.

- Regulators should consider the unintended consequences of fisheries regulations on safety behaviors, and develop programs that account for the indirect impact of these regulations on overall safety in the industry.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Commercial fishing safety: trainings on immersion suits and life rafts in New Bedford.

An Experimental Investigation of the Impact of Ocean Acidification on the Early Life Stages of Surfclams, and the Interactive Effects of Feeding

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 -March 31, 2013

Daniel McCorkle and Anne Cohen-WHOI

NOAA Program Manager – James Widman NMFS/NEFSC

Related NOAA Goal Plan Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme: – Ecosystem Management

PROJECT OVERVIEW

We proposed to work with colleagues at the NMFS laboratory in Milford, CT (Lisa Milke and James Widman) to carry out two ocean acidification experiments on the Atlantic surfclam, *Spisula solidissima*. These included a six-day experiment to investigate the influence of food availability on the impact of elevated pCO_2 on larval development and initial calcification, and a short experiment to investigate OA impacts on surfclam fertilization success and gamete viability. This work was designed to build on initial experiments carried out in the summer of 2011, and to combine Widman's and Milke's expertise in the physiology and development of *S. solidissima* with Cohen's and McCorkle's ocean acidification and biomineralization expertise.

ACCOMPLISHMENTS

We carried out both of the proposed ocean acidification experiments, using the culturing facilities and CO_2 control instruments at the WHOI Environmental Systems Laboratory:

- Experiment 1 (11 June – 17 June 2012) pCO_2 X feeding rate

  Target pCO_2 levels were ambient (~400 ppmv), 1200 ppmv, and 2200 ppmv)

- Feeding rates were 400 cell/mL-dy and 40,000 cell/mL-dy of *Isochrysus galbana*, added by daily batch addition
- Experiment 2 (30 July – 1 August) fertilization success / viability, pCO_2 only (unfed)

  Target pCO_2 levels were ambient (~400 ppmv), 1200 ppmv, and 2200 ppmv)

Results.

Water chemistry.

The culture water alkalinity levels for the high-food treatments were clearly elevated relative to the low-food treatments (Figure 1a), suggesting an alkalinity artifact due to the *T-Isochrysis* additions. We have not observed this effect in previous larval shellfish culture experiments, including our 2011 surf clam experiments. Despite this excess alkalinity in the high-food treatments, the pH (total scale) and aragonite saturation state values were similar in both the high-food and low-food treatments, and showed the expected trends with respect to pCO_2 level (Figures 1b and 1c).

Survival.

There was no significant impact of either pCO_2 level or feeding rate on larval survival at day 3 or day 6 (Figure 2a). This result stands in contrast to the results of our 2011 surfclam experiments, in which survival was negatively correlated with pCO_2 level at days 3, 9, and 15 (Figure 2b. No 2011 day 6 survival data are available.)

Shell length.

On day 3, there was no significant size difference between low-food and high-food treatments (Figure 3). This is not unexpected, as the larvae rely on maternal nutrition through the first ~ 1 to 3 days. Within the low-food group on day 3, the average lengths of specimens from the two elevated pCO_2 treatments were smaller than the ambient (control) treatment, but were not significantly different from each other. Within the high-food group, none of the three pCO_2 treatments were significantly different in average size.

On day 6, the average sizes of specimens from all three high-food treatments were all significantly larger than the averages of the low-food treatments (Figure 4). None of the three pCO_2 treatments within the day 6 low-food group were significantly larger than the other two treatments. In the day 6 high-food group, the ambient pCO_2 (control) specimens were on average significantly larger than the specimens in the 1200 ppmv treatment, but the average size of the specimens in the 2200 ppmv treatment was not significantly different from either the ambient or 1200 ppmv treatments.

The absence of a pCO_2 effect in the low-food group on day 6 was unexpected – we had hypothesized that pCO_2 effects would be more pronounced in the cultures experiencing nutritional stress (just 400 cell/mL-dy feeding rate), but this was not observed. For comparison, in our 2011 surfclam experiments (with a feeding rate of 20-30,000 cells/mL-dy) we observed a significant pCO_2 effect on shell size on day 3, which persisted to day 6. The different responses in the two years may reflect genetic differences in pCO_2 tolerance of the parent surfclams in the two years, differences in maternal nutrition and egg quality, or some other factor.

Shell mass.

The specimens which had been measured at NMFS- Milford were brought to WHOI, soaked in ethanol to remove seawater, and oven-dried for at least 12 hours prior to weighing. Fifty individual shells were counted and weighed together, to provide an average mass of 50 shells. To date, only a subset of the replicate samples have been weighed.

On day 3 there were no obvious differences in shell mass as a function of either feeding rate or pCO_2 level (Figure 5). On day 6 there was a clear feeding rate effect – high-food shells were heavier than low-food shells. Again, however, there was no systematic difference in shell mass as a function of pCO_2 level at either feeding rate. Although our 2011 experiments suggested that shell mass decreases as pCO_2 increases, we have more confidence in the 2012 results, which incorporated improvements in sample processing and microbalance procedures. Alternatively, this year-to-year difference in shell mass response may be real, and reflect the factors noted above, with respect to shell length.

Fertilization.

For the fertilization experiment, adults were held at ambient pCO_2 levels in tanks at the Marine Biological Laboratory in Woods Hole, and were induced to spawn by raising the temperature.

Eggs and sperm from multiple parents were pooled (x females, y males), and the eggs and sperm were mixed in seawater that had been pre-equilibrated to the three target pCO_2 levels, so that fertilization and subsequent development took place at pCO_2 levels of approximately 400, 1200, and 2200 ppmv. The fertilized eggs were then used to inoculate 1 L culture cups of pre-equilibrated seawater, and were maintained at those pCO_2 levels for 48 hours.

No significant difference in viability was observed.

HIGHLIGHTS

Our 2012 surfclam experiments suggest that:

- Elevated pCO_2 does not decrease the 3-day or 6-day survival rate of larval surfclams. This differs from the survival data results of our 2011 experiments, which suggested substantial decreases in survival as a function of elevated pCO_2.

- Elevated pCO_2 resulted in a small but significant decrease in shell length at day 3 in low-food cultures, but did not have a significant impact on shell length at day 3 in high-food cultures. pCO_2 impacts on shell length at day 6 were not significant in the low-food cultures, and were significant at only one of the two elevated pCO_2 levels in the day 6 high-food cultures.

- Shell mass does not appear to be strongly impacted by elevated pCO_2 at either low or high feeding rates.

SOCIETAL BENEFITS

To date, the oceans have absorbed about 25% of the CO_2 emitted by fossil fuel burning and other anthropogenic activities, leading to a decrease in seawater pH and carbonate ion concentration. These changes may make it harder for molluscs to make their shells; larval shell formation may be particularly vulnerable to increasing CO_2, but high food availability may help larvae cope with the stress of high pCO_2. Our results help to document and quantify these ocean acidification impacts and possible mitigating factors, with the goal of informing management practices.

EDUCATION AND OUTREACH ACTIVITIES

These results were presented at the 2013 World Aquaculture Society / National Shellfish Association meeting in Nashville TN, and were included in presentations by McCorkle and by Cohen at the 2012 Northeast Aquaculture Conference and Exposition (NACE) meeting in Groton CT.

McCorkle and Cohen hosted undergraduate Barbara Ramon (California State University – Dominguez Hills) as a WHOI Minority Fellow during summer 2012. Barbara took part in all aspects of the surfclam experiments, and in recognition of her essential role in the success of these experiments was a co-author on the Widman et al. and McCorkle et al. abstracts.

FIGURES

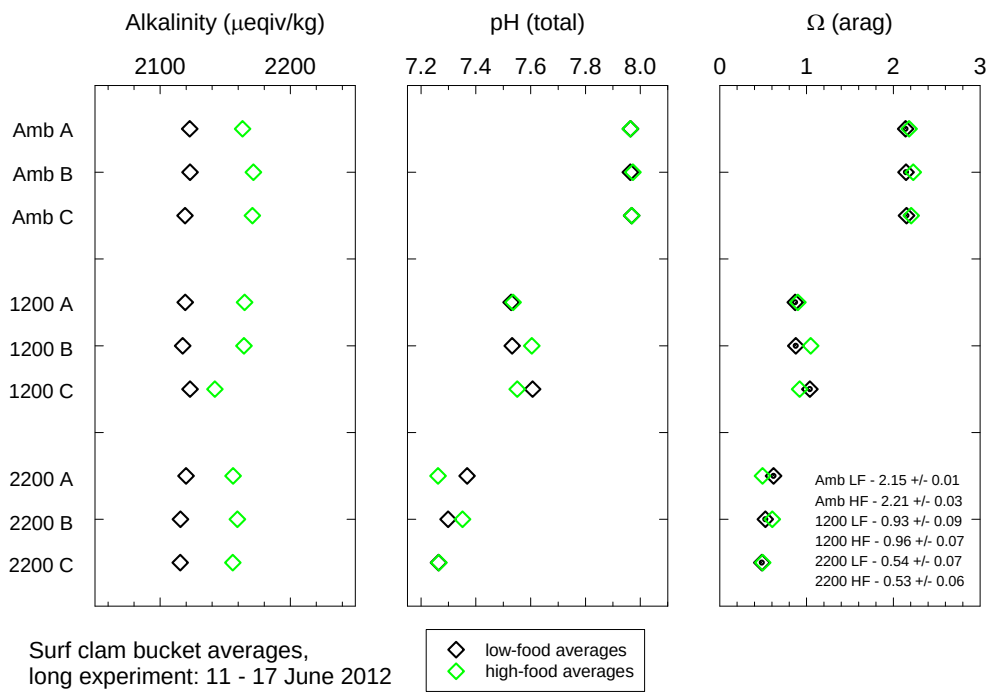


Figure 1. Water chemistry from the 2012 surfclam experiment.

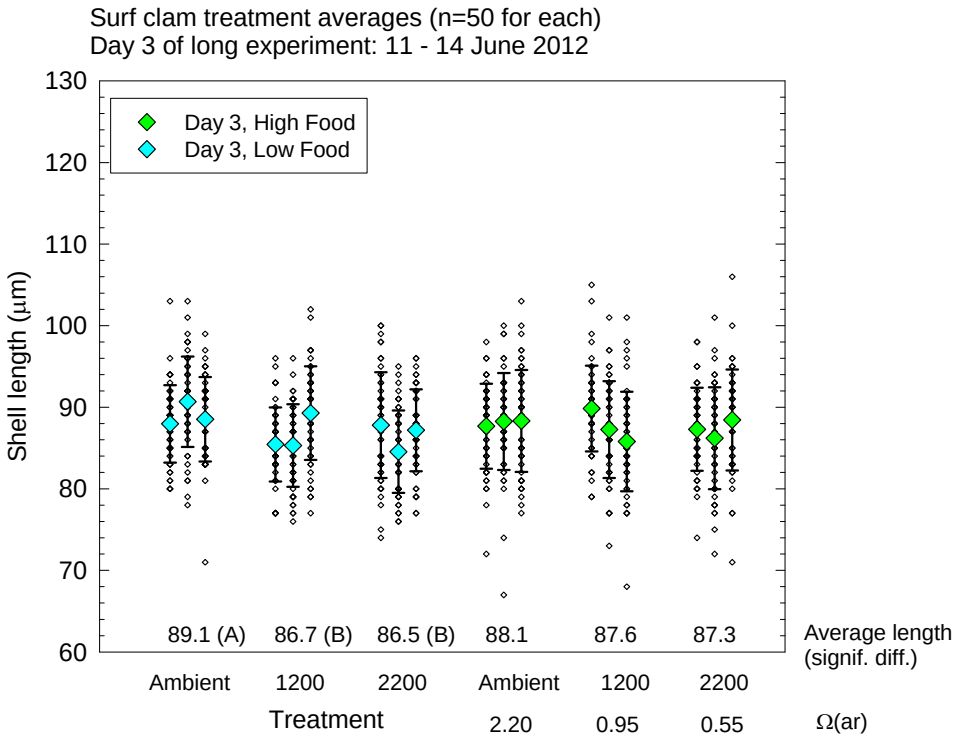


Figure 3 – Shell length (day 3) from 3 replicate buckets at each of 3 pCO_2 levels, for low and high feeding rates. Significant differences between treatments are indicated by capital letters.

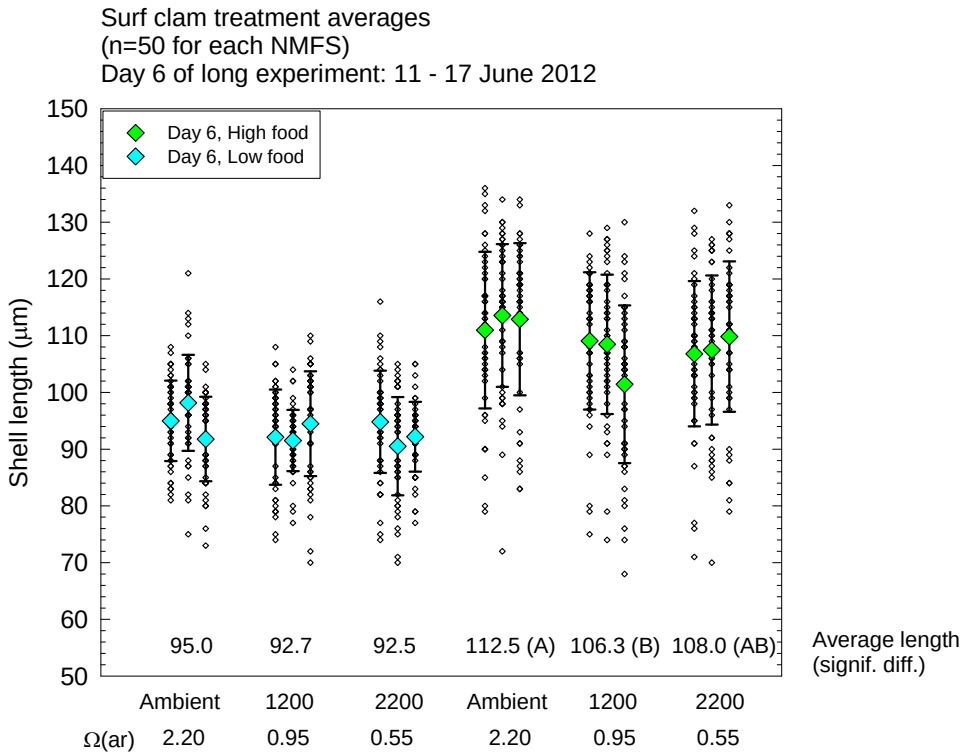


Figure 4 – Day 6 shell lengths by CO_2 level and feeding rate..

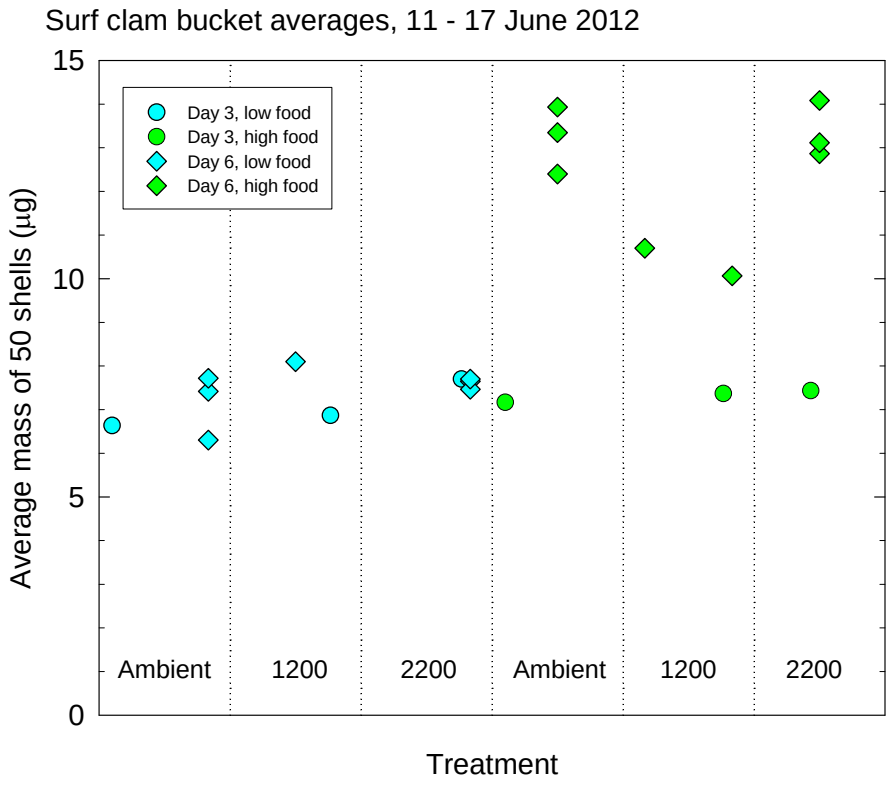


Figure 5. Shell mass (average mass of 50 specimens) by CO_2 level and feeding rate, for day 3 (circles) and day 6 (diamonds).

Evolution of Groundfish Sectors Business Model

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Jen Sun - GMRI

NOAA Program Manager – Andrew Kitts NMFS NEFSC

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems
CINAR Theme – Ecosystem Management

PROJECT OVERVIEW

The overall goal of this project is to provide necessary market information, quota trading analysis, and business plans that will enhance Groundfish Sector viability and profitability, both for sector members and for sectors as effective organizations and their dependent communities.

Specific objectives include:

- Evaluating how the membership profile, landings and leasing history, and ACLs reductions would affect a sector's viability and providing information to identify risk management and income enhancement options for each sector. In addition, since at-sea monitoring (ASM) costs are closely associated with sector viability, GMRI was given permission to use the DMIS dataset to work with New England Fishery Management Council (NEFMC) Groundfish Plan Development Team (PDT) for the ASM analysis; however, no funding from this project was utilized for this analysis.
- Examining how sensitive the monthly ex-vessel prices by market and species are to the quantity of landings and what happens when those landings are redistributed.
- Working with sectors to identify opportunities for increasing revenue from landings through changes in fishing operations to increase allocation utilization, analyze the efficiency of ACE trading in conjunction with the seasonality of landings and market prices, quality handling, and other methods.

ACCOMPLISHMENTS

- The data in this analysis were compiled from the individual trip level DMIS dataset and ACE leasing data from SIMM from FY 2007-2011, which were acquired by PI Sun, through a confidential data access agreement with the Social Sciences Branch of the Northeast Fisheries Science Center for evaluating the viability of sectors as businesses and for analyzing the monthly groundfish and non-groundfish catches by stock/species of all 16 active groundfish sectors.
- More than a dozen meetings were scheduled with 7 out of the 16 active sectors managers and their board members, who participated in our first phases project and they received an in-depth evaluating of their cost-revenue profiles to identify risk management and income enhancement options for each sector.

HIGHLIGHTS

- The output from this analysis included generating a set of graphs required by the phase 1 project for each sector that displayed sector groundfish (such as shown in Figure 1) and non-groundfish landings volume and value from FY 2007-2011, to be able to compare catch under the days-at-sea (DAS) system with catch under sectors.

- Historical daily price and landings volatility of the ex-vessel market for each groundfish and non-groundfish species by ports from 2007 to 2011, shown in Figure 2, are examined to show how sensitive the monthly ex-vessel prices by market and species are to the quantity of landings and what happens when those landings are redistributed and prices and landings by species in each region/ports.

- Markets of cod fishery (shown in Figure 3) by market grade and by ports is further investigated to discuss how will branding and marketing to increase the landings value while the 2013 catch limits for Gulf of Maine and Georges Bank cod are 78 percent and 61 percent lower than the 2012 catch limits, respectively.

- Presented the market findings at a meeting with the majority of the sector managers and several members from their respective board of directors. These results will soon be available on GMRI's website, after all data points are thoroughly checked for confidentiality.

SOCIETAL BENEFITS

The groundfish fishery in New England is in the midst of a transition to this new sector management structure which induces cooperation among harvesters on the shared multispecies stocks. This project is specifically trying to provide analysis of the seasonal landing patterns and market fluctuations for locally-caught fresh groundfish in an effort to provide individual sector-member a tool of business planning and maximized the utilization of their allocation by leasing in/out ACE.

EDUCATION AND OUTREACH ACTIVITIES

- Invited to present "Analysis of Landings/Discards-Proportional Allocation Scheme for the At-Sea Monitoring Program of the Groundfish Fishery in New England" in various NEFMC Groundfish PDT Meetings from July to October 2012.
- Invited to present "Economics of the Groundfish Industry in New England: the Historical Price and Landings Volatility of the Ex-vessel Market by Ports" at Sector Manager Meeting, where all 16 sector managers and their board members were all invited, on March 20, 2013 at Wylie Inn and Conference Center, which was convened by Gulf of Maine Research Institute and sponsored by the Gordon and Betty Moore Foundation.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

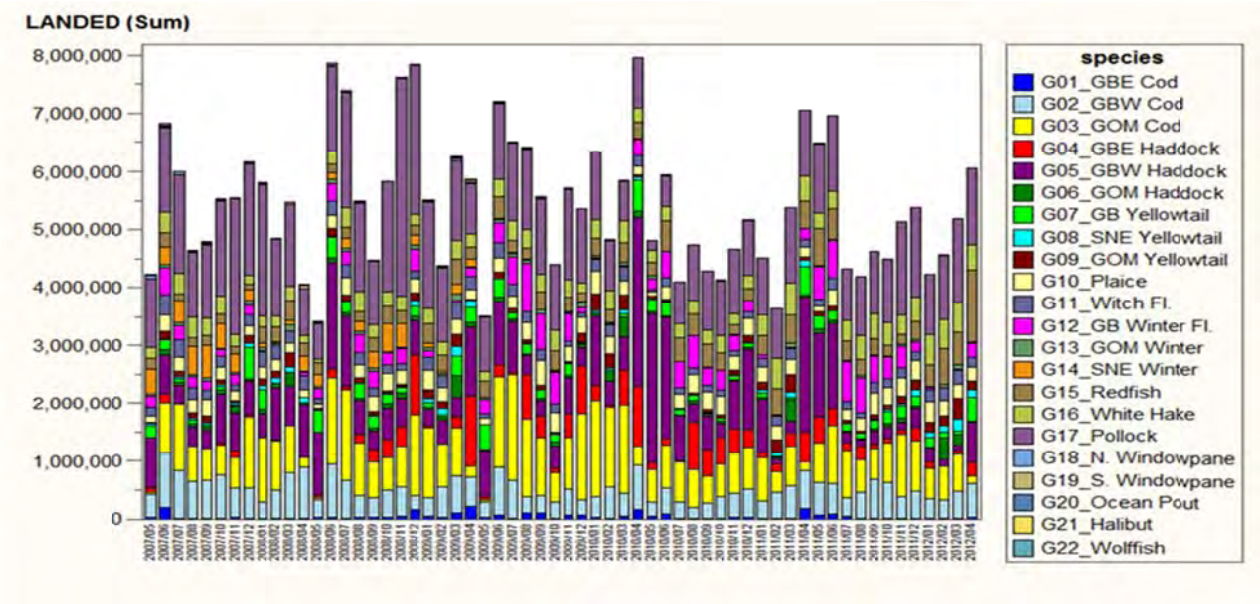


Figure 1 Monthly Landings by Stock/Species of the New England Groundfish Fishery

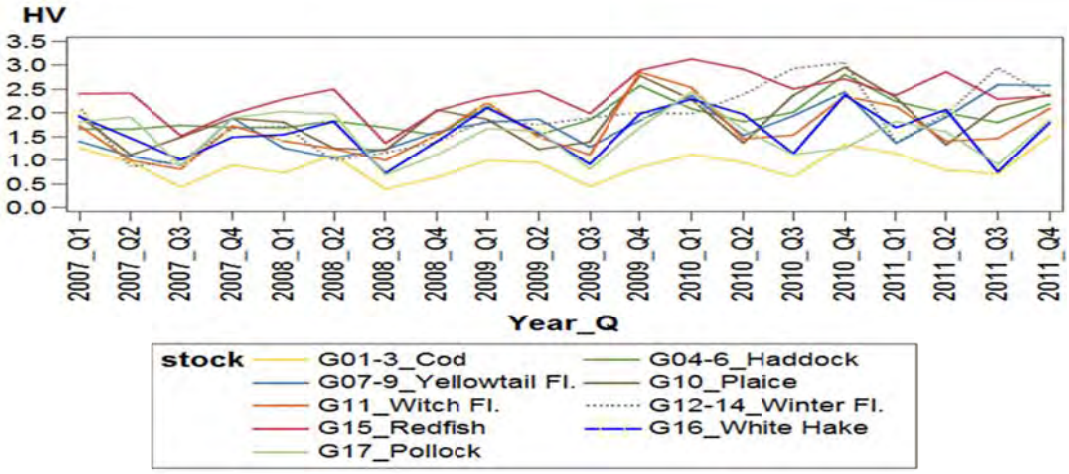


Figure 2 Historical Daily Price Volatility of the Exvessel Market for Each Groundfish Species

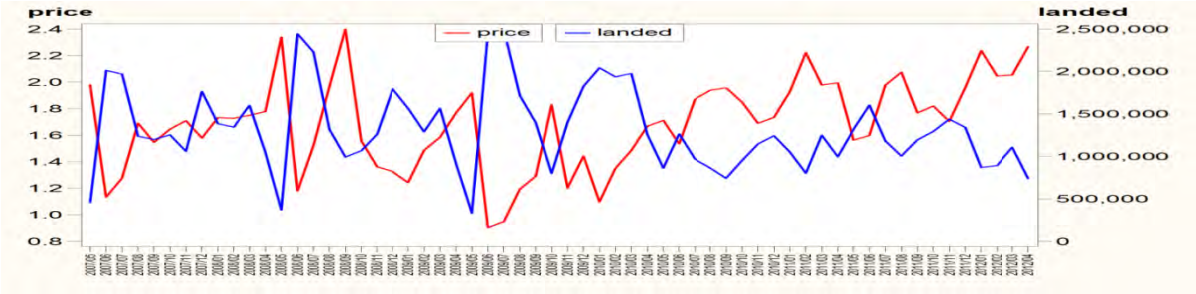


Figure 3 Landings and Prices of Cod in New England by Groundfish Permit Holders

THEME IV. PROTECTION AND RESTORATION OF RESOURCES

Real Time Assessment of Baleen Whale Occurrence Using Moored Passive Acoustics

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Mark Baumgartner- WHOI

NOAA Program Manager – Sophie Van Parijs- NMFS NEFSC

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

The goal of this project is to develop a fully operational moored buoy that will provide real time detections of baleen whales as part of NOAA's ongoing efforts to monitor and assess marine mammal stocks. The moored system relies on (1) the DMON instrument, an extremely low-power hardware platform developed at WHOI that allows audio data to be recorded and analyzed on an integrated fixed-point digital signal processor (DSP), (2) an automated low-frequency detection and classification system (LFDCS) that is currently implemented on the DMON to detect the calls of baleen whales, and (3) significant advancements in moored buoy design for acoustic applications. The utility of this remote real-time technology is being evaluated and assessed in the light of its value in providing year round occurrence data in remote critical habitats and improving information dissemination to mariners on the locations of large whales as an expansion of NOAA's efforts to reduce large whale ship strike mortalities.

The main objective of this project is to fabricate a mooring that will provide long-term detection data for baleen whales. All of the needed technology has been developed at WHOI, so the project is focusing primarily on integration of existing components to achieve our monitoring goal. The project development tasks are therefore organized as follows: (1) selection of mooring components, (2) conceptual integration, (3) physical integration, (4) bench testing, and (5) well testing. Two new hardware components are being employed for this project: (1) a buoy-based data logger and Iridium satellite communications link to facilitate data transfer between the DMON and a shore-based computer, and (2) a quiet mooring suitable for passive acoustic monitoring. The operation of the proposed mooring is relatively simple (Figure 1). The DMON/LFDCS is suspended at depth on the mooring line between an anchor and a subsurface float. The acoustic environment of the DMON/LFDCS is kept quiet by de-coupling the motion of the surface buoy from the subsurface float (and the DMON/LFDCS suspended below the subsurface float) using a "stretch hose". This WHOI-developed component contains a bundle of helically wound conductors that permits communications and power delivery, but it is capable of stretching to twice its relaxed length. Use of the stretch hose enables the motion of the surface buoy caused by surface waves to be significantly dampened so that the lower portion of the mooring remains relatively motionless. Detection data from the DMON/LFDCS is relayed via electromagnetic (EM) cable and the conductors in the stretch hose to a surface buoy where it is stored in a single file on a low-power data logger. At 6-hour intervals, the data logger transmits the file to shore via an Iridium satellite modem (the data logger will operate in an identical fashion to a Webb ocean glider science computer, for which the communication and data transfer

protocols have already been designed and implemented). Upon receipt, the shore-side computer parses the file, create both tabular and graphical displays in HTML, and serve the data on the World Wide Web (see dcs.whoi.edu).

ACCOMPLISHMENTS

Tasks 1-4 have been completed, including selection of mooring components, conceptual integration, physical integration, and bench testing. Well testing will be completed in early May 2013. Work completed over the past year includes the following:

- Integration of surface data logger and DMON/LFDCS – The two main electronic systems required physical integration as well as the development of communication protocols between the two. The DMON uses a standard communication protocol of NMEA-like strings to pass both individual detection data and summary detection reports to an external host. This work is complete. The Iridium board has been programmed over the past 6 months to receive the detection data and summary detection reports from the DMON, store them in FLASH memory for a period of a few hours, and then transmit the packaged data to a shore-side computer via the Iridium modem. Bench testing of this data transfer (from DMON to logger to Iridium satellite) is complete.

- All of the buoy hardware, including the watertight instrument well, has been purchased or fabricated. Integration of the mooring components is underway, and the entire end-to-end system will be tested in the water tank of the Coastal Research Laboratory on the WHOI campus in early May 2013. This test will evaluate all aspects of the mooring's electrical and communication performance, including passing DMON serial data to the Iridium modem/logger via RS485 through EM cable and stretch hose conductors, logging of the data by the Iridium board, transmission to a shore-side computer via Iridium satellite communications, and successful reception of the data via an Iridium RUDICS modem connection.

HIGHLIGHTS

- The design and fabrication of the buoy is now complete, and only final well testing remains. With continued support from the NOAA ASTWG program, we hope to deploy the mooring for in-situ testing during the summer of 2013.

SOCIETAL BENEFITS

The moored DMON/LFDCS will greatly improve our ability to monitor baleen whales, nearly all of which are endangered. We envision the inclusion of this type of moored application in the Integrated Ocean Observatories System (IOOS), which will benefit ecosystem-based and spatially explicit management of living marine resources. The pairing of bio-physical oceanographic moorings with the proposed DMON/LFDCS mooring also provides an opportunity to study the oceanographic features and conditions that influence the occurrence of marine mammals, thus enabling habitat studies that are integral to the NMFS marine mammal stock assessment process.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

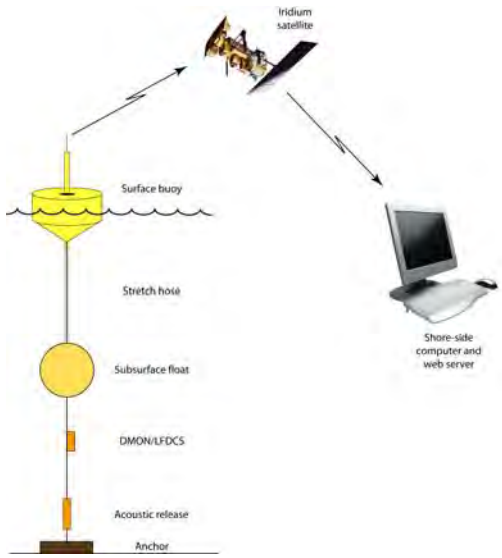


Figure 1. Mooring design concept, including surface buoy with integrated Iridium satellite communications capability, stretch hose with imbedded conductors, subsurface float, DMON/LFDCS, acoustic release and anchor. Whale call detections from the DMON/LFDCS are transmitted via conductors to the surface buoy, stored in the surface data logger, and relayed via Iridium satellite to a shore-side computer every 6 hours where the data is immediately made available on the web in tabular and graphical formats.

Characterizing North Atlantic Right Whale Habitat through Integration of Satellite Tagging, Acoustic, and Visual Survey Data

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 77
April 01, 2012 – March 30, 2013

Mark Baumgartner- WHOI

NOAA Program Manager – Sophie Van Parijs, NMFS NEFSC

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

A tremendous amount of habitat research has been conducted in the small-scale high-use areas occupied by North Atlantic right whales, such as Cape Cod Bay, Great South Channel, and the Bay of Fundy using a variety of tools and approaches. There are only a few methods that have attempted to characterize right whale movements, occurrence, or distribution over larger spatial scales or longer temporal scales. These include broadscale aerial surveys, satellite tagging, and long-term passive acoustic monitoring. Each of these methods provides a very different view of right whale occurrence and habitat, and each of these methods has advantages and limitations depending on the questions and spatial/temporal scales of interest. While habitat modeling can be conducted independently with any one of these methods, to characterize right whale distribution and habitat over large spatial scales and long temporal scales (e.g., annually throughout the Gulf of Maine and Scotian Shelf), it would be extremely useful if data from these three methods could be combined into a single analysis. Techniques to accomplish such an analysis have yet to be developed.

The objective of the this project is to develop a method to combine data from visual surveys, satellite tagging, and passive acoustic monitoring into a single framework to characterize the occurrence of right whales with respect to environmental conditions. This method will allow researchers and managers to reasonably extrapolate the relative probability of right whale occurrence in areas that have sparse occurrence data based solely on oceanographic conditions in those areas.

ACCOMPLISHMENTS

During the reporting period, we have developed a framework in which data from the three disparate sampling methods can be combined for a single analysis. The framework includes creation of tables of occurrence by area and day of the year for each of the three data collection methods. Each entry in the table corresponds to presence, absence, or no data available. The latter designation indicates that no effort was expended to determine presence or absence; for aerial surveys, this means no survey was conducted in the area; for passive acoustic data, this means that no acoustic recorders were deployed in the area; for satellite tagging data, this means that no tag was attached to a whale, no tags were transmitting, or tagged whales could not have possibly reached the area. For both aerial surveys and acoustic recorders, there will be a single annual table that covers all areas. For satellite tagged whales, there will be a single table for each

tagged whale. All of the occurrence tables will be aggregated into a single table using a logical "or". For example, a presence will be coded in the aggregate table for area C on day 10 if a presence appears in any of the occurrence tables for area C on day 10. Using this aggregate table, the minimum daily probability of occurrence in an area can be computed over any time scale as the number of coded ones in the table (indicating presence) for that time period divided by the total number of both ones and zeros for that time period.

An "area" is not defined strictly geographically, but instead is defined as "an oceanographically homogenous region." This definition is critically important, as the presence of one or more whales in a particular location will, in essence, be extrapolated over an area that is oceanographically similar to that location. The underlying assumption of this definition is that if a whale is seen in one area with a set of particular oceanographic conditions, it is more likely that other whales will be in other locations with similar oceanographic conditions. This assumption underlies all habitat modeling efforts, and this project makes the same assumption. The operational delineation of areas is challenging, however. Ideally it will be based on the habitat preferences of right whales derived from other studies. In this project, we are using the surface temperature, surface salinity, bottom temperature, bottom salinity, and surface stratification taken from a climatology of the Gulf of Maine and Scotian Shelf, since Baumgartner and Mate (2005) found that the distribution of satellite-tagged right whales was related to some of these variables. A cluster analysis will be used to identify areas with similar oceanographic properties (e.g., Figure 1). The occurrence tables will be constructed with the areas derived from this cluster analysis. The final product of this habitat analysis will be monthly maps of minimum daily probability of occurrence for each oceanographically distinct area.

HIGHLIGHTS

- Development of the framework has been completed.

SOCIETAL BENEFITS

NOAA has a mandate to protect and conserve endangered marine mammals, including the North Atlantic right whale. Our research will improve understanding of the distribution and habitat requirements of right whales, which in turn will improve efforts to mitigate human-related effects on the population (e.g., ship strikes, fishing gear entanglements).

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

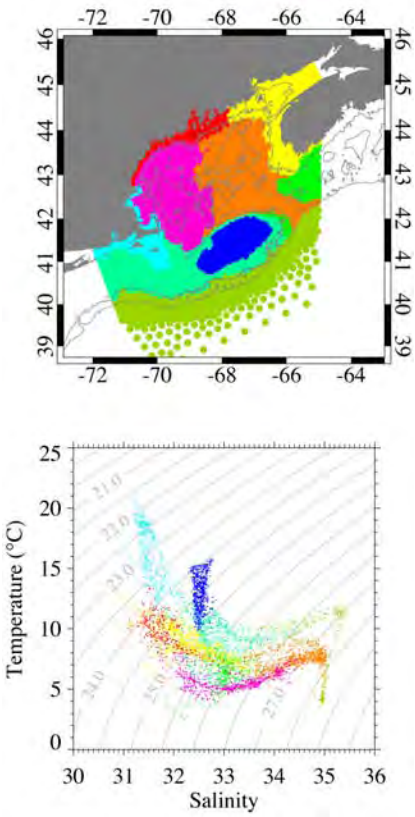


Figure 1. (top) Gulf of Maine with areas indicated in color. (bottom) Areas indicated on a temperature-salinity plot. Areas were derived from a cluster analysis of bottom temperature and salinity, latitude and longitude, and stratification in the upper 50 m of the water column.

Evaluation of the importance of Predator and Prey Field and Ocean Circulation on Atlantic Salmon Growth and Survival in the Gulf of Maine

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Carrie Byron- GMRI

NOAA Program Manager – John Kocik NMFS

Related NOAA Goal Plan – – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems
CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

The goal of this project is to characterize marine phase migration and survivability of Atlantic salmon in the Gulf of Maine (GOM) ecosystem. Our goal was to investigate the importance of coastal currents in the GOM on post-smolt Atlantic salmon migration. Our approach was to use MATLAB to combine physical and bioenergetic models with spatially explicit prey fields. Physical oceanography in the (GOM) is being modeled with the GoMOOS forecast/hindcast model (Xue 2005). A passive particle model based on the physical model allows us to determine the influence of coastal currents on salmon irrespective of their biology or ecology. Salmon bioenergetics was modeled using the Wisconsin model (Hanson et al. 1997) and parameterized according to Smith et al. (2009). After combining the physical and bioenergetics models, the next step was to add characteristics of salmon swimming speeds, directions, and general behavior to the model.

Hanson PC, Johnson TB, Schindler DE, Kitchell JF (1997) Fish Bioenergetics 3.0, Vol. University of Wisconsin System Sea Grant Institute, Center for Limnology.
Smith IP, Booker DJ, Wells NC (2009) Bioenergetic modelling of the marine phase of Atlantic salmon (*Salmo salar* L.). Marine Environmental Research 67:246-258.
Xue H, Shi L, Cousins S, Pettigrew NR (2005) The GoMOOS nowcast/forecast system. Continental Shelf Research 25:2122-2146.

ACCOMPLISHMENTS

The coupled particle-bioenergetics model is complete and currently in peer review. Results suggest that the Nova Scotia Current is an important factor influencing post-smolt migration through the Gulf of Maine. This result suggests that salmon could be influenced by large basin scale oceanographic processes as they are translated to more regional processes that the salmon experience directly, such as a coastal current. Results also suggest that migrating salmon may be experiencing some trade-off between being fast and being fit. A new modeling endeavor is underway to examine this trade-off. Most importantly, John Kocik and I have a clear understanding of expected deliverables prior to the end of the project. John is interested in examining likelihood of presence of salmon in fishing active fishing areas.

HIGHLIGHTS

- Coupled particle movement and bioenergetics model complete and written up in two peer-reviewed publications currently in review
- Two manuscripts submitted peer-review returned, edited and resubmitted for a second review
- Wrote and submitted review manuscript on salmon migration for special issue in Reviews in Fish Biology and Fisheries
- Began developing new dynamic state model to investigate trade-off experienced by migrating post-smolt salmon between swimming fast to their destination or taking their time to eat and be fit along their migration route.

SOCIETAL BENEFITS

Natural populations of Atlantic salmon once sustained an industrious fishing industry and are a nutritious food that is in high demand. This industry is now tightly regulated and restricted due to dwindling populations despite heroic restoration efforts. This research will increase our understanding for poor recovery and hopefully lead to improved management strategies that will benefit Atlantic salmon fisheries and seafood markets.

EDUCATION AND OUTREACH ACTIVITIES

Invitations

- Speaker. School of Marine Sciences, University of Maine. Orono, ME, Oct. 05, 2012.
- Poster Presenter. CINAR 5 year review. Woods Hole, MA, Sep. 06, 2012.
- Speaker. Marine Science Education and Research Center, University of New England. Biddeford, ME, Sep. 05, 2012.
- Poster Presenter. ICES/PICES Oceans of Change, conference for early career scientists. Majorca, Spain. Apr. 24-27, 2012.

Conference Presentations and Posters

- Byron, C., Pershing, A., Xue, H., Stockwell, J., Kocik, J. Migration model of post-smolt Atlantic salmon in the Gulf of Maine. Regional Association for Research in the Gulf of Maine (RARGOM), Portsmouth, NH, October 09, 2012. [oral presentation]

- Byron, C., Pershing, A., Xue, H., Stockwell, J., Kocik, J. Migration model of post-smolt Atlantic salmon in the Gulf of Maine. American Fisheries Society (AFS), Minneapolis-St. Paul, MN, August 19-23, 2012. [oral presentation]

Public Outreach

- Post cards describing project distributed to GMRI guests
- Project goals and results have been incorporated into the GMRI Cohen Center curriculum – an interactive lab experience for 6th graders.

Migration of post Smolt Atlantic Salmon in the Gulf of Maine and Gulf of Saint Lawrence

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Carrie Byron- GMRI

NOAA Program Manager – John Kocik NMFS

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

By modeling post-smolt migration in the Gulf of St. Lawrence (GSL), a comparison of migration success can be made between the Gulf of Maine (GOM) with the GSL which will highlight regional differences in migration strategies. Migration strategies for salmon in the GSL are largely unknown. Conveniently, the GSL is rich in data regarding observations of salmon location at the start and end of their migration through the use of the Ocean Tracking Network and other field sampling methods. The Ocean Tracking Network extends across the Cabot Strait and the Strait of Belle Isle which are the only two passageways out of the GSL (Figure 1). Any tagged fish originating in the GSL must pass by one of the OTN arrays prior to exiting the region. Therefore, the GSL is a much more contained system compared to the GOM where the boundary edges are wide open and unmonitored except for the one OTN line extending from Halifax, Nova Scotia. Additionally, there is reason to suspect that GOM salmon are most susceptible to environmental change because they are at the southern edge of their range. Investigating responses of northerly populations to current strength and water temperature will inform extent and severity of potential climate change impacts on the species.

ACCOMPLISHMENTS

The coupled particle-bioenergetics model structure is built and operable. A few preliminary scenarios have been run on the model. More work needs to be done to improve parameterization so it appropriately reflects GSL fish, as opposed to GOM fish. Preliminary results are promising and suggest that currents also play an important role in the GSL as they do in the GOM (Figures 2-3). Results suggest interannual variability in currents influence ability of fish to make it out of the gulf. What is curious is how large scale oceanographic processes may be translated differently in GSL versus the GOM.

HIGHLIGHTS

- Obtained extended model domain that includes both GoM and GSL; model is running and functional

- Parameterization complete only at preliminary level. Needs to be revised with more appropriate values for the GSL.

- Preliminary results based on few model scenarios and preliminary parameterization values

SOCIETAL BENEFITS

Natural populations of Atlantic salmon once sustained an industrious fishing industry and are a nutritious food that is in high demand. This industry is now tightly regulated and restricted due to dwindling populations despite heroic restoration efforts. This research will increase our understanding for poor recovery and hopefully lead to improved management strategies that will benefit endangered and threatened populations. This work will also identify locations in which salmon may be interacting with active fisheries.

EDUCATION AND OUTREACH ACTIVITIES

Invitations

- Speaker. School of Marine Sciences, University of Maine. Orono, ME, Oct. 05, 2012.
- Poster Presenter. CINAR 5 year review. Woods Hole, MA, Sep. 06, 2012.
- Speaker. Marine Science Education and Research Center, University of New England. Biddeford, ME, Sep. 05, 2012.
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Conference Presentations and Posters

- Byron, C., Pershing, A., Xue, H., Stockwell, J., Kocik, J. Migration model of post-smolt Atlantic salmon in the Gulf of Maine. Regional Association for Research in the Gulf of Maine (RARGOM), Portsmouth, NH, October 09, 2012. [oral presentation]
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Public Outreach

- Post cards describing project distributed to GMRI guests
- Project goals and results have been incorporated into the GMRI Cohen Center curriculum – an interactive lab experience for 6th graders.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Fig 1. Extended domain including both the Gulf of Maine and the Gulf of St. Lawrence. Black lines represent 20 fish tracks for each year (2005-2011). Color bar represents bathymetry.
Fig 2. Percent of successful fish plotted against the percent of time they were pushed by currents.
Fig 3. Current speed experienced by fish along their migration route.

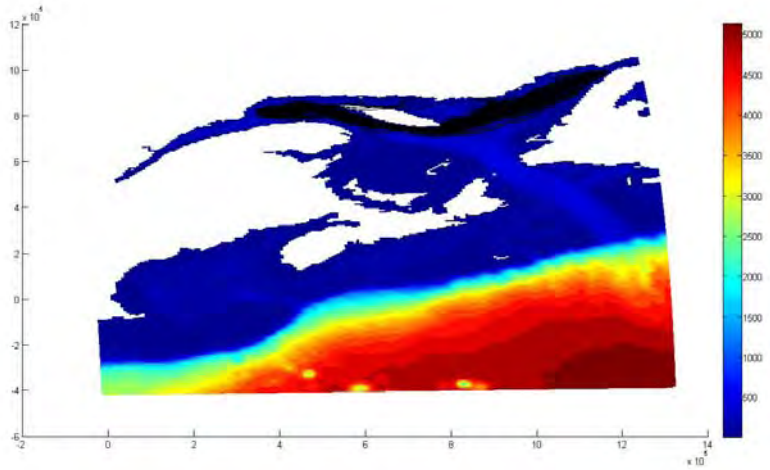


Figure 1.

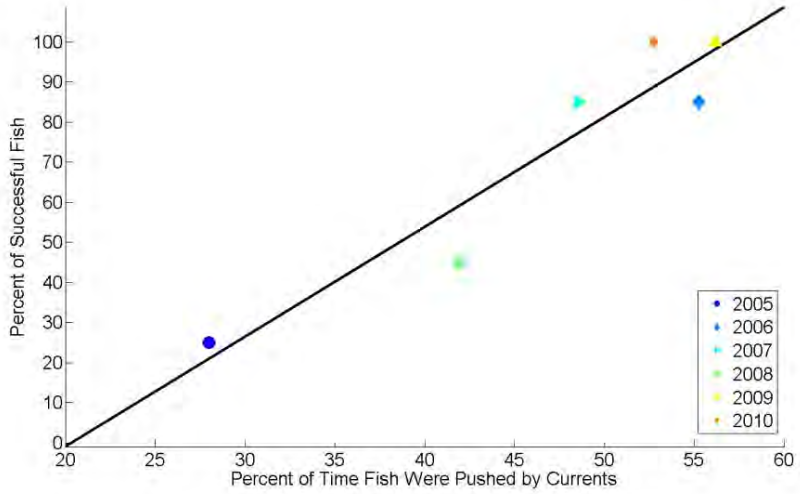


Figure 2.

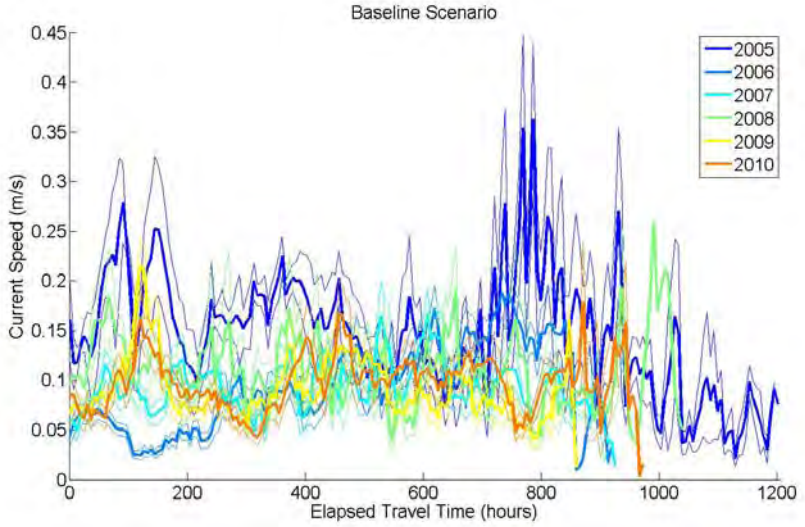


Figure 3.

Estimation of Harbor Seal Numbers in New England

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

James Gilbert- UMaine

NOAA Program Manager – Gordon Waring NMFS/NEFSC

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems
CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

The goal of this research is to estimate the numbers of harbor seals on coastal islands and ledges and adjacent New England waters. This requires: 1) an estimate of a correction factor to adjust aerial surveys for the fraction not observed, 2) an estimate of the number of seals on land and visible in the area, and 3) an estimate of population size of harbor seals with adjustment for correction factors.

In 2011, 21 seals were captured at Cape Cod in March and near Rockland, Maine in April. Aerial counts of harbor seals were not completed in 2011 because of unusual fog conditions during the survey time window. Only one flight was completed, resulting in insufficient samples from which to estimate seal abundance.

A no-cost extension to the research project was requested and granted. The plan is to repeat capture of the harbor seals in late March and late April. Aerial counts are scheduled around mid-day low tides in late May and the first two days of June.

ACCOMPLISHMENTS

Twenty-nine seals were captured and radio-tagged near Cape Cod, MA and in Rockland, ME in the spring of 2012. Eighteen of these seals were located in Maine prior to and during the aerial surveys that were conducted from May 27 through June 2, 2012. Thirteen sample areas were surveyed from the NOAA Twin Otter, from which digital images were taken. Counts were made on some 2600 images, for a total of 19,959 harbor seals and 543 gray seals. These counts were corrected base on the radio-tagged seal availability and extrapolated to the entire Coast of Maine. A draft manuscript summarizing the results is being reviewed within NMFS.

HIGHLIGHTS

- The aerial survey was completed in a minimum of days, thus reducing costly flight time and risk from low altitude flying.

- The estimated number of harbor seals will be used to set potential biological removal levels for fishery regulations.

SOCIETAL BENEFITS

Harbor seal populations are a significant part of the Gulf of Maine ecosystem. The last population estimate was in 2001; a current estimate of population size is necessary to estimate the impacts of fisheries by-catch and of the recent increase in gray seal numbers.

EDUCATION AND OUTREACH ACTIVITIES

Presented results and plans for 2012 at Gulf of Maine Seals – Fisheries Interactions and Integrated Research. October 6-8, 2012, Provincetown, MA.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

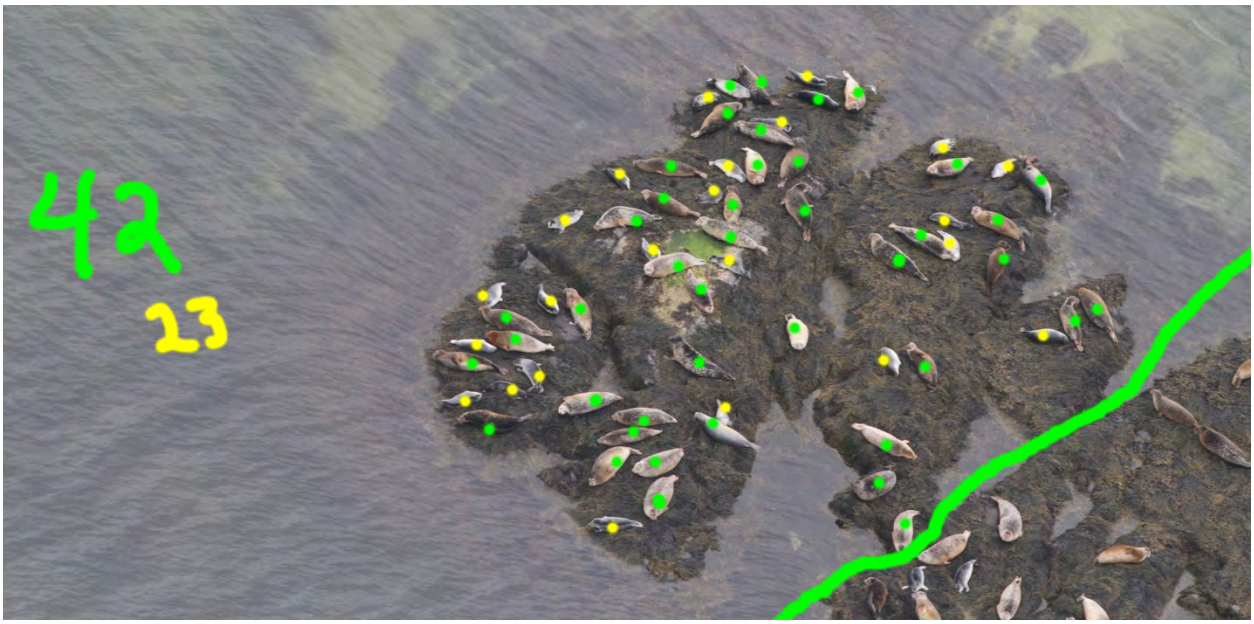


Figure 1. Illustration of a typical digital image with counts of harbor seal adults (42) and pups (23). Seals on the other side of the green line were counted in other images.

Funding Sector Operations and Dockside Monitoring in Fishing Year 2011

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Jonathan Labaree, GMRI

NOAA Program Manager – Dan Morris NMFS/NER

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

The overall objective of the project is to assist New England's groundfish fleet during the transition to sector management. This new output-based approach replaces the effort controls for the vast majority of the fleet. The change, however, requires new organizations - sectors - and vastly increased level of catch monitoring. The project establishes GMRI as the administrator for federal support of the new management regime and assists the new sectors in start-up costs and dockside monitoring (third-party witnessing of the offload of fish from vessel to dealer).

Federal monitoring regulations governing the portion of New England's groundfish fleet enrolled in sectors changed in 2011 when dockside monitoring no longer became mandatory. In response, NOAA staff from the Northeast Regional Office requested that funds formally set aside to cover monitoring costs be redirected to fund the development of the groundfish sectors. Thus, the $600,000 in monitoring funds in this grant were reallocated to support sector operations.

ACCOMPLISHMENTS

During the reporting period, GMRI has distributed a total of $411,208 in operational assistance to groundfish sectors. These funds covered a range of expenses including sector manager salaries, office space, software, legal assistance, and auditing services.

HIGHLIGHTS

- distributed $411,208 in federal funds for sector operational costs

SOCIETAL BENEFITS

The switch from effort-control to output-control in New England's groundfish fishery represents one of the most sweeping changes in natural resource management in the US. The fishery affects the lives of thousands of vessel owners, captains, and crew, along with shoreside infrastructure and seafood markets region-wide. This grant has provided absolutely critical technical and financial assistance to the industry as it transitions to the new system.

EDUCATION AND OUTREACH ACTIVITIES

Education and outreach activities have been directed exclusively at the groundfish industry, sector organizers, and federal regulators. GMRI staff have presented at meetings, training sessions, and engaged in one-on-one training with the fishing industry.

Human Interaction Investigations in Marine Mammals

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Michael Moore- WHOI

NOAA Program Manager – Teresa Rowles, NMFS

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

Part 1 - Human Interaction Investigations in Marine Mammals

This project comprises a single task with three components. The first is to undertake a review of criteria necessary to diagnose human interaction as the proximate or contributing cause of death in a stranded marine mammal. This review would then be assessed and enhanced by a small workshop of invited specialists. The resulting document will then be submitted for peer-reviewed publication and provided to NMFS.

Part 2 - Large Whale Stranding Response and Human Impact Investigation.

The purpose of this project is to respond to reports of live or dead stranded large whales, especially right whales, by providing stranding response-related investigations, including, but not limited to, planning, euthanasia, carcass retrieval and/or towing, necropsy, sample collection, distribution, and analysis, and necropsy report writing. The investigations shall be consistent with those outlined in the "Right Whale Necropsy Protocol" and NOAA Fisheries Service final response protocols/Standard Operating Procedures.

ACCOMPLISHMENTS

Part 1. Human Interaction Diagnostic Criteria.

Following a two-day workshop held at Woods Hole Oceanographic Institution on February 1 and 2, 2012, involving 30 participants from the USA, Canada, Chile and Spain, a substantial manuscript was drafted summarizing the findings of the workshop. This comprised a series of sections that described diagnostic criteria for 5 different types of trauma from human interactions with marine mammals. This was recently published in *Diseases of Aquatic Organisms* as a Theme Section (Moore et al., 2013). The publication can be downloaded at:

http://www.int-res.com/articles/dao_oa/d103p229.pdf.

Part 2. Stranding Response.

This project period has been relatively quiet in terms of cases requiring examination. Two cases were worked up by William McLellan et al.

1. EgNEFL1235, a right whale found dead 3 nm east of Palm Coast, FL. Final Cause of Death awaits histopathological tissue evaluation, though malnourishment from chronic entanglement is the prime finding.
2. CAHA 142 Pma - a sperm whale at Hatteras, NC. No direct cause of death determined on gross examination.

HIGHLIGHTS

- Criteria for the diagnosis of Human Interaction in dead and seriously injured marine mammals were defined and published.

- A right whale carcass was diagnosed as to cause of death.

SOCIETAL BENEFITS

- Accurate diagnosis of anthropogenic mortality and serious injury of endangered and threatened marine mammals is the first step in adequate mitigation of such factors.

EDUCATION AND OUTREACH ACTIVITIES

- Dr. Moore and Dr. Gulland taught a workshop on diagnosing Human Interactions in Marine Mammals at an International Whaling Commission Disentanglement Workshop, held in La Paz, Mexico on November 27, 2013.
- Dr. Moore and other workshop participants presented a webinar on Diagnosing Cause of Death by Human Interactions with Marine Mammals to the US Stranding Network 20th Anniversary of the Marine Mammal Health and Stranding Response Program Seminar Series on March 28, 2013. There were 80 participants on line.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Figure 1. Dorsal tail fluke perspective of right whale EgNEFL1235 showing gear entanglement around the tailstock.

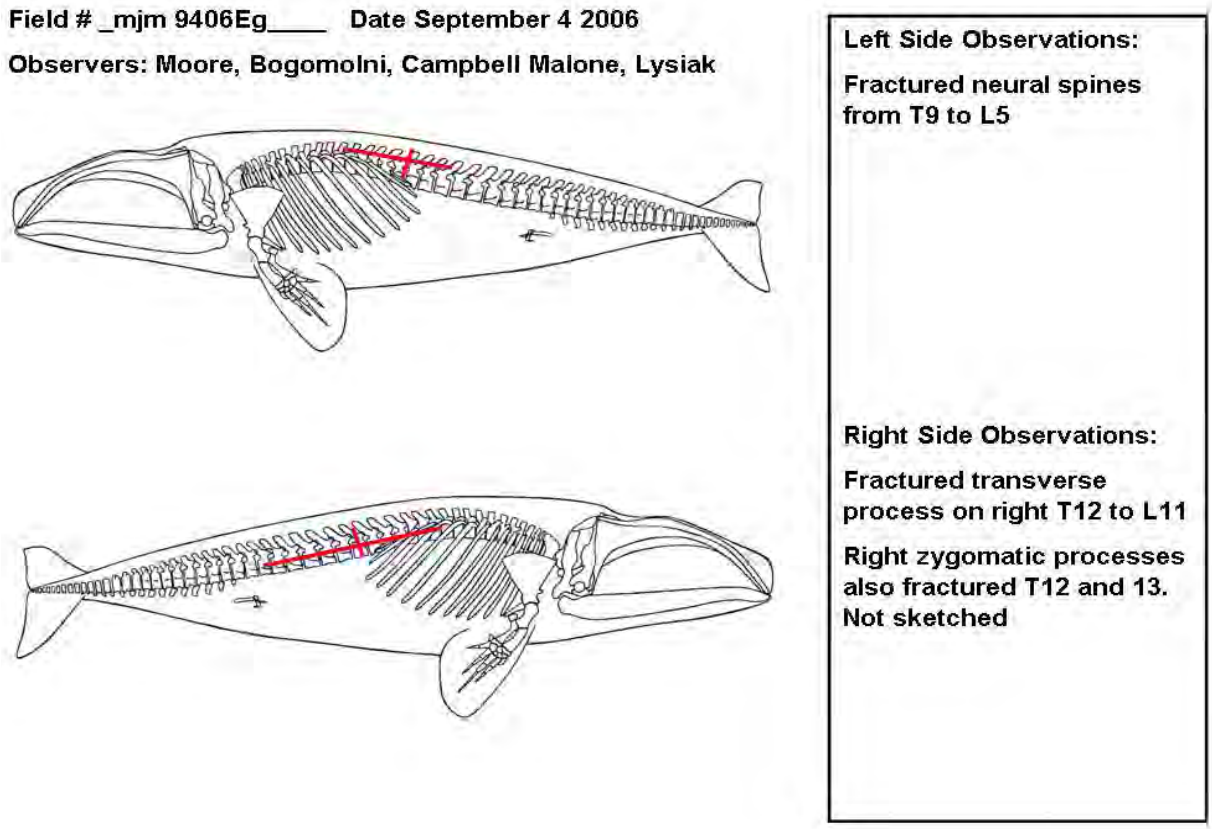


Figure 2. A figure from Moore et al (2013)- showing an example of how human interaction data are recorded during a large whale necropsy to facilitate the accurate diagnosis of cause of death, in the context of case criteria established in the recently published Theme Section in Diseases of Aquatic Organisms. The image shows the fractured vertebral elements discovered during necropsy of MJM 9406 Eg. Fractures have been recorded on necropsy data sheets described in McLellan *et al.* (2004)

McLellan WA, Rommel SA, Moore MJ, Pabst DA. 2004. Right Whale Necropsy Protocol. Final Report to NOAA Fisheries for contract # 40AANF112525 U.S. Department of Commerce, National Oceanic and Atmospheric Administration, available from NOAA Fisheries Service, 1315 East West Highway, Silver Spring, MD 20910, USA http://www.nmfs.noaa.gov/pr/pdfs/health/rightwhale_necropsy_protocol.pdf. 51 pp.

Moore M, van der Hoop J, Barco S, Costidis A, Gulland F, Jepson P, Moore K, Raverty S, McLellan (2013). Criteria and case definitions for serious injury and death of pinnipeds and cetaceans caused by anthropogenic trauma. Diseases of Aquatic Organisms. 103:229-264

Marine Mammal Health and Entanglement Research

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Michael Moore- WHOI

NOAA Program Manager – Teresa Rowles NMFS

Related NOAA Goal Plan – Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

1. To undertake a review of large whale euthanasia and prepare a working paper for an International Whaling Commission workshop.
2. To provide diagnostic imaging studies to the Marine Mammal Health and Stranding Response Program.
3. To undertake a review of large whale entanglement and prepare a working paper for an International Whaling Commission workshop.

ACCOMPLISHMENTS

Task 1. The euthanasia review was undertaken, the paper submitted, and the workshop attended by Moore in Hawaii. The paper is available on line at:
http://iwcoffice.org/_documents/sci_com/SC62docs/IWC-A10-E1Rev.pdf

The workshop report is available on line at:
http://iwcoffice.org/_documents/commission/IWC62docs/62-15.pdf

Task 2. Diagnostic imaging services were provided in 2012/13. Ten agencies received diagnostic radiology services, 5 received radiology consultation. Four papers were published in the past year.

Task 3. The entanglement review was undertaken, the paper submitted and the workshop attended by Robbins in Hawaii. The paper is available online at:
http://iwcoffice.org/_documents/sci_com/SC62docs/IWC-A10-E3.pdf

HIGHLIGHTS

- A review of large whale euthanasia was undertaken and the resulting paper published on line by the International Whaling Commission.
- This review and the workshop helped enhance large whale euthanasia technique on US beaches. Subsequently two large whales have been efficiently euthanized using a combination of intramuscular sedation and intracardiac potassium chloride.

- Radiology services, including interpretation of ultrasound, echocardiography, MRI and CT have been provided to many aspects of the US Marine Mammal Health and Stranding Response Network.

SOCIETAL BENEFITS

Humane care, including appropriate euthanasia of terminally ill large whales is an important capacity to build into the US stranding network. Board certified radiological interpretation is an additional important capacity for rapid and accurate diagnosis and hence humane management of clinical cases involving stranded marine mammals around the US coastlines.

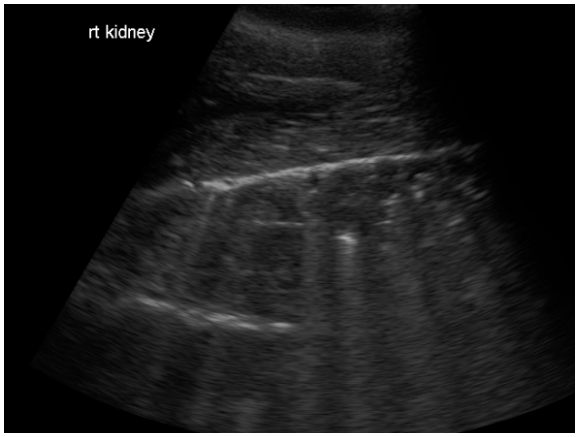
EDUCATION AND OUTREACH ACTIVITIES

International Association of Aquatic Animal Medicine 2012

American College of Veterinary Radiology 2012

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Figure 1: Ringdown artifact demonstrating the presence of multiple small diameter gas bubbles identified in and around the right kidney of stranded common dolphin in Cape Cod.



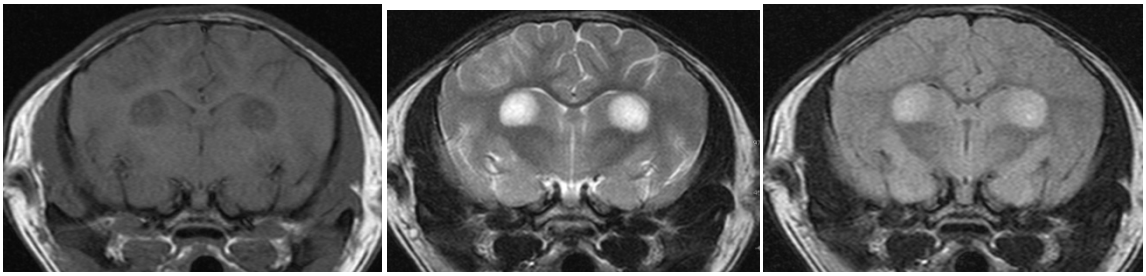


Figure 2. Blinky the northern fur seal demonstrated that not all cases of neurologic disease are due to domoic acid toxicosis that arrive at TMMC. Bilateral caudate nucleus abnormalities were identified on MRI that have not been seen in any other case. Left image. T1W pre Gd transverse image at the level of the caudate nucleus. The patient's right is to the left of the image. The caudate nuclei are bilaterally hypointense. No signal enhancement occurred post Gd. Middle image. T2W transverse image at the same level as Figure 1. The caudate nuclei are hyperintense. Right image. FLAIR transverse image at the same level as Figure 1 and 2. There is no evidence of nullification of the signal from the caudate nuclei. The CSF is adequately nullified.

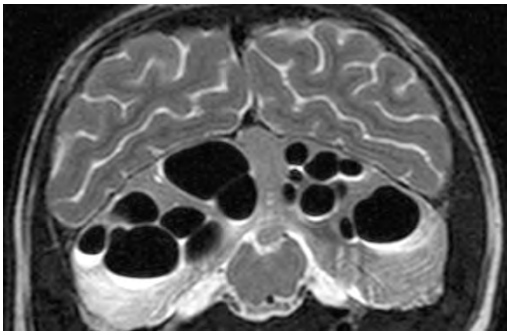


Figure 3. Pneumocerebellum in a California sea lion. This second case bore striking similarities to the first case diagnosed the previous year. Here the black defects in the cerebellum representing gas filled cavitations are seen.

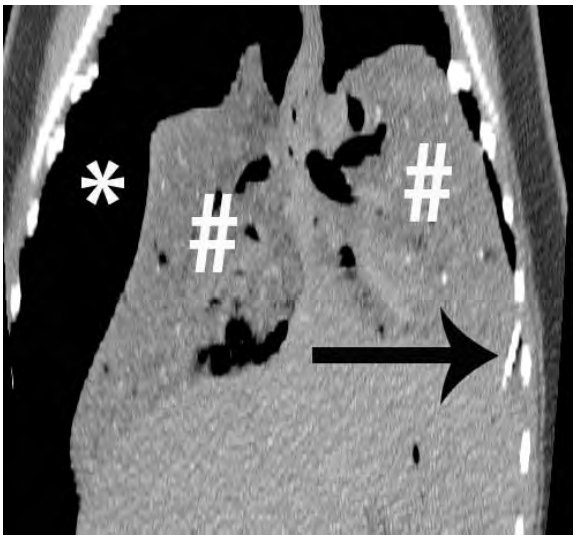


Figure 4.Dorsal reconstruction of a CT on a dead stranded cetacean as part of the sinusitis project. A sting ray barb (black arrow) is seen having punctured the caudal left lung and resulted in lung collapse (#) and pneumothorax (*).

Analysis of CYP1A1 Expression in Cetacean Tissue Samples

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

John J. Stegeman, WHOI

NOAA Program Manager: Teresa Rowles NMFS

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme – Protection and Restoration of Resources

PROJECT OVERVIEW

The goal of this project is to determine levels of expression of cytochrome P450 1A1 (CYP1A1) in tissues of the common bottlenose dolphin (*Tursiops truncatus*), and other cetacean species as needed, possibly including sperm whale (*Physeter macrocephalus*), with such tissues obtained from animals in the Gulf of Mexico or other areas of interest to NOAA. Tissues of interest for examination initially will be skin biopsies, with material from the tissues to be provided by NOAA personnel for purposes of these measurements. The measurement of CYP1A1 expression will be by two methods, immunohistochemistry and quantitative polymerase chain reaction. These are complementary approaches that, together with data on location and timing of sample collection, will provide strong inference regarding levels of CYP1A1 expression.

ACCOMPLISHMENTS

Immunohistochemistry

Skin/blubber biopsies included four zones: epidermis, which extends through the dermal papillae; the superficial blubber layer (scored as Zone 1), which is the layer underneath the epidermis consisting of dense structural fibers and pronounced eosin staining; the middle blubber layer (scored as Zone 2), which lies beneath Zone 1 and consists primarily of adipocytes, and the deep blubber layer (scored as Zone 3) which is at the terminus of the biopsy and like Zone 1, consists primarily of structural fibers and pronounced eosin staining. Zone 3 was not present in all biopsies. Staining was observed only in two cell types: vascular endothelial cells and arteriole smooth muscle, as described by Wilson (2007).

Each H&E slide was marked at the edges of the described zones. The corresponding zones in the 1-12-3 stained slide (positive) were marked by placing the slide on top of the H&E slide, as zones were not distinguishable in the absence of Eosin staining. These demarcations were used to define regions of scoring. The depth of each region was measured (mm) and recorded.

A typical region within each zone present was photographed for each sample stained with 1-12-3. In some cases, when representative staining for both cell types could not be captured in one image, a second photograph was taken. All photos were taken with an AxioCam MRc color camera, with a Zeiss Axiovert 200 in H/DIC mode at 100X magnification, 2.9 V for the incandescent light source intensity, 1 millisecond exposure time, interactively white balanced with color channel settings of cyan/red = 2.09, magenta/green = 0.8, and yellow/blue = 0.11. For each sample subset, photographs of a corresponding (negative) MOPC 31 stained tissue were

also taken in the same region for a selected sample to confirm specificity of observed positive staining. Absence of score indicates that a cell type was not present.

Slides were examined with a Zeiss Axiovert 200 microscope and relative staining intensities were determined subjectively by comparing the staining of samples to that of control and highly induced scup and catfish liver, kidney and ovary sections included in each run. Specificity of staining was confirmed by comparison with MOPC31 stained sections. Staining occurrence was scored as 0-no staining (or equal to MOPC31 staining), 1-rare- few cells staining, 2-many cells staining, 3-multifocal and diffuse-all cells staining. The intensity of staining was scored as 0-none (or equal to MOPC31 staining), 1-mild, 2-moderate, 3- medium, 4-strong, 5-very strong. Intermediate scores were also assigned for occurrence and intensity (e.g., 1.5). A scaled product of staining occurrence times the staining intensity was determined for each cell type within a tissue and zone. This scaled score can range from 0 to 15.

1) Internal standards were included in each staining run to assure the consistency and quality of a run, and to determine maximum (occurrence 3 X intensity 5=15) and minimum (0) staining.

2) A companion slide for all samples was stained with MOPC31 to determine if nonspecific staining was present.

3) As part of the standard Signet protocol, slides were presoaked in 3% H_2O_2 to eliminate endogenous peroxidase activity.

4) Scoring of samples was performed blind (nature of samples was unknown to scorer).

5) For livers, the correlation of subjectively determined CYP1A

Immunohistochemical staining scores with the independent and nonsubjective protein immunoblotting densities of hepatic microsomes from the same livers has been demonstrated in our lab. This correlation has also been shown in our lab for CYP1A1 detected in seal skin biopsies and corresponding protein immunoblots.

Quantitative polymerase chain reaction (qPCR)

The studies to assess expression of CYP1A1 transcript by quantitative polymerase chain reaction (qPCR) were conducted with RNA samples provided by NOAA. The analysis was initiated with evaluation of the primers to be used in qPCR. Specific primers were designed in the based on the sequences previously obtained at WHOI by use of degenerate primers. Amplicons obtained using those specific primers had been sequenced. New specific primers were obtained and evaluation of the primers was accomplished by using them to amplify sequences from one of the RNA samples provided. Amplicons of both CYP1A1 and actin (the reference gene) were sequenced. Subsequently, qPCR was carried out, and the amplicons were used as standards. Details of the study are below.

Confirmation of qPCR amplicon sequences

Sequences of amplicons obtained by qPCR for Tursiops CYP1A1 and actin were re-confirmed using three replicates of cDNA samples derived from one total RNA sample (#82 renamed, see a separate note). Briefly, the amplicons were ligated into pGEM-T Easy vector overnight at 4°C. The ***Mach1***™ T1 Phage-Resistant *E. coli* (Invitrogen) was transformed with the ligated plasmid containing CYP1A1 or actin cDNA. Selection for transformants was carried out on LB/ampicillin/IPTG/X-Gal agar plates. Two positive clones per replicate were grown overnight

in LB in a shaking incubator at 250 rpm at 37°C. Plasmids containing the insert were purified using Qiagen miniprep kit. The sequences were analyzed by Eurofins MWG Operon.

Regarding CYP1A1, five out of six clones sequenced (derived from two clones per replicate) showed 100% match to the *Tursiops* CYP1A1 sequence we previously obtained with the same set of primers. (One clone had one nucleotide mismatch, considered to be due to PCR error.) The sequence is identical to the CYP1A1 sequence (ENSTTRG00000007995) in Ensembl.

For actin, one clone among six was unreadable. The other five clones showed 100% identity to one another, and translated as 100% identical to actin.

Protocol for cDNA synthesis

RNA samples were provided by NOAA and were sent in three boxes. Samples were randomly selected from the three boxes and were coded with new names, as samples 1 to 82. Reverse transcription was performed on 1 µg of RNA, using the iScript cDNA synthesis kit from Bio-Rad, according to the manufacturer's guidelines. Samples re-named 1 to 82 were reverse-transcribed three separate times, yielding 3 cDNA preparations per sample.

The volume of sample corresponding to 1 µg of RNA was mixed with molecular biology water to a final volume of 15 µl. 4 µl of the 5X iScript Reaction Mix and 1 µl of the MMLV RNase H+ Reverse Transcriptase were then added (as a master mix) to obtain a final volume of 20 µl. Gentle vortexing of the samples and short spin was then performed.

Samples were transferred to -20°C until the qPCR run.

Note that RNA concentrations used to calculate the volume of samples required to achieve 1 microgram of RNA are those that were provided by NOAA, except for samples 33, 34, 35, 44 and 45 for which no data were given. In this case, spectrophotometric measurement on a Nanodrop ND1000 was performed to obtain RNA concentrations and the purity of samples was checked; OD ratios (260/230 and 260/280) both were > 1.8.

Protocol for qPCR

Considering the possibility of low levels of expression in the skin, samples were not diluted for qPCR. 1 µl of cDNA was used with a final volume of 20 µl in the wells of 96-well plates. Technical replicates of both CYP1A1 (target gene) and Actin (reference gene) were performed on the same plates. Standards were run multiple times on different plates to confirm the efficiency of the selected protocol for the linear amplification of these genes in our assay conditions. The thermocycler was a MyiQ single color detection system from Bio-Rad.

Results

Results are given as Cycle Threshold (Ct) values by the thermocycler. The baseline threshold value was between 20 and 30 relative fluorescence unit (RFU) for each run performed, a narrow range indicating consistent results. PCR efficiencies were 90% (r2 = 0.997) for CYP1A1 and 87% (r2 = 0.999) for actin. For each sample, mean values of technical replicates for both CYP1A1 and actin were converted to copy number using the respective standard curves. Results were then simply expressed as ratios of CYP1A1 to Actin copy number.

Melt curves

The melt curves are provided for each sample. In the melt curves for CYP1A1, there was a smaller peak well in advance of the target peak for some of the samples. The peak of fluorescence appearing at a lower temperature suggests that this is a primer-dimer. We tested different primer concentrations in qPCR assays and selected a concentration that provided linearity of results for CYP1A1 throughout a large range of Ct values (hence, copy number). Note that at the highest concentrations of plasmids the melt curves do not show the first peak, which is consistent with the emergence of a primer-dimer under some conditions of low signal for the target. While the primer dimer was more pronounced with samples having low CYP1A1 copy numbers, the concentration we used was optimal for linear amplification of CYP1A1.

SOCIETAL BENEFITS

The studies will be important in the understanding of how marine mammals respond to petroleum, which may help in design of remediation, in the event of further large inputs into areas where there are dolphin or other marine mammals.

THEME V. SUSTAINED OCEAN OBSERVATIONS AND CLIMATE

Quarterly Climate Reports

NOAA Cooperative Agreement No. NA09OAR4320129

April 01, 2012 – March 30, 2013

Donald Anderson - WHOI

N***OAA Program Manager – Ellen Mecray NESDIS***
Related NOAA Goal Plan – Goal 2: Climate Adaptation and Mitigation

CINAR Theme – Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

In an effort to deliver a broad range of information on regional climate outlooks and impacts, the National Climate Data Center (NCDC) is producing quarterly reports that address these issues for each of the defined regions. These reports contain information from across the region, including the quarterly NOAA/NCDC State of the Climate report, the Regional Climate Center monthly impact reports, and reports from the NOAA National Weather Service detailing atmospheric observations and trends. What is needed is equivalent information that details the oceanic contributions and responses to climate shifts. CINAR investigators will provide information in the form of data or model results that document important events or observations that may reflect regional climatic conditions within the Northeast Shelf Large Marine Ecosystem stretching from Cape Hatteras to Nova Scotia. These are being provided to the NOAA Regional Climate Services Director, Eastern Region (RCSD-ER) to be incorporated in quarterly 2-page reports that are broadly distributed to regional partners and stakeholders.

ACCOMPLISHMENTS

CINAR investigators regularly attend calls to review draft content for the quarterly climate outlooks produced by NOAA's Regional Climate Services Director (RCSD), Eastern Region. CINAR directly contributed images and text content to the Sept 2012 release. Also, CINAR investigators provide content to the impacts section through ongoing connections maintained on a monthly basis with Andy Pershing, CINAR representative to the RCSD's Eastern Region Climate Team. See also, links to the climate outlook products: http://www.drought.gov/drought/content/resources/reports

HIGHLIGHTS

- CINAR investigators broaden the scope of the outreach content to include ocean-related data including the ocean warming event of summer 2012, as well as impact reports from the fisheries and climate intersection.

SOCIETAL BENEFITS

The distribution of the climate outlooks is wide, across the eastern region, and the Federal, state, local, NGO, and academic partnerships in the Regional Climate Services network. States and local communities have distributed the product to their decision-makers, their planners, and their legislators. It was reported recently that the outlooks have entered the social media space on Twitter and Facebook. They are a resource for a current view of NOAA, and our close partners', results and observations on regional climate.

Bilateral Workshop

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Donald Anderson - WHOI

NOAA Program Manager – Ellen Mecray NESDIS

Related NOAA Goal Plan – Goal 2: Climate Adaptation and Mitigation
CINAR Theme – Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

In an effort to deliver climate services efficiently across this boundary, the National Climate Data Center (NCDC) and the NOAA Climate Program Office's (CPO) international team have been working to build partnerships and ties with the U.S. and Canadian federal agencies. In a similar vein, the U.S. Fish and Wildlife Service (USFWS) has been building ties with their Canadian counterparts through the North Atlantic Landscape Conservation Cooperative (NALCC). In order to strengthen collaborative efforts between NOAA, the USFWS, the NALCC, the ongoing efforts of the Gulf of Maine Council (GOMC) and its climate network, the New England Governors and Eastern Canadian Premiers (NEG-ECP), and additional relevant Canadian partners, a workshop is planned to organize bi-national efforts on climate and its impacts to shared resources in the northwestern Atlantic region. CINAR staff will provide workshop organizing experience, administrative and scientific support, as well as a venue. The workshop will highlight anticipated climate impacts in the region and begin the formulation of projects that could be championed jointly.

ACCOMPLISHMENTS

CINAR is assisting with the logistical preparation for a bi-lateral workshop to be held in June 2013 in Bangor, Maine. A steering committee of Canadian and US Federal employees (2 per country), as well as representatives from 2 provinces and 2 states, has been formed and will convene soon to finalize agendas and provide detailed participant lists.

SOCIETAL BENEFITS

The northwestern Atlantic region borders the Canadian Maritime provinces as well as some of the New England states in the U.S. This region supports some of the most valuable fisheries in the US and Canada. Understanding how this region will respond to climate change is a critical national need for both nations, and thus there is an urgent need to work jointly to plan and prepare for critical habitat shifts anticipated both inland and offshore.

EDUCATION AND OUTREACH ACTIVITIES

Major partners and outreach to: Gulf of Maine Council, Environment Canada, Northeast Regional Ocean Council, North Atlantic Landscape Conservation Cooperative, New England Federal Partners, and states and provinces in the Gulf of Maine watershed (ME, MA, NH, and NB, NS)

Bowhead Whale Feeding in the Western Beaufort Sea Oceanographic Conditions Whale Prey Distributions and Whale Feeding and Foraging Behavior

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Carin Ashjian- WHOI

NOAA Program Manager – Kim Shelden – NMML AFSC
Related NOAA Goal Plan – *Goal 1. Healthy Oceans: Marine fisheries, habitats , and biodiversity sustained within healthy and productive ecosystems*
CINAR Theme – Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Beaufort Sea Shelf to the north and east of Barrow, Alaska is a critical feeding area for bowhead whales, particularly during the fall migration from their summer grounds in the Canadian Arctic to their over-wintering grounds in the northern Bering Sea (e.g., Lowry et al., 2004). The project is a component of the larger "Bowhead Whale Feeding in the Western Beaufort Sea" project coordinated by the National Marine Mammal Laboratory (2007-2012). The project is complemented by an ongoing NSF funded Arctic Observing Network project that describes interannual variability in biological and physical ocean conditions in the Chukchi and Beaufort Seas near Barrow, AK. The work addresses relationships between the formation and distribution of bowhead whale prey (zooplankton) aggregations, oceanographic conditions, and bowhead whale distributions in the Western Beaufort Sea by conducting oceanographic sampling from a 43' boat, including sampling of whale prey, on both the coarse and fine scales. The specific objectives for the past year included completion of data analysis, preparation of data for archiving, assistance in preparation of a report to be submitted by the NMML to BOEM, and participating in project meetings with collaborators to identify syntheses.

ACCOMPLISHMENTS

All of the data collected during the project has been analyzed and is being prepared for archiving in least one national repository. The PI group met to discuss topics for synthesis at a final meeting in January in Anchorage AK, concurrent with the Alaska Marine Science Symposium.

HIGHLIGHTS

- Considerable interannual variability in physical and biological oceanography has been observed between the six years of our observations. To date, 2005, 2007, 2010, and 2011 were years with warm ocean water temperatures and little sea ice while 2006 and 2008 were years with much colder ocean water and considerable sea ice, and 2009 was intermediate in temperature between the two extremes.

- The oceanography and whale prey distribution on the shelf near Barrow are intimately tied to wind forcing.

- A favorable feeding environment for bowhead whales near Barrow is created when krill are upwelled onto the shelf from along the Beaufort Shelf break and subsequently trapped and aggregated there by ocean currents.

- This favorable feeding environment is created predictably each year, despite the considerable interannual variability in ocean conditions.

- Much lower abundances of adult and juvenile krill, key prey for the bowhead whale, were observed on the shelf in 2011 relative to previous years. Krill were predominantly of the furcilia life stage (small).

SOCIETAL BENEFITS

Defining and understanding the interannual variability in ocean conditions and whale prey and how it is associated with larger scale atmospheric and oceanographic conditions is critical to achieving a better understanding of the importance and persistence of the western Beaufort Shelf as a feeding environment for the bowhead whales during their fall migration. This in turn has implications to the success and resilience of Iñupiat subsistence whaling as well as to a better understanding of how to protect and manage the Western Arctic bowhead whale population.

EDUCATION AND OUTREACH ACTIVITIES

- Ashjian, C, Campbell, R., Okkonen, S. Alatalo, P. Year to year variability of krill abundance at a bowhead whale feeding hotspotnear Barrow, AK: 2005- 2012. January 21, 2013, Alaska Marine Science Symposium, Anchorage AK. Poster.

- A teacher, Lisa Seff, participated in our non-CINAR funded fieldwork in Barrow, AK this past summer (2012). Results from the CINAR funded project were communicated to her as part of her research experience. Ashjian and Seff also visited the Point Hope AK school where they taught four high school classes that featured aspects of this research.

- The PI team, lead by UAF collaborator Okkonen, is working with personnel at the University of Alaska Museum of the North to produce a film depicting a year in the life of the bowhead whale. Results of this research will be featured in that film.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

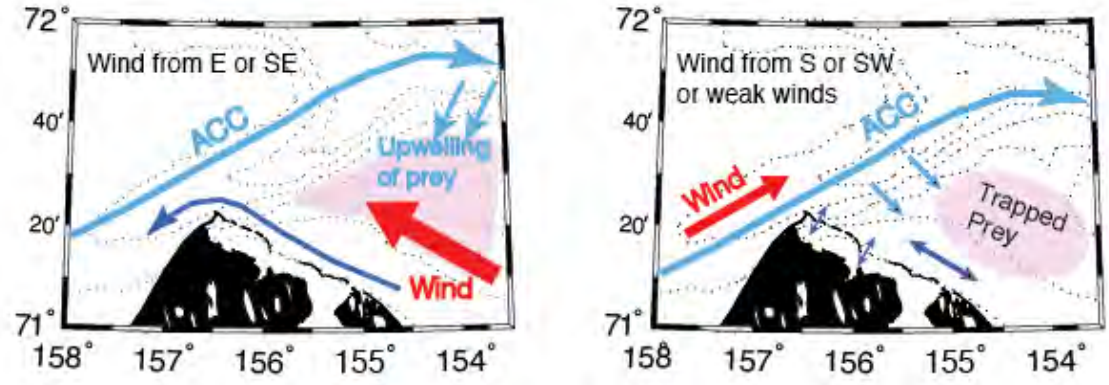


Figure 1. Schematic demonstrating mechanisms aggregating krill on the shelf near Barrow AK. (left) Winds from the east upwell krill onto the shelf and move the strong Alaska Coastal Current offshore, permitting water to exit the shelf to the west around Point Barrow. (right) If easterly, upwelling winds are followed by weak winds or winds from the S-SW, then the ACC moves inshore against the eastern wall of Barrow Canyon, trapping water and krill on the shelf and aggregating the krill in the convergence between shelf circulation and the ACC. (Redrawn from Ashjian et al., 2010).

PUBLICATIONS

Ashjian, C.J., Braund, S.R., Campbell, R.G., George, J.C., Kruse, J. Maslowski, W., Moore, S.E., Nicolson, C.R., Okkonen, S.R., Sherr, B.F., Sherr, E.B., Spitz, Y. 2010. Climate variability, oceanography, bowhead whale distribution, and Iñupiat subsistence whaling near Barrow, AK. Arctic 63: 179-194.

An Eye in the Ocean Exploration of High -Resolution Vertical Distributions of Plankton and Particles and Coincident Hydrography in the Western Chukchi Sea Using a Video Plankton Recorder

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Carin Ashjian- WHOI

NOAA Program Manager – Kathleen Crane OAR/CPO

Related NOAA Goal Plan – Goal 2: Climate Adaptation and Mitigation

CINAR Theme – Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The overall goal of the proposed work is to describe the high-resolution vertical distributions of zooplankton and particles over a range of spatial and temporal scales. Video Plankton Recorder Surveys were conducted in 2009 and 2012 as part of the Russian-American Long-Term Census of the Arctic (RUSALCA) interdisciplinary cruises. Both a broad-scale survey of the different water masses and regions of the Chukchi Sea and a high-resolution survey of Herald Valley were conducted to obtain the high-resolution distribution of plankton/particles and coincident hydrography and to describe physical-biological interactions in Herald Valley. The VPR data from the three RUSALCA interdisciplinary cruises (2004, 2009, 2012) then will be compared to determine inter-annual variability and to understand if climate change is modifying the ecosystem.

ACCOMPLISHMENTS

Research Specialist Susan Mills participated on the 2012 RUSALCA cruise as a member of the WHOI VPR/CTD team. The cruise was conducted from 27 August – 16 September, sailing to/from Nome, AK. Despite very inclement weather, a total of 38 VPR casts were done in conjunction with CTD casts. Data from the VPR casts presently are being processed to obtain in focus-images, identify the images to taxon and particle type, and calculate abundances of taxa/particles in association with temperature, salinity, and fluorescence. The VPR malfunctioned during a subset of the casts so that data density for 2012 will not be as high as for previous RUSALCA cruises. Nonetheless, significant new information will be available once processing is complete.

HIGHLIGHTS

The vertical distributions of copepods and diatoms were closely associated with the vertical structure of the water column and with different water mass types.

SOCIETAL BENEFITS

Predicting the impact of climate on ecosystems requires an understanding of the important components and interactions in the ecosystem, both to identify change and to develop a predictive modeling capability for the ecosystem. Such information can ultimately be used to help us better conserve Arctic ecosystems and, in the future, potentially manage Arctic fisheries.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

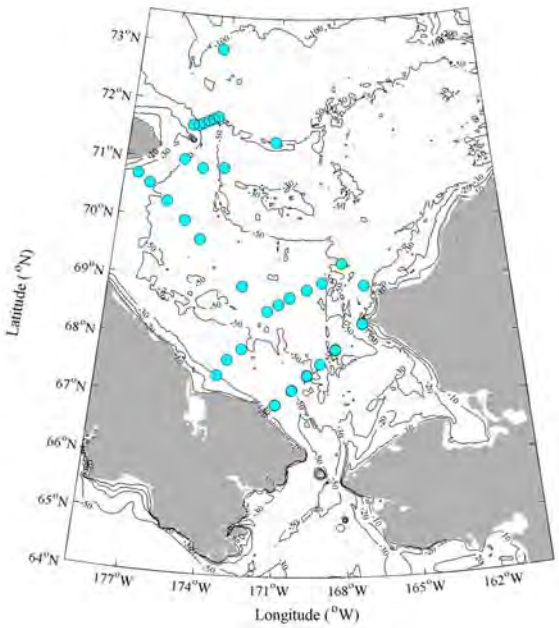


Figure 1. Locations of stations where VPR data were collected on the 2012 RUSALCA cruise.

Pacific Artic Group (PAG) Secretariat Office

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Jessica Grebeier- UMCES

NOAA Program Manager – John Calder OAR CPO

Related NOAA Goal Plan – Goal 2: Climate Adaptation and Mitigation

CINAR Theme – Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Pacific Arctic Group (PAG) is a networked group of international institutes and individuals having a Pacific perspective on Arctic science. Originally organized under the International Arctic Science Committee (IASC), the now independent PAG has as its mission to serve as a Pacific Arctic regional partnership to plan, coordinate, and collaborate on science activities of mutual interest. The current PAG science themes are focused on the structure and function of Arctic ecosystems, including atmosphere, sea ice, oceanography, and modeling. NOAA is supporting efforts to maintain the PAG Secretariat Office at the Chesapeake Biological Laboratory/UMCES and PI Grebmeier was elected Chair of the PAG in fall 2012 for a 2 yr. term. The PAG Secretariat maintains a PAG list server of participants, organizes biannual PAG international meetings, and updates and maintains a PAG website (http://pag.arcticportal.org). The PAG activities are centered around networking oceanographic field activities in the Pacific Arctic region, coordinating the Distributed Biological Observatory (DBO) as an international time-series array of latitudinal transects in the region, and undertaking various synthesis activities to better understand and track ecosystem status and trends in the Pacific Arctic marine region.

ACCOMPLISHMENTS

The PAG Secretariat provided logistical support for both the fall 2012 PAG meeting in Suzhou, P.R. of China and the spring 2013 meeting in Krakow, Poland, for participants from the 6 countries focused on marine work in the Pacific Arctic: Canada, China, Japan, Korea, Russia and the United States.

HIGHLIGHTS

- The PAG has leadership for coordinating national and international sampling on the DBO that was developed as "change detection array" to track biological response to sea ice retreat and environmental change. Repeat collections on standard transect lines from the northern Bering Sea to the northern Chukchi Sea include hydrography, plankton, benthic and upper tropic level parameters, sampled opportunistically by multiple ships from May-October.

- Sponsored the first international DBO data workshop at the PMEL/NOAA in Seattle, Washington in February 2013. Over 30 scientists from most of the PAG member countries presented data sets collected during the DBO 2010-2012 pilot program and discussed data results, data exchange and publications. The draft meeting report will be available in May 2013 on the DBO website http://www.arctic.noaa.gov/dbo

- The DBO is highlighted in the NOAA's Arctic Vision and Strategy report, the US National Ocean Policy, and is a task project within the Sustaining Arctic Observing Network (SAON) of the Arctic Council.

- The PAG has sponsored multiple synthesis products, including publications in the Chinese Journal of Polar Science (2008), EOS (2010), the NOAA Arctic Report Card (2011 and 2012), Deep Sea Research II (2012), and a special Pacific Arctic Region book to be published by Springer in late 2013.

SOCIETAL BENEFITS

The PAG activities are focused on understanding the marine system in the Pacific Arctic sector in order to better understand the status and trends of the rapid sea ice change and ecosystem response in the region. The coordinated, international activities undertaken by the PAG country members provide a cooperative framework for international science planning and activities. The results from these activities are presented to the scientific community, public forums, and to local residents in Alaska to better understand the ecosystem where projected industrial development and transportation activities are projected to increase with the rapid retreat of sea ice in the region.

EDUCATION AND OUTREACH ACTIVITIES

Presentations on the PAG activities, including the DBO, were made at the following national and international meetings:

- October 2012, PICES Fall meeting, poster and oral entitled "The Pacific Arctic Group (PAG): A Pacific Perspective on Arctic science, Grebmeier, J.M. and T. Kikuchi, Hiroshima, Japan
- December AGU, invited talk entitled "The Distributed Biological Observatory (DBO): A Change Detection Array in the Pacific Arctic Region
- April 2013, invited presentation entitled "The Pacific Arctic Group (PAG), to the Forum of Arctic Research Operators (FARO) and the European Polar Board (EPB) at the 2013 Arctic Science Summit Week in Krakow, Poland

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

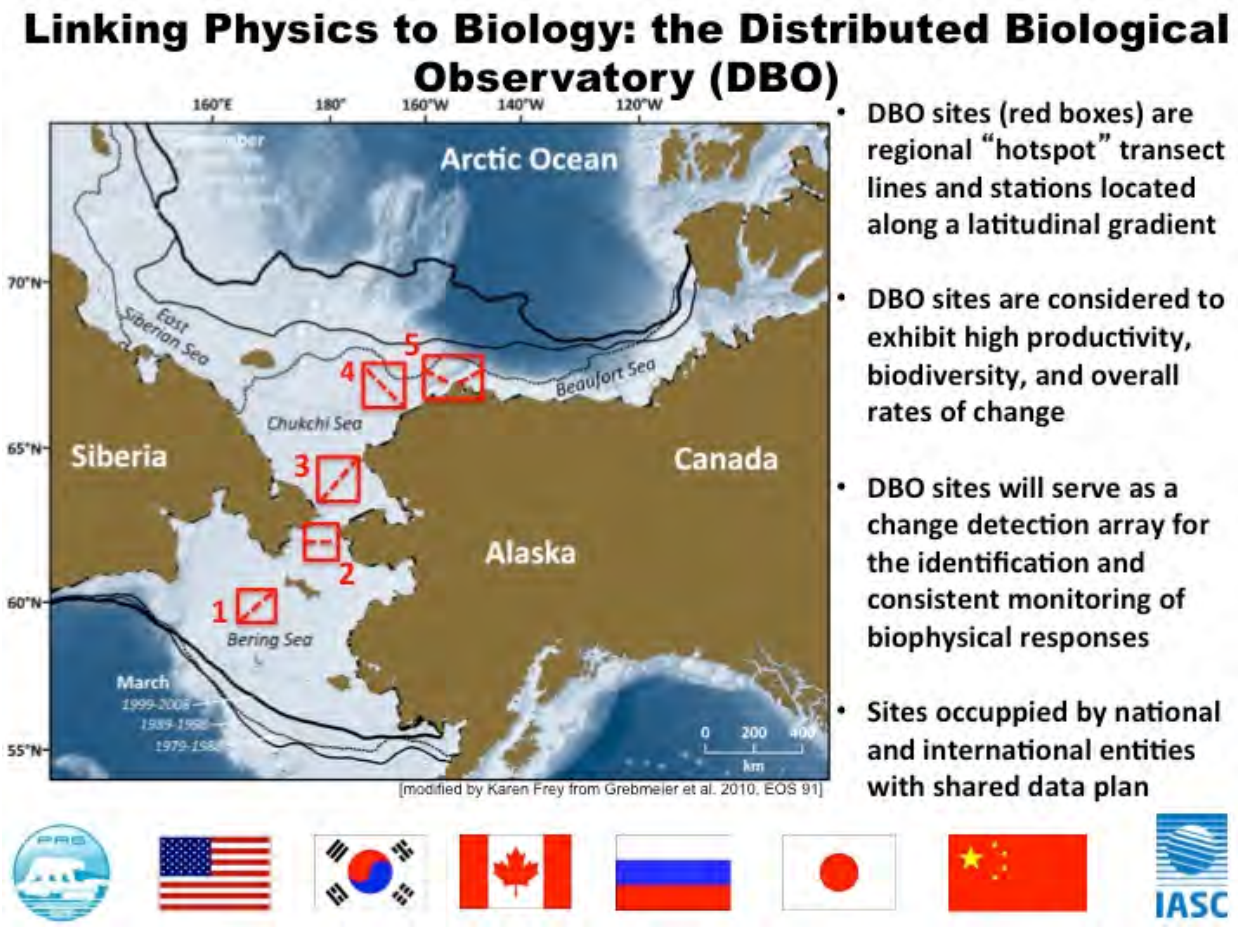


Figure 1. The Distributed Biological Observatory (DBO; http://www.arctic.noaa.gov/dbo) is being developed as a time series, biologically focused observatory in the Pacific Arctic region where international ships agree to sample standard measurements seasonally. The DBO is being coordinated through the Pacific Arctic Group (PAG; http://pag.arcticportal.org).

WHOI Contribution ARGO Float Program (2012 -2013)

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

W. Brechner Owens, Steven R. Jayne and Paul E. Robbins-WHOI

NOAA Program Manager: Dr. Steven Piotrowicz
Climate Program Office

Related NOAA Goal Plan: Goal 2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

CINAR Theme - Theme V**:** Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The goal of the Argo float program is to have 3000 profiling floats reporting profiles of temperature and salinity on a 10-day cycle covering the global ocean. The program reached this goal in October 2007. We have been able to maintain this goal due to increased lifetimes of the floats so that we can observe the changing state of the ocean associated with climate change. The US is expected to provide half the array and the WHOI component of the Argo float program represents approximately 15% of the array.

The Argo float program was designed to provide data for a number of different usages. These range from real-time analyses by operational centers to high precision analyses by climate scientists to investigate decadal climate signals. This breadth has placed an extraordinary demand on both the performance of the instruments and on the infrastructure to process the data so that they are distributed in a timely manner to real-time users and subjected to stringent quality control to provide a high-quality data set that will exponentially increase coverage and quantity of data available to construct ocean climatologies.

ACCOMPLISHMENTS

This grant covers WHOI's contribution to the Argo float program. During the period 1 April 2012 to 31 March 2013, 71 WHOI floats have been launched and 15 floats have been shipped but not yet launched. We presently have an inventory of 25 SOLO-I floats and will produce another 40 floats in the next four months from our inventory of parts. We also have an inventory of 45 SOLO-2 floats. The large inventory and slow deployment of floats are due to two reasons: (1) we have continued to have to change software in both the SOLO-I and SOLO-2 floats and (2) the delivery schedule for the SOLO-2 floats extended over a longer than expected time. We have been actively working with our SOLO-2 collaborators, MRV and Scripps Institution of Oceanography to develop the procedures, software, and product description for this float. In particular, we have developed a set of Unix scripts and C programs that decode the raw data, which we have also installed at Australia's CSIRO.

During the past year, a maximum of 301 and a minimum of 242 WHOI floats have been active and 10,097 profiles have been inserted into the Argo data system. This decrease in the number of floats is due to a significant number of floats that have reached the end of their lifetimes that

were launched 4-6 years ago and the fact that we have held back floats until we are confident that their software is robust. The present status of the array and the launch locations for the past year are shown in figures 1 and 2 below.

Of the over 100,000 profiles from WHOI floats, more than 95% have been reviewed, quality controlled, and had their salinity adjusted. In addition, a new GUI editor has been developed for carrying out quality control on the float profiles. This new editor, using MATLAB, is a significant improvement over an earlier one used in the Argo community and uses the embedded netcdf function calls that are now available in the latest versions of MATLAB. This code has been migrated to other Argo delayed mode quality control operators. We, in collaboration with Annie Wong from the University of Washington, also continue to maintain the software that is used by the Argo community to calibrate the conductivity sensors on the floats.

Over the past year, we have also further developed the WHOI web page that documents the performance of the floats and presents detailed statistics on the floats, plots of data from the individual floats. This web site can be accessed at the following URL:
http://argo.whoi.edu/
There is now a set of webpages displaying the engineering, profile, and vertical pressure time series for all the SOLO-2 floats in the Argo array. These plots are now routinely used by all SOLO-2 users and manufacturers. In addition, we have now developed a relational data base that allows us to access the details of the engineering data for each float, the specifics of the float manufacture, including serial numbers of parts, etc. We have also continued to develop this database for all the Argo fleet that allows us to access subsets of the data easily and make other summaries of the data. This database is being shared with the international Argo Information Center (AIC).

We have continued to be involved in the management of Argo, including membership in and attendance at meetings of the Argo Science Steering Team, Argo Data Management Team, and the US Argo consortium.

HIGHLIGHTS

- Continued maintenance of the 3000 Argo array despite level funding for nearly a decade.
- Production of a high quality delayed mode data set usable for detecting the small climate change signals.

SOCIETAL BENEFITS

The Argo float program is one of the primary backbones of the Global Ocean Observing System, providing *in situ* measurements of temperature and salinity from the sea surface to 2000 m depth. The Argo data are used for operational forecasts of both inter-seasonal and seasonal to inter-annual predictions, such as El Nino forecasts, and by the climate science community to estimate changes in the heat and salt content of the global oceans to monitor the changing climate of the global oceans.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

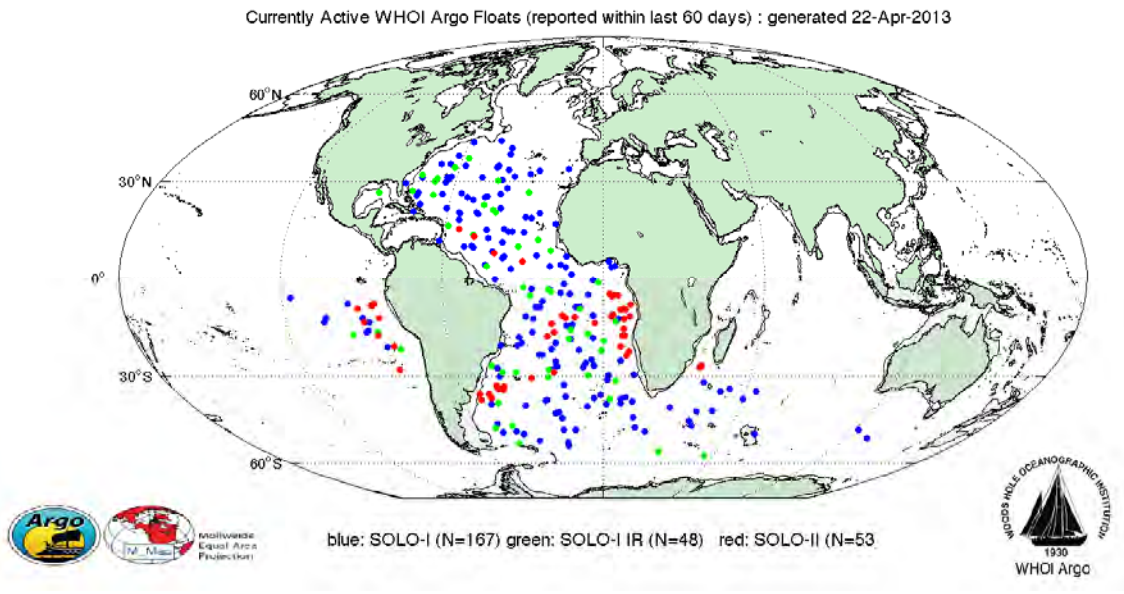


Figure 1. WHOI active floats, April 2013.

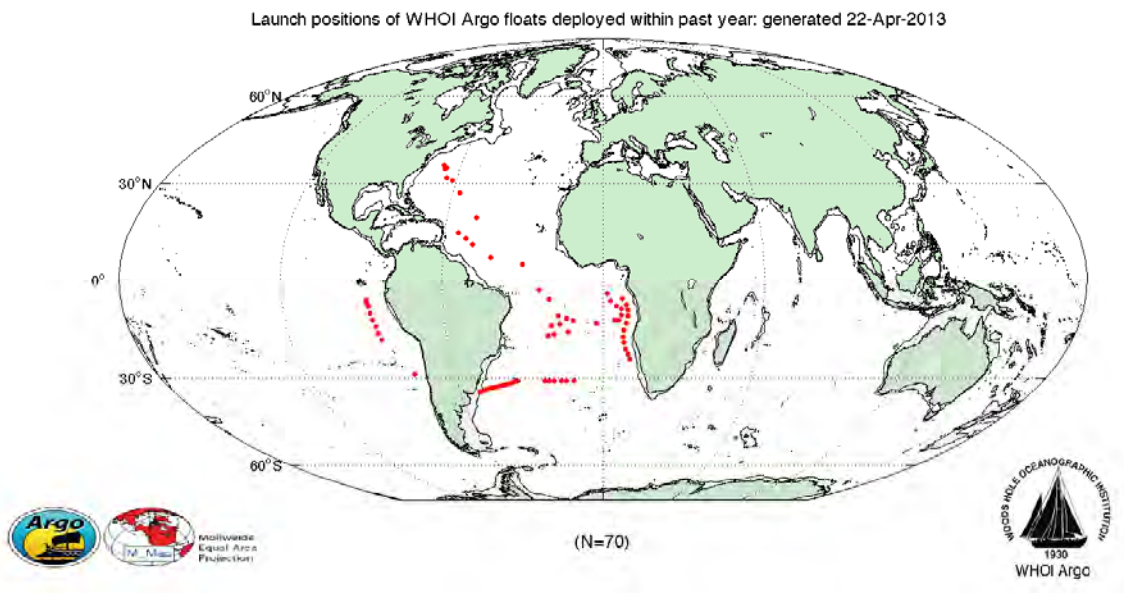


Figure 2. Launch positions of WHOI floats during the past year

Ocean Climate Observations and Analyses (2012-2013)

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI
April 01, 2012 – March 30, 2013

Robert A. Weller and Albert J. Plueddemann, WHOI

NOAA Program Manager: Diane Stanitski, OAR CPO

Related NOAA Goal: Goal 2: Climate Adaptation and Mitigation
CINAR Theme: Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The project provides critical, sustained observations of air-sea fluxes and upper ocean variability in the trade wind regions, which cover roughly 50% of the ocean surface in a wide belt spanning the equator. These regions are where the equatorial concentration of solar heating leads to net ocean heating, where the ocean provides CO_2 to the atmosphere, and where large evaporation and accompanying latent heat flux provide energy and moisture to drive the atmosphere over a range of scales, from the large-scale Hadley circulation to intense hurricanes. To provide climate-quality observing in the trade wind regions, we have developed surface moorings with the capability of making sustained, accurate observations at the sea surface and in the upper water column, and have occupied three key trade wind sites. These surface moorings are known as Ocean Reference Stations (ORS) and the three ORS sites (Fig. 1), are the Chilean stratus region site (Stratus), the Northwest Tropical Atlantic Station (NTAS), and the WHOI Hawaii Ocean Timeseries Station (WHOTS).

The ORS sites form a comprehensive array in two ways. First, they sample distinct branches of the trade wind regime: Stratus samples the descending atmospheric flow in the Hadley circulation near the origin of the trade winds, NTAS samples the ascending branch of the circulation close to the intertropical convergence zone, and WHOTS, samples the fully developed trade winds in between. Second, the three sites have specific regional attributes. Stratus is under persistent marine stratus clouds in a cool, eastern boundary current regime where models often fail to correctly represent the relevant processes. NTAS lies in the North Atlantic trade wind regions through which the hurricanes that reach eastern North America track; accurate representation of how ocean heat and moisture in this region fuel the growth of those hurricanes is needed. WHOTS, close to the Hawaiian Islands where the Keeling time series documents the increase of atmospheric CO_2, provides a critical benchmark time series of oceanic CO_2 and a record of links between changes in the regional hydrological cycle (rainfall, evaporation) and the variability and dynamics of the upper ocean there due to changes in ocean salinity.

ACCOMPLISHMENTS

The ORS meteorological and oceanographic observations provide a set of high quality air-sea fluxes of heat, freshwater and momentum as well as upper ocean heat and salt content. Key attributes are: 1) High temporal resolution to document short-lived events in surface meteorology, air-sea fluxes, and upper ocean structure, 2) High vertical resolution to document the stratified upper ocean that is in close contact to the atmosphere, 3) Sustained observations of changing atmosphere and ocean regimes, and 4) Continuous time series for validation, verification, and calibration of models and remote sensing methods. The ORS results are particularly significant in two areas: First, they provide accurate local climatologies which form the basis for examining model errors and biases and identifying anomalies in surface forcing and upper ocean heat content. Second, they can be used to quantify the processes (the contributors to local heat, freshwater, and momentum balances) that maintain the state of the upper ocean.

During the reporting period, mooring service cruises were conducted for each of the three ORS sites. Stratus was serviced by RV Melville on a cruise from Valparaiso, Chile to the Galapagos May 22 – Jun 4, 2012. The WHOTS mooring was recovered, and a new mooring deployed, in June 2012 from the NOAA Ship Hi'ialakai. The NTAS mooring, which parted after 280 days on station, was successfully recovered, and a replacement mooring was deployed, during a cruise on the NOAA FSV Pisces in December 2012.

HIGHLIGHTS

A preliminary finding from evaluation of newly processed ten-year records of fluxes from Stratus is that trade wind speeds are increasing (Fig. 2), consistent with the hypothesis of Merrifield and Maltrud (2011) that anomalous sea level rise in the western tropical Pacific (~3 times larger than the global average) is related to Pacific trade wind intensification.

SOCIETAL BENEFITS

The Ocean Reference Station project is carried out to provide critical, sustained observations of a key region of the ocean, the trade wind region, which plays an important role in weather and climate. Integrated across the expanse of the trade wind regions, errors and uncertainties in air-sea fluxes are large. Accurate estimates of the exchange of heat, freshwater, momentum, and compounds such as CO_2, in the trade wind region are required to improve understanding of the way in which the atmosphere and ocean interact and how that interaction should be represented in models used to predict weather and climate variability.

EDUCATION AND OUTREACH ACTIVITIES

Teacher at Sea: The ORS effort each year attempts to make space available on its cruises to the NOAA Teacher at Sea (TAS) program. Stratus has hosted six TAS, and one cruise was the subject the first book in the TAS children's book series. Past participation by a Chilean Teacher at Sea has been kept alive by hosting visits from her classes in the port of Arica. NTAS has hosted interns from the Joint Oceanographic Institutions (JOI) who documented their seagoing experience in a blog. WHOTS has hosted four Teachers at Sea and a NOAA Hollings Scholar.

Video: Stratus hosted volunteer Diane Suhm and funded her to produce a video documenting the 2010 cruise. This video was provided to the Climate Observation Division. A shorter version

has run on cable TV in Massachusetts and will be used at public lectures in Woods Hole. A variety of (non-professional) video footage is also available from NTAS and Stratus cruises.

Student Participation and Training: The ORS cruises, whenever possible, offer space to undergraduate and graduate students to provide hands-on experience at sea. Students and postdocs from Bigelow Marine Laboratory, CICESES (Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California), Colorado State University, George Mason University, Scripps Institution of Oceanography, Southampton Oceanography Centre, UK (now National Oceanography Centre), Texas A&M University, the University of Buenos Aires, the University of California (Santa Barbara), the University of Chile (Santiago) the University of Concepcion, the University of Hawaii, the University of Miami, the University of Washington, and WHOI have participated in ORS cruises. An excellent example of impact is Dr. Carlos Moffat. He sailed on a Stratus cruise as an undergraduate at Univ. of Concepcion (UC), liked the work, came to WHOI for graduate school, and returned to UC as faculty in oceanography.

Regional Outreach: Stratus has used opportunities derived from sailing from different Central and South American ports for regional outreach. Staff from INOCAR (Institute of Naval Oceanography) in Ecuador, the Hydrographic Division of the Peruvian Navy (DHN), the Institute of Marine Sciences of Peru (IMARPE), and the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA) have joined Stratus cruises.

PUBLICATIONS – *Please see the attached spreadsheet*

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

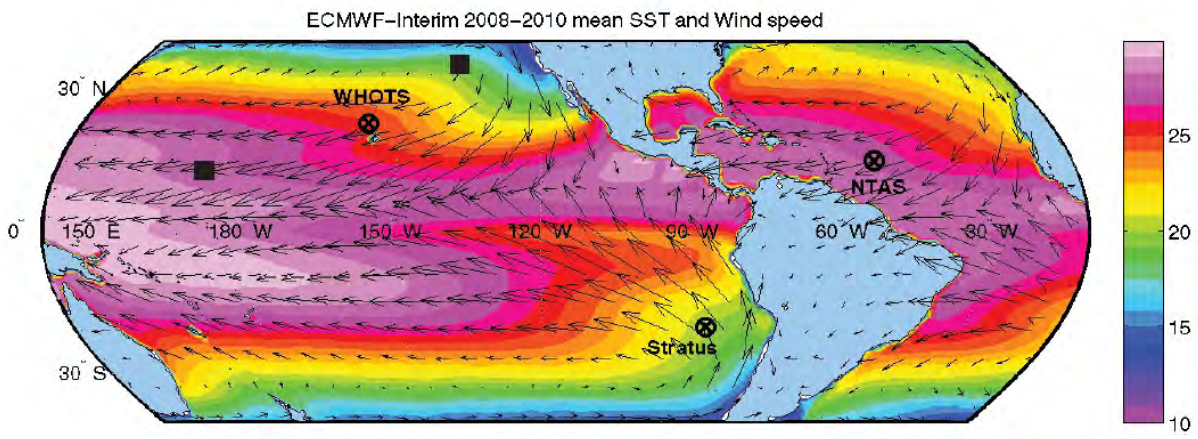


Figure 1. SST (colors) and surface wind vectors from the ECMWF-Interim reanalysis for the period 2008-2010. The positions of the Stratus, NTAS and WHOTS ocean reference station buoys are indicated. The corresponding virtual positions of the Stratus and NTAS buoys, relative to the North Pacific Hadley circulation and SST, are indicated by black squares. From Dr. Roger Lukas, Univ. of Hawaii, partner at WHOTS.

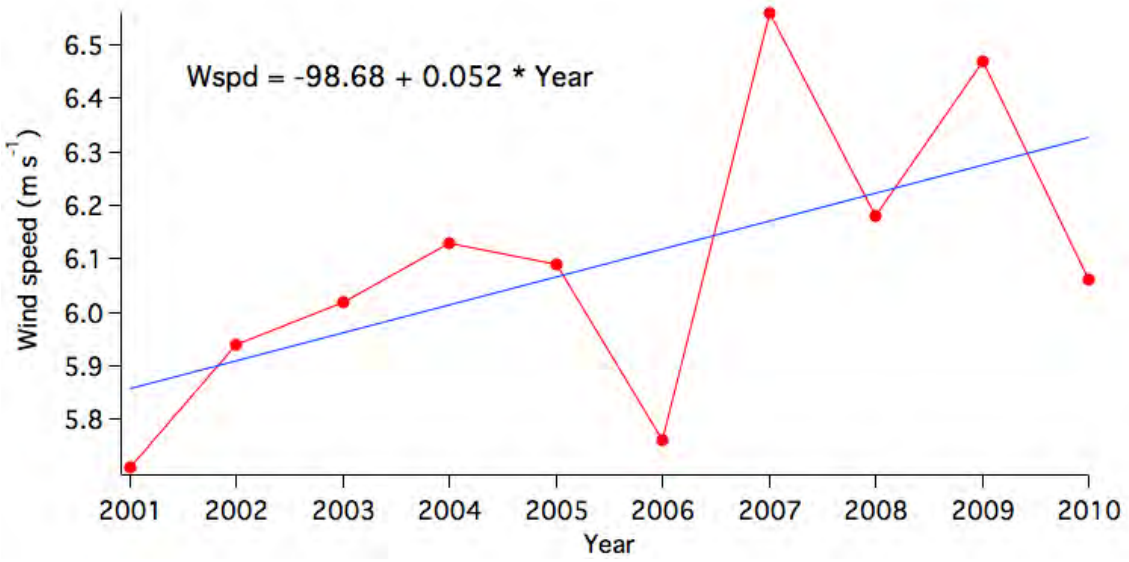


Figure 2. Annual means of the wind speed observed at the Stratus Ocean Reference Station versus time. These are preliminary results from a re-processed ten-year record of air-sea fluxes. A linear fit to the annual means points to an increase of 0.52 m s^{-1} over the last decade, well above the observational uncertainty and consistent with the hypothesis of Merrifield and Maltrud (2011, *Geophys. Res. Lett.*, doi:10.1029/2011GL049576). Further investigation, including comparison to other wind products (e.g. NCEP, ECMWF and NOAA Sea Winds) is ongoing.

50 Year Analysis Global Ocean Surface Heat Flux

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Lisan Yu- WHOI

NOAA Program Manager – NOAA Climate Observations Division

Related NOAA Goal: Goal 2: Climate Adaptation and Mitigation
CINAR Theme: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Objectively Analyzed air-sea Fluxes (OAFlux) project is a research and development project focusing on global air-sea heat, moisture, and momentum fluxes. The project is committed to produce high-quality, long-term, global ocean surface forcing datasets from the late 1950s to the present to serve the needs of the ocean and climate communities on characterization, attribution, modeling, and understanding of variability and long-term change in the atmosphere and the oceans.

The OAFlux project was established on the basis that quality global flux fields can be obtained only when data errors are properly treated. This is due to the fact that global air-sea flux fields are commonly constructed from flux bulk parameterizations that require surface meteorological observables (e.g., wind speed, temperature, humidity, cloud cover, etc.) as inputs. However, no surface meteorological observables are free from errors/biases regardless of whether they are ship-based measurements or space-born satellite retrievals. To take into account data errors, the OAFlux project developed an objective synthesis to include error information in the formulation and to improve the flux estimates through synthesizing measurements/estimates from various sources. The error information of input data is determined from air-sea measurements from surface moorings. The OAFlux established a validation data base consisting of more than 130 flux buoys from the ocean climate observing system, including the tropical moored array network in all three tropical oceans (i.e., the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) in the Pacific, the Prediction and Research Moored Array in the Atlantic (PIRATA), and the Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction (RAMA) in the Indian Ocean), and the OceanSITES Ocean Reference Stations deployed and maintained by the Woods Hole Oceanographic Institution (WHOI) and by the National Oceanography and Atmospheric Administration (NOAA) Pacific Marine Environmental laboratory (PMEL).

The OAFlux project has produced the global 1° resolution, daily/monthly analysis (1958-to present) of ocean evaporation, air-sea latent and sensible heat fluxes, and related surface meteorological variables. The products are distributed online through the project website at http://oaflux.whoi.edu/data.html and updated twice per year. The project makes continuing efforts in developing a high-resolution (0.25°) global analysis of surface heat fluxes to improve the representation of the coupling between the atmosphere and ocean fronts/eddies, developing surface radiative fluxes with improved accuracy, and progressing toward a net heat flux dataset. The OAFlux products have gained wide recognition and appreciation in the community and the OAFlux data user base is growing rapidly.

The OAFlux project demonstrates the important role of integrating air-sea measurements from the global ocean climate observing system in constraining the global flux products. On the other hand, the OAFlux global products broaden, strengthen, and enrich the use of in situ flux measurements. The buoy-validated, complete global, gridded, and temporally homogeneous OAFlux products of several-decade long can help the ocean and climate diagnostic and modeling studies in many ways that the irregularly spaced and sparse buoy time series cannot do.

ACCOMPLISHMENTS

The OAFlux global products of 50-years continue to provide new insights into the fundamental changes in the global climate under warm conditions. The evidence yielded from the OAFlux products leads to a wide recognition on the intensification of ocean evaporation since the late 1970s, providing observational support for the Intergovernmental Panel on Climate Change (ICPP) 5th assessment report (AR5) on the acceleration of the global hydrological cycle in the past warm decades. The OAFlux products lead to the finding of the important role of the strengthening ocean surface wind speed in increasing ocean evaporation, providing a thought-provoking addition to the theory based on the Clausius-Clapeyron equation. The OAFlux datasets lead to the identification of the non-negligible contribution of high-latitude sensible heat flux (i.e. the thermal exchange at the air-sea interface due to air-sea temperature differences) to global energy balance. The OAFlux global products have demonstrated in many ways their value in stimulating advances in our understanding of the role of the ocean in the global energy budget, the global hydrological cycle, and the change and variability of the Earth's climate.

HIGHLIGHTS

With the newly completed global analysis of ocean surface winds, the OAFlux project now provides climate records of global air-sea fluxes of heat, moisture, and momentum and serves the communities' need of multi-decade datasets with accuracy for research on global energy and water cycle.

Global winds have been changing. Tropical trade winds have been strengthening and southern hemisphere westerlies are found to have shifted and intensified poleward.

- The rate of ocean evaporation has been trending downward since 2000, reversing the upward trend that dictated the decades of 1980s and 1990s.

SOCIETAL BENEFITS

The OAFlux project deliverables help to identify and assess changes in forcing functions driving ocean conditions and atmospheric conditions and contribute to elucidate oceanic influences on the global water cycle.

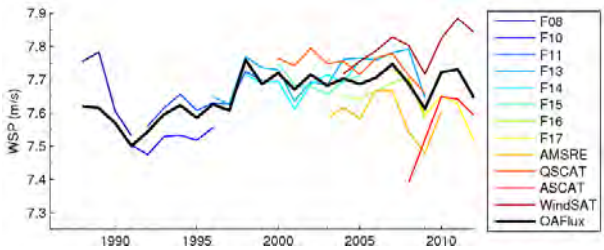
EDUCATION AND OUTREACH ACTIVITIES

The PI routinely presents research results at national and international scientific meetings. She serves on the NOAA Ocean Observing System Team of Experts and has led the analysis of global ocean surface flux for the NOAA State of Climate annual assessment report every year since 2005.

She served as the advisor for Samantha Whitmore, a 2012 WHOI Summer Student Fellow from Harvard University. She was a doctoral thesis advisor for Xiangzhou Song, a visiting Ph.D. student at WHOI. She was a committee member for Julian Schantz, a Ph.D. student of the WHOI/MIT joint program graduated in 2012.

She co-chaired an international CLIVAR workshop on "Ocean Syntheses and Surface Flux Evaluation", which was held at Woods Hole, MA, 27-30 November 2012. The workshop was funded by NASA, NOAA, US CLIVAR, and WCRP. She led a group of experts (including K. Haines, M. Bourassa, M. Cronion, S. Gulev, S. Josey, S. Kato, A. Kumar, T. Lee, and D. Roemmich) and completed a workshop report "Towards achieving global closure of ocean heat and freshwater budgets: Recommendations for advancing research in air-sea fluxes through collaborative activities" (42pp, April 2013).

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



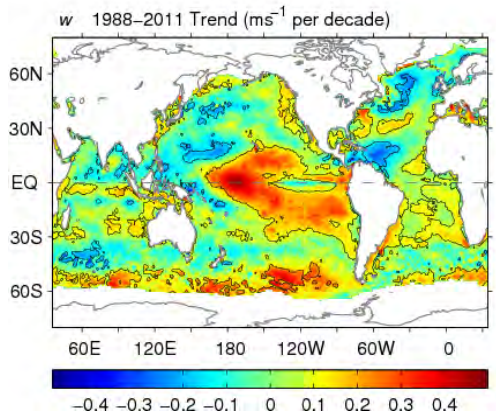


Figure 1: (left) Annual mean time series of globally averaged ocean surface wind speed that was merged from 12 satellite sensors by OAFlux. Figure 2 (right) Linear trends in wind speed, showing that the tropical trade winds and southern hemisphere westerlies have strengthened during the satellite era from 1987 onwards (adapted from Yu and Jin 2012).

THEME VI. EDUCATION.AND.OUTREACH

Research And Education In Quantitative Fisheries and Ecosystem Science

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoints 66, 80, 81, and 82
April 01, 2012 – March 30, 2013

Donald Anderson - WHOI

NOAA Program Manager – Bill Karp NMFS NEFSC

Related NOAA Goal Plan – Goal 2: Climate Adaptation and Mitigation
CINAR Theme: Education and Outreach

PROJECT OVERVIEW

Both NOAA and the NEFSC have a need for skilled personnel and new technologies to assist in stock assessment and quantitative fisheries science. In the Northeast region, there has been considerable controversy within the fishing community and fisheries management councils as well as with NOAA and its scientists because of disagreements concerning the existing size of fish stocks, the acceptable harvesting levels, and the best ways to determine these important parameters. A significant additional complication is the congressionally mandated need to manage fisheries in the context of the complex ecosystem interactions that are involved. As a result, Integrated Ecosystem Assessments and Ecosystem Approaches to Management are now being developed for the Northeast Continental Shelf Ecosystem. These new responsibilities, added to the need for traditional assessment surveys for individual fish stocks, has led to heavy pressure on dwindling budgets for monitoring and assessment activities in the region.

Compounding these challenges is a current and projected shortage of trained fisheries scientists throughout NMFS. With NOAA funding, CINAR has recently initiated a research and education program to address both of these shortfalls through the enhancement of teaching and advising activities in a graduate fisheries program, and the development and implementation of new technologies that can improve and enhance assessment and management capabilities in the region. The program is a partnership between the Woods Hole Oceanographic Institution (WHOI) with its strong research, instrumentation, and modeling capabilities, and the University of Massachusetts School for Marine Science and Technology (SMAST) which has an established graduate program in Fisheries Science and longstanding involvement with fisheries stock assessment, management, and socio-economic research.

ACCOMPLISHMENTS

A competition for CINAR Fellows in Quantitative Fisheries and Ecosystem Science was held in the fall of 2013. We received a remarkably strong set of seventeen applications from WHOI scientists in response to CINAR's call for applications. These files were reviewed and ranked by a committee of WHOI scientists, the WHOI Director of Research, NEFSC representatives, SMAST representatives, and the CINAR Director. With this funding and additional funds provided by both the NEFSC and WHOI, three CINAR Fellows were appointed: Rubao Ji, Associate Scientist, Biology Department, Porter Hoagland, Senior Research Specialist, Marine Policy Center, and Gareth Lawson, Assistant Scientist, Biology Department. Each of these Fellows will receive three months support per year for a period of three years.

Rubao Ji's CINAR Fellowship will allow him to work on transferring the tools and data products developed in his previous and on-going research projects for fisheries stock assessment and management, and to enhance/expand his existing education and training activities with NOAA and SMAST. As a CINAR Fellow, Porter Hoagland will continue work with colleagues on the development of a conceptual framework for the contribution of the social sciences to ecosystem-based fisheries management (EBFM). Further, he will study the implications of competing models of the US northeast shelf ecosystem for the economic and welfare impacts of alternative fishery conservation and management strategies. Of particular interest is the identification of strategies that perform well under different ecological models and are, therefore, robust against model uncertainty. Gareth Lawson, in collaboration with colleagues at the Northeast Fisheries Science Center, plans to focus on the development of acoustic techniques for sampling zooplankton and micronekton for the purpose of ecosystem assessment. He will also apply such techniques to the study of euphausiid ecology in the Gulf of Maine region and ecosystem dynamics at the New England continental shelf break. These efforts will leverage a recent grant from the NOAA Fisheries Advanced Sampling Technology Working Group to Lawson and collaborators as well as a new postdoctoral researcher co-advised by Lawson and NOAA scientists Michael Fogarty and Jason Link.

At SMAST, a review is currently underway to appoint a new faculty member beginning in the fall of 2013. In the meantime, three graduate students have been appointed with these funds. Alexa Kretsch, Master's student, is working with Daniel Georgianna and Kevin Stokesbury to estimate the spatial and temporal distribution of Atlantic surf clams using data collected from the SMAST video survey in order to create an independent estimate of Atlantic surf clam abundance. Brooke Lowman, Master's student, is working with Saang-Yoon Hyun to develop a species interaction model for yellowtail flounder and one of its predators or competitors. Erin Adams, Master's student, is working with Daniel Georgianna to develop and apply metrics to evaluate the Research Set Aside (RSA) program, a cooperative grants program that sets aside a portion of the fishing quota to fund research for use in stock assessment and fisheries management.

SOCIETAL BENEFITS

The need for trained personnel and new technologies in fisheries science is significant and increasing. Dwindling fish stocks and associated economic impacts plus intense political pressures all dictate that immediate steps be taken to enhance the scientific basis of assessment and management of resources and to educate future personnel in quantitative aspects of fisheries science. In response, we are developing a research and education program to provide teaching and advising activities, and to develop and implement new technologies that can improve and enhance fisheries assessment and management capabilities in the US Northeast coastal region.

EDUCATION AND OUTREACH ACTIVITIES

CINAR Fellows are involved in teaching courses related to ecosystem management, such as the Bio-Acoustics summer course at Friday Harbor Laboratories, University of Washington, and Quantitative Methods in Marine Affairs at the University of Rhode Island. Undergraduate, graduate students and postdoctoral investigators are also sponsored in the Fellows' laboratories, where they are exposed to, and participate in, research related to ecosystem science.

US National Office for Harmful Algal Blooms

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 13
April 01, 2012 – March 30, 2013

Donald Anderson - WHOI

NOAA Program Manager – Quay Dortch NOS

Related NOAA Goal: Goal 2: Climate Adaptation and Mitigation

CINAR Theme: Education and Outreach

PROJECT OVERVIEW

The U.S. National Office for Harmful Algal Blooms serves as a "clearinghouse" for information related to national and international activities on HAB issues. One of its primary roles is to assist in the development of an integrated, national HAB research agenda based on technical evaluations of current research efforts, workshop activities, and ongoing Federal and state agency efforts to prevent, control and mitigate HABs. Further, the National Office serves as a focal point for HAB research and information by organizing and providing for scientific community access to the latest research developments, workshop reports, research strategies, and related data and information. **The primary objective of the Office is to facilitate an open exchange of scientific information and advance the state of knowledge and research efforts.** The National Office coordinates the interests of, and fosters collaboration among, the many stakeholders in HAB research and mitigation: Federal agencies with responsibilities to address HAB issues, the academic research community, and regional and local resource managers. The National Office also facilitates coordination and information exchange between the U.S. and international HAB research and mitigation efforts, and when requested, with the U.S. Congress.

ACCOMPLISHMENTS

Communication and Outreach:

National HAB Web Site: The *Harmful Algae* Web Site (www.whoi.edu/redtide) serves as a critical resource for the U.S. HAB community. The site receives between 6,500 and 7,500 visits each month. In addition to maintaining the Web Site, conference announcements, funding opportunities, reports, etc. of interest to the HAB community are routinely posted and circulated through our numerous listservers. We have initiated a survey on our webpage to assess the general readership level and the type of information most visitors desire. The survey results will guide revisions we are planning for the site later this year. We also post approximately 2-3 announcements per week to our Harmful Algae Facebook account for the National Office – typically these are links to harmful bloom events in the US. We have received positive response from the community about this effort with 268 "likes" at present.

Information requests: The National Office deals with many direct requests for information that are elicited by the site. These include frequent requests for photographs or other media products, referrals to experts in particular regions or disciplines, inquiries from students doing reports, and journalist inquiries. Another important type of interaction is with victims of HAB poisonings who are seeking help in the form of information and referrals to appropriate physicians. In many of these cases, direct personal interactions via e-mail and telephone are needed, requiring

considerable time commitments, but also providing a necessary and valuable level of service to the public.

ICES Working Group on HAB Dynamics (WGHABD):

Each year we collect information on HAB events in the U.S. as the ICES *National Coordinating Center for Exchange of Information on Harmful Algal Blooms.* This involves interacting with colleagues around the U.S. to compile reports of all national HAB events each year. We are responsible for the entry of these data into the Harmful Algal Event Database (HAEDAT) maintained by the ICES Science and Communications Center in Vigo, Spain. Presentations on these bloom reports are also given at annual working group meetings of the ICES Working Group on Harmful Algal Bloom Dynamics (WGHABD). National and international bloom reports are provided to all U.S. network participants, as well as to other interested parties. This is the only compilation of U.S. HAB incidents. Decadal maps for all U.S. HAB events are updated annually for ICES as well as posting on the Harmful Algae Web Site (see www.whoi.edu/redtide/page.do?pid=14898&tid=542&cid=47899&c=3 for an example).

At the 2013 WGHABD meeting, PI Anderson presented information regarding a planned workshop entitled *Automated Harmful Algal Blooms in situ Observing Systems*. He also led a discussion on this topic and the decision was made that it was not feasible to hold this workshop until 2014.

Event Response Program

The National Office administers a Rapid Response Program for HAB Events in the U.S. in cooperation with CSCOR administrators. This involves advertising availability of funds to the HAB community as well as accepting requests for funds and administering their dispersal. The National Office works with NOAA Program Managers who decide who receives funds and how much will be needed in each case. Additionally, we make arrangements and process travel, vessel charters, analyses and other expenses associated with these rapid response activities. During the past year we arranged funding for the following events: PSP event, Long Island; PSP event, Alaska; DSP event, Washington state; ASP event, Maine; brown tide, Florida; and *Karenia* event and manatee deaths, Florida.

Scientific Meetings/Workshops:

The National Office often assists with the formulation of scientific agendas, arranging for financial and administrative support, and providing expert representation for national and international HAB workshops, symposia, and conferences. The National Office also assists in selection and disbursement of funds for student travel to national and international conferences, workshops, and training courses. During the project year, meetings we were involved with include: the 15th International HAB Conference, Korea, a workshop on HABs in a Changing World, and the Seventh US HAB symposium.

US HAB symposia. Kleindinst serves on the Steering Committees for the *Seventh Symposium on Harmful Algae in the U.S.,* planned for November, 2013 in Sarasota, FL. She provides administrative support for this meeting, working closely with the organizers throughout the planning process and communicating updates and announcements to the U.S. HAB community. The National Office will also handle travel awards for students and managers for the HAB symposium.

International HAB Conferences. Anderson served on the Steering Committee for the *15th International Conference on Harmful Algal Blooms* which was held in Korea in November 2012. The National Office also assisting by handling applications for U.S. student travel awards and the subsequent processing of reimbursements.

HABs in a Changing World. This workshop took place in March 2013 in Friday Harbor, WA. The National Office helped with organization and providing travel support for some of the U.S. participants. PI Anderson contributed a white paper and led a number of breakout sessions. He will also be coauthor of a publication derived from that meeting.

IOC Intergovernmental Panel on HABS (IPHAB):

PI Anderson serves as one of the US national representatives to this panel and attended the Tenth Session held in Paris, April 2011 and will attend the Eleventh Session in April 2013. One of the resolutions from the Tenth Session was to organize a meeting on "*Impacts and management of toxic and harmful algal blooms at desalination plants and related seawater facilities*". Anderson was selected as Chair of the Organizing Committee and has been devoting time to establishing the Steering Committee, seeking funding for the meeting, and establishing a network of individuals and stakeholders to participate. In support of these activities, he attended the *Expert Workshop on Red Tides and HABs: Impact on Desalination Plants*, sponsored by the Middle East Desalination Research Centre, Muscat, Oman, where he presented three invited talks. He was also the lead author of a report prepared from that workshop. Considerable time will be devoted in the coming year to organizing and convening the IPHAB conference on this topic, probably in early 2014.

National HAB Committee (NHC):

The National HAB Committee was formed in 2005 and is charged with overseeing coordination and implementation of the revised US National Plan. The National Office provides support to the NHC. Each year we request nominations for election of new members from the community and handle the subsequent election and notifications, and, as appropriate, nominations and voting for Committee Chair(s). We initiated and continue to maintain and update the NHC Web Site and listserver, set up for quick communication by this group. Kleindinst provides administrative support to this group and both she and Anderson serve as ex officio members. Kleindinst also serves on the subcommittee on Education and Outreach. The National Office arranges and leads conference calls for the group as well as in-person meetings.

HIGHLIGHTS

- A survey of the Harmful Algae webpage is currently underway. Results will guide revisions to that site planned for later this year.
- A Scientific Steering Committee has been established for the planned international conference on HABs and Desalination, a preliminary agenda prepared, and partial funding obtained. The venue will be Muscat, Oman, with the meeting to be convened in early 2014. A presentation and discussion to aid in planning this workshop will be held at the 11th Intergovernmental Panel on Harmful Algal Blooms. In Paris, April 2013.

SOCIETAL BENEFITS

All of the activity under this project relates to HABs, a serious and growing threat to the nation's fisheries, coastal ecosystem and human coastal communities.

EDUCATION AND OUTREACH ACTIVITIES

- Anderson, D.M., Keynote talk, "The global problem of red tides and harmful algal blooms: an emerging threat to desalination plants", Desalination for the Environment, Barcelona, Spain (April, 2012)

- Anderson, D.M., US Summary of Harmful Algae Events – 2011, ICES WGHABD, Oban, Scotland (April, 2012)
- Harmful algae website – http://www.whoi.edu/redtide
- National HAB Committee Web Site: www.whoi.edu/nationalhab/
- Northeast PSP website - http://www.whoi.edu/northeastpsp/

Marine Resource Education Program: Professional Training for Fisherman in the Northeast Region and a Forum for Dialogue among Fishermen, Scientists and Managers.

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 77
April 01, 2012 – March 30, 2013

Alexa Dayton- GMRI

NOAA Program Manager: Jon Hoey -NMFS

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme*:* Education and Outreach

PROJECT OVERVIEW

The Gulf of Maine Research Institute (GMRI), in collaboration with fishing industry partners, John Williamson and Mary Beth Tooley, delivered 2 three-day workshops of the Marine Resource Education Program, MREP Fishery Science 100 and Management 100, in Baltimore, MD. The objective of these workshops was to duplicate the MREP training experience, long employed for New England fishermen, for a Mid-Atlantic audience.

In advance of the two workshops delivered, we engaged in a process for developing a curriculum tailored to the needs of Mid-Atlantic fishermen. We formed an MREP-MA curriculum steering committee and began the process of building capacity to develop and implement an introductory MREP program for the region. We had originally proposed to deliver the introductory series of MREP 100 Science and Management modules in early 2012, but in response to recommendations of the industry members of this Advisory group, engaged in a more extensive exercise in curriculum development, pushing the delivery dates into the next cycle.

As previously reported, a curriculum steering committee of regional industry members and agency partners was convened in December 2011, making initial recommendations to identify a curriculum suitable to the region and its stakeholders. From that exercise, and consultations with Mid-Atlantic fishermen and Mid-Atlantic Fishery Management Council (MAFMC) members through the winter and spring of 2012, a new set of curriculum parameters were developed, culminating in a second, very fruitful, Mid-Atlantic curriculum steering committee meeting in July 2012.

ACCOMPLISHMENTS

As part of the team approach to conducting MREP, moderators were recruited from the Mid-Atlantic fishing community to facilitate discussion at each three-day workshop. Community facilitators are typically chosen for their leadership skills and familiarity with management process. The two volunteers were highly respected voices of the seafood community who contributed substantially to the agenda design and substance.

In selecting the final roster of attendees, we sought geographic diversity and to orchestrate balance between commercial fishermen and seafood dealers (50%), for-hire recreational fishermen (30%), and private recreational anglers (20%). Two individuals from ENGOs attended both modules as did the MAFMC Coast Guard representative.

Core elements of the MREP-MA Science 100 were adapted from the long-standing New England experience; these included:

- Population Biology
- Sampling, Statistics and Surveys
- Stock Assessments, Modeling and Biological Reference Points

New elements were added based on recommendations of the Mid-Atlantic Curriculum Working Group:

- Biological oceanography and climate change
- Ecological relationships affecting stock assessments
- Avoiding bycatch mortality in recreational fisheries
- Selectivity techniques in commercial fisheries
- A wrap-up session for the Science Center Deputy Director to "pull together all the moving pieces", setting the stage for the management module.

The MREP-MA Management 100 required a somewhat more complex revision. Core elements such as fishing community coaching on effective participation in process and by the Coast Guard were reformulated for a Mid-Atlantic audience. As with the traditional program approach, Day-One introduced:

- Laws and Jurisdictions
- NMFS internal regulatory review process
- MAFMC process

An added new element included:

- ASMFC process and the interaction with federal fishery management

An innovation recommended by the curriculum steering committee involved a role-play exercise meant to offer hands-on exploration of the interaction between state and federal fishery management. Participants were given the description of a fishery management plan (FMP) for a hypothetical fish stock, The Super Fish Case Study, culminating in a management simulation exercise. For this purpose, participants were divided into two teams and assigned roles in the negotiation of an annual specification package, allocating Super Fish landings' quota (ACL) to commercial and recreational fisheries. As part of the exercise, hypothetical "fishery managers" were required to determine an appropriate reduction in ACL to account for added management uncertainty in the FMP performance.

MAFMC staff and the MREP principals served as fact-sources for the negotiations, helping participants to sort out the appropriate responsibilities of the role assignments.

Participants reported that the exercise "made real" the jurisdictional and process facts previously presented. As important, the role-assignments were written to create internal conflicts in the negotiation, ensuring that there would be no easy route to a specification package. Discussion traced the development of an ACL recommendation from the stock assessment process described in the Science Module, systematically through the various elements in the management process.

A version of the "Super Fish Case Study" will be further developed for the New England MREP Management 100 scheduled for June 2013.

HIGHLIGHTS

- A MREP Mid-Atlantic Curriculum Committee; July 17, 2012; Baltimore, MD and ongoing communications by phone and email

- MREP Fishery Science 100; November 27-29, 2012; Wyndham Hotel, Baltimore, MD
- MREP Fishery Management 100; January 22-24, 2013; Wyndham Hotel, Baltimore, MD

- New curriculum tools developed for use in future MREP modules

SOCIETAL BENEFITS

MREP prepares industry members for meaningful engagement in the fisheries management process, to contribute to improvement of fishery data collection, and to trust and believe in science concepts underlying management. Further, it develops a network of dialogue within the fishing community, of people who have "self-selected" as thoughtful and positive toward management.

EDUCATION AND OUTREACH ACTIVITIES

Because of the innovative nature of the material, we treated these initial offerings as "pilots" to be further developed as an ongoing Mid-Atlantic MREP to be led by Mid-Atlantic constituents. We also drew parallels to the "visioning" process currently under way by the MAFMC, relating to recommendations of their Vision and Strategic Plan Committee for the MREP training. At the request of the Mid-Atlantic Council Executive Director and Council Chairman, we marketed these initial MREP offerings to MAFMC Advisors, Council members and a small group of fishing community members recommended as having engaged in the visioning effort. In all, 105 individuals received email invitations from Chris Moore (MAFMC Executive Director), followed by a detailed program description and application by mail. The program description and electronic application were also posted on a webpage dedicated to MREP on the MAFMC website, and similarly on the GMRI MREP web-location. In the run up to the module dates, members of the Implementation Team maintained running conversations with key individuals in the community to encourage awareness and recruit participation. In all, 27 individuals attended one or both modules (26% response rate), 18 for Science and 18 for Management. Eight also pre-registered for the MREP Science 200 (advanced stock assessments) scheduled for May 2013 in Woods Hole.

A consequence of holding the workshops in Baltimore, allowed participation by Bill Chappell, Chief of NMFS Regulatory Services Division, Silver Spring, MD. Bill gave a detailed presentation on NMFS regulatory process which was well received in fishermen's evaluations.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Fishermen listen intently during a presentation on enforcement role in regulatory development, MREP Fishery Management 100, January 2013.

NMFS scientist Gary Shepherd demonstrates biological sampling, MREP Fishery Science 100, November 2012.

Fisheries Science & Management Education for Fishermen in the Southeast Fisheries Region

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2012 – March 30, 2013

Alexa Dayton- GMRI

NOAA Program Manager: Kim Amendola NMFS/SER/SERO

Related NOAA Goal Plan: Goal 1. Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems

CINAR Theme*:* Education and Outreach

PROJECT OVERVIEW

The Gulf of Maine Research Institute (GMRI) proposed to collaborate with partners in the Southeast fisheries region to develop and implement a Fishery Science & Management Education Program for commercial and recreational fishermen, modeled after the highly successful New England Marine Resource Education Program (MREP). This education enables fishermen and others to participate productively in the fisheries management process, and leads to improved cooperation and trust between fishermen, scientists and managers. Fundamentally, a co-learning approach is used in this program, where program developers, program participants and program presenters all learn from one another through their interactions and collaborations.

GMRI proposed to recruit a regional Team of Advisors and engage them in a program development process. The New England curriculum provides a starting point, to be translated and tailored to the fisheries, fishing communities, and management practices of the region. GMRI recognizes that localized cultural differences must be fully understood and will cast a wide net to ensure that the program is tailored and positioned appropriately for the region.

GMRI proposed to recruit twenty program participants for the first of two workshops during the reporting period, and class composition was proposed to reflect a high degree of diversity. Program implementation will consist of a series of two workshops, which build upon each other: a multi-day fishery science workshop, followed by a multi-day fishery management workshop. The format of the workshop creates an open dialogue among participants and presenters in which they explore ways of fostering cooperation among fishermen, scientists and managers.

ACCOMPLISHMENTS

During the summer of 2012, we formed a Steering Committee of 20 individuals with balanced interests and fisheries backgrounds, and supported by scientists and fishery management representatives. This Steering Committee was convened for 2-days in September 2012 to complete an analysis of fishery management issues, and determine the core content of the science and management educational workshops.

Sub-committees were formed to then detail specific aspects of the program, curriculum and presenter selection, as well as logistics. Two individuals were identified to provide overall

industry program leadership and guide the process in partnership with GMRI staff. The program identity, in the form of a new logo and a web page, were developed and used in the promotion of the program and recruiting efforts.

During the winter months from October 2012 – March 2013, the group detailed out the program presentations and content, identified speakers and presenters, and selected a location for the first workshop, in a central location. The team mounted recruiting and program awareness efforts, to generate 60 applications for 20 spaces. A decision to increase the class size to 32 was made based on the demand from industry.

The science workshop was delivered in April, 2013 at the Florida Fish & Wildlife Research Institute in St. Petersburg, FL. A total of 10 presenters, drawn from NMFS, FFWRI and University of South Florida, spoke with the group of fishermen over a period of 3-days. Interactive hands-on stations, research lab tours, and research vessel tours were a part of the curriculum. Ample discussion period, moderator by an industry member provided a neutral forum for dialog between fisheries stakeholders, scientists and managers in the region.

The evaluations from the first workshop were universally positive, and all participants were pleasantly surprised by the effective format, the knowledge, and the new networks they gained from the experience. We asked if they were more of less likely to participate in the fishery management process as a result of this workshop, and the group responses indicated a significant increase in their likelihood to participate.

All participants have indicated a desire to return for the management workshop, which we expect to hold in September 2013.

HIGHLIGHTS

- Established Program Team of Advisors (renamed as "Steering Committee") with balanced representation of key fishery stakeholders.
- Convened two-day Steering Committee meeting to articulate program needs and goals
- Fisheries science education program developed
- Speaker's bureau established for science workshop
- Fisheries science education program delivered for 32 fishermen and an additional 18 speakers and other guests, in St. Petersburg FL April 2 – 4, 2013

SOCIETAL BENEFITS

We delivered the first MREP Southeast Science workshop, as a foundation for improved trust in the stock assessment process.

MREP Southeast has prepared industry members for meaningful engagement in the fisheries management process.

One of the unexpected outcomes was that we enlightened several of the Science workshop attendees to the fact that they have public representation to assist them and answer questions. This completely turned their attitude around, and they will help share this knowledge with others. They learned about the existence of the NOAA Regional Office, and the two fishery

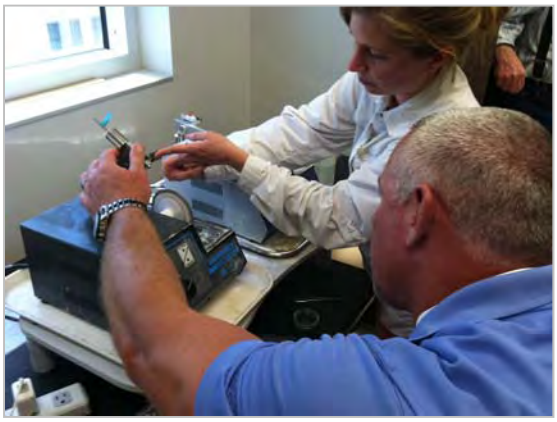
management councils, and made direct contact with people who can listen to their concerns. They were unaware of the existence of this entire Federal governance process until this event.

Another unexpected outcome was that one of our Steering Committee members decided to pursue, and was subsequently offered, the position of Executive Director for the Gulf of Mexico Fishery Management Council.

EDUCATION AND OUTREACH ACTIVITIES

- The full Steering Committee was provided with quarterly updates on curriculum development progress, which written and sent by GMRI staff.
- Program awareness and recruiting for attendees for the science program took place during the months Jan – March 2013.
- We employed a combination of tactics whereby we requested the councils include an announcement in their council meeting updates, and communications to their lists.
- We also enlisted the Steering Committee members as program ambassadors, and the response was tremendous. They reached out to their networks and helped spread the word.
- GMRI staff guided the development of a new and unique logo for the program, with the goal of being a close relative to the New England Program, but also unique enough to ensure regional applicability. The Steering Committee was provided several options for consideration and then provided feedback to arrive at the final result, which has been warmly adopted by all involved in the program thus far.
- We developed a colorful postcard that could be easily circulated and handed out by Steering Committee, and councils alike and provided each person with 20 to hand out, each council with 250.
- We obtained a mailing list of all Federal permit holders in the Southeast region, and another list of dealers and seafood processors. The total potential mailing list size was 18,000 from which we randomly selected 5,000 names to receive the postcard via bulk mail.
- GMRI staff reached out to the NGO community and other associations, including Ocean Conservancy, EDF, Coastal Conservation Association, and Charter Fisherman's association, to inform them of the effort and provide them with an opportunity to ask questions and be involved.
- A unique website page was developed for this effort. We used photos provided by Steering Committee members, and NOAA staff to ensure the proper look and feel for the Southeast region.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Recreational fisherman and radio show host, Captain Mike Anderson, is offered a chance to cut an otolith - a fish bone, which is used to ascertain the age of fish, a critical data input to the fishery stock assessment process.

The group reviewed conservation engineering projects and learned about techniques for safe release of Red Snapper, a species of concern in the Gulf of Mexico and South Atlantic fisheries regions.

Senior scientist, Clay Porch, provides a very simple and easily understood introduction to the methods used in stock assessments; Caribbean fishermen in the foreground ask questions about sources of data used in the process.

Bill Kelly, of the Florida Keys Fisherman's Association, converses with Doug Gregory, of Florida Sea Grant, at MREP Southeast Steering Committee meeting.

APPENDIX 1: CINAR PERSONNEL SUMMARY:

April 1, 2012– March 31, 2013

Task 1 Support

Employees **Appt. Dates**

Don Anderson, CINAR Director 7/01/09 - present
Judy Kleindinst, CINAR Administrator 7/01/09 - present
Ann Stone, CINAR Administrative Professional 9/26/09 - present

Postdoc	CINAR Theme	Appt. Dates	Advisors
Dr. Robert Todd University of California, San Diego	Sustained Ocean Observations and Climate	Fall 2011 (18 month appt.)	Fiammetta Straneo Glen Gawarkiewicz Steven Lentz Albert Plueddemann
Dr. Ke (Kevin) Chen North Carolina State University	Sustained Ocean Observations and Climate	Fall 2012 (18 Month appt.)	Glen Gawarkiewicz Steven Lentz
Dr. Sarah Bender University of Washington	TBD Fall	2013 (18 Month appt.)	TBD

APPENDIX 2 : CINAR PERSONNEL SUMMARY CHART :

April 1, 2012 – March 31, 2013

Category	Number	B.S	M.S	PhD.
Employees who receive ≥ 50% NOAA Funding (not including Students)				
Research Scientist	2	1	1	0
Visiting Scientist	0	0	0	0
Post Doctoral Fellow	2	0	0	2
Research Support Staff	10	5	5	0
Administrative	0	0	0	0
Total	14	6	6	2

Category	Number	B.S	M.S	PhD.
Employees who receive < 50% NOAA Funding (not including Students)				
Research Scientist	38	4	9	25
Visiting Scientist	1	0	0	1
Post Doctoral Fellow	1	0	0	1
Research Support Staff	45	24	16	5
Administrative	14	7	1	0
Total	99	35	26	32

Students	-	-	-	-
Undergraduate Students	5	0	0	0
Graduate Students	4	0	2	2
Total	9	0	2	2

Obtained NOAA employment within the last year	0	0	0	0

CI Name	PI Name / Author Names	Status of Publication (In Review , In Press, Published)	Publication Date	Publication Title	Published In (Journal Name, volume and page number)	Type of Publication	Citation No. (Digital Object Identifier)	CI Lead Author	NOAA Lead Author	Other Lead Author	Peer Reviewed	Non Peer Reviewed
CINAR	Annala, J.	Published	7/24/2012	Report of the Workshop on Stock Structure of Atlantic Cod in the Gulf of Maine Region		Workshop Proceedings		X				X
CINAR	Annis, E.	In Review		Evidence for thermally mediated settlement in lobster larvae, *Homarus americanus*	Canadian Journal of Fisheries and Aquatic Scien	Journal Article				X	X	
CINAR	Bergeron, C.	In Review		Modeling growth of the American lobster, *Homarus americanus* in regions of contrasting oceanography	Canadian Journal of Fisheries and Aquatic Scien	Journal Article				X	X	
CINAR	Bigorre, S. P., R.A. Weller, J. B. Edson	Published	Mar-13	A surface mooring for air-sea interaction research in the Gulf Stream. Part 2: Analysis of the observations and their accuracies	J. Atmos. Oceanic. Tech., 30(3), 450-469	Journal Article	doi: 10.1175/JTECH-D-12-00078.1	X			X	
CINAR	Byron, Burke	In Review		Salmon ocean migration models suggest a wide range of successful strategies	Reviews of Fish Biology and Fisheries	Journal Article		X			X	
CINAR	Byron, Pershing, Xue, Stockwell, Kocik	In Review		Migration model of post-smolt Atlantic S	Fisheries Oceanography	Journal Article		X			X	
CINAR	Cassoff, R, Moore K., McLellan W, Barco S, Rotstein D., Moore M	Published	2011	Lethal entanglement in baleen whales	Target: Diseases of Aquatic Organisms	Journal Article	10.3354/dao02385	X			X	
CINAR	Cenedese, C., R.E. Todd, G.G. Gawarkiewicz, W.B. Owens, A.Y. Shcherbina	In Press		Offshore transport of shelf waters throu	J. Physical Oceanography	Journal Article	10.1175/JPO-D-12-0150.1			X	X	
CINAR	Ciaramella, M.	In Review		Measurement of tissue lipid reserves in t	Canadian Journal of Fisheries and Aquatic Science	Journal Article				X	X	
CINAR	Cowan, D.	In Review		Long-term sustainability of the American lobster fishery: does body size matter?	Canadian Journal of Fisheries and Aquatic Scien	Journal Article				X	X	
CINAR	Cronin, M. F., R.A. Weller, R.S. Lampitt, U. Send	Published	Jan-13	Ocean Reference Stations	In: Earth Observation, R.B. Rustamov and S.E. Salahova (eds.), InTech	Article in Book	ISBN: 978-953-307-973-8		X		X	
CINAR	Davis, X. J., R. A. Weller, S. Bigorre, A. J. Plueddemann	In Press		Local oceanic response to atmospheric forcing in the Gulf Stream region	Deep-Sea Res.	Journal Article				X	X	
CINAR	Duenebier, F. K., R. Lukas, E-M Nosal, J. Aucan, R. Weller	Published	Mar-13	Wind, waves, and acoustic background levels at Station ALOHA	J. Geophys. Res., 117(C03017)	Journal Article	doi:10.1029/2011JC007267			X	X	
CINAR	Edson, J., V. Jampana, R. Weller, S. Bigorre, A. Plueddemann, S. Miller, L. Mahrt, D. Vickers, H. Hersbach	In Press		On the exchange of momentum over the open ocean	J. Phys. Oceanogr.	Journal Article				X	X	
CINAR	Fairall, C.W., M.A. Bourassa, M.F. Cronin, S.R. Smith, R.A. Weller, G. Wick, S. Woodruff, L. Yu, H.-M. Zhang	Published	Nov-13	Observations to quantify air-sea fluxes and their role in global variability and predictability	Proceedings of the IOOS Summit	Conference Proceedings			X			X
CINAR	Fogarty, M.J., D.W. Townsend and E. Klein	Published	12/1/2012	Regime shift in the Gulf of Maine	Stephenson, R.L., J.H. Annala, J.A. Runge and M. Hall-Arber, (Eds). Advancing an Ecosystem Approach in the Gulf of Maine. American Fisheries Society, Symposium 79, Bethesda, MD. 415 pp.	Conference Proceedings				X	X	

CINAR	Gawarkiewicz, G.G, R.E. Todd, A.J. Plueddemann, M. Andres, J.P. Manning	Published	Aug-13	Direct interaction between the Gulf Stream and the shelfbreak south of New England	Nature Scientific Reports, 2(533)	Journal Article	doi:10.1038/srep00553				X		X	
CINAR	Gawarkiewicz, G.G., R.E. Todd, A.J. Plueddemann, M. Andres, J.P. Manning	Published	8/2/2012	Direct interaction between the Gulf Strea	Scientific Reports, 2, 554	Journal Article	10.1038/srep000553				X		X	
CINAR	Gettings, R.M., D.W. Townsend, M.A. Thomas, L. Karp-Boss	In Press	12/1/2013	Dynamics of late spring and summer phytoplankton communities on Georges Bank, with emphasis on diatoms, *Alexandrium* spp., and other dinoflagellates.	Deep-Sea Research II	Journal Article			X				X	
CINAR	Gimeno, L., A. Stohl, R. Trigo, F. Dominguez , K. Yoshimura, L. Yu, A. Drumond, A. Duran-Quesada, R. Nieto	Published	12/31/2012	2012: Oceanic and Terrestrial Sources of Continental Precipitation.	Rev. Geophys., 50, RG4003	Journal Article	10.1029/2012RG000389				X		X	
CINAR	Goldstein, J.	In Review		Seasonal movements of American lobsters in the coastal waters of the southern Gulf of Maine	Canadian Journal of Fisheries and Aquatic Scien	Journal Article	2013-0071				X		X	
CINAR	Grabowski, J.	In Review		Influence of predator identity on the strength of predator avoidance responses in lobsters	Canadian Journal of Fisheries and Aquatic Scien	Journal Article	2013-0067				X		X	
CINAR	Grebmeier, J., R. Pickart, C. Ashjian, L. Cooper, K. Frey, J. He, M. Itoh, M. Kedra, T. Kikuchi, S. Moore, J. Nelson, S. Vagle	Published	12/10/2012	Ecosystem Observations in Barrow Canyon: A Focus for the International Distributed Biological Observatory (DBO)	Arctic Report Card2012	Journal Article	http://www.arctic.noaa.gov/reportcard/barrow_canyon.htm		X				X	
CINAR	Holland, D.S., A. Kitts, J. Wiersma, P. Pinto da Silva	In Press		Social Capital and the Success of Harvest Cooperatives in the New England Groundfish Fishery.	Marine Resource Economics 28(2).	Journal Article			X				X	
CINAR	Holte, J., F. Straneo, C. Moffat, R. Weller, J. T. Farrar	In Press		Structure, properties, and heat content of eddies in the southeast Pacific Ocean	J. Geophys. Res.	Journal Article					X		X	
CINAR	Jin, D.	In Review		The determinants of fishing vessel accident severity	Accident Analysis & Prevention	Journal Article			X				X	
CINAR	Jin, S., L. Yu	In Review	3/31/2013	2013: Assessing high-resolution analysis of surface heat flux in the Gulf Stream region	Journal of Geophysical Research	Journal Article			X				X	
CINAR	Josey, S., S. Gulev, and L. Yu	In Review	1/31/2013	2013: Chapter 3. Exchamges through the ocean surface	World Ocean Circulation Experiment	Book chapter					X		X	
CINAR	Jury, S.	In Review		Seasonal and Sexual Differences in the Thermal Preferences and Movements of American Lobsters	Canadian Journal of Fisheries and Aquatic Scien	Journal Article					X		X	
CINAR	Kato, S, N. G. Loeb, F. G. Rose, D. R. Doelling, D. A. Rutan, T. E. Caldwell, L. Yu, R. A. Weller	Published	31-Dec	2012: Surface irradiances consistent with CERES-derived top-of-atmosphere shortwave and longwave irradiances	Journal of Climate 2012 ; e-View,doi: http://dx.doi.org/10.1175/JCLI-D-12-00436.1	Journal Article	doi: http://dx.doi.org/10.1175/JCLI-D-12-00436.1				X		X	
CINAR	Kato. K. N. G. Loeb, F. G. Rose, D. Doelig, D.A. Rutan, T. E. Caldwell, L. Yu, R.A. Weller	In Press		Surface irradiances consistent with CERES-derived top-of-atmosphere shortwave and longwave irradiances	J. Climate	Journal Article	doi: 10.1175/JCLI-D-12-00436.1				X		X	
CINAR	Knowlton, A.R., Landry, S.C., Robbins, J., McKenna, H., Werner, T.	Published	2011	Case Studies in Entanglements of Right Whales (*Eubalaena glacialis*) and Humpback Whales (Megaptera novaeangliae) from the East Coast of North America	Compiled as a reference for the Dynamics of Large Whale Entanglements in Fishing Gear Workshop, February 9-11, 2011. Held at Woods Hole Oceanographic Institution	Workshop proceedings			X					
CINAR	Kunkel, J.	In Review		A Top-Down Perspective on American Lobster Cuticle	Candian Journal of Fisheries and Aquatic Science	Journal Article					X		X	

CINAR	Kunz, C., Singh, H.	In Review		Map Building Fusing Acoustic and Visual Information using Autonomous Underwater Vehicles	International Journal of Field Robotics	Journal Article			X			X	
CINAR	Laufer, H.	In Review		Alkylphenols have multiple effects on lobster shells, molting and survival	Candian Journal of Fisheries and Aquatic Science	Journal Article					X	X	
CINAR	McGillicuddy, D.J., Jr., D.W. Townsend, B.A. Keafer, M.A. Thomas and D.M. Anderson	In Press	12/1/2013	Georges Bank: A leaky incubator of *Alexandrium fundyense* blooms	Deep-Sea Research II	Journal Article			X			X	
CINAR	McGillicuddy, D.J., Jr., M.L. Brosnahan, D.A. Couture, R. He, B.A. Keafer, J.P. Manning, J.L. Martin, C.H. Pilskaln, D.W. Townsend, D.M. Anderson	In Press	12/1/2013	A red tide *of Alexandrium fundyense* in the Gulf of Maine	Deep-Sea Research II	Journal Article			X			X	
CINAR	McMahan, M.	In Review		Using fine-scale acoustic telemetry to observe the effects of groundfish predator (Atlantic cod, *Gadus morhua*) on the movement behavior of the American lobster (*Homarus*	Canadian Journal of Fisheries and Aquatic Scien	Journal Article					X	X	
CINAR	Moriarty, Byron, Pershing, Stockwell, Xue	In Review		Migration behavior of post-smolt Atlantic salmon (*Salmo salar*) in the Gulf of Maine	Journal of Fish Biology	Journal Article			X			X	
CINAR	Murphy, C., Walls, J., Schneider, T., Eustice, R., Stojanovic, M., Singh, H	In Press		CAPTURE: A Communications Architecture for Progressive Transmission via Underwater Relays with Eavesdropping	IEEE Journal of Oceanic Engineering	Journal Article			X			X	
CINAR	Okkonen, S.R.,C.J. Ashjian, R.G. Campbell, J. Clarke, S.E. Moore, K.D. Taylor	Published	5/11/2011	Satellite observations of circulation features associated with the Barrow area bowhead whale feeding hotspot	Remote Sensing of Environment 115: 2168-2174.	Journal Article	doi:10.1016/j.rse.2011.04.024				X	X	
CINAR	Oppenheim, N.	In Review		Cannibals by night? *In situ* video monitoring reveals diel shifts in inter- and intraspecific predation on tethered American lobsters	Canadian Journal of Fisheries and Aquatic Scien	Journal Article					X	X	
CINAR	Rycroft, N.	In Review		A photographic method for lobster morphometry aimed at site discrimination	Candian Journal of Fisheries and Aquatic Science	Journal Article					X	X	
CINAR	Send, U., R. Weller, M. D. Ohman, T. Martz, F. P. Chavez, D. Demer, R. A .Feely	Published	Nov-13	Opportunities and challenges for integrated, sustained timeseries observations	Proceedings of the IOOS Summit	Conference Proceedings					X		X
CINAR	Shields, J.	In Review		Complex etiologies of emerging diseases in lobsters (*Homarus americanus*) from Long Island Sound	Candian Journal of Fisheries and Aquatic Science	Journal Article					X	X	
CINAR	Smith, P.C. N.R. Pettigrew, P. Yeats, D.W. Townsend and G. Han	Published	12/1/2012	Regime shift in the Gulf of Maine	Stephenson, R.L., J.H. Annala, J.A. Runge and M. Hall-Arber, (Eds). Advancing an Ecosystem Approach in the Gulf of Maine. American Fisheries Society, Symposium 79, Bethesda, MD. 415 pp.	Conference Proceedings					X	X	
CINAR	Song, X., and L. Yu	Published	5/31/2012	2012:High latitude contribution to global variability of sensible heat flux at the air-sea interface	J. Climate, special collection on "CLIVAR/SeaFlux High Latitude Surface Fluxes", 25, 3515-3531	Journal Article	10.1175/JCLI-D-11-00028.1				X	X	
CINAR	Steneck	In Review		Lobster Dynamics in a Brave New Ocean	Candian Journal of Fisheries and Aquatic Science	Journal Article					X	X	
CINAR	Subramanian, A. C., A. J. Miller, B. D. Cornuelle, E. Di Lorenzo, R.A. Weller, F. Straneo	Published	Mar-13	A data assimilative perspective of oceanic mesocscale eddy evolution during VOCALS-Rex	Atmos. Chem. Phys., 13, 3329-3344	Journal Article	doi:10.5194/acp-13-3329-2013				X	X	

CINAR	Sun, Jenny	Published	8/29/2012	Analysis of Landings/Discards-Proportional Allocation Scheme for the At-Sea Monitoring Program of the Groundfish Fishery in New England	New England Fishery Management Council (NEFMC) Groundfish Plan Development Team (PDT) meeting and available at GMRI website: http://www.gmri.org/upload/files/Landings%20and%20discards%20proportional%20monitoring_final%2002-13-2013[1]%20copy.pdf	Presentation				X		X
CINAR	Sun, Jenny	Published	3/20/2013	Economics of the Groundfish Industry in New England: the Historical Price and Landings Volatility of the Ex-vessel Market by Ports	Sector Manager Monitoring Working Group Meeting, convened by Gulf of Maine Research Institute and sponsored by the Gordon and Betty Moore Foundation	Presentation				X		X
CINAR	Tlusty, M.	In Review		Reconciling the past with the future of shell disease	Candian Journal of Fisheries and Aquatic Science	Journal Article				X	X	
CINAR	Todd, R.E., G.G. Gawarkiewicz, W.B. Owens	Published	January 2013	Horizontal scales of variability over the Middle Atlantic Bight shelf break and continental rise from finescale observations	J. Physical Oceanography, 43(1), 222-230	Journal Article	10.1175/JPO-D-12-099.1	X			X	
CINAR	Townsend, D.W., M.A. Thomas, D.J. McGillicuddy, N.R. Rebuck	In Press	12/1/2013	Nutrients and water masses in the Gulf of Maine - Georges Bank region: Variability and importance to blooms of the toxic dinoflagellate *Alexandrium fundyense*	Deep-Sea Research II	Journal Article		X			X	
CINAR	Weller, R.A., S. P. Bigorre, J. Lord, J. D. Ware, J. B. Edson	Published	Sep-13	A surface mooring for air-sea interaction research in the Gulf Stream	J. Atmos. Oceanic. Tech., 29(9), 1363-1376	Journal Article	doi: 10.1175/JTECH-D-12-00060.1	X			X	
CINAR	Yu, L., X.Jin	Published	11/30/2012	2012: Buoy perspective of a high-resolution global ocean vector wind analysis constructed from passive radiometers and active scatterometers (1987–present)	J. Geophys. Res., 117, C11013	Journal Article	10.1029/2012JC008069	X			X	
CINAR	Yu, L., P. W. Stackhouse, and R.A. Weller	Published	8/31/2012	2012: Global ocean heat fluxes [in "State of the Climate in 2011"]	Bull. Ameri. Meteor. Soc., 93(7), S65-S68	Journal Article		X			X	