CINAR

Cooperative Institute for the North Atlantic Region

Annual Progress Report

April 1, 2013 - March 31, 2014

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

1865 THE UNIVERSITY OF MAINE

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CINAR
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Reporting Period: April 01, 2013 - March 31, 2014

Submitted by:

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Submitted to NOAA on 06/30/2014

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Executive Summary *7*

CINAR Annual Research Highlights *9*

Introduction *13*

1.1 Institute and Core Activities 13
1.2 CINAR Vision, Mission, Goals and Organization 13
1.3 Distribution of NOAA Funding by Task, CINAR Themes and NOAA Line Office 18
1.4 Task I Activities with Distribution of Funding 19

2012 CINAR Postdoctoral Scholar Report *23*

2013 CINAR Postdoctoral Scholar Report *26*

CINAR Research Summaries *29*

Theme I. Ecosystem Forecasting **33**

Gulf of Maine 2013 cyst cruise and sample analysis 35
Donald Anderson - WHOI 35
NOAA Sponsor – Richard Stumpf, NOS 35
Technical support and improvement of FVCOM for NOAA modeling activities 38
Robert Beardsley - WHOI 38
NOAA Sponsor – Frank Aikman, NOS 38
Estimating early mortality and implications for reference points for the Atlantic menhaden stock 40
Hongsheng Bi - UMCES 40
NOAA Sponsor – Jonathan Hare, NMFS 40
Stratification indices for stock and ecosystem assessments from a data assimilative circulation model 43
Rubao Ji - WHOI 43
NOAA Sponsor – Jonathan Hare, NMFS 43
Accounting for habitat-dependent observation error in bottom trawl survey indices for pelagic stocks using butterfish (Peprilus triacanthus) as a model 47
Josh Kohut and Nickitas Georgas - Rutgers 47
NOAA Sponsor – Jonathan Hare, NMFS 47
Assessing marine climate impacts in North America using species range shifts and climate velocity 50
Malin Pinsky - Rutgers 50
NOAA Sponsor – Jonathan Hare, NMFS 50
Nutrient dynamics on the NE continental shelf: Sample analyses 52
David Townsend - UMaine 52
NOAA Sponsor – Jonathan Hare, NMFS 52
Sustaining development of National Ocean Service operational forecast systems based on the Regional Ocean Modeling System 55
James Wilkin - Rutgers 55
NOAA Sponsor – Aijun Zhang, NOS 55

Theme II. Ecosystem Monitoring **57**

2013 ROV Jason and AUV Sentry use for NOAA/McDonald (Deepwater Canyons) 59
Andrew Bowen - WHOI 59
NOAA Sponsor – John Tomczuk, OAR 59
NDSF vehicle engineering days 61
Andrew Bowen - WHOI 61
NOAA Sponsor – Karen Kohanowich, OAR 61
The Eastern Gulf of Maine sentinel jigging/longline survey / fishery in 2013 62
Yong Chen - UMaine 62
NOAA Sponsor – John Hoey, NMFS 62
Benthic imaging in support of habitat mapping for renewable energy 66
Scott Gallager – WHOI (with subaward to Kevin Stokesbury, UMass) 66

NOAA Sponsor – Jennifer Samson, NMFS 66
Transition of HabCam Technology to NOAA Operations and Technology Upgrade 80
Scott Gallager – WHOI 80
NOAA Sponsor – Robert Johnston, NMFS 80
The development of light field cameras for AUV obstacle avoidance 83
Hanumant Singh – WHOI 83
NOAA Sponsor – Elizabeth Clarke, NMFS 83

Theme III. Ecosystem Management 85
Evaluating the mechanisms underlying distribution shifts and age-truncation on silver hake (Merloccius bilinearis) survey data 87
James Churchill – WHOI 87
NOAA Sponsor – David Richardson, NMFS 87
Evaluation of cranial facial bone formation and tissue histopathology of embryonic and juvenile commercially important finfish species exposed to increasing levels of Co2 and Ph due to ocean acidification 89
Keith Cooper – Rutgers 89
NOAA Sponsor – Chris Chambers, NMFS 89
An empirical analysis of portfolio management as a tool for implementing Ecosystem Based Fishery Management 92
Di Jin and Porter Hoagland – WHOI 92
NOAA Sponsor – Gerit Depiper, NMFS 92
Improving fishery dependent data collection and integration into NOAA Fisheries data systems 94
Jessica Joyce – GMRI 94
NOAA Sponsor – Douglas Christel, NMFS 94
Thermal habitat dynamics in the Northeast Atlantic and the role of habitat squeeze 97
Josh Kohut and Enrique Curchitser – Rutgers 97
NOAA Sponsor – John Hoey, NMFS 97
Developing wideband acoustic methods for improving fisheries and ecosystem assessments 100
Gareth Lawson and Andone Lavery – WHOI 100
NOAA Sponsor – Michael Jech, NMFS 100
Scientific leadership for the NOAA Ocean Exploration and Research Program 103
Timothy Shank – WHOI 103
NOAA Sponsor – Gene Smith, OAR 103
Evolution of groundfish sectors business model 106
Jenny Sun – GMRI 106
NOAA Sponsor – Andrew Kitts, NMFS 106
The effect of catch restrictions on recreational catch 110
Michael Wilberg – UMCES 110
NOAA Sponsor – Scott Steinback, NMFS 110

Theme IV: Protection and Restoration of Resources 113
Analysis linking study fleet data to habitat and statistic models in the Mid Atlantic Bight 115
Josh Kohut and Olaf Jensen – Rutgers 115
NOAA Sponsor – John Hoey, NMFS 115
An experimental investigation of the impact of ocean acidification on the early life stages of surfclams, and the interactive effects of feeding 118
Daniel McCorkle and Anne Cohen – WHOI 118
NOAA Sponsor – Lisa Milke, NMFS 118
Marine mammal stranding responses capacity building 121
Michael Moore – WHOI 121
NOAA Sponsor – Teresa Rowles, NMFS 121
Evaluation of larval sources and population connectivity in Atlantic sea scallop (Placopecten magellanicus) 123
Daphne Munroe – Rutgers 123

NOAA Sponsor – Deborah Hart, NMFS 123
Analysis of CYP1A1 expression in cetacean tissue samples 127
John Stegeman – WHOI 127
NOAA Sponsor – Teresa Rowles, NMFS 127

Theme V. Sustained Ocean Observations and Climate 133
Global ocean observing coordination activities 135
Donald Anderson – WHOI 135
NOAA Sponsor – Candyce Clark, OAR 135
CINAR input into fisheries/climate regional products 142
Donald Anderson – WHOI 142
NOAA Sponsor – Ellen Mecray, NESDIS 142
An eye in the ocean: Exploration of high-resolution vertical distributions of plankton and particles and coincident hydrography in the Western Chukchi Sea – data synthesis 144
Carin Ashjian – WHOI 144
NOAA Sponsor – Kathleen Crane, OAR 144
Satellite derived climate data records of ocean-atmosphere exchange 147
Carol Anne Clayson – WHOI 147
NOAA Sponsor – Jeff Privette, NESDIS 147
Macroinfauna community structure, biomass and sediment studies during the RUSALCA program 150
Jacqueline Grebmeier – UMCES 150
NOAA Sponsor – Kathleen Crane, OAR 150
Pacific Arctic Group (PAG) secretariat office 2013-2014 153
Jacqueline Grebmeier – UMCES 153
NOAA Sponsor – Kathleen Crane, OAR 153
WHOI contribution to Argo Float Program 156
Steven Jayne, P.E. Robbins, and W. Brechner Owens – WHOI 156
NOAA Sponsor – Steven Piotrowicz, OAR 156
Circulation in the Western Chukchi Sea and its role in the ecosystem 159
Robert Pickart – WHOI 159
NOAA Sponsor – Kathleen Crane, OAR 159
Synthesis of physical measurements from the Pacific Arctic Group: Flux of Pacific water through Barrow Canyon, Chukchi Sea 162
Robert Pickart – WHOI 162
NOAA Sponsor – Kathleen Crane, OAR 162
50 year analysis global surface heat flux 164
Lisan Yu – WHOI 164
NOAA Sponsor – Joel Levy, OAR 164
Ocean climate observations and analyses (2013-2014) 167
Robert Weller and Albert Plueddemann, WHOI 167
NOAA Sponsor – Diane Stanitsky, OAR 167

Theme VI. Education and Outreach 171
Research and education in quantitative fisheries and ecosystem science 173
Donald Anderson, WHOI 173
NOAA Sponsor – Russell Brown, NMFS 173
Refining eastern region stakeholder needs for climate products and services 186
Donald Anderson, WHOI 186
NOAA Sponsor – Ellen Mecray, NESDIS 186
US National Office for Harmful Algal Blooms 187
Donald Anderson, WHOI 187
NOAA Sponsor – Quay Dortch, NOS 187
Marine Resource Education Program: Serving the needs of fishing communities and fishery management in the Northeast region 190

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, with $5.6 million from OAR, $2.8 million from NMFS, and $.04 million from NOS. (total $8.44 million)
- In year five, funding was nearly $10 million with $6.6 million from OAR, $3.1 million from NMFS, and $0.03 million from NOS. (Note that this total does not include Hurricane Sandy supplemental funds (nearly $6 million, with $5.6 million from OAR and 0.4 M from NOS.) as those are funded through separate grant agreements.

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 Ke (Kevin) Chen and Sarah Bender, as part of this year's CINAR progress report.

Education and Outreach

In 2013, CINAR sponsored a program in Minority Traineeships, providing one minority student per year to each partner institution to work with CINAR-sponsored PIs. This program is continuing in 2014. Details are provided under Task I activities.

In 2012, we began a partnership with 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. A detailed progress report on this program begins on page 173.

We hosted an informal workshop, called "CINAR 101" for CINAR investigators, NOAA sponsors, administrative and grant office staff at both NOAA and the CINAR partner organizations. The goal was to explain the process of preparing CINAR proposals, for both WHOI scientists and our partners, beginning with the concept and idea, detailing preparation and submission, review by NOAA program staff and GMD and ending with the award process, including how awards are made to our partners.

In 2014, we are beginning a new program, "*WHOI-NEFSC Special Seminar Series on Fisheries and Ecosystems Acoustics*". More details are provided in the Task I activities section.

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In 2014, we are beginning a new program, "*WHOI-NEFSC Special Seminar Series on Fisheries and Ecosystems Acoustics*". More details are provided in the Task I activities section.

CINAR ANNUAL RESEARCH HIGHLIGHTS

Donald Anderson - Woods Hole Oceanographic Institution
Research and education in quantitative fisheries and ecosystem science

The NOAA NEFSC, WHOI, and the University of Massachusetts School for Marine Science and Technology (SMAST) are working together to train future generations of scientists in a program designed to address an anticipated shortfall of researchers in the fields of quantitative fisheries and ecosystem science. Under NOAA's Quantitative Ecology and Socioeconomics Training (QUEST) program, the partnership focuses on teaching and advising in a graduate fisheries program and developing new technologies to improve assessment and management capabilities.

- Three new fellowships for WHOI scientists and a new faculty position at SMAST were created. These new positions will collaborate to train graduate students in cutting-edge methods, technologies, and research approaches. (See page 173 for detailed progress reports.)

Carin Ashjian - Woods Hole Oceanographic Institution
An eye in the ocean: Exploration of high-resolution vertical distributions of plankton and particles and coincident hydrography in the Western Chukchi Sea – data synthesis

The overall goal of this project is to describe the high-resolution vertical distributions of zooplankton and particles over a range of spatial and temporal scales. Video Plankton Recorder (VPR) 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 vertical distributions of copepods and diatoms and marine snow particles were closely associated with the vertical structure of the water column and with different water mass types.
- Herald Canyon was very dynamic, with multiple water masses and complex velocity patterns. Plankton and particles were spatially heterogeneous. Along- or cross-canyon flux of plankton and particles in this region revealed that most types were primarily advected to the north while on the western side of the canyon substantial flux of algal mats was observed.
- The VPR was an effective means to obtain high-resolution vertical distributions of plankton and particles that can be coupled to hydrography and to velocity in achieving a better understanding of the complex interaction between biology and physics that structures this ecosystem.

Alexa Dayton – Gulf of Maine Research Institution
Marine Resource Education Program for fishermen in the Southeast fisheries region

- Building on the highly successful MREP program that began in the Northeast, a fisheries management education program was developed for the Southeast fisheries region. This program was delivered to 24 fishermen and an additional 18 speakers and other guests, in Tampa, FL September 22 – 24, 2013.
- 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.

Gareth Lawson and Andone Lavery - Woods Hole Oceanographic Institution
Developing wideband acoustic methods for improving fisheries and ecosystem assessments

The goal of this project is to develop wide-band acoustic methods to improve our ability to distinguish butterfish from other non-swimbladder-bearing organisms (e.g., squid, dogfish), as well as provide characterization of the zooplankton prey field.

- Preliminary analyses of the field data confirm the ability of the wide-band transceivers (WBTs) to characterize the acoustic scattering spectra of different organism types and suggest that these spectra can be used in assessment surveys to distinguish between scatterer types. These wide-band acoustic data are the first to be collected spanning nearly two orders of magnitude in frequency on these species, and represent a leap forward in terms of information content relative to traditional narrow-band echo sounders.
- Tests and calibrations of the WBTs highlight advancements and limitations of these systems for large-scale surveys, as well as provide starting points for further research on broad-band acoustic characteristics of the WBTs, transducers, and fish and zooplankton. The new Simrad WBTs utilize existing split-beam composite transducers already standard on many NOAA and UNOLS vessels, facilitating the potential for transition to operations, and software for processing data will be made available to others in the field, including other NMFS Science Centers.

Malin Pinsky - Rutgers
Assessing marine climate impacts in North America using species range shifts and climate velocity

Objectives of this project include: 1) Calculate regional indicators of species distribution shifts, community shifts, and climate velocity for coastal marine regions of the United States; and 2) Integrate the indicators into National Climate Assessment and NEFSC Ecosystem Advisory processes.

- A trial climate indicator using marine fish and invertebrate distributions was developed and circulated. Once refined, this indicator will contribute to the National Climate Assessment's Climate Indicator System.

- The trial indicator shows how marine fish and invertebrates throughout the U.S. have been shifting towards higher latitudes and deeper depths over the last three decades.

Timothy Shank - Woods Hole Oceanographic Institution
Scientific leadership for the NOAA Ocean Exploration and Research Program

The goal of this effort is to provide scientific consultation to the NOAA Ocean Exploration and Research Program that will provide a scientific vision for ocean exploration and catalyzing scientific and stakeholder partnership discussions that result in science priorities for exploration, it's implementation, and the promotion of the legacies of exploration that advance future research endeavors and pathways.

- A working draft of a *Remotely-Operated Vehicle Sampling Protocol* was generated. Multi-disciplinary portions of the scientific community-at-large were engaged to develop this protocol whereby decision, collection methods, and processing methods and practices can be determined.
- The first live telepresence broadcast of ocean exploration and research from the hadal zone of the ocean was conducted below 6,000 meters in an ocean trench (e.g., from 7,100 meters and 9,990 meters). These live broadcasts "from the trench seafloor" of the Kermadec Trench shared the real time experience of exploration and discovery of deep ocean trenches, the habitats and life they contain. A Mobile Telepresence Unit was utilized on board the R/V Thompson with the Hybrid Remotely Operated Vehicle Nereus to provide these live broadcast as well as interactive outreach events with the Smithsonian Institution.

Heidi Sosik - Woods Hole Oceanographic Institution
Deployment of Automated Plankton Microscopy on Recent EcoMon Survey

The goal of this project was to integrate continuous automated microscopic analysis of plankton with a recent Ecosystem Monitoring (EcoMon) program cruise aboard the R/V Okeanos Explorer. Traditional sampling approaches for characterizing plankton are so labor intensive and time-consuming that this kind of information is available only with very limited resolution. New technology developed at WHOI provides a solution that not only meets research needs, but can also contribute to resource management and science-based decision making.

- The successful deployment produced millions of high resolution plankton images that are providing taxon-specific information about spatial distribution patterns in waters of southern New England and the Gulf of Maine.
- This research project paves the way for more efficient and detailed characterization of status and change in lower trophic levels, a critical element of monitoring that supports an Integrated Ecosystem Assessment (IEA) approach for resource management.

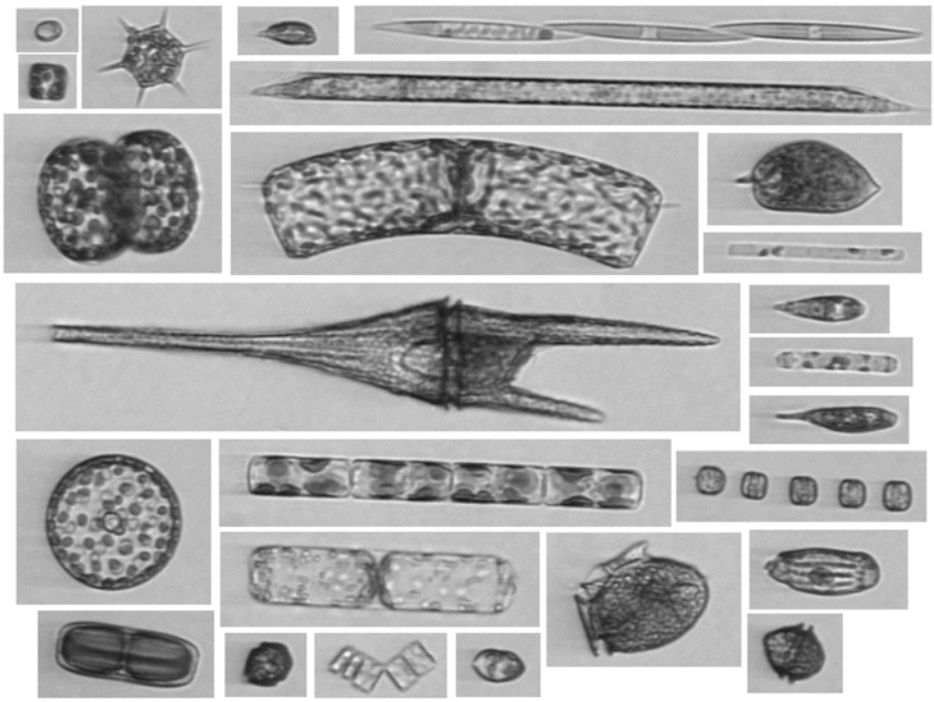


Figure legend: Collage of plankton images showing the diversity of micro-organisms observed by IFCB during the EcoMon survey.

Lisan Yu - Woods Hole Oceanographic Institution
50 year analysis global surface heat flux

The Objectively Analyzed air-sea Fluxes (OAFlux) project focuses 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 evidence yielded from the OAFlux products led 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.
- In many ways, the OAFlux global products have demonstrated 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.
- The OAFlux satellite-based vector wind analysis (1988-2012) shows distinct decadal changes in global ocean surface winds, noted most by the weakening of the winds in the North Atlantic Ocean during the boreal winter season.

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 to 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;

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

10) To develop, carry out, and sustain key observational components of NOAA ocean observing missions.

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.

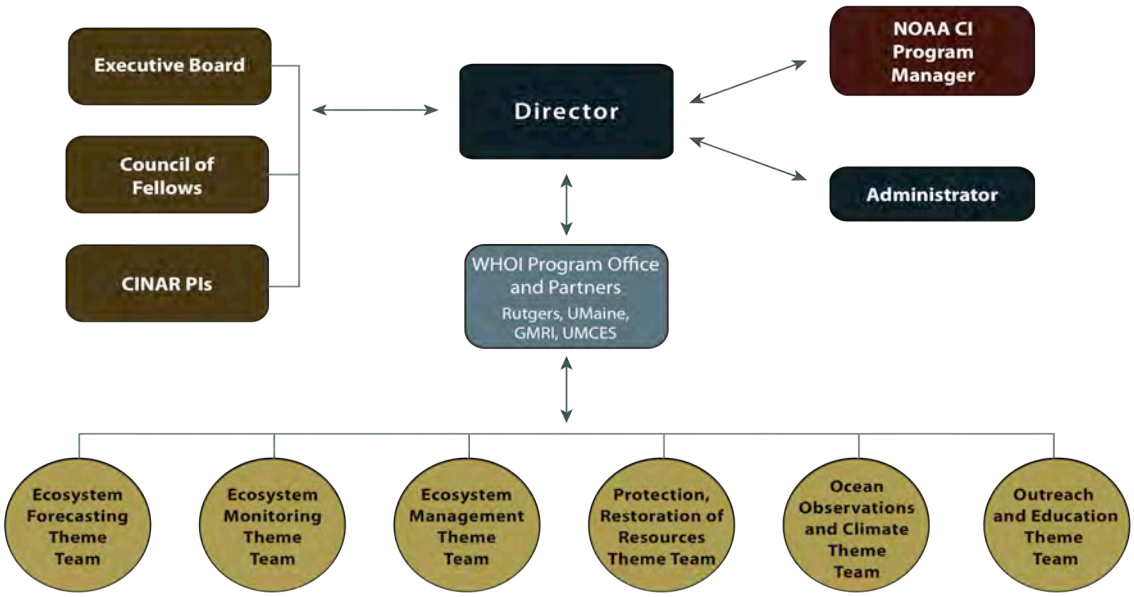


Figure 1. Organizational structure of CINAR

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 Andrew Pershing, *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
Andrew Pershing	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
Fei Chai	CINAR PI, University of Maine
Andrew Pershing	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).

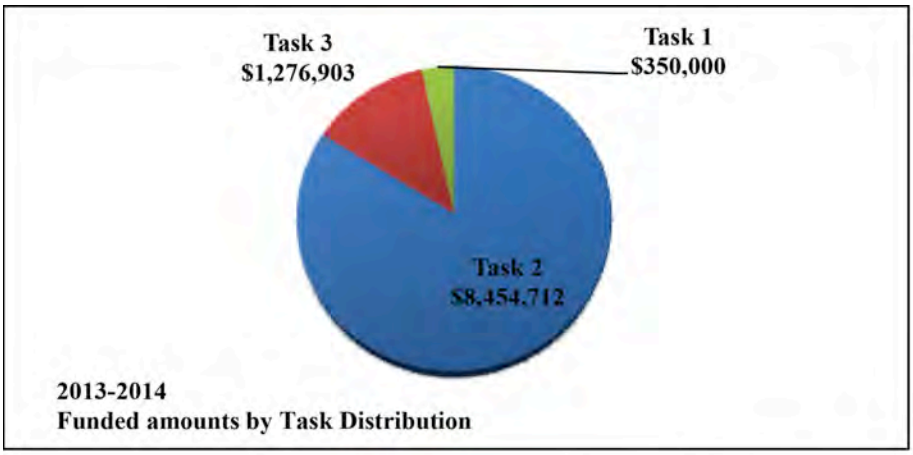
CINAR Research and Administrative staff

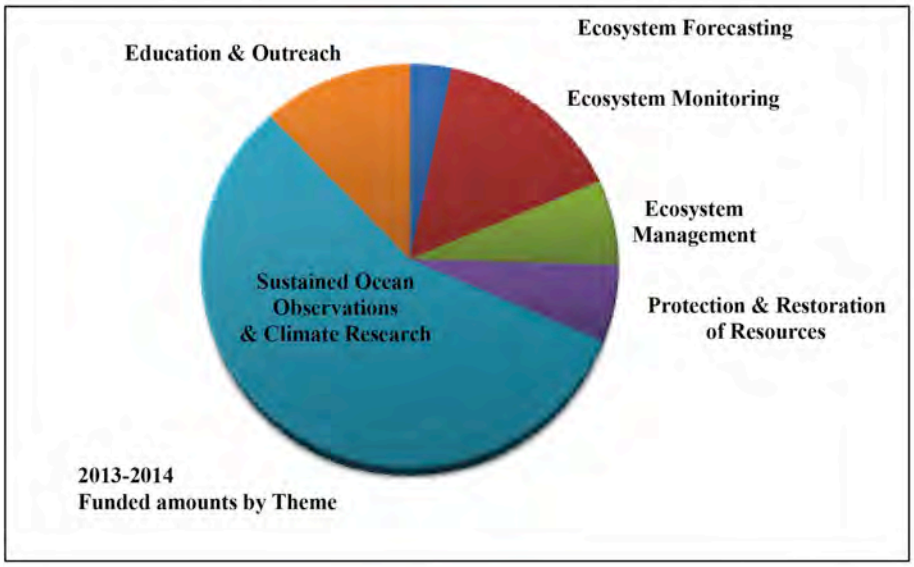
WHOI and the partner institutions provide the administrative staff for grants and contracts management, human resource management, systems administration, procurement, and all necessary support staff roles for CINAR activities. CINAR uses the services of researchers through an appropriate combination 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.

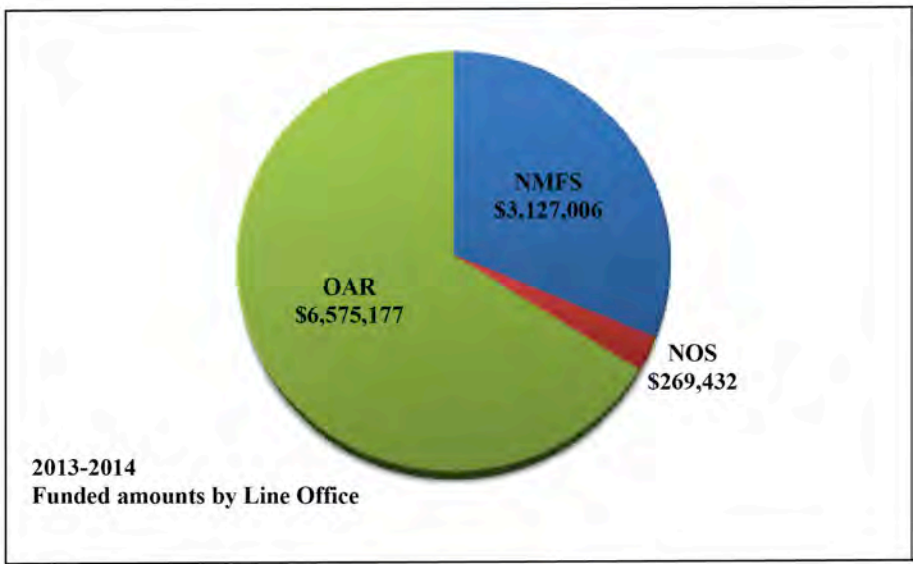
CINAR Program Office

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

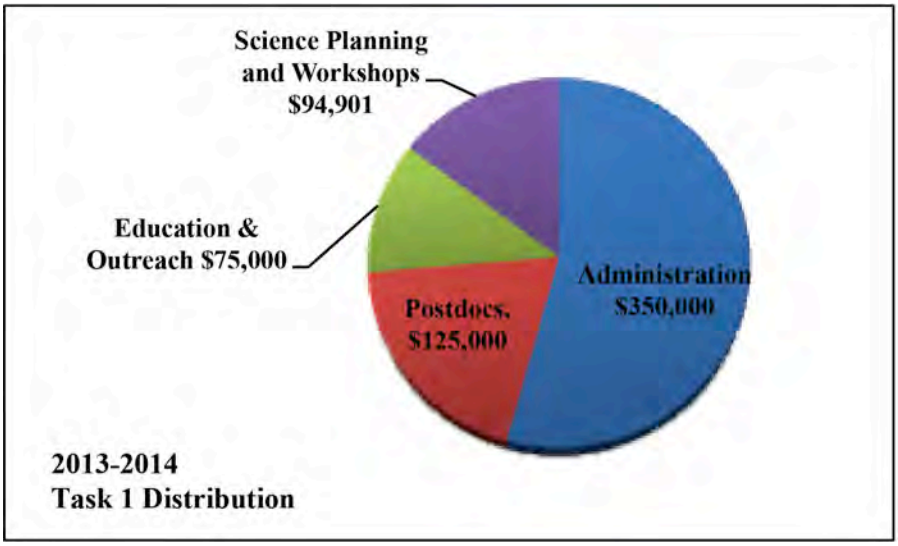
1.3 Distribution of NOAA Funding by Task, CINAR Themes and NOAA Line Office







1.4 Task I Activities with Distribution of Funding



Task I funding is currently provided by three sources – OAR, NMFS and WHOI (cost sharing). In year 5, we received $110,000 from OAR, $240,000 from NMFS and $294,901 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.

Data Management

The National Science Foundation (NSF) funded Biological and Chemical Oceanography Data Management Office (BCO-DMO) maintains access to the finalized 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 Kiefer. These data are accessed by the following URLs:

Bottle Data: http://www.bco-dmo.org/dataset/3358
Underway Data: http://www.bco-dmo.org/dataset/3359
Event Log OC467: http://www.bco-dmo.org/dataset/3501

The project information is available at http://www.bco-dmo.org/project/2118.
BCO-DMO continues to make available the New England Fisheries Science Center (NEFSC) EcoMon data on the hydrology and biology of the Gulf of Maine. These data can be accessed via the following URLs:

Hydrology: http://www.bco-dmo.org/dataset/3309
EcoMon Plankton $10m^2$: http://www.bco-dmo.org/dataset/3327
EcoMon Plankton $100m^2$: http://www.bco-dmo.org/dataset/3328

Additional information about the Hydrology project can be found at http://www.bco-dmo.org/project/2105 and information about the EcoMon project can be found at http://www.bco-dmo.org/project/2106.

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 - Ke (Kevin) Chen and Sarah Bender. Their reports begin on page 23.

Our next Postdoctoral Scholar will be Andrew Jones, Yale University. His report will be included in the next CINAR progress report.

Undergraduate student training: CINAR instituted a Minority Traineeship program in 2013 funding one undergraduate minority traineeship at each partner institution each summer:

Partner Inst.	Student Name	CINAR Investigator	Study Focus
GMRI	Miguel Barajas	Lisa Kerr	Alewife stock structure in Maine watersheds
Rutgers	Brandon Rogers	Scott Glenn	Coupling MARACOOS data to MARCO data portal
WHOI	Christina Hernandez	Julie Kellner Joel Llopiz	statistical and individual-based modeling
UMaine	Ben Francis	Yong Chen	American eel fisheries in Maine
UMCES	Cristina Villalobos	Jamie Pierson	Hypoxic impacts on egg respiaration rates of the copepod *Arcatia tonsa*

We are continuing this program and have already selected and appointed five minority trainees throughout the CINAR consortium for summer 2014.

Outreach.

WHOI-NEFSC Special Seminar Series on Fisheries and Ecosystem Acoustics. CINAR Fellow Gareth Lawson, together with Mike Jeck from the NEFSC and Tim Stanton (CINAR Investigator, WHOI) have organized a new seminar series on fisheries and ecosystem acoustics. The seminars will take place at the NEFSC conference room in Woods Hole, with participation from WHOI, other NOAA laboratories and the Woods Hole scientific community. The topic will be passive and active acoustics, emphasizing applications and technological developments relevant to fisheries and ecosystem research/management and protected species conservation (i.e., relevant to the NMFS mandate).

A webinar format will be used, making this widely available to CINAR partners and NOAA laboratories. Speakers will give a 45-minute talk, followed by 45 minutes of discussion over a brownbag lunch. We envision this series to last approximately three years, with regional speakers, mostly drawn from WHOI and NEFSC, in the first year. Talks will be given every two months (6 talks per year). In the second year we will start to expand nationally to other science centers and other acousticians, who could present via webinar. In the third year we will continue that expansion and transition to a more workshop-focused approach, summarizing what we learned and determining how we take the next steps to making things operational. As international colleagues come through town we will also capitalize on their presence to give a talk.

We are excited about this new program which begins late June. We will provide updates in next year's progress report. Each year we will plan on a summary meeting where we review the past year, as well as a final workshop, which would be particularly good targets for upper management attendance.

CINAR 101. We hosted an informal workshop, called "CINAR 101" for CINAR investigators, NOAA sponsors, administrative and grant office staff at both NOAA and the CINAR partner organizations. The seminar included presentations from CINAR administrative staff and NMFS grants office staff. The goal was to explain the process of preparing CINAR proposals, for both WHOI scientists and our partners, beginning with the concept and idea, detailing preparation and submission, review by NOAA program staff and GMD and ending with the award process, including how awards are made to our partners.

Emphasis was placed on the partnership between NOAA and CINAR - both at the scientist / sponsor level and at the administrative level. We also explained the need to fit proposals into the CINAR themes and regional focus. Participation was quite good (over 50 attendees), both in the meeting and remotely (we conducted this via Webex). There was a lot of discussion and good questions asked and we received positive feedback about the idea and the presentation.

A brief presentation on the goals and items covered was also given by J. Kleindinst at the annual CI Directors meeting in March.

2012 CINAR POSTDOCTORAL SCHOLAR REPORT

NOAA Cooperative Agreement No. NA09OAR4320129
April 1, 2013 – March 31, 2014

Postdoctoral Scholar: Ke Chen, Woods Hole Oceanographic Institution

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

As a CINAR postdoctoral scholar, Ke continued working on the extreme temperature variability in the Northeast U.S. coastal ocean. Understanding the dynamical processes controlling the thermal structure is critical for the entire marine ecosystem. Combining observations and modeling, Ke aims to unravel the dominate process in the interannual temperature variability.

ACCOMPLISHMENTS

Ke has identified a linkage between the atmospheric jet stream variability and the temperature change in the coastal ocean off the Northeast U.S. The jet stream latitude correlates well with both the air-sea heat flux in the winter on the seasonal time scale and the temperature anomaly in the spring on the intraseasonal time scale. The anomalous warming in 2012 was primarily due to the reduced heat loss in the winter of 2011-2012 due to a northward shift of the jet stream. The anomalous heat content persisted into the spring which facilitated the occurrence of high SST induced by the intraseasonal oscillation of the jet stream. Results from numerical modeling work also revealed that the decreased along-shelf advective flux also contributed to the warm anomaly.

HIGHLIGHTS

- Systematic warm anomalies from Gulf of Maine to Cape Hatteras were found to be related to large scale atmospheric forcing.
- 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.
- Reduced along-shelf advection also contributed to the warm anomaly.

SOCIETAL BENEFITS

Better understanding of the dynamic process controlling the thermal structure is important for ecosystem monitoring and forecasting. By establishing a linkage 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. Results from the numerical modeling work will also address the question of predictability of spring temperature based on the heat content in the preceding winter.

EDUCATION AND OUTREACH ACTIVITIES

Chen, K., G. Gawarkiewicz, S. Lentz, J. Bane, Diagnosing the Warming of the Northeastern U.S. Coastal Ocean in 2012: Integrated Data Analysis and Numerical Modeling, *Ocean Sciences Meeting*, Honolulu, HI, 2014.

Chen, K., Middle Atlantic Bight Shelfbreak Circulation Dynamics and Biophysical Interactions, *Graduate School of Oceanography/University of Rhode Island*, Narragansett, RI, 2013 (invited talk).

Chen, K., G. Gawarkiewicz, S. Lentz, J. Bane, Diagnosing the warming in the Northeast US coastal ocean in 2012: Atmospheric forcing or ocean advection?, *MABPOM meeting*, Narragansett, RI, 2013.

Chen, K., G. Gawarkiewicz, S. Lentz, J. Bane, Diagnosing the warming in the Northeast US coastal ocean in 2012: A linkage between remote atmospheric forcing and local response, *Gordon Research Conference*, Biddeford, ME, 2013 (poster).

Media Report: *Oceanus* Magazine. http://www.whoi.edu/oceanus/feature/ocean-heat-wave-linked-to-jet-stream, Originally published online March 19, 2014.

PUBLICATIONS

Chen, K., G. Gawarkiewicz, S. Lentz, and J. Bane (2014), Diagnosing the Warming of the Northeastern US Coastal Ocean in 2012: A linkage between the atmospheric jet stream variability and ocean response, *Journal of Geophysical Research*, VOL. 118, 218–227, doi:10.1002/2013JC009393.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

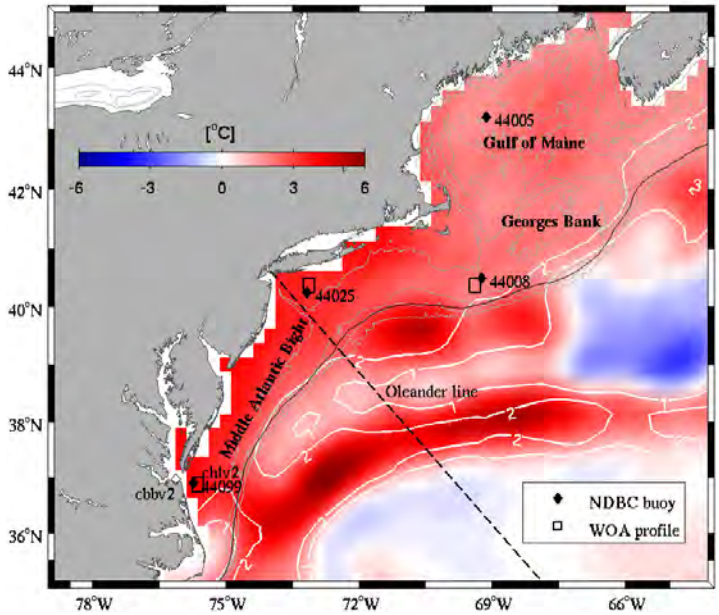


Figure 1. Map of the Middle Atlantic Bight (MAB) and Gulf of Maine (GoM). Shown in the background is the mean SST anomaly in March 2012 referenced to the March average SST for 2000-2010. White contours indicate the region where the March 2012 SST anomalies are greater than one and two standard deviations of 2000-2010 March SST, respectively. Locations of National Data Buoy Center buoys (diamonds) and the Oleander line (grey dashed line) are shown. Square boxes (~0.25°) demonstrate the location of World Ocean Atlas profiles, which are used to estimate the relationship between SST and depth-averaged temperature for nearby buoys in *Chen et al.* (2014). The 50 m, 100 m, 200 m and 1000 m isobaths (from ETOPO-1) are also shown. The thin black line is the smoothed 200 m isobath that is used to define along- and cross-shelf directions in *Chen et al.* (2014).

2013 CINAR POSTDOCTORAL SCHOLAR REPORT

NOAA Cooperative Agreement No. NA09OAR4320129
April 1, 2013 – March 31, 2013

Postdoctoral Scholar: Sarah Bender, Woods Hole Oceanographic Institution

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

The CINAR Postdoctoral Research funding (as part of the Woods Hole Oceanographic Institution Postdoctoral Scholar program) provides a fellowship for Dr. Sara Bender from December 2, 2013 – May 2, 2015. This research is being conducted in the lab of Dr. Mak Saito.

The project focus is on the nuisance algae *Phaeocystis sp*. and was designed to apply molecular-based approaches (transcriptomics and proteomics) to study this unicellular algal species in laboratory cultures, field samples collected in the Ross Sea, Antarctica, and as part of a field campaign in Cape Cod Bay, Massachusetts. The overarching goal of the project is to interrogate the metabolism of *Phaeocystis sp*. using global and targeted proteomics to better understand its metabolic response to changes in macro- and micro- nutrients.

ACCOMPLISHMENTS

The postdoctoral position began on December 2, 2013. During the beginning phase of this research project, four primary objectives were outlined: (1) To use *in silico* approaches to analyze existing transcriptomic and proteomic datasets of *Phaeocystis antarctica* grown under controlled laboratory conditions, (2) To continue with laboratory experiments that examine the response of *P. antarctica* to trace metal inputs, (3) To process field metaproteome samples collected from *Phaeocystis* blooms in the Ross Sea using molecular-tools, and (4) To begin a field campaign in Cape Cod Bay, where *Phaeocystis pouchetii* blooms annually.

Presently, Objective 1 is underway. Preliminary results were presented at a postdoctoral scholar summit in Dorado, Puerto Rico in early February, and more recent findings will be presented in June at a Gordon Marine Microbes conference. Comparisons between the transcriptomes and proteomes for *P. antarctica* cultures have provided insight into intra-species differences in how this organism accesses and stores iron. Results will be used to generate hypotheses for additional laboratory experiments as part of Objective 2.

For Objective 2, multiple strains of *P. antarctica* have been acclimated to growth under different iron concentrations. Additionally, several polar diatoms have been cultured to compare and contrast the metabolic response of distantly related algal species. The next step in this project will be to monitor the response of iron-limited *P. antarctica* cultures to trace metal inputs that simulate ice melt during the Austral spring in the Ross Sea. These laboratory experiments will commence in the summer 2014.

As part of Objective 3, proteins have been successfully extracted from the Ross Sea field samples and Sara Bender is in the process of compiling a database to properly annotate the samples once they have been run on the in-house mass spectrometer. This work will continue over the next year.

Finally, the first field season for Objective 4 has been completed. Upon arrival, a new collaboration was formed with the Provincetown Center for Coastal Studies (PCCS; Dr. Amy Costa) and Sara Bender (Dr. Mak Saito's Lab). The PCCS group conducts monthly sampling in Cape Cod Bay as part of a statewide monitoring program. Sara Bender was able to join the group in March on the R/V Shearwater during a *P. pouchetii* bloom to collect samples for protein and transcript extractions. Protein has been extracted from these samples, and they have been run on the mass spectrometer. This work is now in the queue for computer-analysis, once the annotation database (see Objective 3) has been created. Field sampling will continue in 2014 and 2015.

HIGHLIGHTS

- Formed a new partnership with the Provincetown Center for Coastal Studies (PCCS; Dr. Amy Costa)
- Participated in 1 field campaign (March 18, 2014) in Cape Cod Bay with the PCCS group
- Cultured *Phaeocystis antarctica* (grown under different iron concentrations)
    - Successfully extracted and processed protein samples
- Participated in a postdoctoral summit sponsored by the Gordon and Betty Moore Foundation
    - Presented preliminary proteomic analysis for *Phaeocystis antarctica*
- Conducted community outreach as a science fair judge at the Falmouth Academy and Falmouth High School Science Fairs

SOCIETAL BENEFITS

In Cape Cod Bay, the marine alga *Phaeocystis pouchetii* blooms each spring and is considered a nuisance species. Its presence is hypothesized to be antagonist to higher trophic levels, although the mechanisms behind this relationship remain unclear. This proposal seeks to identify the triggers that drive the seasonal *P. pouchetii* bloom in Cape Cod Bay using metaproteomic approaches and to determine what underlying metabolic machinery may be responsible for its success. Findings will help to explain differences in the timing and strength of the bloom observed in the time-series and to provide valuable information into the present and future health of Cape Cod Bay. Additionally, the development of these tools will enable global analysis of other *Phaeocystis* strains (e.g. Ross Sea *Phaeocystis antarctica*).

EDUCATION AND OUTREACH ACTIVITIES

- Research presentation for the Gordon and Betty Moore Foundation Marine Microbes Initiative Research Associate and Postdoctoral Scholar Summit (Dorado, Puerto Rico)
    - (Poster) Marine Microbial Proteomics: Applications for detection and quantitation of changes in microbial physiology: 3 – 6 February, 2014
- Judge in 2 High School Science Fair Competitions
    - Falmouth Academy, MA: February 13, 2014
    - Falmouth High School, MA: February 28, 2014

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Figure 1. Sample collection on the Provincetown Center for Coastal Studies R/V Shearwater as part of a long-term Cape Cod Bay monitoring program. Water samples collected here have been processed for metaproteomic analysis. (Pictured, left to right: Jennifer Burkhart, Dr. Amy Costa, Dr. Sara Bender).

CINAR RESEARCH SUMMARIES

The following pages provide research summaries of the 44 CINAR projects funded during the period April 1, 2013 through March 31, 2014. The projects are organized by theme.

Theme I. Ecosystem Forecasting

Donald Anderson, WHOI – *Gulf of Maine 2013 cyst cruise and sample analysis*

Robert Beardsley, WHOI - *Technical support and improvement of FVCOM for NOAA modeling activities*

Hongsheng Bi, UMCES – *Estimating early mortality and implications for reference points for the Atlantic menhaden stock*

Rubao Ji, WHOI – *Stratification indices for stock and ecosystem assessments from a data assimilative circulation model*

Josh Kohut and Nickitas Georgas, Rutgers – *Accounting for habitat-dependent observation error in bottom trawl survey indices for pelagic stocks using butterfish (Peprilus triacanthus) as a model*

Malin Pinsky, Rutgers – *Assessing marine climate impacts in North America using species range shifts and climate velocity*

David Townsend, UMaine – *Nutrient dynamics on the NE continental shelf: sample analyses 2013-2014*

James Wilkin, Rutgers - *Sustaining development of National Ocean Service operational forecast systems based on the Regional Ocean Modeling System*

Theme II. Ecosystem Monitoring

Andrew Bowen, WHOI – *2013 ROV Jason and AUV Sentry use for NOAA/McDonald (Deepwater Canyons)*

Andrew Bowen, WHOI – *NDSF vehicle engineering days*

Yong Chen, UMaine – *The Eastern Gulf of Maine sentinel jigging / longline survey / fishery in 2013*

Scott Gallager, WHOI – *Benthic imaging in support of habitat mapping for renewable energy*

Scott Gallager, WHOI – *Transition of HabCam technology to NOAA operations and technology upgrade*

Hanumant Singh, WHOI – *The development of light field cameras for AUV obstacle avoidance*

Theme III. Ecosystem Management

James Churchill, WHOI – *Evaluating the mechanisms underlying distribution shifts and age-truncation on silver hake (Merloccius bilinearis) survey data*

Keith Cooper, Rutgers – *Evolution of cranial bone formation and tissue histopathology of embryonic and juvenile commercially important finfish species exposed to increasing levels of CO_2 and Ph due to ocean acidification*

Di Jin and Porter Hoagland, WHOI – *An empirical analysis of portfolio management as a tool for implementing ecosystem based fishery management*

Jessica Joyce, GMRI – *Improving fishery dependent data collection and integration into NOAA Fisheries data systems*

Josh Kohut and Enrique Curchitser, Rutgers – *Thermal habitat dynamics in the Northwest Atlantic and the role of habitat squeeze in density dependent regulation of forage species populations*

Gareth Lawson and Andone Lavery, WHOI – *Developing wideband acoustic methods for improving fisheries and ecosystem assessments*

Timothy Shank, WHOI – *Scientific leadership for the NOAA Ocean Exploration and Research Program*

Jenny Sun, GMRI – *Evolution of groundfish sectors business model*

Michael Wilberg, UMCES – *The effect of catch restrictions on recreational catch*

Theme IV. Protection and Restoration of Resources

Josh Kohut and Olaf Jensen, Rutgers – *Analysis linking study fleet data to habitat and statistic models in the Mid Atlantic Bight*

Daniel McCorkle and Anne Cohen, WHOI – *An experimental investigation of the impact of ocean acidification on the early life stages of surf clams, and the interactive effects of feeding*

Michael Moore, WHOI – *Marine mammal stranding responses capacity building*

Daphne Munroe, Rutgers – *Evaluation of larval sources and population connectivity in Atlantic sea scallop (Placopecten magellanicus)*

John Stegeman, WHOI – *Analysis of CYP1A1 expression in cetacean tissue samples*

Theme V. Sustained Ocean Observations and Climate

Donald Anderson, WHOI – *Global ocean observing coordination activities*

Donald Anderson, WHOI – *CINAR Input into fisheries/climate regional products*

Carin Ashjian, WHOI – *An eye in the ocean: High-resolution vertical distributions of plankton and particles and coincident hydrography in the Western Chukchi Sea – data synthesis*

Carol Anne Clayson, WHOI – *Satellite derived climate data records of ocean-atmosphere exchange*

Jacqueline Grebmeier, UMCES – *Macroinfauna community structure, biomass and sediment studies during the RUSALCA program*

Jacqueline Grebmeier, UMCES – *Pacific Arctic Group (PAG) secretariat office 2013-2014*

Steven Jayne, Paul Robbins and W. Brechner Owens, WHOI – *WHOI contribution to Argo float program*

Robert Pickart, WHOI – *Circulation in the Western Chukchi Sea and its role in the ecosystem*

Robert Pickart, WHOI – *Synthesis of physical measurements from the Pacific Arctic Group: Flux of Pacific water through Barrow Canyon, Chukchi Sea*

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

Robert Weller and Albert Plueddeman, WHOI - *Ocean climate observations and analyses (2013-2014)*

Theme VI. Education and Outreach

Donald Anderson, WHOI - *Research and education in quantitative fisheries and ecosystem science*

Donald Anderson, WHOI – *Refining eastern region stakeholder needs for climate products and services*

Donald Anderson, WHOI – *US National Office for Harmful Algal Blooms*

Alexa Dayton, GMRI - *Marine Resource Education Program: Serving the needs of fishing communities and fishery management in the Northeast region*

Alexa Dayton, GMRI – *Marine Resource Education Program for fishermen in the Southeast fisheries region*

Theme I. Ecosystem Forecasting

Gulf of Maine 2013 cyst cruise and sample analysis

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Donald Anderson - WHOI

NOAA Sponsor – Richard Stumpf, NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

Over the past several years, an important management tool for red tides or toxic *Alexandrium* blooms in the GOM region has been a numerical model of bloom dynamics developed at the Woods Hole Oceanographic Institution (WHOI). Each week during the bloom season, this model is run, providing a "hindcast" simulation of *Alexandrium* distribution and abundance for the preceding weeks and months, as well as a one-week short-term forecast based on weather predictions. These weekly forecasts are distributed to managers and researchers in the region via the Northeast PSP listserv (over 200 members). The model is initiated from a map of *Alexandrium* cyst abundance in Gulf of Maine bottom sediments and a new map is produced each year from the samples collected from annual cyst surveys.

Cysts are an important part of the organism's life cycle. Cysts are formed when asexually dividing vegetative cells in the overlying bloom waters undergo sexual reproduction and produce new cysts that are deposited to the surface sediments. Those cysts form "seedbeds" that germinate and inoculate the overlying waters in the following year(s) to re-establish subsequent blooms. Past studies have shown that the abundance of cysts in the region varies dramatically year-to-year, and that the cyst abundance measured during the fall or winter in one year is a first-order predictor of the regional bloom magnitude in the next year. This knowledge, as well as the observation of a very high cyst abundance in 2007, led to a seasonal forecast of a major red tide in the Gulf of Maine in 2008, a forecast that was borne out with extensive shellfish closures in Maine, New Hampshire, and Massachusetts, as well as offshore federal waters. Seasonal forecasts have been made every year since, based on the annual cyst map.

Information generated from this project will be used to provide the 2014 seasonal forecast of harmful algal bloom in the Gulf of Maine and weekly forecasts during the 2014 bloom season. This was an important cruise, not only to continue the annual cyst abundance time series and modeling effort to predict *Alexandrium* blooms in the Gulf of Maine, but also to transition the that effort from research at WHOI to operations within NOAA. In all phases of the cruise, NOAA personnel participated and were trained in the cyst methods onboard.

ACCOMPLISHMENTS

Approximately 26 stations were occupied over a 6-day period using the NOAA ship Okeanos Explorer cruise # EX-13-6 (see Fig. 1). At each station, a Craib corer was deployed and a relatively undisturbed surface sediment core was collected. The core was extruded onboard and sectioned into two layers; the top 0-1 cm and the underlying 1-3 cm layers. The sediment samples were processed onboard using standard cyst techniques that are routine in the Anderson lab but were transitioned to NOAA personnel that served on cruise EX-13-06. That processing included protocols for dilution of the raw sediment, sonifying and sieving the sample to yield a 20-100 µm particulate fraction that was initially preserved in 2% formalin and exchanged onboard into 100% methanol for long term storage until counting began.

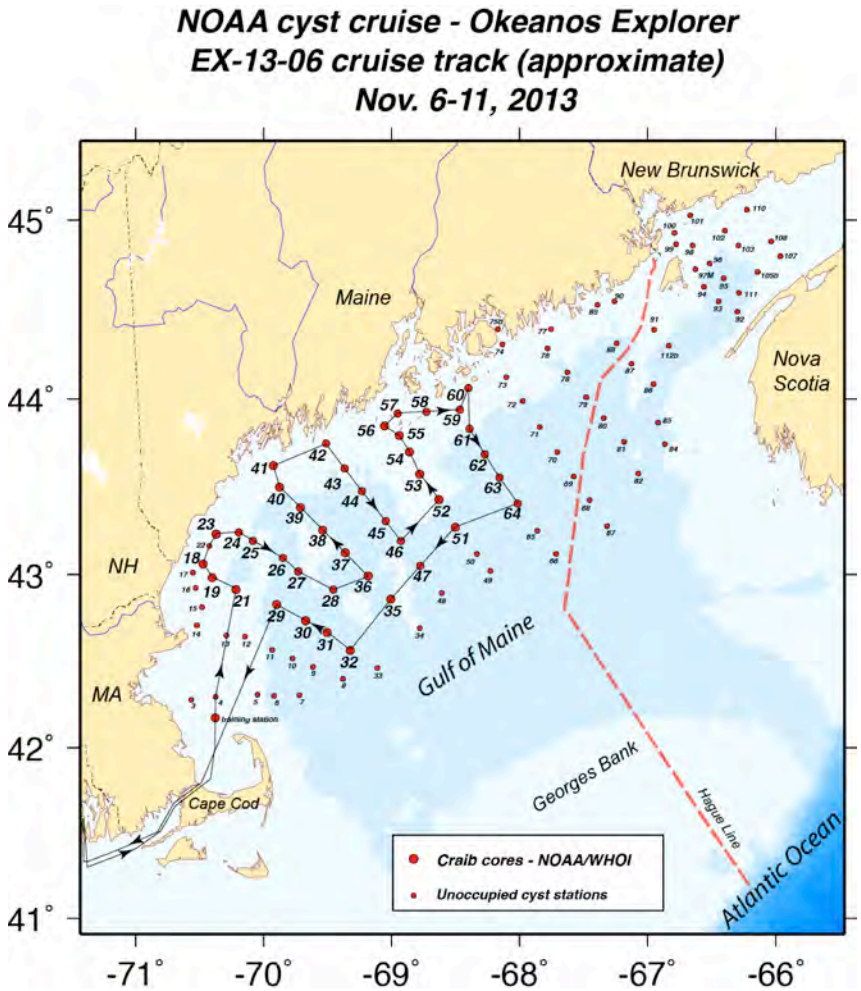


Fig. 1. Station map of the completed fall 2013 cyst survey.

In the shore lab, the formalin/methanol preserved samples were stained with primuline, observed using an epi-fluorescence microscope and counted in a Sedgewick-Rafter counting slide (1ml). Cyst counts were collated into a excel spreadsheet where cyst concentrations (cysts cm^{-3}) were calculated. Final reduced data were provided to Dr. Dennis McGillicuddy (WHOI) for preparation of contour plots and cyst abundance calculations for each layer and sub-regions within the GOM, and to McGillicuddy, Ruoying He (NCSU), and Rick Stumpf (NOAA) for *Alexandrium* GOM model simulations under a separately funded project.

HIGHLIGHTS

- Successful transition of the cyst cruise from a research effort at WHOI to a NOAA vessel and with NOAA personnel for long term operations of that program
- Cyst abundance in 2013 indicated a slight decrease in abundance from the previous year (2012)

- Model simulations based on the 2013 cyst abundance were complete during winter, 2014 with the bloom prediction released (http://www.whoi.edu/news-release/redtide)

SOCIETAL BENEFITS

Harmful algal blooms (HABs) are a serious and growing threat to the nation's fisheries, coastal ecosystem and human coastal communities. Data from this project are used to improve an important management tool for HABs.

EDUCATION AND OUTREACH ACTIVITIES

A Northeastern University cooperative program (undergraduate) student participated in the project and cruise receiving training in *Alexandrium* cyst identification and enumeration as well as training in sampling techniques.

Results of the cruise were discussed at a meeting of academic researchers, regional stakeholders (ME, NH, and ME shellfish resource managers), and NOAA managers as part of the 2014 seasonal PSP forecast discussion.

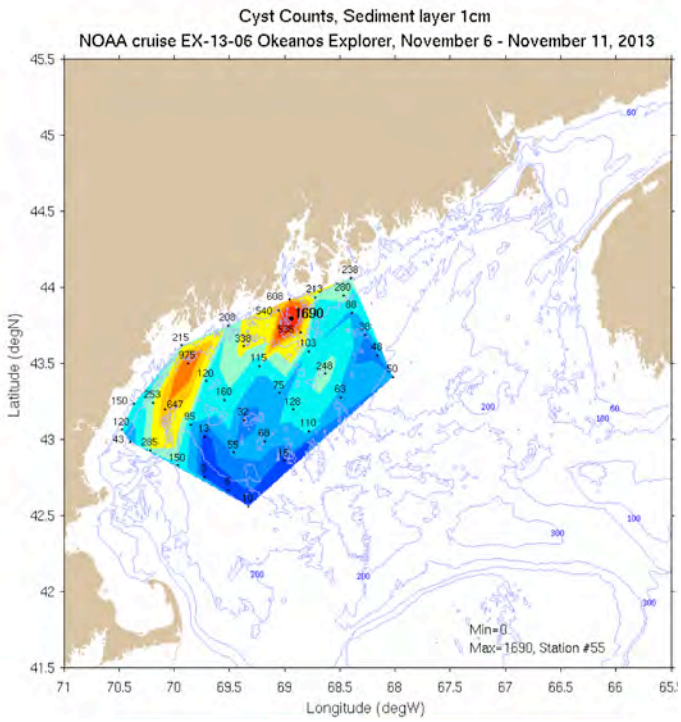


Fig. 2. *Alexandrium* cyst map showing the concentrations observed in the surface sediments (0-1cm) of the Gulf of Maine. The contoured data show a narrow stripe of high cyst concentrations that extends along the offshore waters of the western Gulf of Maine.

Technical support and improvement of FVCOM for NOAA modeling activities

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Robert Beardsley - WHOI

NOAA Sponsor – Frank Aikman, NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. 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 UMASSD 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

- A successful FVCOM workshop was held at CSDL in mid-July 2013. Changsheng Chen (UMASSD) presented improvements and new features in the latest version FVCOM 3.16 and also helped diagnose the CO-OPS San Francisco Bay FVCOM forecast model and Great Lakes FVCOM forecast system.
- Worked on adapting a water quality biological model for DO prediction for use in the CO-OPS North Gulf of Mexico (NGOM) FVCOM forecast model system.
- Conducted several conference calls with the Great Lakes Environmental Research Laboratory (GLERL) to help place FVCOM 3.1.6 into 24/7 forecast operation for the Great Lakes
- Helped modify FVCOM 3.1.6 to include an option for the surface heat flux calculation using the GLERL-developed algorithm.

HIGHLIGHTS

- Provided the regular technical support for CO-OPS in development of the FVCOM-based forecast systems in NGOM, San Francisco Bay, and Great Lakes.
- Helped develop and modify FVCOM modules to meet CO-OPs needs in the forecast system development.

- Guide technically the approach to nest the CO-OPS FVCOM forecast system to the global and regional models and extend the CO-OPS model system into estuaries.

SOCIETAL BENEFITS

- Shared FVCOM development with public users, which helps with the utilization of FVCOM in other coastal regions in the world.
- The development of the FVCOM forecast system provided state and federal government agencies real-time ocean environmental conditions for use in marine ecosystem evaluation, navigation, search and rescue operation planning, coastal inundation, and river flooding.
- Updated the existing NOAA forecast system to a new technical level with better spatial resolution of complex coastal geometry.

EDUCATION AND OUTREACH ACTIVITIES

- Helped trained the new generation modelers in NOAA labs, especially in using unstructured-grid models.
- Enhanced the communication between graduate students in academic universities and scientists in NOAA laboratories.

PUBLICATIONS

Chen, C., Beardsley, R. C., Cowles, G., Qi, J., Lai, Z., Gao, G., Stuebe, D., Liu, H., Xu, Q., Xue, P., Ge, J., Ji, R., Hu, S., Tian, R., Huang, H., Wu, L., Lin, H., Sun, Y., Zhao, L., 2013. An unstructured-grid, finite-volume community ocean model FVCOM user manual (3rd edition). SMAST/UMASSD Technical Report-13-0701, University of Massachusetts-Dartmouth, pp 404.

Estimating early mortality and implications for reference points for the Atlantic menhaden stock

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Hongsheng Bi - UMCES

NOAA Sponsor – Jonathan Hare, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

During the past two decades, Atlantic menhaden (*Brevoortia tyrannus*) has experienced a notable decline in recruitment to the Chesapeake Bay. The primary objective of this study is to examine the coast-wide larval menhaden abundance and identify possible causes for the observed decline.

Larval data were obtained from two major ichthyoplankton surveys conducted by the NOAA Northeast Fisheries Science Center - MARMAP and ECOMON. MARMAP, the Marine Resources Monitoring, Assessment, and Prediction Program, was conducted during 1977- 1987, and ECOMON, the Ecosystem Monitoring Program, was conducted during 1992-present.

Our goal is to better understand the relationship between larval menhaden abundance and recruitment. We are developing a larval abundance index to be used as a spawning stock biomass index of abundance. This requires correcting for any differences between the surveys as well as back calculating hatch date from larval size information in order to correct for early larval mortality. This information will be useful in future stock assessments, as it allows the use of environmental information into stock-recruitment models and development of time-varying reference points.

ACCOMPLISHMENTS

The first step in the analysis required selecting sites and periods for use in the calculation of an index of abundance to ensure consistent sampling both spatially and temporally. Larvae were detected most frequently in surveys conducted in the Mid-Atlantic Bight and Southern New England. From those areas, we also removed strata in which no larvae were collected throughout the span on the available data.

To correct for changes in timing and location of sampling among years, we constructed a general linear model with year, month, and stratum as categorical variables. This provided estimates for a preliminary index of abundance, uncorrected for larval size.

Comparing our preliminary index to a juvenile abundance index from Maryland, we found a negative relationship between larval and juvenile abundance ($p < 0.001$; Figure 1), with high juvenile abundance occurring with low larval abundance and vice versa.

In a similar manor, we estimated mean larval size over time. We found high interannual variation early on, with trends towards smaller sizes in the most recent decade when abundance was measured at its highest. However, abundance and average larval size were not related. Therefore our analysis did not support the existence of density dependent larval growth at this stage.

Lastly, we found an interesting pattern in larval size by month with below average sizes observed May-November and above average sizes December- April (Figure 2). Beginning in September, larval length increased on average by month until April. In May, larvae were observed at an average of 12 mm smaller than in April. This observation warrants further investigation to identify what is driving these trends and whether it is due to changes in mortality, production, or ingression.

HIGHLIGHTS

- Juvenile menhaden abundance was negatively related to larval abundance (Fig. 1)
- No evidence of density dependence larval growth
- Interesting patterns in seasonal larval length observations calling for further investigation (Fig. 2)

SOCIETAL BENEFITS

Atlantic menhaden support the largest fishery on the U.S. east coast. This analysis provides an index of Atlantic menhaden abundance that is independent of the fishery as well as robust spatially and temporally. Modeling changes in larval mortality provides an opportunity to improve the scientific information used to manage this stock by to incorporating environmental processes into the stock assessment and determination of stock status.

EDUCATION AND OUTREACH ACTIVITIES

Bi, H., H. Yu, M.J. Wilberg, A.M. Schueller, G.M. Nesslage, H.J. Walsh, 2013. Estimating early mortality for reference points for the Atlantic menhaden stock, Atlantic menhaden data workshop. September, Baltimore, MD.

Simpson, C.A., M.J. Wilberg, A.M. Schueller, G.M. Nesslage, H.J. Walsh, H. Bi. 2014. Ichthyoplankton-based index of abundance for Atlantic menhaden. Tidewater Chapter American Fisheries Society. 27th Annual Meeting. March 21-23. Newport News, VA.

Simpson, C.A., M.J. Wilberg, A.M. Schueller, G.M. Nesslage, H.J. Walsh, H. Bi. 2014. Ichthyoplankton-based SSB index. Atlantic menhaden data workshop. January 13-16. St. Petersburg, FL.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

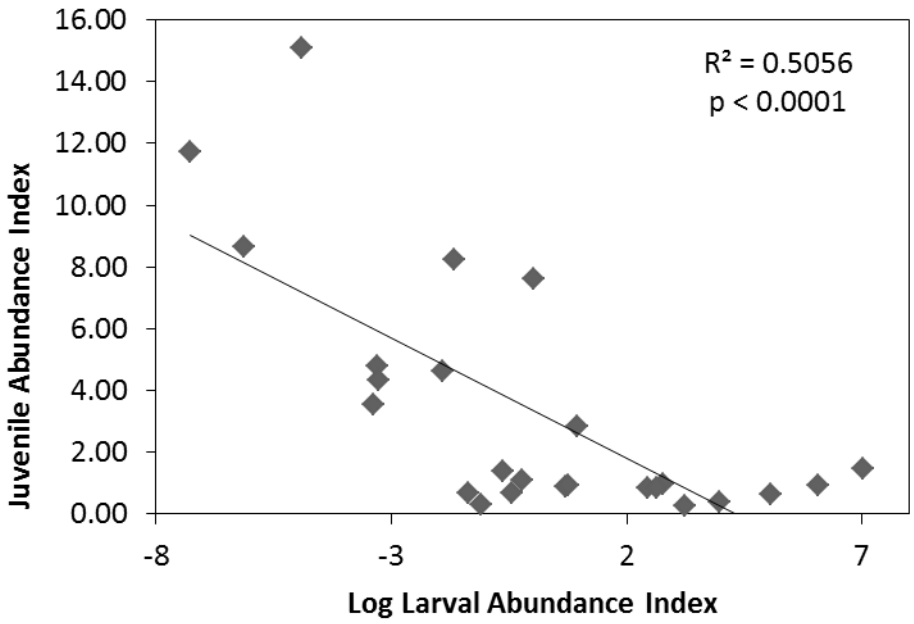


Figure 1. Log larval index of abundance from ECOMON and MARMAP ichthyoplankton surveys compared by year to Maryland DNR's index of juvenile abundance for the entire Chesapeake Bay.

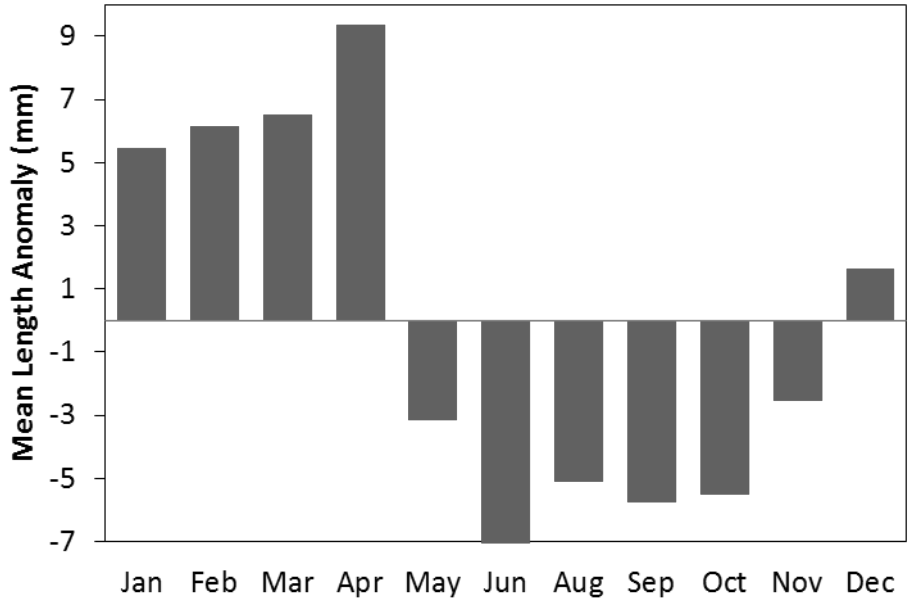


Figure 2. Mean length anomalies by month observed from the MARMAP and ECOMON ichthyoplankton surveys.

Stratification indices for stock and ecosystem assessments from a data assimilative circulation model

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Rubao Ji - WHOI

NOAA Sponsor – Jonathan Hare, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. 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.

Following the first year effort in the evaluation of the reanalysis product (*Objectives 1*), we continued to assess the variability and scales of stratification on the Northeast US shelf (*Objectives 2*). During the report year, we have built a stratification database and derive indices of stratification (*Objectives 3*) and begun to evaluate optimal monitoring design for observing stratification (*Objective 4*).

ACCOMPLISHMENTS

During the second year of this project, we continued to characterize the spatio-temporal variability and scales of stratification on the Northeast US shelf. First, we generated a daily 3-dimensional stratification climatology by averaging model estimates over the 33-year time period. The product corroborates the seasonal progression of stratification inferred from observations (predicted by P. Fratantoni using harmonic curve fitting within individual Ecological Production Units), but also reveals considerable spatio-temporal variability unresolved by the sparse observations alone. In terms of the strength and timing, stratification sets-up/ -down earlier in the Mid-Atlantic Bight (MAB), with stronger peaks on the shelf than in the Gulf of Maine (GoM). The patterns imply a strong interplay between thermal and haline components, whose relative contribution to the seasonal evolution of stratification has been quantified in a novel regime diagram (Fig. 1). It shows that, stratification in the MAB region is thermally-dominated through a larger portion of the year, whereas the Nova Scotian Shelf (NSS) and the east GoM tend to experience more haline control. We also computed the peak timing as

well as the onset/offset timing of thermally-positive and thermally-dominant states of the stratification cycle, and found prominent latitudinal shift and regionality, with important implications for the seasonal cycle of biogeochemical dynamics.

We examined the interannual variations in stratification, with the focus on the joint and respective effects of warming and freshening in the study area. We distinguished the effects of buoyancy control versus heat flux and assessed the phenological shifts of stratification. For all quantities, the long-term trend and interannual fluctuations were assessed using a state-space model, complemented by EOF and cluster analyses. Dominant principle components were compared with the changes in temperature and salinity at the sea surface and 50 m depth to identify key controls. Overall, thermal and haline components play an important role, although the haline effect is more significant in the northern part of the study area and generally plays a larger role at interannual time scales (compared with seasonal).

We explored the forcing mechanisms that drive interannual variations in surface salinity using long-term observations in the NSS-GoM region, identifying alongshore wind-forcing as a dominant control. A "valve" mechanism was proposed to elucidate the role of winds in modulating the sea level slope and along-shelf flow under stronger/weaker southwesterly wind conditions (Fig. 2). The wind-induced variability can influence the transport of low-salinity water from the Gulf of St. Lawrence to the GoM, explaining interannual variations in surface salinity distributions and stratification within the region. The findings offer a viable mechanism, besides the freshening of remote upstream sources, to explain interannual patterns of freshening in the GoM. A peer-reviewed paper on this study has been published in the Journal of Geophysical Research-oceans.

HIGHLIGHTS

Spatially explicit stratification indices, including magnitude and key timings, consisting of climatological and interannual values, are made available for the Northeast US shelf from 1978 to 2010 (http://delmar.whoi.edu:8080/thredds/catalog/testAll/catalog.html).

- Stratification on the Northeast U.S. shelf is largely affected by surface heat flux and the advection of low-salinity water from higher latitude. The relative importance between thermal and haline controls display spatio-temporal variations, and the haline effect becomes more appreciable in the northern part of the study area and/or at the interannual time scales.
- Wind-induced modulation of sea level slope and currents affects the transport of low-salinity water from the Gulf of St. Lawrence to the GoM, and thus explains interannual patterns of freshening in the GoM.

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

Li, Y., R. Ji, C. Chen, P. Fratantoni and J. Hare*, FATE 2012: Stratification Indices for Stock and Ecosystem Assessments From a Data Assimilative Circulation Model, 37th annual larval and fish conferences, June 2-6, 2013, Miami, Florida.

Fratantoni, P., Y. Li, R. Ji, C. Chen, and J. Hare, Variability of stratification on the Northwest Atlantic shelf and its implications for plankton production, 2014 Ocean Sciences Meeting, February 23-28, Honolulu, Hawaii.

Li, Y., R. Ji, P. Fratantoni, C. Chen, and J. Hare, C. Davis and R. Beardsley, Linking wind and surface salinity fluctuations on the Northwest Atlantic shelf: mechanism and implications, 2014 Ocean Sciences Meeting, February 23-28, Honolulu, Hawaii.

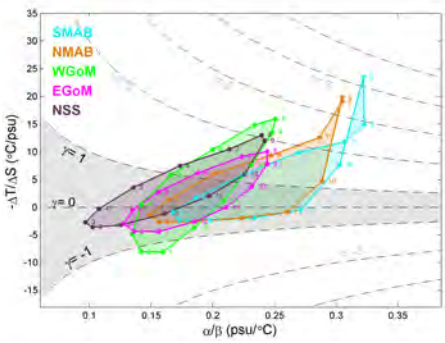
Li, Y., R. Ji*, P. Fratantoni, C. Chen, J. Hare, C. Davis and R. Beardsley. Linking wind and sea surface salinity fluctuation on the Northwest Atlantic shelf: Mechanisms and implications. RARGOM, Annual Science Meeting, October 8, 2013, Portsmouth, NH, USA

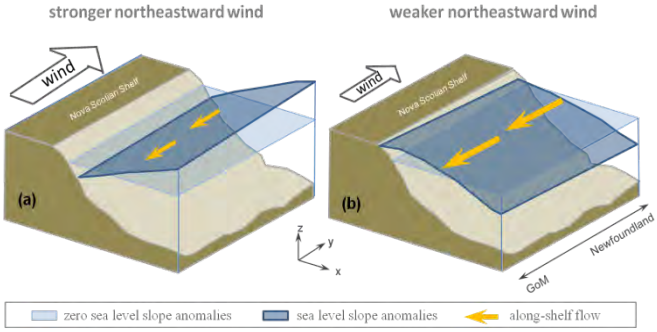
Ji, R. Y. Li, P. Fratantoni, C. Chen, J. Hare, Y. Sun, K. Hyde and C.S. Davis. Stratification on the Northwest Atlantic Shelf: Patterns, Drivers and Implications for Plankton Production. ICES Annual Science Conference. Sep. 23-2, 2013, Reykjavik, Iceland.

PUBLICATIONS

We have prepared 3 publications: 1 paper on interannual wind-modulation published in JGR-oceans on Apr. 16th, 2014; 1 paper on the stratification climatology to be submitted to JGR-oceans, and 1 paper on the interannual variations of stratification in preparation.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS





(left) Figure 1. Regime diagram of annual cycle of stratification in five subregions. The horizontal axis α/β represent the ratio between thermal and haline coefficients; the vertical axis –ΔT/ΔS represents the ratio between surface-to-50m temperature and salinity differences. The gray and white zones delineate regimes dominated by haline and thermal controls, respectively. Each dot represents the monthly mean computed from the daily climatology, and the corresponding month is marked with numbers.

(Right) Figure 2. Schematic diagram for the modulation of sea level slope and flow by alongshore wind stress on the Northwest Atlantic shelf. (a) Under stronger northeastward winds, the southwestward flow is weaker, resulting in a sea level slope that is higher upstream, near the Newfoundland Shelf, and offshore. (b) Under weaker southwestward winds, the Scotian Shelf Current (SSC) becomes stronger, resulting in a sea level slope that is higher downstream and shoreward, so that the overall pattern displays a high anomaly near the Gulf of Maine (GoM).

Accounting for habitat-dependent observation error in bottom trawl survey indices for pelagic stocks using butterfish (Peprilus triacanthus) as a model

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Josh Kohut and Nickitas Georgas - Rutgers

NOAA Sponsor – Jonathan Hare, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

Most NEFSC stock assessments rely on fishery-independent abundance indices developed from spring and fall depth stratified bottom trawl surveys of continental shelf waters 20-365 m deep. Shallow coastal habitats and deep habitats adjacent to the shelf are not sampled. Much of the water column is also not sampled since the bottom trawl headrope heights are ~3-4 meters.

Seasonal temperature variability in the Mid-Atlantic Bight (MAB) on the northeast U.S. shelf is among the highest in the world and many animals in the region undertake long distance migrations in response to changing photoperiod, temperature and other dynamic water column processes. For example, a large proportion of managed stocks use coastal habitats <20 m deep as summer feeding and/or nursery grounds. A large portion of the population then migrates offshore and south during the fall to overwintering grounds near the continental shelf break, including waters >365 m deep (see Low et al. 1982). Inter-annual variability and long term trends in seasonal habitat dynamics can change the proportion of the animal's habitat sampled each year in the trawl survey. Changes in abundance indices resulting from this habitat dependent observation error could be misinterpreted as a change in population size. In addition, habitat dependent observation error occurs when pelagic animals undertake diel vertical migrations and are assessed using round the clock bottom trawl surveys. Ontogenetic or density-dependent changes in diel behavior could affect survey indices if age structure changes or population abundance changes, thereby affecting catchability.

Atlantic butterfish (*Peprilus triacanthus*) is a short-lived pelagic fish with habitats defined primarily by dynamic oceanographic processes (Manderson et al., 2011, Herron 1989, *P. burti*). The species supported a targeted fishery from 1965-1987 (>15,000 mt), but most of the current quota (~2,000 mt) is now reserved for bycatch in the squid fishery. The 2009 butterfish assessment faced several contradictory data streams and model results including: 1) an increasing trend in the spring bottom trawl survey index (>200%), 2) a decreasing trend in the fall index (>60%) from 1985-2008, 3) a declining relative abundance of old fish despite a low calculated fishing mortality rate (0.02), 4) no indication of increased natural mortality from predator diet analyses, and 5) an estimate of total biomass from the previous assessment model that was lower than the swept area biomass estimate from the fall survey (i.e. a catchability of >1). Our objective is to develop a method for quantifying the overlap between the trawl survey and

butterfish habitat (e.g., habitat dependent observation error), with a specific focus on season-specific and ontogentic patterns in catchability through time.

ACCOMPLISHMENTS

Over the last year, our work has focused on the validation of the hindcast temperature model and niche model verification. Monthly climatology corrections are applied to bottom temperature (BT) estimates produced from a high-resolution multidecadal ROMS hindcast to explore the possibility of reducing the model's systematic BT bias in the North West Atlantic Shelf. The model hindcast analysis spans from 1973 to 2012 during the NOAA/NMFS/NEFSC Spring and Fall surveys periods (largely February to June and September to November months). The ROMS hindcast is compared with all *in situ* data available from the NODC World Ocean Database, the NOAA NEFSC database and the fisheries independent bottom trawl surveys. Our analysis shows that while the model hindcast BT captures the observed variability, the monthly climatology has a lower root mean square error (RMSE) when compared to observations. Thus, a climatological adjustment of the model BT hindcast preserved the predicted variability and reduced the RMSE for each fall period when compared to observations. The adjusted RMSE values were used to estimate three alternate states of bottom temperature as input into a niche model used to compute a fisheries habitat suitability index (HSI).

The debiased temperatures were coupled to a thermal niche model to inform the catchability term in this year's butterfish assessment. To do this we quantified the uncertainty in the temperature fields to provide a best estimate with upper and lower bounds. These three temperature estimates provided an envelope of inputs to feed the niche model. The approach was documented and passed the peer-review process of the stock assessment. Future work will center on the incorporation of other available forecast and hindcast models including the higher resolution nearshore output of the Stevens NYHOPS products.

HIGHLIGHTS

- Bottom temperature hindcast was de-biased and uncertainty quantified.
- The hindcast was coupled to a thermal niche model to inform the availability term of catchability in this year's butterfish assessment.
- This approach was peer reviewed during the SARC in January 2014.

SOCIETAL BENEFITS

This project is informed by the butterfish assessment peer-review, and meetings by the PIs with participants in the small mesh trawl fishery. Both groups raised questions about the NEFSC survey indices used in the assessment. Our project will deliver a method for explicitly accounting for habitat-dependent observation errors with the intent of developing more accurate estimates of butterfish population trends for use in the next assessment; trends that both scientists and industry have worked to document.

EDUCATION AND OUTREACH ACTIVITIES

OpenOcean 2014. Marine habitat dynamics and climate change. An inconvenient truth. MAFMC Climate Change and Fishery Science Workshop. New Bern, North Carolina Biological Modeling. Short Live Species Workshop sponsored by Commercial Fisheries Research Foundation and MARACOOS. South Kingston Rhode Island. Sept. 4-5

OpenOcean 2013. An index of availability (ρ_h) of Atlantic Butterfish to surveys using a thermal niche model coupled to debiased hindcasts of bottom temperature from a ROMS model. 2013 Butterfish Stock Assessment Data Meeting. Woods Hole, Massachusets. August, 2013

OpenOcean 2013. Integrating habitat dynamics into population & ecosystem assessment using cooperative research within an IOOS framework. Fisheries Working Group. National Research Council. Highlands New Jersey. July 30, 2013

OpenOcean 2013 Integrating habitat dynamics into population & ecosystem assessment using cooperative research within an IOOS framework. East Coast Fisheries Forum. Annapolis Md. June 27, 2013

Assessing marine climate impacts in North America using species range shifts and climate velocity

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Malin Pinsky - Rutgers

NOAA Sponsor – Jonathan Hare, NMFS

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

The objectives of this project are to 1) Calculate regional indicators of species distribution shifts, community shifts, and climate velocity for coastal marine regions of the United States; 2) Develop open-source software pipelines to process these data in real-time from the original data sources into publicly accessible visualizations; 3) Fully document the pipeline and make it available to NOAA employees and to the public; and 4) Integrate the indicators into National Climate Assessment and NEFSC Ecosystem Advisory processes.

Our initial work focused on Aims 1, 2 and 4 from the above list, including discussions with data providers, testing of indicator visualization methods, and streamlining of the data analysis. Negotiations on a contract to implement 2) were begun.

ACCOMPLISHMENTS

- Discussions with the Northwest Fisheries Science Center clarified that machine-readable data downloads were not possible, but that a standardized data request form was feasible. A data request was sent and data through 2012 were received for informing the national climate indicator.
- Discussions with the Gulf of Mexico SEAMAP project clarified that machine-readable data downloads were not possible, but that a widely accessible file format (CSV) could be posted and downloaded from the website. We are currently waiting for the 2013 data to be uploaded. These data will inform the climate indicator.
- Through discussions with the NEFSC, we developed a method for annually updating the data included in the climate indicator.
- Discussions with NMFS and WHOI explored methods for using iPython to document the data pipeline. We ultimately decided that the method was not feasible given file size limitations on iPython.
- A trial National Climate Assessment indicator was developed and shared with NMFS staff for feedback.

HIGHLIGHTS

- A trial climate indicator using marine fish and invertebrate distributions was developed and circulated. Once refined, this indicator will contribute to the National Climate Assessment's Climate Indicator System.
- The trial indicator shows how marine fish and invertebrates throughout the U.S. have been shifting towards higher latitudes and deeper depths over the last three decades.

EDUCATION AND OUTREACH ACTIVITIES

None to date. However, a public website is under development.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

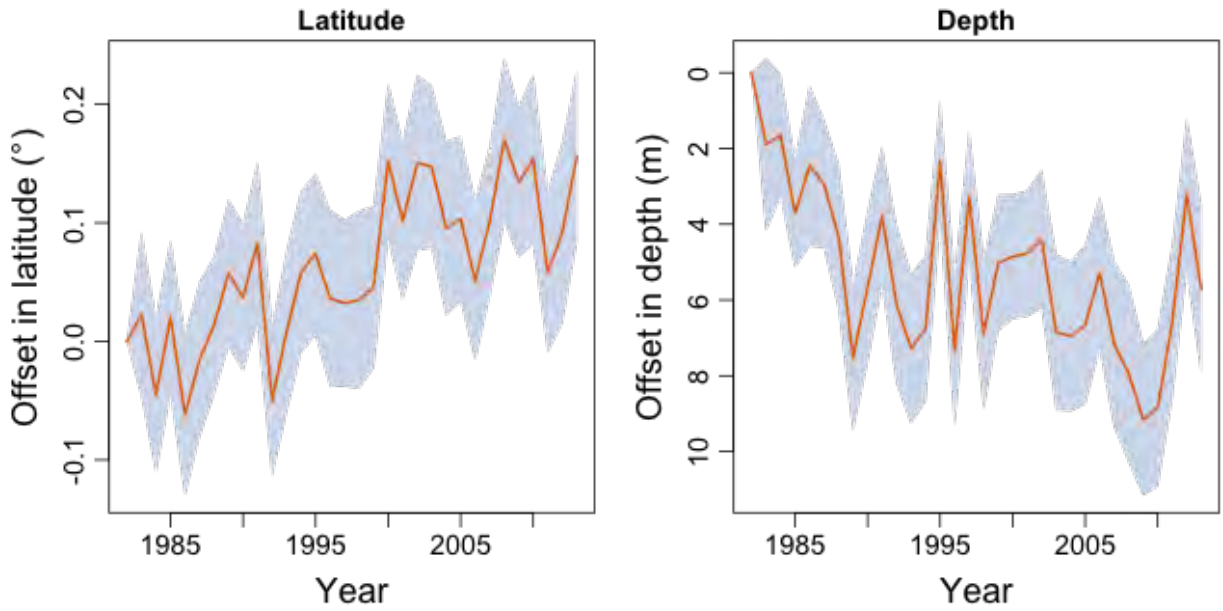


Figure 1: This figure shows annual change in latitude (left) and depth (right) for 131 marine fish and invertebrate species in North America from 1982 to 2013. The shaded band shows the likely range of values, based on the number of species assessed (the standard error). For depth, a downward trend indicates fish moving deeper in the ocean.

Nutrient dynamics on the NE continental shelf: Sample analyses

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

David Townsend - UMaine

NOAA Sponsor – Jonathan Hare, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

This project was initiated in response to the need for better data coverage for nutrients in the Gulf of Maine and adjacent waters of the NE continental shelf. 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 are analyzing samples collected as part of the *NOAA Northeast Fisheries Science Center's Ecosystem Monitoring Program* (EcoMon Program). The EcoMon Program conducts survey cruises approximately four times each year in shelf and slope waters of the Gulf of Maine, Georges Bank, and 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, we have received and processed samples from 16 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 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

- Among notable results from the most recent data are the nutrient profiles taken in the Northeast Channel, Georges Basin and Jordan Basin in the Fall of 2013 (Fig. 2), which show the influx of warm, salty, high-nutrient Warm Slope Water, in contrast to the Fall of 2012 when there was an influx of relatively fresh, cold, and low nutrient shelf water at depths between ca. 50 and 160m.
- 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 fundyense* 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.
- Our nutrient field analyses are helping to forecast the severity of Gulf of Maine "red tides" months in advance.

PUBLICATIONS

Smith, P.C. N.R. Pettigrew, P. Yeats, D.W. Townsend and G. Han. 2012. Regime shift in the Gulf of Maine. pp. 185-203, *In:* 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.

Fogarty, M.J., D.W. Townsend and E. Klein. 2012. Advances in understanding ecosystem structure and function in the Gulf of Maine. pp. 261-272, *In:* 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.

McGillicuddy, D.J., Jr., D.W. Townsend, B.A. Keafer, M.A. Thomas and D.M. Anderson. 2013. Georges Bank: A leaky incubator of *Alexandrium fundyense* blooms. *Deep-Sea Research II* http:// dx.doi.org/10.1016/j.dsr2.2012.11.002

Gettings, R.M., D.W. Townsend, M.A. Thomas, L. Karp-Boss. 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* http://dx.doi.org/10.1016/j.dsr2.2013.05.012

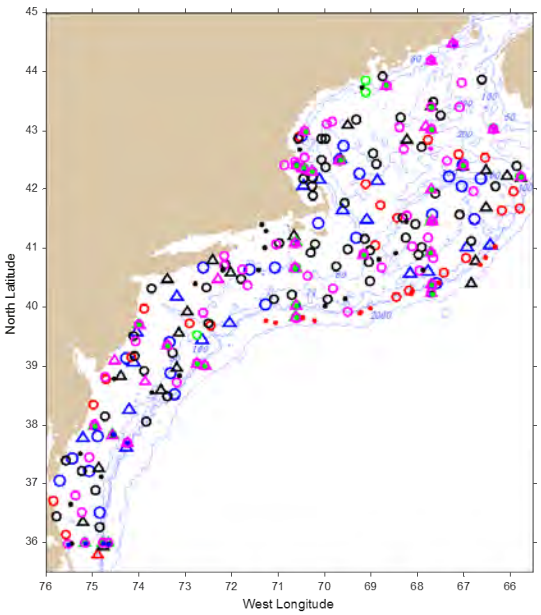
McGillicuddy, D.J., Jr., M.L. Brosnahan, D.A. Couture, R. He, B.A. Keafer, J.P. Manning, J.L. Martin, C.H. Pilskaln, D.W. Townsend, D.M. Anderson. 2013. A red tide *of Alexandrium fundyense* in the Gulf of Maine. *Deep Sea Research II. http://dx.doi.org/10.1016/j.dsr2.2013.05.011*

Townsend, D.W., M.A. Thomas, D.J. McGillicuddy, N.R. Rebuck. ms. 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.*

http://dx.doi.org/10.1016/j.dsr2.2013.08.003
Rebuck, N.D. and D. W. Townsend. 2013. A climatology and time series for dissolved nitrate in the Gulf of Maine region. *Deep Sea Research II.* http://dx.doi.org/10.1016/j.dsr2.2013.09.006

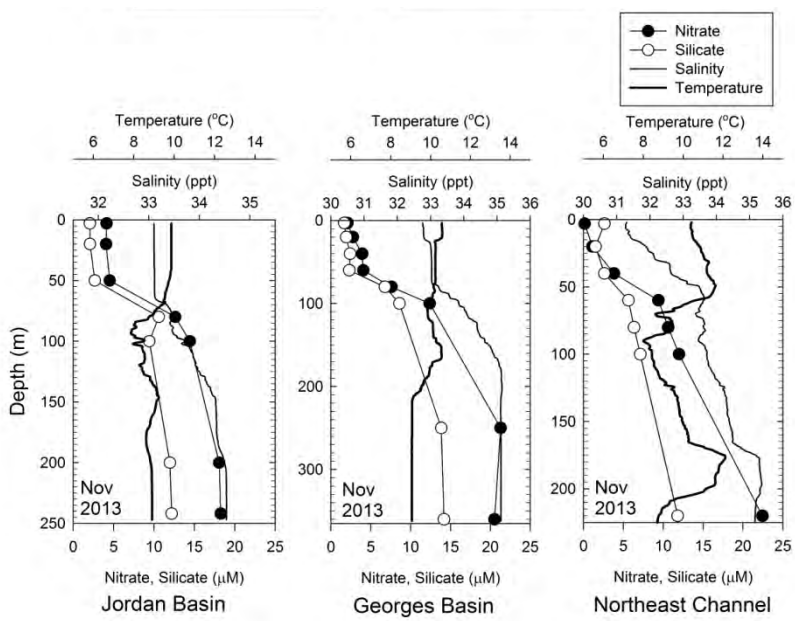
Figure 1. Station Map: NOAA EcoMon Surveys 2009 to 2014.

Nov. 2009 : 26 Stations (88 Nutrient samples)
Feb. 2010 : 19 Stations (64 Nutrient samples)



Nov. 2010 : 25 Stations (94 Nutrient samples)
Feb. 2011 : 1 Station (11 Nutrient samples)
Jun. 2011 : 38 Stations (182 Nutrient samples)
Nov. 2011 : 13 Stations (65 Nutrient samples)
Feb. 2012 : 22 Stations (130 Nutrient samples)
June 2012 : 19 Stations (100 Nutrient samples)
Aug. 2012 : 63 Stations (300 Nutrient samples)
Nov. 2012 : 34 Stations (210 Nutrient samples)
Feb. 2013 : 41 Stations (170 Nutrient samples)
June 2013 : 27 Stations (194 Nutrient samples)
July 2013 : 14 Stations (138 Nutrient samples)
Aug. 2013 : 15 Stations (108 Nutrient samples)
Nov.2013 : 23 Stations (135 Nutrient samples)
*March 2014 : 19 Stations (115 Nutrient samples)

Figure 2. Hydrographic profiles in the Northeast Channel, Georges Basin and Jordan Basin in the Fall of 2013, showing the influx of warm, salty, high-nutrient Warm Slope Water, which is in contrast to the Fall of 2012 when there was an influx of relatively fresh, cold, and low nutrient 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, 2013 – March 30, 2014

James Wilkin - Rutgers

NOAA Sponsor – Aijun Zhang, NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. 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 develops and implements hydrodynamic model-based Operational Forecast Systems (OFS) for sea ports, 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 used for OFSs for the Chesapeake Bay (CBOFS), Delaware Bay (DBOFS), and Tampa Bay (TBOFS) to provide maritime community users with real-time operational products that include now-casts 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. Furthermore, ROMS is being used for the active development of other NOS OFS for Cook Inlet, Alaska, and the Gulf of Maine.

The specific objectives of this project are to facilitate exchange of information between the ROMS developer group and the ROMS users at NOS 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

On April 23-24, 2013, the Rutgers project team met with NOS scientists in Silver Spring to identify future project priorities and action items, consult on Cook Inlet model configuration issues and stability, and relay the projected development path for 2-way synchronous nested ROMS. On November 15, 2013, in a second meeting in Silver Spring, the Rutgers project team met with NOS scientists and other research partners from WHOI (McGillicuddy) and NCSU (He) to scope the porting to a new ROMS ecosystem model - the conceptual framework of McGillicuddy and He's Gulf of Maine Harmful Algal Bloom (HAB) model.

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. Development of operational ecosystem prediction for HABs.

Theme II. Ecosystem Monitoring

2013 ROV Jason and AUV Sentry use for NOAA/McDonald (Deepwater Canyons)

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Andrew Bowen - WHOI

NOAA Sponsor – John Tomczuk, OAR

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

WHOI operates the National Deep Submergence Facility (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 the National Oceanic and Atmospheric Administration (NOAA) on a daily rate basis, to provide deep sea capabilities for funded science programs sponsored by these agencies. R/V *Atlantis* serves 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.

ROV *Jason* objectives:

- Conduct video transects and photo quadrants or photo-mosaics over selected areas of different natural habitat types and shipwrecks
- During each dive, make collections of fauna from various taxonomic groups in different natural habitat types and shipwrecks as follows:
  - Collect live corals (and probably other invertebrates) from selected sites and transport to surface in insulated bioboxes to maintain alive on board ship in chilled deck tank;
  - Make numerous discrete collections of invertebrates (particularly corals) and fishes from multiple sites for various biological studies;
  - Collect large (~ 1 m tall) colonies of selected coral species for age, growth and paleoecology studies (dried and stored in boxes on board ship)
  - Take images and collect voucher specimens of selected taxa from each location
- Deploy site markers at sites as needed
- Collect environmental data including depth, oxygen, temperature, salinity, pH using ROV-mounted instrumentation
- Collect near-bottom water samples using Niskin bottles mounted on the ROV
- Collect video and still imagery of deployed benthic landers (lower priority)
- Collect push cores for sediment sampling

ROV *Jason* was utilized for 34 days of operations onboard the R/V *Ronald Brown* in support of Dr. McDonald's Deepwater Canyons Research Program. Operations occurred in April/ May of 2013.

ACCOMPLISHMENTS

ROV Jason completed 19 dives in the area of the Atlantic Deep Water Canyons. The total bottom time for these dives was 220:50. Maximum depth of dives was 1,611 meters.

NDSF vehicle engineering days

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Andrew Bowen - WHOI

NOAA Sponsor – Karen Kohanowich, OAR

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

This project was for direct support of the at-sea fieldwork requested by NOAA.

Engineering Dive Objectives**:**

ROV *Jason* Run the *Jason* system using the spare topside computer and make sure it's fully up to date, use spare topside computer for the engineering dives. The spare joybox will also be used during the engineering dives to test functionality. Test proformance of various elements of the *Jason* system such as the manipulators, Rapp winch, Effer crane. USBL, doppler, Super Scorpio camera, and Reson. Results are compliled and sent ashore so they can be recorded.

AUV *Sentry* Testing new strobe systems, new sidescan survey techniques (both of these were critical to the follow-on Okeanos Explorer/*Sentry* expedition to the Blake Ridge) improved tracking techniques, new power saving technologies, and upgraded software. A typical engineering dive has between five and ten objectives during the course of the dive which are meant to either gather data for future use or validate a new piece of equipment or technique for regular use by scientific users.

ROV *Jason's* engineering dives took place on Dr. Scott Nooner's cruise out of Seattle, WA in September and Dr. Charles Wheat's cruise out of Puntarenas, Costa Rica in December.

AUV *Sentry's* engineering days took place on Dr. Hans Schouten's cruise out of Bridgetown, Barbados in May, Dr. David Valentine's cruise out of San Francisco, CA in October and Dr. Charles Wheat's cruise out of Puntarenas, Costa Rica in December.

ACCOMPLISHMENTS

ROV Jason and AUV Sentry both benefited from successful engineering dives insuring vehicle systems were fully tested and new functionalities operational for future science dives.

The Eastern Gulf of Maine sentinel jigging/longline survey / fishery in 2013

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Yong Chen - UMaine

NOAA Sponsor – John Hoey, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The Eastern Gulf of Maine Sentinel Survey/Fishery is a groundfish survey conducted in the summer from the western edge of Penobscot Bay to the eastern border with Canada. The survey consists of stratified random stations that are sampled with both demersal longline gear and jigging gear. A portion of the stations are also allocated for fishermen to select where they want to fish based on their knowledge of historic fishing grounds and suitable habitat. The primary objective of the survey is to provide an annual index of abundance as well as habitat preference information for groundfish species (including Atlantic cod, cusk, white hake and Atlantic halibut) in an area that was a traditionally important groundfish fishing ground but is not well covered by commercial fisheries and other monitoring programs.

The overall allocation of sampling efforts in 2013 was modified based on the feedback we have had and based on the analysis we had done with the 2012 survey data. A major change we made in 2013 over the 2012 design was that we added jigging at each type of the stations. Thus, we have the following three types of stations: (1) stratified random longline stations (LL; 30 stations over 3 depth strata); (2) Fishermen's choice longline stations (LF; 14 stations); and (3) jigging stations (JJ; 48 stations over 3 strata with 41 stations in the 1st shallow stratum). In addition to these types of stations, jigging was also applied to stratified longline stations (referred to as JL) and fishermen's choice stations (referred to as JF), which adds an additional 44 (i.e., 30 LL stations and 14 FL stations) jigging stations in 2013. Atlantic cod were the only targeted groundfish species for the JJ, JL and JF. The configuration and operation of longline and jigging followed those in 2012.

ACCOMPLISHMENTS

In 2013 Atlantic cod were caught by longline at 6.7% of stratified random stations (LL); by longline at14.3% fishermen's choice stations (LF); by jigging at 19% of random jigging stations (JJ); by jigging at 6.7% of random longline stations (JL); and by jigging at 0% of fishermen's choice stations (JF). Trends in standardized CPUE of fishermen's choice stations between 2010 and 2013 show a slight increase for white hake; an increase from 2010 to 2012 and then a decrease in 2013 for Atlantic halibut; a decrease from 2010 to 2012 followed by an increase in 2013 for cusk; and an increase from 2010 to 2012 followed by a decrease in 2013 for cod.
The stratified random survey was only conducted in 2013. Thus we only had two years of survey abundance indices for longline and jigging. For longline (LL), the abundance index of cod

increased from 2012 to 2013 although the estimates were associated with large CVs which might result from high spatial variability in longline survey catch of cod. The CVs for jigging were much smaller than those for the longline. Survey based on jigging (JJ) suggests that cod abundance index had a small decrease from 2012 to 2013. We did not use jigging to sample the longline stations in 2012. The estimate of jigging abundance index also had a large CV, comparable to the CV of longling (LL).

Depth was constantly found to be the most important environmental variables influencing the survey catch rates of Atlantic cod, cusk, white hake and Atlantic halibut. A large difference between the 2013 survey year versus previous years is the addition of jigging at all the longline stations. For the random longline stations at which both longline and jigging were used, jigging has the same number of stations as longline for which cod were caught. However, considering longline was equipped with 2000 hooks, jigging was a much more effective way to sample Atlantic cod in these random longline stations. Jigging was efficient in coastal water jigging stations (i.e., JJ) where fixed gear congestion makes it almost impossible for other sampling gears. The analysis also suggests that using depth as the stratification variable is reasonable. Thus, we suggest that the current design of the survey is effective in achieving the goals outlined for this survey/fishery monitoring program.

HIGHLIGHTS

- We successfully designed and conducted a longline/jigging sentinel survey/fishery in the coastal northern Gulf of Maine where information on groundfish population is limited;
- Survey based on jigging (JJ) suggests that cod abundance index had a small decrease from 2012 to 2013;
- Trends in standardized CPUE of fishermen's choice stations between 2010 and 2013 show a slight increase for white hake; an increase from 2010 to 2012 and then a decrease in 2013 for Atlantic halibut; a decrease from 2010 to 2012 followed by an increase in 2013 for cusk; and an increase from 2010 to 2012 followed by a decrease in 2013 for cod.
- Jigging was a much more effective way to sample Atlantic cod in coastal Gulf of Maine compared to longline.
- Depth and sediment types were found to be the most important environmental variables influencing the catch rates of cusk, Atlantic halibut, Atlantic cod, and white hake in the sentinel survey.

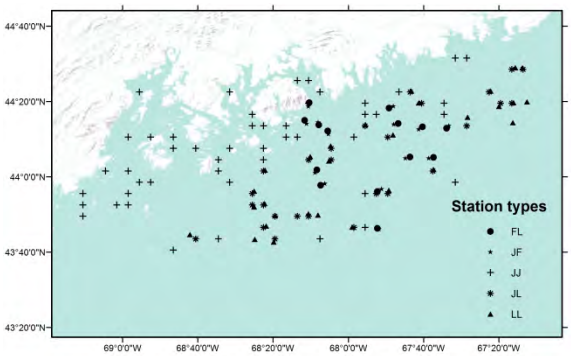
SOCIETAL BENEFITS

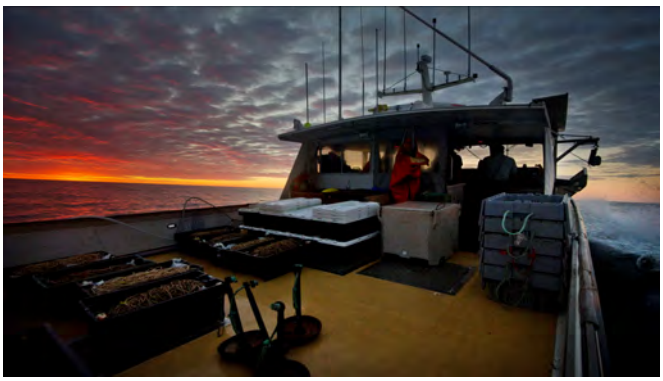
The sentinel survey helps maintain the tradition and historical knowledge of demersal longline fishing in fishing communities in eastern Maine. It also provides an opportunity for fishermen participants to contribute their knowledge and experience to help determine groundfish abundance and distribution.

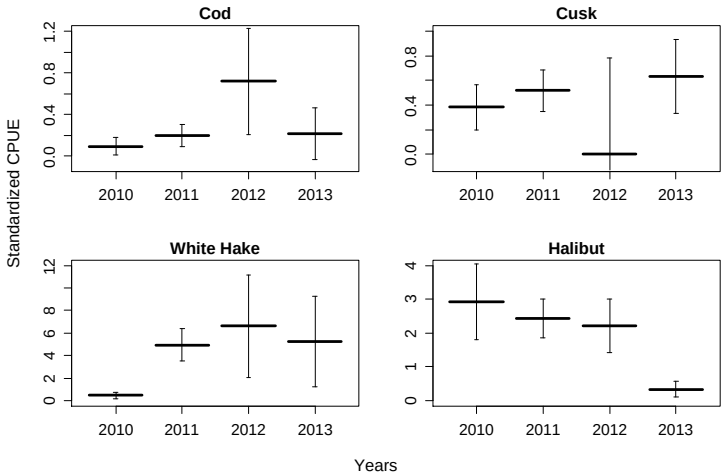
EDUCATION AND OUTREACH ACTIVITIES

- Henry, Anna. 2013. Assessing social resilience of Maine fishing communities and developing a longline groundfish survey. Thesis for the Dual Master of Science degrees in Marine Biology and Marine Policy, School of Marine Sciences, University of Maine, Orono, ME 04469. July 2013.
- Dority, A. and Y. Chen. 2014. *Update on the Eastern Maine sentinel survey/fishery. Presentation at* Northeast Fisheries Science Center. Woods Hole, MA. March 28, 2014.
- Dority, A. and Y. Chen. 2014. Preliminary results of the 2013 *Eastern Maine sentinel survey/fishery.* Presentation at NMFS, Washington D.C., February, 2014.
- Runnebaum, J., A. Henry and Y. Chen. 2013. Eastern Gulf of Maine Sentinel Survey/Fishery. American Fisheries Society annual meeting Aug. 2013
- Runnebaum, J., A Henry, and Y. Chen. 2013. Fine scale spatial sampling of depleted groundfish species from the sentinel survey/fishery. Gadoid Symposium held in St. Andrew, NB, Canada, Nov. 2013.
- Runnebaum, J. and Y. Chen. 2013. Sentinel Survey: Where have all the groundfish gone and will they ever come back. University of Maine School of Marine Sciences Graduate Student Symposium, May 2013
- Runnebaum, J. and Y. Chen. 2013. Sentinel Survey: Where have all the groundfish gone and will they ever come back? Graduate Expo at University of Maine, Nov. 2013.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS







Standardized CPEs for the four key species derived from fishermen's choice's stations from 2010 to 2013.

Benthic imaging in support of habitat mapping for renewable energy

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Scott Gallager – WHOI (with subaward to Kevin Stokesbury, UMass)

NOAA Sponsor – Jennifer Samson, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The Outer Continental Shelf (OCS) off the northeast coast of the US covers over 92 million acres (108,909 square nautical miles). Within this area, the Department of the Interior's (DOI) Bureau of Ocean Energy Management (BOEM) has designated Wind Energy Areas (WEAs) in the Northwest Atlantic from Massachusetts to North Carolina that total >3056 square nautical miles of seafloor as potential lease sites for offshore renewable energy (ORE) development. These WEAs were established and further refined using currently available data on natural resources and existing human uses. However, our knowledge of the oceanic environment and sea floor community structure is limited and, consequently, informed decisions about offshore development become more difficult.

The NEFSC has been funded by BOEM to characterize benthic habitat along the northeast continental shelf as a baseline to construction and operation of offshore wind energy facilities. This CINAR project is in support of the optical imaging sampling component and protocols that were used in this survey.

We conducted surveys using two techniques: the HabCamV4 stereo imaging system and the SMAST pyramid camera system utilizing both transect and quadrate sampling techniques.

ACCOMPLISHMENTS

***HabCam survey*:**

The HABitat mapping CAMera, the NOAA owned HabCam IV utilizes a stereo camera system which consists of two ultra-compact 8 Megapixel machine vision cameras with Gigabit Ethernet interface at frame rates up to 10 frames per second as the vehicle is towed several meters off the bottom at a ship speed of 6-7 kts. Continuous image ribbons or mosaics are constructed from the overlapping stereo image pairs. 300,000 m^2 of seafloor is imaged every day of continuous operation. Data extracted from the stereo image pairs includes micro-bathymetric changes on order 2mm, quantification of substrate particle size distributions, and size and abundance of biological targets greater than 2 mm. Within the telemetry housing, roll, pitch, and yaw sensors provides measurements of vehicle orientation at 20 Hz. An acoustic altimeter provides distance from the seafloor at 5Hz to allow image size calibration. In addition to the photographic record, the instrument package includes a Teledyne Benthos C3D 200 kHz side scan sonar that records a

swath up to 50m either side of the vehicle. Additionally, a Sea Bird SBE49 CTD and Wet Labs EcoPuck provides depth of the vehicle and environmental data on temperature, chlorophyll, turbidity, Dissolved Oxygen, and pH. This system was originally developed by Gallager's group at WHOI with support from the NEFSC with a primary focus on scallop assessments. The current generation, HabCam IV, was put into service in the summer of 2012, again with a focus on the annual sea scallop survey. However, with the changing fishery management approach from single species to ecosystem-based management (EBM) it became apparent that HabCam is also capable of quantifying habitat, and generating information on species richness, diversity, substrate composition, and ecosystem change on a variety of temporal-spatial scales.

The key to the successful implementation of ecological indices and models is sufficient underlying data, which is what we propose to provide for the benthic habitats in the northeast WEAs. The newly adopted national standard of habitat classification Coastal and Marine Ecological Characterization Standard (CMECS), has been adopted to unify each of the environmental data layers for streamlined input into ecological indices. We spent quite some time developing a procedure for mapping our standard substrate analysis approach with HabCam to be consistent with that of the CMECS standard. Annotators viewing HabCam images now are able to quantify percentage cover of each substrate type such that each image can be assigned into a CMECS substrate category. We also have just completed development of an automated substrate classifier that maps each image into CMECS standards without human input after training sets have been developed. This software will be used to go back and evaluate how well human annotators have been consistent in their assignments of substrate in the 2013 image set and will be used in all future habitat surveys.

Objective 1. To operate HabCamV4 on the five-day habitat cruise off the coast of Maryland between July 23-26. S. Gallager and A. York participated in the 5 day cruise. Both WHOI PIs had completed operation of HabCamV4 on the scallop survey, which ran from June 13 to July 16. Gallager then rode the ship down from Woods Hole to Delaware preparing the equipment and computer systems for the habitat cruise. While at sea, the PIs trained the NOAA team how to deploy, retrieve and operate HabcamV4. The vehicle control and data acquisition and processing computer systems can be complicated so some time is required to gain confidence in perfecting operations. Driving the winch which controls the vehicle 2 to 3m above the seafloor also requires some time to master.

Objective 2. To set up a searchable database and annotation software for HabCam imagery (Fig. 1). Following the BOEM cruise, York and Gallager worked at the Sandy Hook lab setting up NOAA owned computers with the image server, database and annotation software. It was anticipated that 5 days of continuous operations should produce about 10 TB of raw tiff stereo pair images, which then was processed to human viewable png format images requiring about the same disk space. A second computer was set up with the light field and color correction software to allow for processing of the raw tiffs. Once the database and annotator were installed on a Linux machine, the annotator program could be accessed over the network via a URL call to the website so there is virtually no limit to the number of annotators that can access the image data at one time or their location. However, the Sandy Hook lab is under severe constraints concerning internet accessibility so it was not possible to gain access to the HabCam servers from outside the lab's local LAN. This greatly reduced the efficiency by which the WHOI team could develop and maintain the annotation software.

Objective 3. To standardize HabCamV4 data output to the CMECS classification schema and train NOAA personnel on image processing, image annotation, database operation, and data interpretation. Following the cruise, WHOI personnel assisted NOAA by providing training in use of the database and annotation software, making annotation assignments using the new management tool, extracting processed data from the database, and helping to build statistical descriptions of substrate and biological targets.

Merging HabCAmV4 annotation classifications with the newly adopted CMECS standard continues to require thought and development. The annotation menus were rebuilt using the CMECS hierarchical classification schema, which then is used directly to identify dominant groupings. The concern here is that the high granularity provided by our current classification strategy would be lost so we have been developing combinations of high taxonomic resolution together with CMECS categories to provide the best of both systems. WHOI continues to work with NOAA personnel to work out the optimal solution to this problem.

A series of "mowing-the-lawn" patterns of lines with 800 – 1200 m spacing was traversed for more detailed coverage of the two fishing reef areas as defined by Capt. Monty Hawkins that overlap the MD WEA (Fig. 2-3). As conditions allowed towing HabCam at a faster speed (~7 kts.) than had been originally planned (4 kts.), there was time available to cover a portion of one reef area (WQCB = Winter Quarter Coral Bed) by mowing-the-lawn with a line spacing of ~60 m, which allowed for full area coverage at high resolution by multibeam and side scan sonars. HabCam continued to collect data through transits between reef areas (Fig. 4) in order to insure that there was ample data collected in "non-reef" areas for comparison with those within reef polygons.

A grid of N-S and E-W lines with 3 statute mile spacing, centering on BOEM 3 X 3 statute mile lease blocks, covered the MD WEA to meet the wind energy habitat investigation goal (Fig. 3). Each line ran through the geographic center of the BOEM lease blocks within the MD WEA. The cruise track followed a grid of N-S and E-W lines with thirteen intersections (A through M) at the centers of each block where N-S and E-W lines crossed. This pattern allowed each intersection to be visited twice: once each during a N-S or S-N passage and during an E-W or W-E passage so as to provide comparisons of visual analysis from differing directions. Bottom grab samples were obtained for sediment and biological analysis from nine of these intersection points on a previous NEFSC cruise (LMRCSC: July 4-9, 2013). The strict N-S:E-W courses of some lines were altered to capture bottom imagery at sites where sediment grain size analysis had been collected by Emily Tewes of UMES as part of her thesis research. As with the grid points, three of these points were also traversed twice from differing directions in order to provide analytic comparisons of the same points from differing aspects. Habitat for Black Seabass (Fig. 5) is being defined using CMECS standards.

SMAST video survey:

Coordinating with the HabCam and Sandy Hook teams we completed 455 stations with the SMAST video pyramid system. The SMAST sampling pyramid, supporting four cameras and eight lights, was deployed from a commercial fishing vessel F/V *Courageous*. A mobile studio including monitors, DVD recorders, DVRs and laptop computers for data entry and survey

navigation (software integrated with the differential global positioning system) was assembled in the vessel's wheelhouse. The entire MA WEA, including two areas identified as potential reef habitat within the MA WEA, was surveyed using the SMAST camera pyramid on a 0.5 km grid that intersected with the HabCam transects matching the 0.5 km grid overlay (Figure 6). Two downward facing video cameras mounted on the sampling pyramid provide 2.84 m^2 and 0.60 m^2 quadrat images of the sea floor. Another video camera, mounted parallel to the seafloor, provided a side profile of the quadrat area to aid in species identification. Lastly, a high-resolution digital still camera (10 megapixels) collected a single frame image of 1.06 m^2 used to verify species identification and habitat characteristics. Footage of the first quadrat was recorded and then the pyramid was raised so the sea floor could no longer be seen. The vessel drifted approximately 50 m and the pyramid was lowered to the sea floor again to obtain a second quadrat; this was repeated four times at each station, thus increasing the sampled area to 11.36 m^2. Video footage of the sea floor was recorded on DVDs and onto a DVR. For each quadrat the time, depth, latitude and longitude were recorded. After each survey the video footage was reviewed in the laboratory and a still image of each quadrat was digitized and saved. Within each quadrat, macroinvertebrates and fish were counted and the substrate was identified. When possible fish and macroinvertebrates were identified to species, otherwise animals were grouped into categories based on taxonomic orders. Counts were standardized to individuals m^{-2}. Sponges, hydrozoa/bryozoa and sand dollars were recorded as present or absent within each quadrat (Figure 6). Sediments were visually identified following the Wentworth particle grade scale from the video images, where the sediment particle size categories are based on a doubling or halving of the fixed reference point of 1 mm; sand = 0.0625 to 2.0 mm, gravel = 2.0 to 256.0 mm and boulders > 256.0 mm. Gravel was divided into two categories, granule/pebble = 2.0 to 64.0 mm and cobble = 64.0 to 256.0 mm (Lincoln et al. 1992). Shell debris was also identified (Figure 7).

Objective 1. Using the SMAST–Industry cooperative video survey on high-resolution grid, we proposed to intensively survey the WEA (Figure 6). These collections will define habitat characteristics and the abundance, spatial distribution, size composition and recruitment patterns of sea benthic invertebrates and some fishes in this area.

Objective 2. The data from the SMAST survey will be compared with the HabCam data. These systems use the two fundamental sampling tools of ecology; the quadrat and the transect. Each has advantages and disadvantages based on the animals' densities and distributions. A complete comparison examining different perspectives will be of both ecological and practical use.

Objective 3. We will examine the CMECS standards and compare them to our sampling protocol. Since 1999, SMAST has completed over 150 video cruises surveying Georges Bank and the Mid-Atlantic (>1000 days at sea), with support from the commercial sea scallop industry, the Massachusetts Division of Marine Fisheries (MADMF), and the sea scallop Research-Set-Aside program (NOAA grants). This unique database covers the entire scallop resource (~70,000 km^2) from 2003 through 2012, representing a time series of 10 years. The video library contains footage from over 300,000 georeferenced video samples. Further, it includes numerous video surveys on a finer scale focusing on scallop aggregations primarily in closed areas of Georges Bank and the Mid-Atlantic. Thus, this provides a unique historic data set as a base line for offshore wind development.

SMAST completed 455 stations with the SMAST video pyramid system. At each station the pyramid was placed on the sea floor four times equaling 1,820 deployments, each of 3 cameras collected quadrat samples for a total of 5,460 images. We have processed and quality controlled all the large camera, the small camera and digital still camera images (Figure 7). The majority of large camera quadrats contained sand-ripple and shell debris substrate (Figure 8), with cobble and rock substrate in less than 1% (Table 1). Of the 53 categories of invertebrates and fish identified in the SMAST database, 28 were observed in the 1,820 large quadrates. Sand dollars (Figure 9) were by far the dominate invertebrate and were present in 24% of the quadrats, followed by sea stars (Table 2). Sea robins were the dominant fish followed by skate (Figure 10, Table 2).

HIGHLIGHTS

- Conducted 5 day survey using HabCamV4 and the SMAST video sampling pyramid in the BOEM wind farm areas off the coast of Maryland.
- Instructed and transitioned HabCam technology to NOAA personnel
- Provided temperature, salinity and sound speed corrections for the combined 100% multi-beam and HabCam survey
- Established an image and metadata database for annotations conducted by NOAA personnel (Fig. 1)
- Redesigned menu inputs on the annotator tool to allow direct measurements of percentage cover for substrate for direct mapping to CMECS habitat standards
- Processed images for large, small and digital still cameras.
- Provided species identification key and data base structure to NOAA scientists for comparison and development.

SOCIETAL BENEFITS

Application of high-resolution non-invasive optical and acoustic imaging is allowing detailed benthic habitat maps to be constructed highlighting critical interactions between substrate, micro topography, and organism distribution and abundance. These maps are allowing managers to make decisions concerning mitigation of impacts to sea floor communities during wind farm installation and operations. Continued surveys will provide a time series of how the environment changes during and recovers following installation.

EDUCATION AND OUTREACH ACTIVITIES

Data collected on these survey cruises were presented by Gallager and Stokesbury at the NOAA habitat assessment workshop run by R. Langton. Two WHOI summer students and one NOAA student and one UNH student participated in the cruises and the processing of images and acoustic data from the surveys.

On the SMAST cruise one PhD student (Fulbright scholar), and two MS students participated with the data collection along with 2 fishermen. The data is being used in one PhD thesis and one MS thesis at the University of Massachusetts Dartmouth. The results from this survey will be included in the SMAST database for use in updating the NAM ERA benthic habitat model and

will be provided to NROC, MARCO and the Northeast Ocean Data Portal for use and publication.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

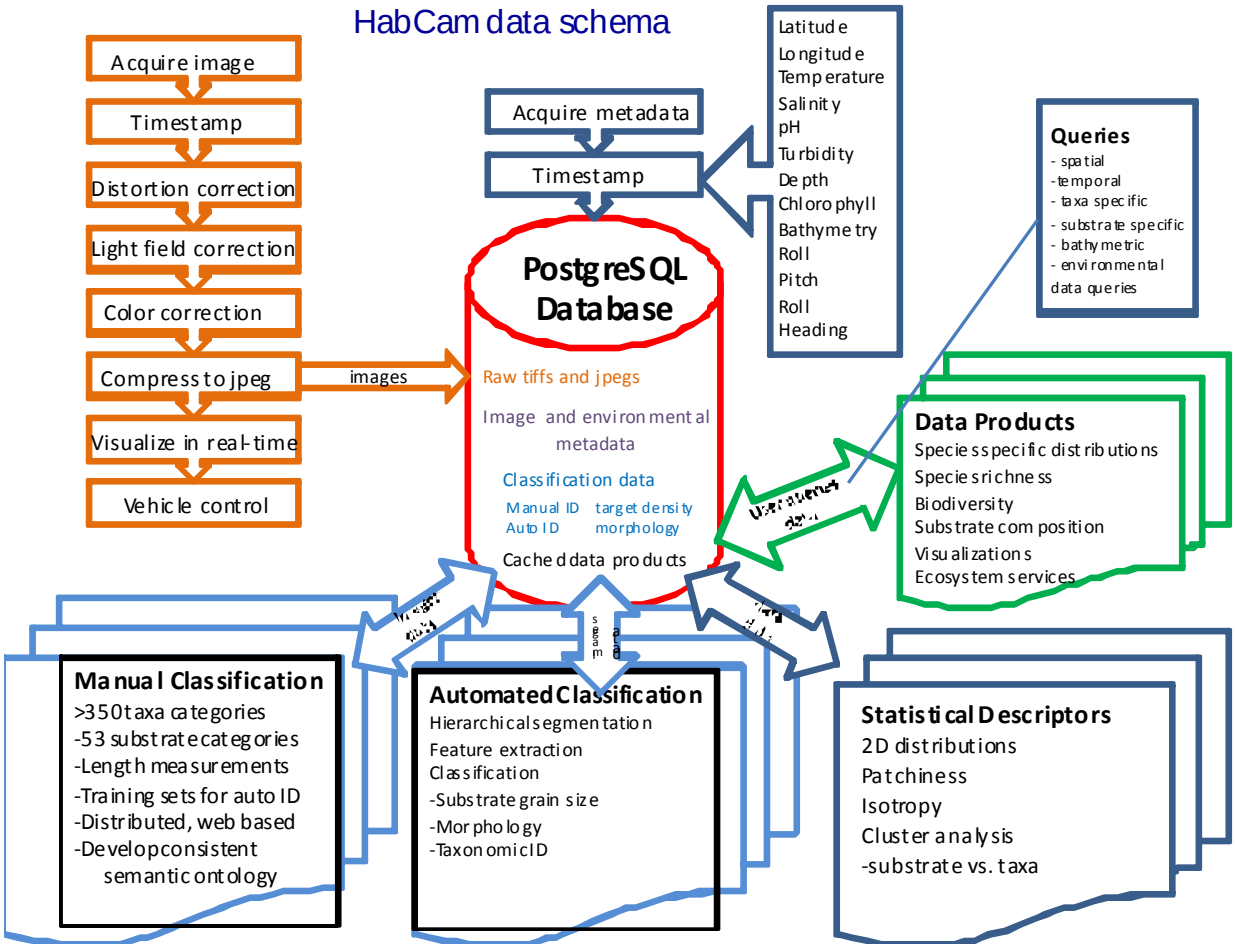


Figure 1. HabCamV4 data schema. Processes in the orange, blue, and red boxes are conducted at sea while underway. Image metadata are uploaded into the database and synchronized with the image server. While still towing the vehicle, the manual annotation software is used to subsample the image set and provide an environment in which operators tag each image with taxonomic and geological (substrate) information. Automated classification of substrate and biological targets in every image can proceed once manual training sets have been built. Statistical descriptions of target distributions, patchiness, diversity, substrate gradients, etc. are calculated via batch queries to the database as part of the data processing workflow.

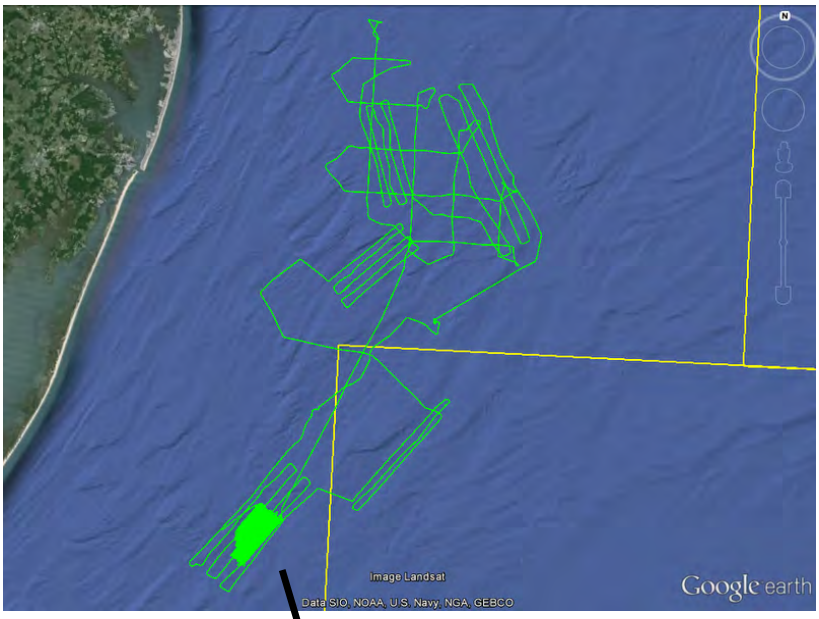


Figure 2. Trackline of the 2013 BOEM potential windfarm area just offshore of Maryland.

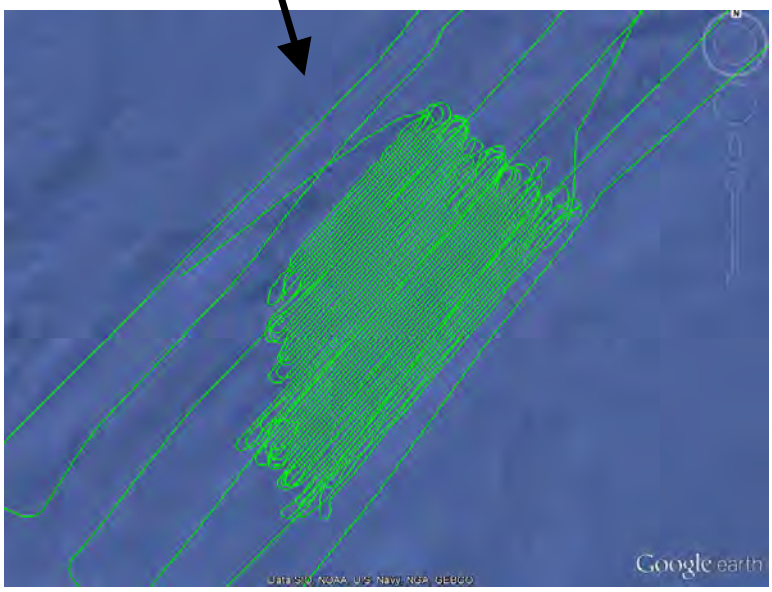


Figure 3. A grid of N-S and E-W lines with 3 statute mile spacing, centering on BOEM 3 X 3 statute mile lease blocks, covered the MD WEA to meet the wind energy habitat investigation goal.

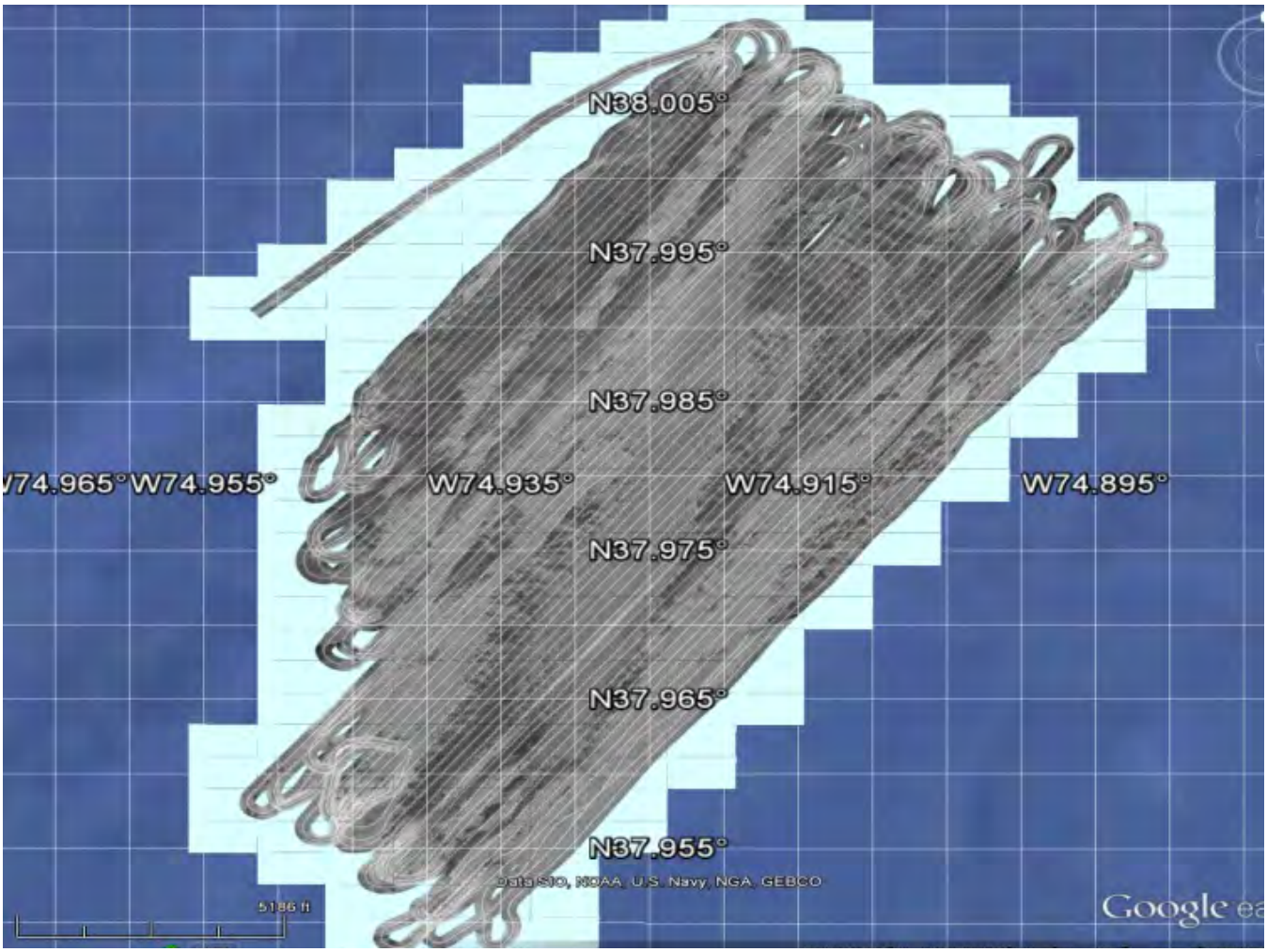


Figure 4. HabCamV4 side scan acoustic data (100% cover) in the BOEM wind farm area off of Maryland. Light grays represent relatively soft sand and mud while darker colors represent gravel and rock outcroppings. Sea bass were found only in rocky areas. Sidescan track width is 100m.

Figure 5. Three images of Black Seabass from the Habcam system.

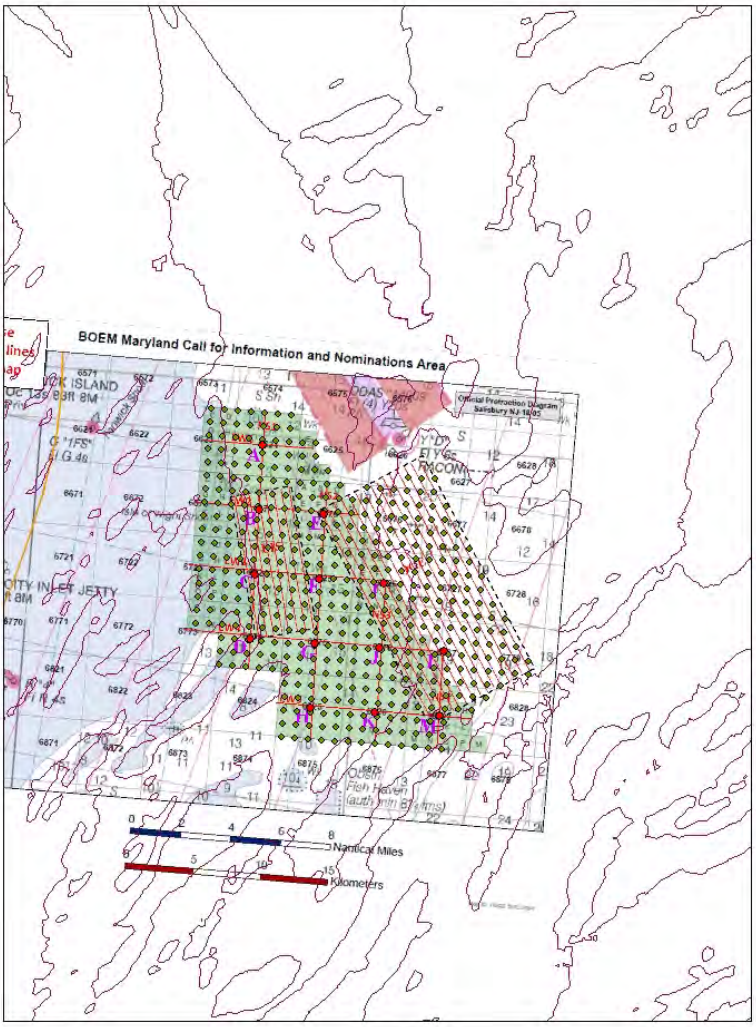


Figure 6. Map showing locations SMAST video samples on a 0.5 km grid overlaid on the Habcam transect locations off of Delaware-Maryland.

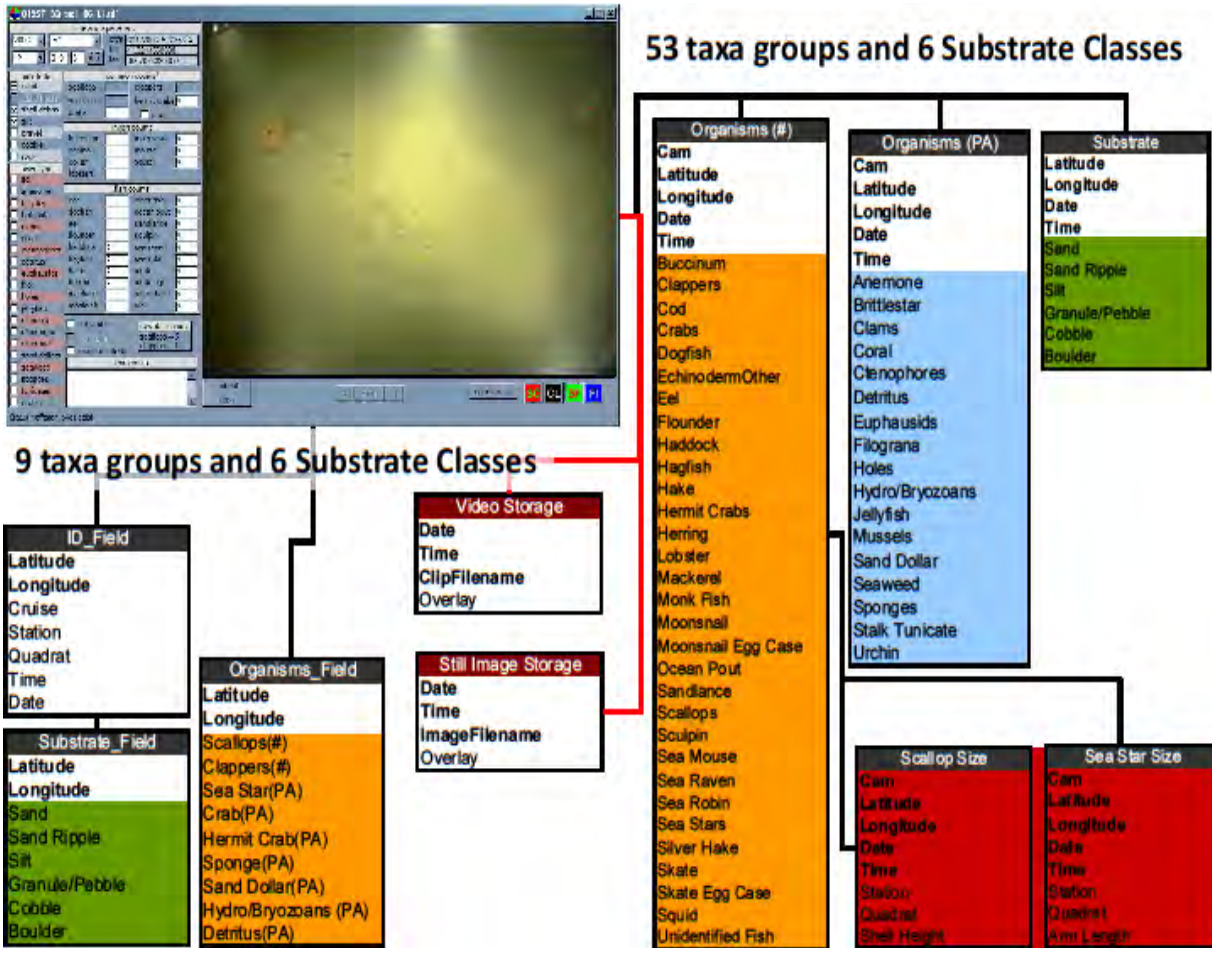


Figure 7. Annotation software used for SMAST video pyramid image analysis. Includes list of organisms and sediment grain size options.

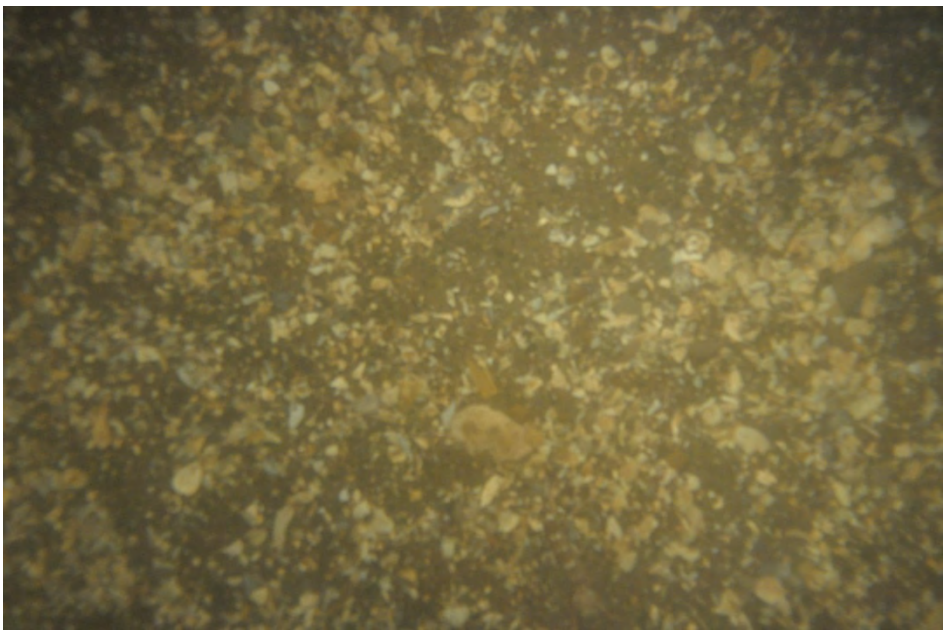


Figure 8. Digital still image of sand, shell debris from the SMAST pyramid station 25, quadrat 4.

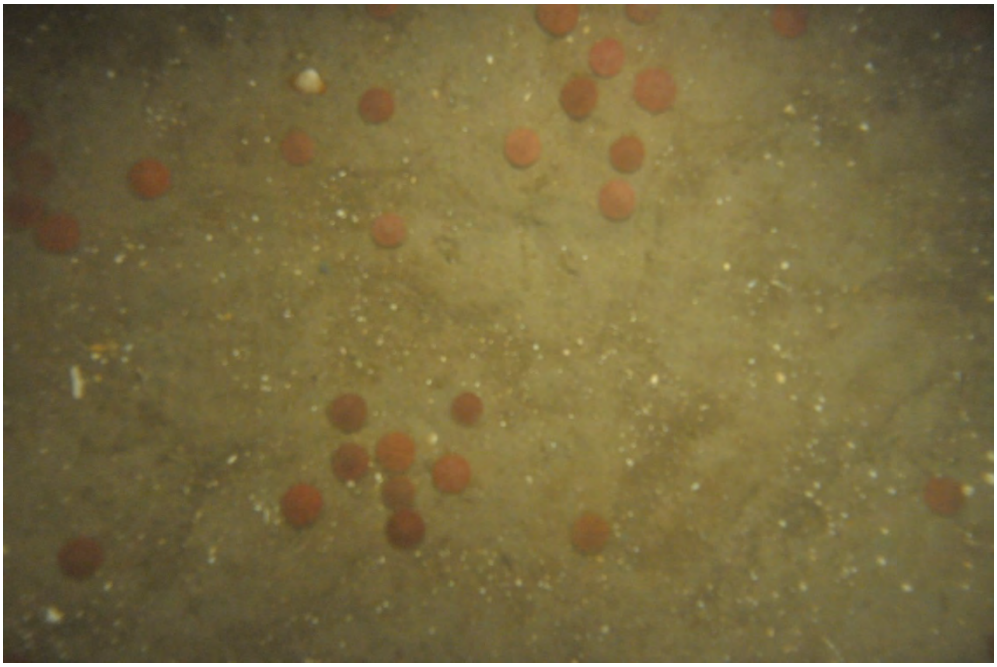


Figure 9. Digital still image of sand dollars; station 6, quadrat 2. From the SMAST pyramid.

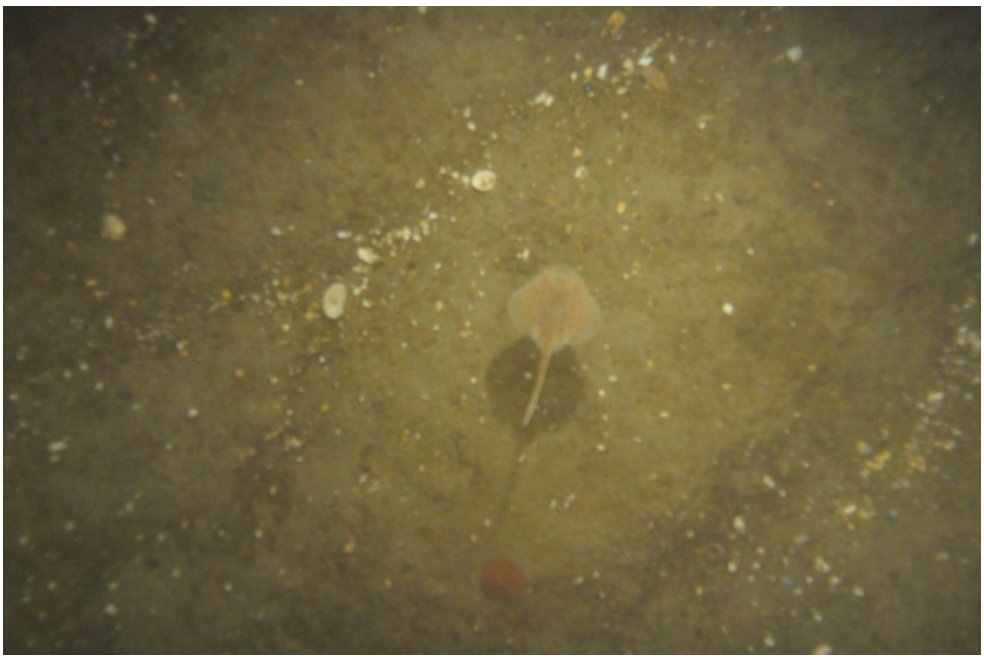


Figure 10. Digital still image of sand dollar, sand ripple and juvenile skate; station 8, quadrat 4. From the SMAST pyramid.

Table 1. The percentage of SMAST quadarts containing each substrate type in the windfarm lease locations. For example, in the windfarm area 80.9% of all quadrats examined contained sand substrate.

Sediment	count	%
sand	563	30.9
sandRipple	1257	69.1
shellDebris	1764	96.9
silt	555	30.5
gravel	219	12.0
cobble	10	0.5
rock	1	0.1

Table 2. Species list and counts from the SMAST large camera.

Species	Counts
sandDollars	433
seaStars	68
euphausids	44
crabs	35
seaRobin	27
detritus	26
moonsnailEggCase	18
skate	18
hermitCrabs	16
hake	15
clams	14
scallops	7
moonsnail	7
holes	6
unidentifiedFish	5
skateEggCase	4
silverHake	4
ctenophores	3
flounder	3
sandlance	3
seed	2
anemone	2
otherCrustaceans	2
otherMolluscs	2
squid	2
sponges	1
sculpin	1
seaRaven	1
clappers	0
echinodermOther	0
lobster	0
ad	0
bHydra	0
brittleStar	0
buccinum	0
coral	0
filo	0
jellyFish	0
mouse	0
mussels	0
seaweed	0
urchin	0
tunicate	0
cod	0
dogfish	0
eel	0
oceanPout	0
haddock	0
hagfish	0
herring	0
mackerel	0
monkFish	0
otherFish	0

Transition of HabCam Technology to NOAA Operations and Technology Upgrade

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Scott Gallager – WHOI

NOAA Sponsor – Robert Johnston, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

This project consisted of three objectives and deliverables specifically addressing the need to transition HabCam technology into operational fisheries assessment and to train NOAA technicians in the operation and maintenance of the entire system. The objectives were the following: 1) To provide to NOAA personnel documentation and training on all HabCamV4 operational procedures including manual annotation, vehicle operations, data ingestion into the database, and production of data products, 2) To participate in the 2013 Scallop Survey on Leg 1, and 3) To provide hardware and software upgrades to the NOAA HabCamV4 instrument to allow continued smooth and efficient operations.

ACCOMPLISHMENTS

Objective 1. This is an ongoing objective that we have been working on for several years. Given the complexity of the HabCam system, we felt it was necessary to continue to collaborate and transfer our working knowledge and experience so that NOAA can fully exploit and benefit from this powerful system. We established an image processing workflow environment in preparation of processing survey images. The goal was to establish an end-to-end processing workflow such that upon return from sea, hard drives are plugged into the server and image processing ensues, providing provenance for each image and associated metadata. This was accomplished and 3 million images from all three legs plus the mini leg were processed within a few weeks of returning to shore. Documentation was developed in the form of a detailed wiki that may be accessed either on land or at sea that includes detailed materials such as electronic pin outs of bulkhead connectors, electronic schematics, mechanical CAD diagrams, and sensor specifications. Hard copies of certain items such as instructional and operational manuals for the system will be useful particularly at sea. Both at sea and on shore training sessions were developed for the web-enabled annotation tools and species and substrate identification guides and for vehicle maintenance procedures. Training sessions were also developed for data handling including real-time and post-cruise data ingestion into the database, extraction from the database, production of data products such as scallop or other target abundance, post cruise procedures, hard drive management, and application of image processing workflows.

Objective 2. It was critical that two HabCam personnel went to sea on all three legs of the scallop survey to ensure operations were performed smoothly and the equipment functioned

normally (Fig.1). Funds were used to cover 40 days at sea of over the side insurance. If the vehicle had been lost or damaged this insurance will reimburse the project up to 90% of the replacement cost ($350,000). One of the most difficult points in the survey was the day before departure when the fiber optic slip ring failed on the Hugh Sharp trawl winch. It required several hours to determine the failure point and by that time it was near midnight the evening before departure. Gallager contacted the UNOLS winch pool at WHOI and was able to secure a small single pass slip ring within a few hours that was transferred to ship personnel in New Jersey and installed on the Hugh Sharp. The system was running by 0900 the following morning. The broken slip ring was sent out to focal technologies for repair.

Objective 3) Hardware upgrades were completed before June 10, 2013 including replacing all fiber optic connectors on both the cameras and electronic bottles, replacing all associated cables, and installing a trigger for both altimeters and the C3D such that all 200 kHz devices are operated sequentially thereby eliminating interference. We also found a hardware solution for operating five 2TB hard drives (10TB) sequentially at sea so that swapping of drives does not need to take place. On shore, the manual annotation program was set up on the WHOI machine molamola such that annotations could be efficiently recorded directly without having an intermediate step of going through the NOAA firewall.

The stereo HabCam system is currently being transitioned to NOAA for scallop and groundfish stock assessments in June 2014. Manual and automated analysis of the stereo image pairs from the stereo NOAA HabCam is essential to utilization of the full capabilities of the imaging system. This software is nearing completion and will be operational on the 2014 survey.

HIGHLIGHTS-

- Operated image acquisition, light-field correction, and color correction in real-time at sea.
- Ran an at-sea database for metadata associated with imagery so manual annotations could be performed by NOAA and WHOI personnel as time permitted.
- Ran scallop classification software in parallel with data acquisition and transferred result to database while at sea.
- Upon transfer of imagery from the ship to the NOAA RAID drives in Gallager's lab by the end of the cruises around July 15, we were able to assist NOAA in completing all assignments for scallop annotations and data processed and plotted for all three legs and the minileg for the August 15, 2013 deadline for presentation to the scallop SARC.

SOCIETAL BENEFITS

This research is providing a direct transition from inefficient and potentially damaging bottom trawling for surveying of scallop populations to a non-invasive high efficiency and cost-effective optical approach to assessing scallops and their patchy distribution.

EDUCATION AND OUTREACH ACTIVITIES

Data collected on the survey cruises were presented by Gallager at the NOAA habitat assessment workshop run by R. Langton. Two WHOI summer students and one NOAA student participated in the cruises and the processing of images from the surveys.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

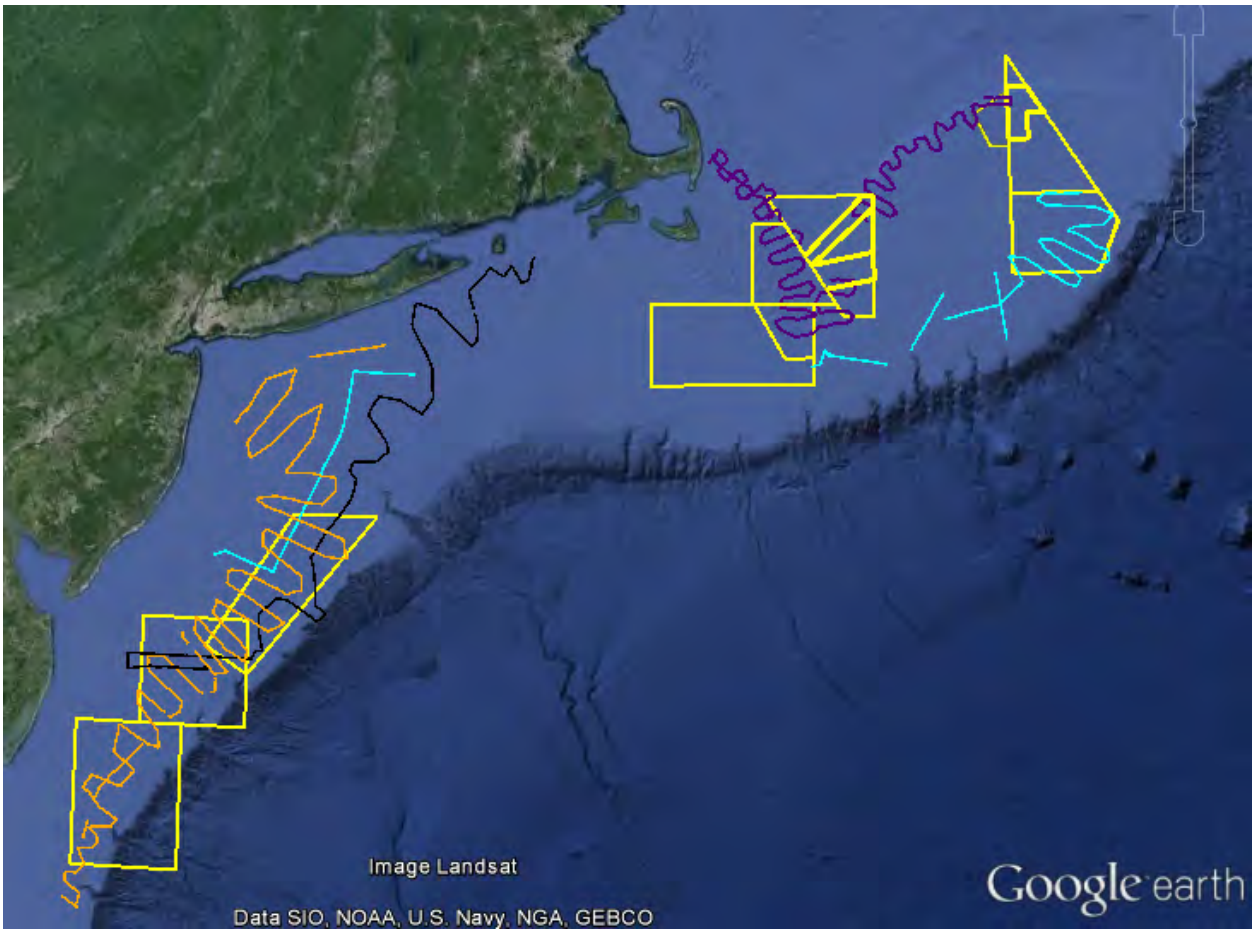


Figure 1. Tracklines for the 2013 annual scallop survey. Leg 1 (orange), Leg 2 (cyan), Leg 3 (purple), Mini Leg (Woods Hole to Delaware- black). Colored tracks are where HabCamV4 was towed and does not include steaming or dredging.

The development of light field cameras for AUV obstacle avoidance

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Hanumant Singh – WHOI

NOAA Sponsor – Elizabeth Clarke, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

Ongoing efforts associated with using the Seabed AUV have been very successful but are now increasingly putting the AUV in harm's way by trying to obtain transects in highly complex terrain. Through this project we seek to extend the capabilities of the Seabed AUV by incorporating a light field camera into the suite of existing sensors on board the AUV.

ACCOMPLISHMENTS

As described in the proposal a commercial grade light field camera was procured (independent of NOAA funding). This process was significantly delayed due to manufacturing issues. Since receiving the camera we have been putting it through calibration procedures specific to the underwater environment. Our work is ongoing. In the summer of 2014 we expect to continue the calibration and begin the process of transitioning such a system onto the Seabed family of AUVs.

HIGHLIGHTS

- We are working on calibrating a light field camera for underwater use.

SOCIETAL BENEFITS

Light field cameras hold out the promise for allowing us to do a multitude of tasks related to in-situ fisheries stock assessment. A single light field camera could conceivably be used for 3D reconstruction of fish, for looking through turbid water, for high dynamic range imaging as well as the thrust of this proposal on obstacle avoidance.

Theme III. Ecosystem Management

Evaluating the mechanisms underlying distribution shifts and age-truncation on silver hake (Merloccius bilinearis) survey data

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

James Churchill – WHOI

NOAA Sponsor – David Richardson, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Our project is directed at a life-stage specific analysis of the mechanisms underlying shifts in the distribution of silver hake (*Merluccius bilinearis*), a commercially important semi-pelagic fish distributed from Newfoundland to South Carolina. Currently, the U.S. manages silver hake as separate northern and southern stocks, with the northern flank of Georges Bank as the dividing line (Almeida 1987, Bolles and Begg 2000). This stock structure has frequently been questioned in the assessment process, and recent assessments have also evaluated a single U.S. silver hake stock. However, the single stock models have not been accepted.

In U.S. waters, management advice for silver hake is currently based on the survey index method using NEFSC bottom trawl survey data. During the 2011 assessment, an age-structured model was also developed using the Age Structured Assessment Program (ASAP). This model run was not accepted by the review panel as it was felt that there was not a consistent and coherent explanation for the simultaneous increases in the survey index and truncation of age-structure in the survey and fishery given that landings were at historically low levels and diet data did not show a substantial increase in natural mortality (NEFSC 2011). The review panel suggested further work on a variety of topics to address the seeming contradictions in the age-structure data and survey indices. Included on the list of topics was the potential for age-structured changes in the distribution of silver hake in response to environmental variability.

Our project seeks to examine the influence of environmental variability on the distribution shift of silver hake by: age-specific distribution modeling using trawl survey and environmental data to evaluate model the joint effects of temperature and age structure on adult silver hake distribution; estimating shifts in spawning distribution using a technique developed in a previous FATE project which utilizes larval distributions from the Ecosystem Monitoring (EcoMon: 1999-present) and Marine Resource Monitoring Assessment and Prediction (MARMAP: 1977-1987) cruises; and numerical modeling to track larvae to their point of origin, estimating shifts in Juvenile nursery grounds by forward tracking silver hake larvae to the age of settlement capability.

ACCOMPLISHMENTS

Due to other commitments by the PI, work on the project has thus far been limited to conferencing about the techniques and status of the data sets to be employed. The analysis and modeling effort will commence, in earnest, in July 2014.

SOCIETAL BENEFITS

Our work will lead to a better understanding of the factors that contribute to the geographic shift in fish population, including factors that influence spawning and juvenile settlement distribution. This understanding, quantified in a modeling framework, will facilitate better management of our marine resource.

Evaluation of cranial facial bone formation and tissue histopathology of embryonic and juvenile commercially important finfish species exposed to increasing levels of Co2 and Ph due to ocean acidification

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Keith Cooper – Rutgers

NOAA Sponsor – Chris Chambers, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Studies will continue to be carried out at the Howard Marine Laboratory, Sandy Hook using their controlled ocean acidification exposure laboratory. Both winter and summer flounder will be exposed from fertilization until metamorphosis to three CO_2levels that represent current to future levels. The fish will be examined for growth parameters, cranial facial formation and histopathological evaluation.

Due to the second year budget cuts, the number of fish to be examined is reduced and only two species will be examined for cranial facial abnormalities and no histopathology will be carried out. We will be able to assess preliminary studies on the effects of ocean acidification but on fewer samples and different species. We will complete the first exposure analysis of fish from the first year (winter flounder) and examine the summer flounder and possibly be able to repeat some of the short-term exposures.

ACCOMPLISHMENTS

An experimental framework was implemented that includes the use of 1) multiple marine fish species of relevance to the northeastern US that differ in their ecologies including spawning season and habitat; 2) a wide yet realistic range of environmental conditions (i.e., concurrent manipulation of CO_2 levels and water temperatures), and 3) a diverse set of response variables related to fish sensitivity to elevated CO_2 levels, water temperatures, and their interactions. The Winter Flounder studies were repeated and are currently being examined for similar findings reported in the earlier exposures. The effects were shown to be reproducible. Summer flounder have also been exposed and these samples are currently being evaluated. In addition, to the parameters outlined above and in previous reports a number of biochemical endpoints are being examined. These include DNA, RNA, protein levels, and a suite of genes related to development.

HIGHLIGHTS

- The flounder species did show subtle changes in growth following exposure to increased CO_2 and decreased pH.

- Similar effects were observed in the flounder species as have been reported in other species, but to a less extent pointing out the importance of species sensitivity.
- There is both a species and individual mating pair sensitivity.
- The histological tissue effects were more evident in the older developing fish.
- Up and down regulation of genes appear to be a very sensitive biomarker of exposure.
- Our initial findings in winter flounder were published in *Biogeochemistry*.

SOCIETAL BENEFITS

The modeling of potential impacts and or reduced impacts on flounder species compared to other aquatic species can be important in stock management decisions. The results may allow managers to concentrate on different fishery stocks because of larger impacts of rising CO_2 levels on open ocean species versus estuarine species.

EDUCATION AND OUTREACH ACTIVITIES

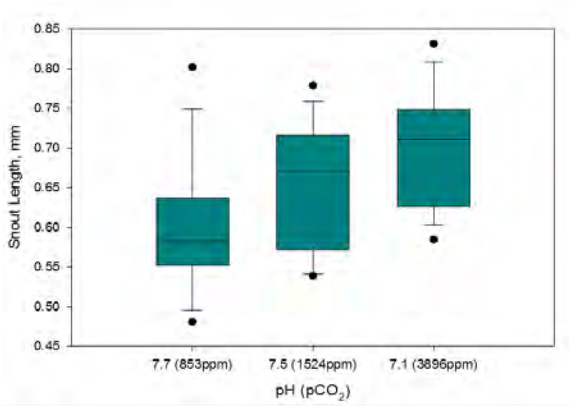
A senior undergraduate student worked on the project and presented her findings at the regional HDSETAC meeting where she came in first place for undergraduate posters. Other students have also worked on this project learning new techniques and developing new assays. Two PhD students are currently involved on this project.

PUBLICATIONS

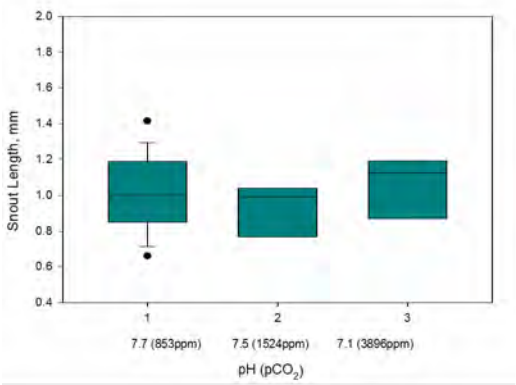
Chambers, R.C., Candelmo A.C., Habeck, E.A., Poach M.E., Wieczorek D., Cooper, K.R., Greenfield, C.E. and Phelan B.A. 2014. Ocean acidification in the early life-stages of summer flounder, *Paralichthys dentatus*. Biogeosciences,11:1613-1626, doi:10.5194/bg-11-1613-2014, 2014.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

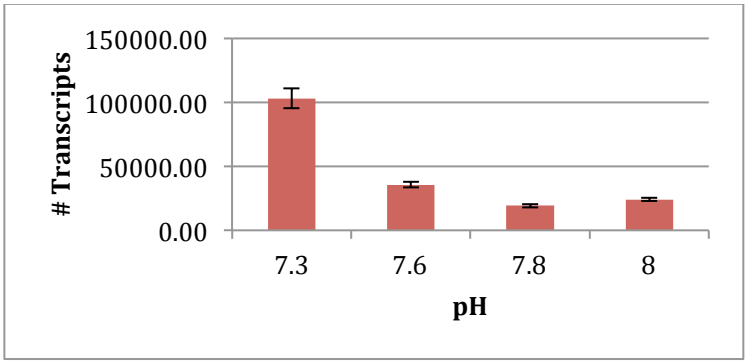
Shown below are examples of observations for both morphometric (snout length at 7 & 39 days) and biochemical gene expression of Beta actin as it relates to pH and CO2 levels.



Exposure to pH (p CO_2) levels of 7.1 (3896ppm) significantly reduced the snout length in winter flounder aged at seven days.



Exposure to pH (pCO2) levels of 7.1 (3896ppm) had no significant effect on the snout length in winter flounder aged 39 days.



Gene expression of Beta Actin: The total number of transcripts for the beta actin gene per each pH treatment normalized to 26s expression. A One-Way ANOVA on ranks between all groups yielded a significant difference ($p<0.05$), specifically comparing the pH 7.3 group to the 7.6 and 8.0 groups

An empirical analysis of portfolio management as a tool for implementing Ecosystem Based Fishery Management

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Di Jin and Porter Hoagland – WHOI

NOAA Sponsor – Gerit Depiper, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

The main objectives of the proposed research are to develop a procedure for constructing portfolio models to assist the implementation of ecosystem based fishery management (EBFM) in the northeastern region, using empirical harvest data and biological (food web) data from NMFS, and to demonstrate the feasibility and usefulness of the above procedure through case studies.

ACCOMPLISHMENTS

A project database has been developed for the portfolio analysis. The database includes commercial fishery landing quantity and value statistics by species and port from 1964 to 2012. SAS programs have been written to extract and process relevant data from the database to perform different analyses. Fish species are grouped using the scheme of NMFS food web model (Atlantis). Matlab programs have been developed to perform portfolio calculations and to plot analytical results. Preliminary portfolio assessments have been developed separately for (1) the entire northeast region; (2) four ecological production units (Gulf of Maine, Georges Bank, Mid-Atlantic Bight, and Scotian Shelf); and (3) three selected ports (Gloucester, New Bedford, and Point Judith).

HIGHLIGHTS

We have developed annual performance measures of the northeast fisheries over the five decades. The performance measures capture the inefficiencies (in terms of risk level for a given level of revenue) in the fisheries, and thus the potential for improvements.

SOCIETAL BENEFITS

While much attention has been directed recently at the potential benefits of implementing EBFM for commercial fisheries, the realization of a more comprehensive management that takes into account the broader effects on the ecosystem and associated human communities remains elusive. Portfolio management has been suggested as a practical tool for helping to implement EBFM. Results of our research will further improve our understanding of the potential for portfolio management as a practical approach to help achieve EBFM in the northeastern region.

EDUCATION AND OUTREACH ACTIVITIES

An abstract entitled "*An empirical analysis of portfolio management as a tool for implementing ecosystem-based fishery management*" has been accepted for presentation at the International Institute of Fisheries Economics and Trade (IIFET) 2014 Conference in Australia.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

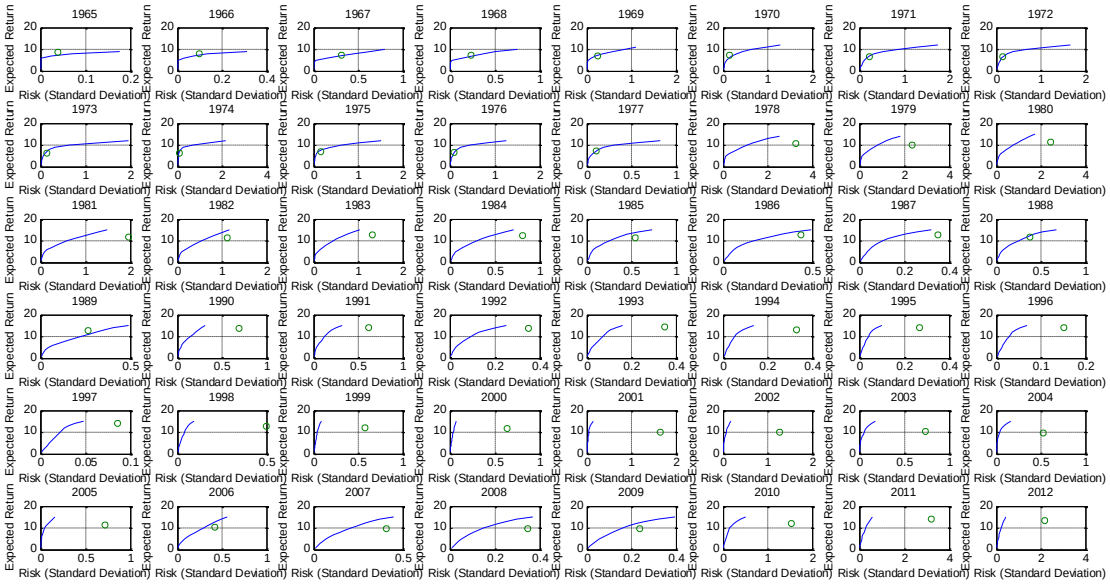


Figure 1: Commercial fishing industry production efficient frontier, Northeast region, 1964-2012. In each sub-plot, vertical axis shows the expected revenue (in 2012 dollars), and horizontal axis the risk level (standard deviation of revenue); green circle denotes the actual risk and revenue in that year.

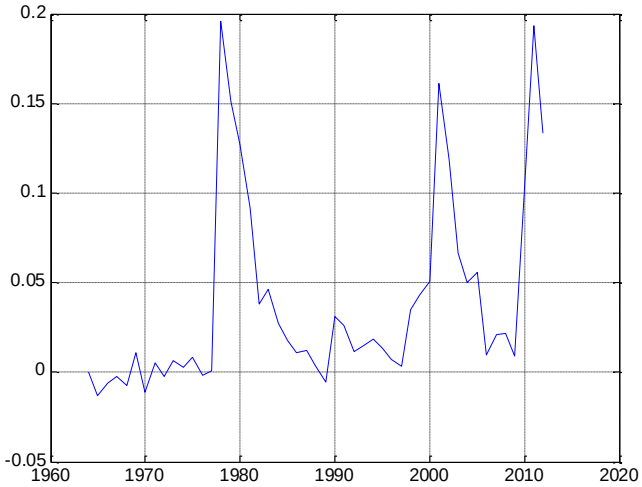


Figure 2: Inefficiency in the commercial fishing industry, Northeast region, 1964-2012. Vertical axis shows the level of inefficiency (risk level per dollar of revenue), and horizontal axis year.

Improving fishery dependent data collection and integration into NOAA Fisheries data systems

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Jessica Joyce – GMRI

NOAA Sponsor – Douglas Christel, NMFS

Related NOAA Strategic Plan Goal: Resilient Coastal Communities and Economies

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Fishery dependent data is essential to the sound management and sustainability of fisheries. NOAA in the Greater Atlantic Region has identified modernizing fishery dependent data systems as an opportunity to create efficiencies and support catch accounting, stock assessments, and fine-scale management approaches through timely and accurate information. The objective of this project is to work with industry stakeholders to articulate a vision of fishery dependent data collection and systems that contributes to NOAA Fisheries' internal review of fishery dependent data in the Greater Atlantic Region. The project is being carried out in three phases.

GMRI's work entails identifying current and future data needs and uses, evaluating the utility of current data collections, capturing the desired characteristics of an ideal data system, articulating potential tools for collection and management, and anticipating future data needs. To complete this work – and ensure that industry perspectives were captured throughout the Greater Atlantic Region – GMRI partnered with the University of Massachusetts School for Marine Science and Technology (SMAST), and awarded contracts to industry consultants, Daniel Salerno and Peter Moore. All the partners are collaborating on the data collection (Phase I) through industry interviews and in the development of a data map and planning of the regional workshop (Phase II).

An industry workshop is planned in New Bedford, Massachusetts on June 30th and July 1st.

ACCOMPLISHMENTS

During this reporting period, we completed Phase I of the project, developing an interview instrument in consultation with NOAA Fisheries, and completing 50 interviews with harvesters, dealers, and other industry groups throughout the Greater Atlantic Region. NOAA Fisheries will have access to the interview results as they have been entered into a database anonymously. These interviews will be used to develop a Phase I report ahead of a May 21st, 2014 project meeting.

The project is now in Phase II, focusing on the development of a data map (see figure below), analysis of interviews, and workshop planning. A Federal Fishery Dependent Data Visioning

workshop for the fishing industry has been planned in New Bedford, Massachusetts on June 30th and July 1st.

GMRI created a project website to share information about the project, including team contacts, and to join the project mailing list, visit www.gmri.org/fishdependentdata.

HIGHLIGHTS

- Creation of Federal Fisheries Dependent Data Visioning project website at www.gmri.org/fishdependentdata.
- Project presentation at the Massachusetts Marine Fisheries Institute 'Monitoring and Survey Selectivity Workshop' in February.
- Completed 50 in-person interviews with members of the fishing industry, covering all fisheries within the Greater Atlantic Region.
- Drafted data maps using responses from industry interviews.
- Scheduled a project workshop for June 30th and July 1st in New Bedford, MA.

SOCIETAL BENEFITS

NOAA Fisheries' collection and management of fishery dependent data has not kept pace with the needs of fishing business, or fisheries science and management. By articulating a vision for the modernization of fishery dependent data collections and systems in the Greater Atlantic Region, this project will significantly contribute to improved management of a public resource.

EDUCATION AND OUTREACH ACTIVITIES

- Project website: www.gmri.org/fishdependentdata
- February 25th presentation at Massachusetts Marine Fisheries Institute's workshop on 'Monitoring and Survey Selectivity'.
- Project update in GMRI monthly *Fisheries Digest* e-mail (February 2014)
- Article in GMRI's newsletter *Waypoints* (May 2014)
- Workshop announcement on NEFMC and MAFMC public calendars

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

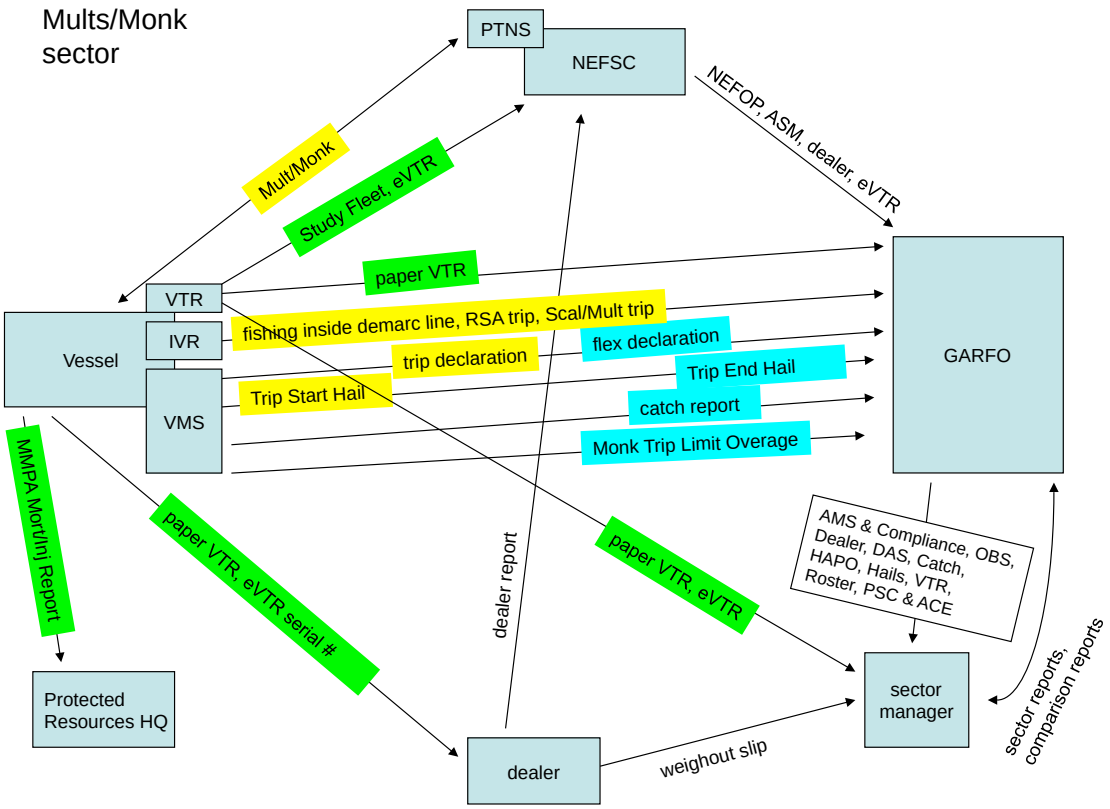


Figure 1: Fishery Dependent Data flows in Northeast Multispecies Sector Program.

Thermal habitat dynamics in the Northeast Atlantic and the role of habitat squeeze

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Josh Kohut and Enrique Curchitser – Rutgers

NOAA Sponsor – John Hoey, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

The first year of the project is focused the following two tasks:

Task 1: Evaluate the temperature estimates from the 50-year ROMS hindcast. Under this task we use available bottom temperature data to evaluate and quantify uncertainties in ROMS hindcasts of bottom water temperature used to project thermal habitat. *In situ* temperatures provided by the NEFSC fisheries independent survey, NEFSC survey fleet data and IOOS ocean observatories are used to quantify the uncertainty in temperature hindcasts.

Task 2: Develop thermal habitat model and estimates of thermal habitat volume. To quantify thermal responses of species using the outer NEUS continental shelf as overwintering habitat we use the habitat modeling approaches and several models we are already developing on a closely linked project *("Accounting for habitat-dependent observation error in bottom trawl survey indices for pelagic stocks using butterfish (Peprilus triacanthus) as a model"*, Manderson (PI)) funded by the NOAA office of Science and Technology HAIP. One of our goals is to determine whether species-specific responses are similar enough that a general thermal response for the winter shelf break community could be used to develop a general winter thermal habitat volume anomaly. We evaluate and quantify uncertainties of thermal habitat models using cross validation and independent datasets including industry based temperature and catch data available from the NEFSC COOP program.

ACCOMPLISHMENTS

Since the project began in August 2013 we are in the early stages of the program. We have conducted our initial PI meeting to identify and organize the steps needed to accomplish our stated tasks. Enrique Curchitser has led the effort to provide hindcast temperature data from the ROMS modeling system. Daily bottom temperatures were hindcast using the Regional Ocean Modeling System (ROMS; Shchepetkin & McWilliams 2003, 2005) numerical ocean circulation model described in Kang & Curchitser (2013). This model extends from the Gulf of Mexico to Nova Scotia, Canada and has a horizontal resolution of 7 km and a vertical resolution of 40 terrain-following levels. Bottom temperatures from ROMS were de-biased using Mid Atlantic Bight Ocean Climatology and Hydrographic Analysis (MOCHA; Fleming & Wilkin 2010). MOCHA is a three-dimensional climatological analysis of temperature and salinity derived from

the ODC World Ocean Database 2005 and the NOAA Northeast Fisheries Science Center oceanographic database. In coordination with another project we will validate these hindcast bottom temperatures against observations provided by the NOAA/NMFS Northeast Fisheries Science Center.

Toward task 2 we have coupled the bottom temperature estimates to a thermal niche model developed by John Manderson at NOAA/NMFS/NEFSC. Dr. Manderson has worked with Josh Kohut to develop an initial thermal based habitat index for longfin squid. This model along with others developed for other shelf break species like butterfish will form the basis for the habitat squeeze analysis. In addition we have begun our discussion with Howard Townsend of NOAA to identify the steps needed to move toward a more holistic ecosystem modeling system.

HIGHLIGHTS

- Completed our Project Kickoff Meeting
- Validated the ROMS hindcast against climatology
- Assembled *in situ* temperature data for validation with the hindcast temperatures and calculated annual and seasonal model RMSE based on *in situ* bottom temperatures
- Coupled hindcast temperatures to thermal niche model of longfin squid along the Shelf break
- Developed our work plan for moving toward an ecological modeling approach to address our hypotheses related to habitat squeeze along the Mid-Atlantic Bight Shelf break.

SOCIETAL BENEFITS

This work will advance our knowledge on how best to apply observed fields relevant to describing key species habitat to various stakeholder groups operating in the Mid-Atlantic Bight. The results of this work will guide the development of appropriate ecosystem and stock assessment indices as they relate to species managed in the Mid-Atlantic Bight.

EDUCATION AND OUTREACH ACTIVITIES

Portions of the hindcast validation (task 1) were part of a larger presentation describing the same model's application to butterfish. These presentations include:

OpenOcean 2013. An index of availability (ρ_h) of Atlantic Butterfish to surveys using a thermal niche model coupled to debiased hindcasts of bottom temperature from a ROMS model. 2013 Butterfish Stock Assessment Data Meeting. Woods Hole, Massachusets. August, 2013

OpenOcean 2013. Integrating habitat dynamics into population & ecosystem assessment using cooperative research within an IOOS framework. Fisheries Working Group. National Research Council. Highlands New Jersey. July 30, 2013

OpenOcean 2013 Integrating habitat dynamics into population & ecosystem assessment using cooperative research within an IOOS framework. East Coast Fisheries Forum. Annapolis Md. June 27, 2013

Palamara, L., J. Manderson, J. Kohut, G. DiDomenico, E. Curchitser, D. Kang, M.J. Oliver, C. Dobson, & A. Snow. 2013. Putting the dynamics of the ocean into marine spatial planning: temporal variation in butterfish habitat. American Society of Limnology and Oceanography Aquatic Sciences Meeting, New Orleans, LA. Abstract ID 10576. 17-22 February 2013

OpenOcean 2013. (*Lead author*) Climate change, thermal habitat dynamics, habitat coverage bias & population dynamics in offshore forage species (butterfish & longfin squid) central to the MAB food web. Mid-Atlantic Fisheries Management Council Meeting February, 14, 2013. Hampton Rhoads, Virginia.

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OpenOcean 2013. (*Lead author*) 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

Developing wideband acoustic methods for improving fisheries and ecosystem assessments

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Gareth Lawson and Andone Lavery – WHOI

NOAA Sponsor – Michael Jech, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Atlantic butterfish (*Peprilus triacanthus*) is a semi-pelagic zooplanktivorous species distributed from south Florida to Nova Scotia that is thought to play an important but little-studied role in continental shelf and shelf break ecosystems. Butterfish are managed as a single stock complex, which is believed to be at record low levels. Currently there is no directed commercial fishery for butterfish and the only information on stock status comes from by-catch statistics from the squid (*Illex* and *Loligo* sp.) fishery, and fisheries-independent bottom-trawl surveys. No acoustic surveys presently target butterfish, but acoustics offer a potentially powerful tool for stock and ecosystem assessment.

The goal of this project is to develop wide-band acoustic methods to improve our ability to distinguish butterfish from other non-swimbladder-bearing organisms (e.g., squid, dogfish), as well as provide characterization of the zooplankton prey field. Our approach has been to 1) evaluate in controlled conditions the performance characteristics of prototype Simrad wide-band transceivers (WBTs) loaned to the project at no-cost, 2) engage a commercial fishing vessel for *in situ* biological sampling and acoustic data collection with WBTs, 3) develop software and methods to process wide-band acoustic data, and 4) develop theoretical acoustic scattering models to interpret wide-band data. This project brings together WHOI and NOAA scientists with members of the fishing and acoustic manufacturing industries.

ACCOMPLISHMENTS

Objective 1) Assessment of System Performance and System Calibration: The Simrad WBTs are in the prototype phase of development and are not yet available to the commercial or scientific markets. We evaluated and calibrated the basic performance characteristics of the WBTs in controlled conditions in the WHOI sea well and the large-tank facility at the University of New Hampshire, where a number of collaborators were invited to participate in the measurements, including Lars Andersen (WBT project lead at Kongsberg Simrad, Norway), Gavin Macaulay (Institute of Marine Research in Bergen, Norway), and Tom Weber and Carlo Lanzoni (UNH). Ultimately, we were able to calibrate five WBTs and one 18-kHz narrow-band General Purpose Transceiver (GPT), all operating split-beam transducers.

Objective 2) Field Measurements: Wide-band acoustic data and targeted biological samples were collected *in situ* during a 5-day cruise in January 2014 on the F/V *Karen Elizabeth* operated by Captain Christopher Roebuck. Based on recent fishing excursions, the study region was the shelf break area south of Cape Cod near Atlantis Canyon, where we were able to collect acoustic and biological data (bottom and mid-water trawl, bongo zooplankton net) on relatively mono-specific aggregations of butterfish, spiny dogfish (*Squalus acanthias*), and krill (*Meganyctiphanes norvegica*). Preliminary analyses of the acoustic data are very encouraging and suggest that the scattering spectra of these species can be characterized successfully with the WBTs. Continued analysis will confirm whether the spectra can also be used to discriminate among species.

Objectives 3&4) Software Development and Scattering Models: We have been developing Matlab code to read, process, and visualize the WBT data. We have not yet actively pursued the scattering model objective.

HIGHLIGHTS

- Prototype Simrad Wide-Band Transceivers (WBTs) were evaluated and calibrated under controlled conditions in the UNH large-tank facility and WHOI sea well.
- A 5-day cruise on the F/V Karen Elizabeth was successfully conducted in January 2014 to the continental shelfbreak region south of Cape Cod. *In situ* acoustic and biological data were collected on relatively mono-specific aggregations of butterfish, spiny dogfish (*Squalus acanthias*), and krill (*Meganyctiphanes norvegica*).
- Preliminary analyses using software developed under the project of the field data confirm the ability of the WBTs to characterize the acoustic scattering spectra of different organism types and suggest that these spectra can be used in assessment surveys to distinguish between scatterer types. These wide-band acoustic data are the first to be collected spanning nearly two orders of magnitude in frequency on these species, and represent a leap forward in terms of information content relative to traditional narrow-band echo sounders.

SOCIETAL BENEFITS

The overarching aim of the work is to demonstrate the feasibility of wide-band techniques for stock and ecosystem assessment. Our tests and calibrations of the WBTs will highlight advancements and limitations of these systems for large-scale surveys, as well as provide starting points for further research on broad-band acoustic characteristics of the WBTs, transducers, and fish and zooplankton. The new Simrad WBTs utilize existing split-beam composite transducers already standard on many NOAA and UNOLS vessels, facilitating the potential for transition to operations, and our software for processing data will be made available to others in the field, including other NMFS Science Centers.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

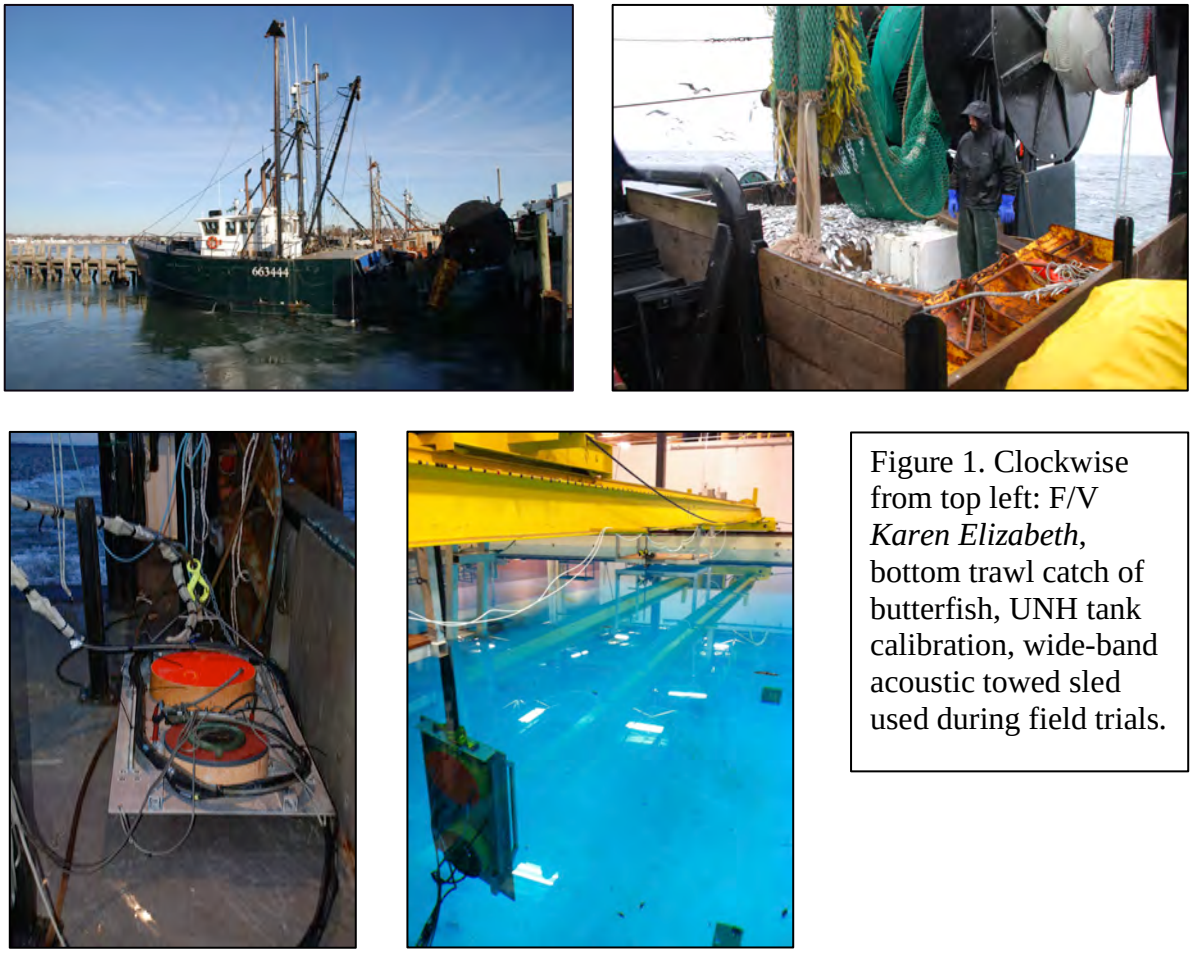


Figure 1. Clockwise from top left: F/V *Karen Elizabeth*, bottom trawl catch of butterfish, UNH tank calibration, wide-band acoustic towed sled used during field trials.

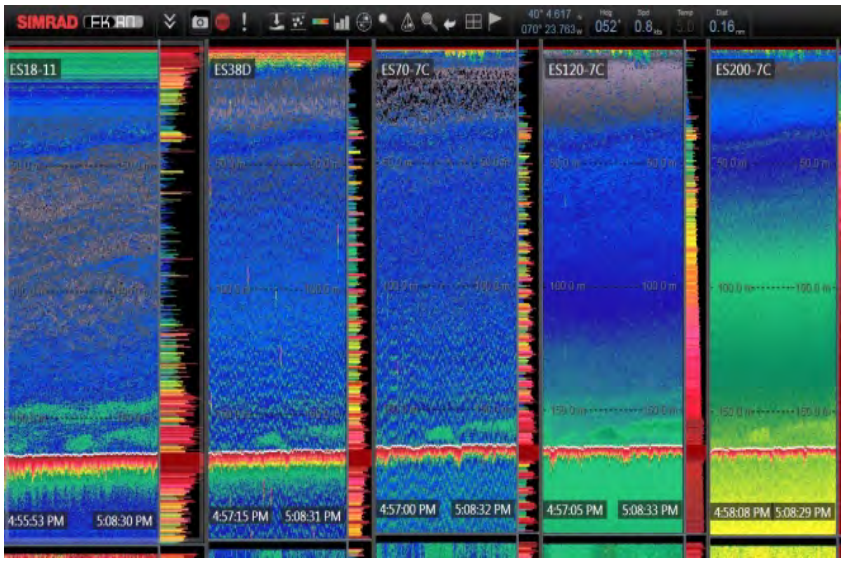


Figure 2. Wide-band acoustic echograms (center frequencies from left to right of 18, 38, 70, 120 and 200 kHz) showing butterfish aggregations near the sea floor, west of Atlantis Canyon at the shelf break south of Cape Cod.

Scientific leadership for the NOAA Ocean Exploration and Research Program

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Timothy Shank – WHOI

NOAA Sponsor – Gene Smith, OAR

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Critical to the future success of ocean exploration and the NOAA Ocean Exploration and Research Program is the advancement of science as both the formative underpinning of all exploration activities and the dissemination of discoveries that include and serve stakeholder partnerships. The goal of this effort is to provide scientific consultation to the NOAA Ocean Exploration and Research Program that will provide a scientific vision for ocean exploration and catalyzing scientific and stakeholder partnership discussions that result in science priorities for exploration, it's implementation, and the promotion of the legacies of exploration that advance future research endeavors and pathways. To this end, the effort supports the scientific interaction of T. Shank with other NOAA offices; engaging NGOs; NOAA OER operations and administrative staff, inter-agency cooperations, through the promotion and communication of exploration and scientific achievements. In addition, the proposed consultation would establish and advance the goals of NOAA OER through the administration of an extramural scientific exploration proposal program. All of these efforts seek to increase the scientific strength of the NOAA OER Program, ensuring that a disciplined scientific evaluation process is integrated into identifying areas to be explored; exploration planning, prioritization, implementation, documentation; and the development of innovative products and outcomes. In short, the Chief Scientist provides expert opinions, conducts activities that promote strategic scientific guidance for the program, the science vision for the program, its integration with other agencies, its contribution to NOAA's strategic goals, and provides guidance so that the results achieved by the program stimulate new scientific endeavors.

ACCOMPLISHMENTS

This program began in September 2013, and during this period:

1) Orientation and advancement meetings, both face to face and conference calls with NOAA OER staff in Washington DC were conducted to discuss and understand the status and direction of NOAA OER activities as they relate to the science underlying exploration and the generation and dissemination of exploration results to the science community, educators, and the general public.
2) External proposals submitted to NOAA OER for their most recent (2013) call were reviewed during this award period. Consultation regarding how best to conduct and organize that review process was provided to the NOAA OER staff.

3) Initiation of discussions directly with data managers to ensure all exploration data are quality assured for community use and openly accessible to the science community in a timely fashion.
4) Generated a working draft of a *Remotely-Operated Vehicle Sampling Protocol*. T. Shank worked with the NOAA OER staff, stakeholders, and portions of the community-at-large to develop a protocol whereby decision, collection methods, and processing methods and practices can be determined. Despite the delivery of a new state-of-the-art 6000m-rated *Remotely-Operated Vehicle* (*Deep Discoverer*). The current protocol includes the submission of samples to a nationally recognized repository to which all scientists will have equal access to the samples. Central to the development of the protocol is the ongoing examination of existing models, such as those employed by ODP, NSF, and the Ocean Exploration Trust to help guide this effort.
5) As part of this effort to promote exploration, outreach and education activities were actively focused on promoting awareness of hadal regions, their importance to other planetary systems, and the ongoing HADES research program, the principal investigator engaged a writer/photographer and videographer to produce a range of near-real-time products, as well as material that will aid in long-term outreach and education of hadal research, the HADES program, and general ocean science.

HIGHLIGHTS

- A working draft of a *Remotely-Operated Vehicle Sampling Protocol* was generated. Multi-disciplinary portions of the scientific community-at-large were engaged to develop this protocol whereby decision, collection methods, and processing methods and practices can be determined.
- We conducted the first live telepresence broadcast of ocean exploration and research from the hadal zone of the ocean, below 6,000 meters in an ocean trench (e.g., from 7,100 meters and 9,990 meters). These live broadcasts “from the trench seafloor” of the Kermadec Trench shared the real time experience of exploration and discovery of deep ocean trenches, the habitats and life they contain. A Mobile Telepresence Unit was utilized on board the R/V Thompson with the Hybrid Remotely Operated Vehicle Nereus to provide these live broadcast as well as interactive outreach events with the Smithsonian Institution.

SOCIETAL BENEFITS

The vast majority of deep-ocean resources (e.g., hydrocarbon reservoirs, commercially-important fisheries, and endemic biological diversity) are currently unknown and only through the advancement of ocean exploration will the first order discovery and characterization of these resources be known for the subsequent and effective ability to protect and manage such resources and the impacts of climate change on these resources and their stewardship.

EDUCATION AND OUTREACH ACTIVITIES

As part of this effort to promote exploration, outreach and education activities were actively focused on promoting awareness of hadal regions, their importance to other planetary systems, and the ongoing HADES research program, the principal investigator engaged a

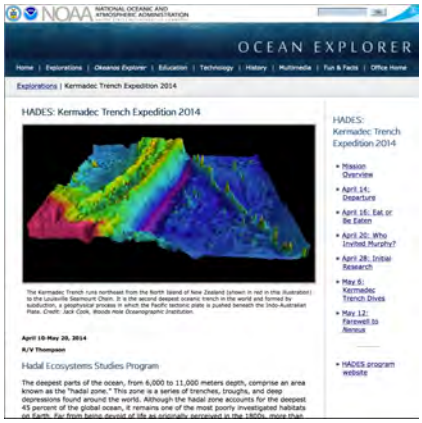
writer/photographer and videographer to produce a range of near-real-time products, as well as material that will aid in long-term outreach and education of hadal research, the HADES program, and general ocean science. The Inner Space Center (ISC) at the University of Rhode Island (URI) was also engaged to set up a Mobile Telepresence Unit (MTU) obtained via the Jason Group at WHOI so that dives by the hybrid remotely operated vehicle (HROV) *Nereus* in the Kermadec Trench could be broadcast live on the internet.

In addition to written posts, outreach materials sent to WHOI (HADES site) and Scientific American included a mix of video and still image content. Videos were both professionally produced mini-features highlighting specific aspects of the cruise and research goals as well as three minimally produced clips: one time lapse and three lander highlight reels. Slideshows with captions were also included with each written post to both WHOI and Scientific American and two additional independent slideshows were sent to WHOI for posting separate from a text post. Although there was considerable overlap among these, all had varying degrees of original content. A total of 33 hours of video and more than 10,000 still photos documented all aspects of the expedition. These will be available for future outreach events, publications, and media requests related to HADES, hadal research, and general ocean science communications needs.

As a result of all of these efforts, this CINAR program provided for the first broadcast of ocean exploration and research dives from the hadal zone of the ocean, below 6,000 meters in an ocean trench (e.g., from 7,100 meters and 9,990 meters). These live broadcasts "from the trench seafloor" shared the real time experience of exploration and discovery of deep ocean trenches, the habitats and life they contain.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Education and Outreach activities included the dissemination of information live through telepresence and also web portals (using featured video interviews, written postings, and slideshows through the HADES Program web portal (www.whoi.edu/hades) and weekly reports through the NOAA OER web portal NOAA OER weekly updates on HADES Kermadec cruise (http://oceanexplorer.noaa.gov/explorations/14hades/) illustrated below.



Evolution of groundfish sectors business model

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Jenny Sun – GMRI

NOAA Sponsor – Andrew Kitts, NMFS

Related NOAA Strategic Plan Goal: Resilient Coastal Communities and Economies

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

There are three phases to this project. Phase 1's focus was to gain an understanding of the economics of the New England Groundfish (GF) industry and that of each individual sector by analyzing GF and non-GF catches of all 17 active sectors followed by an evaluation of individual sector viability through the development of business profiles. Phase 2 further analyzed the seasonal landing patterns and market fluctuations of each GF and non-GF species to understand a sector vessel's ability to maximize the value of landed catch. Future work in Phase 3 will analyze the relationship between fishing operations and allocation utilization as well as annual catch entitlement (ACE) trading efficiency in conjunction with the seasonality of landings and market prices.

This project is in the third phase of the overall sector viability project, assembled in three stages, with the overall goal to provide necessary market information, quota trading analysis, and business plans to sectors. It seeks to support fisheries management that will enhance groundfish sector viability and profitability, for sector members, sectors as effective organizations, and their dependent communities in New England.

The specific objectives are:

- Integrate the analysis of changing fishing operations to increase allocation utilization and investigate the efficiency of ACE trading in conjunction with the seasonality of landings and market prices.
- Supporting phase 1 and 2 of the project to evaluate how the membership profile, landings and leasing history, and ACLs reductions would affect a sector's viability and provide information to identify risk management and income enhancement options for each sector. In addition, since at-sea monitoring costs (ASM) are closely associated with sector viability, GMRI was given permission to use the DMIS dataset to work with New England Fishery Management Council Groundfish Plan Development Team for the cost-effective analysis of discards-proportional allocation scheme for ASM program; however, no funding from this project was utilized for this analysis.
- Profiling of various sector types with distinct features by fishing allocation, ACE trading and effort profile with the diversity in multispecies groundfish fishing activity in each broad fishing area, such as in Gulf of Maine (GOM), George Bank East (GBE), George Bank West (GBW) and Southern New England (SNE), shown in Figure 1.

- A predictive modeling tool that demonstrates the potential risks and opportunities for sector operations and ACE trading for both small boat sector and large boat sector type.
- Presentations to industry with follow up support on business planning, both in terms of sector make-up, allocation profile and for sector operational business planning.
- Identify options to help move the industry from harvest to market driven through supply chain opportunities with Sectors. This exercise may lead to the identification of 'ideal' sector models which could be important in determining Sector strategies for the future. This stage will also include implementation of a dissemination process for industry and management.

ACCOMPLISHMENTS

1) Seasonality and volatility of the ex-vessel price and landings by port

- The dynamics of the ex-vessel price are determined by the timing of the seasonal landings pattern with interaction between the availability of resources, and its substitution with imports market demand.
- In order to influence the local/regional market, one potential strategy for dealing with price volatility to the entire groundfish industry is to collaborate across sectors to maintain a steady stream of supply of fresh catch by developing innovative marketing channels for high quality niche markets and making long-term delivery arrangements with fish buyers.

2) Variability of Leasing Price and the Concept of Time Value of ACE Leasing

- The timing of an ACE lease affects the price (seeking/selling). Prices fluctuate because there is uncertainty about whether the ACE can actually be converted to landings because fish might not be available to catch when desired, what the market value of the landed fish will be, and whether other fish in the market (e.g., imports) drive the ex-vessel price up or down. The efficiency in the ACE trading is defined in conjunction with the timing of landings, market prices, and quality handling.
- The lease market contributes to increase catch but the lease prices are often deterrent to leasing and catching certain species. If market prices were better, the lease prices become less of a deterrent.
- An ACE buyer's demand for ACE is a downward sloping demand curve which is a derived demand from dealers willing to pay for additional landings in the fish market. An ACE seller who is willing to accept for leasing out an additional ACE follows an upward sloping supply curve, i.e., the higher the lease price, the seller is willing to give up more ACE.
- Since the majority of the ACE does not roll into the next year, it is not economically efficient for ACE lessors to overstock near the end of the year. Because the time value of ACE leases trends down by the end of the fishing year, ACE lessees could try to smooth out their landings to obtain more stable and higher prices in the fish market and avoid leasing in the ACE in the beginning of the fishing year when the ACE is not at its economically efficient value.

HIGHLIGHTS

- Presenting the At-Sea-Monitoring proportional monitoring proposal in a workshop hosted by the Massachusetts Marine Fisheries Institute on "Fishery Monitoring and Survey Selectivity" on Feb. 24 - 25 in New Bedford; http://www.eventsbylhc.com/venues/waypoint-event-center/.

- Presenting two talks in the workshop hosted by NOAA Fisheries, in collaboration with GMRI, in Quincy, Massachusetts on April 10, 2014 focusing on developing solutions to improve groundfish businesses through improving the use of sector ACE and increasing the value of ACE to sector members and developing solutions to improve groundfish fishing businesses.
- Fig. 2 shows one of the examples of Catch/ACE/transfer analysis result at the April 10, 2014 NOAA workshop 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

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 induce cooperation among harvesters on the shared multispecies stocks and 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

- The Executive Summary of the sector business viability research output is now available, http://www.gmri.org/mini/index.asp?ID=36&p=186, which is linked from the SSB website http://www.nefsc.noaa.gov/read/socialsci/ on their front page highlight and is going to be featured as a story in Waypoints Spring 2014 issue.
- The Cost-Effective Approach to At-Sea Monitoring report is made available by the community team on the GMRI MWG website, www.gmri.org/monitoringworkinggroup, and is featured as a story in both the GMRI Fisheries Digest: Dec. 2013 and the Waypoints Winter 2013 issue, http://www.gmri.org/mini/index.asp?ID=59&p=178.
- The research derived from this project "Evolution of Groundfish Sectors Business Viability Model in New England" has been accepted for an oral presentation in the 144th American Fisheries Society Annual Meeting that will be held in Québec City from 17 to 21 August 2014.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

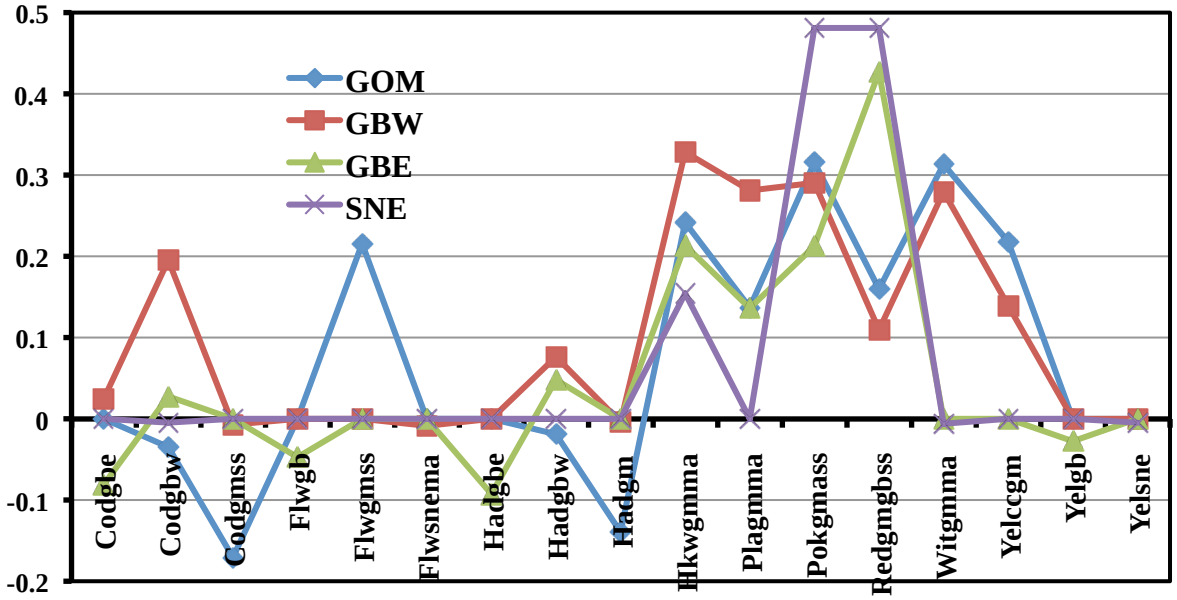


Fig. 1 First Factor in Principle Component Analysis for Catches by Trip in Each Broad-Fishing Area in FY11

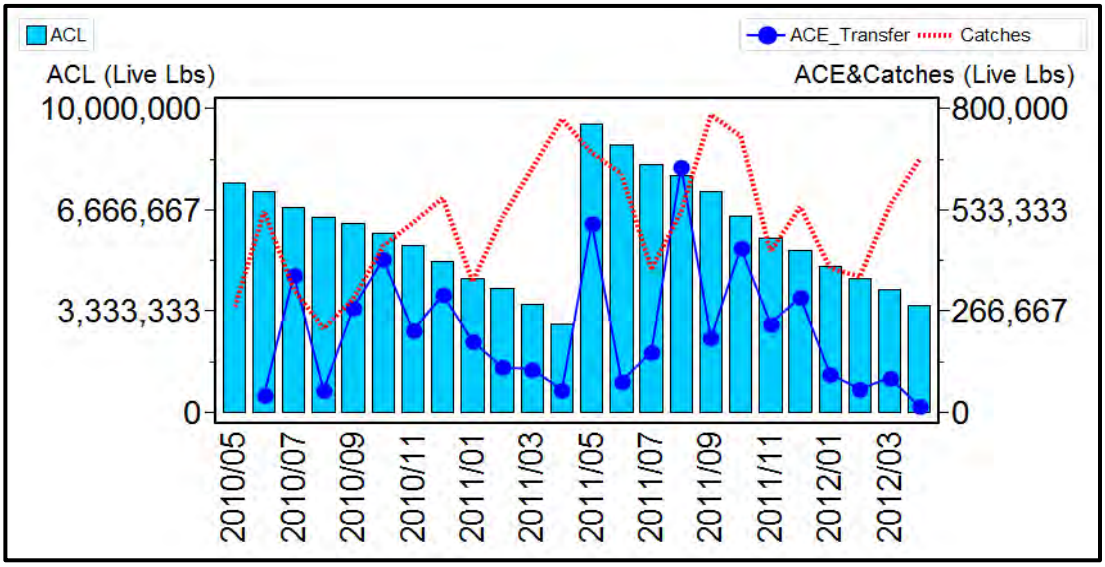


Fig. 2 Monthly ACE, Catches and Transfers for GOM Cod in FY10 to FY11

The effect of catch restrictions on recreational catch

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Michael Wilberg – UMCES

NOAA Sponsor – Scott Steinback, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

In recent years, the competition for harvest between commercial and recreational sectors for nearshore species has increased substantially across the country. This competition has forced fishery managers to impose more restrictions on the recreational sector, and to consider explicit allocations for the respective sectors to mitigate conflicts between user groups. Recreational restrictions typically begin with size limits and bag limits. The effectiveness of these restrictions on the recreational sector depends on how recreational anglers respond to the restrictions. For example, would the imposition of (example of bag limit on cod) induce anglers to fish more to maintain a given catch or would they fish less because the expected catch of the species declines? The answer depends on the preferences for catching different numbers and species of fish on a given fishing trips. This project deals with this problem for the New England groundfish fishery. It estimates the impact of various management restrictions, including size and possession limits. Ultimately, these results will help better understand how different policy measures affect anglers' incentives to engage in recreational fishing, and how those effects depend on anglers' characteristics.

The core of the mail survey is a set of choice experiments that respondents will be asked to perform. These experiments will provide the appropriate information about anglers' preferences for numbers and species of fish. The PI and co-PIs in this project are responsible for developing the survey.

The choice experiment survey will be administered in conjunction with NOAA Fisheries' Marine Recreational Information Program Survey (MRIP) in the coastal areas of Maine, New Hampshire, and Massachusetts during the months of May to October (i.e. waves 3, 4 and 5) of year 2014. All anglers who fish from private boats or party/charter boats intercepted in Maine, New Hampshire, and Massachusetts for MRIP will be asked to participate in a voluntary follow-up mail survey. Anglers who agreed to participate in the follow-up will be sent mail questionnaires using a modified Dillman Design (Dillman, 2000).

ACCOMPLISHMENTS

The main accomplishment during this first phase of the project has been the development of the survey instruments, and identification of key service providers: i) for the mailing of the survey

instruments and processing of the respondents' data, and ii) for the recruiting of the focus groups (i.e. to test the instruments).

HIGHLIGHTS

1. The company that will carry out the mailing of the survey instruments and gathering of the responses has been identified and contracted (Quantech).
2. The survey instruments that will be tested using focus groups have been developed. The development of the draft instruments has been conducted in fluid communication with NOAA scientists, to ensure that the instruments meet their needs.
3. The company that will recruit the focus groups in Massachusetts has been identified and contracted (Market Decisions), and the focus groups schedules for May 14th and 15th in the Boston area.

SOCIETAL BENEFITS

The purpose of this project is to provide critical economic data related to marine recreational fishing. The data collected as part of the choice experiment survey will provide preference information necessary to measure the economic effects of regulation changes on the recreational fishing community in Maine, New Hampshire and Massachusetts.

Theme IV: Protection and Restoration of Resources

CINAR

Cooperative Institute for the North Atlantic Region

Analysis linking study fleet data to habitat and statistic models in the Mid Atlantic Bight

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Josh Kohut and Olaf Jensen – Rutgers

NOAA Sponsor – John Hoey, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

The first year of the project is focused the following two tasks:

Task 1: Evaluate the temperature estimates from the 50-year ROMS hindcast. Under this task we use available bottom temperature data to evaluate and quantify uncertainties in ROMS hindcasts of bottom water temperature used to project thermal habitat. *In situ* temperatures provided by the NEFSC fisheries independent survey, NEFSC survey fleet data and IOOS ocean observatories are used to quantify the uncertainty in temperature hindcasts.

Task 2: Develop thermal habitat model and estimates of thermal habitat volume. To quantify thermal responses of species using the outer NEUS continental shelf as overwintering habitat we use the habitat modeling approaches and several models we are already developing on a closely linked project *("Accounting for habitat-dependent observation error in bottom trawl survey indices for pelagic stocks using butterfish (Peprilus triacanthus) as a model"*, Manderson (PI)) funded by the NOAA office of Science and Technology HAIP. One of our goals is to determine whether species-specific responses are similar enough that a general thermal response for the winter shelf break community could be used to develop a general winter thermal habitat volume anomaly. We evaluate and quantify uncertainties of thermal habitat models using cross validation and independent datasets including industry based temperature and catch data available from the NEFSC COOP program.

ACCOMPLISHMENTS

Since the project began in August 2013, we are still in the early stages of the program. We have conducted our initial PI meeting to identify and organize the steps needed to accomplish our stated tasks. Enrique Curchitser has led the effort to provide hindcast temperature data from the ROMS modeling system. Daily bottom temperatures were hindcast using the Regional Ocean Modeling System (ROMS; Shchepetkin & McWilliams 2003, 2005) numerical ocean circulation model described in Kang & Curchitser (2013). This model extends from the Gulf of Mexico to Nova Scotia, Canada and has a horizontal resolution of 7 km and a vertical resolution of 40 terrain-following levels. Bottom temperatures from ROMS were de-biased using Mid Atlantic Bight Ocean Climatology and Hydrographic Analysis (MOCHA; Fleming & Wilkin 2010). MOCHA is a three-dimensional climatological analysis of temperature and salinity derived from

the ODC World Ocean Database 2005 and the NOAA Northeast Fisheries Science Center oceanographic database. In coordination with another project we will validate these hindcast bottom temperatures against observations provided by the NOAA/NMFS Northeast Fisheries Science Center.

Toward task 2 we have coupled the bottom temperature estimates to a thermal niche model developed by John Manderson at NOAA/NMFS/NEFSC. Dr. Manderson has worked with Josh Kohut to develop an initial thermal based habitat index for longfin squid. This model along with others developed for other shelf break species like butterfish will form the basis for the habitat squeeze analysis. In addition we have begun our discussion with Howard Townsend of NOAA to identify the steps needed to move toward a more holistic ecosystem modeling system.

HIGHLIGHTS

- Completed our Project Kickoff Meeting
- Validated the ROMS hindcast against climatology
- Assembled *in situ* temperature data for validation with the hindcast temperatures and calculated annual and seasonal model RMSE based on *in situ* bottom temperatures
- Coupled hindcast temperatures to thermal niche model of longfin squid along the Shelf break
- Developed our work plan for moving toward an ecological modeling approach to address our hypotheses related to habitat squeeze along the Mid-Atlantic Bight Shelf break.

SOCIETAL BENEFITS

This work will advance our knowledge on how best to apply observed fields relevant to describing key species habitat to various stakeholder groups operating in the Mid-Atlantic Bight. The results of this work will guide the development of appropriate ecosystem and stock assessment indices as they relate to species managed in the Mid-Atlantic Bight.

EDUCATION AND OUTREACH ACTIVITIES

Portions of the hindcast validation (task 1) were part of a larger presentation describing the same model's application to butterfish. These presentations include:

OpenOcean 2013. An index of availability (ρ_h) of Atlantic Butterfish to surveys using a thermal niche model coupled to debiased hindcasts of bottom temperature from a ROMS model. 2013 Butterfish Stock Assessment Data Meeting. Woods Hole, Massachusets. August, 2013

OpenOcean 2013. Integrating habitat dynamics into population & ecosystem assessment using cooperative research within an IOOS framework. Fisheries Working Group. National Research Council. Highlands New Jersey. July 30, 2013

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Palamara, L., J. Manderson, J. Kohut, G. DiDomenico, E. Curchitser, D. Kang, M.J. Oliver, C. Dobson, & A. Snow. 2013. Putting the dynamics of the ocean into marine spatial planning: temporal variation in butterfish habitat. American Society of Limnology and Oceanography Aquatic Sciences Meeting, New Orleans, LA. Abstract ID 10576. 17-22 February 2013

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OpenOcean 2013. (*Lead author*) 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. (*Lead author*) 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

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, 2013 – March 30, 2014

Daniel McCorkle and Anne Cohen – WHOI

NOAA Sponsor – Lisa Milke, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

We proposed to work with colleagues at the NMFS laboratory in Milford CT (Lisa Milke and James Widman, since retired) to carry out an ocean acidification experiment on the Atlantic surfclam, *Spisula solidissima*. The experiment was to run for ~9 days, and to include three pCO2 levels and two feeding rates, to investigate the influence of food availability on the impact of elevated pCO_2 on larval development and initial calcification. This work combined 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, and built on earlier collaborative surfclam experiments we carried out in the summers of 2011 and 2012.

ACCOMPLISHMENTS

We carried out two ocean acidification experiments in summer 2013, using the culturing facilities and CO_2 control instruments at the WHOI Environmental Systems Laboratory:

Experiment 1 (29 May – 4 June 2013) pCO_2 X feeding rate
- Initial stocking – 30 larvae / mL
- 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 *Tisochrysus lutea* (T-ISO), added by daily batch addition

Experiment 2 (11 July – 19 July 2013) pCO_2 X feeding rate
- Initial stocking – 30 larvae / mL
- 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 *Tisochrysus lutea* (T-ISO), added by daily batch addition

RESULTS

The first experiment was terminated on day 6, because initial larval counts revealed very low and highly variable survival. The design of the second experiment was the same as the first, and it ran for the full planned duration; only the experiment 2 results are summarized below.

Water chemistry.

The carbonate chemistry of the cultures was determined based on measurements of pH and total dissolved inorganic carbon (DIC) (figure 1).The average pH values (total scale) and aragonite saturation state values showed the expected trends with respect to pCO_2 level (Table 1), and were similar in both the high-food and low-food treatments.

Shell length and mass.

We observed no significant CO_2 or food effect on either shell length (Figure 2) or shell weight (Figure 3). This contrasts with our 2012 results, and with published studies of other species, where a strong food effect was evident. The lack of food effect in 2013 samples suggest that the larvae were either not feeding, or for some reason were not gaining proper nourishment from their food. We infer that the 2013 larvae were not in good health, and conclude that it is not appropriate to assess CO_2 impacts based on the growth rates observed in these experiments.

HIGHLIGHTS

As we prepare our surfclam results for publication, we will focus on the results of our 2012 experiments. These 2012 experiments suggested that:

- Elevated pCO_2 does not decrease the 3-day or 6-day survival rate of larval surfclams. This differed from the survival data results of our 2011 experiments, which had suggested substantial decreases in survival as a function of elevated pCO_2. We do not know whether this year-to-year difference reflects genetic differences between the two sets of parents, or differences in maternal environmental or nutritional conditions, which impacted egg quality and/or larval response.

- After an initial period when the larvae rely on maternal (egg) nutrition, shell size is strongly influenced by feeding rate. In the 2012 experiment, high feeding rate larvae grown under elevated pCO_2 were larger than low feeding rate larvae grown under ambient 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 was not significantly influenced by elevated pCO_2 at either low or high feeding rates, but the small number of independent weight measurements limited the power of this assessment. (Each weight determination yielded a single average mass from ~50 individuals.)

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

McCorkle and Cohen hosted undergraduate Jillian Lyles (Cornell University) as a WHOI Guest Student during summer 2013. Jillian took part in all aspects of the surfclam experiments, and will to enter graduate school (Conservation Biology) in Fall 2014.

Milke and Widman hosted undergraduate Jaclyn Fisher (University of South Carolina) as a NOAA Hollings Scholar. Jaclyn also took part in all aspects of the 2013 experiments.

Lisa Milke, James Widman, Anne Cohen and Daniel McCorkle. "Physiological effects of elevated CO_2 on Atlantic surfclams." Poster, Ocean Acidification PIs' meeting, Washington D.C., September 2013.

Anne Cohen, Daniel McCorkle, Lisa Milke, James Widman, Barbara Ramon. "An experimental investigation of the surfclam response to ocean acidification." Northeast Coastal Acidification Network (NECAN) / NERACOOS webinar, 10 March 2014, *www.youtube.com/watch?v=pwkKDDi_ypY*

Daniel McCorkle. "Shellfish, fossil fuels, and our changing coastal waters" Public lecture as part of the Research at the Reserve lecture series, Waquoit Bay National Estuarine Research Reserve, 8 April 2014.

Daniel McCorkle. Participant and presenter at the NOAA-sponsored NECAN "State of the Science" Workshop, Portsmouth, NH, 10-11 April 2014.

Marine mammal stranding responses capacity building

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Michael Moore – WHOI

NOAA Sponsor – Teresa Rowles, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

Task 1
Large Whale Training Module

Develop a training module to teach large whale necropsy technique in conjunction with Task 2. This will include Powerpoint presentations on large whale necropsy technique and assembly of an on line image library for diagnosing gross trauma in large whales.

Task 2
Developing a National Stranding and Entanglement Response Tool Kit
Overall Objective:
Organize an international strategy framing workshop with participation from select 4-5 national/international stranding response training programs. The purpose of this workshop would be multi-fold:

1) Develop training and capacity building goals, criteria and objectives. Specifically, a standardized list of training objectives for the various skills or goal sets, a list of training methods, and overall stranding response toolkit;
2) Develop criteria for evaluation of training effectiveness;
3) Develop training modules/defined curriculum for a) basic stranding response; b) necropsy sessions; c) human interaction detection; and d) entanglement response in small cetaceans and pinnipeds.

ACCOMPLISHMENTS

Task 1 is complete in first draft form. It was presented at a training session in St. Martin, Nov 12, 2013. It will be refined and edited to dovetail with Task 2.

Task 2 is fully underway with draft lesson elements prepared, a draft workshop agenda circulated, and participant travel booked for a planning workshop to be held at Woods Hole June 3-5 2014.

HIGHLIGHTS

- We have assembled an excellent group of international experts to undertake this exercise.

SOCIETAL BENEFITS

This toolkit will provide NMFS with a coordinated approach to assist and transfer knowledge for maximum conservation effect in many developing countries, which are in the process of building a stranding network or pursuing marine mammal research and conservation activities. Our ultimate goal is to increase capacity within specific geographic areas to enhance their evaluation of entanglements or other direct human interactions and to increase public awareness of marine mammal issues in line with the implementation of the International Marine Mammal Action Plan.

EDUCATION AND OUTREACH ACTIVITIES

When the stranding toolkit is completed, it will provide substantial educational and outreach benefit to users.

PUBLICATIONS

A summary of the lesson plan modules in preparation:

I. INTRODUCTORY PRESENTATIONS
II. DATABASES
III. BUILDING A STRANDING NETWORK/INFRASTRUCTURE NEEDS
IV. CETACEAN STRANDING RESPONSE
V. SIRENIAN STRANDING RESPONS
VI. PINNIPED STRANDING RESPONSE
VII. HUMAN INTERACTION EVALUATION AND DOCUMENTATION
VIII. SMALL CETACEAN (Provide Primer; ADVANCED ISSUES), PINNIPED & LARGE WHALE DISENTANGLEMENT
IX. DATA SHEETS (BASIC AND INTERMEDIATE LEVELS)

Evaluation of larval sources and population connectivity in Atlantic sea scallop (Placopecten magellanicus)

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Daphne Munroe – Rutgers

NOAA Sponsor – Deborah Hart, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

The Atlantic sea scallop (*Placopecten magellanicus*) fishery is the most valuable fishery in the U.S. This fishery has shown remarkable recovery from a severely overfished state in the early 1990s. One probable contributor to the recent recovery is the system of rotational fishery closures that have enhanced broodstock biomass and may have led to elevated downstream recruitment. Our objective is to examine the linkage between increased broodstock abundance and potential for increased recruitment downstream. To do this, we will create a scallop larval model that will be coupled to a physical circulation model (Regional Ocean Modeling System, ROMS). This coupled bio-physical model will ultimately be used to simulate larval dispersal dynamics and connectivity for the scallop stock. Simulations will specifically examine the trajectories of larval dispersal from areas of increased scallop biomass resulting from management actions and will allow us to address the following questions:

1. Did scallop larvae from broodstock in harvest area closures settle in the high recruitment events following the closure?
2. What are the patterns of general connectivity and larval sources and sinks along the Middle Atlantic Bight (MAB)?
3. Is there evidence that area closures facilitate improved recruitment and fertilization success?

ACCOMPLISHMENTS

Larval Model

A larval model was developed that simulates the growth and swimming for Atlantic sea scallop (*Placopecten magellanicus*) larvae. This model is a particle-tracking submodel that can be linked to ROMS as a coupled bio-physical dispersal model for this species in the Mid-Atlantic Bight. Larvae are initiated in the model at 75 µm shell length, with growth following a linear function based on time and modified by temperature. Larvae are able to swim (upward and downward) and sink. The relative time spent swimming upward versus downward depends on the temperature environment that the larvae experiences and the swimming and sinking speed depend on the larval size. The dependency of swimming and sinking on larval size means that

net movement varies ontogenetically with larvae >240µm tending to move downward to the bottom for settlement.

Validation tests were performed wherein larvae were initiated into a simulated water column 50 m deep, with a bottom temperature of 8°C, a thermocline at ~20m depth, and a surface temperature of 21°C (Figure 1, lower right panel). These larvae swam up to the thermocline in approximately 5 days (Figure 1) and maintained their position in the thermocline through to day 38. At day 38 (240 µm shell length) the larvae began to descend to the bottom to settle. Additional tests of the model were run wherein larvae were mixed above and below the thermocline during their development (Figure 2). In both cases, when larvae were mixed up to 4 to 7 m above or below the thermocline, they were able to return to the thermocline within 3 to 5 hours of displacement. Despite displacement and mixing, larvae were still able to grow to settlement size within 38 to 40 days.

Physical Model

A ROMS domain has been created that includes the region of the federal scallop fishery, with the portions of the stock of interest in this study (Hudson Canyon South and Elephant Trunk) included. Grid points in the domain have been parameterized for larval release points (Figure 3) and each release point has been scaled relative to adult biomass estimated from annual stock assessments at that location. Biomass scaling for larval release has been parameterized independently for each of the six years from 2006 through 2011. Initial larval model runs have recently begun and simulated larval performance evaluated.

HIGHLIGHTS

- A larval scallop model was developed that has been coupled to ROMS. This model calculates growth and swimming for larval Atlantic sea scallops.
- A physical oceanography model domain has been created and scaled to release larvae, throughout the distribution of the scallop stock along the Mid-Atlantic Bight, according to adult biomass from the years 2006 to 2011.

SOCIETAL BENEFITS

- This research will provide a greater understanding of population connectivity in an economically and ecologically important fishery along the Atlantic coast.
- Results of larval dispersal simulations will aid in understanding how rotating stock closures and fishery management of the Mid-Atlantic Bight Sea scallop stock is interacting with recent increases in stock biomass.

PUBLICATIONS

Munroe, D., Hart, D., Shank, B., Haidvogel, D., Powell, E., Klinck, J., & Hofmann, E. 2013. ‘The Role of Larval Sources and Population Connectivity in Rotating Closures in the Atlantic Sea scallop (*Placopecten magellanicus*) Fishery, MidAtlantic Council Meeting, Annapolis MD, Dec. 10 2013'.

Munroe, D., Hart, D., Shank, B., Haidvogel, D., Powell, E, Klinck, J., Hofmann, E. 2014. The Role of Larval Sources and Population Connectivity in Rotating Closures in the Atlantic Sea scallop (*Placopecten magellanicus*) Fishery. Poster presentation, National Shellfisheries Association Annual Meeting, Jacksonville, FL, March 29-April2, 2014.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS –

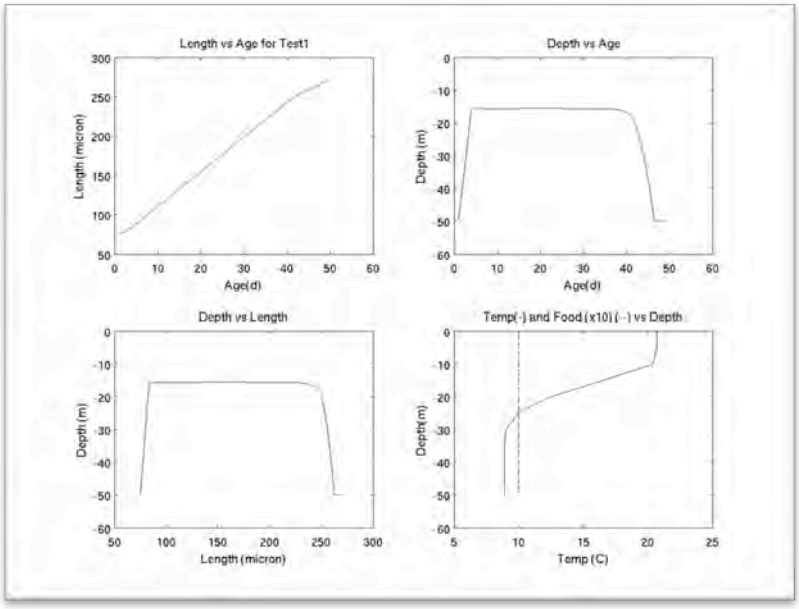

Figure 1: Base case larval growth in a 50 m water column with a thermocline at approximately 8 m depth.

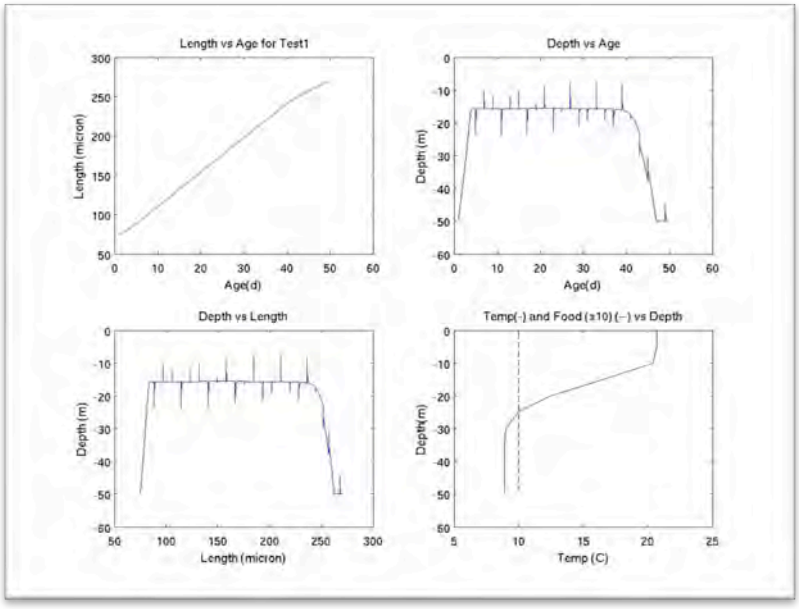

Figure 2: Test of larval growth and behavior under conditions that abruptly mix larvae above and below the thermocline.

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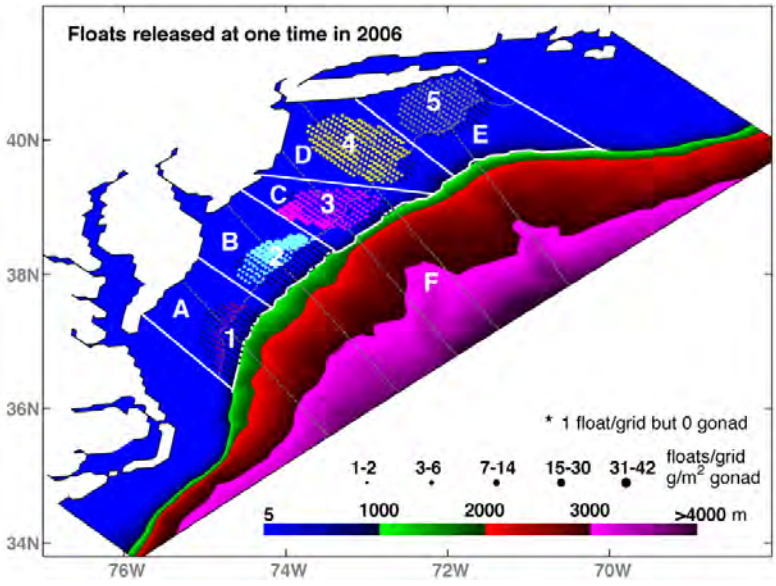


Figure 3: Example of release points within the ROMS grid. Depth contours shown with various colors, release regions along the shelf are labeled with letters and the larval release points are shown with mapped points which are scaled by adult biomass represented by the size of the point.

Analysis of CYP1A1 expression in cetacean tissue samples

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

John Stegeman – WHOI

NOAA Sponsor – Teresa Rowles, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

This project involved further analysis of cetacean tissues (*Tursiops truncatus*) by immunohistochemistry, for detection of cytochrome P450 1A (CYP1A) staining and assessment of strength of signal in different organs and cell types, including in skin/blubber samples from numerous individuals.

ACCOMPLISHMENTS

The analyses revealed a range of CYP1A staining intensities. As in prior sample analyses, expression of CYP1A was detected in endothelial cells in skin biopsies, and in endothelial cells and epithelial cells in the other organs examined. The correlation of staining with possible exposure history of the animals was determined by NOAA personnel.

HIGHLIGHTS

- The analyses were consistent with the prior set of immunohistochemical results.
- The correlation studies raised several questions, which were addressed in a response and conference call with NOAA personnel. The answers provided to those questions are appended to this report.

SOCIETAL BENEFITS

The studies are relevant to the current and future approaches to the assessment of oil spill effects.

EDUCATION AND OUTREACH ACTIVITIES

Confidentiality issues prohibited public presentation of the results at this time.

PUBLICATIONS

Confidentiality issues prohibited public presentation of the results at this time.

Questions/requests regarding CYP1A results

IHC data

- Scoring using IHC method
  - Can we obtain one score per sample instead of different scores per layer/zone?
    → Should we compare some single scores we initially obtained to the various layers? [If so, Chi will request single scores from Lori Schwacke]

    We did score the expression in layers of the samples initially given one score, and provided those results earlier. There would have to be a consistent depth to rely on comparisons of a single score, as indicated below.

    What is the scientific validity or biological reason behind separating or keeping one layer over others?

    The biological reason for scoring the different layers separately is first that they have different abundances of various cell types, some in which CYP1A is expressed, and some not. If two biopsies differ in the amounts of a particular layer, including perhaps absence of a layer from one but not the other, it could artificially affect the comparison between these biopsies. The differences in the cellular composition of the layers are consistent with differing biological processes in those layers. Which layer might more accurately reflect some exposure is still a matter of uncertainty.

  - Is there a specific layer/zone or a scientifically consistent standard that is recommended to use for CYP1A analysis?
  - We are the ones who initiated the use of IHC analysis of CYP1A in skin biopsies (following our finding of high levels of CYP1A in endothelial cells in the mid-1980s). Our analyses to date of how levels of expression in different layers relate to possible variables that we think might contribute to the CYP1A response are strongly suggestive but there has not been a systematic analysis, due principally on the difficulty to obtain funding for a complete analysis.
  -
  - Which scores indicate high/low exposure?
  - High scores indicate greater level of expression; greater level of expression indicates a greater level of exposure or potency of some AHR agonist(s).
  -
- Many samples from epidermal layer and zone 3 have no IHC scores available (i.e., blank cells in excel sheets). Does this indicate no staining or no scores are available (i.e., no testing was done) or is it because there is not complete full thickness sample based on histology
- The absence of a score for a layer or zone indicates that the layer or zone was not present in that sample.
-

- Does length of time samples held in formalin from field to embedding make a difference in CYP1A levels measured by the IHC staining intensity/occurrence scores?
- We have seen very strong signal persist in fish tissues held in formalin for years. There is can be a reduction but in our experience this is not substantial. Time in fixative has not been tested directly in *Tursiops* samples.
-
- Does post mortem interval/level of autolysis/time from biopsy to fixative alter the IHC staining intensity/occurrence scores? Did you do an independent assessment of tissue quality through the H&E examination and has that been evaluated relative to the scores?
- Longer post-mortem time to tissue fixation has been seen to result in autolytic change in tissues of other dolphins, but that was observed with liver. H & E stained sections of all of the biopsies in the current study were examined, in order to identify and demarcate the zones. There was no noticeable difference among the samples and autolysis generally was not seen. However, it would be prudent to ask a pathologist familiar with cetacean skin to examine the samples.
-
- Have remote biopsy samples been analyzed from beluga whales, especially belugas from the St. Lawrence, where PAH exposure is higher compared to other beluga populations (see Wilson et al., 2005)?
- Not by us. Not aware of any. (Also, not sure what you mean by "remote".)
-
- Need to obtain all IHC results from Tier II sample set sent to WHOI (Chi waiting response from Lauren McGeorge on specific number of samples) including the stranded animal samples.
- We are not sure to what you are referring.
-
- Can dispersant exposure alter CYP1A levels?
    - Link to dispersant (i.e., Corexit 9500 and 9527) components used: http://www.epa.gov/bpspill/dispersants-qanda.html
    - This is a good question. Dispersant exposures would have to be done directly to assess the dispersant alone. The presence of dispersant could make the petroleum more available for uptake. However, the literature is mixed on the results of this. To our knowledge. there are not any studies directly on dolphin,

PCR data

- Graphs with "molecule numbers per well" were provided for both actin and CYP1A for some of the samples, but we do not have the actual values and would like to request them for further analyses. Also, "molecules per well" should be converted to copies (or molecules) per µg of input RNA or input cDNA (if measured), or per genome. Can we also obtain those values and does John's group know how their values compare to the values published in the literature (if there are any relevant)?
- The conversion to molecule numbers of RNA is simply to multiply by 20. The data will be provided in that way. We will also send you the Ct values.. As for

comparison to literature values for CYP1A in skin of cetaceans, there are few examples for such comparison. The values reported by Christina Panti et al (Ecotoxicology (2011) 20:1791–1800) show a 3-fold range in CYP1A expression levels between the highest and lowest levels in skin of striped dolphin. Note, that they used GAPDH and YWHAZ as reference genes, not ß-actin, as we were instructed to do.

-
- What are the error bars in the copy number graphs (e.g., S.D.)
- (yes, SD)
- and are they based on 3 RTs x 2 PCR's each or an N=6 per sample?
- The values are means of RTs for each sample, and there were two technical replicate PCR reactions for each RT. So the results are for an N=3.
- Where there are huge error bars within one sample, is the variability due to one RT product?
- In general, yes.
- Can we obtain data on the technical replicates?
- Yes, of course.
-
- Were the RNA integrity number (RIN) values measured for each sample and were all samples with RIN values above 6 used for further analysis?
- RIN Values were determined by NOAA, and only those with RIN above 6 were sent to us. We began to do nanodrop analyses on the samples, but ceased when told to use the values provided by NOAA. Note that the RNA concentrations we measured for the first set of samples analyzed (n = 45) generally substantially differed (i.e., were lower) than those provided by NOAA. We will send you this information, if desired. Note that there were few samples for which NOAA did not provide RNA concentrations. In these cases, we used the values measured with nanodrop.
- We sent 3 series (TYP120718-01A-D; TYP120724-04A-D; and TYP120731-01A-D) of experimentally degraded samples with decreasing RIN values (4 levels each) to validate what the lowest acceptable RIN should be for this assay but have not received all results. Based on one set of results we have obtained, it indicated >3-fold decrease in CYP1A copy number between a RIN of 8 and a RIN of 6.5. We would like the results of the other two series.
- We searched but did not receive the other series mentioned. All the samples we received should now be back in the hands of NOAA, so that can be checked again there, against the CoC forms.
- Obtain standard curves for CYP1A and actin (i.e., what concentrations make up the standard curves for CYP1A and actin)? The efficiencies of both the CYP1A1 (90%) and actin (89%) primers are marginal– generally 90% is the minimum accepted.
- The issue of standard curves is a concern. First, standards were included on each plate for both actin and CYP1A. The standard curves for CYP1A were consistently good and with efficiencies between 90 and 110 %. However, the efficiencies with actin were below acceptable limits, for all but four plates. Given the cost of reagents and time, it would not have been possible to run more plates or to select a new reference gene; actin was indicated as the gene to use. The next best thing was to use the four acceptable actin standard curves as a proxy for the individual plates. The problems with

actin lead to our presentation of the data as we did (i.e. not normalized to actin). In any case, the CYP1A results appear to be quite valid.

- At what Ct ranges do samples run? A table of Ct's for each of the replicates performed on each sample should be provided.
- This will be provided. The range of Ct values for actin ranged from 15.45 to 21.45and from 24.15 to 32.98 for CYP1A (mean of technical replicates).

Potential follow up action items

- Were offshore animals from Gunter Cruise presumably exposed to oil? [Laurie S will follow up]
- Correlation/regression between CYP levels and contaminant levels [Chi to obtain validated chemistry data on samples that measured CYP1a and compare with CYP levels, especially in the first remote biopsy samples from May and August of 2010]
- Is there a seasonal/location difference regarding CYP levels in cetaceans? Create a map with the following three items [request Jill Bodnar's help possibly using NESDIS oiling products]:
    - CYP levels
    - Location → may apply to MS Sound
    - Time (date of collection) → seasonal changes may apply to Chandeleur Sound
- Request contaminant data from St Joe Bay samples? [Gina]
- Look at health status of animals and CYP1A levels in captured dolphins – may be able to determine if health is a potential confounding factor

Theme V. Sustained Ocean Observations and Climate

Global ocean observing coordination activities

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Donald Anderson – WHOI

NOAA Sponsor – Candyce Clark, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

This project supports contributions to the World Meteorological Association's (WMO) global ocean observing coordination activities for 2012-2015 via the U.S. NOAA's Climate Program Office. These activities focus on developing international consensus on the requirements for ocean observations and technical support to ocean observing networks participating in the WMO-led Global Climate Observing System (GCOS) coordination activities which encompass, *inter alia*, the Global Ocean Observing System (GOOS). In investing in multilateral cooperation, the United States ensures that its substantial investment in global ocean observations is matched by other national investment in a system that is compatible and shares standardized data in real time.

Specifically supported is technical coordination within JCOMMOPS, the Observing Programme Support Centre of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). JCOMMOPS serves:

- the Data Buoy Cooperation Panel that maintains a network of surface drifting floats measuring temperature, pressure, and surface current,
- the Ship Observations Team that maintains volunteer commercial ship observations of meteorological parameters, as well as underway measurements of surface and subsurface ocean variables, and
- the Argo Information Center, a technical support and coordination activity for the global network of more than 3000 Argo profiling floats.

Support is also included for the GOOS component of GCOS via the Ocean Observations Panel for Climate (OOPC), which provides scientific oversight for open ocean GOOS, identifying the requirements for observations for climate and other societal benefit areas, and ensuring the outputs of the system are fit for purpose.

ACCOMPLISHMENTS

Data Buoy Cooperation Panel

Each month and ongoing, the DBCP TC provides the status of the drifting and moored buoys (and select rigs and platforms) to the Member States in the form of maps and graphs. These are available on the DBCP Website: http://dbcp.jcommops.org/network/status.html. The DBCP TC maintains a website for the Panel at http://dbcp.jcommops.org. The website has information on project overview, platforms, status and maps, data and metadata, community contacts, upcoming meetings, news items, etc. The website is constantly updated to reflect current information and recent status of the network.

In addition to the website, the DBCP TC and JCOMMOPS maintain numerous mailing lists (email) to inform the community of changes. The DBCP sends out at least 1 message per month on the status of the array as well as any other pertinent information to the community.
Reports are published at DBCP Annual Meetings and are available on the JCOMM Website.
Updates to the DBCP Implementation Strategy – DBCP Technical Document #15
Updated DBCP Operating Principles. Update Data Buoy Operations Safety Document.

OceanSITES

Support is given to the OceanSITES science team, who is working to develop requirements for each of the several networks embedded with the OceanSITES programme (www.oceansites.org)

Argo

Support to the Argo programme is provided via a dedicated TC and Argo Information Centre activities and website. Status maps and charts are regularly provided to the Argo Steering and Data teams (e.g.). See http://argo.jcommops.org/maps.html). New analysis tools are regularly designed and added. EEZ notification and warning system is gradually improved and maintained operational, to facilitate program managers tasks. Guidance is regularly provided to the community on the international regulations and best practices.

The AIC maintains appropriate tools to facilitate the implementation planning and optimize the network distribution. A scoring system of deployment plans has been designed. In depth analysis and report son delays have permitted to dramatically improved them and discover weaknesses in the data flow for some national centers (see here). The AIC is also fostering the review of the Argo design (see report) to define and dimension rationally the requirements (number of floats per year, distribution, etc.).

Ships

The new ship coordinator started to work for JCOMMOPS in February 2013. The period until 31 March 2014 was accompanied by continuous familiarization with the different communities and tasks. The ship coordinator serves i) SOT, ii) GO-SHIP and iii) other observing programmes in all ship related matters, in particular DBCP and Argo for deployment opportunities.

For SOT, the production of maps was resumed and various new maps developed, which include statistics on participating countries, data quality, automatization and timeliness or masking schemes. The TC reported at the 7th session of SOT in Victoria, Canada. Details and documents: www.jcomm.info/sot7.

For SOOP, the collection of metadata was resumed. Contrary to VOS, the collection of these data remains to be difficult. Only very few operators provide data as planned and requested, which made the production of SOOP statistics based on other sources than the GTS not possible, but good progress was made in this matter at the end of the period.

VOS metadata, gathered in WMO publication n°47, are continuously monitored and incoherencies reported to the responsible national focal points, with the request to review and update their data. A large number of wrongly registered platforms was successfully identified, reported and modified.

Mask information are gathered and compiled at JCOMMOPS and made available to authorized users through the JCOMMOPS system. The origin of approximately 300.000 VOS observations, which were inserted twice on the GTS, through different GTS nodes and with different IDs (thus not really duplicates) in the period, was identified and the problem was already almost solved at the end of the period. As a result, VOS Statistics based on the JCOMMOPS metadata base are now of excellent quality.

For GO-SHIP, information on planned or recently accomplished cruises were gathered and compiled in a global cruise plan. Where no national focal points existed, appropriate scientists were identified and recruited for almost all active countries by the TC. A meeting with all focal points was fully organized by the TC prior to OSM 2014 in Hawaii, including all logistics, reporting, and remote attendance. The meeting allowed for the definition of the ongoing decadal survey with line status and parameters at different levels, and to set up an executive group for more urgent matters. At OSM in Hawaii, a town hall was organized and a poster was presented, both with involvement of the TC. Details and documents: www.jcomm.info/go-ship4.

Across the programs coordinated by JCOMMOPS, the development of a cruise information center was initiated. It will centralize on international level information on cruises from particularly research, commercial and sailing ships, with the aim to identify synergies, in particular deployment opportunities. Contacts with key sources such as UNOLS and POGO for research vessels have been established, agreements achieved and technical synchronization issues discussed.

Reports were provided to panels and steering teams on deployment opportunities (see here) and partnerships developed and finalized, or initiated with many new actors (industry, NGOs, sailing community, maritime operator, etc.).

JCOMMOPS

JCOMMOPS as a whole is also a growing structure which requires efforts with regards to its development, budget management, infrastructure, IT developments, staff issues, relationship with host, performance monitoring, etc. This is covered by the senior TC of the centre (Argo).

To be noted the optimistic options offered by a potential move of the office in Brest.

The funding, justification and recruitment of a new TC, to focus on ship information was definitely a real progress, applauded by the community, as well as the firm establishment of a dedicated software engineer in support of all JCOMMOPS activities.

Many challenges are still on JCOMMOPS plate, in a rather complex governance model, and very diverse community. A decade of integrated services is in sight, including a new set of website and web based services, a new integrated ship time service, via a strengthened team.

OOPC

OOPC is a scientific expert group charged with making recommendations for a sustained global ocean observing system for climate in support of the goals of its sponsors. This includes recommendations for phased implementation. The panel also aids in the development of strategies for evaluation and evolution of the system and of its recommendations, and supports global ocean observing activities by interested parties through liaison and advocacy for the agreed observing plans.

In the past, OOPC has mainly focused on physical ocean variables in the open ocean. For the climate-relevant biogeochemical and biological ocean variables, OOPC has been in close collaboration with the International Ocean Carbon Coordination Programme (IOCCP). Due to the restructuring within GOOS following the development of the Framework for Ocean Observing (FOO), and the new GOOS expert panels for biology and ecosystem variables, OOPC's role has now evolved to oversee the ocean component of GCOS and the physical variables for GOOS, while defining sustained ocean observing requirements for WCRP, especially in regard to the WCRP Climate Variability and Predictability Project (CLIVAR).

Chaired by new co-chairs Dr.Mark Bourassa (University of Florida, United States) and Dr Toshio Suga (Tohoko University, Japan), OOPC met for its Sixteenth Session from 3-5 September 2013 at the NOAA Climate Programme Office in Silver Spring, United States. The last day of the meeting was organized as a joint day with the Fifth Session of the Observations Coordination Group (OCG) of the WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM). The main goal of the session was to define OOPC's new role in global ocean observation, including (1) to seek guidance on drivers and priorities from the OOPC sponsors, (2) to initiate the revision of the new OOPC Terms of Reference, (3) to develop the OOPC Work Plan for the next period of 2013-2018, and (4) to identify initial steps in implementing the Work Plan. At the session, OOPC members decided that future attention of the ocean observing community in the upcoming years would focus on the following issues:

- Develop and evaluate the design of global ocean observing systems, considering developments in applications and technologies through workshops and evaluation exercises.
- Identify and address gaps in the sustained observing system such as boundary currents, the Deep Ocean, and observations in coastal and shelf areas.
- A need to improve the observation coordination at a regional level, and engaging with GOOS Regional Alliances (GRAs) and also the GCOS/GTOS/WCRP Terrestrial

Observation Panel for Climate (TOPC), particularly on issues such as coastal inundation and fresh water fluxes.

The OOPC Secretariat played a major role in organizing the Tropical Pacific Observation System 2020 Workshop (27-30 January 2014, Scripps Institute of Oceanography, San Diego, United States), which was sponsored by GCOS, GOOS, NOAA, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the Korean Institute for Ocean Science and Technology (KIOST), and the China State Oceanic Administration (SOA). The workshop was attended by 65 invitees from 13 different countries and 35 institutes, and included scientific talks based on 14 white papers and 9 agency presentations. The aims of the workshop were to evaluate the requirements for sustained observations in the Tropical Pacific, and make recommendations for the evolution of the Tropical Pacific Observing System to meet these requirements in the future. The meeting was prompted by the challenge in sustaining the TAO/TRITON mooring array (supported by NOAA and JAMSTEC). However, a scientific evolution is timely as the scientific applications of the Tropical Pacific have evolved (e.g., Argo, profiling floaters), and so has the observing system since the TAO array was established. It was recommended by participants of the workshop to establish a TPOS 2020 project that will oversee the transition to a more resilient and integrated observing system to meet the identified gaps as well as future needs as they are identified. It was considered essential that the organizations interested in Tropical Pacific observations maintain proper dialogue. The goals of the proposed TPOS project are:

- To refine and adjust the TPOS to monitor, observe and predict the state of ENSO, and advance scientific understanding of its causes.
- To determine the most efficient and effective methods for sustained observations to support prediction systems for ocean, weather and climate services of high societal and economic utility, including underpinning research.
- To advance and refine the knowledge of the predictability horizon of the Tropical Pacific variability (physical and biogeochemical), as well as its impact in global climate.
- To determine how inter-annual to multi-decadal variability and human activities impact the relation between marine biogeochemistry and biology to carbon budgets, food security and biodiversity.

At the Sixty-Sixth Executive Council of the WMO, the OOPC Secretariat and Dr.Neville Smith, new co-chair of the TPOS 2020 Steering Committee, informed WMO Member States of the workshop and the proposed project, and encouraged them to contribute technical expertise to TPOS design activities, and to discuss future support for this critical observing system.

OUTREACH AND EDUCATION

Outreach and education is an issue in the long run for all JCOMMOPS programs, in the context of sustained networks. This is a growing activity given the demand and potential. A number of technical developments have been made to democratize this access to information (e.g. Google Earth layers) and JCOMMOPS is participating in a number of training workshops, or specific actions (e.g. school visits, collaboration with aquariums, teacher, etc). Some others tools based on social Medias are gradually being set up (e.g.: picasa albums, twitter news).

An important outreach initiative led by JCOMMOPS is to have the sailing community (individuals, adventurers, navy schools, sailing races, NGOs) participating in the deployment (and soon the funding) of the GOOS networks. Famous skippers can attract medias much more than scientists and tell the whole story.

JCOMMOPS is fostering the integration of such activity across programmes, and setting up a proper forum with UNESCO to deal with these educational issues. Cooperation with educational sector at all levels is being gradually developed.

Webinar-GOOS started a monthly webinar series as an opportunity to hear about any activities or topics of interest to the GOOS and OOPC community, and to interact with the speakers directly. On 2 May 2014, Toshio Suga (co-chair of OOPC) and Katherine Hill (OOPC Secretariat) presented the current status and outcomes of the Tropical Pacific Observing System 2020 Workshop to a broad range of experts from all over the world. The TPOS webinar can be re-watched here:
https://oceanleadership.adobeconnect.com/_a1126222939/p4xznd78w8r/?launcher=false&fcsContent=true&pbMode=normal.

Website–OOPC is hosting a website (http://ioc-goos-oopc.org), where all OOPC-related meeting documents are freely available. Furthermore, the website explains the wider concept of ocean observing, including which technical applications are currently being used, and how specific ocean indices (e.g., sea ice, ocean acidification) can be measured.

PUBLICATIONS AND REPORTS

Publications by Principal Investigators

Beyond daily support, monthly status reports, JCOMMOPS TCs provide technical reports to the panels and steering team, and to JCOMM OPA, on a yearly basis. It is an important and routine task. Most of them are available from jcomm.info website.

JCOMMOPS delivers yearly reporting to its communities to cover different aspects of the programs:
- Implementation (e.g. national contributions, planning, network density, network design, requirements dimensioning, network growth)
- Instrumentation (e.g. instrument reliability, market evaluation)
- Data flow (quantitative, qualitative, delays analysis, etc.)
- Operations (deployment opportunities)

This reporting needs to be rationalized and integrated as other JCOMMOPS services.

It is to be noted that JCOMMOPS monitoring products such as maps and charts are often used in scientific publications, and national reports or proposals.

Other Relevant Publications

- OOPC (2014): The Tropical Pacific Observing System 2020 Workshop – Volume I: Workshop Report and Recommendations.
- OOPC (2014): The Tropical Pacific Observing System 2020 Workshop – Volume II: White Papers.
- OOPC (2013): Summary Report of the Fifteenth Session of the GCOS/GOOS/WCRP Ocean Observations Panel for Climate.

CINAR input into fisheries/climate regional products

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Donald Anderson – WHOI

NOAA Sponsor – Ellen Mecray, NESDIS

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

CINAR Theme – Theme V: Sustained Ocean Observations and Climate

PROJECT OVERVIEW

In an effort to expand its sector-specific information delivery on regional climate impacts, the National Climate Data Center (NCDC) will be producing quarterly reports, and an online dashboard, that address some of the important sectors and sub-regional geographies within NOAA's Eastern Region. These reports will 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. Here we propose that CINAR investigators will lead the development of content, and also develop an online prototype dashboard format, for the fisheries/climate sectoral outlook product. Content would be in the form of oceanographic 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 will be provided to the NOAA Regional Climate Services Director, Eastern Region (RCSD-ER) to be incorporated in quarterly 2-page reports that will be broadly distributed via email, as well as an online dashboard format, to regional partners and stakeholders.

ACCOMPLISHMENTS

Outlooks. CINAR investigators attend regular monthly calls to contribute oceanographic content to the Eastern Region Climate Team. Additionally, per this agreement, CINAR investigators serve on the Outlook working group calls that produced quarterly climate outlooks with NOAA's Regional Climate Services Director (RCSD), Eastern Region (RCSD-ER). CINAR directly contributed images and text content for each of the releases (September and December 2013, and March and June 2014). See also, links to the climate outlook products: http://www.drought.gov/drought/content/resources/reports

Dashboard. CINAR investigator, Andy Pershing (GMRI) together with CINAR Administrative Associate Ann Stone (WHOI) were instrumental in assisting to host the first of several meetings between fisheries managers, scientists, and industry representatives on June 12, 2014. This

meeting was intended to set the stage for work on the fisheries sectoral dashboard under development.

HIGHLIGHTS

- The Quarterly Climate Impacts and Outlook report content was greatly enhanced by the addition of ocean-specific information contributed from CINAR representatives.
- The RCSD worked closely with CINAR leadership to draft the fisheries and climate dashboard, and to lead the sector-specific meeting that served as the kick-off to this product's development in the coming year.

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. The Outlooks are also capitalizing on social media with posts from NOAA and partners on Twitter and Facebook. They are a resource for a current view of NOAA, and our close partners', results and observations on regional climate.

EDUCATION AND OUTREACH ACTIVITIES

The outlook is an outreach activity, and serves multiple audiences across federal, state, academic, and local audiences.

An eye in the ocean: Exploration of high-resolution vertical distributions of plankton and particles and coincident hydrography in the Western Chukchi Sea – data synthesis

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Carin Ashjian – WHOI

NOAA Sponsor – Kathleen Crane, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR 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) will be compared to determine interannual variability and to understand if climate change is modifying the ecosystem. For this year, the main goal was to finish the data processing and start data synthesis.

ACCOMPLISHMENTS

Analysis of the 2012 VPR data was completed. Data from 2004, 2009, and 2012 were archived on the data archive as two types of data files: Matlab files and ascii files. Ashjian participated in the May 2013 PI workshop held in St. Petersburg, Russia. Ashjian also participated in a PI synthesis meeting held in Honolulu, HI in February 2014. At this later meeting, specific papers for synthesis and the contributions of several collaborators were identified. Also, a plan for moving forward to prepare the papers for inclusion in a 2015 issue of Oceanography was identified.

HIGHLIGHTS

- The vertical distributions of copepods and diatoms and marine snow particles were closely associated with the vertical structure of the water column and with different water mass types (Figure 1).
- Herald Canyon was very dynamic, with multiple water masses and complex velocity patterns. Plankton and particles were spatially heterogeneous. Along- or cross-canyon flux of plankton and particles in this region revealed that most types were primarily

advected to the north while on the western side of the canyon substantial flux of algal mats was observed. (Figure 2)

- The VPR was an effective means to obtain high-resolution vertical distributions of plankton and particles that can be coupled to hydrography and to velocity in achieving a better understanding of the complex interaction between biology and physics that structures this ecosystem.

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. Information on the high-resolution distributions of plankton in association with hydrography and currents can enhance our understanding of the ecosystem and contribute ultimately to better modeling of the system.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

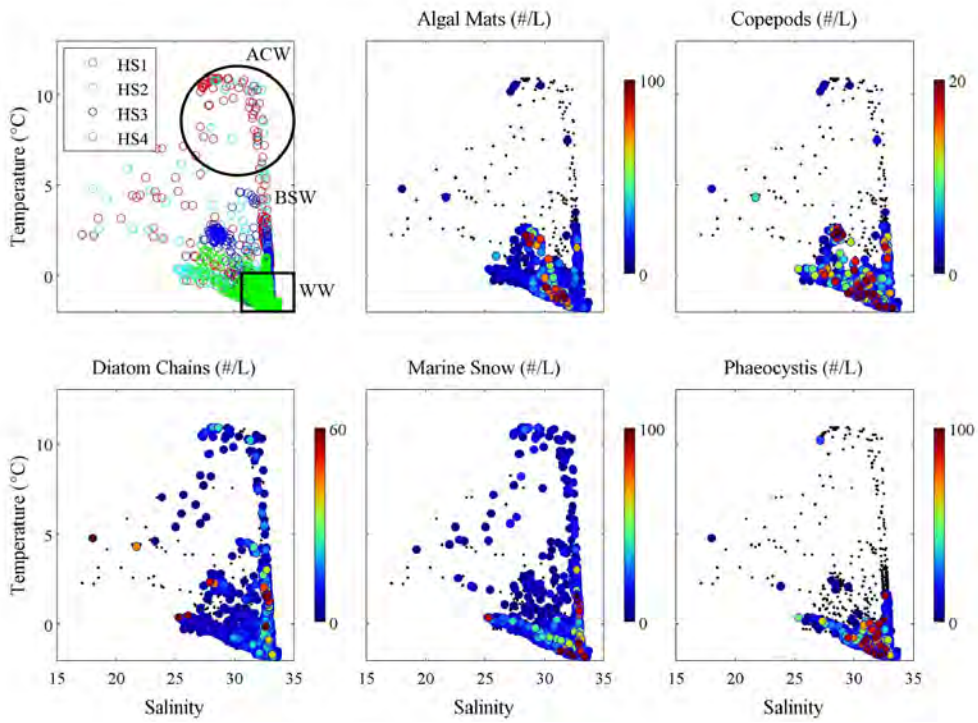


Figure 1. Temperature-salinity-plankton diagrams for Herald Canyon in August 2004. Upper left panel shows the TS for all of the tows with the different transects indicated in different colors and dominant water types indicated. The remaining panels shows TSP plots for dominant plankton/particles. Strong affinities of some types to different water masses were seen. In particular, algal mats, phaeocystis, and copepods were in highest abundance in the upper water column, above the cold, salty remnant Winter Water (WW). Marine snow and diatom chains

were found in all water mass types, including the warm Alaska Coastal Water (ACW) seen primarily on transects HS1 and HS2 and in the Bering Sea Water (BSW).

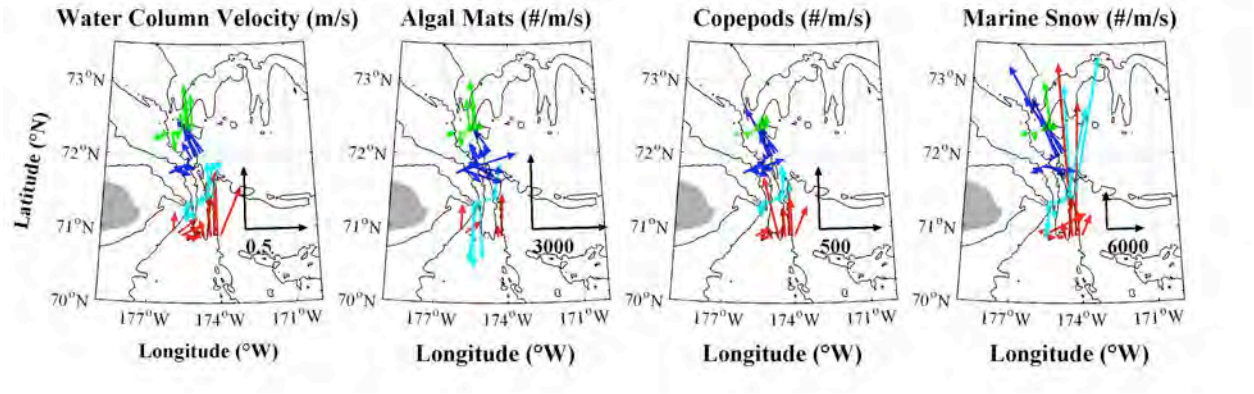


Figure 2. Mean water column velocity (m/sec) and the mean water column flux (#/m/sec) of algal mats, copepods, and marine snow through Herald Canyon in the western Chukchi Sea in August 2004. Flux was calculated by combining the water column abundance of plankton or particles with the mean water column velocity. Concentration data for plankton and particles measured using the Video Plankton Recorder. High flux results from high velocities and/or from high abundances of the target particle or plankton. Note the high southward flux of algal mats in the western side of the Canyon on the two middle lines (blue and cyan). High abundances of algal mats in those regions relative to other locations resulted in a high flux. By contrast, flux of copepods was much less on the western side of the Canyon because fewer copepods were present there.

Satellite derived climate data records of ocean-atmosphere exchange

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Carol Anne Clayson – WHOI

NOAA Sponsor – Jeff Privette, NESDIS

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

This project was designed to create a bundle of Thematic Climate Data Records (TCDRS) for sea surface temperature, near-surface wind speed, near-surface air temperature, near-surface specific humidity, and sensible and latent heat flux. In addition to the data itself, the appropriate documentation for the dataset, as well as the codes and a procedure for quality control will be developed.

ACCOMPLISHMENTS

Initially we had been working with the neural net (NN) retrievals to attempt a one neural net weighting for all of the SSM/I satellites. Our initial results indicated that it might not be possible; however in discussions with C. Kummerow and W. Berg (providers of the CSU CDR on SSM/I brightness temperatures) there was some evidence that this was due to EIA variability. Thus, in the last six months we have re-done the matches to encompass the EIA-adjusted brightness temperatures. This enabled us to be close to fully successful in allowing a common NN retrieval for all the satellites. The one exception is F8, and this is due to the very incomplete 85GHz channel recordings. Thus, for F8 we determined that we would create its own NN retrieval that does not include the 85 GHz channels. The error characteristics for the F8 retrievals are higher than for the other satellites due in part to the increased noisiness of the brightness temperatures. Thus the inclusion of EIA adjustments moved us past the difficulties with the varying satellites and we now have a successful retrieval methodology.

All NN retrievals are now complete for the years 1988 through 2007. The swath level retrievals of winds, air specific humidity, and temperature, are complete. The sea surface temperature field based on the Reynolds with the diurnally-varying component is complete for these time periods as well. The swath level fields have been gridded, and ice and land masks have been applied. A paper has been submitted and is now in revision describing the dataset in the International Journal of Climatology. Samples of the output data set have been prepared and accepted by NOAA. An Archive Request, data flow diagrams, and source code have also been submitted to NOAA. We are currently working on a draft version of the ATBD.

As noted above we have finished revising the paper about the SeaFlux dataset version 1.0. For this paper we have done an extensive uncertainty analysis of the original SeaFlux dataset, using propagation of errors, and will use the same comparison dataset and techniques for analysis of

the full 20-year product. A few examples of the uncertainties for Version 1.0 are shown in Figures 1 and 2. The comparisons and those for the other parameters as shown in Figure 1 are used as inputs for the analysis of the total uncertainties as shown in Figure 2.

HIGHLIGHTS

- Preparation of a satellite-based high-resolution dataset of evaporation and other near-surface parameters as a Climate Data Record is being completed.

SOCIETAL BENEFITS

Ocean-atmosphere fluxes of energy and water establish the link between ocean surface temperature changes and atmospheric circulation variability, and provide the mechanism by which ocean variability is forced by the atmosphere. Accurate knowledge of the flux variability is extremely important for understanding and simulating variations in the coupled ocean-atmosphere system and the feedbacks in the climate system. This project is motivated specifically by the needs for ocean surface fluxes to evaluate coupled climate models, to force ocean models, and for use in ocean reanalysis, as well as for use in diagnosing changes in the global patterns of energy and water exchange.

EDUCATION AND OUTREACH ACTIVITIES

Clayson, C. A., 2014: Air-sea satellite flux datasets and what they do (and don't) tell us about the air-sea interface in the Southern Ocean. *Workshop on Clouds, Aerosols, Radiation and Air-Sea Interface of the Southern Ocean: Establishing Directions for Future Research*. University of Washington, Seattle, WA 18 March 2014.

Clayson, C. A., 2013: Weather regimes and air-sea fluxes: linking the ocean heat budget and the atmosphere. EUMETSAT/AMS Satellite Meteorology, Oceanography, and Climatology Conference, Vienna, Austria, 16 September 2013.

The importance of oceans to climate variability. Presentation to the Tennessee Environmental Conference, Kingsport, TN 25 March 2014.

The ocean's impact on water variability. Presentation to the Scituate Science Symposium, Scituate, MA 10 April 2014.

PUBLICATIONS

Publication is currently in revision: Clayson, C.A., J.B. Roberts, and A. Bogdanoff, 2013: Seaflux Version 1: a new satellite-based ocean-atmosphere turbulent flux dataset. *Int. J. Climatol*., submitted.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

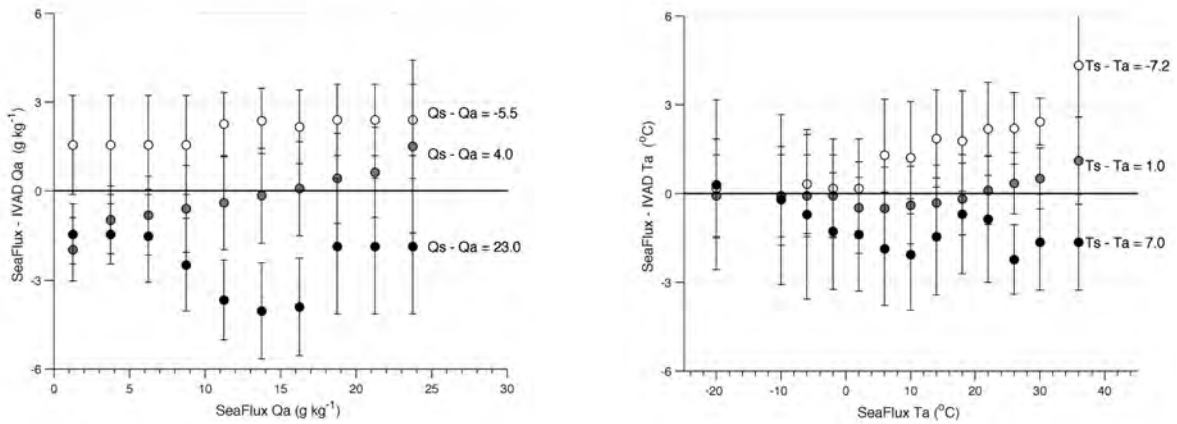


Figure 1. Biases and standard deviations of the SeaFlux Version 1.0 dataset in comparison with the ICOADS-value added dataset of the near surface specific humidity and temperature.

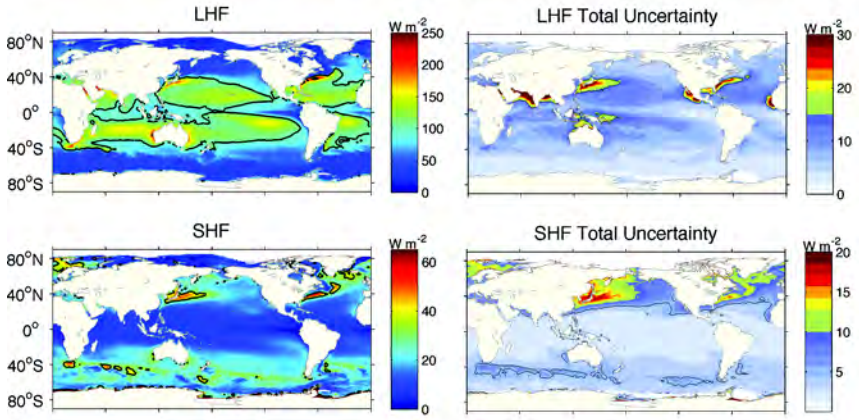


Figure 2. Means and uncertainties of the surface fluxes from the SeaFlux Version 1.0 dataset.

Macroinfauna community structure, biomass and sediment studies during the RUSALCA program

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Jacqueline Grebmeier – UMCES

NOAA Sponsor – Kathleen Crane, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Russian-American Long-term Census of the Arctic (RUSALCA) is a NOAA-sponsored program to document the long-term ecosystem health of the Pacific Arctic ecosystem, particularly as changes in various components are observed associated with climate forcing. Three full-scale ecosystem cruises were undertaken in August 2004, and August-September 2009 and 2012 in the Chukchi Sea (plus East Siberian Sea in 2009 only). Within the RUSALCA program our project objectives are to evaluate the benthic community structure and carbon cycling in the Pacific-influenced waters in the Amerasian Arctic. Our work is particularly focused on benthic biological communities and associated sediment chemistry. Some of our benthic findings indicate higher export of carbon in the SE Chukchi Sea in areas of high primary production and in areas around Wrangell Island and on the western side of Herald Canyon. We are also observing decadal changes in organic carbon processing and regional decline in benthic biomass at some time series sites in the SE Chukchi Sea.

ACCOMPLISHMENTS

We completed the processing of all RUSALCA 2012 cruise samples, including macrobenthic infaunal identification, abundance and biomass determinations, sediment parameters and oxygen uptake rate calculations. We are undertaking statistical comparisons with prior RUSALCA cruises as well as other data sets from the Chukchi Sea, specifically population community analyses of benthic macroinfaunal organisms focused on time-series collections in the southern and western Chukchi Sea. We also analyzed the community oxygen consumption rates as an indicator of carbon export to the benthos in the context of the other oceanographic data. These RUSALCA data include a subset of samples as a contribution to the Distributed Biological Observatory (DBO) effort that continues a 30-yr time series in the southern Chukchi Sea as well as at other RUSALCA time series locations started in 2004. We have completed radioisotopic (Cs-137 and Pb-210) measurements for downcore determination of sedimentation rates for cores collected in 2009 and 2012. We have begun making GIS kriging of the data set for comparison, statistical analyses using PRIMER software, as well as submission for the RUSALCA data archive, with appropriate metadata, and publications as part of the 2nd yr funding of this project. We are continuing to submit RUSALCA data and metadata files to the agreed data archive.

HIGHLIGHTS

- Highest observed infaunal benthic biomass was observed at the head of Herald Valley in the southeast Chukchi Sea in the known "hotspot" of *Macoma* bivalves that extends from across the US-Russian boundary, with values ranging from 30 to ~100 gC m^{-2})
- Lowest observed macroinfaunal biomass (0-10 gC m^{-2}) occurred towards the NW and offshore to the northern most stations, with the lowest biomass in coastal areas (Fig. 1)
- Dominant infauna: bivalves and polychaetes are important prey to walruses, gray whales, and bearded seals (Fig. 1)
- The persistent benthic biomass "hotspot" in the SE Chukchi Sea is tied to tight pelagic-benthic coupling between the upper water column production zone and underlying benthos during annual primary production and deposition events (Fig. 2)
- Sediment stable carbon isotopes indicate marine vs. terrestrial influenced carbon on the Chukchi continental shelve
- The sediment grain size data can act as an indicator of current speed. Results from the three RUSALCA cruises indicate a reduction of current speed and coincident deposition of fine silt and clay sediment (high %≥5 phi) in a northwest direction from Bering Strait down Herald Valley and Herald Canyon northward to the slope in all cruises
- Higher silt and clay (%) in upper/central Herald Valley and western side of Herald Canyon; also around Wrangell Island
- Sandy sediments (low % silt/clay) are found along the Alaskan and Chukotka coastline
- Sedimentation rates were lowest in the East Siberian Sea (apparent bomb fallout peak at 3 cm) that indicates low bioturbation and well-preserved profile suggesting lower current flow in the overlying waters. Low values in high current regimes (Herald Canyon). By comparison, the slower current region in the center of Long Strait allowed for moderately high sedimentation rates

SOCIETAL BENEFITS

The RUSALCA project is aligned with the CINAR mission to "conduct and coordinate cutting-edge research engaging both NOAA and academic scientists to enable informed decisions by NOAA for sustainable and beneficial management [including the Arctic]", particularly through its foci to *"understand climate variability and change to enhance society's ability to plan and respond."*

EDUCATION AND OUTREACH ACTIVITIES

Reports from the cruises of research activities and photos are available for both the 2009 and 2012 cruises through NOAA's Ocean Exploration program:http://oceanexplorer.noaa.gov/explorations/12arctic/logs/sept13/sept13.html
Results of all aspects of the RUSALCA program were presented at the 2014 RUSALCA PI meeting in Honolulu, Hawaii, USA and new summaries of activities and findings across all RUSALCA cruises are available on the NOAA RUSALCA website http://www.arctic.noaa.gov/aro/russian-american/. We are also cross-linking RUSALCA data at the SE Chukchi Sea DBO3 line for the DBO observing project http://www.arctic.noaa.gov/dbo/.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

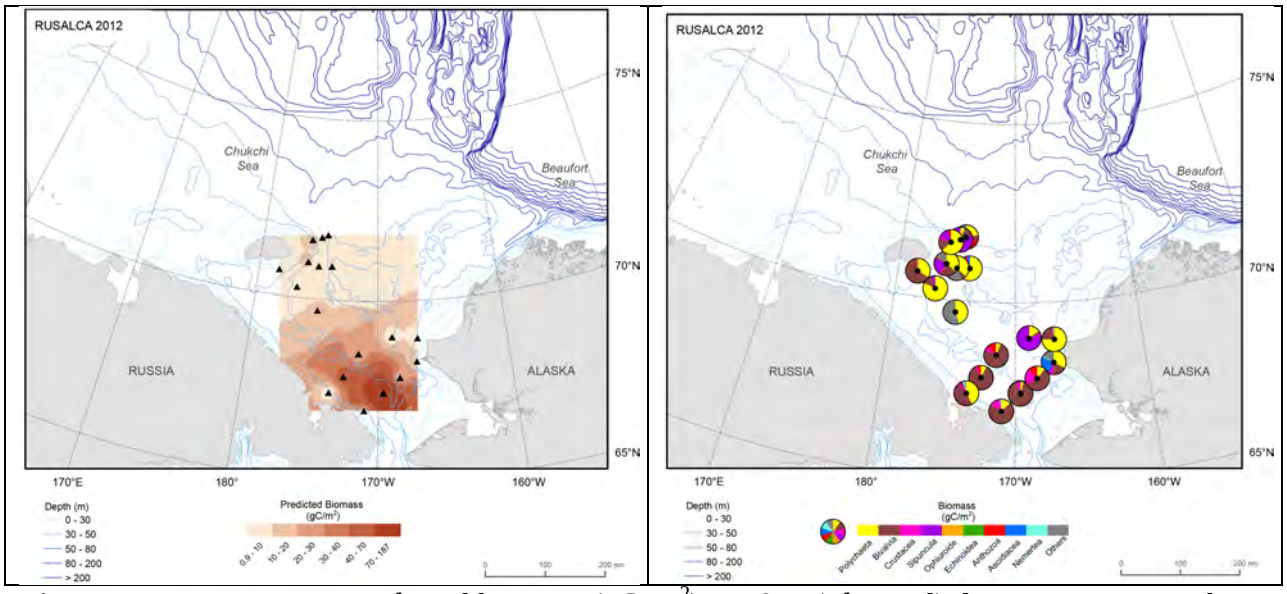


Figure 1. Dominant macroinfaunal biomass (gC m^{-2}) in 2012 (eft panel) dominant taxa type by gC m^{-2} biomass (right panel).

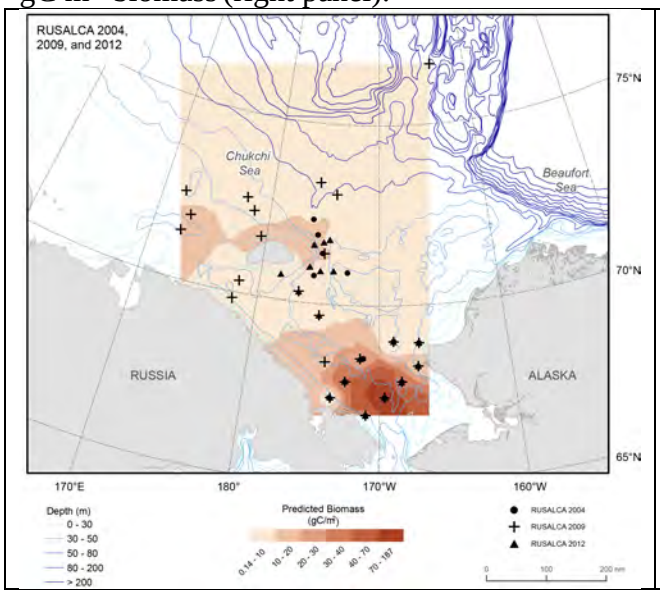


Figure 2. Composite of station benthic biomass collected during RUSALCA 2004, 2009, and 2012 that indicates the persistence of the benthic macroinfaunal "hotspot" in the SE Chukchi Sea. This "hotspot" is also part of the DBO observing network studies.

Pacific Arctic Group (PAG) secretariat office 2013-2014

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Jacqueline Grebmeier – UMCES

NOAA Sponsor – Kathleen Crane, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR 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 year 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 October 2013 PAG meeting in Incheon, South Korea and the spring 2014 meeting in Helsinki, Finland, for participants from the 6 countries focused on marine work in the Pacific Arctic: Canada, China, Japan, South Korea, Russia and the United States. These meetings were also open to all other countries interested in the Pacific region activities. PAG, with NOAA support, published the synthesis book **"**The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment, Grebmeier JM and W Maslowski (eds), DOI 10.1007/978-94-017-8863-2_1, © Springer Dordrecht 2014, 450 p. in June.

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.

- The PAG/DBO is highlighted in the US 2014 Implementation Plan for The National Strategy for the Arctic Region, the US Arctic Research Plan (FY2013-2017), the 2014 NOAA Arctic Science Implementation plan, and is a task project within the Sustaining Arctic Observing Network (SAON) of the Arctic Council.
- The PAG and NOAA published a special Pacific Arctic Region synthesis book in June 2014 covering topics from atmosphere, sea ice, physical oceanography and chemical processes, lower and upper trophic level structure, and physical and biochemical modeling. See the Springer website for further information: http://www.springer.com/environment/global+change+-+climate+change/book/978-94-017-8862-5 (2014, XV, 450 p. 153 illus., 129 illus. in color).
- PI Grebmeier is also co-editor for an ongoing Deep-Sea Research II special issue of the results from the Korean Arctic expeditions on the RV ARAON under the PAG umbrella.

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 2013, PICES Fall meeting, PAG oral entitled “The Pacific Arctic Group (PAG): Status and Direction Towards ICARPIII”, presented by Dr. Bill Williams (DFO/IOS/Canada)
- October 2013: Fall PAG meeting, Incheon, South Korea; multiple update talks on the PAG activities (field, synthesis, future planning); JM Grebmeier (Chair) and other PAG country representatives made presentations
- April 2014, invited presentation entitled “The Pacific Arctic Group (PAG): Updates and Direction” to the Forum of Arctic Research Operators (FARO) during Arctic Science Summit Week in Helsinki, Finland
- Grebmeier is co-Chair of the US IARPC (Interagency Arctic Research and Policy) Committee Distributed Biological Observatory Interagency Collaborative Team with Chair, Dr. Sue Moore (NOAA) on US interagency planning and field efforts to implement the Arctic Research Plan: FY 2013-2017 objectives.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

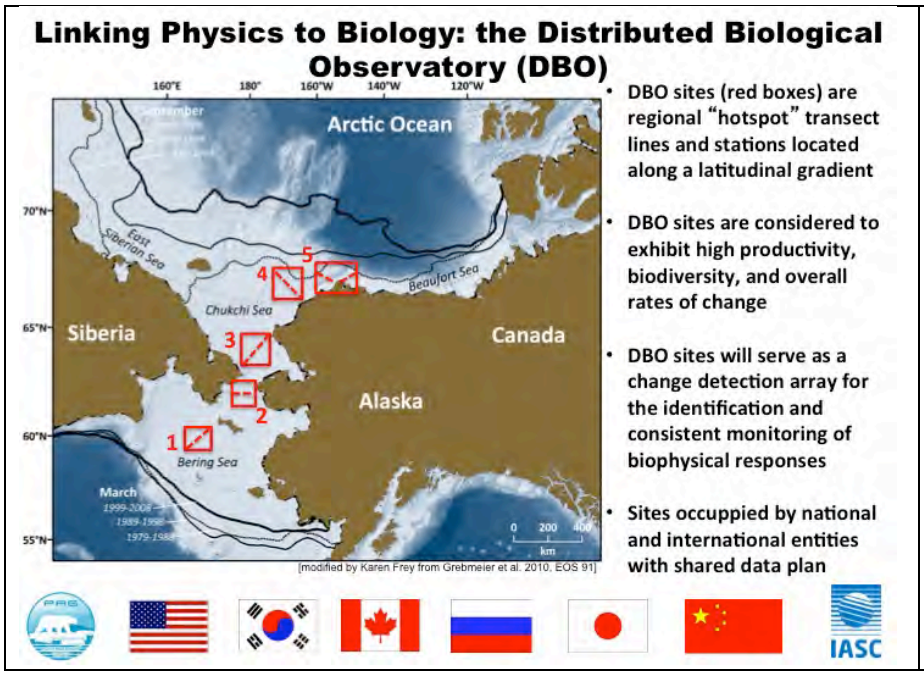


Figure 1. The Distributed Biological Observatory (DBO; http://www.arctic.noaa.gov/dbo) is being developed as a time series, biologically focused observatory in the Pacific Arctic region where international projects on oceanographic ships agree to sample standard measurements seasonally. The DBO is coordinated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

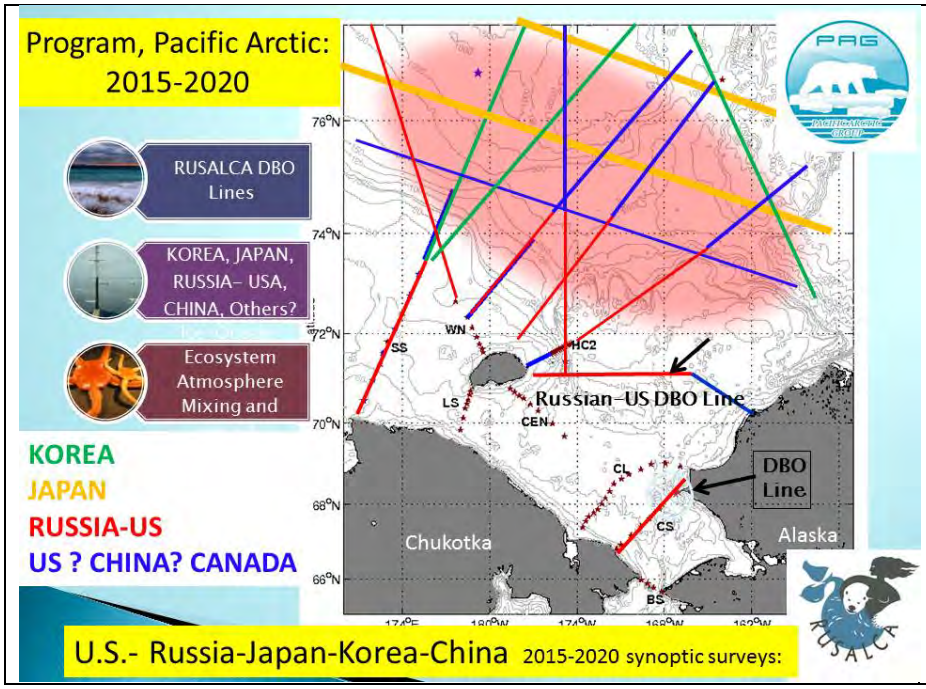


Figure 2. PAG planning activities in the Chukchi Sea (RUSALCA-DBO activities) and for developing an international synoptic surveys and a "climate line" for multi-national occupations during the 2015-2020 period. The discussions are ongoing.

WHOI contribution to Argo Float Program

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Steven Jayne, P.E. Robbins, and W. Brechner Owens – WHOI

NOAA Sponsor – Steven Piotrowicz, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR 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 2013 to 31 March 2014, 117 WHOI floats have been launched and 12 floats have been shipped but not yet launched. We presently have an inventory of 40 SOLO-I floats and an inventory of 44 SOLO-2 floats. During the past year, a maximum of 308 and a minimum of 246 WHOI floats have been active and 10,500 profiles have been inserted into the Argo data system. Also in the past year, we have initiated effort to increase number of Argo floats in Gulf of Mexico and Caribbean. Seven floats deployed in Gulf of Mexico from R/V Pelican in August 2013, and two floats deployed in Caribbean March 2014 from Sea Education Association's SSV Cramer.

Of the over 122,000 profiles from WHOI floats, more than 80% 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.

We have been actively working with our SOLO-2 collaborators, MRV and Scripps Institution of Oceanography continuing to develop the procedures, software, and product description for this float. For example, the newest version of floats can have their mission altered after deployment by sending commands via Iridium. This has necessitated development of web interface to inspect mission parameters and generate messages to send new commands to float. It is hoped this ability will decrease beachings and groundings, and thus increase overall average float lifetimes. We have also developed a set of Unix scripts and C programs that decode the raw data, which we are also providing to NOAA AOML so that they can begin decoding SOLO Iridium float transmissions.

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

We have also developed a search my SQL database of the metadata reported by all float providers to the Global Data Assembly Center:

http://argoweb.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 floats in the global 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 Niño 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

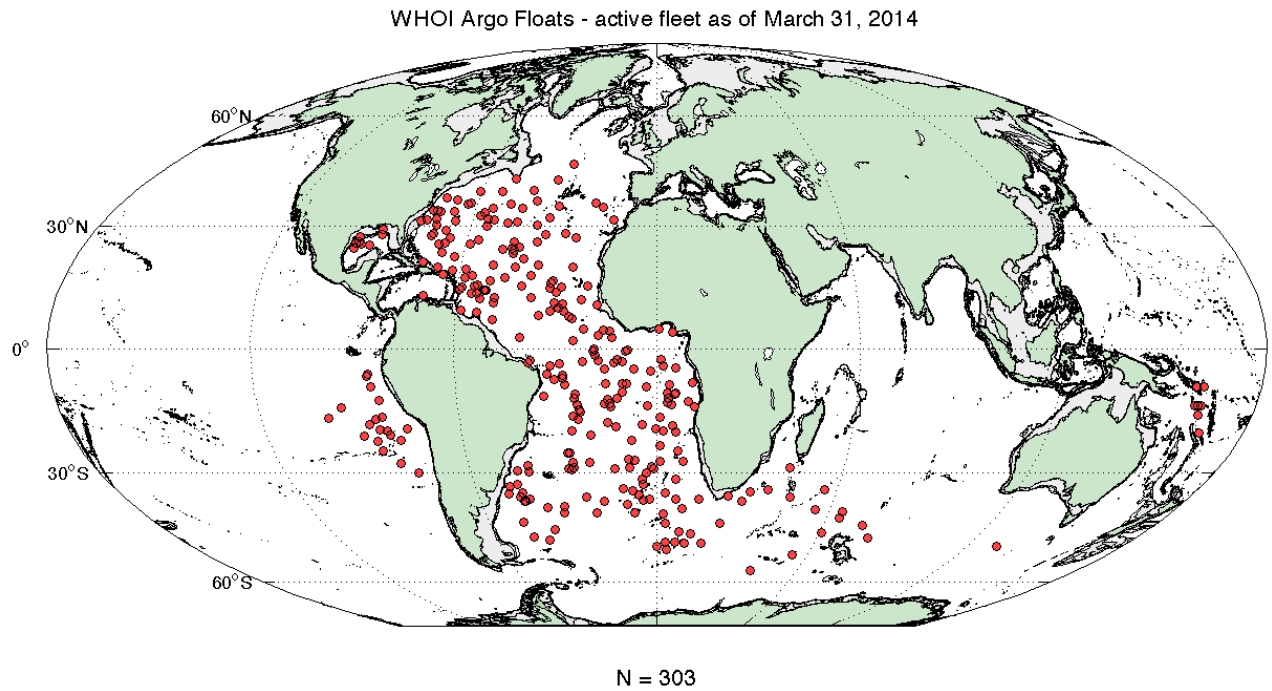


Figure 1. WHOI active floats as of March 31, 2014.

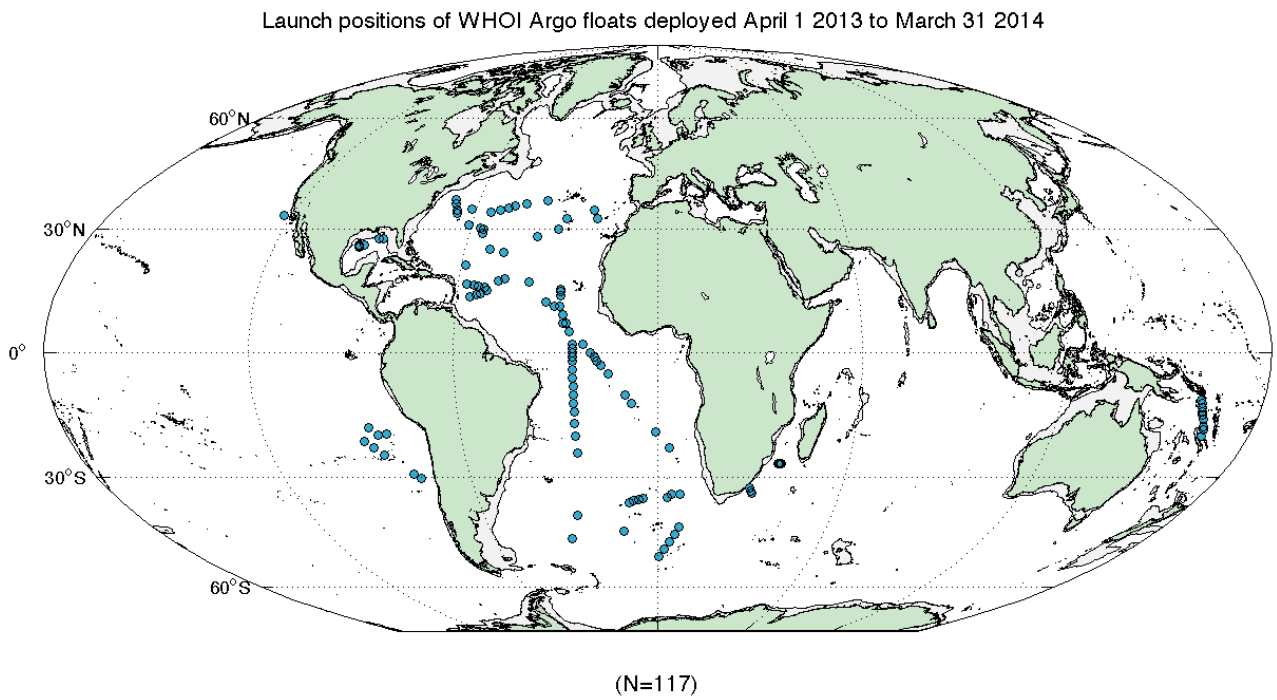


Figure 2. Launch positions of WHOI floats during the past year.

Circulation in the Western Chukchi Sea and its role in the ecosystem

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Robert Pickart – WHOI

NOAA Sponsor – Kathleen Crane, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The overall goal of the Russian-American Long-term Census of the Arctic (RUSALCA) program is to document and understand the ecosystem response of the Pacific sector of the Arctic Ocean to the pronounced recent changes in climatic forcing. The broad-scale component of RUSALCA has included a series of multi-disciplinary cruises sampling the water column and benthos of the Chukchi Sea (and eastern portion of the East Siberian Sea). To date there have been three broad-scale surveys: in August 2004, September 2009, and September 2012. The flow of Pacific water into the Chukchi Sea is of fundamental importance to the western Arctic ocean-atmosphere-ice system, with consequences for ice-cover, carbon cycling, and ventilation of the interior halocline. A major, yet largely unexplored, conduit through which the Pacific water enters the Arctic basin is Herald Canyon. The primary goals of the physical oceanographic component of RUSALCA are to (1) quantify the flow of Pacific-origin water through Herald Canyon and understand its dynamics, (2) explore the relationship between conditions in the canyon and interannual climate variability, and (3) understand the impact of the canyon flow on the distribution of nutrients, zooplankton and fish entering the Arctic. In addition to this, the circulation and water masses of the broad Chukchi shelf, and part of the East Siberian shelf, are being examined in support of the biogeochemical component of RUSALCA.

ACCOMPLISHMENTS

The processing of the hydrographic and velocity data from all three of the RUSALCA large-scale surveys is now complete and the data are available to the RUSALCA community. During this study period two different analysis projects have been carried out, and the results are being written up for publication. The first study focuses on the Herald Canyon region, using data from the first two RUSALCA cruises (2004 and 2009) plus data from a Russian-Swedish expedition that sampled the canyon in 2008. The conditions in the canyon were markedly different in the different years, and the reasons for this – including atmospheric forcing and upstream forcing (Bering Strait) – were explored. The second study focuses on the entire western Chukchi Sea shelf using data from the 2009 survey, which included measurements surrounding Wrangel Island and in the East Siberian Sea. The pathways of the different Pacific water masses were mapped out and the dynamics of the circulation elucidated.

HIGHLIGHTS

- Comparison of the hydrographic properties in Herald Canyon with those measured by the Bering Strait moorings has demonstrated that Pacific water is not simply advected from the strait into the canyon. Atmospheric forcing, polynya formation near Wrangel Island, and mixing all serve to modify the Pacific water, affecting the ventilation of the interior Canada Basin.

- The distribution of Pacific-origin water on the Chukchi shelf was markedly different in 2009 than during the earlier survey in 2004. Most notably, warm and fresh Alaskan Coastal Water (ACW) was present in Herald Canyon, in contrast to the normal situation in which it is found next to the Alaskan coast. Using the mooring data from Bering Strait, in conjunction with a simple numerical model, it was shown that enhanced northerly winds in 2009 caused the ACW to switch sides in the strait and penetrate the western Chukchi Sea.

SOCIETAL BENEFITS

By documenting the changes in the circulation and ecosystem of the western Chukchi Sea, including the atmospheric forcing and links to the Bering Strait inflow, we will improve our understanding of how the western Arctic Ocean responds to climate warming. This impacts issues such as marine mammal habitat and fisheries management.

EDUCATION AND OUTREACH ACTIVITIES

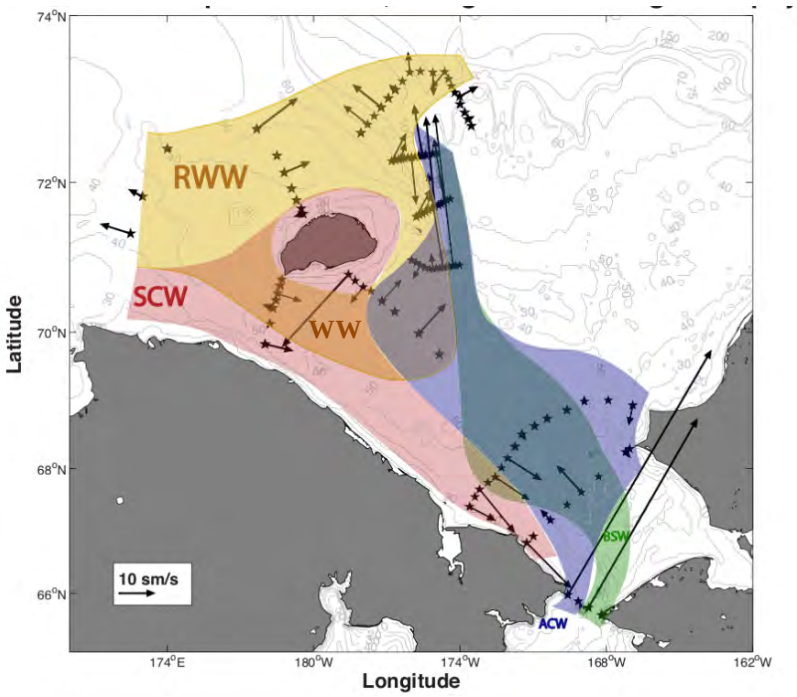
- The study of the Chukchi shelf using the 2009 data was presented at the 2014 Ocean Sciences Meeting.
- A guest student, Maria Pisareva from Shirshov Institute of Oceanology in Moscow, visited WHOI for a year to undertake the Chukchi shelf study, advised by the PI.
- A graduate student, Johanna Linders, from the University of Gothenburg, Sweden collaborated with the PI to undertake the Herald Canyon study.

PUBLICATIONS DURING THE STUDY PERIOD

Pisareva, M.N., R.S. Pickart, M.A. Spall, and G.W.K. Moore. Flow of Pacific water in the western Chukchi Sea: Results from the 2009 RUSALCA expedition, manuscript in preparation.

Linders, J., R.S. Pickart, and G. Bjork. Water masses and circulation in Herald Canyon, manuscript in preparation.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



This figure shows the pathways of the different water masses in the western Chukchi Sea based on the 2009 RUSALCA broad-scale survey. The water massses are: ACW = Alaskan Coastal Water; BSW = Bering Sea Water; WW = Newly Ventilated Winter Water; RWW = Remnant Winter Water; SCW = Siberian Coastal Water. The vectors are the depth-averaged currents measured from the lowered ADCP.

Synthesis of physical measurements from the Pacific Arctic Group: Flux of Pacific water through Barrow Canyon, Chukchi Sea

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Robert Pickart – WHOI

NOAA Sponsor – Kathleen Crane, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

In 2012 a program called the Distributed Biological Observatory (DBO) was started in the Pacific sector of the Arctic Ocean. The goal of the DBO is to document and understand the changing ecosystem in the Bering and Chukchi Seas and determine the physical drivers responsible for those changes. Five transects were identified across the latitudinal extent of the domain, and the plan is for ships of opportunity to occupy these transects and collect measurements in the water column, sediments, and sea-ice as time and logistics permit. The implementation of the DBO has required significant coordination and communication, and the Pacific Arctic Group (PAG) is helping lead this effort. To date, four years of DBO data have been collected and NOAA is funding the initial scientific analysis of a portion of the data. The goal of the present project is to analyze the collection of DBO transects across Barrow Canyon (DBO line 5) to characterize the water masses in the canyon, document the seasonal evolution, and determine the role of wind forcing in dictating the conditions in the canyon.

ACCOMPLISHMENTS

A total of 24 DBO transects have been occupied across Barrow Canyon during the period 2010-14, with roughly even coverage during the months of July – October. The conductivity-temperature-depth (CTD) data from each transect were used to construct vertical sections of hydrographic variables (potential temperature, salinity, potential density, buoyancy frequency) on a standard grid. The interpolation was done using a Laplacian-Spline routine with the same grid spacing for each transect, allowing for quantitative analyses. An overall mean was constructed along with seasonal composites. Using the wind record from the Pt. Barrow meteorological station, transects done during upwelling-favorable conditions were identified. The upwelling response in the water column was characterized, and the seasonality of the water masses in the absence of such events was determined.

HIGHLIGHTS

- In the mean, cold Pacific-origin winter water flows poleward through Barrow Canyon on the western flank, while warm Alaskan coastal water is confined to the eastern flank. In the absence of wind forcing, the winter water is coldest and saltiest in August, while the

Alaskan coastal water is warmest and freshest during the same month. This indicates that the two water masses arrive at the canyon via different pathways.

- Upwelling occurred during roughly one-third of the transects, significantly altering the hydrographic structure in the canyon. During these northeasterly wind events anomalously salty water appeared throughout the eastern flank of the canyon, while the temperature response was more of a dipole signal with warmer water on the western side of the canyon and cooler water on the eastern side. This suggests that a complex interplay of Pacific- and Atlantic-origin water masses occurs during summertime upwelling events.

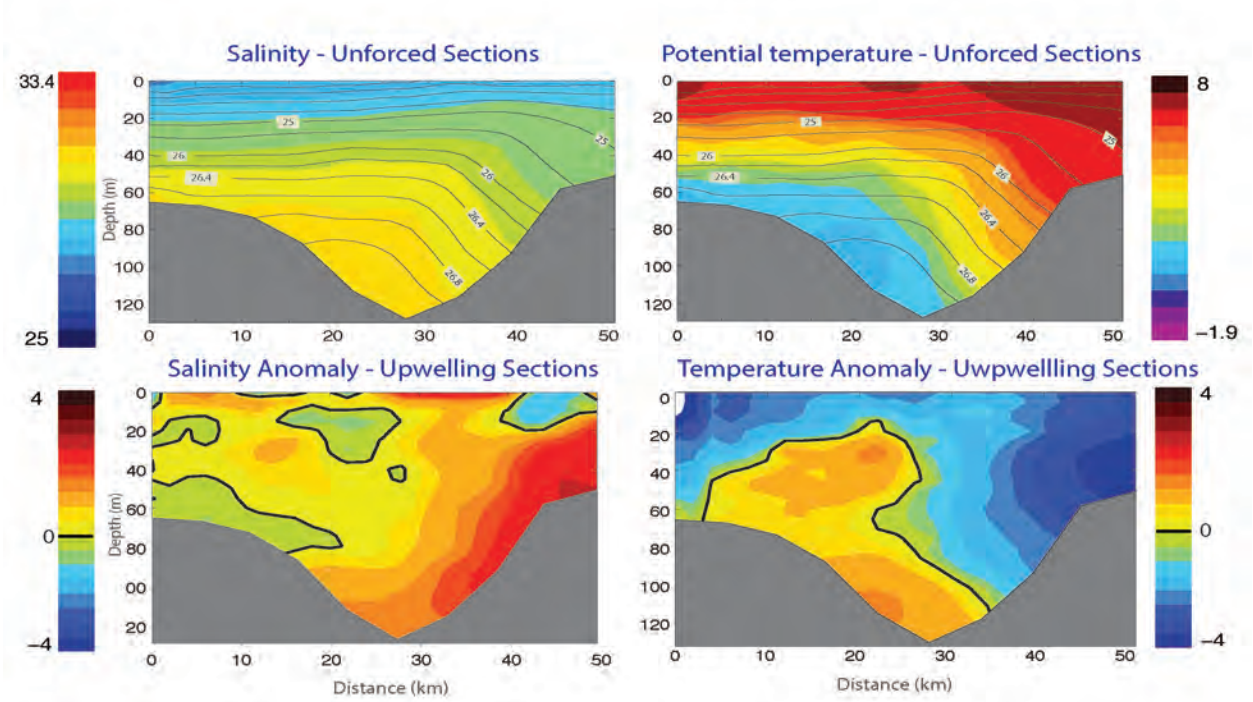
SOCIETAL BENEFITS

Detecting changes in the Pacific Arctic via long timeseries, such as that provided by the DBO, will enable us to better understand the impacts of a warming climate on this high-latitude ecosystem. This has bearing on issues such as marine mammal habitat and fisheries management in the Bering and Chukchi Seas.

EDUCATION AND OUTREACH ACTIVITIES

- The results (to date) of this study were presented at the 2014 Ocean Sciences Meeting.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Effect of upwelling in Barrow Canyon. The top panel shows the mean temperature (left) and salinity (right) in the absence of storms. The contours are density. Cold, salty winter water is present at the bottom of the western flank of the canyon, and warm, fresh Alaskan coastal water resides near the top of the eastern flank. The bottom panel shows the temperature anomaly (left) and salinity anomaly (right) when upwelling occurs. The anomaly is computed as the difference between the mean conditions without upwelling and that when upwelling takes place.

50 year analysis global surface heat flux

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Lisan Yu – WHOI

NOAA Sponsor – Joel Levy, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. 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 database 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

- The OAFlux satellite-based vector wind analysis (1988-2012) shows distinct decadal changes in global ocean surface winds, noted most by the weakening of the winds in the North Atlantic Ocean during the boreal winter season.

SOCIETAL BENEFITS

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

Highlights of the PI's activities in the past year include: 1) authored/co-authored 7 refereed publications (4 out, 3 in review), 1 book chapter, and 1 meeting report. 2) Member of International CLIVAR Global Synthesis and Observation Panel. 3) Member of 3 NASA mission science teams (sea-surface temperature, salinity, and wind). 4) Member of NOAA climate expert team. 5) Member of a newly established NOAA Climate Reanalysis Task Force. 6) Served on NOAA proposal review panel. 7) Severed on 2 NASA proposal review panels. 8) Attended 6 national/international conferences/workshops. 9) Had 7 oral presentations.

- Presentation at the AGU Ocean Sciences meeting on “Sea-surface Salinity Dynamics in the Freshwater Regime”, Honolulu, Hawaii, February, 2014.
- Invited presentation at the 2nd Korea – US Ocean Scientist Workshop on “The WHOI OAFlux project: Quantify the magnitude of climate change and variability in ocean surface forcing functions”, Honolulu, Hawaii, February, 2014
- Invited presentation at the NASA SST science team meeting on “Sea-surface salinity fronts at high and low latitudes”. Seattle, Washington, October, 2013.
- Invited presentation at the NCAR workshop on “Frontal scale air-sea interaction”, Boulder, Colorado, August 2013.
- Invited presentation at the IUGG Joint Assembly, session “North Atlantic and Climate”, Gothenburg, Sweden, July 2013.
- Presentation at the International ocean vector wind science team meeting, Big Island, Hawaii, May 2013.
- Invited presentation at the NOAA headquarter on the OAFlux project, Silver Spring, April 2013.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

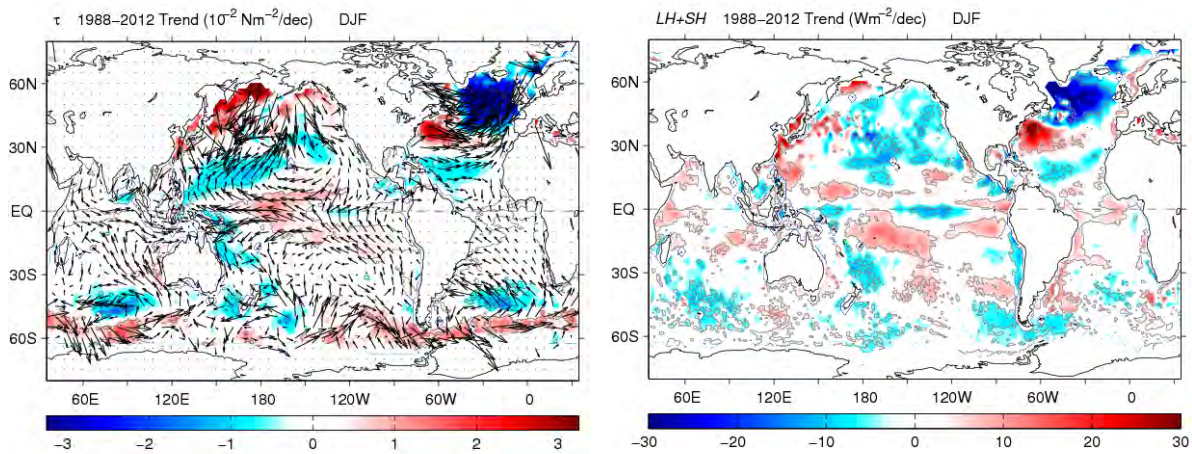


Figure 1. Linear trends in (a) wind stress and (b) ocean latent and sensible heat fluxes derived from the 25-year (1988-2012) time series of the OAFlux high-resolution analysis for the winter season. The ocean surface winds have weakened significantly in the North Atlantic in the past two decades, and the weakened winds led to reduced latent and sensible heat loss at the ocean surface that was a major forcing for the observed sea surface warming in the region.

Ocean climate observations and analyses (2013-2014)

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Robert Weller and Albert Plueddemann, WHOI

NOAA Sponsor – Diane Stanitsky, OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

To provide sustained, climate-quality observing of the trade wind region, we have developed surface moorings with the capability of making sustained, accurate observations at the sea surface and in the water column and have chosen and occupied three key trade wind sites. These surface moorings are known as Ocean Reference Stations (ORS). The three sites are the Stratus ORS, the NTAS (Northwest Tropical Atlantic Station) ORS, and the WHOTS (WHOI Hawaii Ocean Timeseries Site) ORS. Together, the three sites form a comprehensive array by sampling distinct branches of the trade wind regime while focusing on specific regional processes.

In FY2013, the WHOI Ocean Reference Station project carried out cruises to two of the three sites to recover moorings in service for a year and deploy new moorings. NTAS was serviced by the NOAA Ship Pisces in November-December 2012. WHOTS was recovered and redeployed in July, 2013 on the NOAA Ship Hi'ialakai. A surface buoy, mooring, and associated instrumentation were prepared for the FY2013 cruise to the Stratus ORS, which was planned for June-July 2013. NOAA was unable to provide ship time in 2013. The Stratus cruise finally happened in February-March 2014, after the mooring had been in the water for 20 months. Batteries were exhausted. The mooring broke the third week of January 2014. On the cruise the upper and lower parts of the mooring were recovered; 8 instruments were crushed. Significant loss of surface meteorological, air-sea flux, and ocean time series data occurred.

ACCOMPLISHMENTS

The basic deliverables - the data from the ORS are high quality data, supported by the documentation of the cruises and methods used to collect the data. The directly observed data fall into three main categories: 1) Surface meteorology and air-sea fluxes; 2) Surface oceanographic data; 3) Ocean observations of temperature, salinity, and velocity along the mooring line in the upper thermocline and surface layer; 4) Air-sea fluxes of heat, freshwater, and momentum. All of the presently deployed ORS moorings include additional sensors to obtain deep ocean temperature and salinity (within 40 m of the seafloor). Ancillary observations by cooperating investigators add: 5) surface wave data by NDBC at Stratus and NTAS; 6) pCO_2 by NOAA PMEL at Stratus and WHOTS; 7) dissolved oxygen observations at Stratus by Lothar Stramma from Kiel, Germany; and 8) in the water radiance observations at WHOTS by Sam Laney of WHOI. Surface meteorology is available in real time and the remaining data follow as described above.

The data return from WHOI-deployed meteorological and upper ocean instrumentation on ORS had been sustained at high level over much of the 31 buoy-years of deployments. Up through 2012 the statistics for "usable data" – data of sufficient quality to be carried to post processing and used in analysis, although in some cases requiring post calibration or adjustment – are given here. For meteorological variables we find usable data return of 93.5% at Stratus (over 10 years), 96.5% at NTAS (over 10 years) and 97.7% at WHOTS (over 7 years). It is important to note that because we deploy redundant meteorological sensors on each buoy, a single instrument failure does not compromise the deliverables. Considering the deliverable for surface meteorology a single record of surface meteorological variables created from the best performing sensor of each pair, the usable data return increases further from the values quoted above. For subsurface variables we find usable data return of 90.1% at Stratus (over 10 years) and 92.5% at NTAS (over 9 years). The high usable data return allows continuous multi-year time series of air-sea fluxes and upper ocean response to be constructed which serve a variety of purposes.

HIGHLIGHTS

The ORS provided these science findings:

- The Stratus site serves as a benchmark for climate research in the Stratus region and for the VOCALS ReX (VAMOS (Variability of the American Monsoon System) Ocean Cloud atmosphere Land Study Regional Experiment) in particular. The Stratus mooring points to the role of ocean processes in freshening and cooling the ocean mixed layer. There is a shallow mode water below the surface layer that is a potential source of the required cooling and freshening, but the presence of the low oxygen or oxygen minimum layer just below that mode water poses questions about the realism of invoking strong vertical mixing. To address this, we have added oxygen sensors and partnered with Lothar Stramma (Kiel, Germany). Of note is the finding at the Stratus site of a long-term increase in the speed of the Pacific trade winds, 0.52 m s^{-1} over a decade.

- At WHOTS, we partner with the University of Hawaii (R. Lukas with NSF funding). Recent work by R. Lukas points to several processes acting to control the local ocean state, including changes in the balance between surface rainfall and evaporation and transports by eddies of masses of water from distant locations. It is found that salinity in the mixed layer is increasing in association with a negative freshwater flux (loss of freshwater from the ocean) while temperature is decreasing, resulting in a density increase that is statistically significant over the first 8 years of the WHOTS record. Comparisons between WHOTS and global models (e.g. ECMWF ERA-Interim) show that the ORS observations are regionally representative, yet the models do not necessarily show seasonal to decadal variability in surface fluxes consistent with those of the observations. Evaluation of upper ocean trends relative to the regional hydrological cycle and observed and modeled surface fluxes is an area of ongoing effort.

- The NTAS ORS is in a region where the mechanisms controlling SST and upper ocean heat content are of interest. The seasonal cycle dominates the net heat flux, with the migration of the ITCZ modulating cloud cover and rainfall. Interannual variability is evident in the minimum and maximum seasonal values as well as the timing of seasonal

transitions. The extent to which NWP forecasts and reanalysis reproduce the amplitude and timing of the annual cycle and seasonal transitions is being evaluated. NTAS is a region where interaction between wind, evaporation and SST are important, and there is interest in the role of advective cooling during periods of wind relaxation when evaporative cooling is reduced and thus there is a tendency for local SST increase (without advection).

SOCIETAL BENEFITS

The ORS results are particularly significant in two areas: 1) Providing benchmarks to validate and improve climate and weather models and 2) Quantifying the processes at work to maintain the state of the upper ocean. The ability of society to prepare for and mitigate weather and climate variability depends heavily on the accuracy of models, and the withheld, high quality time series from the ORS are a key asset in the effort to improve models. The ORS data are also of high value in building an improved understanding of the role of the ocean in the earth system.

EDUCATION AND OUTREACH ACTIVITIES

Whenever possible, ORS cruise involve NOAA Teachers at Sea, undergraduate and graduate students.

PUBLICATIONS

Subramanian, A. C., A. J. Miller, B. D. Cornuelle, E. Di Lorenzo, R.A. Weller, and F. Straneo, 2013. A data assimilative perspective of oceanic mesocscale eddy evolution during VOCALS-Rex. *Atmos. Phys. And Chem.*, Atmos., 13, 3329-3344, 2013 www.atmos-chem-phys.net/13/3329/2013/ doi:10.5194/acp-13-3329-2013

Kato, S., N. G. Loeb, F. G. Rose, D. R. Doeling, D. A. Rutan, T. E. Caldwell, L, Yu, and R.A. Weller, 2013. Surface irradiances consistent with CERES-derived top-of-atmosphere shortwave and longwave irradiances. *J. Climate*, **26**, 2719–2740. doi: http://dx.doi.org/10.1175/JCLI-D-12-00436.1

Plueddemann, A., J. Ryder, B. Pietro, J. Smith, C. Duncombe Rae, R. Lukas, C. Nossee, J. Snyder, L. Bariteau, S.J. Park D. Hashisaka, E. Roth, C. Fumar, A. Andrews and N. Seymour, 2013. WHOI Hawaii Ocean Timeseries Station (WHOTS): WHOTS-9 2012 mooring turnaround cruise report, WHOI Tech. Rept., WHOI-2013-04, 93 pp.

Prytherch, J. J. Thomas Farrar, and Robert A. Weller, 2013: Observations and models of the diurnal warm layer. *J. Geophys. Res.*, 118, doi:10.1002/jgrc.20360.

Mechoso, C. R., R. Wood, R. Weller, C. S. Bretherton, A. D. Clarke, H. Coe, C. Fairall, J. T. Farrar, G. Feingold, R. Garreaud, C. Grados, J. McWilliams, S. P. de Szoeke, S. E. Yuter , and P. Zuidema, 2014. Ocean-Cloud-Atmosphere-Land Interactions in the Southeastern Pacific: The VOCALS Program. Bull. American. Met Soc., in press.

Weller, R. A., S. Majumder, and A. Tandon, 2014. Diurnal restratification events in the Southeast Pacific tarde wind regime. *J. Phys. Oceanogr.*, submitted.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

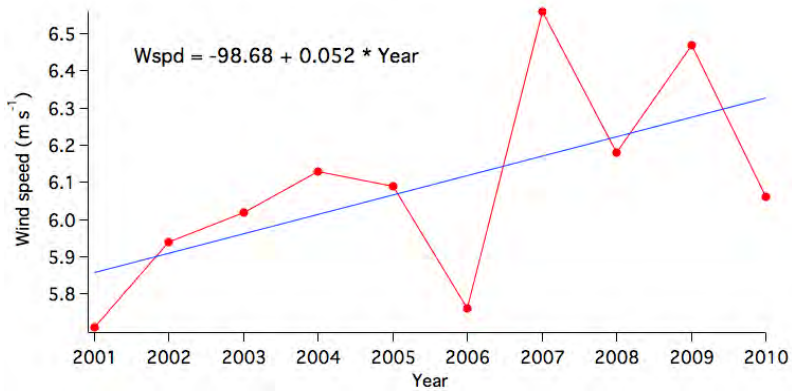


Figure 1. Annual means of the wind speed observed at the Stratus buoy versus time. A linear fit to the annual means points to an increase of 0.52 m s^{-1} over the last decade.

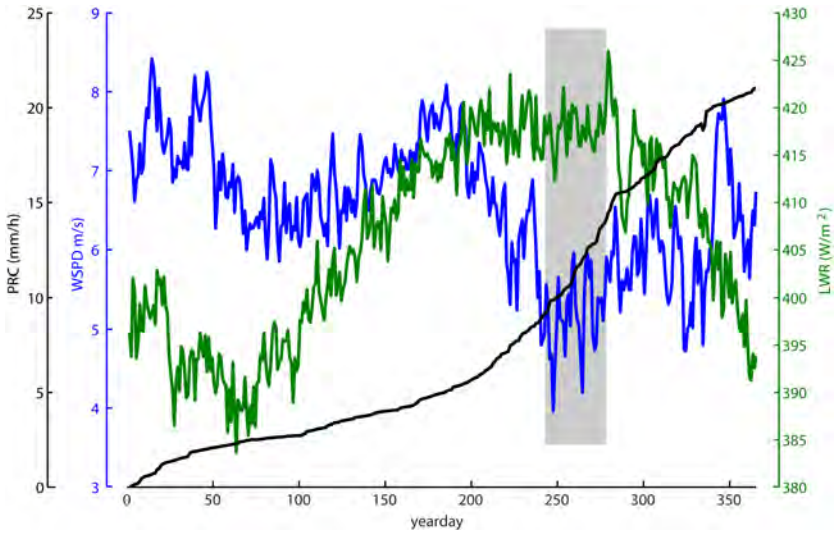


Figure 2. Ten-year mean (2001-2010) annual cycle of cumulative precipitation, wind speed and incoming longwave radiation for NTAS. September to early October (shaded region) is when the ITCZ influences the site, and is characterized by low wind, steady cloud cover and increased precipitation.

Theme VI. Education and Outreach

CINAR

Cooperative Institute for the North Atlantic Region

Research and education in quantitative fisheries and ecosystem science

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Donald Anderson, WHOI

NOAA Sponsor – Russell Brown, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. 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

This program began in 2012. The first CINAR Fellows were appointed during in early 2013. Progress reports on their activities are given in the attached Appendix.

Rubao Ji, Associate Scientist, Biology Department. Dr. Ji's CINAR Fellowship is allowing him to work on transferring the modeling 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.

Porter Hoagland, Senior Research Specialist, Marine Policy Center. As a CINAR Fellow, Porter Hoagland is continuing 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 is studying 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, Assistant Scientist, Biology Department. In collaboration with colleagues at the NEFSC, Dr. Lawson is focusing 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.

SMAST Faculty. Assistant professor Dr. Gavin Fay will join the Department of Fisheries Oceanography in the fall 2014 semester. In his current research as a postdoctoral associate at NOAA's National Marine Fisheries Service in Woods Hole, Dr. Fay is using marine ecosystem models to evaluate the performance of ecosystem-based fisheries management strategies for the northeast U.S. continental shelf. As he develops his research program at SMAST, he is expected to use interdisciplinary multi-model approaches to extend the scope of applications for fisheries and ecosystem assessment.

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

See individual reports (Appendix A)

APPENDIX A
CINAR Fellow Progress Reports

CINAR Fellow: Porter Hoagland

PROJECT OVERVIEW

- Linking economic and ecological models for ecosystem based fisheries management (EBFM) with a focus on their relationship to and use in coastal and marine spatial planning
- Teaching graduate and undergraduate students in the Department of Marine Affairs, University of Rhode Island
- Mentoring graduate students at WHOI

ACCOMPLISHMENTS

- Two papers have been published:
  Hoagland P, Kite-Powell HL, Jin D, Solow AR. 2013. Supply-side approaches to the economic valuation of coastal and marine habitat in the Red Sea. *J. King Saud Univ.-Sci.* 25:217-228. http://dx.doi.org/10.1016/j.jksus.2013.02.006.
  Jin D, Hoagland P, Wikgren B. 2013. An empirical analysis of the economic value of ocean space associated with commercial fishing. *Marine Policy* 42:74-84.
- A presentation was delivered at the Dimensions of Political Ecology 2014 meeting at the University of Kentucky in Lexington, KY:
  Hoagland P. 2014. How Do We Design, Implement, and Manage a System of Ocean Zoning? *Proc. Conf. on the Dimensions of Political Ecology 2014*. Lexington, KY (February 28, 2014).
- Participated in a workshop on fisheries science and management entitled "Seeking Synergy: Social & Natural Science" sponsored by the MIT Sea Grant College Program (May 5, 2014)
- Two abstracts have been accepted for presentation at the International Institute of Fisheries Economics and Trade 2014 meeting at the Queensland University of Technology in Brisbane, QLD:
  Hoagland P, Jin D, Dalton T, Dwyer J. 2014. Coastal and marine spatial planning in the context of ecosystem-based fisheries management: assessing tradeoffs between wind farms and marine fisheries in New England. *Proc. International Institute of Fisheries Economics and Trade 2014*. Brisbane (July 7-11, 2014).
  Jin D, DePiper G, Hoagland P. 2014. An empirical analysis of portfolio management as a tool for implementing ecosystem-based fishery management. *Proc. International Institute of Fisheries Economics and Trade 2014*. Brisbane (July 7-11, 2014).

HIGHLIGHTS

- Understanding the economic value of ocean space is critical for implementing coastal and marine spatial planning (CMSP). In analyzing data on the economic value of fish yields and effort, we found that average fishing effort exhibited a positive response to increases in expected revenues and a negative response to variability in revenues. Most of the variability in catch revenue can be explained by changes in fishing effort, implying that the spatial patterns of fishery resources are relatively stable at the 10-minute square level. An important

conclusion is that a spatial scale of at least the 10-minute square is appropriate for undertaking CMSP involving allocations of commercial fisheries.

- Three broad institutional approaches to ocean zoning can be distinguished: government or centralized ocean zoning; ocean zoning through a community, also known as a common property regime; and private property or decentralized ocean zoning. We explore the conditions affecting the dynamic emergence of institutions for ocean zoning, including factors affecting the evolution from one particular institutional approach to another. Using real-world examples from the New England region, we characterize conditions favoring the emergence of hybrid forms of governance as feasible and potentially optimal institutions for managing ocean zoning.

- We develop an approach to CMSP "decision support," comprising a regional economic computable general equilibrium (CGE) framework. We employ the framework to examine the interactions among the different industrial sectors of a coastal economy, where a commercial fisheries sector may be displaced in part by a renewable energy sector, and where the fisheries are affected by alternative realizations of a marine food web. Introduction of the food web into the framework allows resource managers to assess broader ecosystem-based concerns. Through comparative analyses, we show how economic and distributional tradeoffs among alternative leasing policies can be evaluated by examining changes in several metrics of interest to coastal and marine resource managers, including changes in measures of economic surplus and employment.

- We have developed an ecosystem-based fisheries management (EBFM) portfolio model for the US northeastern region, using empirical data from NMFS for 1964-2012 and species grouping used in food web models of the same region. We develop annual performance measures of the northeast fisheries over five decades to capture the inefficiencies (in terms of risk level for a given level of revenue) in the fisheries, and thus the potential for improvements. We demonstrate the usefulness of the model and results through case studies of different portfolios by ecological production unit (EPU) and by fishing port. Results of our research will further improve understanding of the potential for portfolio management as a practical approach to help achieve EBFM in the northeastern region.

SOCIETAL BENEFITS

- This research has led to advances in understanding theories and practice relating to linked models of economics and marine ecology in the areas of ecosystem service valuation, coastal and marine spatial planning, and ecosystem-based fisheries management.
- These advances, particularly the modeling approaches, are likely to see eventual adoption as sources of decision support.
- The research has been communicated to social scientists and natural scientists in a variety of professional forums.
- The research has been communicated to students in the field of Marine Affairs.

EDUCATION AND OUTREACH ACTIVITIES

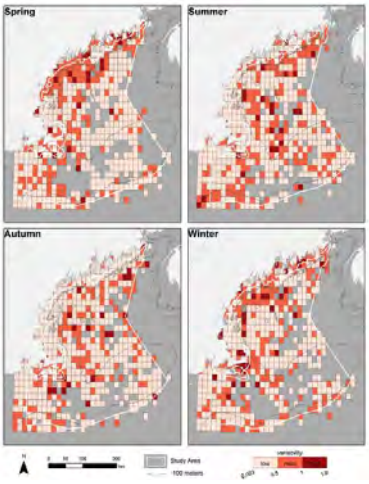
Department of Marine Affairs, University of Rhode Island: Taught MAF 482: Quantitative Methods in Marine Affairs (Spring 2013, Spring 2014).
Mentoring of students working on related research:
Joseph Dwyer, Ph.D. Candidate, Department of Marine Affairs, University of Rhode Island
Kelly Heber, Ph.D. Candidate, Department of Urban Planning, Massachusetts Institute of Technology

PUBLICATIONS

Hoagland P, Kite-Powell HL, Jin D, Solow AR. 2013. Supply-side approaches to the economic valuation of coastal and marine habitat in the Red Sea. *J. King Saud Univ.-Sci.* 25:217-228. http://dx.doi.org/10.1016/j.jksus.2013.02.006.

Jin D, Hoagland P, Wikgren B. 2013. An empirical analysis of the economic value of ocean space associated with commercial fishing. *Mar Pol'y* 42:74-84.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Plots of the variability of catch per unit effort (CPUE) by season during 1999-2008 (Jin *et al*. 2013). This figure depicts the coefficient of variation ($s/\bar{x}$) of CPUE in the Northeast commercial fisheries at the ten minute square level. Most squares exhibit low to medium CPUE variability. Most of the variability in catch revenue can be explained mainly by changes in fishing effort, implying that the spatial patterns of fishery *resources* (*i.e.*, fish stocks) are relatively stable at the 10-min square level.

CINAR Fellow: Rubao Ji

PROJECT OVERVIEW

This project has three major components, including research, education/training and outreach.

1) Research: develop research proposals for the Northeast US Continental Shelf region; write research papers with scientists from NOAA and CINAR partner institutes.
2) Education/training: develop a quantitative fisheries oceanography course; advise students from the MIT-WHOI joint program and from School for Marine Sciences and Technology (SMAST) at University of Massachusetts. Advise a Postdoc investigator working on a NOAA-WHOI joint Fisheries And The Environment (FATE) project.
3) Outreach: disseminate research results through international meeting; play a leadership role in research community activities.

ACCOMPLISHMENTS

1. Successfully developed an MIT-WHOI Joint Program topics course: Quantitative Fisheries Oceanography. The course exposes students to a variety of quantitative skills that related to fisheries oceanography, including oceanography data analysis, stock assessment and numerical modeling. The course also serves as a platform for NOAA scientists to share their expertise with the future generation of fisheries oceanographers. Five scientists from NMFS (Mike Fogarty, Sarah Gaichas, Greg Lough, Tim Miller and David Richardson) were invited to give guest lecturers for the class. The course has also received strong support from Jon Hare and Jason Link at NMFS.
2. Worked on seven papers with scientists from NOAA and/or CINAR collaborators, with 4 papers published and 3 papers in preparation. The topics of the papers cover hydrodynamics, lower-trophic level food web and zooplankton population dynamics on the Northeast US Continental Shelf.
3. Developed two proposals related to the CINAR region, including an NSF BioOce proposal to examine the zooplankton population connectivity and persistence along the Northwest Atlantic Shelf, and a NOAA FATE proposal on multi-decadal simulation of food-web dynamics on the Northwest Atlantic Shelf.
4. Advised two PhD students and one Postdoc investigator. Served as an advisor for one MIT-WHOI Joint program student (Ben Jones) and as a committee member for one UMass student (Yu Zhang). Advised one NOAA Postdoc (Dr. Yun Li) who is working in my lab on a FATE project with Drs. Paula Frantantoni and Jon Hare from NMFS and Dr. Changsheng Chen from UMass.

HIGHLIGHTS

1. Developed a MIT-WHOI Joint Program Course “Quantitative Fisheries Oceanography”
2. Published 4 papers and working on 3 more papers focusing on the CINAR region through collaboration with NOAA and CINAR partner institutes.

SOCIETAL BENEFITS

1. Provided training for next generation fisheries oceanographers.
2. Produced oceanography products that can help stock assessment and ecosystem-based management

EDUCATION AND OUTREACH ACTIVITIES

1) Co-chair ICES Working Group on Integrated, Physical-biological and Ecosystem Modelling (*WGIPEM*). Organized annual working group meeting in Haarlem, the Netherlands in March 2014.
2) Co-convene two sessions in the 2014 Ocean Science Meeting (081: Climate Impacts on Living Marine Resources; 133 Dynamic Physical and Ecological Drivers of Marine Metapopulation Connectivity)
3) Plan to co-convene a session in the 2014 IMBER Open Science Meeting in Bergen, Norway (C3 - Integrated studies of the impact of climate change on marine ecosystems)
4) Selected presentation 1: Ji, R. Y. Li, P. Fratantoni, C. Chen, J. Hare, Y. Sun, K. Hyde and C.S. Davis, 2013. Stratification on the Northwest Atlantic Shelf: Patterns, Drivers and Implications for Plankton Production. ICES Annual Science Conference. Reykjavik, Iceland.
5) Selected presentation 2: Li, Y., R. Ji*, P.S. Fratantoni, C. Chen, J.A. Hare, C.S. Davis and R.C. Beardsley, 2013. Linking wind and sea surface salinity fluctuation on the Northwest Atlantic shelf: Mechanisms and implications. RARGOM, ASM, Portsmouth, NH, USA (* Ji gave the presentation).
6) Selected presentation 3: Fratantoni, P.; Li, Y.; Ji, R*., Chen, C., Hare, J. 2014. Variability of stratification on the Northwest Atlantic Shelf and its implications for plankton production. 2014 AGU/ASLO/TOS Ocean Science Meeting, Honolulu, Hawaii (* Ji gave the presentation).

PUBLICATIONS

Bi, H., R. Ji, H. Liu, Y.-H. Jo, and J. A. Hare (2014), Decadal Changes in Zooplankton of the Northeast U.S. Continental Shelf, edited by H. G. Dam, *PLoS ONE*, *9*(1), e87720, doi:10.1371/journal.pone.0087720.

Li, Y., R. Ji, P. S. Fratantoni, C. Chen, J. A. Hare, C. S. Davis, and R. C. Beardsley (2014), Wind-induced interannual variability of sea level slope, along-shelf flow, and surface salinity on the Northwest Atlantic shelf, *J. Geophys. Res. Oceans*, doi:10.1002/2013JC009385.

Tian, R., C. Chen, J. Qi, R. Ji, R. C. Beardsley and C. S. Davis, 2014. Model Study of Nutrient and Phytoplankton Dynamics in the Gulf of Maine: Patterns and Drivers for Seasonal and Interannual Variability. ICES Journal of Marine Sciences, in press

Batchelder, H., K. Daly, C. Davis, R. Ji, M. Ohman, W. Peterson, and J. Runge (2013), Climate Impacts on Zooplankton Population Dynamics in Coastal Marine Ecosystems, *Oceanography*, *26*(4), 34–51, doi:10.5670/oceanog.2013.74.

Li, Y. P. Fratantoni, R. Ji, C. Chen, J. Hare, R. C. Beardsley, 2014. Spatio-temporal patterns of stratification on the Northwest Atlantic shelf. To be submitted to Journal of Geophysical Research.

Friedland, K. D., R. T. Leaf, J. Kane, D. Tommasi, R. G. Asch, N. Rebuck, **R. Ji**, S. I. Large, C. Stock, V. S. Saba, 2014. Spring Bloom Dynamics and Zooplankton Biomass Response on the US Northeast Continental Shelf. To be submitted to Continental Shelf Research.

Saba, V. S., coauthors, **R. Ji**, coauthors, 2014. Ocean circulation and wind driven variability of spring phytoplankton biomass in the Northwest Atlantic Shelf. In preparation.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

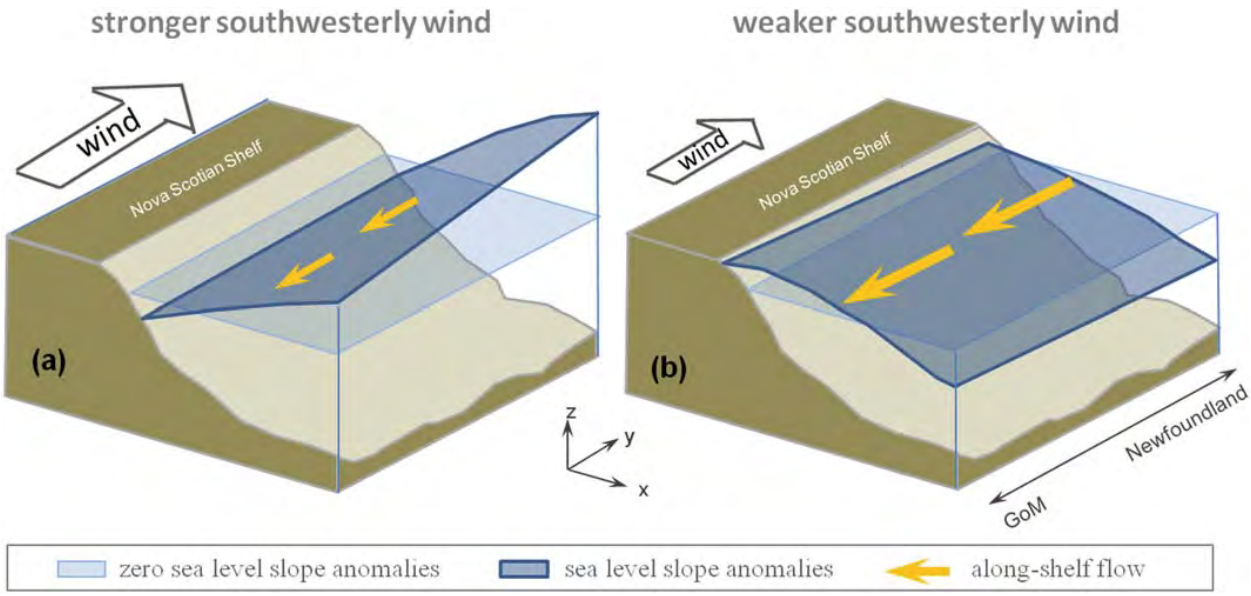


Figure 1. Schematic diagram for the modulation of sea level slope and flow by alongshore wind stress on the Northwest Atlantic shelf. (a) Under stronger southwesterly (northeastward) winds, the southwestward flow is weaker and induce sup wind sea levels lope along the shelf and a depression of sea level inshore via geostrophic relationship. Therefore, the overall sea level exhibits a high anomaly in the upstream Newfoundland Shelf (NF) region.(b) Under weaker southwesterly winds, the Scotian Shelf Current (SSC) becomes stronger, resulting in a sea level slope that tilts downstream and shoreward, so the overall pattern displays a high anomaly near the Gulf of Maine.

CINAR Fellow: Gareth Lawson

PROJECT OVERVIEW

My research program examines the physical and biological processes that determine the distribution and movements of zooplankton and micronekton, as well as the interactions of these animals with commercial fishes and marine mammals. An important component of my research involves the development and application of new sampling technologies, especially high-frequency acoustics. My CINAR fellowship activities focus on research and education concerning two inter-related topics: (1) Development of acoustic methods for sampling zooplankton and micronekton for the purpose of stock and ecosystem assessment, (2) Application of acoustic techniques for the study of euphausiid ecology and fisheries interactions in the Gulf of Maine region and ecosystem dynamics at the New England continental shelf break. This research program is highly collaborative, involving colleagues from the NEFSC and the commercial fishing and acoustic manufacturing industries, as well as multiple students and postdocs.

ACCOMPLISHMENTS

In the past year my CINAR fellowship research activities have focused on two projects. My NEFSC collaborators Debra Palka, Michael Jech, Jonathan Hare, and myself have collected a variety of multi-frequency acoustic data, along with independent ground-truthing information from net and optical systems, during marine mammal surveys conducted in August of 2013 and February of 2014. The goal of this work is to assess the use of such acoustic data collected incidental to routine, non-acoustic NEFSC assessment surveys as indices of zooplankton, micronekton, and fish abundance for use in Integrated Ecosystem Assessment and in marine mammal habitat modeling and spatial planning. Analysis of these data is ongoing.

Together with collaborators Michael Jech (NEFSC), Andone Lavery (WHOI), Jeffrey Condiotty (Simrad), and Captain Christopher Roebuck (commercial fisherman) I have also conducted tests and field deployments of a prototype new broadband acoustic system for stock and ecosystem assessment. Test applications during a 5-day cruise in January of 2014, funded by the NOAA Advanced Sampling Technologies Working Group (ASTWG), to Atlantic butterfish (*Peprilus triacanthus*), spiny dogfish (*Squalus acanthias*), and Northern krill (*Meganyctiphanes norvegica*) provided very encouraging preliminary data suggesting that the acoustic spectra of these species can be resolved and used in acoustic surveys to discriminate these organisms from other targets. Publications based on these initial findings are currently in preparation.

My fellowship-related educational and outreach activities have focused on teaching courses on acoustics in the context of ecosystem studies and assessment, and on training of undergraduate and graduate studies via their participation in research related to acoustics and ecosystem science. I have also sought to promote understanding of acoustics and ecosystem assessment via lectures to the public and school groups. I have continued my participation in the ICES Fisheries ASTWG, an international group of scientists using acoustics for assessment purposes. I have also been working closely with Glen Gawarkiewicz (WHOI) and Margaret Petruny-Parker (Commercial Fisheries Research Foundation) to develop and promote a federally-funded

cooperative research program examining the New England shelf break ecosystem in the context of ecosystem-based management, understanding climate change, and developing offshore energy resources. This effort is an outgrowth of a highly successful CINAR workshop we convened on this topic in January of 2013 bringing together academics, federal agency scientists, and members of the commercial fishing industry.

HIGHLIGHTS

- Multi-frequency acoustic and related net and hydrographic data were successfully collected ancillary to marine mammal surveys at the New England continental shelf break and slope as part of an effort to develop zooplankton and micronekton abundance indices for Integrated Ecosystem Assessment and for marine mammal habitat modeling. Analysis is underway.
- As part of a study examining the capabilities of broadband acoustic techniques for distinguishing butterfish from squid and zooplankton prey, successful field applications of a prototype broadband echosounder were conducted from the F/V *Karen Elizabeth* at the New England continental shelf break. Publications are in development.
- Multiple educational activities were conducted, including participation in the Friday Harbor Laboratories Bio-Acoustics course and involvement of students in acoustic research.

SOCIETAL BENEFITS

My work using multi-frequency data collected during routine non-targeted assessment surveys leverages an under-utilized data stream to address the need for indices for Integrated Ecosystem Assessment, while the more experimental work on broadband acoustics addresses the problem of target identification, a chronic issue in acoustic assessment surveys. My ongoing studies of euphausiid ecology and of the New England shelf break are drawing attention to the management relevance of these under-studied organisms and this under-sampled region, filling gaps in currently available data and providing key information for ecosystem models and ecosystem-based fisheries management. The educational activities I am pursuing center on developing the necessary acoustic expertise in the next generation of assessment scientists.

EDUCATION AND OUTREACH ACTIVITIES

Education

- Guest lecturer for one week in the Friday Harbor Labs summer Bio-Acoustics course, incorporating results from my fellowship research into the lectures. Multiple current NMFS acousticians have passed through this intensive training and recruiting grounds.
- Thesis committee member and WHOI advisor for Robert Levine, a graduate student in the Cornell-WHOI Master's program working on krill at the New England shelf break. Mr. Levine has recently accepted a contract position in the acoustics group at the NMFS AFSC.
- Advisor to Camille Pagniello and Shannon Crosby, undergraduates from Dalhousie and DePauw Universities who worked in my research lab on acoustics and zooplankton net samples in summer 2013 and winter 2014, respectively.
- WHOI host for Erin LaBrecque and Julia Burrows, Ph.D. students at Duke University working on acoustic methods for assessing marine mammal prey fields via the WHOI-Duke Fellowship in Marine Mammal Conservation.

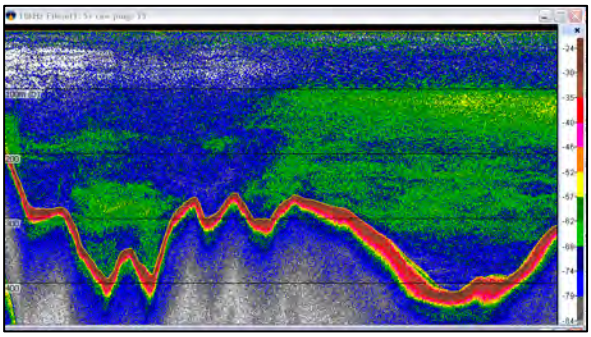
- Co-advisor with Michael Fogarty and Jason Link (NEFSC) of NOAA post-doctoral researcher Michael Lowe, who is working on shelf break trophic interactions and fisheries.

Presentations

- **Lawson, G.L.,** A.C. Lavery, P.H. Wiebe, J.M. Jech, and N.J. Copley. Multi-sensor studies of euphausiid-fish interactions in the Gulf of Maine. ICES Annual Science Conference, Reykjavik, Iceland, September 2013.
- **Lawson, G.L.**, A.C. Lavery, P.H. Wiebe, J.M. Jech, J.R. Fincke, and N.J. Copley. Field applications of broadband techniques for discriminating among sources of scattering and quantifying zooplankton. ICES Working Group on Fisheries Acoustics Science and Technology, San Sebastian, Spain, April 2013.
- **Lawson, G.L.** Plankton in the Gulf of Maine: Just how Important are Krill to New England Fisheries? Large Pelagics Research Center Fish and Fisheries Public Seminar Series, Gloucester Maritime Center, Gloucester, MA, April 2013.
- Co-convenor of a session on "Insights into marine ecosystem dynamics from acoustic techniques" at the AGU-ASLO Ocean Sciences Meeting, Honolulu, HI, February 2014.
- Talks given to primary school students, including 4th-6th graders at the Boston-based i2 summer camp and 6th graders from the Chapin School visiting WHOI.

Workshops

- Participant. Understanding Climate Impacts on Fish Stocks of the Northeast Shelf Large Marine Ecosystem: Key Research Needs and Future Directions, Providence, RI, July 2013.
- Invited Participant, COMPASS Ocean Acidification Communication and Leadership Workshop, Washington, DC, September 2013.



Left: Michael Jech (NEFSC, left) and Gareth Lawson calibrating a prototype broadband acoustic system. Right: echogram of acoustic data collected in Wilmington Canyon during a summer 2013 marine mammal survey.

Refining eastern region stakeholder needs for climate products and services

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Donald Anderson, WHOI

NOAA Sponsor – Ellen Mecray, NESDIS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

The NART climate sub-team expects to hold one to three focus groups with key regional stakeholders to review, focus and prioritize some of the needs captured in the literature review. It's expected that these meetings will be geographically distributed across the North Atlantic region. Approximately 10-15 stakeholders would participate in each session. The meetings would be organized and led by sub-team members, who will be responsible for developing a synthesis of regional needs for review at the stakeholder meetings. Funding would be used to support travel for key stakeholders. These meetings would also provide an opportunity to share climate adaptation lessons learned, which is frequently identified as a need for North Atlantic stakeholders.

ACCOMPLISHMENTS

- CINAR investigator, Andy Pershing (GMRI) and CINAR Administrative Associate Ann Stone (WHOI) were instrumental in assisting to host the first of several meetings between fisheries managers, scientists, and industry representatives on June 12, 2014. This meeting was intended to set the stage for work on the fisheries sector-specific dashboard under development.
- CINAR/NART funds were used to support travel for key constituents to attend the meeting from Boulder, CO, Princeton, NJ and around the North Atlantic region.

HIGHLIGHTS

- The RCSD worked closely with CINAR leadership to draft the fisheries and climate dashboard, and to lead the sector-specific meeting that served as the kick-off to this product's development in the coming year.

SOCIETAL BENEFITS

The joint work of the NOAA RCSD and the CINAR leadership team led to a productive first meeting of the fisheries sector leads from across the region. It is anticipated that this work will be further supported in 2014-15 and lead to the development of climate and fisheries products useful across a broad range of scientists and managers of this industry.

US National Office for Harmful Algal Blooms

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Donald Anderson, WHOI

NOAA Sponsor – Quay Dortch, NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. 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 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 394 "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 2014 WGHABD meeting, PI Anderson presented a US summary of events for 2013.

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: brown tide, Florida; and *Karenia* event; cyanoHABs, Pennsylvania, and PSP, Alaska.

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 16th International HAB Conference, Korea, the Seventh US HAB symposium, Florida, and an International Conference on HABs and Desalination in Oman.

US HAB symposia. Kleindinst served on the Steering Committees for the *Seventh Symposium on Harmful Algae in the U.S.*, held November, 2013 in Sarasota, FL. She provided 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 also handled travel awards for students and managers for the HAB symposium.

International HAB Conferences. Anderson serves on the Steering Committee for the *16th International Conference on Harmful Algal Blooms* which will be held in New Zealand in October 2014. The National Office will also assist by handling applications for U.S. student travel awards and the subsequent processing of reimbursements.

International Conference on HABs and Desalination. This conference took place in April 2014 in Muscat, Oman. PI Anderson served as co-Chair of the meeting, helping to secure funding, plan the scientific program, invite speakers, review and make decisions on presentations, etc. He also gave a plenary talk on HABs.

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

- Organization of the International Conference on HABs and Desalination, Muscat, Oman, attended by 125 individuals and 18 countries, representing researchers and students from the HAB and desalination plant communities, as well as plant engineers.

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., Plenary, "Harmful algal blooms", International Conference on Harmful Algal Blooms and Desalination, Muscat, Oman (April, 2014)
- Anderson, D.M., US Summary of Harmful Algae Events – 2013, ICES WGHABD, Haarlem, the Netherlands (April, 2014)
- Anderson, D.M. Invited webinar presentation - New technologies for HAB cell identification and monitoring. EPA Webinar - How to Track a HAB: New Technologies and Methods for Identifying and Monitoring Harmful Algal Blooms (Aug., 2013)
- 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: Serving the needs of fishing communities and fishery management in the Northeast region

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Alexa Dayton, GMRI

NOAA Sponsor – Earl Meredith, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

For 2013, the MREP Northeast Implementation Team proposed to carry out four initiatives:

- Deliver one MREP 100 Science module and one MREP 100 Management module in a New England location; (previously reported on)
- Deliver a MREP 200 *Insights into Stock Assessments* for New England and Mid-Atlantic fishermen;
- Perform active outreach in building a fishing community network to support ongoing development of professional training opportunities in the MREP model, incorporating both Mid-Atlantic and New England social structure; and
- Design and deliver an "experimental" MREP-concept module to a target community identified in outreach, with material specific to the needs of that community.

For 2014 the MREP Implementation Team proposed to carry out five initiatives:

- Deliver one MREP Science 100 module and one MREP Management 100 module in a Mid-Atlantic location;
- Deliver a MREP 200 *Insights into Stock Assessments* for New England and Mid-Atlantic fishermen;
- Convene a taskforce of select fishery leaders, NMFS, MAFMC, NEFMC and institutional partners to design a long-term governance structure appropriate to a permanent regional program and a strategy for transition;
- Develop a new MREP 200 module to be offered to MREP graduates; and
- Perform active outreach in building a fishing community network to support MREP training and recruiting throughout the Northeast Region, and seek opportunities to expand the program training reach to more fishermen at less cost.

We further proposed that program delivery will be evaluated along established protocols, with continuing development of instruments to track program relevance. Testimonials and other feedback have been captured both in writing and with photography.

ACCOMPLISHMENTS

Gloucester, MA – A team of 5 industry members, including Northeast Seafood Coalition representative Jackie O'Dell and Northeast Sector Service Network, (NESSN) NESSN's Libby Etrie and Nick Brancaleone, plus representatives from the Regional Office, and Science Center convened to articulate the community issues and design a tailored workshop curriculum in response to these needs; audience and outreach strategies were also outlined.
Chatham, MA - A team of 6 industry members from Chatham and Cape Cod, including sector manager Claire Fitzgerald, plus representatives from the Regional Office, and Science Center convened to articulate the community issues and design curriculum in response to these needs, as well as discuss audience and outreach strategies.

We delivered the following workshops as outlined in our proposed scope of work:
May 21st - 23rd MREP 200 Science – 2 Days, Woods Hole, MA
Jan 2nd - 3rd MREP Introductory workshop – 2 Days**,** Gloucester, MA
Jan. 21rd – 23rd MREP 100 Science – 3 Days, Baltimore, MD
February 3rd – 4th MREP Introductory Science workshop – 2 Days, Chatham, MA
February 20th – 21st MREP Introductory Management workshop – 2 Days, Chatham, MA
March 11th -13th MREP 100 Management – 3 Days**,** Baltimore, MD
April 7th – 8th MREP 200 Science – 2 Days, Woods Hole, MA
In 2014, we have delivered one pair of Fishery Science 100 and Fishery Management 100 modules in Baltimore, MD following the traditionally offered MREP curriculum and length.

In keeping with stated goals of attracting participation from Mid-Atlantic fisheries, we delivered the paired MREP 100 Science and Fishery Management Modules in Baltimore, MD; as a result the class drew 90% of attendance from fisheries managed primarily by the Mid-Atlantic Fishery Management Council (MAFMC); 3 participants traveled south from New England.

Because of the emphasis on Mid-Atlantic fisheries, we sought advice from participants in the previous Baltimore offerings, enlisted community members Greg DiDomenico (Garden State Seafood Association, NJ) and Jeff Kaelin (Lund Fisheries, NJ) to present parts of the Management Module, and invited presentations from MAFMC SSC chairman John Boreman and MAFMC staff.

The modules continued steady evolution of curricula. The Science Module featured a very well-received new presentation by NOAA scientist John Manderson discussing environmental drivers potentially affecting butterfish stock assessment; the presentation was a preview of this data to be considered in the Butterfish benchmark assessment scheduled for the SAW/SARC in April.

The Superfish Case Study was offered for the third time at the Fishery Management Module and continues to be developed through practice and participant input. As an exercise in management process (annual specification-setting for a hypothetical managed species) the number of assigned roles was expanded and the tailored instructions for role-play negotiations were given more detail. The size of the group allowed a single simulated negotiation (rather than two or three break-out groups), with "stronger" participants assisting the less experienced. MREP Implementation Team members served as negotiation facilitators, keeping the negotiation focused on key management principles.

In 2014 we have also experimented with alternative delivery formats, as a way to reach and respond to communities, which have been under-served, target individuals reluctant to take time away from fishing businesses, and provide basic information to more people at lower cost per individual.

In Chatham, MA we delivered a four-day series with the following differences:

- A 2-day Fishery Science module featuring only the core curriculum elements.
- A 2-day Fishery Management module featuring only the core curriculum elements.
- Class size capped at 60.
- Participation drawn from the local community within 30-minutes' drive of Chatham.
- Participants commute from home.
- Roster comprised >90% of active fishermen.
- Diversity limited to the range of local fisheries – a largely homogeneous roster of participants.

In Gloucester, MA we delivered a two-day workshop scheduled to maximize fleet availability (two days following the New Year holiday). Significantly condensed from the typical MREP program, this offering differed in the following elements:

- One day of Fishery Science, a summary of the core curriculum;
- One day of Fishery Management with focus on laws, jurisdiction and process.
- Open enrollment.
- Participation drawn from the immediate local community of Gloucester.
- Participants commute from home.
- Roster comprised >90% of active fishermen.
- Diversity limited to the range of local fisheries – a largely homogeneous roster of participants.

Initial analysis of these experiments with alternative delivery formats demonstrated some positive and some negative results in comparison to the well-tested typical MREP 100 format. A workshop with MREP principals and partners is planned for July 2014 to evaluate lessons learned from these experiments and to make recommendations for broadening the MREP experience.

Program Impacts and Case Studies:
Monty Hawkins, a party-boat owner/operator out of Ocean City, MD, attended both the 2013 Science and Management offerings in Baltimore, MD. Monty has long-been a vocal proponent of marine habitat restoration and enhancement, with considerable on-line following; he also has many unique research ideas. As result of the MREP experience, Monty is pursuing collaborative research, has explored specific research hypothesis with Maryland DMF, and has approached members of the Maryland Congressional delegation seeking support for habitat research.

A thank you note received from a participant in the 2014 Baltimore MREP modules: "[The MREP I attended] was an excellent opportunity to meet with other stakeholders, scientists and managers in a way that was not inherently confrontational, and gave the group opportunities to

see past ideological differences and create pathways toward positive communication in the future. Bonnie Brady, Executive Director, Long Island Commercial Fishing Association"

HIGHLIGHTS

- Delivered 7 workshops total, attracting 129 total unique participants, of which 90 were active commercial and recreational fishermen. A majority of the individuals attended more than one workshop;
- Broadened program's geographic reach to include Mid-Atlantic;
- Experimented with alternative workshop lengths and content;
- Broadened planning team and industry input through networking approach with community-based organizations such as NESSN, CCFCHA, and Garden State Seafood;
- Expanded speaker's bureau and program content to meet evolving industry needs and increased geographic breadth.

EDUCATION AND OUTREACH ACTIVITIES

With these alternative formats used in Gloucester and Chatham, the MREP Implementation Team was responding to requests from local fishing industry associations; in both cases we formed informal steering committees of MREP alumni and Implementation Team members to adapt the curriculum structure and marketing plan. In both communities, the fishing associations' local contact networks were the primary means to disseminate information and invitations to federal permit-holders and became the conduit by which individuals submitted applications.

Recruiting efforts tapped existing fishing community networks for marketing of the modules. With concurrence of Greg DiDomenico we enlisted the Garden State Seafood Association membership coordinator, Katie Dowe. Katie provided a list of 24 outside fishery organizations, commercial and recreational, and contacted many of principals. Katie also built MREP awareness with a steady stream of Twitter and Facebook notifications.

An attempt to advance MREP awareness on prevalent recreational fishery blog-sites was less successful, but indicated another large opportunity for reaching another hard-to-reach community segment. We will continue to explore this avenue for future outreach.

In the final push however, the majority of sign-ups came from people already focused on the MAFMC process. The MAFMC devoted a webpage to the MREP agenda and application, and maintained the relevant MREP modules on its events calendar.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Marine Resource Education Program for fishermen in the Southeast fisheries region

NOAA Cooperative Agreement No. NA09OAR4320129
April 01, 2013 – March 30, 2014

Alexa Dayton, GMRI

NOAA Sponsor – Kim Amendola, NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

The Gulf of Maine Research Institute (GMRI) proposed to continue the collaboration with partners in the Southeast fisheries region to develop and implement a Fishery Science and 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 20 program participants for the first management workshop during the reporting period, and also recruit an additional 20 participants for a second science workshop, with class compositions that reflect a high degree of diversity. Program implementation consists 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.

GMRI further proposed to reconvene the regional steering committee and engage them in a program review and evaluation of the first year. The New England curriculum provided a starting point, which was translated and tailored to the fisheries, fishing communities, and management practices of the region. GMRI recognized that localized cultural differences must be fully understood and cast a wide net to ensure that the program was tailored and positioned appropriately for the region. The second annual committee meeting provided an opportunity to evaluate the effectiveness of this approach, and identify opportunities for continuous improvement.

ACCOMPLISHMENTS

Fishery Management Workshop

The second of the two-part workshop series, the MREP Management Workshop, was held in Tampa, Florida September 24-26, 2013 and also included participants from the South Atlantic, Gulf of Mexico and Caribbean. A total of 24 participants attended the workshop, representing commercial, recreational and charter fishermen as well as fish house owners/dealers and media.

The 12 presenters at the Management Workshop included council staff, as well as staff from NOAA Fisheries Science Center, NMFS Southeast Regional Office, NOAA General Counsel, NOAA Office of Law Enforcement, and the National Weather Service. Bob Gill served as the discussion moderator, supported by Alexa Dayton with GMRI who facilitated the workshop.

The Executive Directors from the South Atlantic, Gulf of Mexico and Caribbean Fishery Management Councils attended the workshop and presented overviews from their respective Councils on "*Sustainable Fisheries, Visioning and Current Issues*." NOAA Fisheries Regional Administrator, Dr. Roy Crabtree also attended the workshop.

Agenda items for the workshop included:

- The Fishery Management Process – An Overview
- Role of Science in Management
- How to Get Involved
- Legal Framework
- Enforcement Overview
- Council Role Playing Session

MREP Southeast Steering Committee Meeting(s)

The MREP Steering Committee first met in September 2012 to design the tailored regional program. The group (plus three new industry members) was reconvened in Charleston, SC in November 2013 to revisit 2012 Committee recommendations, program achievements for 2013, workshop curriculum and presentations, and evaluations from participants. The committee discussed program participation, governance issues, program funding, and provided recommendations for moving forward with MREP Southeast 2014.

Meeting Guidance, Conclusions & Summary:

- MREP creates a neutral forum, and offers a unique and important educational experience desperately needed in the Southeast region.
- MREP workshops foster dialog and fuel understanding.
- Going forward, add to number of workshops offered and rotate locations throughout the regions after a second year in the central Florida location.
- The feedback on the curriculum was excellent; especially the stock assessment overview, and the Council Case Study, and modest revisions were suggested overall.

- The brand is strong, and attendees seek recognition for program attendance via a certificate.
- Steering Committee program leadership is vital, and we should continue to evolve membership.
- The Regional Office and Science Center were encouraged by the strong response to program recruiting and outreach efforts and new industry members were reached.
- The program provides multiple direct pathways for further industry engagement: SEDAR pool and Council attendance.
- The Steering Committee agreed to engage in ongoing mentoring of program participants.

The Steering Committee agreed to reconvene in one year's time in person, and to participate in sub-committee work over the next 12-month time period.

HIGHLIGHTS

- Fisheries management education program developed
- Speaker's bureau established for management workshop
- Fisheries management education program delivered for 24 fishermen and an additional 18 speakers and other guests, in Tampa, FL September 22 – 24, 2013
- Reconvened Team of Advisors (renamed as "Steering Committee") in November 2013, and with three new members selected from inaugural workshop attendees.
- Identified Steering Committee meeting feedback and suggested modifications to program approach based on evaluations.
- Performed extensive outreach and networking to generated a second year of program applicants.

SOCIETAL BENEFITS

We delivered the first MREP Southeast Fisheries Management workshop, as a foundation for improved trust in the Fishery Management process. MREP Southeast has prepared industry members for meaningful engagement as articulated and envisioned by Magnusson Stevens Act.

EDUCATION AND OUTREACH ACTIVITIES

- The full Steering Committee was provided with quarterly updates on curriculum development progress, which was written and sent by GMRI staff. They were invited to work in sub-committees and the planning team as a way to directly shape the program content.
- Program awareness and recruiting for attendees for the science program took place primarily during the months Jan – March 2014.
- We enlisted the Steering Committee members and first year program attendees as program ambassadors, and the response was tremendous. They reached out to their networks and helped spread the word.
- Steering Committee Member Brandon Shuler presented at RESTORE priorities meetings in Texas in Spring 2013.
- Steering Committee member Bob Gill presented a poster about the MREP Southeast

program during the recent Managing Our Nation's Fisheries 3 National Conference in Washington, DC held May 7-9, 2013.

- July 2013 – South Atlantic Council staff provided a brief overview of the MREP Southeast Science Workshop, and sought input and comment from Education Advisory Panel.
- August 2013 – Gulf of Mexico Council staff provided a brief overview of the MREP Southeast Science Workshop.
- September 2013 – At Caribbean Council Meeting, MREP science workshop attendee, Roberto Silva, provided a brief overview of the MREP Southeast Science Workshop, and presented argument for a similar workshop offering tailored to the U.S. Virgin Islands.
- December 2013 – At South Atlantic Council meeting, MREP Steering Committee member Kenny Fex, Jr. briefed the Council on the results of the November Steering Committee meeting.
- January 2013 – At Gulf of Mexico Council meeting, MREP Steering Committee member Shane Cantrell briefed the Council on the results of the November Steering Committee meeting.
- We developed another colorful postcard that could be easily circulated and handed out by the 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.
- We employed a combination of tactics whereby we requested the councils include an announcement in their council meeting updates, and communications to their lists, on behalf of the program.
- As well, individual Steering Committee members engaged in social media such as Facebook posts to reach a younger audience
- 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

Program participants engage in a Council Role Play exercise during the Management workshop, and directly apply concepts learned earlier in the program.

Fisheries stakeholders from a variety of regions and sectors (Recreational, Commercial, Charter) work together in small groups during hands-on activities and build relationships which persist long after the program has concluded.

APPENDIX 1: CINAR PERSONNEL SUMMARY:

April 1, 2013– March 31, 2014

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. 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	Ecosystem Monitoring	Fall 2013 (18 Month appt.)	Mak Saito
Dr. Andrew Jones	Ecosystem Management	Fall 2014 (18 Month appt.)	Joel Llopiz Simon Thorold

APPENDIX 2 : CINAR PERSONNEL SUMMARY CHART :

April 1, 2013 – March 31, 2014

Category	Number	B.S	M.S	PhD.
Employees who receive ≥ 50% NOAA Funding (not including Students)				
Research Scientist	4	2	2	0
Visiting Scientist	0	0	0	0
Post Doctoral Fellow	2	0	0	2
Research Support Staff	8	4	1	2
Administrative	0	0	0	0
Total	14	6	3	4

Category	Number	B.S	M.S	PhD.
Employees who receive < 50% NOAA Funding (not including Students)				
Research Scientist	49	1	5	43
Visiting Scientist	0	0	0	0
Post Doctoral Fellow	2	0	0	2
Research Support Staff	43	20	18	3
Administrative	13	9	0	0
Total	107	33	23	48

Students	-	-	-	-
Undergraduate Students	6	4	0	2
Graduate Students	4	0	1	3
Total	10	4	1	5

Obtained NOAA employment within the last year	0	0	0	0

APPENDIX 3: CINAR PUBLICATIONS FOR REPORTING PERIOD:

Publication Request Template for CI's												
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	Batchelder, H., K. Daly, C. Davis, R. Ji, M. Ohman, W. Peterson, and J. Runge	Published	2013	Climate Impacts on Zooplankton Population Dynamics in Coastal Marine Ecosystems	Oceanography, 26(4), 34–51	Journal Article	DOI: doi:10.5670/oceanog.2013.74	X			X	
CINAR	Bi, H., R. Ji, H. Liu, Y.-H. Jo, and J.A. Hare	Published	2014	Decadal Changes in Zooplankton of the Northeast U.S. Continental Shelf	PLoS ONE, 9(1), e87720	Journal Article	DOI: doi:10.1371/journal.pone.0087720	X			X	
CINAR	Chambers, R.C., Candelmo A.C., Habeck, E.A., Poach M.E., Wieczorek D., Cooper, K.R., Greenfield, C.E. and Phelan B.A.	Published	2014	Ocean acidification in the early life-stages of summer flounder, Paralichthys dentatus	Biogeosciences, 11:1613-1626,	Journal Article	DOI: doi:10.5194/bg-11-1613-2014, 2014	X			X	
CINAR	Chen, C., R.C. Beardsley, G. Cowles, J. Qi, Z. Lai, G. Gao, D. Stuebe, H. Liu, Q. Xu, P. Xue, J. Ge, R. Ji, S. Hu, R. Tian, H. Huang, L. Wu, H. Lin, Y. Sun, and L. Zhao	Published	2013	An unstructured-grid, finite-volume community ocean model FVCOM user manual (3rd edition)	SMAST/UMASSD Technical Report-13-0701, University of Massachusetts-Dartmouth, pp 404.	Journal Article		X				X
CINAR	Chen, K., G. Gawarkiewicz, S. Lentz, and J. Bane	Published	2014	Diagnosing the warming of the Northeastern US coastal ocean in 2012: A linkage between the atmospheric jet stream variability and ocean response	J. Geophys. Res. 118: 218-227	Journal Article	DOI: 10.1002/2013JC009363	X			X	
CINAR	Clayson, C.A., J.B. Roberts, and A. Bogdanoff	In review		2013: Seaflux Version 1: a new satellite-based ocean-atmosphere turbulent flux dataset	Int. J. Climatol.	Journal Article		X			X	
CINAR	Gawarkiewicz, G., G.L. Lawson, M. Petruny-Parker, P. Fratantoni, and J. Hare	Published	2013	The Shelf Break Ecosystem off the Northeastern United States: Current Issues and Recommended Research Directions	CINAR Workshop Report	Workshop Proceedings		X				X
CINAR	Gettings, R.M., D.W. Townsend, M.A. Thomas and L. Karp-Boss	Published	5/1/14	Dynamics of late spring and summer phytoplankton communities on Georges Bank, with emphasis on diatoms, Alexandrium spp., and other dinoflagellates	Deep Sea Research II, 103: 120-138	Journal Article	DOI: 10.1016/j.dsr2.2013.05.012	X			X	
CINAR	Grebmeier, J, B. Bluhm, L. Cooper, S. Denisenko, K. Iken, M. Kedra	Presentation	2014	Time series benthic community structure, biomass and sediment studies during the RUSALCA program 2004-2012, and development of the Distributed Biological Observatory international network	RUSALCA PI Meeting, Honolulu, HI, Feb. 2014	Presentation		X				X
CINAR	Grebmeier, J.M., W. Maslowski	Published	6/13/14	Chapter 1: The Pacific Arctic Region: An Introduction.	In: Grebmeier JM, Maslowski W (eds) The Pacific Arctic Region: ecosystem status and trends in a rapidly changing environment. Springer, Dordrecht, p 1-16	Publication List	DOI: 10.1007/978-94-017-8863-2_1	X			X	
CINAR	Grebmeier, J.M.	Presentation	4/6/14	The Distributed Biological Observatory (DBO): 2014 Updates of Activities and Data Workshops		Presentation		X				X
CINAR	Hoagland, P., H.L. Kite-Powell, D. Jin, and A.R. Solow	Published	2013	Supply-side approaches to the economic valuation of coastal and marine habitat in the Red Sea	J. King Saud Univ.-Sci. 25:217-228	Journal Article	DOI: http://dx.doi.org/10.1016/j.jksus.201	X			X	
CINAR	Henry, A.	Published	7/1/13	Assessing social resilience of Maine fishing communities and developing a longline groundfish survey	Thesis for the Dual Master of Science degrees in Marine Biology and Marine Policy, School of Marine Sciences, University of Maine, Orono, ME 04469	Publication List		X				X
	Jin, D., P. Hoagland, and B. Wikgren B.	Published	2013	An empirical analysis of the economic value of ocean space associated with commercial fishing	Marine Policy 42: 74-84	Journal Article		X			X	
CINAR	Jin, X., L. Yu	Published	10/15/13	2013: Assessing high-resolution analysis of surface heat flux in the Gulf Stream region.	J. Geophys. Res. Oceans, 118, 5353–5375	Journal Article		X			X	

CINAR	Jin, X., L. Yu, D.L. Jackson, and G A. Wick	In review		An improved near-surface specific humidity and air temperature climatology for the satellite period.	J. Atmos. Oceanic Technol..	Journal Article			X			X	
CINAR	Josey, S., S. Gulev, L. Yu	Published	11/25/13	2013: Chapter 3. Exchamges through the ocean surface	Ocean Circulation and Climate, 2nd Edition, 115-140pp	Book Chapter					X	X	
CINAR	Lawson, G.L., A.C. Lavery, P.H. Wiebe, J.M. Jech, and N.J. Copley	Published	2013	Multi-sensor studies of euphausiid-fish interactions in the Gulf of Maine	ICES Council Meeting Document 2013/P:10	Conference Proceedigns			X				X
CINAR	Li, Y., R. Ji, P.F. Fratantoni, C. Chen, J.A. Hare, C S. Davis, R.C. Beardsley	Published	4/16/14	Wind-induced interannual variability of sea level slope, along-shelf flow, and surface salinity on the Northwest Atlantic shelf	J. Geophys. Res. Oceans, 119	Journal Article	DOI: 10.1002/2013JC009385			X		X	
CINAR	Mathis, J.T., J.M. Grebmeier, D.A. Hansell, R.R. Hopcroft, D.L. Kirchma, S,H, Lee, S.B. Moran, N.R. Bates, S. VanLaningham S, J.N. Cross and W.-J.Cai	Published	6/13/14	Chapter 9: Carbon biogeochemistry of the western Arctic: primary production, carbon export and the controls on ocean acidification.	In: Grebmeier JM, Maslowski W (eds) The Pacific Arctic Region: ecosystem status and trends in a rapidly changing environment. Springer, Dordrecht, p 223-268	Publication List					X	X	
CINAR	Mathis, J.T., J.M. Grebmeier, D.A. Hansell, R.R. Hopcroft, D.L. Kirchman, S.H. Lee, S.B. Moran, N.R. Bates, S. VanLaningham, J.N. Cross, W.-J. Cai	Published	6/13/14	Chapter 9: Carbon biogeochemistry of the western Arctic: primary production, carbon export and the controls on ocean acidification.	In: Grebmeier JM, Maslowski W (eds) The Pacific Arctic Region: ecosystem status and trends in a rapidly changing environment. Springer, Dordrecht, p 223-268	Publication List					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	Published	5/1/14	A red tide of Alexandrium fundyense in the Gulf of Maine	Deep Sea Research II, 103: 174-184	Journal Article	DOI: http://dx.doi.org/10.1016/j.dsr2.201		X			X	
CINAR	McGillicuddy, D.J., Jr., D.W. Townsend, B.A. Keafer, M.A. Thomas and D.M. Anderson	Published	5/1/14	Georges Bank: A leaky incubator of Alexandrium fundyense blooms	Deep-Sea Research II, 103: 163-173	Journal Article	DOI: 10.1016/j.dsr2.2012.11.0		X			X	
CINAR	Mechoso, C.R., R. Wood, R. Weller, C.S. Bretherton, A.D. Clarke, H. Coe, C. Fairall, J.T. Farrar, G. Feingold, R. Garreaud, C. Grados, J. McWilliams, S.P. de Szoeke, S.E. Yuter , P. Zuidema	In Press		Ocean-Cloud-Atmosphere-Land Interactions in the Southeastern Pacific: The VOCALS Program	Bull. American Met. Soc	Journal Article	DOI: 10.1175/BAMS-D-11-00246.1			X		X	
CINAR	Munroe, D., D. Hart, B. Shank, D. Haidvogel, E. Powell, J. Klinck, and E. Hofmann	Published	3/29/14	The Role of Larval Sources and Population Connectivity in Rotating Closures in the Atlantic Sea scallop (Placopecten magellanicus) Fishery.	National Shellfisheries Association Annual Meeting, Jacksonville FL	Presentation			X				X
CINAR	Munroe, D., D. Hart, B. Shank, D. Haidvogel, E. Powell, J. Klinck, and E. Hofmann	Published	12/10/13	The Role of Larval Sources and Population Connecti	MidAtlantic Council Meeting, Annapolis MD	Presentation			X				X
CINAR	Nelson, R.J., C. Ashjian, B. Bluhm, K. Conlan, R. Gradinger, J. Grebmeier, V. Hill, R. Hopcroft, B. Hunt, H. Joo, D. Kirchman, K. Kosobokova, S. Lee, W.K.W. Li, C. Lovejoy, M. Poulin, E. Sherr, and K. Young	Published	6/13/14	Chapter 10: Biodiversity and biogeography of the lower trophic taxa of the Pacific Arctic Region – sensitivities to climate change.	In: Grebmeier JM, Maslowski W (eds) The Pacific Arctic Region: ecosystem status and trends in a rapidly changing environment. Springer, Dordrecht, p 269-336	Publication List					X	X	
CINAR	Plueddemann, A., J. Ryder, B. Pietro, J. Smith, C. Duncombe Rae, R. Lukas, C. Nossee, J. Snyder, L. Bariteau, S.J. Park D. Hashisaka, E. Roth, C. Fumar, A. Andrews and N. Seymour	Published	2013	WHOI Hawaii Ocean Timeseries Station (WHOTS): WHOTS-9 2012 mooring turnaround cruise repor	WHOI Tech. Rept., WHOI-2013-04, 93 pp.	Technical Report			X				
CINAR	Prytherch, J., J. T. Farrar, and R. A. Weller	Published	9/13/13	Moored surface buoy observations of the diurnal warm layer	J. Geophys. Res. 118, 4553-4569	Journal Article	DOI: 10.1002/jgrc.20360				X	X	
CINAR	Rebuck, N.D. and D.W. Townsend	Published	5/1/14	A climatology and time series for dissolved nitrate in the Gulf of Maine region	Deep Sea Research II, 103: 223-237	Journal Article	DOI: http://dx.doi.org/10.1016/j.dsr2.2013.09.006			X		X	
CINAR	Song, X., and L. Yu	Published	7/22/13	2013: How much net surface heat flux should go into the Western Pacific Warm Pool?	J. Geophys. Res. Oceans, 118, 3569–3585	Journal Article	DOI: 10.1002/jgrc.20246				X	X	
CINAR	Sun, J.	Published	2/24/14	Cost-Effective Analysis of Discards-Proportional Allocation Scheme for the At-Sea Monitoring Program of the Groundfish Fishery in New England	Workshop on "Fishery Monitoring and Survey Selectivity" hosted by Massachusetts Marine Fisheries Institute, New Bedford, MA, Feb. 24 - 25, 0014	Presentation			X				X

CINAR	Sun, J.	Published	4/10/14	Seasonality and volatility of the ex-vessel price and landings by port	Workshop "Developing Solutions to Improve Groundfish Fishing Businesses," hosted by the Social Science Branch in Northeast Fishery Science Center with fishermen, along with GMRI and Greater Atlantic Regional Fisheries Office, Quincy, Massachusetts, April 10, 2014	Presentation			X					X
CINAR	Sun, J.	Published	4/10/14	Variability of Leasing Price and the Concept of Time Value of ACE Leasing	Workshop "Developing Solutions to Improve Groundfish Fishing Businesses," hosted by the Social Science Branch in Northeast Fishery Science Center with fishermen, along with GMRI and Greater Atlantic Regional Fisheries Office, Quincy, Massachusetts, April 10, 2014	Presentation			X					X
CINAR	Sun, J., A. Kitts, and J. Joyce	Published	8/17/14	Evolution of Groundfish Sectors Business Viability Model in New England	144th American Fisheries Society Annual Meeting, Québec, Canada, August 17 to 21, 2014	Conference Proceedigns			X				X	
	Tian, R., C. Chen, J. Qi, R. Ji, R.C. Beardsley and C.S. Davis	In press		Model Study of Nutrient and Phytoplankton Dynamics in the Gulf of Maine: Patterns and Drivers for Seasonal and Interannual Variability.	ICES Journal of Marine Sciences	Journal Article			X				X	
CINAR	Townsend, D.W., M.A. Thomas, D.J. McGillicuddy, and N.R. Rebuck	Published	5/1/14	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, 103: 238-263	Journal Article	DOI: 10.1016/j.dsr2.2013.08.003		X				X	
CINAR	Weller, R. A., S. Majumder, and A. Tandon	In review		Diurnal restratification events in the southeast Pacific trade wind regime	J. Phys. Oceanogr	Journal Article			X				X	
CINAR	Wilkin, J., E. Hunter	Published	6/13/13	An assessment of the skill of real-time models of Middle Atlantic Bight continental shelf circulation	Journal of Geophysical Research - Oceans	Journal Article	DOI::10.1002/jgrc.20223		X				X	
CINAR	Yu, L., and X. Jin	In review (revised)		A Satellite-Derived High-Resolution Ocean Surface Vector Wind Analysis (1987 onward): Part I. Insights on the synergy between scatterometers and radiometers.	Journal of Geophysical Research	Journal Article			X				X	
CINAR	Yu, L., and X. Jin	In review		A Satellite-Derived High-Resolution Ocean Surface Vector Wind Analysis (1987 onward): Part II Confidence and sensitivity analysis.	Journal of Geophysical Research	Journal Article			X				X	
CINAR	Yu, L., X. Jin, and P. W. Stackhouse	Published	8/6/13	2013: Global ocean surface heat fluxes	[in "State of the Climate in 2012"]. Bull. Amer. Meteor. Soc., 94 (8), s53-56.	Journal Article	DOI: 10.1175/2013BAMSStateoftheClimate.1		X				X	