



Annual Progress Report

April 1, 2010 - March 31, 2011

Donald M. Anderson, Director

Submitted to:
National Oceanic and Atmospheric Administration
Ocean and Atmosphere Research (OAR)
April 2011



CINAR
Annual Progress Report

Reporting Period: April 01, 2010 - March 31, 2011

Submitted by:

Donald M. Anderson, Director

Submitted to NOAA on 04/29/2011

The Cooperative Institute for the North Atlantic Region is funded by:
National Oceanic and Atmospheric Administration Award # NA09OAR4320129

Table of Contents

EXECUTIVE SUMMARY	5
CINAR ANNUAL RESEARCH HIGHLIGHTS	7
INTRODUCTION	10
1.1 Institute and Core Activities.....	10
1.2 CINAR Vision, Mission, Goals and Organization	10
1.3 Distribution of NOAA Funding by Task, CINAR Themes and NOAA Line Office.....	15
1.4 Task I activities with Distribution of Funding	16
2010 CINAR POST DOCTORAL SCHOLAR PROGRESS REPORT	20
CINAR Research Summaries.....	22
Theme I. Ecosystem Forecasting.....	25
Nutrient Dynamics on the NE Continental Shelf; Sample Analyses	26
David Townsend - University of Maine at Orono	26
NOAA Program Manager: Timothy Sheehan NOAA Fisheries Service	26
Development of National Ocean Service Operational Forecast Systems based on the Regional Ocean Model System.....	29
John Wilkin - Rutgers, the State University of New Jersey	29
NOAA Program Manager: Aijun Zhang NOAA NOS/COOP	29
Theme II. Ecosystem Monitoring	32
Field Testing and Expansion of Capabilities of the Environmental Sample Processor: Necessary Steps toward Operational HAB Monitoring and Forecasting in the Gulf of Maine	33
Donald Anderson -Woods Hole Oceanographic Institution	33
NOAA Program Manager: Dr. Juli Trtanj NOS/ASTADM	33
Groundfish Vessel Crew Rapid Assessment	36
Kate Burn and Jessica Joyce - Gulf of Maine Research Institute	36
NOAA Program Manager: Patricia Pinto da Silva NOAA/NMFS	36
Development of a HabCAM System for NOAA/NMFS Phase I of III: Construction of a Stereo Camera and Telemetry System.....	39
Scott Gallager - Woods Hole Oceanographic Institution.....	39
NOAA Program Manager: Dr. Russell W. Brown NOAA/NMFS	39
Image Analyses Tools for Quantitative Mensuration and Classification of High Resolution Optical Imagery, Improving Visual Survey Methods for Groundfish and Reef Fish Using the SeaBED AUV	45
Hanumant Singh - Woods Hole Oceanographic Institution	45
NOAA Program Manager: Dr. John Rooney Pacific Islands Fisheries Science Center	45
SeaBED AUV Tech Support and Development.....	47
Hanumant Singh - Woods Hole Oceanographic Institution	47
NOAA Program Manager: Dr. Elizabeth Clarke NOAA Northwest Fisheries Science Center	47

Development of Automated Tools for Underwater Photographic Analysis: Improving Visual Survey Methods for Groundfish and reef Fish Using the SeaBED AUV	49
Hanumant Singh - Woods Hole Oceanographic Institution	49
NOAA Program Manager: Dr. Elizabeth Clarke NOAA Northwest Fisheries Science Center.....	49
THEME III Ecosystem Management	51
US National Office for Harmful Algal Blooms	52
Donald Anderson - Woods Hole Oceanographic Institution.....	52
NOAA Program Manager: Dr. Quay Dortch NOAA Coastal Ocean Program, N/SC12.....	52
The Mid Atlantic Cold Pool and Stock Assessments: Developing Environmental Indices at the Range Limit of Species	55
Donald Anderson -Woods Hole Oceanographic Institution and David Mountain, University of Arizona	55
NOAA Program Manager: Jonathan Hare NOAA NMFS Oceanography Branch.....	55
Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior	57
Carin Ashjian - Woods Hole Oceanographic Institution	57
NOAA Program Manager: Mr. David Rugh NMML/AFSC.....	57
Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior	62
Mark Baumgartner - Woods Hole Oceanographic Institution.....	62
NOAA Program Manager: Mr. David Rugh NMML/AFSC	62
Autonomous Gliders for Real Time Passive Acoustic Remote Sensing	66
Mark Baumgartner - Woods Hole Oceanographic Institution	66
NOAA Program Manager: Dr. Sofie Van Parijs NOAA/NMFS.....	66
Incorporating Sediment and Hydrography Data in Assessments for Tilefish and Lobster	69
Yong Chen - University of Maine at Orono.....	69
NOAA Program Manager: Kristen Larson NMFS F/ST4.....	69
Social Capital in the NE Ground Fish Industry: Request for Supplemental Funding.....	75
Daniel Holland - Gulf of Maine Research Institute	75
NOAA Program Manager: Patricia Pinto da Silva NMFS/ Social Science Branch	75
Understanding the Economic Structure of the Gulf of Maine Lobster Industry	79
Daniel Holland - Gulf of Maine Research Institute	79
NOAA Program Manager: Eric Thunberg NEFSC/ Social Science Branch	79
THEME IV. Protection and Restoration of Resources	82
Evaluation of Biomarkers and Bioindicators for Fundulus heteroclitus in a Contaminated and Reference Location.....	83
Keith Cooper - Rutgers	83
NOAA Program Manager: Reyhan Mehran NOAA Assessment and Restoration Division.....	83
Funding Sector Operations and Dockside Monitoring in Fishing Year 2011	85
Jonathan Labaree - Gulf of Maine Research Institute.....	85
NOAA Program Manager: Dan Morris NMFS/NER.....	85
Marine Mammal Health and Entanglement Research	88
Michael Moore - Woods Hole Oceanographic Institution	88

NOAA Program Manager: Dr. Teresa Rowles Marine Mammal Health and Stranding Response Program	88
Health Implications of Entanglements of Large Whales.....	93
Michael Moore, Woods Hole Oceanographic Institution	93
NOAA Program Manager: Richard Merrick Northeast Fisheries Science Center.....	93
Impact on Oceanographic Changes on Atlantic Salmon Survival in the Northwest Atlantic	97
Andrew Pershing - University of Maine at Orono	97
NOAA Program Manager: Timothy Sheehan NOAA Fisheries Service	97
Evaluation of the Importance of Predator and Prey Field and Ocean Circulation on Atlantic Salmon Growth and Survival in the Gulf of Maine.....	99
Jason Stockwell - Gulf of Maine Research Institute	99
NOAA Program Manager: Kelly Taranto NMFS/ NEFSC	99
Collaborative Research Program Focusing on Behavioral Ecology and Reactions to Sound Populations of Short-Finned Pilot Whales and Other Cetaceans Off Cape Hatteras, North Carolina.....	103
Peter Tyack - Woods Hole Oceanographic Institution.....	103
NOAA Program Manager: Kenric Osgood NOAA/NMFS Office of Science and Technology / Marine Ecosystems Divisions.....	103

THEME V. Sustained Ocean Observations and Climate 117

WHOI Contribution ARGO Float Program (2010-2011).....	118
W. Brechner Owens - Woods Hole Oceanographic Institution.....	118
NOAA Program Manager: Dr. Steven Piotrowicz Climate Program Office	118
NOAA State of the Arctic Report (2010)	120
Andrey Proshutinsky - Woods Hole Oceanographic Institution	120
NOAA Program Manager: Dr. John Calder Climate Program Office, R/CPO	120
Development, Enhancement and Operation of Software Components for the IOOS Data Portal.....	124
Thomas Shyka and Riley Young Morse - Gulf of Maine Research Institute	124
NOAA Program Manager: Zdenka Willis NOAA Integrated Ocean Observing Program	124
R/V Atlantis Support of NOAA CalNEX 2010 Cruise.....	128
Albert Suchy - Woods Hole Oceanographic Institution	128
NOAA Program Manager: LCDR James Illg R/PMEL	128
R/V Oceanus Use in Support of NOAA/AOML's Western Boundary Time Series Research	131
Albert Suchy - Woods Hole Oceanographic Institution	131
NOAA Program Manager: Diane Stanitski Climate Program Office / Climate Observation Division.....	131
Ocean Climate Observations and Analyses (2010-2011)	133
Robert Weller - Woods Hole Oceanographic Institution	133
NOAA Program Manager: Dr. David Goodrich Climate Program Office.....	133
Global Ocean Surface Heat Flux Analysis.....	142
Lisan Yu - Woods Hole Oceanographic Institution.....	142
Robert A. Weller - Woods Hole Oceanographic Institution	142
NOAA Program Manager: Dr. David Legler Climate Program Office.....	142

APPENDIX 1: Personnel Supported by CINAR Funding..... 147

APPENDIX 2: CINAR Publications for Reporting Period..... 149

EXECUTIVE SUMMARY

CINAR began operations 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. CINAR's thematic focal areas are: 1) Ecosystem Forecasting; 2) Ecosystem Monitoring; 3) Ecosystem Management; 4) Protection and Restoration of Resources; 5) Sustained Ocean Observations and Climate Research; and 6) Education and Outreach.

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. The number of projects increased to 30, and the number of supported investigators to 25.

Database Development

Last year CINAR initiated discussions between the Northeast Fisheries Science Center (NEFSC) personnel and the NSF-funded Biological and Chemical Oceanography Data Management (BCO-DMO) Office. The objective was to make NEFSC's large compilation of EcoMon data on the hydrography and biology of the Gulf of Maine available to a broader group of scientists and other users within the region. As a result of these discussions, the NEFSC has provided the EcoMon datasets to the BCO-DMO Office, which has made them available online. The data collections began in 1997 and are now processed through 2009 and 2007, for hydrography and plankton respectively.

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. In an effort to broaden the participation of postdoctoral investigators within CINAR and to include our partners, CINAR and NMFS submitted a joint proposal to the PACE (Postdocs Applying Climate Expertise) Fellowship Program at UCAR. Our proposal was well received and we were selected as a suitable site for PACE postdoctoral investigators. This year none of the recent PACE postdoctoral awardees chose CINAR sponsors to work with. We are hopeful, however, that in the future we will be able to establish and support linkages between PACE postdoctoral investigators and CINAR investigators.

Program Development

CINAR Theme Leaders, working with the CINAR Council of Fellows and Executive Board, have developed a series of workshops for CINAR investigators and NOAA program managers and scientists. The primary goal of these workshops is to match capabilities of CINAR with the needs of NOAA. These workshops, organized around CINAR themes, outline NOAA's needs in a particular area, as well as their plans for future programs. This is an opportunity for new approaches and technologies to be highlighted in a common effort to identify gaps or impediments as well as potential solutions. We believe this format will enhance the ability of CINAR investigators to develop relationships with NOAA programs and managers, potentially leading to future funding opportunities. One outcome of each workshop will be a white paper which will describe the problem area or issue being addressed, and include a specific set of recommendations on programs or collaborative efforts required to address NOAA's needs.

Once all the workshops have been completed, we will convene a meeting of the CINAR Executive Board to review the recommendations and discuss next steps. We will also meet with the Council of Fellows to decide if future workshops are warranted and decide the process to solicit further topics. We are currently working with the NOAA NART (North Atlantic Regional Team) office to see if there are any workshops they would be interested in supporting.

In September we had an opportunity to showcase CINAR capabilities to a broad range of NOAA programs and managers through a NOAA Climate Board meeting and subsequent individual meetings with program managers. We are following up on these discussions and ideas for such activities as joint meetings or workshops that are now being pursued.

CINAR ANNUAL RESEARCH HIGHLIGHTS

Donald Anderson – Woods Hole Oceanographic Institution

Field Testing and Expansion of Capabilities of the Environmental Sample Processor: Necessary Steps toward Operational HAB Monitoring and Forecasting in the Gulf of Maine

The overall goal of this project is to bring the first commercially produced Environmental Sample Processor (ESP) and the first commercially available ESP mooring to the stage where an instrument can be deployed in the Gulf of Maine to demonstrate its capabilities in HAB monitoring.

- Laboratory testing of the ESP was conducted utilizing field samples collected during *Alexandrium fundyense* blooms in local waters. The ESP was tested across a wide range of cell concentrations and matrixes, and performed extremely well.

Carin Ashjian - Woods Hole Oceanographic Institution

Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior

The specific objective of this project was to sample on the Beaufort Sea shelf from Barrow, AK east to ~152 °E using high vertical-resolution oceanographic sampling along several shore-shelfbreak transects in regions where bowhead whales were observed to be feeding.

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

Mark Baumgartner -Woods Hole Oceanographic Institution

Autonomous Gliders for Real Time Passive Acoustic Remote Sensing

This project is exploring the capability of autonomous gliders to provide real time locations of marine mammals as part of the NEFSC's ongoing efforts to monitor and assess marine mammal stocks

- Three ocean gliders were successfully deployed in the southwestern Gulf of Maine during spring 2010 for 4 weeks; gliders recorded a variety of baleen whale calls, including those from humpback, fin, sei, and North Atlantic right whales.

Daniel Holland - Gulf of Maine Research Institute
Understanding the Economic Structure of the Gulf of Maine Lobster Industry

This project aims to provide managers and industry with critical data, analysis and evaluation tools on which to base new policies and programs to increase the profitability of the lobster industry and to evaluate impacts of regulatory actions.

- Surveys collected to date demonstrate a high degree of variability in input use, productivity, cost per unit of catch, income and profitability across the vessels surveyed. Of the 18 vessels surveyed, average accounting profit is \$35,935 while average economic profit (loss) that accounts for the opportunity cost of capital and their own labor is -\$6,935.
- Measures of gross revenues from lobstering should provide a reasonably good means of approximating net revenues which is a useful measure of profitability. A simple linear regression of net revenues (i.e. gross margin) against gross revenues yields an R2 of 0.89 and suggests that marginal net revenues are about 69% of gross revenues.

Daniel Holland - Gulf of Maine Research Institute
Social Capital in the NE Ground Fish Industry: Request for Supplemental Funding

The New England groundfish fishery is undergoing a major transformation with the expansion of the “sector” allocations to 17 new sectors in addition to the two existing sectors. This new approach, which devolves substantial management responsibilities to groups of fishermen, represents a potential transformation in the relationship among fishermen as well as the relationship between fishermen and the management councils

- The survey results showed that a high degree of social capital exists in the industry as a whole including a high level of trust among fishermen and substantial cooperation through information sharing. These social capital features are likely to be critical to the success of sectors and to sector management in general.

Jonathan Labaree - Gulf of Maine Research Institute
Funding Sector Operations and Dockside Monitoring in Fishing Year 2011

The aim of the project is to assist New England's groundfish fleet during the transition to sector management. This new output-based approach replaces the effort controls for the vast majority of the fleet.

- \$386,039 in federal funds was distributed to support sector dockside monitoring
- \$306,996 in federal funds was distributed for sector start-up costs

In addition, GMRI has provided training to the groundfish sectors in managing and tracking federal grant funds.

Andrey Proshutinsky - Woods Hole Oceanographic Institution
NOAA State of the Arctic Report (2010)

The major project goal is to provide and effectively document current and unbiased observations on the state of the Arctic Ocean in a way that is accessible to a wide audience.

- Analysis of Arctic Ocean climate observations over the past decade indicates more or less stable conditions since 2008 with little variability relative to a mean state over the period 1997-2010. The system appears to have shifted to a new climate regime in 2007, adjusted to new conditions in 2008, and is now characterized by less sea ice, a warmer and fresher upper ocean and changing ecosystem parameters. Evidence since 2008 points to a stabilization of the system at this new climatic state.

David Townsend - University of Maine at Orono
Nutrient Dynamics on the NE Continental Shelf; Sample Analyses

The accelerated melting of the Greenland ice sheet and the Arctic ice cap in recent decades are well documented climate change-related phenomena that are cause for a broad range of environmental concerns. In order to capture opportunities to monitor this apparent change in the ecosystem of the Northwest Atlantic continental shelf, we have analyzed samples collected as part of the NEFSC (EcoMon Program) in collaboration with Dr. Jon Hare.

- Results from this study are confirming results of earlier analyses, that waters are becoming fresher and colder and proportions of nitrate and silicate are changing.
- Early analyses of data collected by the latest EcoMon cruise in February 2011 are showing that freshening of waters in the Gulf of Maine observed in 2010 is not only continuing into 2011, but water masses entering the Gulf of Maine through the Northeast Channel are among the freshest on record.

Peter Tyack - Woods Hole Oceanographic Institution
Collaborative Research Program Focusing on Behavioral Ecology and Reactions to Sound Populations of Short-Finned pilot Whales and Other Cetaceans Off Cape Hatteras, North Carolina

Initially, project plans were to deploy Digital Archival Tags (DTags) on pilot whales near pelagic longlines in the Cape Hatteras Special Research Area (CHSRA) to investigate their foraging behavior around fishing gear. Due to a lack of tuna, there was no pelagic longline fishing effort in the study area during July 2010. Instead, DTags were deployed on pilot whales to examine their baseline foraging behavior away from fishing gear.

- Ten field days were completed during which 10 DTags were deployed on pilot whales.
- 4,099 pilot whale dorsal fin images were obtained for photo and collected six biopsy samples from tagged pilot whales. Most animals showed a low to medium level of response to the biopsy attempts.

INTRODUCTION

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

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

1.1 Institute and Core Activities

1.2 CINAR Vision, Mission, Goals and Organization

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

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

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

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

- 1) To establish CINAR as a leader in promoting “rational ocean stewardship” and serving as a model for development of similar ecosystem approaches to management in other regions;
- 2) To coordinate research, education and outreach with NOAA scientists in support of responsible stewardship of coastal and marine resources in the region;
- 3) To conduct research that identifies and evaluates linkages among productivity, fish and fisheries, pollution, climate change and ecosystem health;
- 4) To conduct research and develop decision-support tools for sustainable fisheries management;
- 5) To conduct research and develop tools to restore degraded habitats and support restoration and rebuilding of protected species to healthy population levels;
- 6) To improve integration and availability of ocean observations from global to local scales;
- 7) To provide mechanisms for transition of predictive/forecasting and monitoring tools into operational use for management;
- 8) To improve ability to distinguish shifts in marine resource status caused by human impact from those due to climate and other natural forcing; and,
- 9) To develop robust indicators of ecological health and socioeconomic benefits that can be utilized by resource managers.

CINAR Organization

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

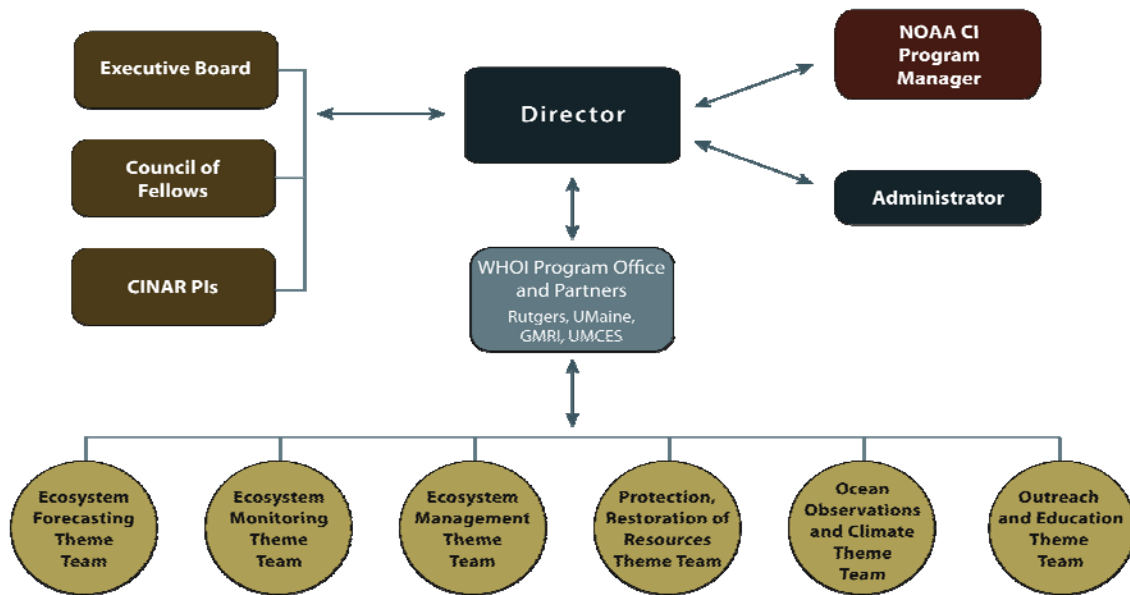


Figure 1. Organizational structure of CINAR

CINAR PIs

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

CINAR Executive Board

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

The CINAR Executive Board members are:

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

CINAR Council of Fellows

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

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

The CINAR Council of Fellows members are:

Donald Anderson, Chair	CINAR Director
Oscar Schofield	CINAR PI, Rutgers
Michael Roman	CINAR PI, UMCES
Peter Jumars	CINAR PI, University of Maine
John Annala	CINAR PI, Gulf of Maine Research Institute
Paulinus Chigbu	MSI Representative / UMCES
Fred Serchuk	NMFS/NEFSC
Dave Goodrich	OAR/Climate Program Office
Ellen Mecray	OAR/NMFS Liaison
Philip Hoffman, <i>ex officio</i>	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).

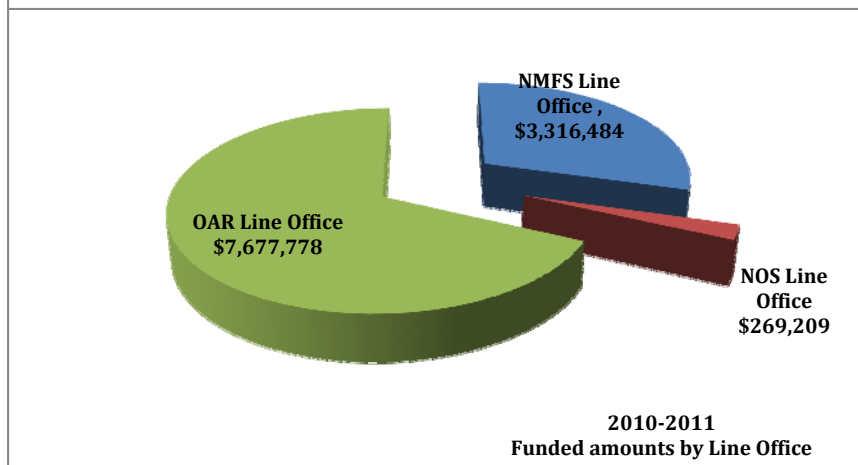
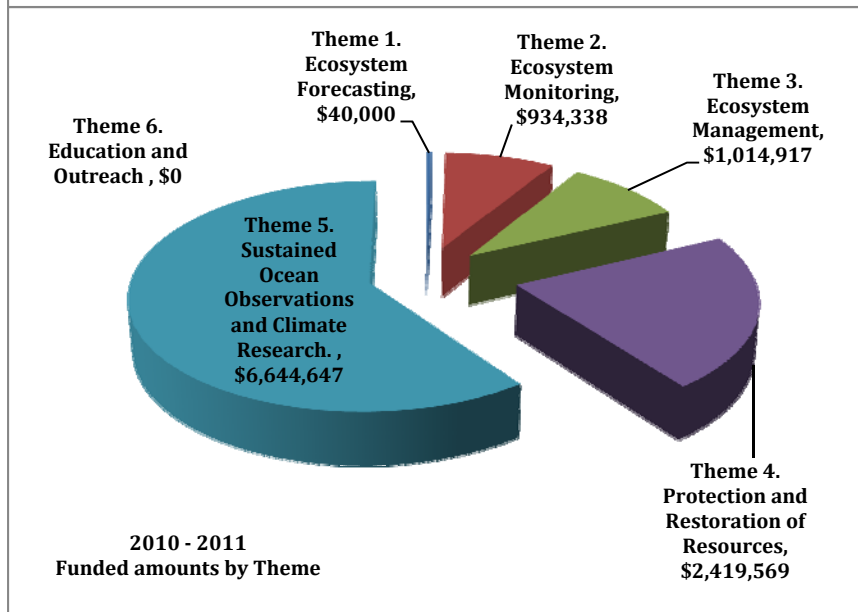
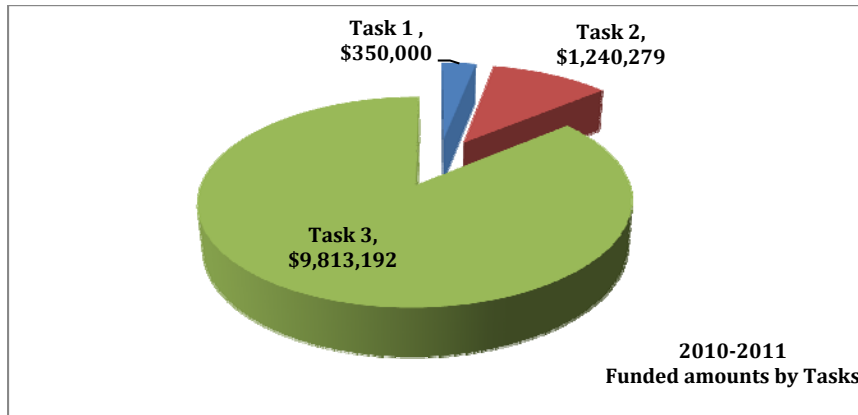
CINAR Research and Administrative staff

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.

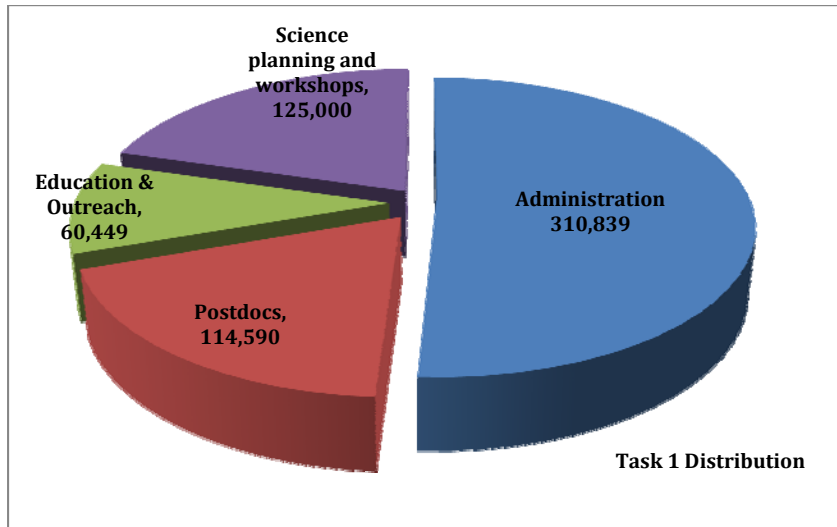
CINAR Program Office

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 provided by three sources, OAR, NMFS and WHOI (cost sharing). In year 2, we received \$110,000 from OAR, \$240,000 from NMFS and \$260,000 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

Last year CINAR initiated discussions between NEFSC personnel and the NSF funded Biological and Chemical Oceanography Data Management (BCO-DMO) Office. The objective was to make NEFSC's large compilation of EcoMon data on the hydrography and biology of the Gulf of Maine available to a broader group of scientists and other users within the region. As a result of these discussions, the NEFSC has provided the EcoMon datasets to the BCO-DMO Office, which has made them available online. The data collections began in 1997 and the data are processed through 2009 and 2007, for hydrography and plankton respectively.

The data can be accessed via the following URLs:

Hydrography:

<http://data.bco-dmo.org/jg/serv/BCO/NEFSC/hydrodata.brev0%7Bdir=data.bco-dmo.org/jg/dir/BCO/NEFSC.info=data.bco-dmo.org/jg/info/BCO/NEFSChydrodata%7D>

EcoMon 10m²:

<http://data.bco-dmo.org/jg/serv/BCO/NEFSC/plankton10m2.brev0%7Bdir=data.bco-dmo.org/jg/dir/BCO/NEFSC.info=data.bco-dmo.org/jg/info/BCO/NEFSCplankton10m2%7D>

EcoMon 100m³:

<http://data.bco-dmo.org/jg/serv/BCO/NEFSC/plankton100m3.brev0%7Bdir=data.bco-dmo.org/jg/dir/BCO/NEFSC,info=data.bco-dmo.org/jg/info/BCO/NEFSCplankton100m3%7D>

Information about the NEFSC and these two projects are available at:

<http://osprey.bco-dmo.org/program.cfm?flag=view&id=22&sortby=program>

During 2010 the metadata for NEFSC's hydrography and EcoMon plankton datasets were updated to include additional information about how the data were collected and processed.

Also, to simplify the use of the EcoMon plankton datasets, as of July 30, 2010 we replaced the taxonomic abbreviations with the actual names in the displayed data. The original abbreviations are included in the metadata record for historical purposes.

Education and Outreach

Through the WHOI cost-sharing for CINAR, we will appoint an 18-month Postdoctoral Scholar during each year of the cooperative agreement. Postdocs are selected from a national competition at WHOI of very strong applicants in all fields of oceanography. Our current Scholar is Joel K. Llopiz from the Rosenstiel School of Marine and Atmospheric Science, University of Miami. This has been an ideal CINAR Postdoc appointment, as Dr. Llopiz is working closely with Jonathan Hare and others at the NEFSC participating in stock assessment survey cruises. Please see Dr. Llopiz's report on page 18.

Our next Postdoctoral Scholar will be Robert Todd, University of California, San Diego. His report will be included in the next CINAR progress report

Executive Board meeting

Our next Executive Board meeting will be scheduled once all of the CINAR Workshops have taken place, to discuss the next steps and possibility for future workshops.

Climate Board meeting

In September 2010, CINAR Director Don Anderson and Andrew Pershing (UMaine) gave a presentation to the NOAA Climate Board, and met with program managers and others within OAR and NMFS in Silver Spring, MD. This presented an opportunity to showcase CINAR capabilities to a broad range of NOAA programs and managers. It also led to several suggestions for future activities such as joint meetings or workshops that are now being pursued.

Seminars

We have sponsored the following seminars:

1. *FATE Annual Meeting* **Jon Hare**, NOAA NMFS Northeast Fisheries Science Center, Chief, Oceanography Branch, Woods Hole, MA
2. *Predicting copepod abundance and right whale distributions in Cape Cod Bay and the Gulf of Maine* **Andrew Pershing** School of Marine Sciences, University of Maine and Gulf of Maine Research Institute
3. *Options for Ecosystem-Based Fishery Management on the Northeast U.S Continental Shelf* **Michael J. Fogarty** Ecosystem Assessment Program Northeast Fisheries Science Center, Woods Hole, MA
4. *Climate-Driven Changes in the Georges Bank/Gulf of Maine Ecosystem* **David Mountain** University of Arizona
5. Picky feeding by larval fish alters so-called size-structured food webs **Joel Llopiz** Postdoctoral Scholar, WHOI Department of Biology / CINAR
6. *Modeling impact of mesoscale eddies on biological productivity in the South China Sea and Gulf of Alaska* **Fei Chai** School of Marine Sciences, University of Maine

Workshops

The CINAR Program Office is actively working with investigators at all the partner institutions to strengthen existing relationships with NOAA programs and build new ones that can lead to funded research in support of the Institute's themes. A major activity in this regard is the organization of five joint workshops with NOAA to highlight CINAR expertise and capabilities regarding NOAA goals. The following workshops have taken place or are planned.

- **Population Connectivity on the East Coast of the United States**, Linthicum Heights, MD 22-24 February 2011
- **CINAR Workshop on Climate and Ecosystem Change in the NW Atlantic**, Woods Hole, MA 01-03 March 2011
 - A. Models and Ecosystem Indicators for Integrated Ecosystem Assessment: What can CINAR Contribute?
 - B. Forecasting the impact of Climate Change on Primary and Secondary Production in the CINAR Region.

- **The Role of Social Sciences in Ecosystem-Based Management,**
Woods Hole MA 02-04- May 2011
- **Application of New Tools and Technologies for Understanding and Managing Marine Ecosystems, TBD**
- **Education, Research Translation and Outreach Associated with CINAR Science Programs, TBD**

Each workshop will produce a white paper describing the problem or issue being addressed, and include a specific set of recommendations on programs or collaborative efforts required to address NOAA's needs. Once all the workshops have been completed, we will convene a meeting of the Executive Board to review the recommendations and discuss next steps. We will also meet with the Council of Fellows to decide if future workshops are warranted and decide on steps to solicit further topics. We are also working with the NART office to see if there are any workshops they would be interested in supporting.

PI Conference calls

Because of the consortium nature of CINAR, consisting of geographically separated partners, the CINAR PIs have periodic conference calls to discuss internal issues.

2010 CINAR POST DOCTORAL SCHOLAR PROGRESS REPORT

NOAA Cooperative Agreement No. NA09OAR4320129 – WHOI Subpoint 34
April 01, 2010-March 31, 2011

Post Doctoral Scholar: *Joel Llopiz*
Woods Hole Oceanographic Institution

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

Joel Llopiz began his CINAR Postdoctoral Scholar position at Woods Hole Oceanographic Institution (WHOI) in December 2010. He had previously held a postdoctoral position at the University of Miami's Rosenstiel School of Marine and Atmospheric Science where he also received his PhD under the supervision of Robert Cowen. His work has generally focused on the larval stage of many taxa of marine fishes that occur in the lower latitudes of the Atlantic Ocean. More specifically, this work has mostly been related to the feeding ecologies of larval fishes and the specific roles that individual fish taxa play in the larger planktonic food web. Other work has focused on the influence of feeding upon larval growth and the temporal and spatial distributions of fish larvae and zooplankton in the Straits of Florida region.

Though Joel began his position late in this CINAR reporting period, he has been busy splitting his time between getting previous work published, actively collecting new data, and laying the foundation for the bulk of the research he will be conducting during his 18-month position. Future work will likely be related to a Sea Grant pre-proposal submitted in February with Simon Thorrold (one of his advisors) to apply the recently developed technique of compound-specific stable isotope analysis to the NOAA Northeast Fisheries Science Center's collection of haddock scales that spans multiple decades. The promise in compound-specific stable isotope analysis lies in how the isotopic signatures of certain essential amino acids do not change as they are transferred from resource to consumer. Therefore, the temporal variability in the signatures of these amino acids is a direct result of changes at the base of the food web. While it has been speculated that changes at the base of the Georges Bank food web have occurred, this study would be the first to directly test this hypothesis by analyzing haddock scales collected annually on Georges Bank from 1929 to 1994. Such information should make a strong contribution to our understanding of how climate and oceanographic variability can translate up the food web to influence the recruitment, survival, and trophic interactions of important fishery species, in addition to shedding light on ecosystem-level processes affecting fish populations in general.

Another focus of Joel's work will be using the compound-specific stable isotope approach to examine latitudinal patterns in the isotopic signatures in fish larvae. Collaborating with Jon Hare (NOAA) and Simon Thorrold, this work will analyze larvae from NOAA cruises in the Gulf of Mexico and in the Northwest Atlantic in the fall of 2011 and spring of 2012. Similar to the haddock scale work, this will allow for insight into how the base of planktonic food webs changes with latitude, including estimating the relative contribution of the microbial food web to the feeding and survival of fish larvae. The comparative approach over different latitudes, temperatures and planktonic ecosystems should provide some insight into the possible effects of a changing ocean on the processes influencing larval fish survival.

Joel will also join Carin Ashjian (another of his advisors) on her 6-week cruise in the Arctic during the 2011/2012 winter. A proposal will likely be submitted to seek funding to cover his work that would also involve stable isotope analysis of the various copepod species in the region. This work would focus on elucidating the ultimate sources of carbon for copepods during the dark winter period—a time of year for which little knowledge of planktonic processes exists.

Additional activities Joel has been involved in during his first four months include obtaining preliminary stable isotope data on fish larvae from the Straits of Florida and Georges Bank; presenting his previous research in a WHOI Biology Department seminar; serving as a mentor/resource for a Joint Program student; and writing two manuscripts for submission in April and May—one on previous work and the other a meta-analysis on larval fish feeding patterns that will be part of a special issue associated with the IMBER (Integrated Marine Biogeochemical and Ecosystem Research) program. In addition to and on top of his responsibilities as the CINAR Postdoctoral Scholar, Joel is also the instructor for an undergraduate course (Biology of Fishes) that is part of the Marine Studies Consortium, which allows students from Boston-area universities and colleges (including Tufts, Northeastern, Wellesley, Wheaton, and UMass Boston) take marine science related courses not offered by their institution's faculty. This unique course is being taught once per week this spring semester at the New England Aquarium.

CINAR RESEARCH SUMMARIES

The following pages provide research summaries of the 30 CINAR projects funded during the period April 01, 2010 through March 31, 2011. The projects are organized by theme.

Theme I. Ecosystem Forecasting

1. David Townsend, UMaine – *Nutrient Dynamics on the NE Continental Shelf; Sample Analyses*
2. John Wilkin, Rutgers - *Development of National Ocean Service Operational Forecast Systems based on the Regional Ocean Model System*

Theme II. Ecosystem Monitoring

1. Donald Anderson, WHOI - *Field Testing and Expansion of Capabilities of the Environmental Sample Processor; Necessary steps toward operational HAB Monitoring and Forecasting in the Gulf of Maine*
2. Kate Burns, GMRI- *Groundfish Vessel Crew Rapid Assessment*
3. Scott Gallager, WHOI - *Development of a HabCAM System for NOAA/NMFS Phase I of III: Construction of a Stereo Camera and Telemetry System*
4. Hanumant Singh, WHOI - *Image Analyses Tools for Quantitative Mensuration and Classification of High Resolution Optical Imagery, Improving Visual Survey Methods for Groundfish and Reef Fish Using the SeaBED AUV*
5. Hanumant Singh, WHOI - *NWFSC SeaBED Tech Support and Development*
6. Hanumant Singh, WHOI – *Development of Automated Tools for Underwater Photographic Analysis: Improving Visual Survey Methods for Groundfish and Reef Fish Using the SeaBED AUV*

Theme III. Ecosystem Management

1. Donald Anderson, WHOI - *US National Office for Harmful Algal Blooms*
2. Donald Anderson, WHOI and Dave Mountain, U of Arizona - *The Mid Atlantic Cold Pool and Stock Assessments: Developing Environmental Indices at the Range Limit of Species*
3. Carin Ashjian, WHOI - *Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior*
4. Mark Baumgartner, WHOI - *Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior*
5. Mark Baumgartner, WHOI - *Autonomous Gliders for Real Time Passive Acoustic Remote Sensing*
6. Yong Chen, UMaine – *Incorporating Sediment and Hydrography Data in Assessments for Tilefish and Lobster*
7. Daniel Holland, GMRI- *Social Capital in the NE Ground fish Industry: request for Supplemental Funding*
8. Daniel Holland, GMRI-*Understanding the Economic Structure of the Gulf of Maine Lobster Industry*

Theme IV. Protection and Restoration of Resources

1. Keith Cooper, Rutgers - *Evaluation of Biomarkers and Bioindicators for Fundulus heteroclitus in a contaminated and reference location*
2. Jonathan Labaree, GMRI - *Funding Sector Operations and Dockside Monitoring in Fishing Year 2011*
3. Michael Moore, WHOI - *Marine Mammal Health and Entanglement Research*
4. Michael Moore, WHOI – *Health Implications of Entanglements of Large Whales*
5. Andrew Pershing, UMaine - *Impact on Oceanographic Changes on Atlantic Salmon Survival in the Northwest Atlantic*
6. Jason Stockwell, GMRI - *Evaluation of the Importance of Predator and Prey Field and Ocean Circulation on Atlantic Salmon Growth and Survival in the Gulf of Maine*

7. Peter Tyack, WHOI – *Collaborative Research Program Focusing on Behavioral Ecology and Reactions to Sound Populations of Short-Finned Pilot Whales and other Cetaceans Off Cape Hatteras, North Carolina*

Theme V. Sustained Ocean Observations and Climate Research

1. W. Brechner Owens, WHOI - *WHOI Contribution ARGO Float Program (2010-2011)*
2. Andrey Proshutinsky, WHOI - *State of the Arctic (2010)*
3. Thomas Shyka / Riley Young –Morse, GMRI - *Development, Enhancement and Operation of Software Components for the IOOS Data Portal*
4. Albert Suchy, WHOI – *R/V Atlantis Support of CalNEX 2010 Cruise*
5. Albert Suchy, WHOI - *R/V Oceanus Use in Support of NOAA/AOML's Western Boundary Time Series Research*
6. Robert Weller, WHOI - *Ocean Climate Observations and Analyses (2010-2011)*
7. Lisan Yu, WHOI - *Global Ocean Surface Heat Flux Analysis*

THEME I. ECOSYSTEM FORECASTING



Nutrient Dynamics on the NE Continental Shelf; Sample Analyses

NOAA Cooperative Agreement No. NA09OAR4320129 UMaine Subpoint 01
April 01, 2010-March 31, 2011

David Townsend - University of Maine at Orono

NOAA Program Manager: Timothy Sheehan NOAA Fisheries Service

Related NOAA Goal Plan:

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

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

The accelerated melting of the Greenland ice sheet and the Arctic ice cap in recent decades are well documented climate change-related phenomena that are cause for a broad range of environmental concerns. One aspect of these phenomena that appears to be influencing marine ecosystems far removed from the Arctic is an apparent associated change in the circulation of the Labrador Sea and the Northwest Atlantic continental shelf and slope waters, which in turn appears to have resulted in an increased baroclinic transport of low salinity shelf waters to regions farther south. Consequently, those changes are altering 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).

In order to capture opportunities to monitor this apparent change in the ecosystem of the Northwest Atlantic continental shelf, we have been funded by CINAR to analyze samples collected as part of the ***NOAA Northeast Fishery Science Center's Ecosystem Monitoring Program*** (ECOMON Program) in collaboration with Dr. Jon Hare. The ECOMON Program conducts survey cruises approximately four times each year in the Gulf of Maine – Georges Bank – New England shelf region. 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 (March 29, 2011) we have received and processed samples from three cruises conducted in November 2009, and February and November of 2010; station locations are given in Figure 1. Upon completion of our nutrient measurements we combine the resulting data with the CTD data and produce profiles of the hydrography and nutrient properties, such as those given here in Figure 1. We plan to continue to study – with our NOAA and Woods Hole Oceanographic Institution colleagues – the hydrographic and nutrient data collected on future ECOMON cruises, as the data density becomes suitable for more in depth analysis. As with all of our nutrient data processed in our laboratory, we are incorporating them into our regional nutrient and hydrographic database (Rebuck et al., 2009).

HIGHLIGHTS

Results from this study (see Fig. 1) are confirming results of our earlier analyses, that waters are becoming fresher and colder, and proportions of nitrate and silicate are changing (Townsend et al., 2010). Notice in the two stations shown in Figure 1, from the November 2009 cruise, that the deep water concentrations of nitrate and silicate relative to one another reverse. At Station 90, nitrate concentrations exceed silicate at all depths, but at Station 102, silicate concentrations at and below 150 m depth are greater than nitrate.

- Early analyses of data collected by the latest ECOMON cruise in February 2011, By McGillicuddy et al., (2011) are showing that freshening of waters in the Gulf of Maine observed in 2010 is not only continuing into 2011, but water masses entering the Gulf of Maine through the Northeast Channel are among the freshest on record.
- Our analyses of the nutrient samples collected on that February ECOMON cruise will be extremely important in our interpretations of this year's conditions of Paralytic Shellfish Poisoning (PSP) from *Alexandrium* populations. It also follows that continuation of the ECOMON cruises, and analyses of nutrients from those cruise, will be important in interpreting the severity of PSP events into the future.

SOCIETAL BENEFITS

Populations of the red tide dinoflagellate, *Alexandrium fundyense*, appear to have been suppressed through the spring and summer of 2010 as a result altered nutrient loads (McGillicuddy et al., 2011). Early analyses of data collected by the latest ECOMON cruise in February 2011 are showing that this freshening is not only continuing into 2011, but water masses entering the Gulf of Maine through the Northeast Channel are among the freshest on record; therefore, our analyses of those nutrient samples will be extremely important in our interpretations of this year's conditions of Paralytic Shellfish Poisoning (PSP) from *Alexandrium* populations. It also follows that continuation of the ECOMON cruises, and analyses of nutrients from those cruise, will be important in interpreting the severity of PSP events into the future.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

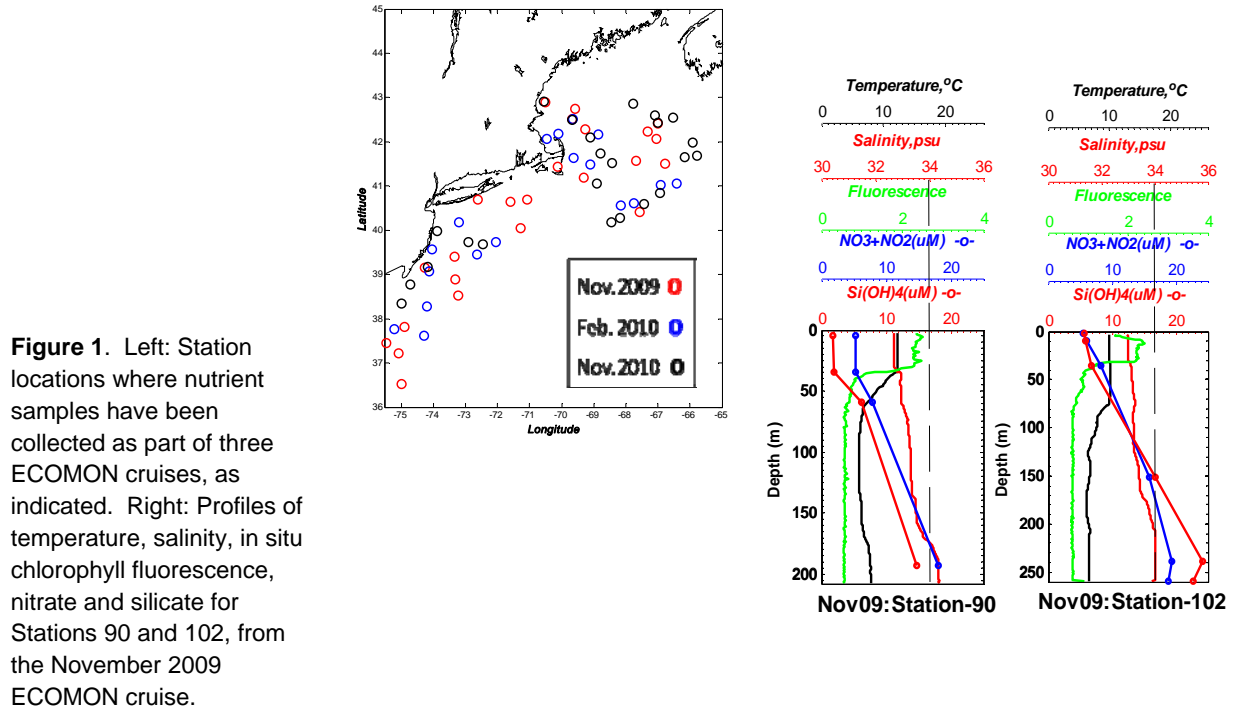


Figure 1. Left: Station locations where nutrient samples have been collected as part of three ECOMON cruises, as indicated. Right: Profiles of temperature, salinity, in situ chlorophyll fluorescence, nitrate and silicate for Stations 90 and 102, from the November 2009 ECOMON cruise.

References cited:

- Rebeck, N.D., D.W. Townsend and M.A. Thomas. 2009. Gulf of Maine Region Nutrient and Hydrographic Database. <http://grampus.umeoce.maine.edu/nutrients/>
- McGillicuddy, D.J., Jr., D.W. Townsend, R. He, B.A. Keafer, J.L. Kleindinst, Y. Li, J.P. Manning, D.G. Mountain, M.A. Thomas, D.M. Anderson. 2011. Suppression of the 2010 *Alexandrium fundyense* bloom by changes in physical, biological, and chemical properties of the Gulf of Maine. Submitted *Limnol & Oceanogr.* 2011.
- Townsend, D.W., N.D. Rebeck, M.A. Thomas, L. Karp-Boss, and R. M. Gettings. 2010. A changing nutrient regime in the Gulf of Maine. *Continental Shelf Res.* 30: 820–832.

Development of National Ocean Service Operational Forecast Systems based on the Regional Ocean Model System

NOAA Cooperative Agreement No. NA09OAR4320129 Rutgers Subpoint 01
April 1, 2010 - June 30, 2011

John Wilkin - Rutgers, the State University of New Jersey

NOAA Program Manager: Aijun Zhang NOAA NOS/COOP

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

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

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

ACCOMPLISHMENTS

A workshop on ROMS NOS OFS applications was organized and hosted by Aijun Zhang and Frank Aikman on Nov. 8-9, 2010 in Silver Spring, MD. Participants included personnel from the Center for Operational Oceanographic Products and Services (CO-OPS), the Coast Survey Development Laboratory (CSDL) of Office of Coast Survey, and Drs. John Wilkin and Hernan Arango from Rutgers University.

At the workshop, Dr. Aijun Zhang described NOAA's Coastal Ocean Modeling Framework (COMF), hardware and software of NOAA's Central Computer System (CCS) which is used to run NOAA coastal ocean OFS, and configurations of the three ROMS-based OFS for Chesapeake Bay, Delaware Bay, and Tampa Bay. Drs. Dick Schmalz and Lyon Lanerolle described lessons learned during development of CBOFS and DBOFS and open issues in need of resolution. Dr. Arango gave a detailed presentation of the latest version of ROMS, emphasizing changes since regional OFS development commenced. Features and capabilities of the next ROMS version that would be useful to OFS development were described, including composite/nested model grids, and better and more efficient variational data assimilation techniques. Dr. Wilkin described ROMS applications that couple hydrodynamic models with biochemical models, sediment transport models, and wave models, and data assimilation.

Best practice for keeping OFS code up-to-date was agreed upon, and a schedule for was established to implement NOS requirements on spatially variable bottom drag formulations, NetCDF compliance for consistency with NOS Data Tanks, and resolution of CCS compiler issues.

The NOS code was updated to ROMS latest release in early January, and all code modifications for NOS requirement were implemented by January 30, 2011, completed the schedule of work under this contract.

HIGHLIGHTS

On March 29, 2011, the three ROMS-based CBOFS, DBOFS and TBOFS systems went into operational implementation. Louis Uccellini, Director of the National Weather Service, commended this success to the Assistantship and Deputy Assistant Administrators of NWS.

Date: Mon, 28 Mar 2011 22:32:07 -0400

Subject: Operational implementation of 3 Bay models by NOS on March 29, 2011 From: Dr. Louis Uccellini <Louis.Uccellini@noaa.gov>

To: Jack Hayes and Laura Furgione

Jack/Laura: Tuesday will mark an historic day for NOAA as numerical prediction models for the Chesapeake, Delaware, and Tampa Bays will be implemented on the operational CCS by NOS/NCO, producing 48 forecasts of 3-D salinity, temperature, currents, and 2-d water levels and surface winds. This represents a major effort on behalf of NOS model developers and NCEP (NCO and EMC) to fulfill the goals established through the NOAA agreement to the SAB recommendation in 2005 that the NCEP central computer be used as a "backbone" for NOS computer forecast models and related ocean and coastal services. By taking this step, NOS made several important enhancements to these models including 1) going from 2d to 3d which yielded marked improvements in water level forecasts; 2) increasing resolutions with a range from 50m to 5 km (expandable/flexible grids); 3) more reliable and quicker access to weather model fields (e.g. model winds); 4) able to feed off the initial and boundary conditions from the NCEP Atlantic HYCOM model; 5) distribute the output via the web and also through NOMADS. Furthermore, the models now run nearly 4x faster than originally planned (due in part to the excellent partnership which developed between the NOS modelers and NCO and will be part of the overall model suite running with 99.98% on time delivery. Last but not least, given the success of these models, it is now possible for NOS and other NOAA components to pursue ecological forecast systems in these Bays. A banner day! I have asked Mary Erickson to share the NOS briefing with the Regional and local WFO's that provide services for these Bays so they too can see what is now possible. Louis.

SOCIETAL BENEFITS

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

THEME II. ECOSYSTEM MONITORING



Field Testing and Expansion of Capabilities of the Environmental Sample Processor: Necessary Steps toward Operational HAB Monitoring and Forecasting in the Gulf of Maine

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 33
April 01, 2010-March 31, 2011

Donald Anderson - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Juli Trtanj NOS/ASTADM

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme I. Ecosystem Forecasting Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

The overall goal of this project is to bring the first commercially produced Environmental Sample Processor (ESP) and the first commercially available ESP mooring to the stage where an instrument can be deployed in the Gulf of Maine to demonstrate its capabilities in HAB monitoring. Until now, all ESP deployments have been by the developer, Chris Scholin at the Monterey Bay Aquarium Research Institute (MBARI).

ACCOMPLISHMENTS

Overall, this project is proceeding well, despite a number of unforeseen issues. It is understandable that some obstacles would have arisen given the transition of an instrument from the developers to commercial production and field deployment by a new team. This was exactly the intention of this funding support from NOAA and thus this project is meeting all of its expectations.

Frequent meetings and conference calls have been held between staff from the Anderson laboratory, and personnel from the ESP manufacturer (McLane Laboratories), the mooring manufacturer (EOM Offshore LTD) and engineers from MBARI. As a result of these discussions, a new cradle was designed and is being manufactured for the ESP, including specialized power cables and battery power supplies. Communications between the ESP (which will be moored at 20 meters depth) and the surface buoy have been complex due to the configuration of the existing cable in the mooring system that is to be utilized. Modifications to that cable, as well as modifications to the ESP itself appear to be necessary. In the long run, these discussions have also indicated that future mooring purchases will

require a different cable configuration with more conductors to facilitate two-way communication with the ESP.

We have contracted with an engineer to oversee the many communications issues associated with deployment. This includes communications between the ESP and the surface buoy, between CTDs and other instruments and the surface buoy, and the surface buoy and shore.

HIGHLIGHTS

- Personnel in the Anderson Laboratory were trained in the operation and maintenance of the ESP. This required several trips to MBARI, and participation in an ESP deployment in Monterey Bay.
- Laboratory testing of the ESP was conducted utilizing field samples collected during *Alexandrium fundyense* blooms in local waters. The ESP was tested across a wide range of cell concentrations and matrixes, and performed extremely well.
- Our MBARI collaborators have generously agreed to ship an instrument and their mooring to WHOI. This instrument will be deployed as a backup should the EOM mooring not be ready for deployment of our own ESP at the beginning of the bloom season in late April. This way, the project team will gain experience in preparing the ESP for deployment, and in the actual deployment and data collection and analysis. Subsequently, the MBARI instrument will be replaced with the WHOI ESP and mooring system to finish the field season.

SOCIETAL BENEFITS

There are significant societal benefits from this project's activities. First, the project team is discovering and solving a number of impediments to deployment of the ESP in coastal waters. The modifications to the mooring system, the development of communications hardware and software, the modifications to the ESP itself, and many other results of this project will directly benefit other users of the ESP in the future, leading to a more rapid adoption of this new technology by scientists and managers throughout the US and the world. This in turn, will lead to improved monitoring of HABs, providing enhanced protection to public health and fisheries resources. It is indeed fortunate that this first phase of the transition of ESP from development to application is being conducted by a team that has extensive seagoing experience, one of the best mooring groups in the world, as well as skilled marine and electronic engineers. The challenges have been significant, but the project is proceeding toward the planned deployment in 2011.

EDUCATION AND OUTREACH ACTIVITIES

Anderson, D.M., D.J. McGillicuddy, Jr., .A. Keafer, and R. He. "Bloom dynamics of the red tide dinoflagellate *Alexandrium fundyense* in the Gulf of Maine: A synthesis and progress towards a forecasting capability", PICES 2010 Annual Science Meeting, Portland, OR (Oct. 2010)

Anderson, D.M., Invited plenary, "Population dynamics of *Alexandrium fundyense* of the Gulf of Maine: A synthesis and outlook for improved management and forecasting", 14th International Conference on Harmful Algae, Hersonissos-Crete, Greece (Nov. 2010)

Anderson, D.M., Invited talk, "Forecasting the New England Red Tide", Nankai University, Tianjin China (Nov. 2010)

Anderson, D.M., Invited talk, "Population dynamics of *Alexandrium fundyense* of the Gulf of Maine: A synthesis and outlook for improved management and forecasting", Jinan University, Guangzhou, China (Jan. 2011)

Anderson, D.M., Invited talk, "Bloom dynamics of the red tide dinoflagellate *Alexandrium fundyense* in the Gulf of Maine: A synthesis and progress towards a forecasting capability", ASLO 2011 Aquatic Sciences Meeting, Puerto Rico (Feb. 2011)

Anderson, D.M., Invited talk, "Bloom dynamics of the red tide dinoflagellate *Alexandrium fundyense* in the Gulf of Maine: a synthesis and progress towards a forecasting capability", Northeast Shellfish Sanitation Association, Rye, NH (March 2011)

Anderson, D.M., Invited talk, "Forecasts of toxic red tides and shellfish toxicity in the Gulf of Maine: Modeling and ocean observations applied to a significant societal problem", NOAA CSCOR, Silver Spring, MD (Mar. 2011)

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Figure 1. Bruce Keafer works with the ESP in the laboratory.

Groundfish Vessel Crew Rapid Assessment

NOAA Cooperative Agreement No. NA09OAR4320129 GMRI Subpoint 06
April 01, 2010-March 31, 2011

Kate Burns and Jessica Joyce - Gulf of Maine Research Institute

NOAA Program Manager: Patricia Pinto da Silva NOAA/NMFS

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II: Ecosystem Monitoring

PROJECT OVERVIEW

The project objectives are threefold:

1. To identify demographic and other characteristics of vessel crew
2. To understand how sector implementation will likely affect this population
3. To identify the best methods to reach this group of stakeholders for follow up research/data collection efforts, e.g., surveys and oral histories.

Our work thus far on the Crew Rapid Assessment (CRA) project has been following these objectives since work commenced in November 2010. Specifically, we have been collecting data on all three objectives during each interview. While information on objectives one and two have been easily expressed during interviews, number three has been more difficult to collect. We ask this question at the end of each interview, and most captains do not have any suggestions. A few have suggested advertising in newspapers, etc.; however one consistent approach has not been identified. We will continue to explore this objective during the data analysis and drafting of the report. We are asking individuals if they are willing to be contacted again in the future and are compiling a contact sheet based on positive responses. Many individuals we've spoken to appreciate that they are being asked for input finally, as they have the sense that they are not generally being considered in management issues.

ACCOMPLISHMENTS

Preliminary outreach on the project was conducted through a notice in *Commercial Fisheries News*, information on GMRI's website, and word-of-mouth. Port visits followed soon thereafter, with focus groups in New Bedford, Gloucester, Pt. Judith, Seabrook, and Portland. One-on-one interviews have been conducted in all ports included in the proposal: Pt. Judith, New Bedford, Scituate, Chatham, Gloucester, Boston, Portsmouth, Portland, and Port Clyde. The turnout at the focus groups has been varied, with up to ten participants in

New Bedford, to one in Portland, and none in New Hampshire. Nevertheless, each interview has been fruitful and informative. During the month of March, we are on schedule to fill-in gaps in underrepresented ports and begin data analysis. Aside from the focus groups, which we are advertising through posters placed in strategic locations in the ports, the Saving Seafood events calendar and GMRI's website, we have primarily been contacting crew and captains through the snowball approach and generally reaching out to boat owners asking permission to speak with their hired captains and crew. Thus far, we have conducted over 60 interviews with hired captains and crew operating under sector management, representing a diverse cross section of ports, cultures, and economic status. As identified in the Social Indicators and Performance Measures project GMRI was involved with in 2009/2010, finding crew who are available and willing to speak with us has continued to be a challenge. Therefore, as the proposal states, we are focusing on obtaining a sufficient number of interviews to represent diverse interests rather than a certain sample size.

HIGHLIGHTS

- The majority of crew have taken a pay cut from operating under sector management (estimated decrease of ~50-75%). This is primarily due to low allocations that result in less fishing effort, and also high lease prices for ACE that have limited small boat owners from leasing ACE and/or lease prices have been taken off the top resulting in lower wages for crew.
- A minority of crew who operate for a multi-permit holder who has been leasing ACE and consistently fishing have seen a significant increase in their wages (~20%).
- There have been many crew jobs lost, and it continues to be difficult to contact crew who have lost their jobs, as many boat owners do not even have contact information. Many of these individuals have sought out non-fisheries related work such as construction, scrap metal, etc.
- Generally speaking about governance, learning and complying with the new DSM requirements during offloads has not been problematic for crew. However, the reporting requirements for captains are time consuming and redundant. Regarding at-sea monitors, smaller boats tend to feel more impact of the presence of an ASM due to space limitations.
- Regarding health and well-being, there has been a significant increase in stress and all the related physical manifestations, including anxiety, blood pressure, heart problems, etc. due to financial concerns.
- When asked to comment on any positive impact from sectors, almost everyone said that regulatory discarding had come to an end, and many fewer fish were being tossed over dead, which pleased them.
- Many individuals commented on and expressed concern over the lack of young people entering the fishery. Younger crewmen (approximately age 45 or younger) who had hoped to buy a permit and enter the fishery felt this had become either undesirable (due to lack of ability to make money and/or enjoy the job) or that this goal was out of reach now, though a few felt that access to a community fishing permit bank may help them in getting a foot in the door.

- Many expressed concern about the impact of decreased revenues and increasing costs on vessel safety--less maintenance work is being done because owners simply can't afford it.

SOCIETAL BENEFITS

Throughout the industry, and even among some managers, there is a perception that the socioeconomic impacts of catch shares, and specifically groundfish sectors are not being assessed at an appropriate level. While this project focuses on one segment of the industry, hired captains and crew, it is still a positive step towards understanding social and economic impacts, and will contribute to a survey instrument that will more broadly record these impacts in the future.

EDUCATION AND OUTREACH ACTIVITIES

No specific outreach and education activities have occurred to date; however the project managers plan to attend the CINAR workshop on conceptual framework for the contribution of the social sciences to ecosystem-based fishery management (EBFM) to integrate project findings into the Framework where applicable. We may also select additional events to present findings once the project has been completed. In addition, through posting focus groups on Saving Seafood, the project has gained attention at the national level, and we have received calls and inquiries from as far as Alaska.

PUBLICATIONS

This contract does not include publication of project results, and we understand that the data are ultimately the intellectual property of the Social Science Branch. Should the Social Science Branch publish results from the project, however, GMRI personnel would be happy to contribute as co-authors.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

We do not have any photographs specifically because of the personal one-on-one nature of these interviews; we do not want to make the fishermen feel uncomfortable.

Development of a HabCAM System for NOAA/NMFS Phase I of III: Construction of a Stereo Camera and Telemetry System

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 29,30,31,and 32
April 01, 2010-March 31, 2011

Scott Gallager - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Russell W. Brown NOAA/NMFS

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

We proposed to provide NOAA Fisheries Service with the tools to enable more efficient and comprehensive surveys of commercially important benthic organisms such as sea scallops and groundfish along with the development of a benthic observatory system capable of quantifying habitat, including species richness, diversity, substrate composition, and ecosystem change on temporal-spatial scales of minutes to decades and mm to 1000s km. The full proposal outlined a three Phase program to implement the development and delivery of a HabCam to the NOAA Fisheries. All three Phases are described below, while Phase I was funded with fiscal Year 2010 funds. Funding became available at the end of September, 2010.

The three Phases are:

Phase I: The construction of a stereo camera and telemetry system and testing in a large seawater tank system.

Phase II: The design and construction of a towed vehicle, software development for stereo imaging, integration of the stereo camera and side scan acoustics systems, field testing, and transitioning the technology into operational oceanography.

Phase III: The development and integration of image informatics tools for automated classification into an image processing pipeline and database.

ACCOMPLISHMENTS

Phase I: Construction of a stereo camera and telemetry system and large tank testing

This module defines the hardware and software necessary to acquire, process, record, and visualize stereo pair images. The stereo HabCam imaging system is a dual machine vision camera, fiber optic based telemetry package capable of producing 1360x1024 pixel, color image pairs 5 times per second. An internal accelerometer provides instrument orientation at 15 Hz. Additional instrumentation may be connected through 8 serial (RS232) ports and 4 GigE Ethernet ports. All data are merged subsea on a local area network and telemetered to the surface over a single mode fiber optic cable. Processing on the top-side computer includes Bayer demosaicing, color correction, light field correction, and compression into a jpeg about 2 MB in size. Images are time stamped to allow registration with ancillary data, metadata, and GIS information including vehicle and ship position, and gyro and meteorological data. All metadata will also be embedded in the image header as they are compressed into a jpeg to ensure data provenance. Cost for this module is \$432,719.

Detailed description of each objective and current status

Objective 1. To design and construct a high resolution GigE digital stereo camera package.

The stereo camera subsystem consists of two ultra-compact 1.4 Megapixel machine vision cameras with Gigabit Ethernet interface at frame rates up to 20 frames per second. Each of the cameras is contained in its own stainless steel housing (3" x 12") with a flat port of 3/4" borosilicate glass. The cameras are rigidly mounted in the housings to avoid movement relative to the glass window. A 12mm F1.4 machine vision lens provides a focal length of about 2.2 meters in water. The two cameras are mounted in a ridged aluminum frame at a baseline spacing of 10cm. The entire stereo camera subsystem is then mounted on the vehicle frame on rubber shocks to minimize vibration.

Depth Rating: The cameras, strobe and telemetry housings were designed to a 500m depth rating. However, after considerable discussion with NOAA personnel concerning a 500m vs 1000m depth rating, we conducted a cost analysis to determine the additional funds required to provide a 1000m depth rating. A full stress analysis on the glass windows, connectors, and o-rings would require development of 3D CAD solid models of all components, virtual hydrostatic loading, and linear eigenvalue buckling analysis. The cost to perform the re-design was \$4,800 for the strobe housings and similar amounts for the cameras and telemetry system housing for a total of about \$15,000. The actual cost to build the housings with a 1000m depth rating was calculated to be only about 20% more than a 500m rating. We also priced out the cost to use titanium vs aluminum for the housings. Because of this additional unbudgeted cost it was decided that we should keep the 500m depth rating and use aluminum for the housings. The current design is good to 500m with a 2x margin, 670m at 1.5x or 800m at 1.25x. Therefore, the design is workable to 670-700m without a problem.

The cameras have been purchased and are undergoing testing and calibration with the new control software (see below). The housings have been fabricated and await assembly.

The cameras will be calibrated in a seawater tank against a standard grid pattern at various altitudes and vehicle orientations. This provides a full calibration model of intrinsic (focal length, principal point, skew, distortion and associated errors) and extrinsic (rotation and translation matrix) parameters. The model allows for correction of image warping due to lens distortion and vehicle orientation, as well as an assessment of pixel level errors in measurements of targets from the corrected image.

Objective 2. To construct a high output strobed lighting package.

The lighting subsystem consists of 4 high output strobes synchronized with the two cameras. The strobes are 20Ws machine vision strobes with xenon bulbs mounted in 10" diameter aluminum housings with a 4" diameter flat glass window. A custom trigger board contained in each housing was designed to accept the TTL trigger signal from the master camera and convert it to a diode protected 10 Vpp signal to drive the strobe. A power supply converts 110VAC to 12VDC to power the trigger board and strobe. A small fan circulates air throughout the strobe housing. The exposure of the strobes is approximately 1 microsecond providing motion artifact free, stop action images while traveling at 5 kts. The lighting subsystem will have a depth rating of 500m. Strobes have been purchased and the housings have been fabricated.

Objective 3. To construct a fiber optic-based data and image telemetry system.

The Telemetry Subsystem consists of a 10x24" aluminum housing containing necessary components for supplying power to the two cameras, one optical Ethernet converter, four strobes, two 8 port Ethernet switches and two, 4 port serial to Ethernet converters. On the end caps there are 6 Gigabit Ethernet fiber optic connectors (two from the cameras, one for the sidescan, and 3 for expansion), 8, 6 pin connectors supplying power (12 and 24 VDC) and serial communications (RS232) to external sensors (4 are used currently with 4 additional for expansion), connectors for power and communications to the strobes and cameras, a 3 pin connector for power from the surface cable, and a four-pass optical conductor Subconn connector to transmit optical information from the fiber optic tow cable to the Telemetry Subsystem.

Telemetry between cameras and the surface will be based entirely upon gigabit ethernet. Coarse Wave Division Multiplexing techniques are used to bring 3 separate gigabit ethernet channels up a single fiber. Each camera bottle has its own gigabit connection, while ancillary sensors and control will occupy another. At the surface, these connections will be de-multiplexed and supplied to the appropriate computing subsystems. This system is a derivative of that used on the WHOI-designed Nereus Hybrid ROV, and will use entirely Commercial Off The Shelf (COTS) equipment. The strobes and cameras are triggered by a hardware board located in the telemetry housing. This provides a hardware trigger synchronizing both cameras and the four strobes at whatever frequency that is set by the user through the GUI. The advantage of using a hardware trigger over software control is absolute time synchronization of the stereo cameras. Components for the telemetry system are being tested. The telemetry housing has been fabricated.

Objective 4. To develop the software necessary to collect, transmit and store stereo image pairs and ancillary environmental data.

Running on a topside high end computer, a GUI provides a selection of a variety of parameters for vehicle operation and image acquisition including acquisition rate (1-20 Hz), exposure, and strobe synchronization. Images are displayed in a window as the vehicle is towed over the seafloor. Initial image processing on the ship includes acquisition and logging of the raw images, Bayer demosaicing, color and light field correction, image de-warping using the camera calibration model, and conversion and compression to a jpeg or other compressed image format.

This software package is operational on the benchtop with the cameras and control board. We are running the cameras in unicast mode, but acquire the data using a publish and subscribe system that makes it available on the network to other nodes--this system is called LCM, and it has been successfully used for this purpose. Metadata logging is similar to the current stereo system in that an ascii flat file is produced with no front end logger. Metadata are also written into the raw (png) image headers as it is stored for a permanent record. The raw image pairs are simultaneously sent to several PCs, one to store them and one to do image processing (color and field correction. Bench top test show that stereo pair images may be written either to separate PCs or to the same PC but to separate drives. A color corrected image will be created on the fly (most likely on a GPU) for bitblipping on a display for driving purposes. A jpeg or similar compressed image may be created and stored for instant viewing purposes. Data from up to 8 serial devices are packetized and sent via the CWDM over the network to be picked up and logged by the second PC and also sent to the SQL database. The image name associated with each line of metadata is recorded along with each data record. Four Ethernet expansion ports are available on the telemetry housing to allow additional high bandwidth sensors (e.g., sidescan sonar) to be recorded by PCs on the surface.

HIGHLIGHTS

- A stereo HabCam system has been designed and is currently being constructed
- Software to acquire stereo image pairs and process and record them has been completed.
- We are on track to complete and deliver the new system to NOAA for a test cruise on the R/V Sharp departing Woods Hole on June 20, 2011.

SOCIETAL BENEFITS

This project will provide NOAA NMFS with a complete optical system to quantify scallops and groundfish which will be considerably more efficient and accurate than methods currently in use.

EDUCATION AND OUTREACH ACTIVITIES

1. New Bedford Working waterfront booth
2. Presentations at the 2010 and 2011 Mass Marine Educators conference
3. Development of a citizen's science web portal similar to zoiniverse

FIGURES/PHOTOGRAPHS

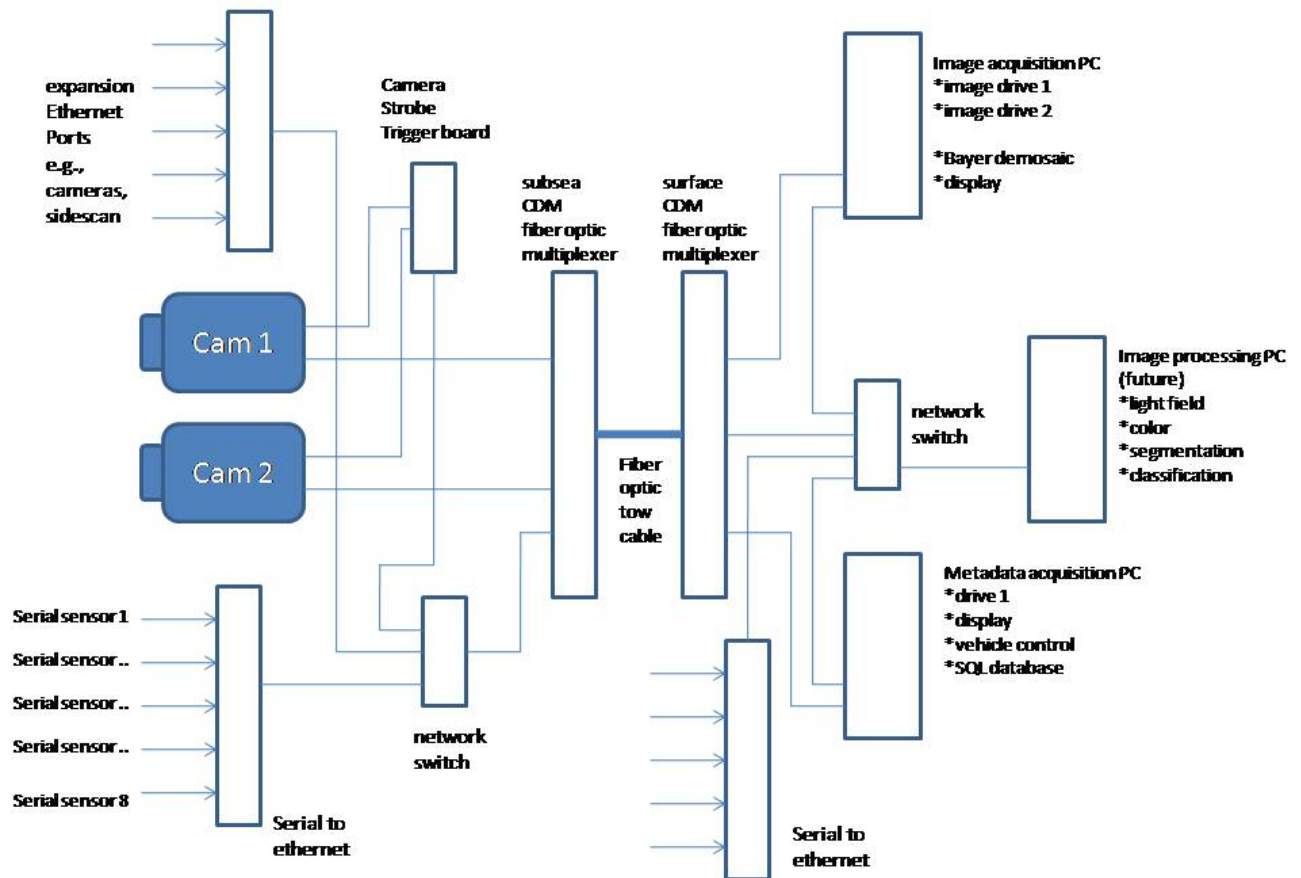


Figure 1. The Stereo HabCam Imaging System

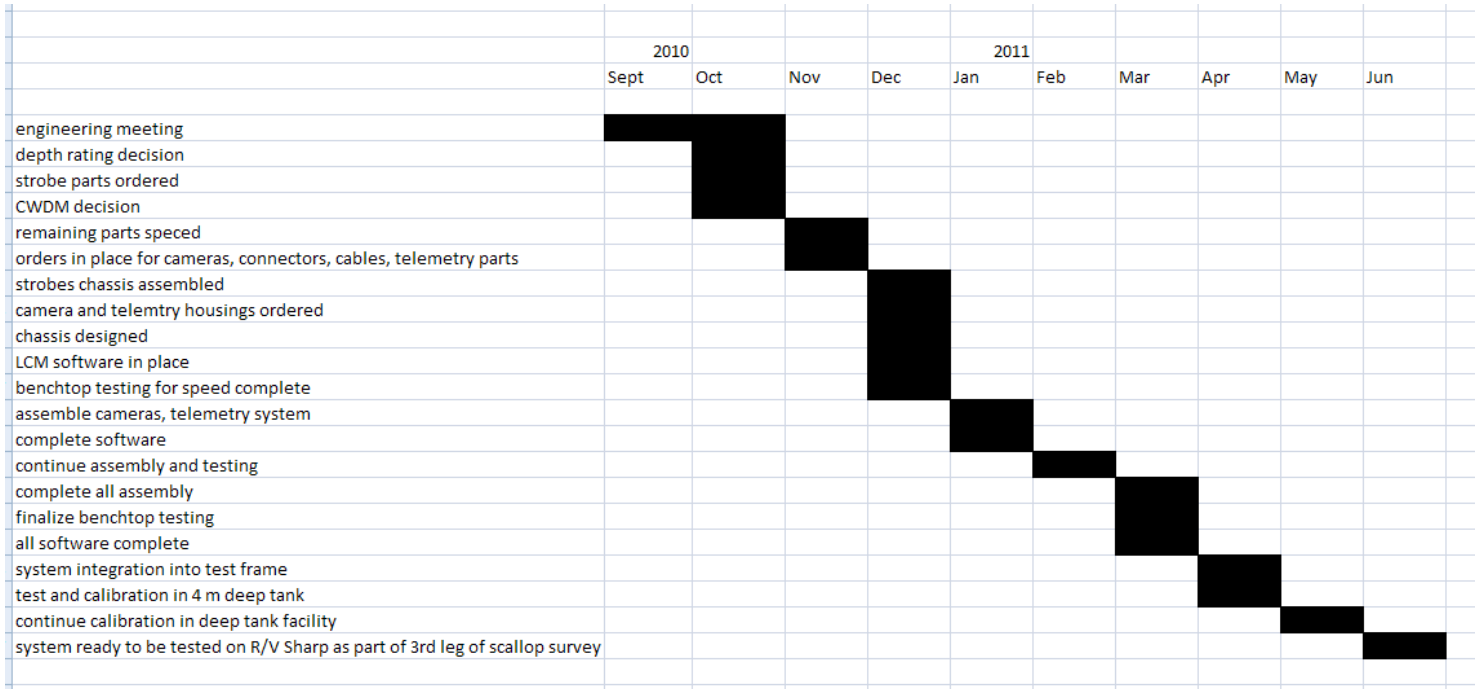


Figure 2. Timeline for construction of the Stereo HabCam Imaging System

Image Analyses Tools for Quantitative Mensuration and Classification of High Resolution Optical Imagery, Improving Visual Survey Methods for Groundfish and Reef Fish Using the SeaBED AUV

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 03
April 01, 2010-March 31, 2011

Hanumant Singh - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. John Rooney Pacific Islands Fisheries Science Center
NOAA Fisheries

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW:

This effort is aimed at building new tools to aid in the quantitative mensuration and automated classification of underwater imagery. In this context it will form a package of tools that include:

- Classification tools for merging and examining the imagery in the context of all the metadata
- Methods for the fusion of multi-sensor (optical and acoustic) imagery
- Tools for making quantitative measurements of individual organisms from calibrated camera systems
- Tools for automatically classifying the background habitat associated with a particular image

ACCOMPLISHMENTS:

This project is ongoing.

Our prototype tool has now been developed and is being used by NOAA personnel. As part of the efforts associated with this annual cycle, this tool is in the process of being augmented to allow for analysis specific to the coral reef community. This will provide the functionality of adding point clouds in the imagery that is the de facto method for coral reef ecological studies.

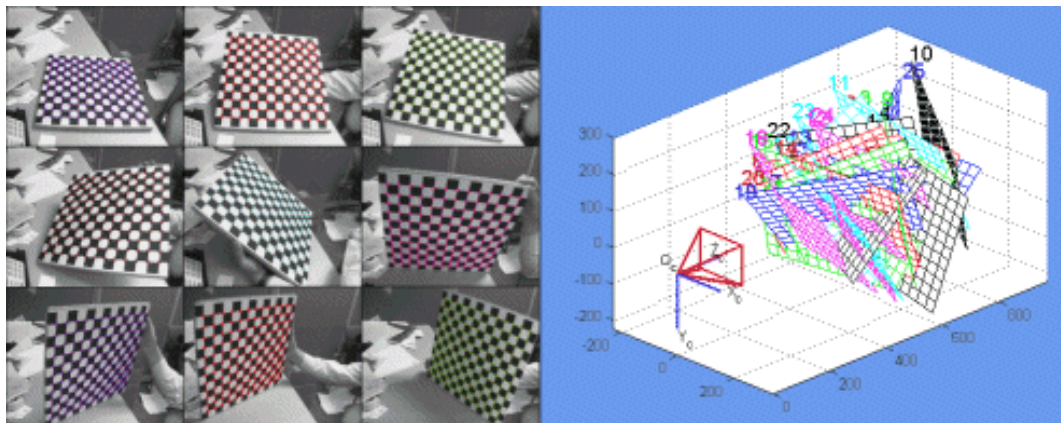
We have also continuing to integrate a larger forward facing optical camera on the AUV which will allow for far greater resolution in the imagery at high data rates 5-6Hz in areas where ambient light is available. This will be accomplished while preserving all the aspects of high dynamic range that are of high interest for the coral reef imaging applications.

HIGHLIGHTS:

New functionality is being added to the fishrock tool for automated classification and mensuration especially for coral reef studies.

- A new high resolution camera is being added to the AUV for enhanced imaging.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Camera Calibration (utilizing the Camera Calibration Toolbox from Jean Yves-Bouguet) is now incorporated into all camera classification efforts so as to reduce the effects of lens distortion on the sizing of organisms

SeaBED AUV Tech Support and Development

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 28
April 01, 2010-March 31, 2011

Hanumant Singh - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Elizabeth Clarke NOAA Northwest Fisheries Science Center

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW:

This effort is aimed at supporting the Northwest Fisheries Science Center in its efforts to continue to use the Seabed AUV for the collection of imagery off areas of interest on the seafloor. It includes ongoing efforts to enhance the vehicle capabilities by adding functionality for real-time acoustic telemetry, and for enhanced camera systems.

ACCOMPLISHMENTS:

This project is ongoing.

Personnel were involved in a number of cruises to utilize the vehicle for collecting fisheries related data along the West Coast.

We have also been continuing to integrate a larger optical camera on the AUV which will allow for far greater resolution (11 Megapixel) in the imagery to enable greater resolution in aiding in fish classification to the species level.

The camera enhancements were considered in part with enhancements to existing vehicle network bandwidth considerations so as to ensure the overall system reliability and functionality.

HIGHLIGHTS:

Newer higher resolution cameras are being added to the AUV for enhanced imaging.
- Ongoing support for data collection efforts while at sea



FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



A New 11 Megapixel, 12 bit dynamic range self logging camera was integrated onto the AUV which will allow for far greater resolution to enable species level identification of fish on the seafloor.

Development of Automated Tools for Underwater Photographic Analysis: Improving Visual Survey Methods for Groundfish and Reef Fish Using the SeaBED AUV

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 02
April 01, 2010-March 31, 2011

Hanumant Singh - Woods Hole Oceanographic Institution

***NOAA Program Manager: Dr. Elizabeth Clarke NOAA Northwest Fisheries Science
Center***

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through
Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW:

This effort is aimed at building new tools to aid in the quantitative mensuration and
automated classification of underwater imagery. In this context it will form a package of
tools that include:

- Classification tools for merging and examining the imagery in the context of all the
metadata
- Methods for the fusion of multi-sensor (optical and acoustic) imagery
- Tools for making quantitative measurements of individual organisms from calibrated
camera systems
- Tools for automatically classifying the background habitat associated with a particular
image

ACCOMPLISHMENTS:

This project is ongoing.

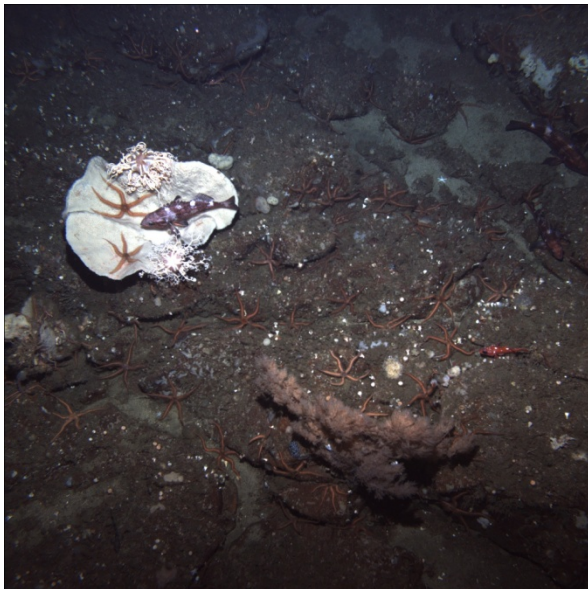
Our prototype tool has now been developed and is being used by NOAA personnel. As part of the efforts associated with this annual cycle, this tool is in the process of being augmented to allow for calibration data to be collected for lens distortion parameters and such that the imagery can be corrected for such errors prior to its use for habitat and species level classification and mensuration. We have also been continuing to integrate a larger optical camera on the AUV which will allow for far greater resolution (11 Megapixel) in the imagery while preserving all the aspects of high dynamic range that are of high interest underwater.

HIGHLIGHTS:

New functionality is being added to the fishrock tool for automated classification and mensuration of fish

A new high resolution camera is being added to the AUV for enhanced imaging.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Current work is aimed at the automated classification of habitat and in the mensuration of fish species from calibrated optical imagery.

THEME III ECOSYSTEM MANAGEMENT



US National Office for Harmful Algal Blooms

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 13
April 01, 2010-March 31, 2011

Donald Anderson - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Quay Dortch NOAA Coastal Ocean Program, N/SC12

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through

CINAR Theme:

Theme III. Ecosystem Management

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 is among the top 5 WHOI sites visited each month, typically with over 6,000 visits per 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 are continuing to expand our state and regional resource section with the help of a subcommittee of the National HAB Committee on education and outreach.

A recent web activity that will continue through next year is in support of the NHC subcommittee on Freshwater HABS. That group is compiling material that can complement the content already on the *Harmful Algae* site. Considerable coordination will be needed to provide the appropriate links, to maintain a consistent format, and to avoid overlap while filling important gaps.

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:

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.who.edu/redtide/page.do?pid=14898&tid=542&cid=47899&c=3 for an example).

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.

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 14th International HAB Conference, Crete, Gordon Research Conference, and the Sixth US HAB symposium,

US HAB symposia. Kleindinst serves on the Steering Committees for the *Sixth Symposium on Harmful Algae in the U.S.*, which will be held in November 2011 in Austin, TX. She is providing significant administrative support for this meeting, working closely with the organizers throughout the planning process.

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

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. Anderson has served as Co-Chair for the past five years and Kleindinst provides administrative support and serves as an ex officio member. She 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

- PI Anderson participated as a plenary speaker at the “*Changing Oceans and Human Health*” session, 11th National Conference on Science, Policy, and the Environment, Washington, DC

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., “Modeling and forecasting *Alexandrium* blooms and shellfish toxicity in the Gulf of Maine”, Stakeholder workshop on modeling climate and toxic blooms of *Alexandrium catenella* in Puget Sound, University of Washington, Seattle, WA (August 2010)

Anderson, D.M. “Report on ICES HAB working group and potential areas of collaboration”. PICES 2010 Annual Science Meeting, Portland, OR (October 2010)

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/>



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

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI subpoint 27
April 01, 2010-March 31, 2011

***Donald Anderson - Woods Hole Oceanographic Institution and David Mountain,
University of Arizona***

NOAA Program Manager: Jonathan Hare NOAA NMFS Oceanography Branch

Related NOAA Goal Plan:

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

CINAR Theme:

Theme I. Ecosystem Forecasting

PROJECT OVERVIEW

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

ACCOMPLISHMENTS

The location of four sections across the MAB (off Martha's Vineyard, Long Island, New Jersey and Delaware Bay) and a section along the middle of the cold pool were chosen. For the cross-sections the length along each section with water less than 12 c was determined for each fall since 1968. The 12 c value was chosen because the Essential Fish Habitat document for yellowtail flounder indicated that the population, particularly juveniles, preferred temperatures below 12 c. The minimum and mean temperature along the mid-line of the cold pool was determined for each fall since 1968. The mean temperature along the mid-line was determined for all surveys of the region, regardless of time of year. An annual cycle was fit to these values and anomalies from the annual cycle determined, allowing comparison between years even when the observations were not at same time each year. For the MAB from Nantucket to Delaware Bay (the characteristic distribution of yellowtail flounder) a volumetric average temperature and salinity were determined for the shelf water (water with salinity < 34), as well as the volume of the shelf water for all surveys that covered the region. Annual cycles and anomalies were determined for these parameters. Preliminary analysis did not find any obvious relationship between these oceanographic series and the yellowtail flounder spawning stock biomass, recruitment or recruit per spawning stock biomass time series.

HIGHLIGHTS

- For the Long Island, New Jersey and Delaware Bay transects the time series for the extent of water less than 12 c were quite similar, suggesting that the temperature changes were broadly coherent and that temperature indices likely would not need to be sub-regional nor be highly dependent on having data from specific locations.
- The anomalies of shelf water volume and shelf water temperature were well correlated suggesting that changes in water temperature were associated in large part with the advection of more or less water into the MAB from the Gulf of Maine/George Bank region to the northeast.

Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 07& 12
April 01, 2010-March 31, 2011

Carin Ashjian - Woods Hole Oceanographic Institution

NOAA Program Manager: Mr. David Rugh NMML/AFSC

Related NOAA Goal Plan:

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

CINAR Theme:

Theme III. Ecosystem monitoring

PROJECT OVERVIEW

The Beaufort Sea Shelf to the north and east of Barrow AK is a critical feeding area for migrating bowhead whales, particularly during the fall migration from their summer grounds in the Canadian Arctic to their over-wintering grounds in the northern Bering Sea (e.g., Lowry et al., 2004). The project is a component of the larger "Bowhead Whale Feeding in the Western Beaufort Sea" project coordinated by the National Marine Mammal Laboratory (2007-2010) and follows two years (2005 & 2006) of oceanographic surveys conducted as part of an NSF funded project (Ashjan, Lead PI) that was part of the Study of the Northern Alaska Coastal System (SNACS) program. The work addresses relationships between the formation and distribution of bowhead whale prey (zooplankton) aggregations, oceanographic conditions, and bowhead whale distributions in the Western Beaufort Sea by conducting oceanographic sampling, including sampling of whale prey, on both the coarse (shore-shelfbreak) and fine (on the shelf, near feeding bowhead whales) scales.

The specific objective of this project was to sample on the Beaufort Sea shelf from Barrow, AK east to ~152 °E during mid-August to mid-September 2010 using high vertical-resolution oceanographic sampling along several shore-shelfbreak transects from a 43' boat and fine scale oceanographic and prey sampling in regions where bowhead whales were observed to be feeding.

There were no significant changes to objectives, approach, methodology, or rationale.

ACCOMPLISHMENTS

Fieldwork was conducted from Aug. 17-Sept. 20, 2010 using the *R/V Annika Marie*, based in Prudhoe Bay, AK. Surveys concentrated on three sampling lines that had been sampled during 2005-2009, with complete or partial surveys of Line 1 (once), Line 2 (three times), Line 4 (three times), Line 5 (once), and Line 6 (twice) (Figure 1). One of the samplings of Line 2, on September 1, was conducted completely at night to sample in darkness. The sampling of Line 1 also is a component of the 2010 Distributed Biological Observatory repeat transect sampling that was designed by the an international group of researchers as a means to gain repeated sampling at a common location. Additional sampling near where feeding bowhead whales were observed also was conducted.

The oceanographic sampling was highly successful. One hundred twenty-six (126) stations were conducted, including many with multiple types of instrument deployments or collections. The Acrobat towed vehicle (temperature, salinity, chlorophyll and CDOM fluorescence, optical backscatter) and the acoustic Doppler current profiler (ADCP) were towed along most lines. Sampling at discrete stations was conducted using a CTD, ring nets, a Tucker Trawl, and Niskin bottles to collect water samples for determination of chlorophyll *a* and nutrient concentrations, for flow cytometry analyses to enumerate the abundances of phytoplankton and coccooid cyanobacteria (an indicator of Pacific Water), and for microscopic analysis for microplankton composition and abundance (a component of our companion NSF-funded Arctic Observing Network project). Bird (Aug. 19-Sept. 6) and marine mammal (entire period) distributions also were recorded.

Significant year-to-year variability in the temperature-salinity characteristics of the waters sampled within the Barrow Canyon-western Beaufort shelf study area has been observed over the six years (2005-2010) (Fig. 2). Ocean temperatures this year were similar to those observed during 2005, with warmest ocean temperatures at $\sim 8^{\circ}\text{C}$. The 2005, 2007, 2009, and 2010 surveys encountered very warm Pacific Water ($>4^{\circ}\text{C}$), whereas the 2006 and 2008 surveys encountered much cooler Pacific Water. The presence of extensive sea ice cover in 2006 is reflected in the prevalence of sea ice meltwater; meltwater also was observed in 2008 but not significantly in the other four years.

The plankton community in 2010 was notable in that it contained high abundances of chaetognaths, ctenophores, small copepods, and medusae. High abundances of euphausiids (krill), a key prey item for bowhead whales) were not, qualitatively, observed on the shelf through much of the sampling period. Even when krill did become abundant, medusae and ctenophores were still very abundant and dominated the plankton biomass at many locations.

Shorter-term variability in conditions on the shelf was intimately tied to the direction and strength of the wind. Wind forced upwelling along the shelf followed by weak winds or winds from the east produce high abundances of krill on the shelf near Barrow. Bowhead whales were observed feeding following formation of the krill "hot spot" during September 2010.

HIGHLIGHTS

- Considerable interannual variability in physical and biological oceanography has been observed between the six years of our observations. To date, 2005, 2007, and 2010 were years with warm ocean water temperatures and little sea ice while 2006 and 2008 were years with much colder ocean water and considerable sea ice, and 2009 was intermediate in temperature between the two extremes.
- The oceanography and whale prey distribution on the shelf near Barrow are intimately tied to wind forcing.
- A favorable feeding environment for bowhead whales near Barrow is created when krill are upwelled onto the shelf from along the Beaufort Shelf break and subsequently trapped and aggregated there by ocean currents.
- This favorable feeding environment is created predictably each year, despite the considerable interannual variability in ocean conditions.
- Much lower abundances of krill, key prey for the bowhead whale, were observed on the shelf in 2010 relative to previous years.
- The presence of photosynthetic coccoid cyanobacteria is an indicator of the presence of Pacific Water in the Arctic, with no cyanobacteria present in the two cold years (2006, 2008) but present in high abundance in the warmer years (2005, 2009) (Note: no sampling for cyanobacteria was conducted in 2007). It appears that coccoid cyanobacteria are present only when water temperature exceeds $\sim 4^{\circ}\text{C}$ (not shown). Strangely, coccoid cyanobacteria were observed in only a few samples of very warm Pacific Water in 2010. The presence of Pacific Water (PW) at Barrow is tied to larger scale atmospheric conditions that promotes or inhibits transport of PW north through Bering Strait.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

Ashjian, C.J., Campbell, R.G., Okkonen, S.R., Sherr, B.F., Sherr, E. B. 2011. Year-to-year variability of ocean conditions across Barrow Canyon and the western Beaufort Shelf: 2005-2010. Alaska Marine Science Symposium, January 19, 2011. Oral.

Okkonen, S.R., Ashjian, C.J., Campbell, R.G. 2011. Does the Alaska Coastal Current carry krill to the Arctic? Alaska Marine Science Symposium, January 18, 2011. Poster.

Vate Brattstrom, L., Goetz., K.T., Rugh, D.J, Ashjian C.J., Okonen, S.R., Campbel, R.G. 2011. Bowhead whales feeding in echelon formation. Alaska Marine Science Symposium, January 18, 2011. Poster.

Okkonen, S.R., Ashjian, C.J., Campbell, R.G. 2010b. Sea ice as a tracer for circulation features associated with the Barrow area Bowhead whale feeding hotspot. AGU Fall Meeting, December 16, 2010. Poster.

Ashjian, C.J., Braund, S.R., Campbell, R.G., George, J.C., Kruse, J.A., Maslowski, W, Moore, S.E., Nicolson, C.R., Okkonen, S.R., Sherr, B.F., Sherr, E.B., Spitz, Y.H. 2010a. Environmental Variability, Bowhead Whale Distributions, and Iñupiat Subsistence Whaling near Barrow, AK. State of the Arctic, March 16-19, 2010, Miami, FL. Oral.

Ashjian was invited to present results from the Bowhead Whale Feeding Study at the mid-summer quarterly meeting of the Alaska Eskimo Whaling Commission in Fairbanks AK.

PUBLICATIONS

Okkonen, S.R., Ashjian, C.J., Campbell, R.G., Clarke, J., Moore, S.E., Taylor. Satellite observations of circulation features associated with the Barrow area bowhead whale feeding hotspot. In Revision for Remote Sensing of the Environment.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

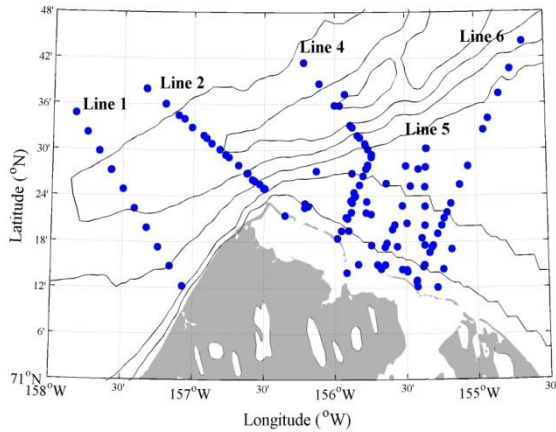


Figure 1. Locations of stations sampled in 2010. Underway sampling using the Acrobat towed vehicle and the ADCP also was conducted on the outbound legs of most samplings of Lines 2, 4, and 6. Line 1 was included as a component of the international 2010 Distributed Biological Observatories.

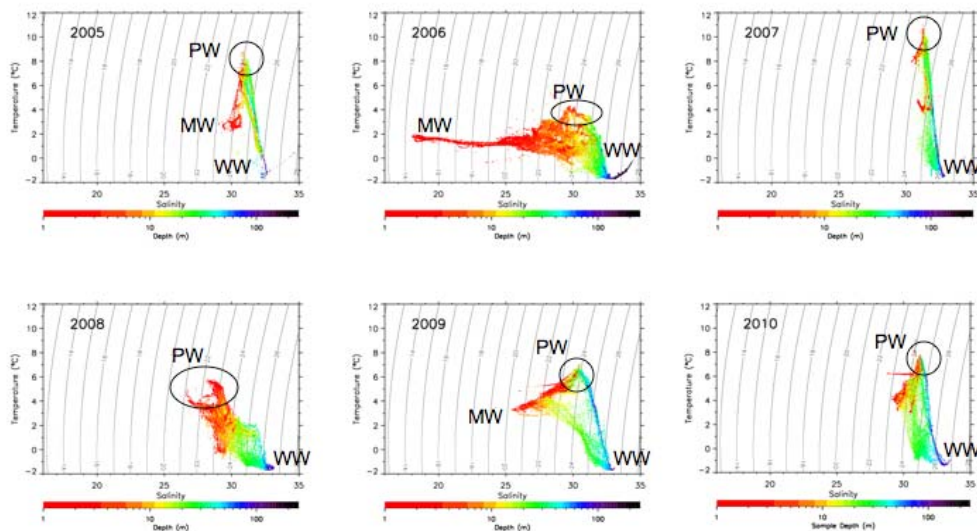


Figure 2. Temperature-Salinity plots of each year's aggregate (Acrobat and individual cast) CTD data. Representative water masses are Pacific Water (PW), Winter Water (WW), and Meltwater (MW). Curved lines are isopycnals (constant σ_t). Color indicates water depth at each data location.

Bowhead Whale Feeding in the Western Beaufort Sea; Oceanographic Conditions, Whale Prey Distribution and Whale Foraging Behavior

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 12
April 01, 2010-March 31, 2011

Mark Baumgartner - Woods Hole Oceanographic Institution

NOAA Program Manager: Mr. David Rugh NMML/AFSC

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme I. Ecosystem Monitoring

PROJECT OVERVIEW

The Beaufort Sea Shelf to the north and east of Barrow, Alaska is a critical feeding area for migrating bowhead whales, particularly during the fall migration from their summer grounds in the Canadian Arctic to their winter grounds in the northern Bering Sea. The project is a component of the larger “Bowhead Whale Feeding in the Western Beaufort Sea” project coordinated by the National Marine Mammal Laboratory (2007-2010). The project addresses relationships between the formation and distribution of bowhead whale prey (zooplankton) aggregations, oceanographic conditions, and bowhead whale distribution and feeding behavior (e.g., diving patterns relative to prey distribution) in the Western Beaufort Sea by deploying oceanographic moorings, by conducting oceanographic sampling on both the coarse (shore-shelfbreak) and fine (on the shelf, near feeding bowhead whales) scales, and by tagging feeding bowhead whales for periods of hours to describe foraging and feeding behavior relative to prey distributions.

ACCOMPLISHMENTS

Field operations for tagging and fine-scale oceanography took place from August 18 to September 21, 2010. Our objectives for the fieldwork were to (1) attach archival tags to bowhead whales, and (2) intensively sample oceanographic conditions and prey distribution in proximity to the tagged whales. As in 2009, we used a dermal attachment short-term tag developed specifically for this project (Figure 1). The new tag was designed to overcome (1) difficulties in approaching bowheads at close enough range for tagging, and (2) irregularities in the skin that made suction-cup tags ineffective.

During 15 days at sea, we tagged 8 bowhead whales, 6 of which had attachments lasting between 45 minutes and 2.3 hours. A total of 42 casts with the vertical profiling instrument package were conducted in proximity to the tagged whales. The tagged whales tended to travel over relatively large distances while tagged, ranging from 7 to 21 km. Swimming speeds during these events ranged from 3.2 to 4.9 knots. It is unlikely that any of the tagged bowhead whales were actively feeding during the time we tracked them. Observations from the video plankton recorder collected in proximity to the tagged whales indicated that zooplankton abundance was quite low. Gelatinous zooplankton (e.g., hydromedusae and ctenophores) were more abundant near the tagged whales, but they were also numerically more abundant than euphausiids and large copepods across the entire study area. The abundance of euphausiids and large copepods, the two main prey items of bowheads on the Beaufort Sea shelf, were well below concentrations that could be considered profitable for a feeding whale. From the diving and movement behavior of the tagged whales, there was no evidence of bowheads feeding on any of these taxa during the tagging events.

Bowhead whale movements did not appear to be associated with any fine-scale oceanographic features on the shelf. Colder and fresher conditions prevailed in the eastern part of the study area, and warmer saltier water, likely of Pacific origin, was predominant in the western part of the study area; however, the tagged whales were found in both of these conditions and in some cases, crossed over the boundary between these two water masses. Both along-shelf and cross-shelf movements were observed.

HIGHLIGHTS

- Our new dermal attachment tag proved quite successful for tracking and monitoring the diving behavior of bowhead whales during the 2010 field season.
- The abundance of bowhead whale prey off of Barrow, Alaska, in late summer 2010 was very low, and no feeding behavior was observed among the tagged whales (although small scale feeding aggregations comprised of non-tagged whales were occasionally observed during the study period).
- Observations of coordinated movements among widely distributed bowheads led us to hypothesize that bowhead whales forage cooperatively using acoustic signals to facilitate coordinated movements and activities.

SOCIETAL BENEFITS

Studying the movements and foraging behavior of bowhead whales will allow us to better understand why the western Beaufort Sea shelf is such an important area for the whales during their spring and fall migrations. Significant changes are underway in this ecosystem, including climate change and increase industrial activity (e.g., shipping, oil and gas exploration and extraction, and eventually fishing), which will undoubtedly affect both the whales and the Iñupiat communities that depend on the bowhead whale for subsistence. Mitigating impacts to the whales will require a fundamental understanding of the ecology of this important species.

EDUCATION AND OUTREACH ACTIVITIES

Baumgartner, M.F. and T. Hammar. 2010. Using a new short-term dermal attachment tag to study bowhead whale foraging ecology in the western Beaufort Sea. AGU/ASLO Ocean Sciences Meeting. Portland, Oregon. February 22-26, 2010.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

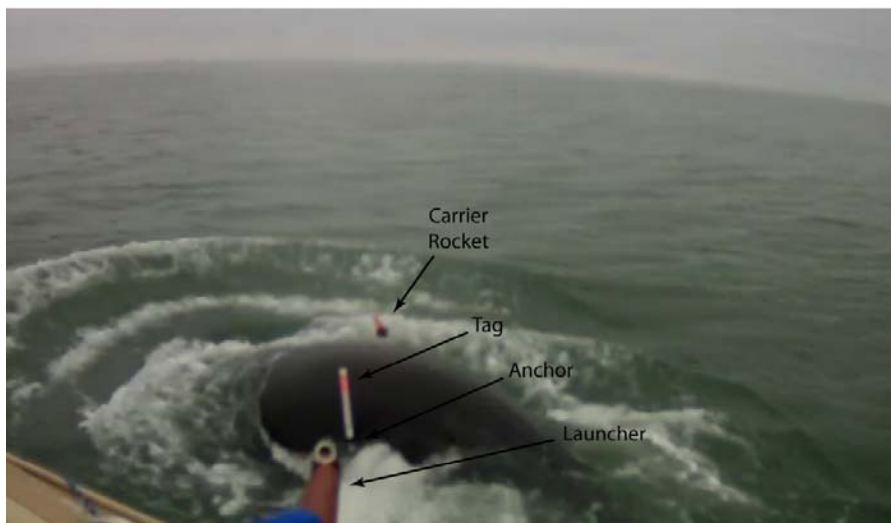


Figure 1. (top) Close approach to bowhead whale immediately prior to tagging with short-term dermal attachment tag. Note launcher in the foreground. (bottom) Successful attachment of projectile dermal attachment tag showing separation of dermal anchor, tag, and carrier rocket after contact with the whale. Images taken from video camera mounted two inches from tagger's right eye.

Autonomous Gliders for Real Time Passive Acoustic Remote Sensing

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 26
April 01, 2010-March 31, 2011

Mark Baumgartner - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Sofie Van Parijs NOAA/NMFS

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

The overarching goal for this project is to explore the capability for autonomous gliders to provide real time locations of marine mammals as part of the NOAA Northeast Fishery Science Center's ongoing efforts to monitor and assess marine mammal stocks. Our specific objectives for the work are (1) to demonstrate the efficacy of near real-time detection, classification, and reporting of baleen whale calls from ocean gliders, and (2) to validate the performance of the detection/classification/reporting system using concurrent visual and acoustic observations of baleen whales.

This project relies on two enabling technologies: Slocum coastal gliders and the DMON acoustic instrument. Gliders are autonomous vehicles that can move both vertically and horizontally, carry a full suite of oceanographic sensors, and can report location, sensor data, and vehicle status remotely via Iridium satellite communications. Slocum gliders can sample at temporal scales of several weeks and spatial scales of several hundreds of kilometers. The DMON is a new instrument developed at WHOI capable of recording broadband acoustic data (10 Hz to 60 kHz) and analyzing those data in near real time to detect and classify species-specific calls. Integration of the DMON with Slocum ocean gliders allows summary detection/classification data to be sent to shore-based researchers via the gliders' native Iridium satellite communication system. The development of the DMON, its integration into gliders, and the development of detection/classification algorithms for baleen whales has been supported by the Office of Naval Research, and is now available for evaluation by NOAA as a research and management tool. In year 1 of this 2-year project (the current reporting year), we deployed DMON instruments aboard ocean gliders in record-only mode to test the integration of the instrument with the glider. We have recently implemented the real-time reporting and classification system on the DMON, so we will be doing full real-time detection, classification and reporting during our year 2 field trials.

ACCOMPLISHMENTS

In the first year of this 2-year project, we deployed three DMON-equipped ocean gliders in the Great South Channel (southwestern Gulf of Maine) during the spring of 2010. Gliders were operational for just under 4 weeks and completed repeated longitudinal and latitudinal transects (Figure 1) during which they recorded acoustic data from a variety of sources. The Great South Channel is of particular management interest because of the seasonal occurrence of the highly endangered North Atlantic right whale. In addition to the right whale, the Great South Channel is a seasonal habitat for humpback, fin, sei, and minke whales during the springtime. Each glider completed four transects across the Channel between Nantucket Island and Georges Bank, and acoustic recordings of baleen whale calls are currently being processed using a custom built automated detector (Baumgartner and Mussoline in press). The NEFSC right whale surveillance program carried out an aerial survey in the Great South Channel to verify the presence of whales near the glider and to estimate the abundance of those whales. In conjunction with the glider deployments, the NEFSC North Atlantic right whale cruise on the R/V *Delaware II* recorded sightings of marine mammal species throughout the Great South Channel as well as photo ID, biopsy and oceanographic studies near aggregations of right whales and other baleen whales.

HIGHLIGHTS

- Successfully deployed 3 ocean gliders in the southwestern Gulf of Maine during spring 2010 for 4 weeks; gliders recorded a variety of baleen whale calls, including those from humpback, fin, sei, and North Atlantic right whales.
- Completed manuscript on a generalized baleen whale call detection and classification system, and the paper is now in press with the Journal of the Acoustical Society of America.
- Implemented the generalized baleen whale call detection and classification system on the DMON, and are preparing for in-field testing of the real-time detection and reporting capabilities.

SOCIETAL BENEFITS

This research project will improve our understanding of the distribution and habitat of endangered baleen whales in the Gulf of Maine and will provide a new monitoring tool for NOAA's mandated marine mammal assessment responsibilities.

PUBLICATIONS

Baumgartner, M.F. and S.E. Mussoline. 2011. A generalized baleen whale call detection and classification system. *Journal of the Acoustical Society of America*. in press.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS -

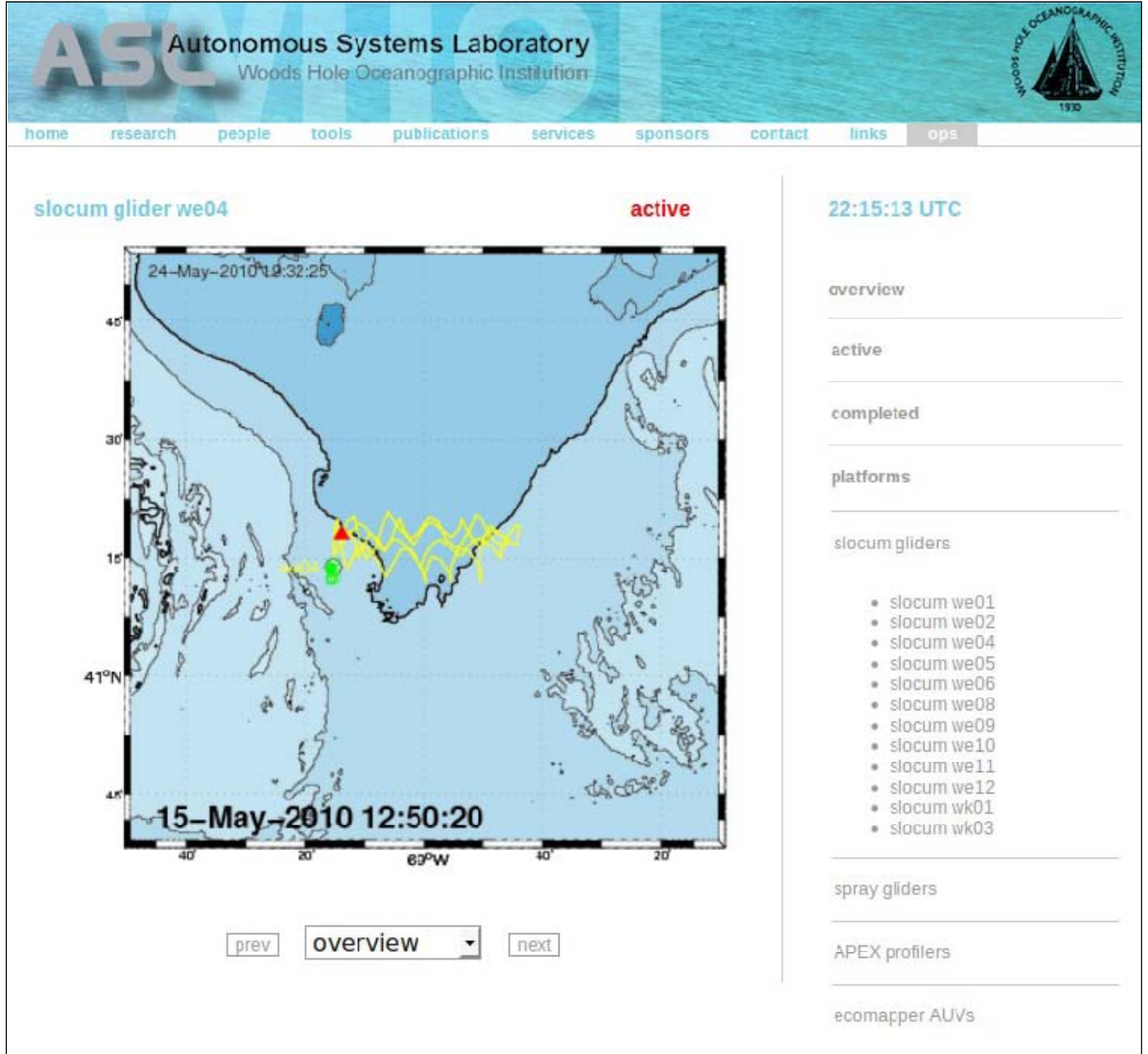


Figure 1. Glider transect plan for the Great South Channel, with initial glider deployment location shown as a green circle and the retrieval location shown as a red triangle. In spring 2010, three gliders were deployed along these transect lines. The location of the transect was chosen based on maximum encounter rates of baleen whales during visual shipboard surveys conducted in 2004-2007.

Incorporating Sediment and Hydrography Data in Assessments for Tilefish and Lobster

NOAA Cooperative Agreement No. NA09OAR4320129 UMaine Subpoint 00
April 01, 2010-March 31, 2011

Yong Chen - University of Maine at Orono

NOAA Program Manager: Kristen Larson NMFS F/ST4

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme II. Ecosystem Monitoring

PROJECT OVERVIEW

The objectives of this study as identified in the original proposal include employing a generalized additive modeling approach to 1) identify habitat associations for Gulf of Maine (GoM) American Lobster and Gulf of Mexico (GoMex) golden tilefish, 2) develop maps for lobster and tilefish in relation to various sediment and hydrographic factors, 3) improve precision of CPUE estimates by including habitat in index standardization, and 4) develop prior distributions for virgin biomass or recruitment (tilefish) for use in assessment models, leading to improved data quality and stock assessment.

We used a two-stage generalized additive models (GAMs) to identify key habitats influencing lobster distributions. This two-stage GAM, an extension that parallels delta-lognormal modeling approaches, allows for the explicit modeling of the probability of occurrence and the density given a positive observation and preserves the information content associated with of zero observations, but avoids problems associated with unrealistic assumptions such as assumed monotonic responses and normality of the predictors. Data are obtained from various sources including fisheries-independent surveys.

During the report time period, we focused our research efforts on American lobster, but also started to compile and analyze tilefish data.

ACCOMPLISHMENTS

We have accomplished the following tasks for the American lobster:

- The Maine-New Hampshire inshore trawl survey data for 2000 to 2009 were analyzed by season and sex;
- Lobster survey density for each tow record was log transformed and standardized by tow distance;
- The derived survey density was then standardized using GAM model with Gaussian error structure and identity link function. Four models, fall-female, fall-male, spring-female and spring-male models were constructed and seven variables, latitude, time of the day fishing, depth, bottom temperature, bottom salinity, wave condition, and year, were included in the models;
- In order to compare the standardized year coefficient to the non standardized ones, besides the full model with seven variables, a model with only year variable was also constructed for each of the four modeling groups;
- For the fall models, the seven variables were all significant with 47.1% and 48.5% deviance explained for females and males, respectively (Fig. 1);
- For the spring models, wave condition and time of the day fishing were not significant and were not retained in the final models. The spring model explained 44.5% and 45.9% of the deviances for females and males, respectively (Fig. 2);
- The trend of standardized year coefficients was similar to the non standardized ones. Reverse trends were only found for between 2000 to 2001 and 2006 to 2007 for both sexes in the fall and 2005 to 2006 for both sexes in the spring (Fig. 3).

We are currently using the standardized survey CPUE data to run the stock assessment for the lobster in the Gulf of Maine. We have found that the assessment model cannot be converged with the new standardized survey CPUE, indicating that the impacts of environmental variables on survey catchability may have large impacts on the stock assessment. We are currently conducting simulation study to quantify such impacts. We are preparing a manuscript to describe this study.

For the tilefish, we have started to identify key habitat variables and compile the data. A trip has been planned in May 24-27 for two PhD students (Jui-Han Chang and Sam Truesdell) to work with Dr. John Walter and Dr. John Quinlan in the NOAA Miami Lab. All the computer program codes have been developed and will be re-fined at the meeting.

HIGHLIGHTS

- Habitat variables can greatly influence distribution of American lobster in the Gulf of Maine
- The lobster habitat model we have developed provides us a capacity to project how spatial distribution of American lobster may change with changes in temperature fields in the Gulf of Maine (climate changes)

- Although temporal trend is similar between nominal and standardized lobster survey abundance indices, standardized survey abundance index tends to show more temporal variability and may greatly affect the lobster stock assessment results.

SOCIETAL BENEFITS

This study provides us with a better understanding of how fish distributions may be affected by environmental variables. The model developed in this study allows us to project potential consequences of changes in some key habitat variables such as temperature and bottom type. As a result, society can have a better understanding of dynamics of ecosystems.

EDUCATION AND OUTREACH ACTIVITIES

Two PhD students (Jui-Han Chang and Sam Truesdell) are involved in this project, which helps them understand the importance of habitats and modeling skills. No presentations have been made, but we plan to present some results in a fine-scale stock structure workshop in June 2011 and some results on the lobster work will be presented at UMaine School of Marine Sciences Graduate Symposium in May 2011. More presentations will be planned once we have completed work in the tilefish.

PUBLICATIONS

We are preparing a manuscript for the lobster work described in this study.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

(See attached figures that are cited in Accomplishment section)

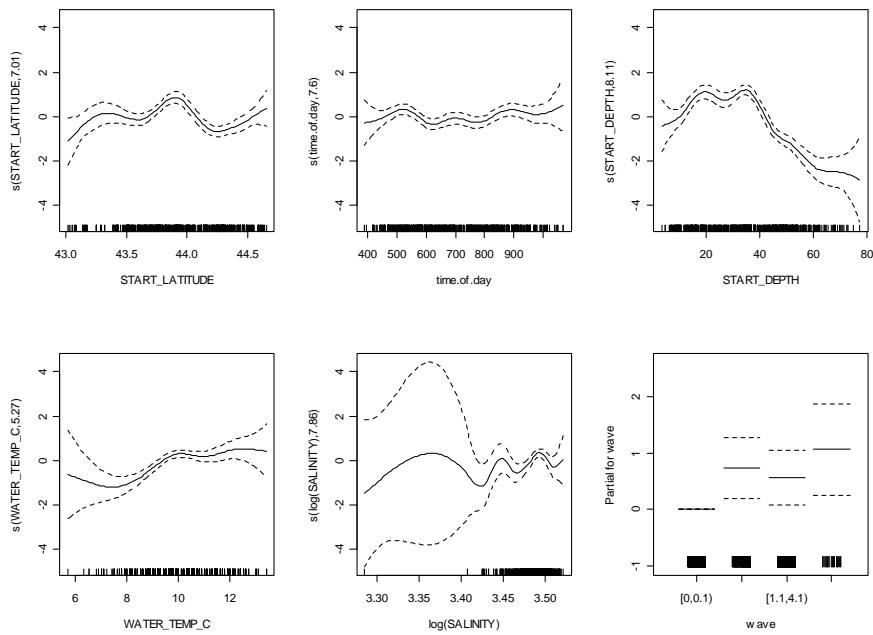


Fig. 1-a Estimated smoothing of the six environmental variables (latitude, time of the day fishing, depth, temperature, salinity, and wave condition) on the density of female lobster in the fall.

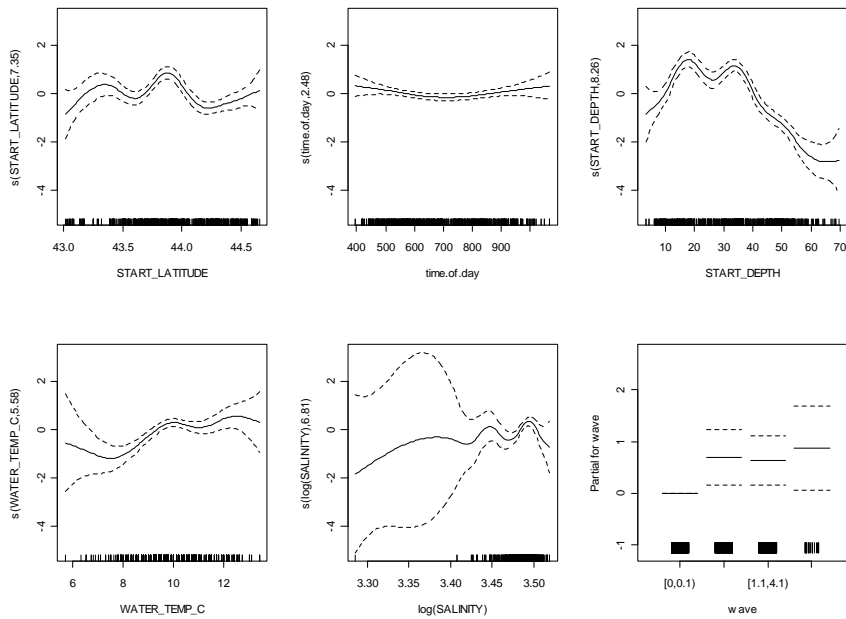


Fig. 1-b Estimated smoothing of the six environmental variables (latitude, time of the day fishing, depth, temperature, salinity, and wave condition) on the density of male lobster in the fall.

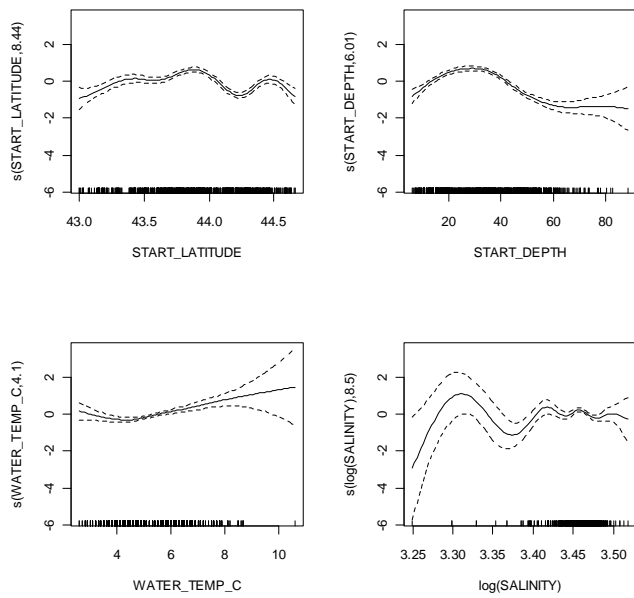


Fig. 2-a Estimated smoothing of the six environmental variables (latitude, depth, temperature, and salinity) on the density of female lobster in the spring

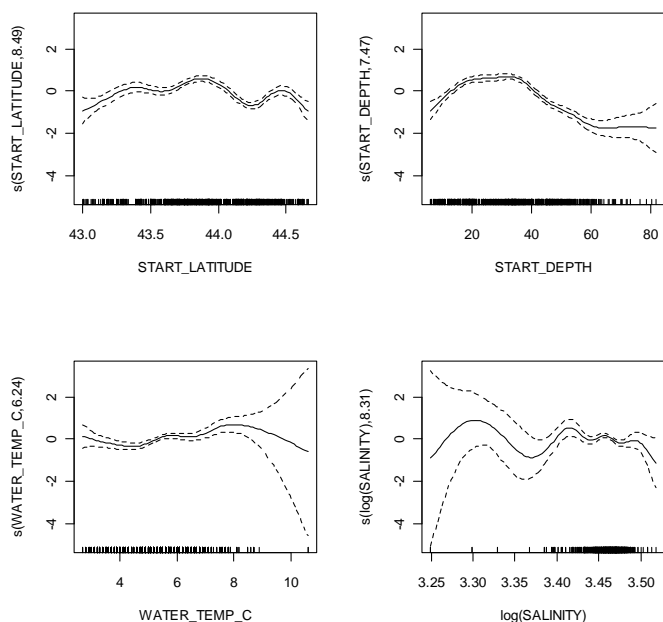


Fig. 2-b Estimated smoothing of the six environmental variables (latitude, depth, temperature, and salinity) on the density of male lobster in the spring.

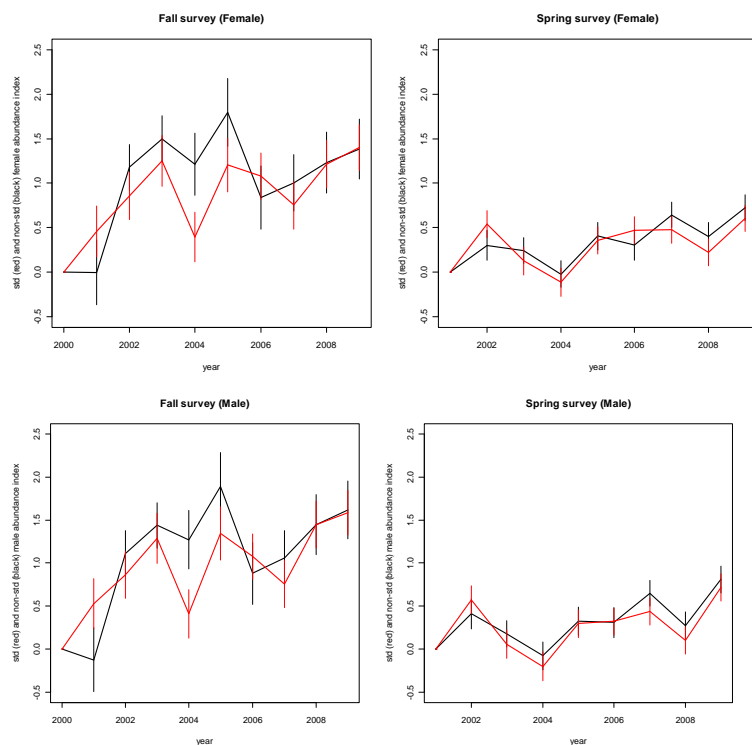


Fig. 3 Plot of standardized and non standardized year coefficient of lobster survey density by sex and season.

Social Capital in the NE Groundfish Industry: Request for Supplemental Funding

NOAA Cooperative Agreement No. NA09OAR4320129 GMRI Subpoint 00
April 01, 2010-March 31, 2011

Daniel Holland - Gulf of Maine Research Institute

NOAA Program Manager: Patricia Pinto da Silva NMFS/ Social Science Branch

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme III. Ecosystem Management

PROJECT OVERVIEW

The New England groundfish fishery is undergoing a major transformation with the expansion of the “sector” allocations to 17 new sectors in addition to the two existing sectors. This new approach, which devolves substantial management responsibilities to groups of fishermen, represents a potential transformation in the relationship among fishermen as well as the relationship between fishermen and the management councils. The success of sectors is likely to depend largely on the attitudes and capabilities of the members that join them and skills and commitment of sector leaders. We hypothesize that their success will depend in part on the strength of the relationships between members including their degree of trust and collaboration.. Because sectors will be able to trade annual catch entitlement with other sectors to balance catches that exceed their initial allocation, we hypothesize that the connections and ability to cooperate with other sectors will also be important determinants of success. These are the basic dimensions of social capital at the community level: strong’ intra-community ties (“bonds”) and ‘weak’ extra-community networks (“bridges”). Both are needed to evaluate social capital at the community level. We also expect that sectors will build norms and new networks for better information sharing that will enable increased collective action over time. Sectors might also build better relationships with heterogeneous groups or institutions, often in a position of influence or power, referred to as linking social capital. The collective value of these relationships is commonly referred to in social and economic literature as social capital.

There has been no evaluation of the social capital of existing Groundfish sectors or of the proposed sectors or other baseline information that may explain their future success or failure. We designed and implemented a survey to collect the baseline information necessary to measure the social capital of existing sectors and of new sectors before they

begin operation. We also surveyed a sample of permit holders that have not joined sectors. In addition to information relevant to measuring social capital, we collected baseline information that can be used to measure performance of groundfish sectors in terms of socio-cultural and safety outcomes. We will utilize the data collected from the survey to derive assessments of social capital of the sectors. We plan to follow this with one or more additional surveys after the sectors have been operating to determine the role social capital played in their success (or lack thereof) and how whether and how the social capital of the sectors has evolved over time. The resulting Groundfish Social Capital Sector Survey will be pilot tested and administered as a phone survey targeted at active groundfish permit holders.

We attempted a census (approximate population=500) of permit owners of all active groundfish vessels and a sample of inactive groundfish permit with the goal of completing more than 375 interviews (75%). We attempted to reach at least a 50% response rate by individual sector.

ACCOMPLISHMENTS

We completed development of the survey in 2009 and contracted with Market Decisions (a market research company) to implement the survey as a phone survey. In order to reach some of the permit holders who are Portuguese speakers, we had the survey translated into Portuguese and sent a paper version to permit owners identified as Portuguese speakers.

The survey was implemented in January-March 2010 and achieved a greater than 50% response rate for all but two of the sectors and the sample common pool vessels. In total, 542 groundfishermen completed the survey. The original list of permit holders included 907 groundfishermen. Overall response rate was 64% with the majority of sectors reaching a 50% or greater response rate. Only NFS IV (0%), NFS IX (38%), and NFS VII (40%) did not reach 50% (mostly due to poor response to the Portuguese language survey). Most sector response rates were between 50% and 70% with NCCS (100%), NFS XII (80%), and Port Clyde Community (74%) responding above 70%.

We completed an initial analysis of the data from the survey and produced a summary report of the findings as a Northeast Fisheries Science Center Reference Document. Additional analysis of the survey data is underway. That analysis will develop social capital indices and scores for each sector and will statistically analyze the relationships between individuals' expectations of success of sectors and trust of fellow sector members with the social capital scores of the sectors to which they belong.

In order to develop social capital indices and scores for each sector, an extensive literature review was done to define the different dimensions of social capital referenced above: bridging, bonding, information sharing and linking social capital. Questions from the survey were then grouped into these different dimensions of social capital based on multiple discussions with the project team about the relevance and significance of each question in defining an index score for each of these social capital dimensions. The survey

data was then recoded so that indices can be consistently compared within and between sectors; and so that the social capital indices may be used as explanatory variables to explain the relationship between social capital and important outcomes of social capital.

HIGHLIGHTS

The survey results showed that a high degree of social capital exists in the industry as a whole including a high degree of trust among fishermen and substantial cooperation through information sharing. These social capital features are likely to be critical to the success of sectors and to sector management in general. Preliminary analysis of the social capital indices also show that level of social capital initially endowed in sectors varies across sectors, in aggregate; and that the social capital indices vary within sectors. For instance, some sectors are endowed with more bonded social capital and less bridging social capital, and other sectors have opposite endowments. The social capital literature argues that both bonding and bridging social capital is needed for maximum economic potential within groups, communities, or in our case, sectors. Too much bonding social capital could isolate the sector from external business opportunities. Too much bridging social capital could make sector members feel like “outsiders”, who might be denied access to privileged information or local business opportunities. Since we wish to determine the baseline level of social capital in sectors, we can only say how much endowed social capital exists based on a constructed index designed to measure the key components of social capital thought to define bonding and bridging relationships.

The survey also revealed that permit holders in the groundfish fishery are generally dissatisfied with the current fishery management system and there remains substantial trepidation about the new sector system. There also remains a high degree of uncertainty about expected income over the next few years, both in sectors and the common pool.

SOCIETAL BENEFITS

Sector management has the potential to better ensure the sustainability and increase the profitability of the Northeast Multispecies fishery. This project will show the role that social capital plays in the success of sectors, what types of social capital are important, and how social capital is developed. Understanding the role of social capital in the success of sectors will help sectors and regulators identify ways to invest in developing social capital to improve the success of sectors in the future in this fishery and others.

EDUCATION AND OUTREACH ACTIVITIES

An abstract was submitted and accepted to the Biennial Conference of the North American Association of Fishery Economists (NAAFE) which will be held in Honolulu in May 2010. Josh Wiersma, Dan Holland, Patricia Pinto Da Silva and Andrew Kitts are co-authors and Josh Wiersma will present the paper.

PUBLICATIONS

Holland DS, Pinto da Silva P, Wiersma, J. 2010. A survey of social capital and attitudes toward management in the New England groundfish fishery. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-12; 13 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at <http://www.nefsc.noaa.gov/nefsc/publications/>

Understanding the Economic Structure of the Gulf of Maine Lobster Industry

NOAA Cooperative Agreement No. NA09OAR4320129 GMRI Subpoint 05
April 01, 2010-March 31, 2011

Daniel Holland - Gulf of Maine Research Institute

NOAA Program Manager: Eric Thunberg NEFSC/ Social Science Branch

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme III. Ecosystem Management

PROJECT OVERVIEW

This project was designed to provide managers and the industry with critical data, analysis and evaluation tools on which to base new policies and programs to increase the profitability of the lobster industry and to evaluate impacts of regulatory actions. The project provides the data, analysis and analytical tools necessary to evaluate how profitability may be affected by changes in lobster abundance, input and output prices, regulations such as effort reduction, and changes in fishing practices such as shifting production to seasons when lobster quality and price are higher.

The data collection was focused on Maine which accounts for 90% of landed value from LCMA1 but included some vessels from Massachusetts and New Hampshire. In addition to collecting detailed cost, earnings and effort data on a representative set of LMA1 lobster vessels, the project provides vessel level profit simulators that can be used to evaluate how profitability at the vessel level is affected by changes in input and output levels and prices, catch and catch rates, etc. The project also served to develop and test a set of survey questions that will be integrated into a larger, though somewhat less detailed, economic survey of LMA1 lobstermen.

Data were collected through pre-scheduled in-person interviews with a sample of LCMA permit holders. We gathered detailed information on revenues, catch, effort and fixed and variable costs. Lobstermen were selected primarily from Maine where the vast majority of LCMA1 lobstermen operate. Using individual interviews to collect data allowed us to acquire high quality and detailed data but also limited the number of individual that can be surveyed. To make the most of the limited sample we deliberately targeted a range of representative lobstering operations that reflects the diversity of the industry. We also

stratified our data collection into four regions: (1) Downeast Maine, (2) Midcoast Maine, (3) Southern Maine, and (4) New Hampshire and Northern Massachusetts with five surveys carried out in each of the Maine regions and three surveys carried out on vessels from New Hampshire and Northern Massachusetts.

We developed individual vessel-level profit simulators for each of the lobster operations surveyed. The simulators allow the user to specify key expected input prices (e.g. fuel and bait prices) and output prices (lobster price by season and grade), and seasonal catch rates. The user can also specify activity levels and the simulator will then calculate expected profits. These vessel simulators allow for analysis of how profitability is impacted by changes in input and output prices, changes in activity level, and changes in catch rates. The simulators also facilitate analysis of the impacts of shifting activity amongst seasons given varying catch rates and prices.

ACCOMPLISHMENTS

A survey instrument was developed in an electronic (spreadsheet) form allowing for direct data entry during the survey. A vessel cost and profit simulator was developed to draw data directly from the survey form. A total of 18 surveys were completed, and vessel simulators have been completed for all vessels. The data from the project, some summary analysis and a final report on the project has been delivered to the Northeast Fishery Science Center.

HIGHLIGHTS

The surveys collected to date demonstrate a high degree of variability in input use, productivity, cost per unit of catch, income and profitability across the vessels surveyed. Because the sample of lobsterman is not random (but rather designed to enable modeling a representative fleet of vessels), averages of survey variables or calculated values such as profit cannot be assumed to represent industry wide averages. However they should be indicative of economic performance for the active fleet. Most of the lobstermen surveyed are operating with an accounting profit when not taking into account their own labor costs; however, many of them are operating at a loss when the opportunity cost of their own labor and a return on capital are considered as costs. Of the 18 vessels surveyed, average accounting profit is \$35,935 while average economic profit (loss) that accounts for the opportunity cost of capital and their own labor is -\$6,935. The survey also shows that bait costs are on average 1.6 times total fuel costs and account for about 14% of gross revenues suggesting that profitability of the fishery is vulnerable to increases in bait costs. Despite the diversity in operations in terms of total revenues, total effort, and spatial and temporal distribution of effort, net revenues (gross revenues minus fuel, bait and crew costs) has a very high correlation with gross revenues. This suggests that measures of gross revenues from lobstering, which should now be available for all vessels in LMA 1, should provide a reasonably good means of approximating net revenues which is a useful measure of profitability. A simple linear regression of net revenues (i.e. gross margin) against gross revenues yields an R² of 0.89 and suggests that marginal net revenues are about 69% of gross revenues.

SOCIETAL BENEFITS

American lobster is the most valuable fishery in the northeastern United States in terms of gross value with landings valued at over \$303 million in 2009 --down from a peak of \$415 million in 2005 (NFMS 2009). LCMA 1 accounts for over of 90% of US American lobster landings. Maine accounts for around 90% of LCMA1 Lobster landings in recent years and the Maine fishery supports over 5500 permit holders, but there is almost no economic data available on the Maine fleet at the vessel level. Although the gross value of the fishery is high, the profitability of the fishery is low (GMRI 2008) and is decreasing with increases in fuel and bait prices and recent declines in ex-vessel price. Better economic data on this fishery will enable stakeholders and managers to design and evaluate management reforms to maintain or improve the profitability of the fishery and will also enable regulators to determine the likely impacts of regulations and changes in prices on industry profitability.

EDUCATION AND OUTREACH ACTIVITIES

The data and vessel simulators were provided to the Maine Lobsterman's Association (MLA) who will in turn provide the individual simulators to the individual's that completed the surveys. MLA will also be able to use these simulators to predict potential economic impacts on their members of changes in input and output prices and other factors.

THEME IV. PROTECTION AND RESTORATION OF RESOURCES



Evaluation of Biomarkers and Bioindicators for *Fundulus heteroclitus* in a Contaminated and Reference Location

NOAA Cooperative Agreement No. NA09OAR4320129 Rutgers Subpoint 00
April 01, 2010-March 31, 2011

Keith Cooper - Rutgers

NOAA Program Manager: Reyhan Mehran NOAA Assessment and Restoration Division

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW

There are no significant changes in the objective approach or methods.

The population-based bioindicators examined included:

- effort versus biomass collected;
- gonadal to body weight ratios;
- number of eggs stripped from ripe individual females;
- fertilization rate;
- successful stage development;
- hatching success; and,
- three days post hatch survival.

Additional studies will be carried out during the current breeding period. Larval samples will be fixed and held for potential additional evaluation with Alcian blue staining for proper head and jaw formation.

ACCOMPLISHMENTS

Chronic exposure to *Fundulus heteroclitus* populations inhabiting a reference location and a mercury/PAH/PCB tidal marsh have resulted in altered reproduction. Specific subgroups within the population have shown altered fecundity and biochemical biomarkers at the enzyme levels. The unequal response is likely due to different chemical exposures to the subgroups within the population. Studies will be continued over the 2011 breeding period to determine if these effects can be reproduced and whether there is a shift in the dose response between the reference and exposed populations

HIGHLIGHTS

Subgroups within the contaminated site showed altered enzymatic activity at the expression and protein level.

- There does appear to be adaptation to the contaminants as they relate to reproduction and Cyp 1A levels.

SOCIETAL BENEFITS

This type of research allows for a determination as to whether there is a persistent impact on indigenous populations living in a partially restored contaminated wet land. This also can indicate potential impacts on people living near this area. There is also the determination if the site was adequately restored.

EDUCATION AND OUTREACH ACTIVITIES

Both an undergraduate and a graduate student were involved in the analysis of this data.

Funding Sector Operations and Dockside Monitoring in Fishing Year 2011

NOAA Cooperative Agreement No. NA09OAR4320129 GMRI Subpoint 03
April 01, 2010-March 31, 2011

Jonathan Labaree - Gulf of Maine Research Institute

NOAA Program Manager: Dan Morris NMFS/NER

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW

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

GMRI worked with sector organizers to develop a formula to distribute dockside monitoring funds based on pounds of fish landed, fishing trips monitored, and the use of roving monitors (when a vessel offloads its catch to a truck, which then goes to a dealer). Since May, 2010, GMRI has been administering federal funds for dockside monitoring of sector trips and provided funds to cover start-up costs for New England's groundfish sectors.

GMRI has instituted a subaward process whereby each sector has a signed subaward that includes a budget and payment terms. In addition, GMRI has provided training to the groundfish sectors in managing and tracking federal grant funds.

ACCOMPLISHMENTS

During the reporting year, GMRI has distributed a total of just over \$386,039 in funding for dockside monitoring. Funds have been distributed to each of the 16 actively fishing groundfish sectors (one sector is a lease-only sector and does not engage in active fishing). GMRI has also distributed a total of \$306,996 in start-up assistance. These funds covered a range of expenses including sector manager salaries, office space, software, legal assistance, and auditing services. Each sector has received start-up funds, many at the maximum \$18,824.

GMRI has provided training to the sectors and financial oversight on the federal funds. GMRI maintains close communication with NMFS regarding the cost of dockside monitoring and the progress of that program.

HIGHLIGHTS

- distributed \$386,039 in federal funds to support sector dockside monitoring
- distributed \$306,996 in federal funds for sector start-up costs
- provided training to sector managers in federal grant administration

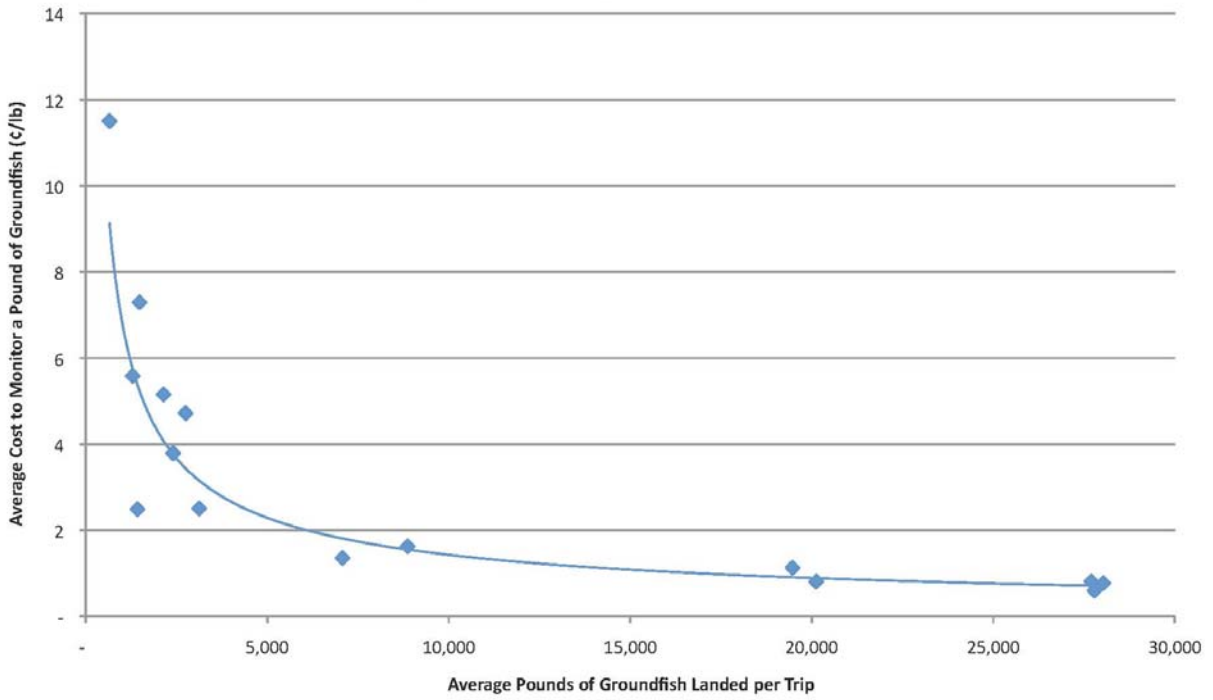
SOCIETAL BENEFITS

This is not strictly a research project, but the societal benefits include assisting fishing communities throughout the region make the transition to sector management. Sector management, in turn, is expected to yield benefits to society that will include rebuilding the groundfish stocks while allowing fishing families more flexibility in running their businesses.

EDUCATION AND OUTREACH ACTIVITIES

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

**Cost of dockside monitoring for New England's groundfish sectors
May, 2010 through January, 2011**



Marine Mammal Health and Entanglement Research

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 08
April 01, 2010-March 31, 2011

Michael Moore - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Teresa Rowles Marine Mammal Health and Stranding Response Program

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW

Dr Michael Moore to undertake a review of large whale euthanasia and prepare a working paper for an International Whaling Commission workshop in Maui, Hawaii April 12-16, and to attend that workshop in year one.

- A subaward to Dr Sophie Dennison to provide diagnostic imaging studies to the Marine Mammal Health and Stranding Response Program for 50 days in the year and to attend the National Stranding Conference in Shepherdstown, WV April 5 to 9 2010.
- A subaward to Dr Jooke Robbins to undertake a review of large whale entanglement and prepare a working paper for an International Whaling Commission workshop in Maui, Hawaii April 12-16 2010, and to attend that workshop.

ACCOMPLISHMENTS

Task 1. The euthanasia review was undertaken, the paper submitted, and the workshop attended by Moore in Hawaii. The paper is available on line at:

http://iwcoffice.org/_documents/sci_com/SC62docs/IWC-A10-E1Rev.pdf

The workshop report is available on line at:

http://iwcoffice.org/_documents/commission/IWC62docs/62-15.pdf

Task 2. Diagnostic imaging services were provided , and the National Stranding Meeting was attended by Dr Dennison. Onsite/Offsite case loads were as follows: Ultrasound 18/10, Echocardiography 17/0, Radiography 10/66, CT 1/20, MRI 3/3. So in all a total of 148 cases were worked up.

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

HIGHLIGHTS

- A review of large whale euthanasia was undertaken and the resulting paper published on line by the International Whaling Commission.
- This review and the workshop helped enhance large whale euthanasia technique on US beaches. Subsequently two large whales have been efficiently euthanized using a combination of intramuscular sedation and intracardiac potassium chloride.
- Radiology services, including interpretation of ultrasound, echocardiography, MRI and CT have been provided to The Marine Mammal Center and other stranding network agencies.

SOCIETAL BENEFITS.

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

EDUCATION AND OUTREACH ACTIVITIES

April 2010 – National Stranding Network Meeting
April 2010 – Gas Kinetics workshop, WHOI
May 2010 – IAAAM
January 2011 – Regional Stranding Network Meeting
February 2011 – Domoic Acid Workshop, TMMC

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Ultrasound of Live Stranded and Captured Dolphins

Gas bubbles have been noted surrounding the kidneys in both stranded (Cape Cod and CA) and wild-caught (Sarasota, FL) dolphins.

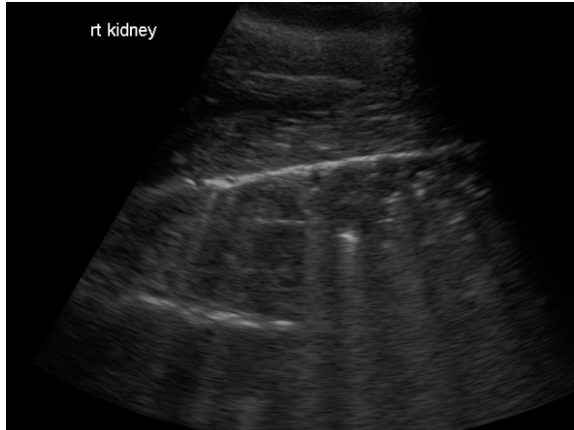


Figure 1: Ringdown artifact demonstrating the presence of multiple small diameter gas bubbles identified in and around the right kidney of stranded common dolphin in Cape Cod. Northern Fur Seal with Neurologic Abnormalities

Blinky the northern fur seal demonstrated that not all cases of neurologic disease are due to domoic acid toxicosis that arrive at TMMC. Bilateral caudate nucleus abnormalities were identified on MRI that have not been seen in any other case. Histology results are pending.

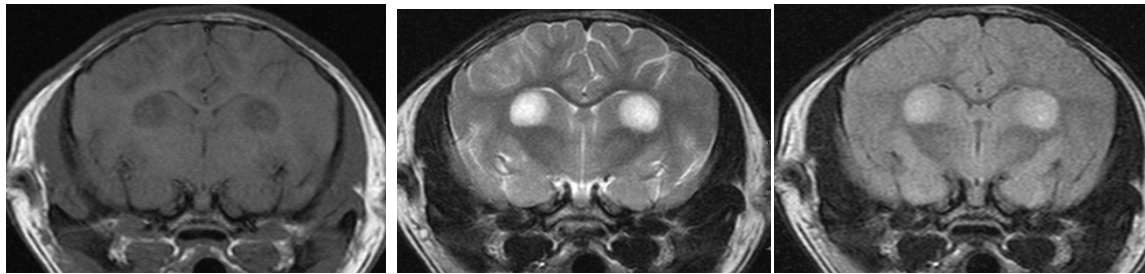


Figure 1: Left image. T1W pre Gd transverse image at the level of the caudate nucleus. The patient's right is to the left of the image. The caudate nuclei are bilaterally hypointense. No signal enhancement occurred post Gd.

Figure 2: Middle image. T2W transverse image at the same level as Figure 1. The caudate nuclei are hyperintense.

Figure 3: Right image. FLAIR transverse image at the same level as Figure 1 and 2. There is no evidence of nullification of the signal from the caudate nuclei. The CSF is adequately nullified.



SOPHIE DENNISON BVM&S MRCVS DACVR

Consultant Veterinary Radiologist

vetradiologist@hotmail.com www.marinemammalradiology.com

Report on Radiology Services Provided April 2010 to February 2011 Inclusive

Total number of days work permitted for time period: 47 (50 days plus 2 days for the National Stranding Meeting permitted over the 12 months).

Total number of days claimed: 47

Onsite Services:

Onsite services have been provided to The Marine Mammal Center, California Academy of Sciences and the dolphin hospital in Hilo, HI. Onsite services include image acquisition and a formal report of the study.

Detailed breakdown:

Abdominal Ultrasound: 18

Echocardiography: 17

Radiography: 10

Radiology Rounds (TMMC): Weekly sessions from April through October inclusive

CT: Attendance and image acquisition of a dead stranded Risso's dolphin at VMS/VSA CT scanner in San Mateo

MRI: Attendance at Animal Scan in Redwood City during three MRIs on animals with atypical clinical signs

Remote services:

Remote services include studies submitted either as hard copy or electronically that were formally reported.

Ultrasound interpretation: Two TMMC studies, eight WHOI/IFAW studies

Radiography interpretation: 63 reports for TMMC

CT interpretation: 14 studies for WHOI/IFAW, HI stranding network, Dr. Harms, UNE/MARC

MRI interpretation: Three studies for TMMC

Manuscript preparation and submission:

The following manuscripts have been prepared and most submitted during the time period:

Report summarizing Radiology Services provided to the Marine Mammal Stranding community from April 2010 to February 2011 inclusive

1

- Dennison S, Moore MJ, Fahlman AJ, Touhey Moore K, Sharp S, Harry CT, Hoppe J, Niemeyer M, Lentell B, and Wells RS. Bubbles in Live Dolphins.
- Van Bonn W, Montie E, Dennison S, Pussini N, Cook P, Greig D, Barakos J, Colegrove K, & Gulland F. Evidence of injury caused by gas bubbles in a live marine mammal: Barotrauma in a California sea lion (*Zalophus californianus*). In second review with Disease of Aquatic Animals.
- Dennison SE, Van Bonn W, Boor M, Adams J, Pussini N, Spraker T, Gulland FMD. Antemortem diagnosis of ventricular septal defect in a California sea lion (*Zalophus californianus*). Accepted for publication in Disease of Aquatic Animals.
- Dennison SE, Boor M, Van Bonn W, Greig D, Gulland FMD. *Foramen ovale* and *Ductus arteriosus* patency in neonatal harbor seal pups (*Phoca vitulina*) in rehabilitation. Accepted for publication in Aquatic Mammals.
- Dennison SE, Fravel V, Van Bonn W. Caudate nucleus necrosis in a northern fur seal pup: Clinical signs and MRI findings. (In preparation)

Meetings Attended:

April 2010 – National Stranding Network Meeting

April 2010 – Gas Kinetics workshop, WHOI

May 2010 – IAAAM

January 2011 – Regional Stranding Network Meeting

February 2011 – Domoic Acid Workshop, TMMC

Sophie Dennison BVM&S MRCVS DACVR

Health Implications of Entanglements of Large Whales

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 08
April 01, 2010-March 31, 2011

Michael Moore, Woods Hole Oceanographic Institution

Amy Knowlton, New England Aquarium

Jooke Robbins, Provincetown Center for Coastal Studies

NOAA Program Manager: Richard Merrick Northeast Fisheries Science Center

Protected Species Branch

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW

The goal of this project is to evaluate photographic, necropsy and other data obtained from North Atlantic large whales observed entangled in fishing gear to determine the potential short- and long-term health effects of these entanglements. Entanglement in fishing gear is a source of injury and mortality to large whales, but the magnitude of lethal and sub-lethal events is not well-understood. We compiled and assessed data on documented humpback whale and right whale entanglements to better understand entanglement events, as well as to inform entanglement survival and fecundity analyses. The Provincetown Center for Coastal Studies (PCCS) is using mark-recapture statistical modeling and other approaches to estimate entanglement survival and fecundity impacts on Gulf of Maine humpback whales. Entanglement survival and fecundity is being estimated relative to unexposed animals from the same population and relative to key covariate data. New England Aquarium (NEAq) is also collaborating with PCCS to assess survival and fecundity effects in North Atlantic right whales. In addition the Woods Hole Oceanographic Institution is undertaking an analysis of necropsy reports of large whales that have been examined and shown to have died from entanglement in the past two decades. The ultimate product of the study will be three papers published in the peer reviewed literature, reflecting analyses of the right whale, and humpback whale mark-recapture and fecundity studies, and the necropsy analyses.

ACCOMPLISHMENTS

The necropsy analysis is complete, and the manuscript is in the final stages of pre-submission editing. We have assessed live humpback whale entanglement events for which gear was observed on the whale and documentation was adequate to assess one or more parameters of interest. This included factors with the potential to affect entanglement outcome, such as the age, sex and status of affected individuals, entanglement duration, entanglement severity, injury severity and the overall apparent health of the individual. We have also compiled humpback whale sighting histories, performed goodness of fit testing and developed mark-recapture models to estimate humpback whale survival and fecundity subsequent to entanglement. We are in the process of completing analyses of entanglement survival based on sighting histories of individuals that were a) observed with entangling gear between 1998 and 2009 and b) could be reliably recognized if re-sighted with or without that gear. These results are compared to the apparent survival to individuals with no entanglement evidence (as assessed in an independent scar-based study of entanglement). We continue to evaluate alternate approaches in light of the fact that some individuals die without first being observed entangled. We are also completing analyses of female reproductive impacts based on the annual entanglement status and calving histories of 279 females, 1997-2009. This analysis includes both cases of observed gear and those in which entanglement was inferred from recent injuries at the caudal peduncle. It is based on 121 entanglement events documented among females (29 calving, 92 resting) versus 971 annual sightings of females with no new entanglement evidence (297 calving, 674 resting). Final analysis will incorporate covariate data identified during entanglement coding.

For right whales, all relevant images for individuals seen carrying gear have been scanned from slides or pulled from the digital archive. These images have been integrated into a case study template along with relevant life history information, a drawing of the entanglement configuration, and information about the gear when available. Forty-six case studies have been created and are in the process of final review. An example of a case study is depicted as Figure 1. Encounter history data have been compiled for 66 right whales carrying gear. Goodness of fit testing has been completed and mark-recapture analysis is underway. For the entanglement fecundity analysis, two approaches to evaluating impacts of severity on fecundity have been developed by NEAq and data analysis is underway.

Aspects of the entanglement analyses performed in this project were reported in the “Dynamics of Large Whale Entanglements in Fishing Gear Workshop” hosted by NEAq at WHOI in early February 2011. This separately-funded workshop was intended to bring together fishermen, scientists and managers to better understand how to mitigate entanglements.

HIGHLIGHTS

Preparation of a major manuscript describing the pathobiology of lethal large whale entanglement.

- Evaluation and coding of documented humpback whale entanglements on the US East Coast.
- Development of forty-six right whale entanglement case studies.
- Progress on analyses of large whale entanglement survival and fecundity.
- Presentation of data and selected results at an entanglement workshop including managers, scientists and fishermen.

SOCIETAL BENEFITS

A mechanistic understanding of the effects of entanglement on large whales, in terms of resultant pathology, and impacts on fecundity and survival is an essential element of efforts to reduce these impacts on endangered and threatened species, and to relieve the fishing industry of the economic burden of the ongoing whale entanglement problem.

EDUCATION AND OUTREACH ACTIVITIES

Presentations by Moore, Knowlton and Robbins were made at the Dynamics of Large Whale Entanglements in Fishing Gear Workshop held at WHOI on February 9-11, 2011.

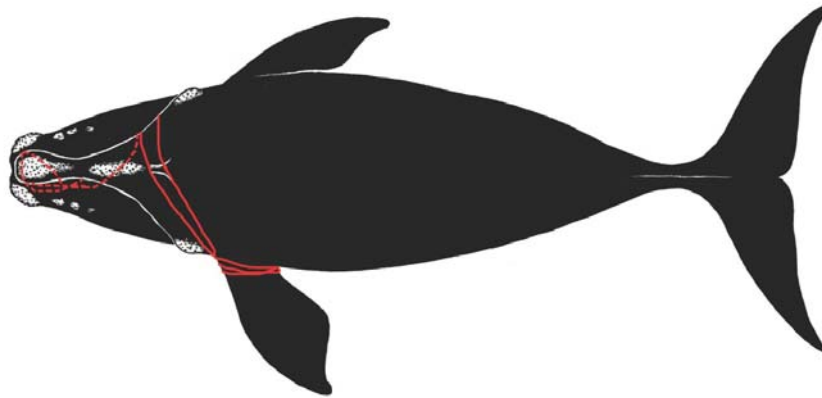
FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

A detailed drawing and additional information describing the entanglement configuration and resulting wound severity, life history information about an individual animal, the duration of the entanglement and status of the animal, and details about the rope retrieved during disentanglement or from a carcass

Species	Right Whale	Whale ID	Eg #2301
---------	-------------	----------	----------

Date First Observed Entangled	6 Sept. 2004				
Sex	Female	Birth Year	1993	Age at entanglement	11

Case Study ID	PCCS	NMFS	GEAR ID	
	WR-2001-21	E20-04	J090604 a-c	
Gear Sample Collected?	Yes		Gear Type	Unknown



Reproductive prior to entanglement detection?	Yes				
Reproductive after entanglement detection?	No				
Wound severity	Mouth	Head/Rostrum	Flippers	Body	Flukes
	None	High	High	Medium	Medium
Duration of time carrying gear	Minimum 178 days, maximum 531 days				
Disentangled?	No				
Status	Dead 3 Mar 2005				
Number of prior entanglement interactions	3				

Entanglement Configuration	Line wrapping over head from right mouthline to left flipper wraps; line essentially cleated from baleen on right to flipper on left.			
Anchoring Point(s)	Mouthline, flipper			
Gear Configuration Confidence	Moderate			
Remaining Questions	The extent of wrapping at left flipper unknown; bitter ends cannot be accounted for and unclear if any line was trailing.			
Comments	Extensive weaving of line through baleen was documented at necropsy.			
Polymer Type	PP	PP/PET	PP/PET	
Gear Component				
Rope Diameter (inches)	3/8 (0.394)	1/2 (0.472)	7/16 (0.425)	
Breaking Strength (lbs)	Tested	486	900	700
	New	2 430	4 500	3 500

Impact on Oceanographic Changes on Atlantic Salmon Survival in the Northwest Atlantic

NOAA Cooperative Agreement No. NA09OAR4320129 UMaine Subpoint 02
April 01, 2010-March 31, 2011

Andrew Pershing - University of Maine at Orono

NOAA Program Manager: Timothy Sheehan NOAA Fisheries Service

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW

The abundance of Atlantic salmon (*Salmo salar*) stocks in the Gulf of Maine region have declined over recent decades to all time low levels. Human activities (e.g., dams, habitat degradation) are believed to be responsible for some of this decline; however, there is strong evidence that changes in ocean survival underly much of the recent trends. Our project will analyze available hydrographic and biological (plankton and fish) time series from the Gulf of Maine, Scotian Shelf, and Newfoundland region. We will examine correlations between salmon returns in Maine rivers with oceanographic conditions along their migration route and feeding areas. We will also contribute to a companion project led by Dr. Jason Stockwell at the Gulf of Maine Research Institute. We will provide information on circulation variability in the Gulf of Maine from the Gulf of Maine Princeton Ocean Model hindcasts.

ACCOMPLISHMENTS

The first step in our project is to assemble consistent indices of salmon at-sea survival for the Penobscot and Narraguegus Rivers. Both rivers are regularly stocked with hatchery reared fish, although the number and life stage varies between the rivers and from year to year. Our major accomplishment to date has been to develop a consistent estimate of the output of post smolts from each river that can be compared with the number of adults returning. These estimates are made by “discounting” different life stages based on expected mortality rates.

HIGHLIGHTS

- Developed a procedure to produce standardized “smolt-output” time series for Atlantic salmon populations in Maine rivers.

SOCIETAL BENEFITS

Atlantic salmon are currently listed under the Endangered Species Act. Our work will help NOAA scientists and managers gauge the effectiveness of management actions (stocking, river restoration) by isolating the signal from oceanic conditions.

EDUCATION AND OUTREACH ACTIVITIES

Postdoctoral associate Katherine Mills participated in the Salmon Stock Assessment workshop this spring.

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

NOAA Cooperative Agreement No. NA09OAR4320129 GMRI Subpoint 08
April 01, 2010-March 31, 2011

Jason Stockwell - Gulf of Maine Research Institute

NOAA Program Manager John Kocik NMFS/ NEFSC

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW:

The goal of this project is to characterize marine phase migration and survivability of Atlantic salmon in the Gulf of Maine (GOM) ecosystem. We will evaluate the importance of predator and prey fields and ocean circulation on Atlantic salmon growth and survival. Our proposed hypotheses are:

- Hypothesis 1:* Aggregations of diadromous forage fishes (alewife, blueback herring, rainbow smelt, and shad) reduce potential predation risk but decrease growth (via competition) of Atlantic salmon post-smolts in estuarine environments.
- *Hypothesis 2:* Aggregations of juvenile marine forage fishes (Atlantic herring and Atlantic mackerel) reduce potential predation risk and increase growth of Atlantic salmon post-smolts in marine environments.
 - *Hypothesis 3:* The timing, strength, and duration of the Eastern Maine Coastal Current play a critical role in determining the survival of post-smolts migrating out of the GoM.

Our approach is to use MATLAB to combine physical and bioenergetic models with spatially explicit prey fields. Physical oceanography in the (GOM) is being modeled with the GoMOOS forecast/hindcast model (Xue 2005). A passive particle model based on the physical model will allow us to determine the influence of the Eastern Maine Coastal Current on salmon irrespective of their biology or ecology (hypothesis 3). Salmon bioenergetics will then be modeled using the Wisconsin model (Hanson et al. 1997) and parameterized according to Smith et al. (2009).

After combining the physical and bioenergetics models, the next step is to add characteristics of salmon swimming speeds, directions, and general behavior to the model. Prey fields will be characterized and added to the model so that we can address the first two hypothesis regarding predator prey interactions.

Hanson PC, Johnson TB, Schindler DE, Kitchell JF (1997) Fish Bioenergetics 3.0, Vol. University of Wisconsin System Sea Grant Institute, Center for Limnology.

Smith IP, Booker DJ, Wells NC (2009) Bioenergetic modelling of the marine phase of Atlantic salmon (*Salmo salar* L.). Marine Environmental Research 67:246-258

Xue H, Shi L, Cousins S, Pettigrew NR (2005) The GoMOOS nowcast/forecast system. Continental Shelf Research 25:2122-2146

ACCOMPLISHMENTS:

Please note that the project activities did not begin until the hiring of the postdoctoral research associate in January 2011. The accomplishments listed below, therefore, reflect a 3 month period only.

The scope and scale of the modeling environment were identified and the conceptual framework for the model was developed in January. Project collaborators met with external scientists for input at the US Atlantic Salmon Committee Meeting on March 8-10, 2011 in Portland, ME as well as other informal venues. Project collaborators met with the program manager, John Kocik, to update progress and solicit feedback on January 26, 2011 which is two months ahead of proposed schedule. Project goals and objectives were presented at the 13th annual Salmon Ecology Meeting in Seattle, WA on March 23-24, 2011.

Completed a passive particle tracking model through the Gulf of Maine that allows random selection of starting points and starting dates of migration within specified spatial and temporal windows. The model tracks the particles across the dynamic sea-scape during the time period of typical salmon migration to the Scotian Shelf. The model outputs the distance traveled and determines whether the particles made it to the Scotian Shelf. This model is the first step in evaluating our third hypothesis on whether the Eastern Maine coastal current differentially influences post-smolt migration success on an annual basis.

Completed MATLAB coding of the bioenergetics portion of the model. In summary, the physical and the bioenergetics components of the model have been coded. Although further refinement will be necessary moving ahead, it can be considered a sizable accomplishment to have essentially completed these two major components of the model.

Assembled and read extensive publications and resources on marine phase of Atlantic salmon. This database of information will help to parameterize the model and will be used in a review paper that is in preparation.

Solicited applications for an undergraduate summer intern and are interviewing potential candidates now.

HIGHLIGHTS:

- Hired post-doc (started January 1, 2011) and identified framework for model and data needs.
- Met with program manager to update gross and solicit feedback on January 26, 2011.
- Attended US Atlantic Salmon Committee Meeting in Portland, ME on March 8, 2011.
- Presented project objectives and goals at the 13th Annual Salmon Ecology meeting in Seattle, WA on March 23-24, 2011.
- Completion of passive particle model to evaluate influence of Eastern Maine Coastal Current on migration and survivability of post-smolts.
- Coded physical portion of model using MATLAB.
- Coded bioenergetic portion of model using MATLAB.
- Assembled literature and resources for the parameterization of the models.
- Began preparing a review paper on marine phase of Atlantic salmon.
- In the process of hiring a summer intern.

SOCIETAL BENEFITS:

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

EDUCATION AND OUTREACH ACTIVITIES:

Byron, C.J., Stockwell, J., Pershing, A., Xue, W. Are post-smolts running on empty? Migration and survival in the Atlantic. Abstract and Presentation for the:

- 13th Annual Salmon Ocean Ecology Meeting. Seattle, WA. March 23-24, 2011.
- NASCO/ICES Salmon Summit. 'Salmon at Sea: Scientific Advances and their Implications for Management.' Symposium La Rochelle, France. October 11-13, 2011.

PUBLICATIONS:

Byron, C., Mills, K. in progress. Review paper on marine phase of Atlantic salmon.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS:

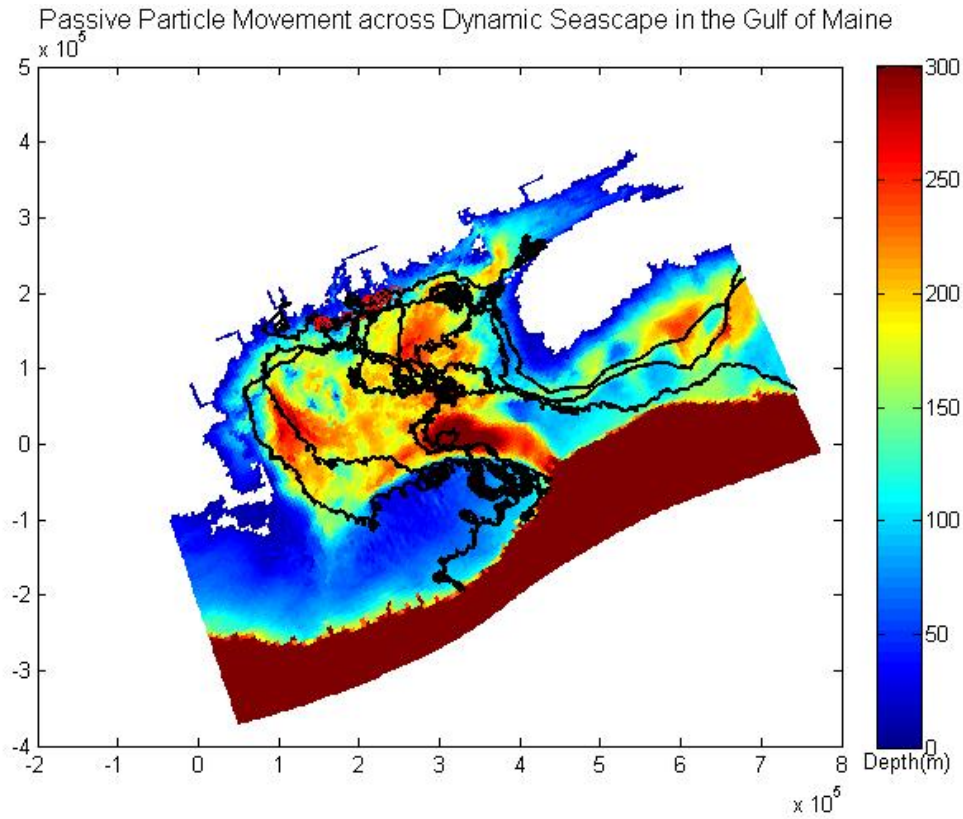


Diagram of the bathymetry of the Gulf of Maine using the GoMoos forecast model. The black lines indicate 10 particle tracks across the Gulf of Maine between May-July for multiple years chosen at random between 2002-2010. All particles started at the mouth of the Penobscot Bay, ME. The x and y axis units are in meters from Boston, MA.

Collaborative Research Program Focusing on Behavioral Ecology and Reactions to Sound Populations of Short-Finned Pilot Whales and Other Cetaceans Off Cape Hatteras, North Carolina.

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 09
April 01, 2010-March 31, 2011

Peter Tyack - Woods Hole Oceanographic Institution

NOAA Program Manager: Kenric Osgood NOAA/NMFS Office of Science and Technology / Marine Ecosystems Divisions

Related NOAA Goal Plan:

Goal 1. Protect, Restore and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

CINAR Theme:

Theme IV. Protection and Restoration of Resources

PROJECT OVERVIEW

Our initial objective was to deploy Digital Archival Tags (DTags) on pilot whales near pelagic longlines in the CHSRA to investigate the foraging behavior of pilot whales around fishing gear. Unfortunately, due to a lack of tuna, there was no pelagic longline fishing effort in the study area during July 2010. Instead, we deployed DTags on pilot whales to examine their baseline foraging behavior away from fishing gear.

ACCOMPLISHMENTS

The DTags yielded important information on the foraging behavior of short-finned pilot whales. We also deployed five DTags in May 2008, so our total sample size is now 15, including several overnight deployments. This provides us with a rich picture of baseline foraging behavior of pilot whales in the CHSRA. We hope that it will be possible to deploy tags on pilot whales around pelagic longline gear at some point in the future, so that we can compare whales engaging in depredation with those in our current data set.

HIGHLIGHTS

A. Survey Effort

We completed ten field days on this project during 2010: seven days in July, and three in September, all within the CHSRA. We made seven sightings of pilot whales in the CHSRA in July and ten in September, all in water depths greater than 200m (Figure 1).



B. Deployment of Digital Archival Tags (DTags) and Behavioral Observations

We deployed 10 DTags on pilot whales; eight in July and two in September. All of the tagged animals were physically mature. The length of deployments ranged from 38 minutes to 17 hours and 27 minutes. All tags were deployed during daylight hours, but three tags remained on whales overnight. Table 1 summarizes the tag deployments on each pilot whale. The spatial distribution of the tagged whales revealed an interesting pattern of habitat use; all of the animals were tagged in close proximity to the continental shelf break, near the 200-m isobath. We conducted focal follows on eight of the ten tagged whales, ranging in duration from 1 hour 23 minutes to just under five hours (see Table 1).

Analysis of Tag Data

To date, we have completed comprehensive calibration and archiving of all DTag data collected in 2010. We have examined each dive record and, after calibrating the sensors, generated prh files (pitch, roll, heading) and estimated the 3D-track of the tagged whale. These files can be analyzed in Matlab, or converted into a format for use in other visualization programs, such as Trackplot. To date we have imported all tag records into Trackplot (see Figure 17 for an example of the Trackplot figure for Gm_10_267a). We have begun to define the features and characteristics within each dive. For example, we have defined a dive as a submergence to 20 meters or deeper. For each dive we have identified every attempt to capture prey, defined by echolocation buzzes. These buzzes contrast with echolocation clicks, which represent the search phase of foraging behavior, but not necessarily prey capture attempts.

We have also completed audits of the acoustic data recorded on the Dtags, which involves the identification of pilot whale vocalizations, including start and end of echolocation clicks and time of each feeding buzz. We conducted these audits using a custom Matlab program that plots spectrograms of 15 sec intervals of audio data along with playing back the sound. The number of dives analyzed (≥ 20 meters depth) per deployment ranged from 1 to 49, with a minimum dive depth of 21 meters and a maximum dive depth of 1044 meters. The number of feeding buzzes (or prey capture attempts) per tag ranged from 0 to 579 – see Table 1; (Gm_10_266a had the maximum number of total buzzes, see Figure 11). A total of 138 dives (of ≥ 20 m depth) were analyzed from all 2010 deployments, with a total of 1176 feeding buzzes identified. Figures 3-12 show the dive record of each whale with the time of the start and end of the echolocation clicks, represented by the black stars, and the feeding buzzes, represented by the red stars. Figures 13-15 show patterns found to date for diel variation in diving behavior of the whales tagged in 2010. We are currently working to link the timing of buzzes with the tag sensor files to characterize the body orientation and movement patterns that are associated with feeding events.

C. Hydrography and Prey Mapping

We are still analyzing oceanographic and prey field data. Figure 16 shows preliminary results of one tagged whale relative to prey distribution in the water column. To provide some indication of the utility of the latter, however, we provide an example of prey fields from the 38 kHz system and the synoptic dive record from a single pilot whale (Gm_10_208a)

on July 27, 2010 (Figure 18). The whale responded to diel changes in the vertical distribution of prey throughout the late afternoon and into the evening (Figure 18). For example, in the afternoon (17:09) the whale was still diving to the layer of prey between 300 and 350 m deep. At dusk (19:38), however, the whale began to forage on the rising deep scattering layer and, particularly, a strong band of prey at 150 m. The prey aggregation dissipated after dusk (21:42) and the whale stopped diving. We still have a considerable amount of analysis to complete with respect to the vertical distribution of prey and the integration of pilot whale foraging behavior.

D. Photo-identification

We obtained 4,099 pilot whale dorsal fin images for photo-identification during July and September 2010. We will attempt to match these individuals to our photo-identification catalog from previous surveys. Preliminary analysis of images from previous work indicates that at least some pilot whales are present over multiple seasons and multiple years in the CHSRA (Figure 19).

E. Biopsy Samples

We collected six biopsy samples from tagged pilot whales during July and one sample in September 2010 (Table 1). Most animals showed a low to medium level of response to the biopsy attempts. We were unable to obtain samples for three of the tagged whales. We provided all biopsy samples to Dr. Patricia Rosel (NOAA-NMFS-SEFSC Marine Mammal Genetics Lab in Lafayette, LA) for genetic analysis of stock structure. All of the 62 animals we have sampled to date within the CHSRA have been short-finned pilot whales.

SOCIETAL BENEFITS

Attempts to reduce the frequency of entanglements of pilot whales in pelagic longlines have been hampered by a lack of information regarding the ways in which pilot whales interact with this fishing gear. The Pelagic Longline Take Reduction Team (PLTRT), convened by the National Marine Fisheries Service in 2005 to address the by-catch of pilot whales in this fishery, identified a series of information needs to better understand the nature of these interactions (see recommendations at: <http://www.nmfs.noaa.gov/pr/interactions/trt/pl-trt.htm>). Our work addresses the research priorities identified by the PLTRT.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS –

Table 1. Summary of DTag deployments on pilot whales, focal follow duration, biopsy samples collected, and audits of Dtag acoustic records.

Date	Tag ID	Time On	Duration of tag audio files	Max.Div e Depth (m)	Total # Feeding buzzes	Focal Follow (hh:mm)	Biopsy ID
4-Jul-10	Gm_10_185b	14:30:46	6:00:33	414	47	3:15	ASF-10_002
5-Jul-10	Gm_10_186a	11:10:27	0:38:08	61	1		
5-Jul-10	Gm_10_186b	14:32:47	5:31	34	0	1:36	ASF-10_003
6-Jul-10	Gm_10_187a	8:31:31	2:33:29	294	12	1:23	
6-7-Jul-10	Gm_10_187b	12:53:00	17:22	n/a	n/a	4:52	ASF-10_004
27-Jul-10	Gm_10_208a	14:50:21	9:10:47	362	123	3:48	ASF-10_005
28-Jul-10	Gm_10_209a	8:55:09	1:24:29	438	37		ASF-10_006
28-Jul-10	Gm_10_209c	13:19:38	7:03:09	587	22	4:31	ASF-10_007
23-24 Sep-10	Gm_10_266a	18:35:00	17:27:19	1044	579	2:37	AJR-10-001
24-25 Sep-10	Gm_10_267a	14:38:00	13:04:32	903	355	3:24	

Figure 1. Sighting locations of pilot whales in the CHSRA in July and September 2010, including those from previous research cruises conducted in 2006-2008.

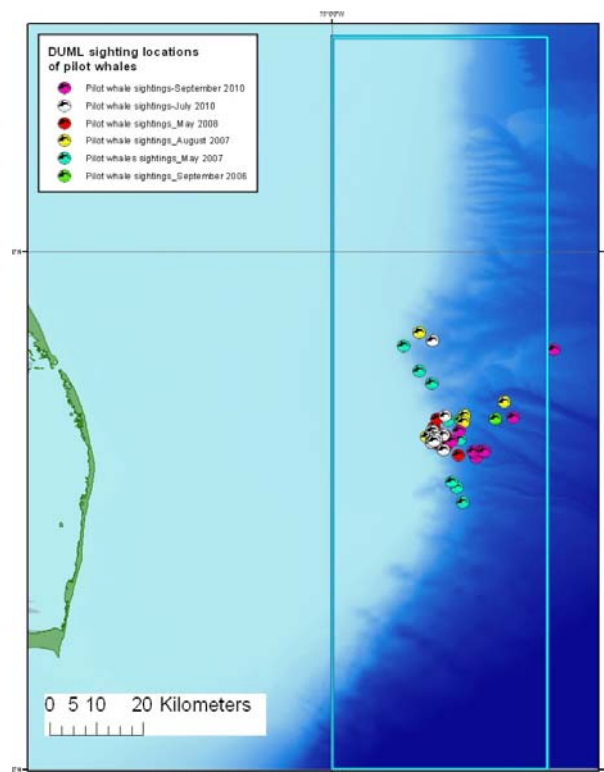


Figure 2. Deploying the D-Tag on a pilot whale in the CHSRA.



Figure 3. Dive profile and acoustic record for pilot whale Gm_10_185b, tagged on July 4, 2010. Black crosses represent clicks, and red crosses represent buzzes.

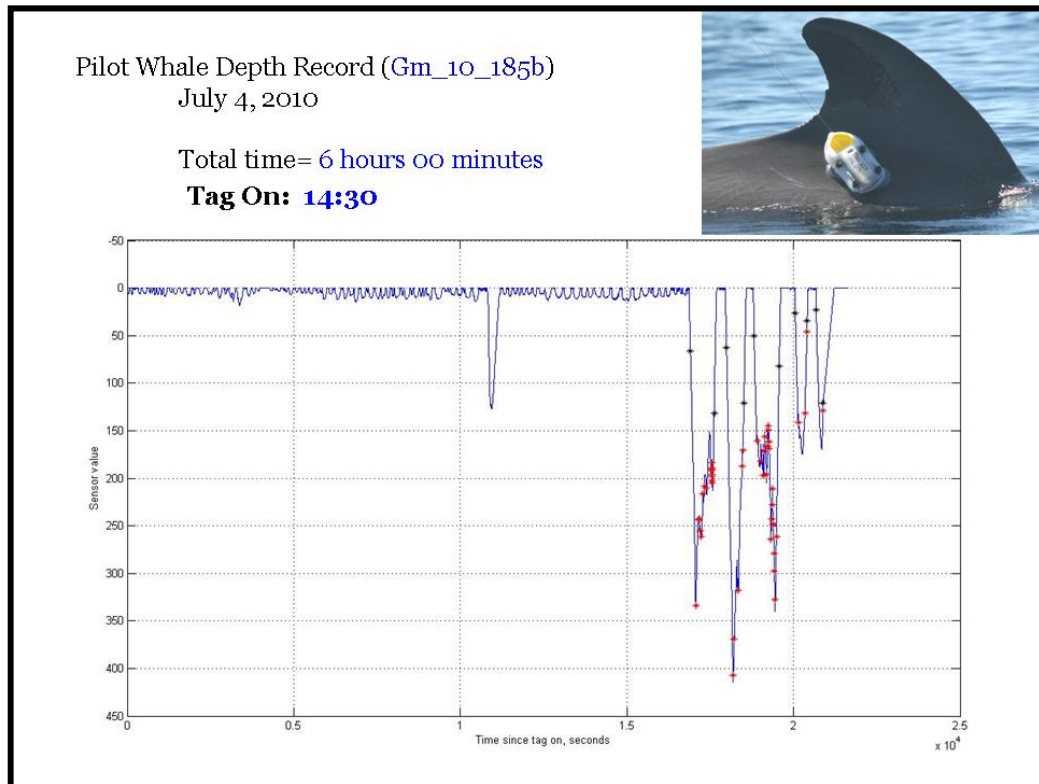


Figure 4. Dive profile for pilot whale Gm_10_186a, tagged on July 5, 2010. Black crosses represent clicks, and red crosses represent buzzes.

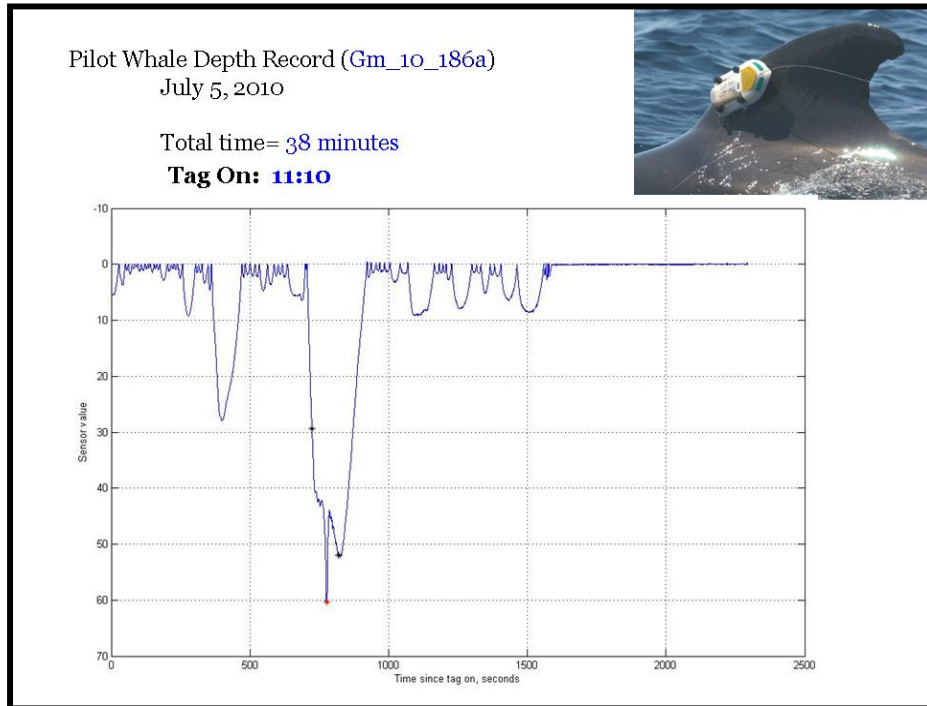


Figure 5. Dive profile for pilot whale Gm_10_186b, tagged on July 5, 2010. No buzzes or clicks were recorded in the acoustic record for this animal.

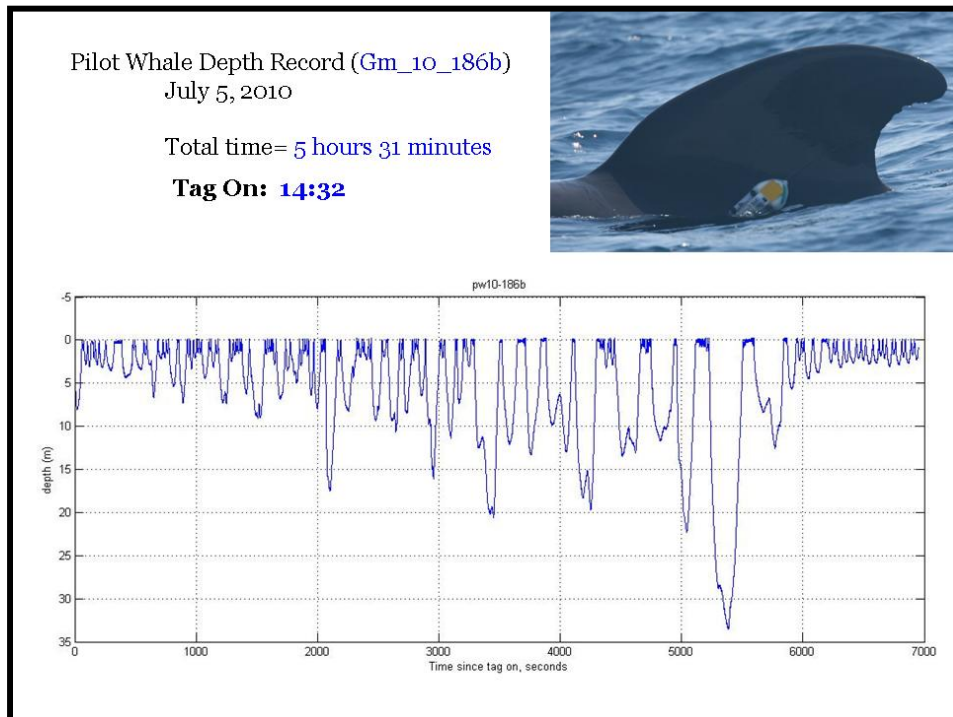


Figure 6. Dive profile for pilot whale Gm_10_187a, tagged on July 6, 2010. Black crosses represent clicks, and red crosses represent buzzes.

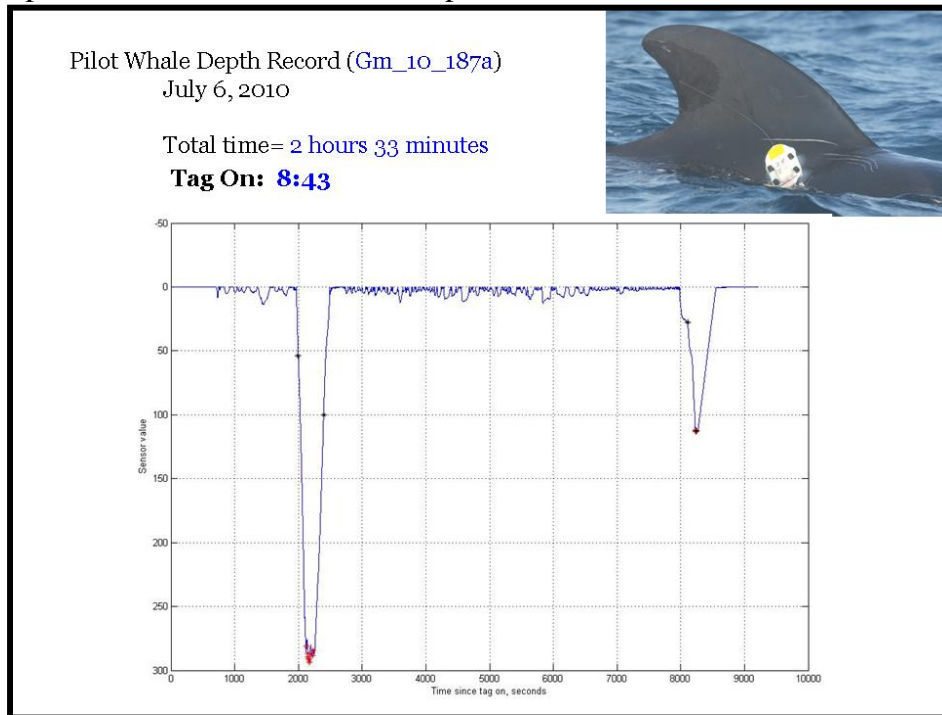


Figure 7. Dive profile for pilot whale Gm_10_187b, tagged on July 6, 2010. There were defective acoustic records for this tag; therefore, there were no records of clicks or buzzes.

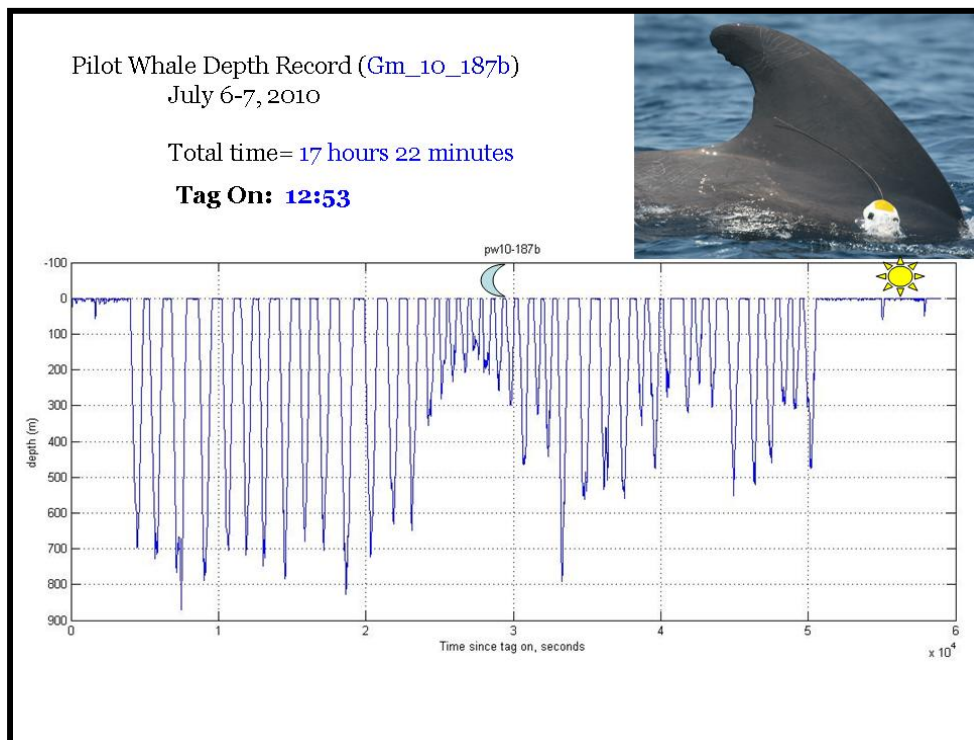


Figure 8. Dive profile for pilot whale Gm_10_208a, tagged on July 27, 2010. Black crosses represent clicks, and red crosses represent buzzes.

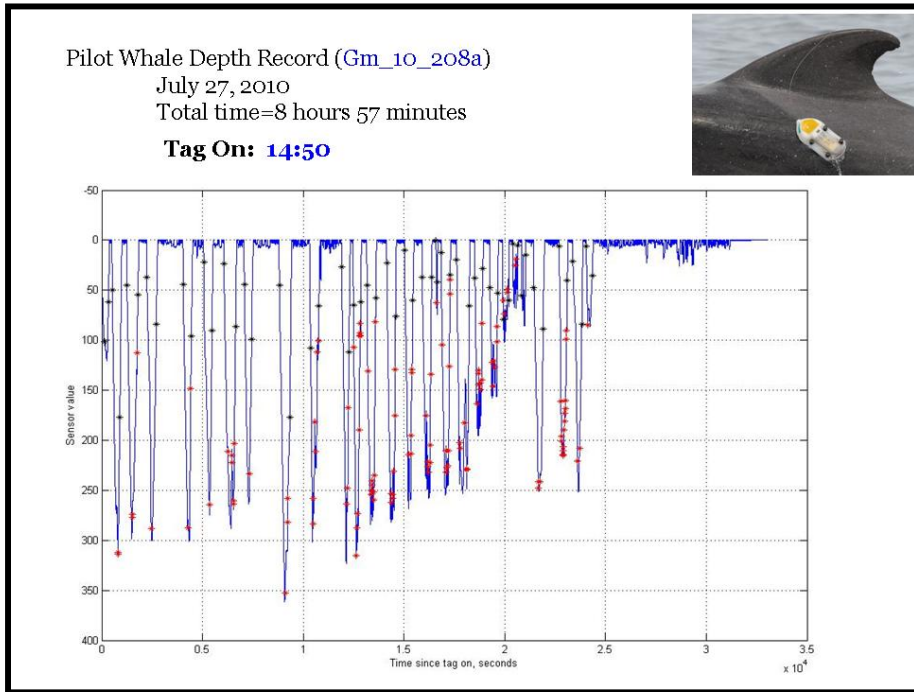


Figure 9. Dive profile for pilot whale Gm_10_209a, tagged on July 28, 2010. Black crosses represent clicks, and red crosses represent buzzes.

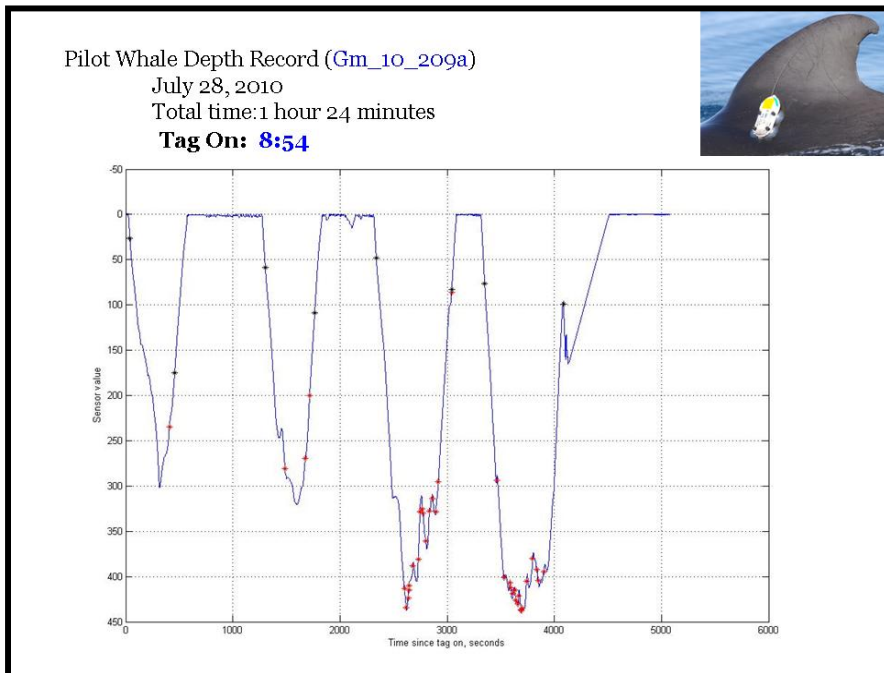


Figure 10. Dive profile for pilot whale Gm_10_209c, tagged on July 28, 2010. Black crosses represent clicks, and red crosses represent buzzes.

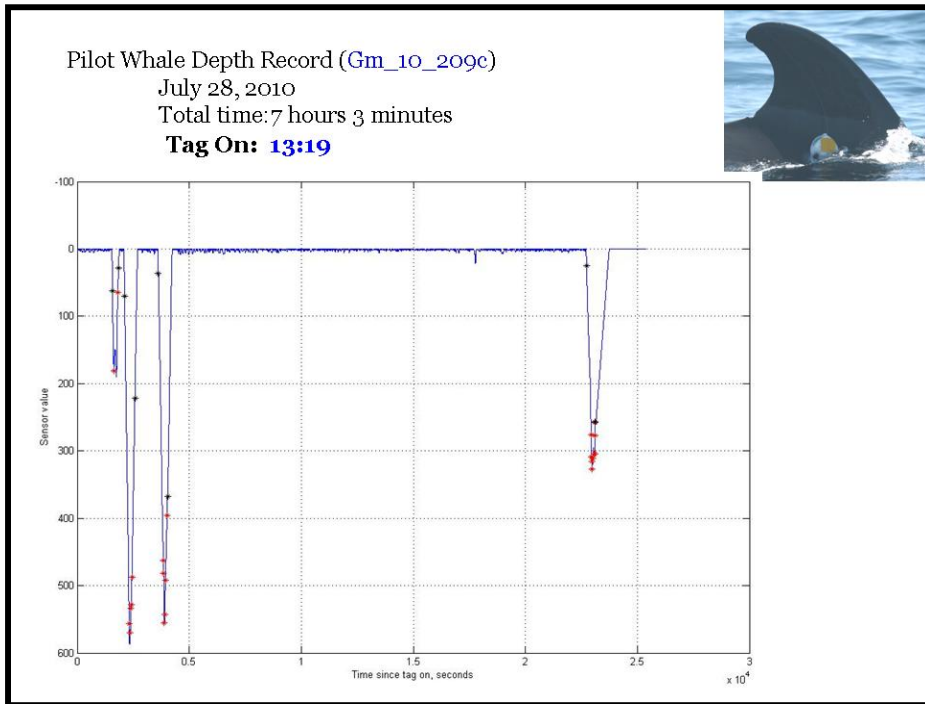


Figure 11. Dive profile for pilot whale Gm_10_266a, tagged on September 23, 2010. Black crosses represent clicks, and red crosses represent buzzes.

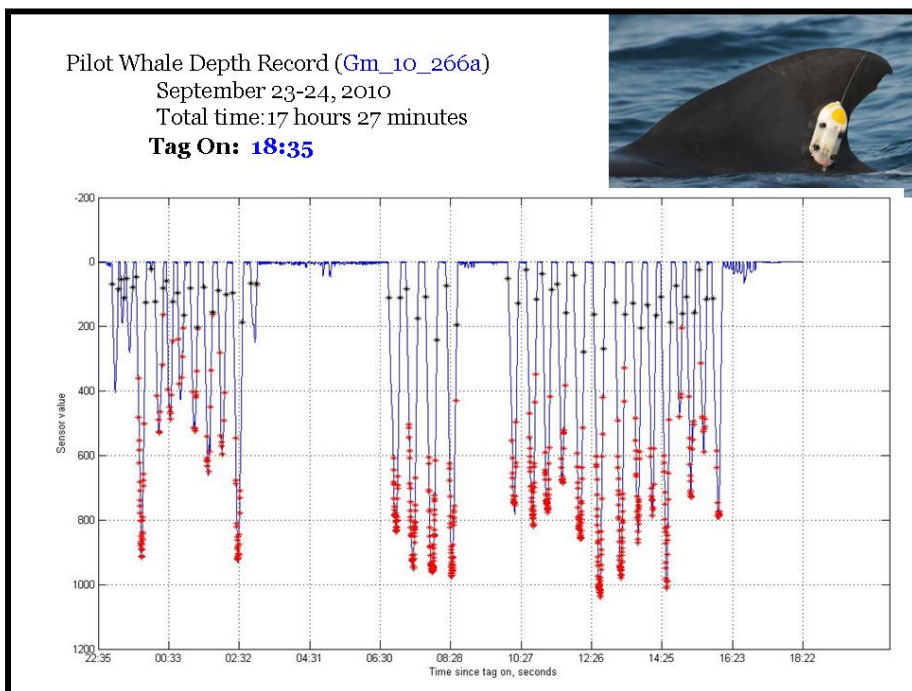


Figure 12. Dive profile for pilot whale Gm_10_267a, tagged on September 24, 2010. Black crosses represent clicks, and red crosses represent buzzes.

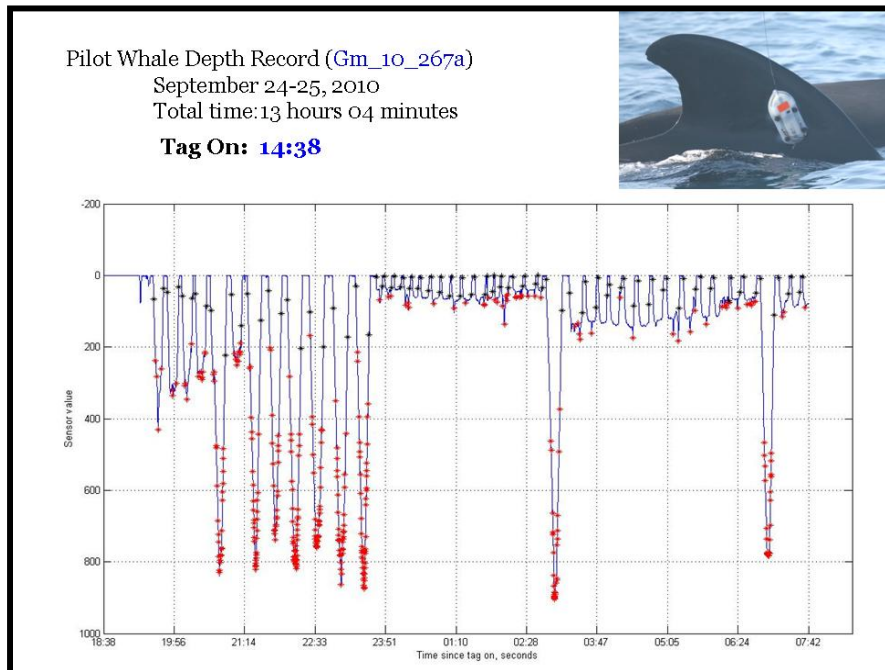


Figure 13. Plots showing diving behavior and feeding buzzes of pilot whales at depth.

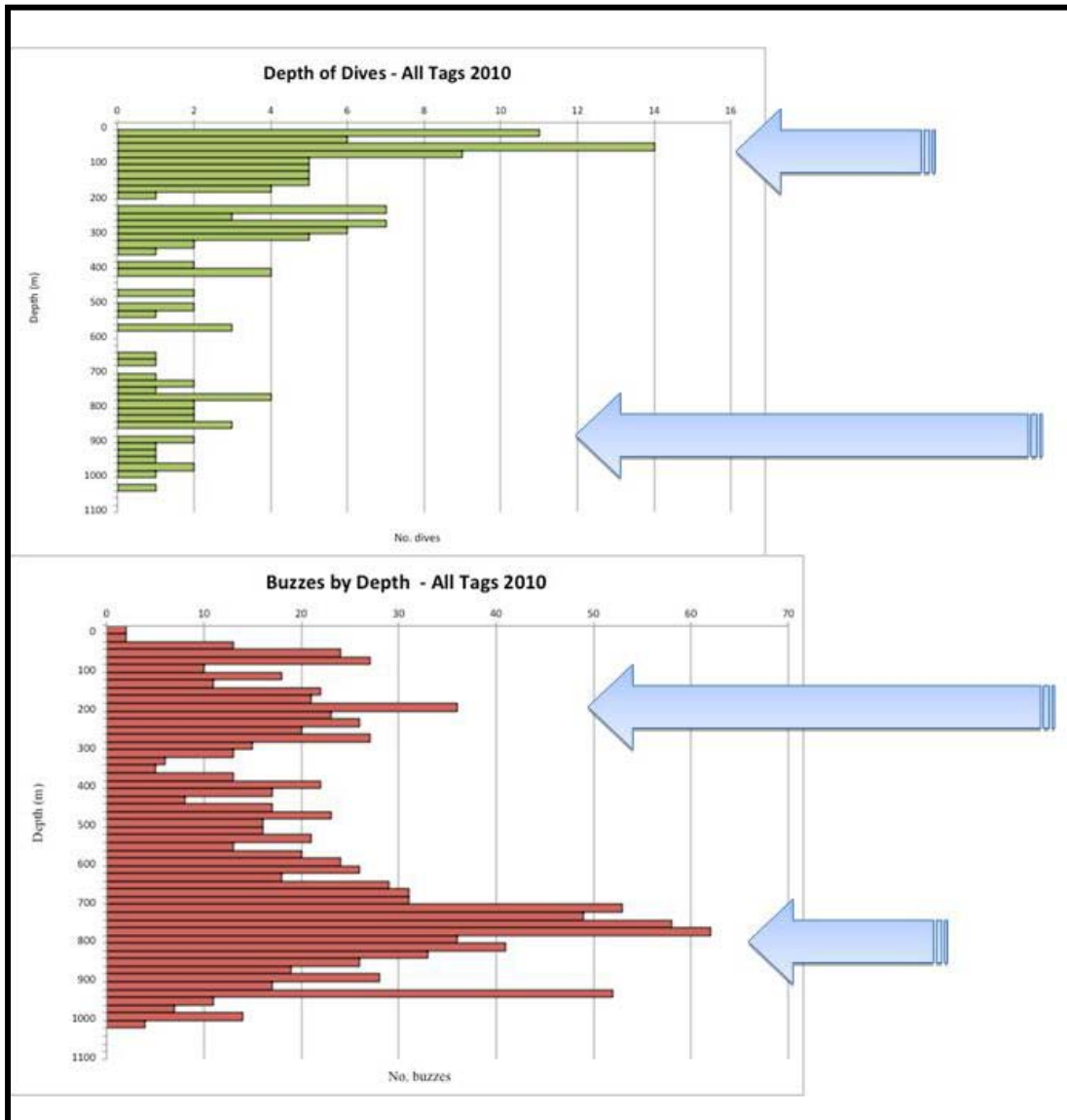


Figure 14. Plots showing dives by depth and buzzes by depth for day and night dives.

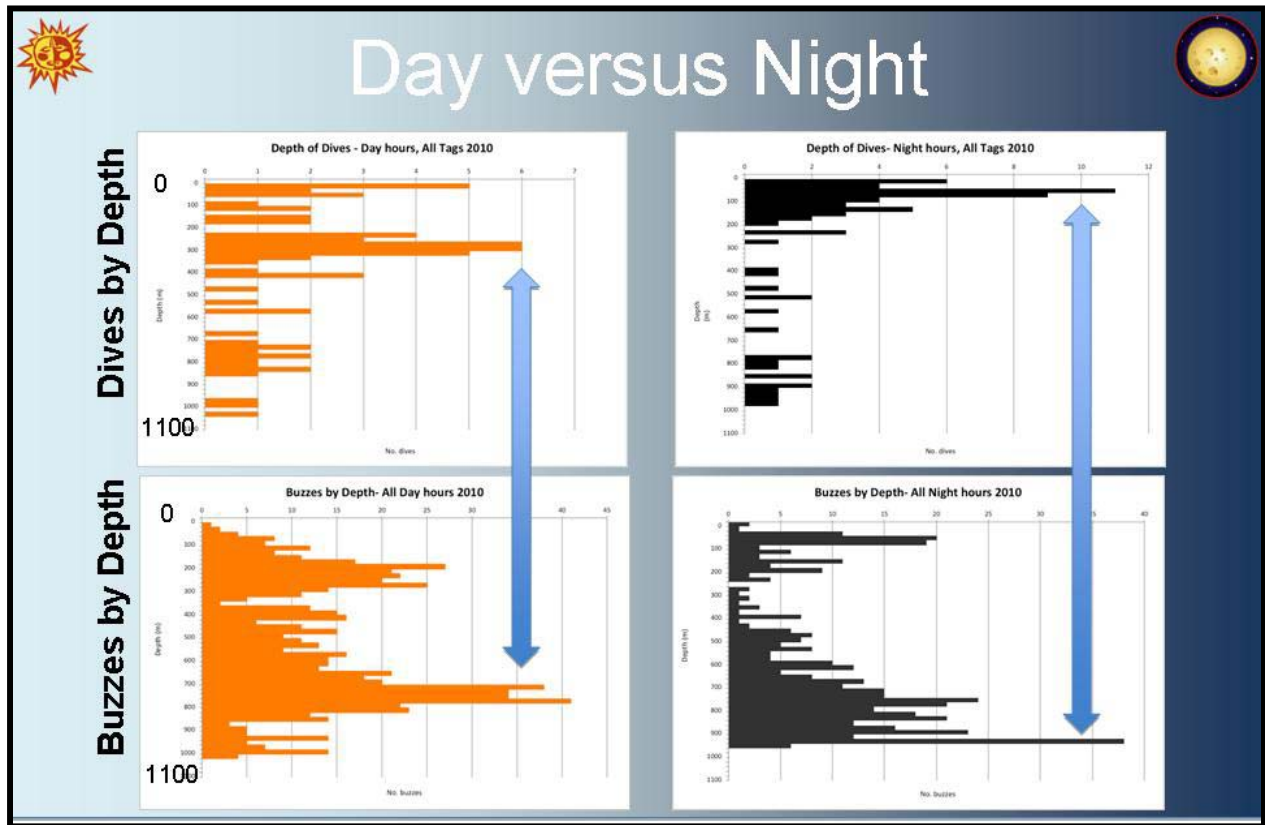


Figure 15. Example of individual diving record showing deep foraging dives during day and nighttime.

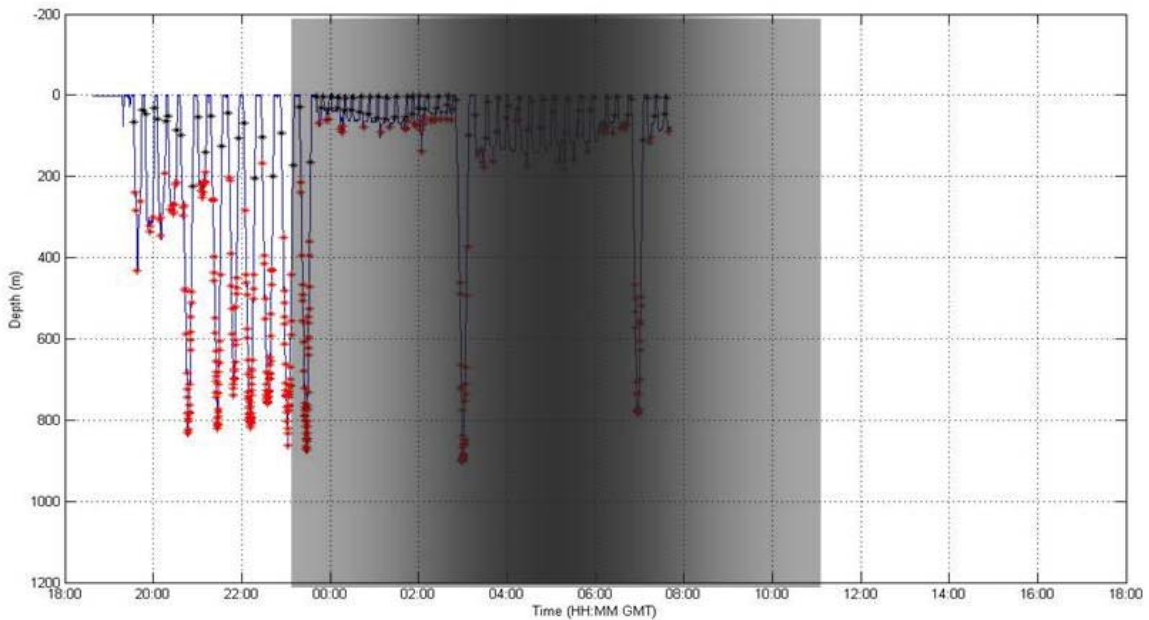


Figure 16. Diving behavior of a short-finned pilot whale in relation to the biomass at depth. The whale switched from deep dives, apparently feeding on multiple small prey, to shallow dives, perhaps pursuing single large targets.

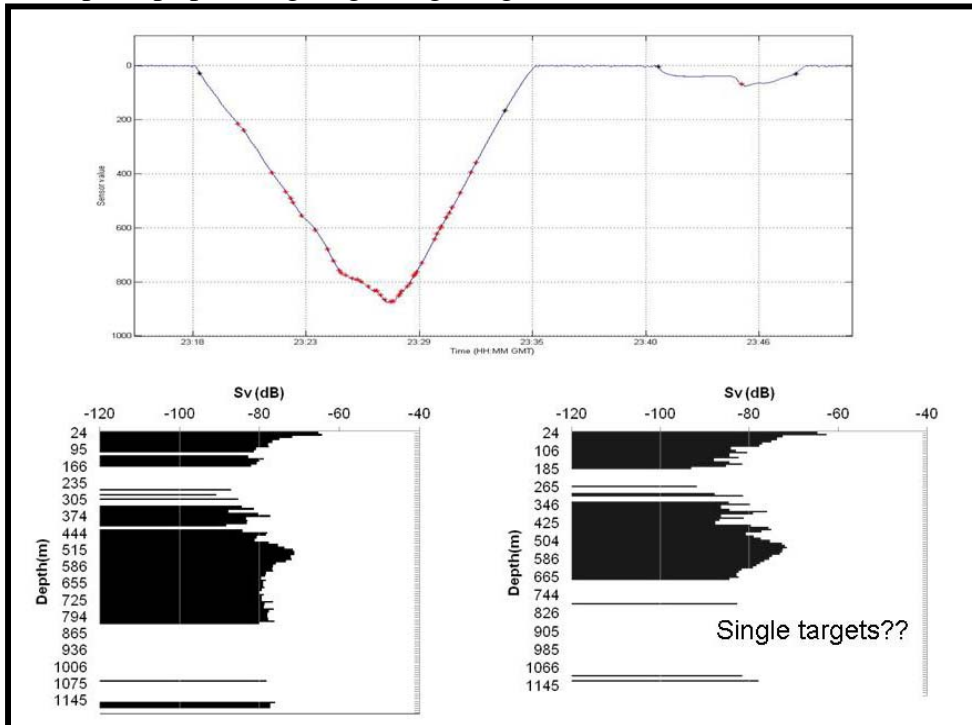


Figure 17. Example of track plot depiction of a foraging dive of a short-finned pilot whale.

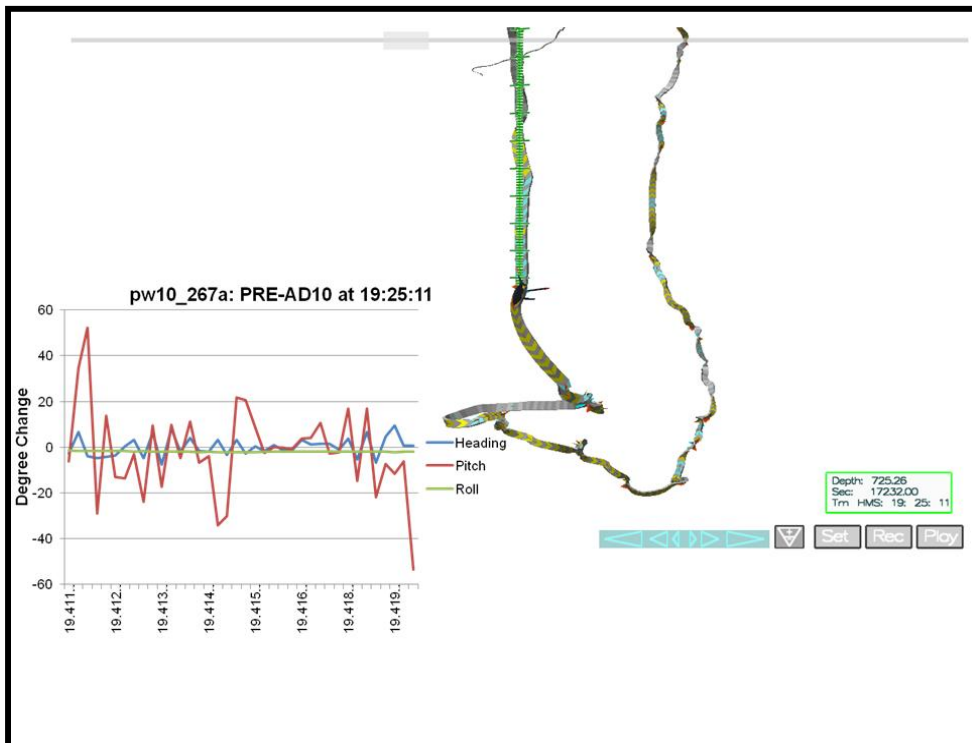


Figure 18. Example of pilot whale dive record in response to diel changes in the vertical distribution of prey throughout the late afternoon and into the evening.

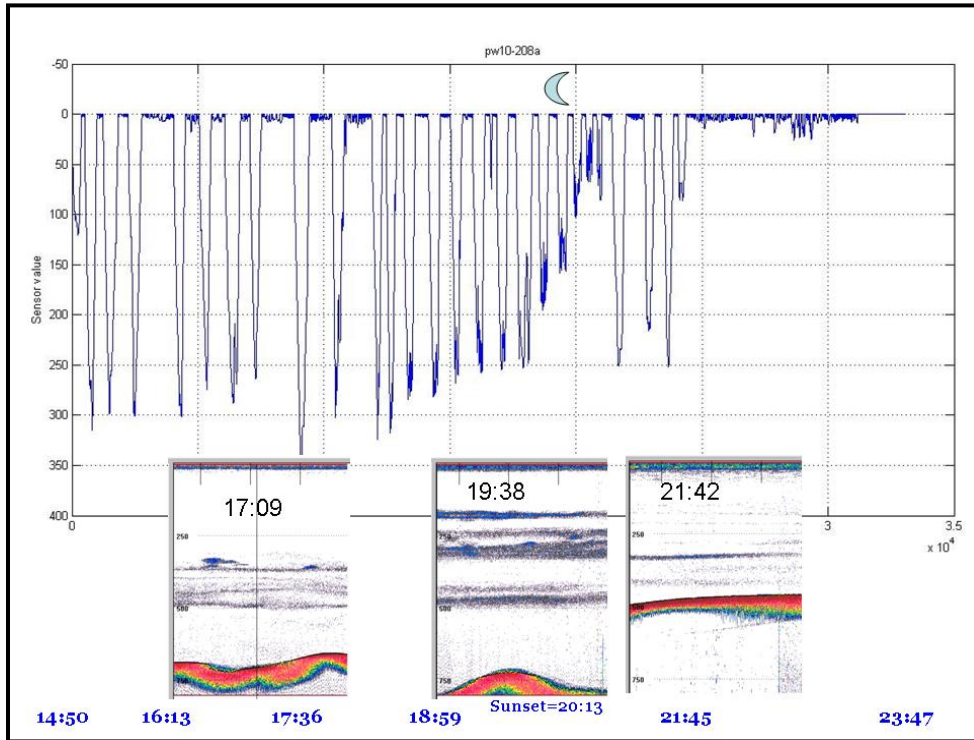


Figure 19. Example of pilot whale biopsied in August 2007 and then re-sighted near the same location in May 2008.



THEME V. SUSTAINED OCEAN OBSERVATIONS AND CLIMATE



WHOI Contribution ARGO Float Program (2010-2011)

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoints 15,16,17,18, and 19
April 01, 2010-March 31, 2011

W. Brechner Owens - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. Steven Piotrowicz Climate Program Office

Related NOAA Goal Plan:

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The goal of the Argo float program is to have 3000 profiling floats reporting profiles of temperature and salinity on a 10-day cycle covering the global ocean. The program reached this goal in October, 2007. The present goal is to sustain this array 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 the data is 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. The activities carried during the present year of this grant include manufacturing of 65 floats for the Argo array, quality-control of the data for approximately 400 floats, and contributions scientific management of the Argo Float program. The manufacturing of floats was delayed due to the recall of Seabird CTDs. The remaining parts of the float have been manufactured and we expect to deploy the extra 30 floats during the next year.

HIGHLIGHTS

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

SOCIETAL BENEFITS

The Argo float program is one of the primary backbones of the Global Ocean Observing System, providing *in situ* measurements of temperature and salinity from the sea surface to 2000 m depth. The Argo data are used for operational forecasts of both inter-seasonal and seasonal to inter-annual predictions, such as El Nino forecasts, and to 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.

NOAA State of the Arctic Report (2010)

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 11
April 01, 2010-March 31, 2011

Andrey Proshutinsky - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. John Calder Climate Program Office, R/CPO

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The major project goal is to provide and effectively document current and unbiased observations on the state of the Arctic Ocean in a way that is accessible to a wide audience. The project's objective is to directly support NOAA's Program Plan for Building a Sustained Ocean Observing System for Climate by expanding current efforts to monitor and document the state of the Arctic Ocean.

ACCOMPLISHMENTS

Changes of the Arctic Ocean physical and biogeochemical parameters in 2011 relative to climatology of the 1970s and 2009-2010 were analyzed and described based on available observations and publications. Among analyzed parameters are: wind-driven circulation of ice and water, water temperature and salinity fields with some integral parameters like heat and fresh water content, rates of sea level change, and biology and geochemistry in the Chukchi and Beaufort Seas. Results of this report will be published in special issue of Bulletin of American meteorological society, posted at NOAA's web site and material of this study will be reported at EGU General Assembly in April 2011 (Vienna, Austria) and 11th Polar meteorology and oceanography conference in Boston (May 2-6, 2011), USA.

HIGHLIGHTS

Analysis of Arctic Ocean climate observations over the past decade indicates more or less stable conditions since 2008 with little variability relative to a mean state over the period 1997-2010. The system appears to have shifted to a new climate regime in 2007, adjusted to new conditions in 2008, and is now characterized by less sea ice, a warmer and fresher upper ocean and changing ecosystem parameters. Evidence since 2008 points to a stabilization of the system at this new climatic state.

SOCIETAL BENEFITS

Information about Arctic climate change will be available to wide community.

EDUCATION AND OUTREACH ACTIVITIES

Important project results will be presented at EGU General Assembly in 3-8 April (Vienna, Austria), 2011 and all information will be posted at NOAA's web site "Arctic report card": <http://www.arctic.noaa.gov/reportcard/>

PUBLICATIONS

Proshutinsky, A., M.-L. Timmermans, I. Ashik A. Beszczynska-Moeller, E. Carmack, I. Frolov, M. Itoh, T. Kikuchi, R. Krishfield, F. McLaughlin, S. Nishino, B. Rabe, U. Schauer, K. Shimada, V. Sokolov, M. Steele, J. Toole, W. Williams, R. Woodgate, M. Yamamoto-Kawai and S. Zimmermann, 2011: Ocean, [in "State of the Climate in 2010"]. *Bull. Amer. Meteor. Soc.*, submitted

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

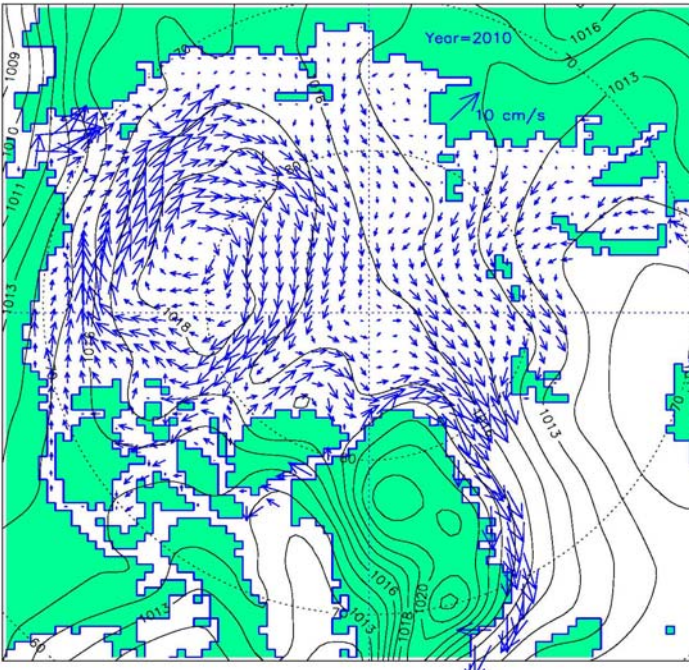


Figure 1 Annual 2010 simulated wind-driven ice motion (arrows) and sea level atmospheric pressure (hPa, black lines). Results from a 2-D coupled ice-ocean model (Proshutinsky and Johnson, 1997; 2010) forced by wind stresses derived from 2010 NCEP/NCAR reanalysis 6-hourly sea level pressure fields.

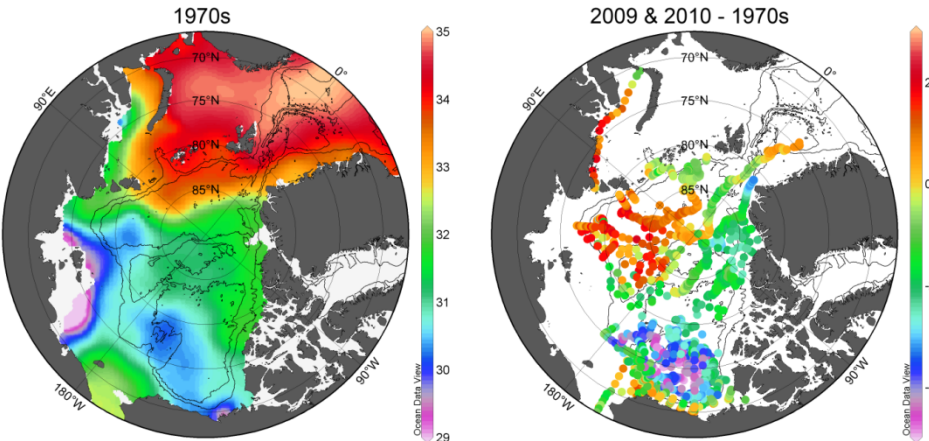


Figure 2 Anomalies of salinity at 20 m depth in 2009-2010 (right) relative to 1970s climatology (left). The 500 and 2500 m isobaths have been plotted using the IBCAO grid.

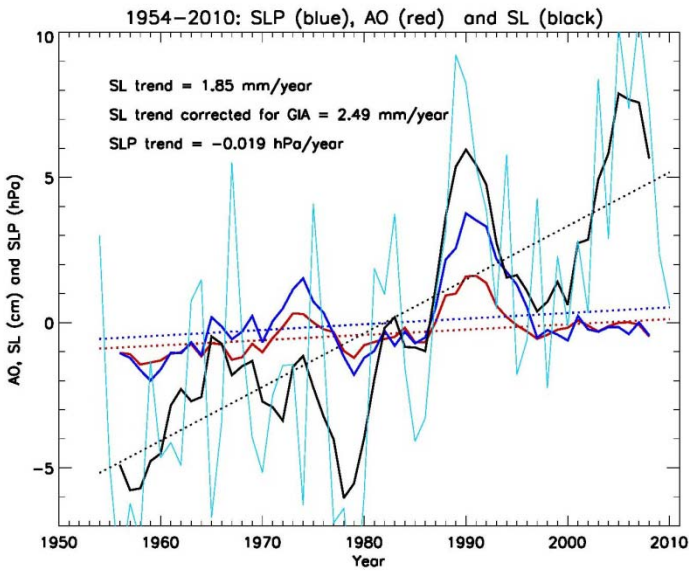


Figure 3 5-yr running mean time series of: annual mean sea level at nine tide gauge stations located along the coasts of the Kara, Laptev, east Siberian, and Chukchi seas (black line); anomalies of the annual mean Arctic Oscillation index (AO, Thompson and Wallace, 1998) multiplied by 3 for better visual comparison with other factors (red line); sea surface atmospheric pressure at the North Pole (from NCAR–NCEP reanalysis data) multiplied by -1 (inverted barometer effect, dark blue)

Development, Enhancement and Operation of Software Components for the IOOS Data Portal

NOAA Cooperative Agreement No. NA09OAR4320129 GMRI Subpoint 07
April 01, 2010-March 31, 2011

Thomas Shyka and Riley Young Morse - Gulf of Maine Research Institute

NOAA Program Manager: Zdenka Willis NOAA Integrated Ocean Observing Program

Related NOAA Goal Plan:

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The goal of the Data Catalog and Map Viewer project is to provide a single point of access to the standardized data servers that have been and will be established as part of IOOS. Specific objectives include: **Data Catalog** - a spatial database capable of storing metadata, observations and model outputs from IOOS data access services; **Harvester** that obtains metadata from SOS services and populate (a) the Data Catalog and (b) a Web-Accessible Folder (WAF) for indexing by search engines; an **interface to DAP/WCS/WMS harvester**; a map-based, web-accessible **Map Viewer** that provides a visual interface to the Data Catalog; and a **Search Form** providing a textual interface to the data catalog.

ACCOMPLISHMENTS

Version 1.0 of the IOOS Catalog/Map Viewer went live in June 2010 at <http://ioos.gov/catalog>. The catalog functions by back end polling and harvesting of both federal and regional SOS and THREDDS services to extract metadata and recent observations and create a geo-spatial database and web delivered display of the results. The map viewer allows rapid access to all recent observations and filtering by time range, geospatial boundaries, organization, service types, data types, etc. This enables users to determine the availability, relevance and location of available services.

Data Catalog: A spatial database was developed, based on the OpenIOOS database, to store spatial, temporal, data type, organization and service metadata about most IOOS DMAC Services at the national and regional level. It was found, particularly at the Regional level, that many services are not yet compliant or lack sufficient metadata to be properly represented in the Catalog.

Phase 2 tasks: Increase the number of IOOS participants.

1. **SOS Harvester:** A harvester was created to poll SOS endpoints and populate the Data Catalog. Organization and platform-specific metadata and recent observation values are collected hourly and the catalog is updated. In Phase 1, SWE versions were not included, only the IOOS DIF GML Schema type services were considered.
Phase 2 tasks: WAF output for SOSs and the ability to obtain SOS endpoints from the IOOS Service Registry, inclusion of SWE versions with numerous output formats.
2. **Interface to DAP/WCS/WMS harvester:** An automated WAF harvester was developed to convert metadata into a format that can be displayed and queried through the Map Viewer. Many of the THREDDS results lacked sufficient metadata to allow full querying via the Map Viewer. A common metadata model should be developed and wider use of both THREDDS and SOS metadata is encouraged by all service providers.
Phase 2 tasks: Expand the catalog database schema to handle the DAP/WCS/WMS metadata.
3. **Map Viewer:** A Google Maps based Map Viewer was established which allows querying far beyond the initial requirements. Future versions will address methods to compress the data, increase the map load times, increase inclusion of regional services and assist data providers with improving metadata. Phase 2 tasks: Map display of WMS services, time series plots, etc.
4. **Search Form:** Time and resource limitations limited the ability to complete this task. Much of the search functionality was included in the Map Viewer itself.
Phase 2 tasks: Enhanced Catalog database schema will allow for implementation of web-based search form.

Lessons were learned about metadata needs for DMAC SOS, DAP, WCS and WMS. The team recommends the use of the ISO 19115-2 and 19119 standards available in WAFs for DMAC Service metadata and documentation. Additionally, the use of SensorML in SOS services to improve metadata across both federal and regional assets should be encouraged.

The work on this project was extremely successful and was completed on time to meet the June 30, 2010 deadline. Efforts were made to successfully allow for numerous demonstrations prior to the project deadline.

HIGHLIGHTS

Development and launch of the catalog and map viewer: <http://ioos.gov/catalog/>

- IOOSCatalogDocumentationV1 Source code documentation and logic flow
- Zip file containing all source code is available

SOCIETAL BENEFITS

The development of a centralized catalog that provides access to all IOOS assets directly supports Goal 1 of the IOOS Strategic Plan - "Improve access to high-quality, integrated data."

EDUCATION AND OUTREACH ACTIVITIES

IOOS Director, Zdenka S. Willis, reported in the "Bi-Weekly Z-GRAM - 17 September 2010":

- **IOOS Data Catalog:** Jeff assessed the completion status of the IOOS Catalog functional requirements. This is part of the planning for the catalog's evolution. All Priority 1 requirements are at least partially complete, and most are 100% complete. Some of the Priority 2 and 3 requirements are 100% complete or partially complete.

PRESENTATIONS

A presentation was made by Eric Bridger of GMRI at the 2011 Coastal GeoTools Conference held on March 23, 2011 in Charleston, SC. The talk was entitled: "THE IOOS DATA CATALOG - HARVESTING AND DISPLAYING IOOS WEB SERVICES"

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Figure 1: A screen shot of the main interface of the catalog <http://ioos.gov/catalog>

R/V Atlantis Support of NOAA CalNEX 2010 Cruise

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 10
April 01, 2010-March 31, 2011

Albert Suchy - Woods Hole Oceanographic Institution

NOAA Program Manager: LCDR James Illg R/PMEL

Related NOAA Goal Plan:

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

This NOAA study was a collaboration between NOAA, the California Air Resources Board and the California Energy Commission. NOAA and its California partners planned a combined regional air quality and climate study within California and the eastern Pacific coastal region. This field campaign targeted the formation of pollution within California urban, industrial and agricultural regions; transport of pollution offshore; and the resulting impacts on regional air quality and climate. The R/V Atlantis, a UNOLS vessel operated by The Woods Hole Oceanographic Institution, was used in combination with ground sites and airborne platforms to determine how the transport and transformation of gaseous and aerosol chemical species influence air quality and climate forcing.

ACCOMPLISHMENTS

The UNOLS vessel Atlantis was deployed during the months of May and June 2010 off the coast of California and operated in coastal waters off California concentrating on the ports of San Diego, Los Angeles/Long Beach, San Francisco/Oakland, and Stockton/Sacramento. These operations included joint work with the NOAA P3, NOAA Twin Otter, and CIRPAS Twin Otter aircraft. The activities on this cruise included surface seawater and atmospheric continuous sampling.

HIGHLIGHTS

- A database was designed to populate the information obtained offshore to analyze the condition of the pollution levels contained in the waters and air offshore the San Diego, California area.

SOCIETAL BENEFITS

Pollution levels both in the air and in the water are a primary concern for both the citizens of California and for the nation. The level of contaminants in this area also impacts future climate and pollutant changes worldwide.

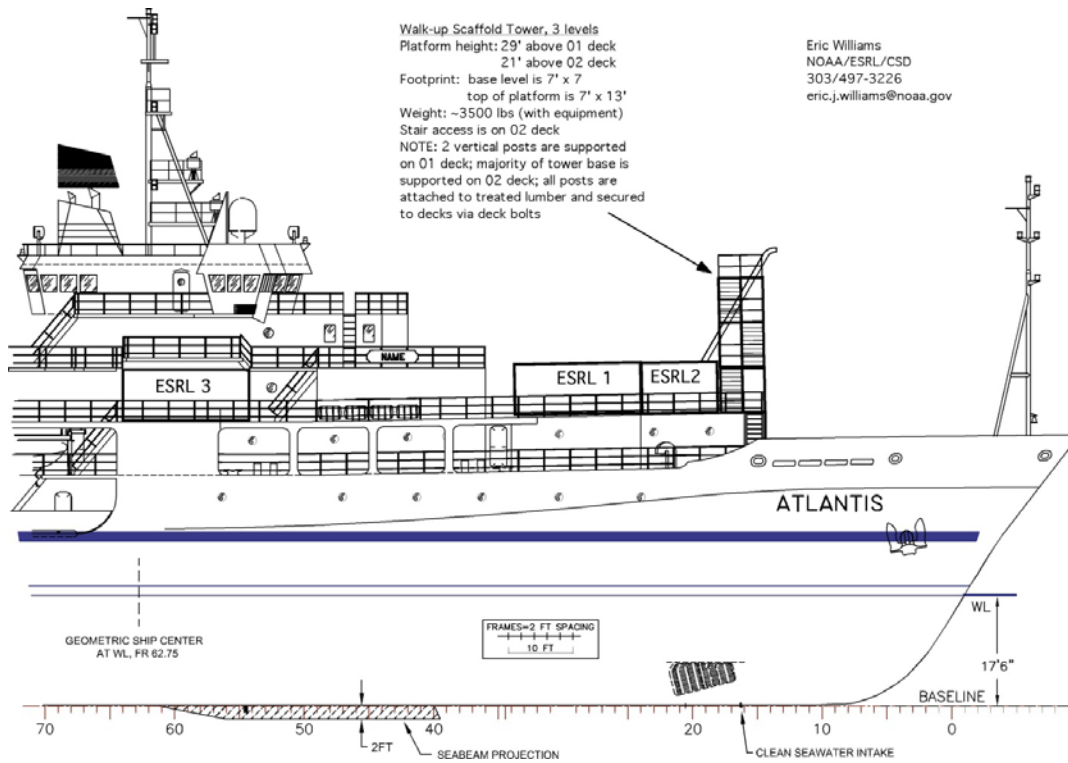
EDUCATION AND OUTREACH ACTIVITIES

The information analyzed from the database will provide useful information for both the state of California and NOAA and serve as a platform for future analysis of this area.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



Atlantis completely mobilized and preparing to depart San Diego May 14, 2010



Load-out Plan for CalNex Voyage May-June 2010

R/V Oceanus Use in Support of NOAA/AOML's Western Boundary Time Series Research

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 06
April 01, 2010-March 31, 2011

Albert Suchy - Woods Hole Oceanographic Institution

NOAA Program Manager: Diane Stanitski Climate Program Office / Climate Observation Division

Related NOAA Goal Plan:

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Woods Hole Oceanographic Institution provided the R/V Oceanus with a SSSG Technician for Molly Barringer to carry out her research on time series work mooring arrays along the continental slope east of Abaco Island, Grand Bahamas. The repeated hydrographic and tracer sampling at Abaco established a high resolution, high quality record of water mass properties in the Deep Western Boundary current at 26.5 degrees N. Events such as the intense convection period in the Labrador Sea and the renewal of classical Labrador Sea Water in the 1980's have clearly reflected in the cooling and freshening of the Deep Western Boundary Current waters off Abaco with the arrival of a strong chlorofluorocarbon pulse approximately 10 years later. This data set is unique in that it is not a single time series site but instead a time series of transport sections, including high quality water property measurements.

ACCOMPLISHMENTS

The UNOLS vessel Oceanus was deployed during the months of March and April 2010 out of Port Everglades Florida. A new monitoring system which includes a moored array of Inverted Echo Sounders (IESs) with each instrument equipped with a bottom pressure gauge (PIES) and a bottom current meter (ICPIES) was positioned across the shallow northward flowing Antilles Current as well as the southward flowing Deep Western Boundary current.

HIGHLIGHTS

The IES monitoring system was compared to a series of measurement systems that have been deployed as part of an interagency and international partnership that is testing a variety of low cost methods for observing the complete meridional overturning circulation cell at 26.5 degrees N in the Atlantic.

SOCIETAL BENEFITS

This time series study will provide a snapshot for observing the complete meridional overturning circulation cell in the Atlantic.

EDUCATION AND OUTREACH ACTIVITIES

This research will provide the basis for future studies with the NOAA Subtropical Atlantic Climate Studies program.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



RV Oceanus

Ocean Climate Observations and Analyses (2010-2011)

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 21, 22, 23, 24, and 25

April 01, 2010-March 31, 2011

Robert Weller - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. David Goodrich Climate Program Office

Related NOAA Goal Plan:

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The goal of this observational project is to maintain long-term surface moorings, known as Ocean Reference Stations (ORS), as part of the integrated ocean observing system. Ocean Reference Stations collect long time series of observations of surface meteorology and upper ocean variability in regions of key interest to climate studies. The resulting meteorological and oceanographic observations provide a set of high quality air-sea fluxes of heat, freshwater and momentum as well as upper ocean heat and salt content. The scientific rationale for the collection of these flux products is manifold: 1) to describe the upper ocean variability and the local response to atmospheric forcing; 2) to motivate and guide improvement to atmospheric, oceanic, and coupled models; 3) to calibrate and guide improvement to remote sensing products and capabilities; and 4) to provide anchor points for the development of new, basin scale fields of the air-sea fluxes. Model, satellite, and climatological fields of surface meteorology and air-sea fluxes have large errors; high quality, in-situ time series are the essential data needed to improve our understanding of atmosphere-ocean coupling and to create more accurate global fields. Given that the ocean covers 70% of the earth's surface and plays a large role in the dynamics governing weather and climate variability and change, it is critical to understand and accurately quantify the exchange of heat, freshwater, and momentum between the ocean and atmosphere and observe how the ocean stores heat and freshwater. This knowledge and these observations are essential for society to develop and evolve the abilities to understand and predict weather and climate variability and the role of the ocean in events such as prolonged drought and warming of surface temperatures. At present, very few sustained observing sites exist in the ocean away from the tropics, and these Ocean Reference Stations are building blocks of the international plans to establish an oceanic network of such sites.

Three Ocean Reference Stations are being maintained: A site at 20°S, 85°W under the stratus cloud deck off northern Chile (Stratus), the Northwest Tropical Atlantic Station



(NTAS) at 15°N, 51°W, and a site north of Hawaii near the Hawaii Ocean Time-series (HOT) site at 22.75°N, 158°W known as the WHOI Hawaii Ocean Time-series Station or WHOTS. Moorings at the Stratus and NTAS sites were initially deployed and serviced annually under NOAA OGP support; these sites have now transitioned to long-term Ocean Reference Stations. WHOTS was established in 2004, in collaboration with investigators that have made shipboard and moored observations in that region in recent years.

The Ocean Reference Stations project is managed under four task areas: 1) Engineering, oversight, and data management, 2) Maintenance of the Stratus site, 3) Maintenance of the NTAS site, and 4) Maintenance of the WHOTS site. Accomplishments in each of the task areas are reported in more detail below.

The data from the Ocean Reference Stations are widely used. They are served by a WHOI website (<http://uop.whoi.edu>), by the OceanSITES Global Data Assembly Centers (GDACs) at the National Data Buoy Center (NDBC) and Coriolis at IFREMER (French Institute for the Exploration of the Sea) in France. WHOI exchanges data with the European Centre for Medium Range Weather Forecasts (ECMWF) and the U.S. National Centers for Environmental Prediction (NCEP) for validation, verification of and work to improve numerical weather prediction (NWP) models. ORS Stratus data have been used in studies of atmospheric, oceanic, and coupled ocean-atmosphere dynamics in the stratus deck region off northern Chile, as a key part of the data resource for the VOCALS (VAMOS (Variability of the American Monsoon Systems) Ocean Cloud Atmosphere Land Study), and to ground truth remote sensing (SST, surface waves) off northern Chile. ORS Stratus, WHOTS, and NTAS data are being used to examine the realism of global NWP and climate models, as anchors to global flux databases, and as ground-truth for remote sensing and products derived from remote sensing.

ACCOMPLISHMENTS

The deliverables in the Work Plan are summarized below for each element of our program. A more detailed discussion on accomplishments, including contribution to overall program deliverables, work done, what was learned and its importance, risks due to funding and other issues, relevant websites, and key information about our data collection and distribution has been provided to the NOAA Climate Program Office directly in the Fall annual report.

Ocean Reference Stations - Deliverables

Engineering, Oversight and Data Management

Deliverables: The basic deliverable is the data, shared via our website (<http://uop.whoi.edu>). Success of the oversight and management of the Ocean Reference Station project is reflected in continued availability of high quality surface data and, with the work now underway, will also be reflected in the coming availability in near-real time of subsurface data to accompany the present telemetry of the surface data. NTAS subsurface data is available in near-real time. The basic deliverable, data, is also made available via OceanSITES, using NDBC as our GDAC (Global Data Assembly Center) for telemetered surface meteorology and for delayed mode, post-processed data. We have

used ORS data as a demonstrator for international data exchange via OceanSITES, and our staff participates in OceanSITES data management and science teams. The sustaining engineering effort ensures the continuity and quality of the data, and, if funding permits, to increase the volume of data provided in real time.

Stratus, NTAS, and WHOTS Ocean Reference Stations

Deliverables: The deliverables from these tasks are: 1) the cruise documentation in the form of the preliminary cruise report and final cruise report field with NOAA's NMAO and for Stratus, through them to the U.S. Department of State, 2) the cruise data distributed to all cruise participants and particularly for the Stratus ORS to foreign National Observers in compliance with U.S. Department of State regulations, 3) the near-real time, telemetered surface meteorological and ocean data made available via our website and ftp data server, 4) the unique, continuous, climate-quality records of surface meteorology, air-sea fluxes, and upper ocean variability at key locations, including delayed-mode data recovered from the moored and buoy instruments which were internally recorded, processed and made available on our web site once quality control and post-deployment calibration and sensor performance studies are finished.

Additional site-specific deliverables include:

Stratus: 5) surface wave data from a data sparse region through partnership with NDBC, 6) surface ocean carbon dioxide data through partnership with Chris Sabine at NOAA PMEL, 7) surface meteorology, air-sea fluxes, and upper ocean variability at the Chilean DART site. NTAS: 8) publications and presentation based on the analysis of the NTAS data, WHOTS: 9.) surface carbon dioxide observations by hosting instrumentation provided by Chris Sabine, NOAA PMEL, and 10) upper ocean variability, including temperature, currents, and salinity by partnering with investigators at the University of Hawaii.

HIGHLIGHTS

Engineering, Oversight and Data Management

- To increase bandwidth over our existing Argos telemetry system, we have implemented an Iridium telemetry system, including mooring controllers and an automated, shore-based decoding and processing system. This modular system allows storage, buffering and transmission of surface meteorology, subsurface data transmitted via inductive link, subsurface data transmitted via acoustic modem, or all three.
- Complimentary instrumentation to ORS installations now includes: pCO₂ instrumentation developed by Chris Sabine (NOAA PMEL) on both Stratus and WHOTS buoys; wave sensors on the Stratus buoy are also being used to measure surface waves in collaboration with the National Data Buoy Center (NDBC). This allows the ORS equipped with Sabine's sensor to contribute to the program deliverables for carbon. Knowledge of surface waves improves understanding of air-sea fluxes and supports the deliverable on air-sea exchanges.
- As a result of the collaboration between WHOI UOP and the NOAA National Data Buoy Center (NDBC) WHOI ORS data is in a format that can be utilized by standard

NDBC processing and display tools and ORS sites are now accessible as stations within the NDBC buoy network (see Stations 32ST0, 41NT0 and 51WH0, at <http://www.ndbc.noaa.gov>).

- WHOI UOP works with the OceanSITES team to develop protocols, policies and data format recommendations and ORS data is currently being served by OceanSITES in NetCDF format.
- The data from the Stratus ORS have been used to accurately quantify the role of air-sea interaction in maintaining the sea surface temperature and upper ocean heat and freshwater content; the conclusion was that ocean processes must cool and freshen the upper layer. This finding led to work on quantifying the role of ocean eddies in upper ocean dynamics in the region and to work with ocean modelers to examine and improve ocean model performance.

SOCIETAL BENEFITS

Given that the ocean covers 70% of the earth's surface and plays a large role in the dynamics governing weather and climate variability and change, it is critical to understand and accurately quantify the exchange of heat, freshwater, and momentum between the ocean and atmosphere and observe how the ocean stores heat and freshwater. This knowledge and these observations are essential for society to develop and evolve the abilities to understand and predict weather and climate variability and the role of the ocean in events such as prolonged drought and warming of surface temperatures. At present, very few sustained observing sites exist in the ocean away from the tropics. The Ocean Reference Stations are building blocks of the international plans to establish an oceanic network of such sites.

EDUCATION AND OUTREACH ACTIVITIES

Robert A. Weller

Dr. Weller routinely presents research results at national and international scientific meetings. He has served as Director of CICOR, the NOAA-WHOI Cooperative Institute for Climate and Ocean Research, which is closing in June 2011. He also serves on the NOAA Climate Working Group and on the NOAA Climate Observing System Council. He presents science and technology talks each year suitable for a general audience, for example to incoming graduate students, program officers, visiting officials, industry representatives and journalists. A number of these talks focus on the value of ocean observations and on the oceans role in climate. He reviews research papers and proposals. He hosts a NOAA Teacher at Sea whenever possible on STRATUS ORS and WHOTS ORS cruises. He has advised 3 Ph.D. students at WHOI, several Postdoctoral Scholars and Investigators and Summer Student Fellows.

Interactions with NOAA:

NOAA Climate Working Group: Member.

NOAA Climate Observing System Council: Member.



Office of Climate Observation: Presentations at Annual System reviews, 2003–20010.
Pacific Marine Environmental Laboratory: Cooperation with Dr. Sabine to deploy pCO₂ sensors on STRATUS and WHOTS ORS buoys. Cooperation with Dr. Meghan Cronin, Paul Frietag, and Chris Meinig on surface mooring sensors, surface mooring deployments, work at PAPA.

Earth System Research Laboratory: Cooperation with Dr. Fairall and his group on field intercomparisons of meteorological data and determination of sensor accuracy. External reviewer of PSD.

National Data Buoy Center: Cooperation with Dr. Teng on deployment of NDBC surface wave packages on ORS buoys and on deployment of radiation sensors on NDBC buoys on the New England Shelf. NDBC Advisory Group.

NOAA-WHOI Cooperative Institute for Climate and Ocean Research (CICOR): Director.

NOAA-WHOI Cooperative Institute for the North Atlantic Region (CINAR): Theme lead, Sustained Ocean Observations and Climate.

NOAA Ship Ronald H. Brown: Users' meeting, Norfolk, VA.

NOAA OAO Advisory Committee (chaired by Judy Gray): Member

Hosted NOAA Staff: Hosted Amanda McCartney, NOAA Climate Program, on WHOTS-7

Education and Outreach and Ocean Observing Related Activities (2010):

CLIVAR VOCALS (VAMOS Ocean Cloud Atmosphere Land Study): Scientific Steering Group Member

NOAA Teacher at Sea: Hosted TAS Steven King on WHOTS-7

Hosted CIRA (Colorado) Student: Hosted Jessica Ram, student of Tom Von der Haar on Stratus cruise, January 2010

IEEE Oceans – Buenos Aires: Outreach to Argentine colleagues on ocean observing; presented talk.

IEEE Oceans – Seattle: Outreach to ocean observing community, presented talk on an ocean observing collaboratory.

UNESCO/IOC Ocean Observations Panel for Climate (OOPC): Member.

JCOMM-OPS, Data Buoy Cooperation Panel: Attended Oban, Scotland meeting

GEOSS Capacity Building Panel: Member.

GEOSS Science and Technology Committee: Member.

Discipline Expert, Group on Earth Observations (GEO)

Discipline Expert, Interagency Working Group on Earth Observations (IWGEO)

International Time Series Science Team (OceanSITES): Co-chair.

CNO/SecNav Chair in Oceanography

NRC Committee on Intraseasonal to Interannual Prediction: Chair and Member, briefed report to Koblinsky, Rosen, Kumar and others at NOAA

Commonwealth of Massachusetts: Briefing to John Adams Innovation Fund to secure funding for adding radiation sensors to NDBC buoys off Massachusetts

Reviewer: Journal of Physical Oceanography, Journal of Geophysical Research, Deep-Sea Research, Journal of Marine Research, Geophysical Research Letters, Journal of Atmospheric and Oceanic Technology, Atmospheric Chemistry and Physics.

Albert J. Plueddemann

Dr. Plueddemann routinely presents research results at national and international scientific meetings. He also presents many science and technology talks each year suitable for a general audience, for example to incoming graduate students, program officers, visiting officials, industry representatives and journalists. He routinely reviews research papers and proposals and has served as Associate Editor for Reviews of Geophysics and the Journal of Atmospheric and Oceanic Technology. He served on the advisory committee for the New England Center for Ocean Sciences Education Excellence (COSEE), and has participated in COSEE-sponsored workshops on scientific communication and ocean literacy. He has participated in the Cambridge Science Festival. He has sponsored student interns, as well as NOAA Teacher at Sea and Teacher in the Lab participants on research cruises. He has advised or co-advised 5 postdoctoral scholars, 1 Ph.D. student, 1 M.S. student, 3 guest students, 8 Summer Student Fellows and 1 Undergraduate Research Fellow.

Interactions with NOAA:

Pacific Marine Environmental Laboratory: Cooperation with Dr. Sabine to deploy pCO₂ sensors on WHOTS ORS buoy.

Earth System Research Laboratory: Cooperation with Drs. Fairall and Pezoa on field intercomparisons of meteorological data and determination of sensor accuracy.

National Data Buoy Center: Cooperation with Dr. Teng on deployment of NDBC surface wave packages on ORS buoys and on deployment of radiation sensors on NDBC buoys on the New England Shelf; ongoing discussions about passing Atlantic ORS data to NHC/TPC.

National Hurricane Center – Tropical Prediction Center: Discussions with Eric Blake, Tropical Analysis and Forecast Branch, about making Atlantic ORS data available.

NOAA-WHOI Cooperative Institute for the North Atlantic Region (CINAR): Member of CINAR

Advisory Group.

Education and Outreach Activities(2010):

Committee member, PhD student Katie Silverthorne, 2006-2010

Project Scientist, Ocean Observatories Initiative, 2007-

Member, WHOI Ocean and Climate Change Institute Advisory Committee, 2008-

Advisor, Postdoc Emily Shroyer, 2009-

Member, Cooperative Institute for the North Atlantic Research Advisory Group, 2009-

Member, WHOI Information Technology Advisory Committee, 2009-

Co-Advisor (with R. Pickart), Postdoc Jeremy Kasper, 2010-

Participant, National Research Council Ocean Infrastructure 2030 Meeting, February 2010

Presenter, Barrow Arctic Science Consortium Schoolyard Project, March 2010

Presenter, WHOI Ocean Science Journalism Fellows, September 2010

Reviewer: Journal of Physical Oceanography, Journal of Geophysical Research, Deep-Sea Research, Journal of Marine Research, Limnology and Oceanography, Geophysical Research Letters, Reviews of Geophysics, Journal of Atmospheric and Oceanic Technology, IEEE Journal of Oceanic Engineering, Nature.

PUBLICATIONS

- Balch, W.M, **A.J. Plueddemann**, B.C. Bowler and D.T. Drapeau, 2009. ChalkEx – Fate of CaCO₃ particles in the mixed layer: Evolution of patch optical properties, *J. Geophys. Res.*, 114, C07020, doi:10.1029/2008JC004902.
- Colbo, K. and **R. A. Weller**, 2009. The accuracy of the IMET sensor package in the subtropics. *Journal of Atmospheric and Oceanic Technology*, **26**, 1867-1890.
- Cronin, M., Bond, N., Booth, J., Ichikawa, H., Joyce, T., Kelly, K., Kubota, M., Qiu, B., Reason, C., Rouault, M., Sabine, C., Saino, T., Small, J., Suga, T., Talley, L., Thompson, L. and **Weller, R.**, (2010). "Monitoring Ocean - Atmosphere Interactions in Western Boundary Current Extensions" in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2)*, Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.cwp.20
- Emery, W. J., E. Eshed, S. L. Castro, G.A. Wick, and **R.A. Weller**, 2010. Sea surface temperature measurements from drifting and moored buoys. *J. Geophys. Res.*, in review.
- Fairall, C., Barnier, B., Berry, D., Bourassa, M., Bradley, E., Clayson, C., de Leeuw, G., Drennan, W., Gille, S., Gulev, S., Kent, E., McGillis, W., Quartly, G., Ryabinin, V., Smith, S., **Weller, R.**, Yelland, M. and Zhang, H., (2010). "Observations to Quantify Air-Sea Fluxes and Their Role in Climate Variability and Predictability" in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2)*, Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.cwp.27
- Gerbi, G.P., J.H. Trowbridge, E.A. Terray, **A.J. Plueddemann**, and T. Kukulka, 2009, Observations of turbulence in the ocean surface boundary layer: Energetics and diffusivity, *J. Phys. Oceanogr.*, 39(5), 1077-1096, DOI: 10.1175/2008JPO4044.1.
- Ghate, V. P., B. A. Albrecht, C. W. Fairall, **R. A. Weller**, 2009: Climatology of surface meteorology, surface fluxes, cloud fraction and radiative forcing over south-east Pacific from buoy observations. *J. Climate*, **22**, 5527-5540.
- Kukulka, T., **A.J. Plueddemann**, J.H. Trowbridge and P.P. Sullivan, 2009. Significance of Langmuir circulation in upper ocean mixing: Comparison of observations and simulations, *Geophys. Res. Lett.*, 36, L10603, doi:10.1029/2009GL037620.
- Kukulka, T., **A. J. Plueddemann**, J. H. Trowbridge and P.P. Sullivan, 2010. Rapid mixed layer deepening by the combination of Langmuir and shear instabilities: A case study, *J. Phys. Oceanogr.*, in press.
- Lentz, S.J., R.K. Shearman and **A.J. Plueddemann**, 2010. Heat and salt balances over the New England shelf, August 1996 to June 1997, *J. Geophys. Res.*, 155(C07017), doi: 10.1029/2009JC006073.
- Send, U., **Weller, R.**, Wallace, D., Chavez, F., Lampitt, R., Dickey, T., Honda, M., Nittis, K., Lukas, R., McPhaden, M. and Feely, R., (2010). "OceanSITES" in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2)*, Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.cwp.79
- Song**, X., and **L. Yu**, 2010: High latitude contribution to global variability of air-sea sensible heat flux. *J. Climate*. Special issue on CLIVAR/SeaFlux High Latitude Surface Fluxes with due date on 1/7/11.

Whelan, S., F. Santiago-Mandujano, F. Bradley, A. **Plueddemann**, L. Barista, J. Ryder, R. Lukas, P. Lethaby, J. Snyder, C. Sabine, D. Stanitski, A.D. Rapp, C.W. Fairall, S. Pezoa, N. Galbriath, J. Lord and F. Bahr, 2010. WHOI Hawaii Ocean Timeseries Station (WHOTS): WHOTS-6 Mooring Turnaround Cruise Report, WHOI Tech Rept., WHOI-2010-02, 107 pp.

Wood, R., C.S. Bretherton, C. R. Mechoso, **R. A. Weller** et al., 2010. The VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment (VOCALS-Rex): goals, platform, and field operations. *Atmos. Chem. Phys. Discuss.*, 10, 1-53. Doi:10.5194/acpd-10-1-2010.

Vialard, J., J-P. Duvel, M. McPhaden, P. Bouruet-Aubertot, B. Ward, E. Key, D. Bourras, **R. Weller**, P. Minnett, A. Weill, C. Cassou, L. Eymard, T. Fristedt, C. Basdevant, Y. Dandoneau, O. Duteil, T. Izumo, C. de Boyer Montégut, S. Masson, 2009, Cirene: Air Sea Interactions in the Seychelles-Chagos thermocline ridge region, *Bull. Am. Met. Soc.*, 90, 45-61.

Yu, L., and **R. A. Weller**, 2010: Global ocean heat fluxes [in "State of the Climate in 2009"]. *Bull. Amer. Meteor. Soc.*, **91** (7), S59-S63.

* WHOI-MIT joint program student

** visiting student

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Figure 1. Monthly mean net shortwave from the Stratus buoy (green), ECMWF (blue), and NCEP (red). Note how the models are challenged to get shortwave radiation correct and how, during the spring-summer, the two models can differ by up to 100 W m^{-2} .

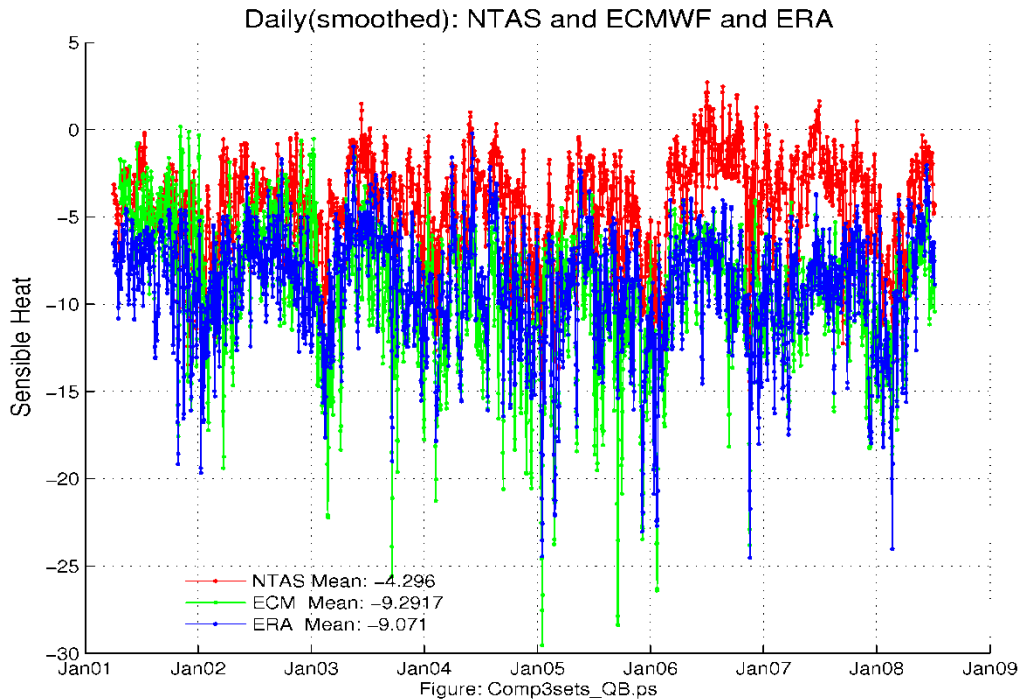


Figure 2. Sensible heat flux for NTAS-1 through NTAS-7 (red) compared with the ECMWF operational forecast (green) and the ERA-Interim reanalysis (blue) for the grid cell containing the buoy. Note the persistent overestimate of heat loss by both the forecast and reanalysis during 2006 and 2007.

Global Ocean Surface Heat Flux Analysis

NOAA Cooperative Agreement No. NA09OAR4320129 WHOI Subpoint 14
April 01, 2010-March 31, 2011

Lisan Yu - Woods Hole Oceanographic Institution

Robert A. Weller - Woods Hole Oceanographic Institution

NOAA Program Manager: Dr. David Legler Climate Program Office

Related NOAA Goal Plan:

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

CINAR Theme:

Theme V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The goal of the project is to establish a one-stop shop for high-quality, long-term global ocean surface forcing datasets, including air-sea heat (latent, sensible, shortwave, and longwave), momentum, and freshwater (evaporation) fluxes, to serve the needs of ocean and climate research and modeling community. The scientific rationale for developing and maintaining these global flux time series is that reliable, long-term, climate records are essential for characterizing long-term changes in surface forcing conditions, for attributing the causes of climate variability and change that occurred in both the atmosphere and the ocean, and for quantifying the oceanic role in the global energy budget and water cycle and their variability and change.

Direct flux measurements are limited, and global air-sea fluxes are commonly constructed from the flux bulk parameterizations based on surface meteorological variables (e.g., wind speed, temperature, humidity, cloud cover, etc). However, these meteorological variables are not immune from errors/biases regardless their sources, i.e., ship-based measurements, satellite derived products, and atmospheric reanalyses. This project, which is termed "Objectively Analyzed air-sea heat Fluxes (OAFlux)", is established on the basis that quality global flux fields can be produced from an advanced statistical approach that objectively synthesizes the advantages of the existing data sources.

At present, the OAFlux project has produced global 1° resolution, daily/monthly analysis (1958-to present) of ocean evaporation, air-sea latent and sensible heat fluxes, and related surface meteorological variables. These products are being maintained online (<http://oaflux.whoi.edu/data.html>) with twice-per-year updates. The OAFlux new



datasets, developed in coordination with other projects, are the global 0.25° and 1° resolution analyses of daily ocean vector wind fields covering the period of satellite passive/active sensors from 1987 to present. The current effort is directed toward a global net heat flux dataset with reduced biases/errors, especially in satellite-based surface radiation estimates. Steady progress has been made and the project is on track toward achieving the targeted goal.

ACCOMPLISHMENTS

Tasks carried out in FY10 included: 1) Maintenance and update of the online OAFlux long-term time series in support of the effort to deliver reliable OAFlux data record with best quality, 2) Improving net heat flux dataset by reducing biases/errors in satellite-based surface radiation estimates to achieve a globally balanced surface energy budget, and 3) Climate applications of OAFlux products to investigate the long-term change of the global water cycle and its role in the observed decadal variations of ocean salinity.

1) Maintenance and update of the online OAFlux long-term time series

OAFlux daily analysis includes global ocean evaporation, latent heat flux, sensible heat flux, and related surface meteorology. A framework was developed that supports data update twice per year to meet the demands of the growing OAFlux user base. During FY10, the updates were completed in May and October 2010, and the updated data, together with existing time series since 1958, are disseminated online via the project website at <http://oaflux.whoi.edu>.

2) Improving net heat flux dataset

Efforts have been made to quantify bias and errors in available surface radiation from the satellite-based global analyses such as ISCCP (International Satellite Cloud Climatology Project) and SRB (Surface Radiation Budget). Biases in the mean values and spurious jumps are found in these time series, which are caused by changes of satellite platforms, and artificial boundaries in space domain caused by merging of different sensors. A postdoc investigator was onboard in November 2010 and is currently working on quantification of biases in radiative products. A visiting student is working on regional budget analysis to understand the physical representation of net heat flux products.

3) Application of OAFlux products to study ocean salinity and the global water cycle

A series of studies were conducted to (a) study the intensification of evaporation and precipitation during the past warm decades as seen from the multi-decade data records of OAFlux and GPCP, and (b) use OAFlux and GPCP time series to determine the cause of the observed pattern change in the global salinity field. The effort has led to five peer reviewed publications (Yu, 2010a&b; Schanze et al., 2011; Yu and McPhaden 2011; Yu 2011).

HIGHLIGHTS

- OAFlux data products are available online with two updates per year. The user base grows rapidly with years.
- OAFlux time series establishes observational evidence of the role of the ocean in the change of the global water cycle during the past warm decades, and is included in the IPCC 5th assessment report (AR5).
- OAFlux products are a base dataset used in NOAA's annual assessment of State of the Climate. The report is published annually in *Bulletin of the American Meteorological Society*.
- The project was in NOAA OCO Highlight for Our Changing Planet 2010: Sustained Ocean Observations Demonstrate Increasing Evaporation.

SOCIETAL BENEFITS

Reliable, long-term, climate records of air-sea heat, freshwater, and momentum fluxes are important for characterizing long-term changes in surface forcing conditions, for attributing the causes of climate variability and change that occurred in both the atmosphere and the ocean, and for quantifying the oceanic role in the global energy budget and water cycle and their variability and change.

EDUCATION AND OUTREACH ACTIVITIES

The PI actively engages in educational and outreach activities. She attends national and international meetings and gives research presentations based on the OAFlux project. She was a contributing author to the IPCC Fifth Assessment Report. She was an invited participant at the JPL Earth Science Future Principal Investigators' workshop. She was an invited speaker at the symposium on "Climate prediction and information for the society" hosted by JAMSTEC, Japan. Her educational activities in FY10 include co-supervising WHOI-MIT Joint Program Ph.D student (Julian Schanze) (resulting in one publication: Schanze, Schmitt, and Yu, 2011), advising visiting student, Xiangzhou Song (resulting in one manuscript submission: Song and Yu 2011), co-advising postdoctoral investigator, Sachiko Yoshida. She also assisted NASA Education and Outreach Program (EOP) to create data-driven tools (e.g. bookmarks, short videos, etc) using OAFlux data products.

PUBLICATIONS

Yu, L., 2010a: Sea surface exchanges of momentum, heat, and freshwater determined by satellite remote sensing. *Elements of Physical Oceanography: A Derivative of the Encyclopedia of Ocean Sciences*. S. Thorpe (Ed). Academic Press, London, UK. 627pp. 135-144.

Yu, L., 2010b: On surface salinity skin effect under evaporation conditions and implications for remote sensing of ocean salinity. *Journal of Physical Oceanography*. 40, 85-102.

Nof, D., S. Gorder, and L. Yu, 2010: Thoughts on a variable meridional overturning cell and a variable heat-flux to the atmosphere. *Geophysical & Astrophysical Fluid Dynamics*. 104, doi:10.1080/03091929.2010.481383.

Yu, L., and R. A. Weller, 2010: Global ocean heat fluxes [in "State of the Climate in 2009"], *Bull. Amer. Meteor. Soc.*, 91 (7), S59-S63

Masumoto, Y., Yu, W., Meyers, G., D'Adamo, N., Beal, L., de Ruijter, W., Dyoulgerov, M., Hermes, J., Lee, T., Lutjeharms, J., McCreary Jr., J., McPhaden, M., Murty, V., Obura, D., Pattiaratchi, C., Ravichandran, M., Reason, C., Syamsudin, F., Vecchi, G., Vialard, J. and Yu, L., (2010). "Observing Systems in the Indian Ocean" in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2)*, Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306, doi:10.5270/OceanObs09.cwp.60

Schanze*, J. J., R. W. Schmitt, and L. Yu, 2011: The global oceanic freshwater cycle: A best-estimate quantification. *Journal of Marine Research*, 68, 569-595.

Yu, L., and M. J. McPhaden, 2011: Ocean pre-conditioning of Cyclone Nargis: Interaction between Rossby waves, surface fresh waters, and sea surface temperatures. *Journal of Physical Oceanography*. In Press.

Yu, L., 2011: A global relationship between the ocean water cycle and near-surface salinity. *Journal of Geophysical Research – Oceans*. Accepted

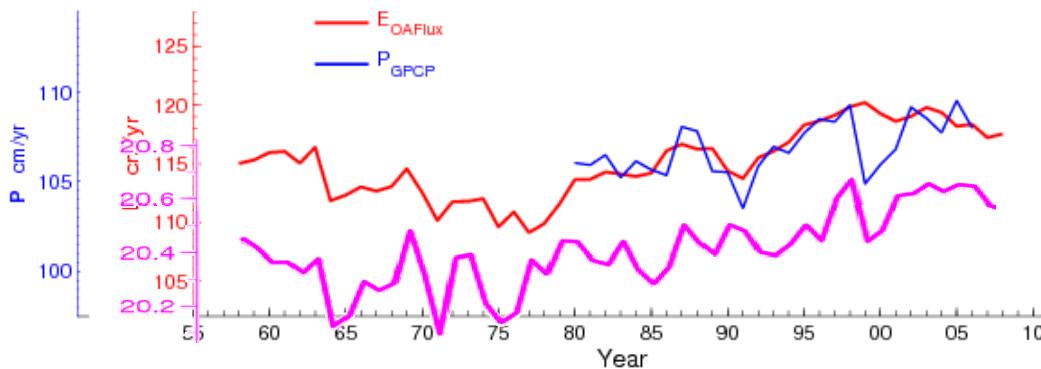
Song**, X., and L. Yu, 2011: High latitude contribution to global variability of sensible heat flux at the air-sea interface. *Journal of Climate*, Special collection on "CLIVAR/SeaFlux High Latitude Surface Fluxes". Submitted.

Yu, L., X. Jin, and R. A. Weller, 2011: Global ocean heat fluxes [in "State of the Climate in 2010"], *Bull. Amer. Meteor. Soc.*, submitted.

* WHOI-MIT joint program student

** WHOI visiting student

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



The figure shows that variations of ocean evaporation (red), precipitation (blue), and sea surface temperature (SST, magenta) since late 1950s. Time series of evaporation features a distinct transition from a downward trend to an upward trend around 1977-78. During the upward period between 1977 and 1999, surface warming was most pronounced and the mean global ocean evaporation was up about 11 cm/yr (~9%), from a low at 114 cm yr⁻¹ in 1977 to a peak at 125 cm yr⁻¹ in 1999. The close relationship between ocean evaporation and SST shows the important role of the oceans in climate variability and change of the global water cycle. It is known that one intuitive consequence of climate warming is the increase of moisture holding capacity of the atmosphere following the Clausius-Clapeyron equation. While warmer air holds more moisture and warmer sea surface evaporates more readily, evaporation is expected to increase with increasing temperature. The increased evaporation in turn causes an increase in global precipitation, and hence the acceleration of the global water cycle.

APPENDIX 1: PERSONNEL SUPPORTED BY CINAR FUNDING

Personnel summary:

April 1, 2010 – March 31, 2011
Task I Support

Employees

Appt. Dates

Don Anderson, CINAR Director
Judy Kleindinst, CINAR Administrator
Ann Stone, CINAR Administrative Professional

7/1/09 - present
7/1/09 - present
9/26/09-present

Postdoc	CINAR Theme	Appt. Dates	Advisors
Dr. Joel Llopiz University of Miami Rosensteil School of Marine and Atmospheric Science	Ecosystem Monitoring	Fall 2010 (18 month appt.)	Carin Ashjian Cabell Davis Simon Thorrold
Dr. Robert Todd University of California, San Diego	TBD	Fall 2011 (18 month appt.)	Fiammetta Straneo Glen Gawarkiewicz Steven Lentz Albert Plueddemann

PERSONNEL SUMMARY:

Category	Number	B.S	M.S.	Ph. D.
Employees that receive \geq 50 %		NOAA Funding	(not including	Students)
Research Scientist	6	2	1	3
Visiting Scientist	0	0	0	0
Post Doctoral Fellow	2	0	0	2
Research Support Staff	8	6	1	1
Administrative	0	0	0	0
TOTAL	16	8	2	6
Employees that receive $<$ 50 %		NOAA Funding	(not including	Students)
Research Scientist	24	0	3	21
Visiting Scientist	0	0	0	0
Post Doctoral Fellow	2	0	0	2
Research Support Staff	32	12	17	4
Administrative	11	5	3	0
TOTAL	69	17	23	27

Students	0	0	0	0
Undergraduate Students	0	0	0	0
Graduate Students	5	0	5	0
TOTAL	5	0	5	0

Obtained NOAA employment within the last year	0	0	0	0
--	----------	----------	----------	----------

APPENDIX 2: 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	Moore, M.J./Knowlton, A.R., Landry, S.C., Robbins, J., McKenna, H., Werner, T.	Published	2011	Case Studies in Entanglements of Right Whales (Eubalaena glacialis) and Humpback Whales (Megaptera novaeangliae) from the East Coast of North America	Compiled as a reference for the Dynamics of Large Whale Entanglements in Fishing Gear Workshop, February 9-11, 2011. Held at Woods Hole Oceanographic Institution	Workshop proceedings		X				X
CINAR	Moore, M.J./ Dennison S, Moore MJ, Fahlman AJ, Touhey Moore K, Sharp S, Harry CT, Hoppe J, Niemeyer M, Lentell B, and Wells RS.	In Review	2011	Bubbles in Live Dolphins	Proceedings Royal Society B	Journal Article		X			X	
CINAR	Moore, M.J./Van Bonn W, Montie E, Dennison S, Pussini N, Cook P, Greig D, Barakos J, Colegrove K, & Gulland F.	In 2nd review	2011	Evidence of injury caused by gas bubbles in a live marine mammal: Barotrauma in a California sea lion (<i>Zalophus californianus</i>)	Diseases of Aquatic Organisms	Journal Article				X		
CINAR	Moore, M.J./Dennison SE, Van Bonn W, Boor M, Adams J, Pussini N, Spraker T, Gulland FMD.	In Press	2011	Foramen ovale and Ductus arteriosus patency in neonatal harbor seal pups (<i>Phoca vitulina</i>) in rehabilitation	Diseases of Aquatic Organisms	Journal Article		X				
CINAR	Moore, M.J./Dennison SE, Van Bonn W, Boor M, Adams J, Pussini N, Spraker T, Gulland FMD.	In Press	2011	Antemortem diagnosis of ventricular septal defect in a California sea lion (<i>Zalophus californianus</i>)	Diseases of Aquatic Organisms	Journal Article		X				
CINAR	Ashjian C./ Okkonen, S.R., Ashjian, C.J., Campbell, R.G., Clarke, J., Moore, S.E., Taylor.	In Review	2011	Satellite observations of circulation features associated with the Barrow area bowhead whale feeding hotspot	Remote Sensing of the Environment	Journal Article				x	x	
CINAR	Holland, D.S./ Holland, D.S., P. Pinto da Silva, J. Wiersma	Published	2010	A survey of social capital and attitudes toward management in the New England groundfish fishery	US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-12; 13 p.	Journal Article		X				X
CINAR	Baumgartner, M.F./Baumgartner, M.F. and S.E. Mussoline	In Press	2011	A generalized baleen whale call detection and classification system	Journal of the Acoustical Society of America	Journal Article		X			X	
CINAR	Proshutinsky, A., M.-L./ Proshutinsky, A., M.-L. Timmermans, I. Ashik A. Beszczynska-Moeller, E. Carmack, I. Frolov, M. Itoh, T. Kikuchi, R. Krishfield, F. McLaughlin, S. Nishino, B. Rabe, U. Schauer, K. Shimada, V. Sokolov, M. Steele, J. Toole, W. Williams, R. Woodgate, M. Yamamoto-Kawai and S. Zimmermann	In Review	2011	Ocean, [in "State of the Climate in 2010"]	Bull. Amer. Meteor. Soc.	Journal Article		X			X	
CINAR	Plueddemann, A.J./ Balch, W.M, A.J. Plueddemann, B.C. Bowler and D.T. Drapeau	Published	2009	ChalkEx - Fate of CaCO3 particles in the mixed layer: Evolution of patch optical properties	J. Geophys. Res., 114, C07020,	Journal Article	doi:10.1029/2008JC004902			X	X	
CINAR	Weller, R. A./Colbo, K. and R. A. Weller	Published	2009	The accuracy of the IMET sensor package in the subtropics	Journal of Atmospheric and Oceanic Technology, 26, 1867-1890	Journal Article				X	X	
CINAR	Weller, R. A./Cronin, M., Bond, N., Booth, J., Ichikawa, H., Joyce, T., Kelly, K., Kubota, M., Qiu, B., Reason, C., Rouault, M., Sabine, C., Saino, T., Small, J., Suga, T., Talley, L., Thompson, L. and Weller, R.	Published	2009	Monitoring Ocean - Atmosphere Interactions in Western Boundary Current Extensions"	Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21-25 September 2009 Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306,	Conference Proceedings	doi:10.5270/OceanObs09.cwp.20			X	X	
CINAR	Weller, R. A./Emery, W. J., E. Eshed, S. L. Castro, G.A. Wick, and R.A. Weller	In Review.	2010	Sea surface temperature measurements from drifting and moored buoys	J. Geophys. Res.	Journal Article				X	X	

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	Weller, R. A./Fairall, C., Barnier, B., Berry, D., Bourassa, M., Bradley, E., Clayson, C., de Leeuw, G., Drennan, W., Gille, S., Gulev, S., Kent, E., McGillis, W., Quartly, G., Ryabinin, V., Smith, S., Weller, R. , Yelland, M. and Zhang, H.	Published	2010	Observations to Quantify Air-Sea Fluxes and Their Role in Climate Variability and Predictability	Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306,	Conference Proceedings	doi:10.5270/OceanObs09.cwp.27			X	X	
CINAR	Plueddemann,A.J./Gerbi, G.P., J.H. Trowbridge, E.A. Terray, A.J. Plueddemann , and T. Kukulka	Published	2009	Observations of turbulence in the ocean surface boundary layer: Energetics and diffusivity	J. Phys. Oceanogr., 39(5), 1077-1096, DOI: 10.1175/2008JPO4044.1.	Journal Article				X	X	
CINAR	Weller, R. A./Ghate, V. P., B. A. Albrecht, C. W. Fairall, R. A. Weller ,	Published	2009	2009: Climatology of surface meteorology, surface fluxes, cloud fraction and radiative forcing over south-east Pacific from buoy observations	J. Climate, 22, 5527-5540.	Journal Article				X	X	
CINAR	Plueddemann,A.J./Kukulka, T., A.J. Plueddemann , J.H. Trowbridge and P.P. Sullivan	Published	2009	009. Significance of Langmuir circulation in upper ocean mixing: Comparison of observations and simulations	Geophys. Res. Lett., 36, L10603, doi:10.1029/2009GL037620	Journal Article				X	X	
CINAR	Plueddemann,A.J./Kukulka, T., A. J. Plueddemann , J. H. Trowbridge and P.P. Sullivan,	In Press.	2010	2010. Rapid mixed layer deepening by the combination of Langmuir and shear instabilities: A case study	J. Phys. Oceanogr.,	Journal Article				X	X	
CINAR	Plueddemann,A.J./Lentz, S.J., R.K. Shearman and A.J. Plueddemann ,	Published	2010	2010. Heat and salt balances over the New England shelf, August 1996 to June 1997.	J. Geophys. Res., 155(C07017),	Journal Article	doi: 10.1029/2009JC006073			X	X	
CINAR	Weller, R. A./Send, U., Weller, R. , Wallace, D., Chavez, F., Lampitt, R., Dickey, T., Honda, M., Nittis, K., Lukas, R., McPhaden, M. and Feely, R.,	Published	2010	"OceanSITES"	in Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306,	Conference Proceedings	doi:10.5270/OceanObs09.cwp.79			X	X	
CINAR	Yu,L. /Song**, X., and L. Yu ,	In Review	2011	High latitude contribution to global variability of air-sea sensible heat flux	J. Climate, Special issue on CLIVAR/SeaFlux High Latitude Surface Fluxes	Journal Article				X	X	
CINAR	Plueddemann,A.J./Whelan, S., F. Santiago Mandujano, F. Bradley, A. Plueddemann , L. Barista, J. Ryder, R. Lukas, P. Lethaby, J. Snyder, C. Sabine, D. Stanitski, A.D. Rapp, C.W. Fairall, S. Pezoa, N. Galbriath, J. Lord and F. Bahr	Published	2010	WHOI Hawaii Ocean Timeseries Station (WHOTS):	WHOTS-6 Mooring Turnaround Cruise Report, WHOI Tech Rept., WHOI-2010-02, 107 pp.	Journal Article				X		X
CINAR	Weller, R. A./Wood, R., C.S. Bretherton, C. R. Mechoso, R. A. Weller et al.,	Published	2010	The VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment (VOCALS-Res): goals, platform, and field operations.	Atmos. Chem. Phys. Discuss., 10, 1-53.	Journal Article	Doi:10.5194/acpd-10-1-2010			X	X	
CINAR	<u>Weller, R. A./Vialard, J.</u> -P. Duvel, M. McPhaden, P. Bouruet-Aubertot, B. Ward, E. Key, D. Bourras, R. Weller , P. Minnett, A. Weill, C. Cassou, L. Eymard, T. Fristedt, C. Basdevant, Y. Dandoneau, O. Duteil, T. Izumo, C. de Boyer Montégut, S. Masson,	Published	2009	Cirene: Air Sea Interactions in the Seychelles-Chagos thermocline ridge region	Bull. Am. Met. Soc., 90, 45-61.	Journal Article				X	X	
CINAR	Weller, R. A./Yu, L., and R. A. Weller	Published	2010	Global ocean heat fluxes [in "State of the Climate in 2009"]	Bull. Amer. Meteor. Soc., 91 (7), S59-S63.	Journal Article		X			X	

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	Yu,L./Yu, L.	Published	2010	Sea surface exchanges of momentum, heat, and freshwater determined by satellite remote sensing. Elements of Physical Oceanography: A Derivative of the Encyclopedia of Ocean Sciences. S.Thorpe (Ed)	Academic Press, London, UK. 627pp. 135-144.	Journal Article		X			X	
CINAR	Yu,L./Yu, L.	Published	2010	On surface salinity skin effect under evaporation conditions and implications for remote sensing of ocean salinity	Journal of Physical Oceanography. 40, 85-102.	Journal Article		X			X	
CINAR	Yu,L./Nof, D., S. Gorder, and L. Yu	Published	2010	Thoughts on a variable meridional overturning cell and a variable heat-flux to the atmosphere.	Geophysical & Astrophysical Fluid Dynamics. 104,	Journal Article	doi:10.1080/03091929.2010.481383			X	X	
CINAR	Yu,L./Yu, L., and R. A. Weller	Published	2010	Global ocean heat fluxes [in "State of the Climate in 2009"]	Bull. Amer. Meteor. Soc., 91 (7), S59-S63	Journal Article		X			X	
CINAR	Yu,L./Masumoto, Y., Yu, W., Meyers, G., D'Adamo, N., Beal, L., de Ruijter, W., Dyoulgerov, M., Hermes, J., Lee, T., Lutjeharms, J., McCreary Jr., J., McPhaden, M., Murty, V., Obura, D., Pattiaratchi, C., Ravichandran, M., Reason, C., Syamsudin, F., Vecchi, G., Vialard, J. and Yu, L.,	Published	2010	"Observing Systems in the Indian Ocean"	in Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306,	Conference Proceedings	doi:10.5270/OceanObs09.cwp.60			X	X	
CINAR	Yu,L./Schanze*, J. J., R. W. Schmitt, and L. Yu,	Published	2011	The global oceanic freshwater cycle: A best-estimate quantification	Journal of Marine Research, 68, 569-595.	Journal Article				X	X	
CINAR	Yu,L./Yu, L., and M. J. McPhaden	In Press.	2011	Ocean pre-conditioning of Cyclone Nargis: Interaction between Rossby waves, surface fresh waters, and sea surface temperatures.	Journal of Physical Oceanography.	Journal Article		X			X	
CINAR	Yu, L.	In Press	2011	A global relationship between the ocean water cycle and near-surface salinity	Journal of Geophysical Research – Oceans.	Journal Article		X			X	
CINAR	Yu,L./Song**, X., and L. Yu	In Review	2011	High latitude contribution to global variability of sensible heat flux at the air-sea interface	Journal of Climate, Special collection on "CLIVAR/SeaFlux High Latitude Surface Fluxes".	Journal Article				X	X	
CINAR	Yu,L./Yu, L., X. Jin, and R. A. Weller	In Review	2011	Global ocean heat fluxes [in "State of the Climate in 2010"]	Bull. Amer. Meteor. Soc.,	Journal Article		X			X	