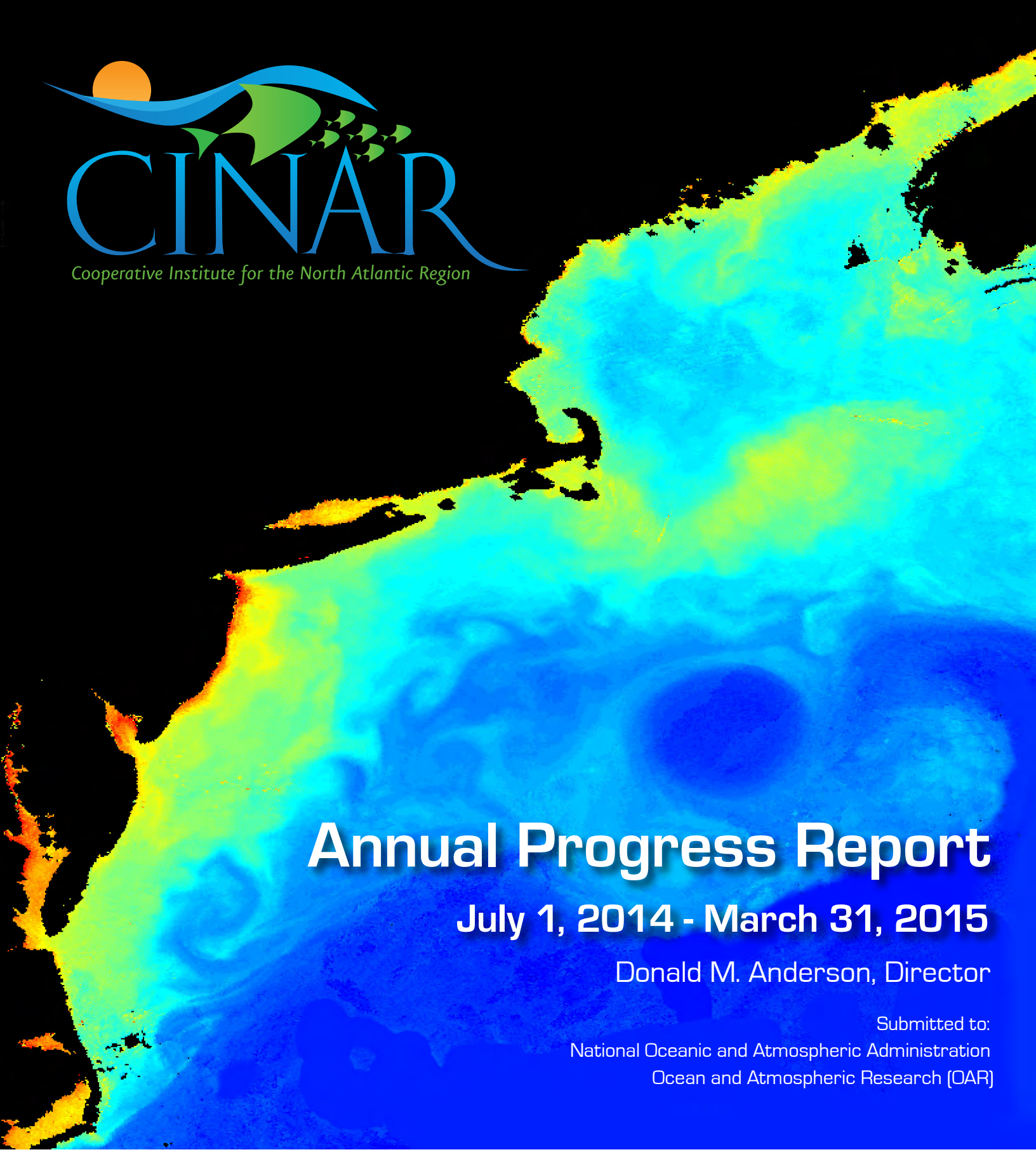
CINAR

Cooperative Institute for the North Atlantic Region



Annual Progress Report

July 1, 2014 - March 31, 2015

Donald M. Anderson, Director

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

Gulf of Maine Research Institute

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University of Maryland CENTER FOR ENVIRONMENTAL SCIENCE

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CINAR
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Reporting Period: July 01, 2014 - March 31, 2015

Submitted by:

Donald M. Anderson, Director

Submitted to NOAA on 06/30/2015

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Executive Summary

CINAR began operation on July 1, 2009 and the CINAR renewal agreement began July 1, 2014. WHOI is the lead institution in partnership with the University of Maryland Center for Environmental Science, Rutgers University, University of Maine and the Gulf of Maine Research Institute.

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

Funding:

- During the first year of operation under the renewal award (July 1, 2014 through March 31, 2015), CINAR received $7,856,027 from OAR, $3,111,641 from NMFS, $648,368 from NOS and $44,245 from NESDIS.

Education and Outreach

CINAR continued its program in summer Minority Traineeships, providing one minority student to each partner. These students received training through one or more CINAR investigators. Details about the summer 2014 program are provided under Task I activities.

Following up on the successful informal workshop we held in 2014 called “CINAR 101” to explain the process of preparing CINAR proposals, submission, and the award process for our partners, CINAR staff visited UMaine and GMRI. At each location, tailored presentations were given and meetings were held with both researchers and administrative staff to answer individual questions and clear up some misconceptions.

Last year, we began a new program, “*WHOI-NEFSC Special Seminar Series on Fisheries and Ecosystems Acoustics*”. That successful seminar series has been well received and will continue for the foreseeable future. More details are provided under the Task I activities section.

In 2012, we began a partnership with the University of Massachusetts School of Marine Science and Technology (SMAST) and the NEFSC to address issues related to Massachusetts and regional fishing communities. Two components are included: 1) a series of rotating, competitive Fellow awards for WHOI scientists working in areas relevant to the central theme of quantitative fisheries science; and 2) faculty support at SMAST to conduct research and educational activities related to stock assessment and quantitative fisheries science. Detailed progress reports from each CINAR Fellows and SMAST faculty are provided, beginning on page 197.

Mark Baumgartner – Woods Hole Oceanographic Institution
Passive acoustic monitoring from autonomous platforms

The objectives of this project are to (1) demonstrate the utility of real-time passive acoustic monitoring of baleen whales from autonomous platforms using the digital acoustic monitoring (DMON) instrument and the low-frequency detection and classification system (LFDCS), (2) validate the accuracy of *in-situ* detection and classification capability when used on a variety of stationary and mobile autonomous platforms, and (3) incorporate this new technology into NMFS whale and fish monitoring efforts. The project will provide flexible tools for long-term reduction in analytical effort and improved efficiency of existing monitoring technologies (e.g., visual surveys).

- This project deployed the Nomans Land moored buoy to incorporate near real-time whale acoustic detections in Coast Guard gunnery exercise scheduling to reduce impacts to endangered baleen whales.
- Passive acoustic detection of Atlantic cod, baleen whales, and dolphins was carried out from two Slocum gliders in Stellwagen Basin, with simultaneous detection of tagged Atlantic cod and measurement of oceanographic conditions for three weeks.
- Near real-time passive acoustic monitoring capability was implemented from wave gliders.

Damian Brady - University of Maine
Characterizing the Penobscot River estuarine transition zone to determine environmental challenges for Atlantic salmon, their prey, and other sea-run species

The abundance of Atlantic salmon *Salmo salar* has precipitously declined in recent decades, despite considerable conservation efforts. One reason for this decline is high mortality and smolt loss during their seaward migration through estuaries, which is higher than monthly mortality in open ocean systems. This project will provide a rare survey of migrating smolts along with spatially-coupled measurements of physical variables and available prey to elucidate the major obstacles hindering smolt migration and salmon recovery.

- Together with NOAA, we are creating an ecosystem-based framework for monitoring the U.S.'s largest river restoration program. In addition to current sampling for anadromous fish, we are expanding the monitoring protocol to include measurements of water quality and prey abundance along important migration corridors.

Anne Cohen – Woods Hole Oceanographic Institution
Carbonate mineralogy of Alaskan corals

This project seeks to determine skeletal mineralogy and composition of Alaskan corals belonging to a range of coral taxa. Skeletal mineralogy and magnesium (Mg) content of skeletal carbonates are considered important criteria in evaluating the vulnerability of deep and cold-water taxa to ocean acidification.

- The diverse collections of archived specimens at the Auke Bay Laboratories and Smithsonian Institution were carefully sorted through and 108 specimens from all major groups of corals were selected for laboratory analyses.
- Corals were selected to cover major taxonomic groups, species of particular ecological importance (i.e., those that form large single species assemblages), and specimens of the same species from multiple depth and geographic zones.
- During this study we obtained skeletal ratios (aragonite, calcite, high Mg-calcite) for a total of 108 specimens from all major groups of corals, and examined intraspecific variation in skeletal mineralogy across broad geographic scales and depth.
- Data from this study will help address the effects of ocean acidification on coral reefs.

Alexa Dayton – Gulf of Maine Research Institute
Marine Resources Education Program: Northeast Region

This program represents a continuation of the collaboration between the Gulf of Maine Research Institute and partners in the Northeast fisheries region to refine and implement another set of Marine Resource Education Program (MREP) workshops, a fishery science and management education program for commercial and recreational fishermen. This program enables fishermen and others to participate productively in the fisheries science and management processes, and leads to improved cooperation and trust between fishermen, and scientists and managers. Fundamentally, a co-learning approach is used, where program developers, program participants, and program presenters all learn from one another through their interactions and collaborations. During the past year, MREP made substantial progress in several areas, by:

- Expanding our network structure to incorporate new and underserved communities.
- Integrating workshop recruiting, delivery, and curricula to attract fishermen across the Mid-Atlantic and New England regions.
- Adapting module delivery to allow larger, more diverse classes, reaching more fishermen.
- Delivering three workshops total, attracting 54 total unique participants.
- Expanding speaker's bureau and program content to meet evolving industry needs and increased geographic breadth.

Chris German – Woods Hole Oceanographic Institution
Exploration of the Arctic Ocean with Nereid-Under-Sea

The primary objectives of this project were two-fold: first, to conduct the first under-ice dives of the new hybrid ROV Nereid Under Ice (NUI) to evaluate its capabilities for polar ocean exploration and research; second, while on station at the Gakkel Ridge, to explore for, and ideally locate, the first high temperature "black smoker" hydrothermal vents to be tracked to source in this ice-covered ocean.

- The first dives of the NUI vehicle under ice were carried out successfully, in both ROV and AUV form, and documented surprisingly abundant and diverse life immediately at/beneath the ice-ocean interface.
- The evolution of a spring bloom was documented over the course of four dives.
- During the dives, we discovered the first black smoker hydrothermal vents in the ice-covered Arctic Ocean.

Jacqueline Grebmeier – The University of Maryland Center for Environmental Science
Pacific Arctic Group Secretariat Office 2013-2014

The Pacific Arctic Group (PAG) is a networked group of international institutes and individuals, and has as its mission to serve as a Pacific Arctic regional partnership to plan, coordinate, and collaborate on science activities of mutual interest. The PAG activities are centered around networking oceanographic field activities in the Pacific Arctic region, coordinating the Distributed Biological Observatory (DBO) as an international time-series array of latitudinal transects in the region, and undertaking various synthesis activities to better understand and track ecosystem status and trends in the Pacific Arctic marine region.

- The PAG has leadership for coordinating annual national and international sampling on the DBO that was developed as a "change detection array" to track biological response to sea ice retreat and environmental change. Repeat collections on standard transect lines from the northern Bering Sea to the northern Chukchi Sea include hydrography, plankton, benthic, and upper tropic level parameters, sampled opportunistically by multiple ships from May-October.
- The coordinated, international activities undertaken by the PAG country members provide a cooperative framework for international science planning and activities. The results from these activities are presented to the scientific community, public forums, and to local residents in Alaska to better understand the ecosystem where industrial development and transportation activities are projected to increase with the rapid retreat of sea ice in the region.

Raleigh Hood - The University of Maryland Center for Environmental Science
Chesapeake Bay National Estuarine Research Reserves (CBNERRS): An Integrated System of Sentinel Sites to Understand Baywide Climate Impacts for Stakeholders

In a collaborative venture, CBNERRS, NOAA, and UMCES have partnered to use the CBNERRS long-term environmental monitoring data to assess how changes in climate variability and extreme events affect the ecosystem services, vulnerability, and resiliency of Chesapeake Bay's shallow water habitats. Our approach focuses on the use of observations to investigate system and organismal responses to recent climate variability in a manner that leverages stakeholder's memories of past events to enhance public outreach efforts. The final outcome of this collaboration will be a set of web-based, interactive products and peer-reviewed publications with active participation from the CBNERRS managers, which can be used to address educational and managerial questions throughout the Chesapeake Bay watershed.

- We have assessed and identified historical trends for 26 climate indices to establish how extreme climate change and variability has already manifested in Chesapeake Bay over the last century.
- Findings will be used to develop educational materials and exhibits that connect historic and contemporary climate changes and events to future climate change, in order to support and encourage coastal communities, decision-makers, and the general public to contemplate and create adaptation plans and mitigation strategies that will enhance their resilience to future climate and ecosystem changes and events.

- Workshops were convened with Maryland and Virginia program managers to define specific project objectives and review analyses that have been undertaken to date, and we have also developed a blog for the general public that is updated weekly: http://www.sciencepensieve.org.

Steven Jayne – Woods Hole Oceanographic Institution
WHOI Contribution to the ARGO Float Program (2014-2015)

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. Data usages from this program range from real-time analyses by operational centers to high precision analyses by climate scientists to investigate decadal climate signals. This breadth has placed an extraordinary demand on both the performance of the instruments and on the infrastructure to process the data so that they are distributed in a timely manner to real-time users and subjected to stringent quality control.

- Data collected by the Argo array are used for operational forecasts of both inter-seasonal and seasonal to inter- annual predictions, such as El Niño forecasts, and by the climate science community to estimate changes in the heat and salt content of the global oceans to monitor climate-driven changes.
- Maintenance of the 3000 floats in the global Argo array has continued, despite level funding for nearly a decade.
- The Argo program has produced a high-quality delayed mode data set usable for detecting small climate change signals.

Daniel McCorkle – Woods Hole Oceanographic Institution
The impact of ocean acidification on larval sea scallops (Placopecten magellanicus), and possible mitigation by feeding an initial experimental study

The goal of this study was to quantify the impact of ocean acidification (OA) on the early development of two commercially important shellfish species, bay scallops and sea scallops, and to assess the influence of food availability on this OA impact.

- Experiments using bay scallops suggested that quantifiable shell-development data (e.g., frequency of deformities) will be a valuable metric for the impact of stressors such as elevated CO_2 levels and reduced food supply, and perhaps elevated temperature.
- The larval stages of bay scallops and sea scallops showed significant negative responses (growth, shell development) to elevated CO_2, and also showed a positive response to feeding rate. Both of these environmental factors are likely to shift in the decades ahead (higher CO_2, and in some regions, lower food supply), and both need to be considered in models of recruitment and fisheries yield.

Michael Moore – Woods Hole Oceanographic Institution
Effects of Drag from Entanglement in Fishing Gear in Right Whales

Entanglement is the leading cause of death in large whales in the Northwest Atlantic. Entanglement may become protracted when individuals break free and carry a portion of the entangling gear, often for months to years. Evidence acquired thus far from one right

whale entanglement case has suggested that entanglement imposes significant energy drain, therefore, quantifying drag imposed by entangling gear as well as the potential for survival or recovery is critical. Combining empirically derived drag estimates with individual life history information from the North Atlantic Right Whale catalog, we are investigating the energetic impact of 15 specific entanglement cases to determine the predictability of lethality and post-disentanglement survival. Thus far, this project has:

- Increased our understanding of the magnitude and variability of drag imposed from different entangling gear scenarios.
- Provided formulae from which we can confidently estimate the drag on an entangled whale based on the length of the gear and whether or not floats or buoys are involved.
- Informed disentanglement operations in terms of how much drag is reduced as trailing gear are removed, to be balanced with maintaining an acceptable amount of gear that would enable individuals to self-disentangle or for follow-up disentanglement attempts to occur.
- Estimated the potential for entanglement in fishing gear to affect the reproductive output of North Atlantic right whales. Thus, for the first time there is the potential to introduce the concern of entanglement reducing fecundity in how the U.S. Government accounts for fisheries impacts on this endangered species.

Robert Pickart – Woods Hole Oceanographic Institution
The Western Chukchi Sea: Physical Drivers and Biological and Geochemical Responses

The overall goal of the Russian-American Long-term Census of the Arctic (RUSALCA) program is to document and understand the ecosystem response of the Pacific sector of the Arctic Ocean to the pronounced recent changes in climatic forcing. The broad-scale component of RUSALCA included a series of multi-disciplinary cruises sampling the water column and benthos of the Chukchi Sea (and eastern portion of the East Siberian Sea). To date there have been three broad- scale surveys: in August 2004, September 2009, and September 2012. Presently we are in the synthesis stage, bringing together the various data sets to understand how this important ecosystem functions – and how it might react to the changing environmental conditions. Our study aims to relate the physical drivers on the shelf, including the circulation, atmospheric forcing, and sea-ice concentration, to different components of the biological system, including the benthic community and water column distributions of nutrients, chlorophyll, and zooplankton.

- The strong northeasterly winds in September 2009 caused a transposition of the water masses in Bering Strait, such that Alaskan coastal water switched to the Russian side of the strait and subsequently flooded the western portion of the shelf, all the way into Herald Canyon. By considering the cumulative Ekman Flux and invoking a simple numerical model, it was shown how the secondary circulation in the strait caused this transposition and why the entire shelf was impacted. Among other things, this process alters the distribution of heat and freshwater in the Chukchi Sea, which in turn will influence sea ice melt and freshwater export to the basin.
- By documenting the changes in the circulation and ecosystem of the western Chukchi Sea, including the atmospheric forcing and links to the Bering Strait inflow, we will improve our understanding of how the western Arctic Ocean responds to climate

warming. This impacts issues such as marine mammal habitat and fisheries management.

Grace Saba – Rutgers University
Physiological Ecology and Habitat Suitability: Combining Experiments and Surveys to Inform Stock Assessments

Inclusion of habitat information into stock assessment models is increasingly important, as stock dynamics and observations of stock abundance are impacted by habitat characteristics. Part of the difficulty in accomplishing this is due to the scale of most habitat studies, which is often not matched to the scale of most assessments. One recent success was the development of a habitat suitability model, coupled with a circulation model hindcast, for the assessment of pelagic forage fish, Atlantic Butterfish (*Peprilus triacanthus*). The overall goal of this project is to parameterize mechanistic thermal niche models by measuring temperature and size-dependent metabolic rates for butterfish, compare habitat suitability models based on field and experimental data, then evaluate the effect of parameterization on catchability estimates for butterfish along the U.S. east coast in the context of the stock assessment model.

- This project demonstrated that at sea respirometry is feasible with proper set-up and maintenance, and can provide valuable physiological information under controlled conditions (i.e., temperature) for target fish species.
- Follow-up experiments will provide temperature- and size-dependent butterfish physiological data needed for habitat suitability models.
- Physiological results from this proposed work will be incorporated into the butterfish stock assessment and will provide information for estimating catch efficiency based on a habitat suitability model and identification of priority habitat areas for butterfish.

David W. Townsend - University of Maine
Nutrient Dynamics on the NE Continental Shelf: Sample Analyses

This project was initiated in 2011 in response to the need for better data coverage for dissolved inorganic nutrient concentrations in waters of the Gulf of Maine (GOM) and adjacent regions of the Northeast U.S. continental shelf. We report here on the analysis of samples collected during ECOMON survey cruises in shelf and slope waters of the GOM. Additionally, we were recently funded by the NOAA IOOS Program to deploy *in situ* optical nitrate sensors on GOM buoys. Using these data, we hope to better understand the nature of water mass variability in the GOM and its influence on the nutrient field, which is of fundamental importance to our understanding of basic biological phenomena from red tides to changing fish abundances and distributions.

- Fall 2014 samples collected in the eastern offshore GOM captured the fall phytoplankton bloom, showing how *in situ* chlorophyll was elevated in waters above a rather deep pycnocline. With accompanying nutrient data, this is a first; to our knowledge, there is no other account of a fall phytoplankton bloom in the GOM, apart from satellite images. With these data, we have a first-of-its-kind snapshot of the bloom.
- Our continued analyses of the nutrient samples will be extremely important in our interpretations of conditions of Paralytic Shellfish Poisoning (PSP) from *Alexandrium* populations, and are already being used to help initiate simulation models to forecast the severity of GOM “red tides” months in advance.

- This research is providing baseline data for future interpretations of climate change-induced alterations to the marine environment of the Northwest Atlantic continental shelf. Our data have already provided evidence in support of earlier expressed concerns about far-field effects of Arctic melting.

Richard Wahle – University of Maine
Using the American Lobster Settlement Index and Environmental Indicators to Forecast Lobster Fishery Recruitment

This project is investigating the predictive links between parallel time series generated by the American Lobster Settlement Index and state/federal trawl surveys, and additional environmental indicators. Project objectives were to: (1) Evaluate spawner-to-settler relationships; (2) Evaluate cohort fate over first years of benthic life; (3) Forecast fishery recruitment; and (4) Make stock level data available for use in the stock assessment model. Preliminary results from this project suggest that:

- Our initial effort to test the predictive power of the settlement index for fishery recruitment is promising. We found statistically significant relationships between our settlement based hindcasts and lobster landings for five of seven regions analyzed. The two non-significant results were for locations that had relatively stable landings over the period.
- If our forecasts are accurate, the eastern Gulf of Maine should be expecting a downturn in fishery recruitment over the next few years following a decade-long boom in landings.

Lisan Yu – Woods Hole Oceanographic Institution
50 Year Analysis Global Ocean Surface Heat Flux

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

- We provide near real-time online updates of the OAFlux analysis to maintain timely dissemination of climate records of global air-sea fluxes of heat, moisture, and momentum from 1958 to the present, and to meet the communities' need for accurate, multi-decadal datasets for research on the global energy and water cycle.
- The OAFlux products are used as a reference dataset to validate climate model simulations and atmospheric reanalysis products; in particular, to identify the biases in reanalysis flux products.
- The new time series depicts a slowdown or "pause" in global temperature and humidity since 2000, which followed a period of rapid acceleration in the 1990s. Similarly, the rate of ocean evaporation has been trending downward since 2000, reversing the upward trend that was dominant during the 1980s and 1990s.

Introduction

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

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

CINAR Vision, Mission, Goals and Organization

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CINAR Organization

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

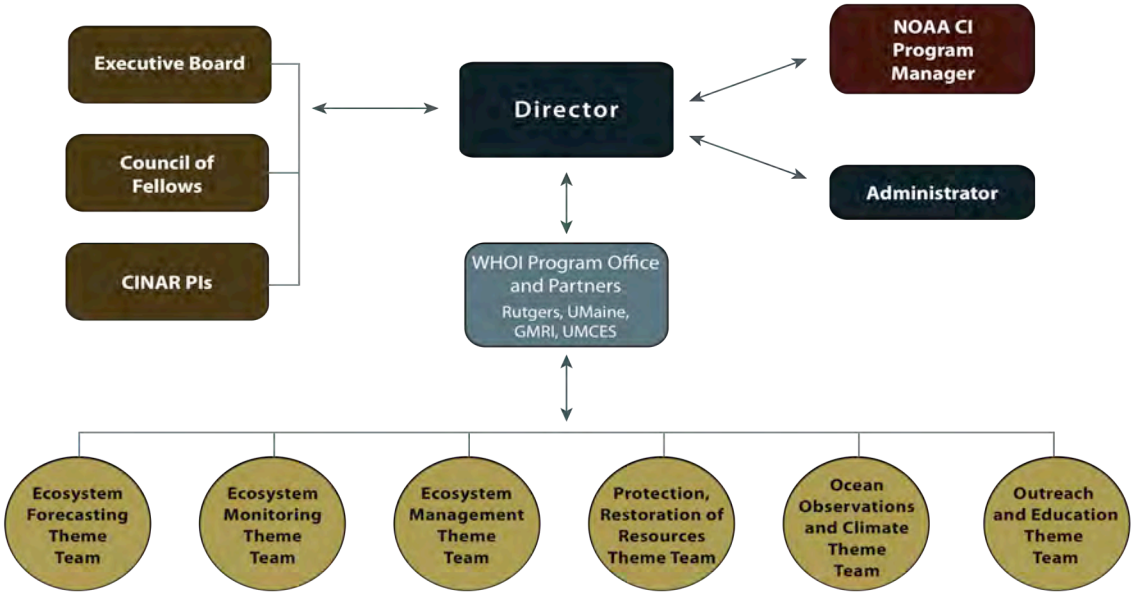


Figure 1. Organizational structure of CINAR.

CINAR PIs

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

CINAR Executive Board

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

The CINAR Executive Board members are:

William Karp, Chair	NMFS NEFSC
Venkatachalam Ramaswamy	OAR Representative
Russell Callender	NOS Representative
Ned Cyr	NMFS/OST
Donald Anderson	CINAR Director
Fei Chai	CINAR PI, University of Maine
Peyton Robertson	North Atlantic Regional Team Representative
Laurence Madin	WHOI Leadership
Cynthia Decker	Interim OAR CI Program Director

CINAR Council of Fellows

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

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

The CINAR Council of Fellows members are:

Donald Anderson, Chair	CINAR Director
Mark Miller	CINAR PI, Rutgers
Michael Roman	CINAR PI, UMCES
Fei Chai	CINAR PI, University of Maine
Andrew Pershing	CINAR PI, Gulf of Maine Research Institute
Paulinus Chigbu	MSI Representative / UMCES
Position to be filled	NMFS/NEFSC
Position to be filled	OAR/Climate Program Office
Ellen Mecray	NESDIS/NCDC
Cynthia Decker, *ex officio*	Interim OAR CI Program Director

CINAR Theme Leaders

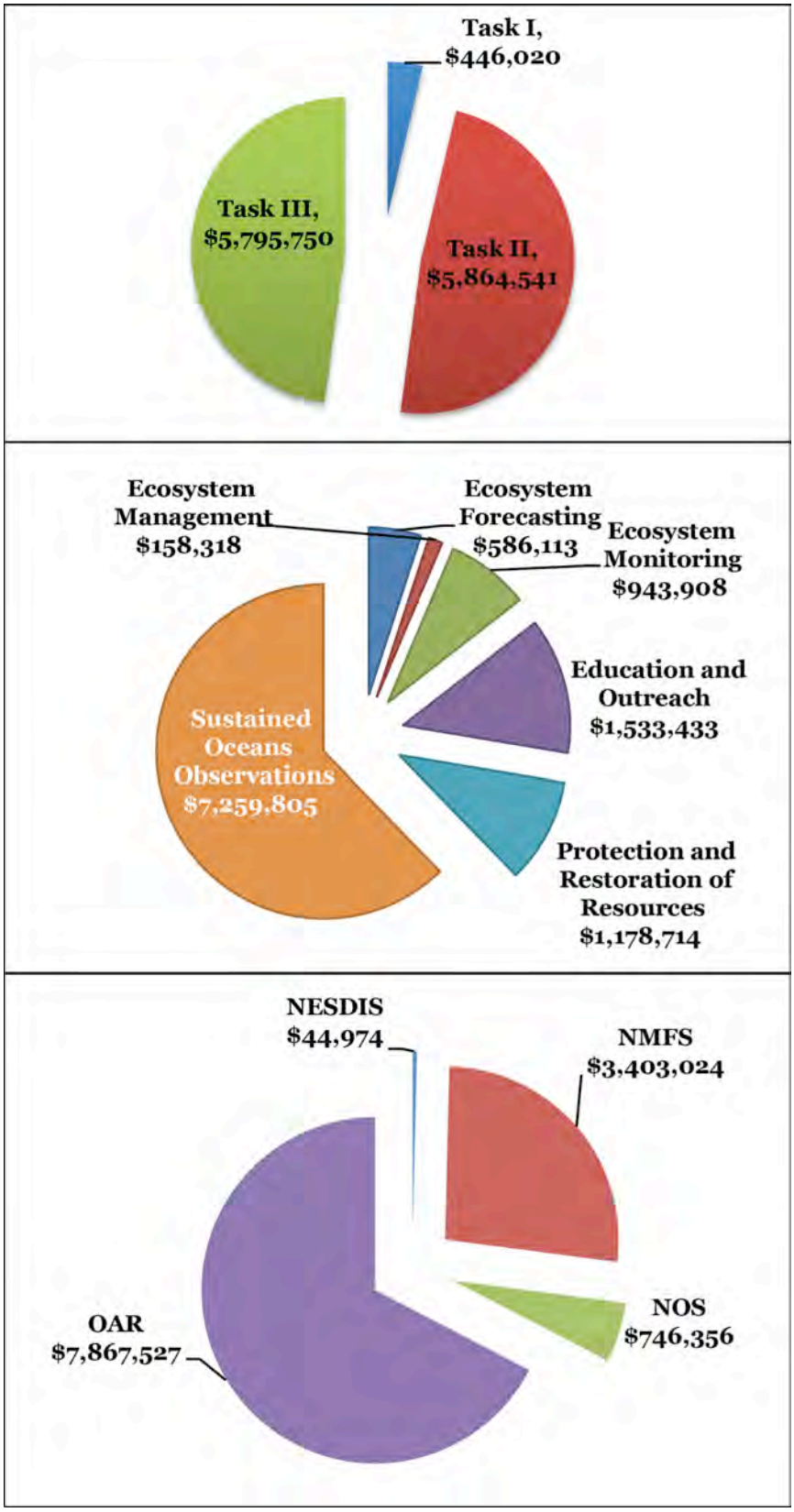
Includes individuals from the partner institutions with long-term and significant interactions with NOAA who will serve as representatives for their respective CINAR research theme. Each leader is supported by Theme Coordinators at each partner institution, each of whom represents a large group of participating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

CINAR Research and Administrative staff

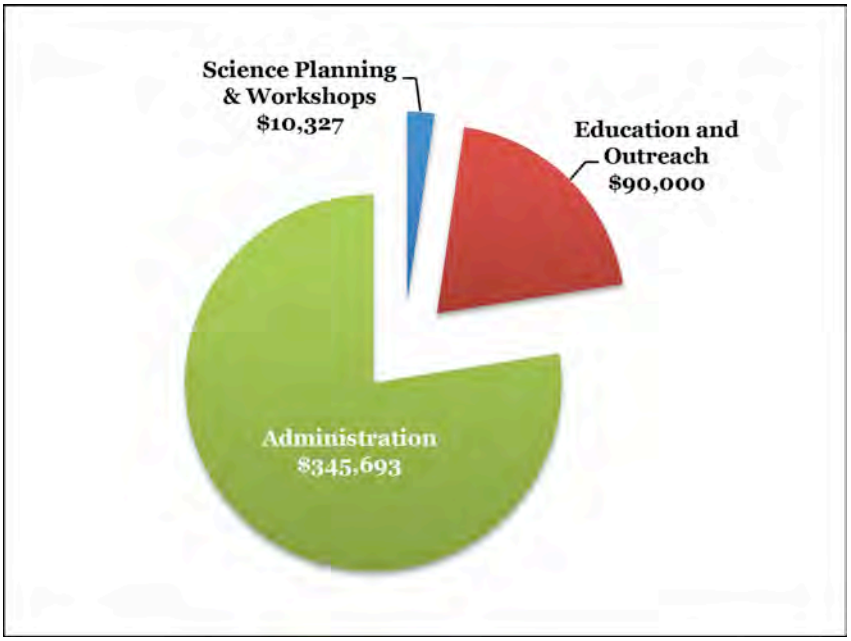
WHOI and the partner institutions provide the administrative staff for grants and contracts management, human resource management, systems administration, procurement, and all necessary support staff roles for CINAR activities. CINAR uses the services of researchers through an appropriate combination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


Task I, $446,020
Task III, $5,795,750
Task II, $5,864,541
Ecosystem Management $158,318
Ecosystem Forecasting $586,113
Ecosystem Monitoring $943,908
Education and Outreach $1,533,433
Sustained Oceans Observations $7,259,805
Protection and Restoration of Resources $1,178,714
NESDIS $44,974
NMFS $3,403,024
NOS $746,356
OAR $7,867,527

Task I Activities with Distribution of Funding



Task I funding received from NOAA during this period totalled $300,327. WHOI provided $145,693 as cost-sharing to cover salary and related costs for part of CINAR Director Anderson's time.

Data Management

The NSF funded Biological and Chemical Oceanography Data Management Office (BCO-DMO) continues to make available the New England Fisheries Science Center (NEFSC) EcoMon data on the hydrography and biology of Gulf of Maine. These data can be accessed via the following URLs:

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

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

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

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

Education and Outreach

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

Partner Inst.	Student Name	CINAR Investigator	Study Focus
GMRI	Christina Hernandez	Andrew Pershing	Species distribution changes from the 1980s to the present
WHOI	Alexis Wood	Lauren Mullineaux	Dynamics of phytoplankton blooms and their biogeochemical implications
UMaine	Darnell Dinwiddie	Gayle Zydlewski	Various aspects of sturgeon of the Gulf of Maine from scutes to habitat
UMCES	Sarah Black	Nick Nidzieko	Algorithms to adaptively track salinity gradients with an autonomous underwater vehicle

It is of note that Minority Trainee Christina Hernandez has now been accepted into the MIT/WHOI Joint Program in Oceanography.

WHOI-NEFSC Special Seminar Series on Fisheries and Ecosystems Acoustics.

A new seminar series was started in June of 2014, sponsored jointly by NEFSC, CINAR, and the WHOI Biology and Applied Ocean Physics and Engineering Departments and co-convened by CINAR Fellow Gareth Lawson, Andone Lavery, and Tim Stanton of WHOI, together with Michael Jech of NEFSC. The series focuses on bio-acoustics, both passive and active, emphasizing applications and technological developments relevant to fisheries and ecosystem research and management as well as protected species conservation. The intent is to promote interactions between WHOI and NEFSC personnel on these topics and in general. In order to maximize attendance from both institutions, the seminars take place in the NEFSC Clark Conference Room and occur as a special seminar during the regular AOPE time slot. The talks are also distributed live as a webinar, via the OneNOAA Science Seminar series.

The seminar series has convened approximately every two months and has been very well received. The presentations have covered a variety of topics, ranging from new developments in broadband acoustic technologies (Andone Lavery, WHOI), passive acoustic monitoring of vocalizing marine mammals (Danielle Cholewiak, NEFSC), autonomous platforms for such monitoring of cetaceans (Mark Baumgartner, WHOI), active acoustic assessments of reef fish in untrawlable habitats (Christopher Taylor, NOAA NOS), to passive acoustic monitoring and tagging of spawning cod (Micah Dean, MA DMF). Attendance at these seminars has been very high, and the question/discussion periods following the presentations have been insightful. Remote attendance via the webinar has equally been high, with participants joining in from as far

away as the PIFSC in Hawaii (despite the time change). The webinar system has successfully allowed these participants to engage fully in the seminars by asking questions and making comments, and the large number of remote attendees indicates a strong interest in this topic. In the coming year the seminar series will continue with talks from WHOI and NEFSC scientists, and increasingly with speakers drawn from the greater region.

CINAR Research Summaries

The following pages provide research summaries of the 47 CINAR projects funded during the period July 1, 2014 through March 31, 2015. The projects are organized by theme.

Theme I. Ecosystem Forecasting

Donald Anderson, WHOI - *Gulf of Maine annual cyst cruise and sample analysis*

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

Hongshen Bi, UMCES - *Estimating early mortality for reference points for the Atlantic menhaden stock*

David Townsend, UMaine - *Nutrient dynamics on the NE continental shelf: Sample analyses*

Richard Wahle, UMaine - *Using the American lobster settlement index and environmental indicators to forecast lobster fishery recruitment*

Michael Wilberg, UMCES - *Development and testing of a new method for selecting among stock assessment models*

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

Theme II. Ecosystem Monitoring

Heather Benway, WHOI - *Publication of a special issue of Oceanography magazine on emerging themes in ocean acidification science*

Damian Brady, UMaine - *Characterizing the Penobscot River estuarine transition zone to determine environmental challenges for Atlantic salmon, their prey, and other sea-run species*

Yong Chen, UMaine - *Annual Eastern Gulf of Maine sentinel jigging/longline survey/fishery*

Scott Gallager, WHOI - *Operational support for Habcam V4 on scallop surveys, post-cruise processing, machine vision efforts, habitat classification, yellowtail surveys, and lobster habitat*

Kathy Mills, GMRI - *Impacts of a changing ecosystem on Atlantic salmon marine productivity*

Hanumant Singh, WHOI - *Field experimentation to determine catchability of advanced technologies*

Rhian Waller, UMaine - *Investigating coral communities in the Gulf of Maine*

Theme III. Ecosystem Management

Di Jin, WHOI - *Statistical analysis of trip cost data collected by the Northeast Observer Program*

Raleigh Hood, UMCES - *Chesapeake Bay National Estuarine Research Reserves (CBNERRS): An integrated system of sentinel sites to understand baywide climate impacts for stakeholders*

Malin Pinsky, Rutgers – *Indicators of marine climate impacts in North America*

Grace Saba, Rutgers - *Physiological ecology and habitat suitability: Combining experiments and surveys to inform stock assessments*

Timothy Shank, WHOI - *Advancing the 6th International Deep-Sea Coral Symposium*

Riley Young Morse, GMRI - *Accessing and visualizing satellite data for use by fisheries managers in the Northeast*

Theme IV. Protection and Restoration of Resources

Mark Baumgartner, WHOI – *Passive acoustic monitoring from autonomous platforms*

Anne Cohen, WHOI - *Carbonate mineralogy of Alaskan corals*

Michael Moore, WHOI - *East coast marine mammal health assessment*

Michael Moore, WHOI - *Effects of drag from entanglement in fishing gear in right whales*

Donald Peters, WHOI - *A passive acoustic ocean observing system for monitoring and mapping marine mammals and noise in the Chukchi Sea ecosystem*

Timothy Shank, WHOI - *Habitat suitability modeling for deep-sea corals and sponges in the Northeast and Mid-Atlantic regions – version 2 and ground trothing of potential deep-sea coral areas*

Theme V. Sustained Ocean Observations and Climate

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

Carin Ashjian, WHOI - *An eye in the ocean: Exploration of high-resolution vertical distributions of plankton and particles and coincident hydrography in the western Chukchi Sea*

Andrew Bowen, WHOI - *2014 ROV Jason use for Chadwick Moyer cruise*

Carol Anne Clayson, WHOI - *Satellite-derived climate data records of ocean-atmosphere exchange: Ocean surface bundle CDR*

Enrique Curchitser, Rutgers – *Assessing regional sea-ice predictability in the US Arctic: A multi-model approach*

Christopher German, WHOI - *Exploration of the Arctic Ocean with the Nereid under-ice vehicle*

Jacqueline Grebmeier, UMCES - *Pacific Arctic Group (PAG) Secretariat Office 2014-2015*

Jacqueline Grebmeier, UMCES - *Synthesis activities within the RUSALCA Program 2014-2015*

Steven Jayne, WHOI - *WHOI contribution to the ARGO Float Program (2014-2015)*

Daniel McCorkle, WHOI - *The impact of ocean acidification on larval sea scallops (Placopecten magellanicus) and possible mitigation by feeding: An initial experimental study*

Andrew Pershing and Kathy Mills, GMRI - *Climate adaptation in fishery ecosystems*

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

Robert Pickart, WHOI - *The western Chukchi Sea: Physical drivers and biological and geochemical responses*

Robert Weller and Albert Plueddemann, WHOI – *Ocean climate observations and analyses (2014-2015)*

Riley Young Morse, GMRI - *Building tools for applying climate science to fisheries management*

Lisan Yu, WHOI - *50 year analysis global ocean surface heat flux*

Theme VI. Education and Outreach

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

Donald Anderson, WHOI – *U.S. National Office for Harmful Algal Blooms*

Alexa Dayton, GMRI - *Marine Resources Education Program: Northeast region*

Alexa Dayton, GMRI - *Marine Resources Education Program: Southeast fisheries region*

Gayle Zydlewski, UMaine - *UMaine Cooperative Education*

THEME I. ECOSYSTEM FORECASTING

Gulf of Maine annual cyst cruise and sample analysis

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Donald Anderson - WHOI

NOAA Sponsor – Richard Stumpf - NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

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

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

Information generated from this project will be used to provide the annual seasonal forecast of harmful algal bloom in the Gulf of Maine and weekly forecasts during each bloom season.

ACCOMPLISHMENTS

Approximately 73 stations were occupied over a 9-day period using the NOAA ship Okeanos Explorer cruise # EX-14-05 (see Fig. 1). At each station, a Craib corer was deployed and a relatively undisturbed surface sediment core was collected. The core was extruded onboard and sectioned into two layers; the top 0-1 cm and the underlying 1-3 cm layers. The sediment samples were processed onboard using standard cyst techniques that are routine in the Anderson

lab but were transitioned to NOAA personnel that served on cruise EX-14-05. That processing included protocols for dilution of the raw sediment, sonifying and sieving the sample to yield a 20-100 µm particulate fraction that was initially preserved in 2% formalin and exchanged onboard into 100% methanol for long term storage until counting began.

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

HIGHLIGHTS

- Successful transition of the cyst cruise from a research effort at WHOI to a NOAA vessel and with NOAA personnel for long term operations of that program
- Cyst abundance in 2014 indicated a slight increase in abundance from the previous year (2013)
- Model simulations based on the 2014 cyst abundance were complete during winter, 2015 with the bloom prediction released (http://coastalscience.noaa.gov/news/topics/misc/gulf-maine-red-tide-forecast-suggests-moderate-bloom-spring-summer/)

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

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

Results of the cruise were discussed at a meeting of academic researchers, regional stakeholders (ME, NH, and ME shellfish resource managers), and NOAA managers as part of the 2015 seasonal PSP forecast discussion.

FIGURES/PHOTOS/ILLUSTRATIONS

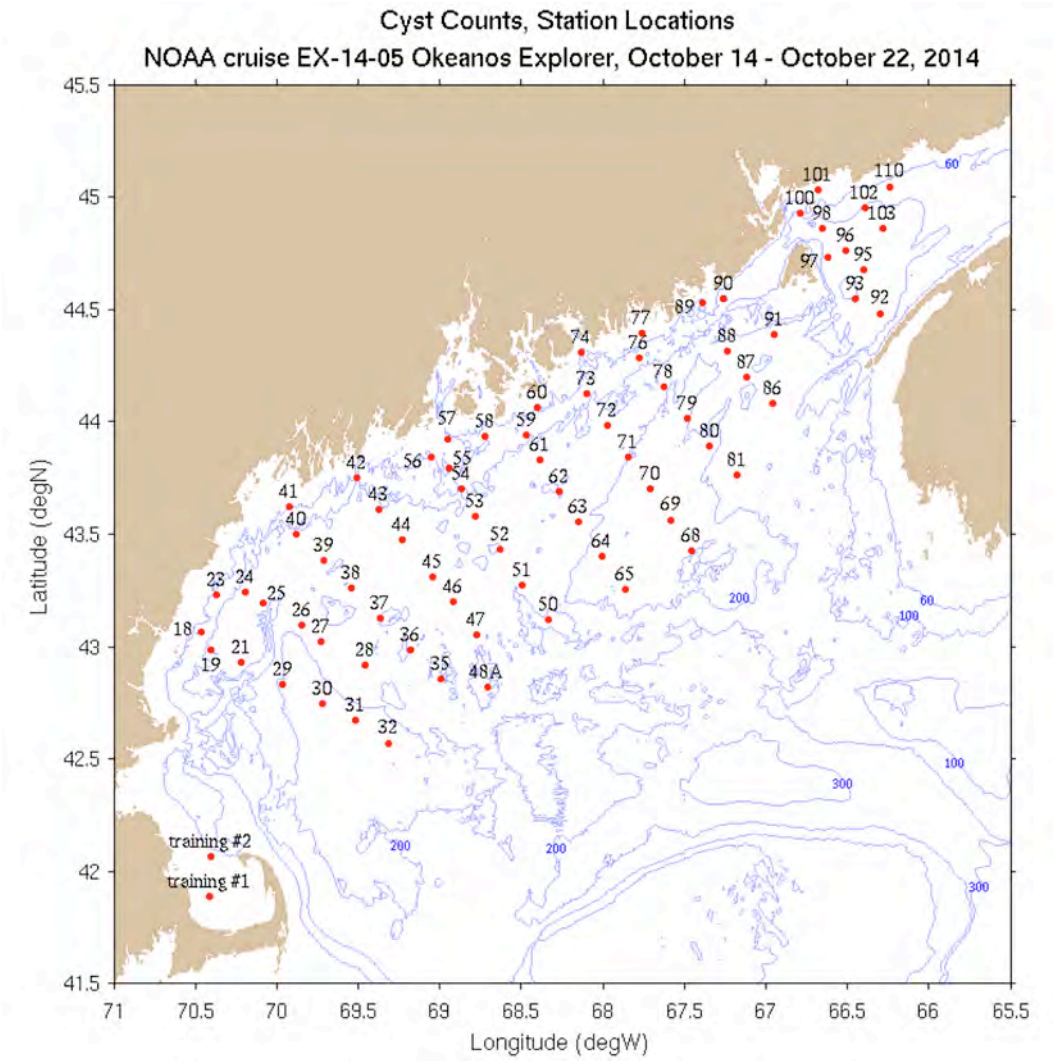


Fig. 1. Station map of the completed fall 2013 cyst survey.

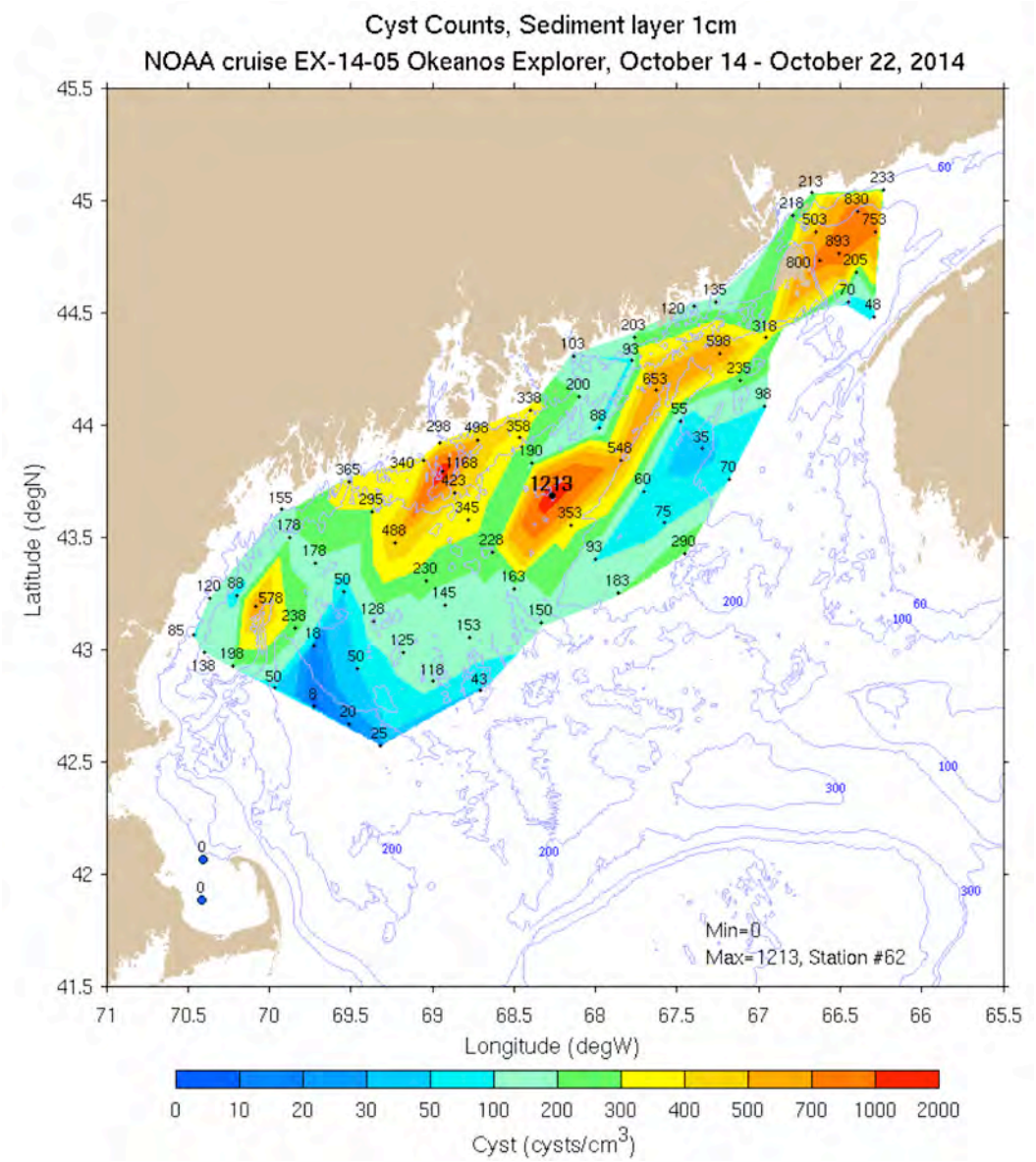


Fig. 2. *Alexandrium* cyst map showing the concentrations observed in the surface sediments (0-1cm) of the Gulf of Maine.

Technical support and improvement of FVCOM for NOAA modeling activities

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Robert Beardsley - WHOI

NOAA Sponsor – Eugene Wei - NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

The objectives of this project are to: 1) hold an FVCOM workshop at the NOAA Coast Survey Development Laboratory (CSDL) to update NOAA modelers on FVCOM and to address NOAA questions; 2) host CSDL modelers for technical consultation at UMASSD as needed; 3) hold conference calls with CSDL modelers as needed, and 4) support CSDL in applying FVCOM multi-domain nesting techniques. Advanced new techniques are being developed for the U.S. Northeast Coastal Ocean Forecast System (NECOFS). FVCOM teams will provide updated examples of techniques used for NECOFS to support the NOAA modeling activities.

ACCOMPLISHMENTS

CSDL-WHOI-UMASSD organized an FVCOM workshop at CSDL on September 8-9, 2014. Robert Beardsley (WHOI) and Changsheng Chen (UMASSD) gave two presentations: 1) an update of FVCOM development and improvement, and 2) new development of FVCOM. Before the workshop, a new version of FVCOM 3.2 was introduced and delivered to CSDL. Beardsley and Chen have addressed questions about the use of the new version during the workshop. The CSDL scientists gave several reports on the FVCOM forecast system development in the Gulf of Mexico shelf, San Francisco Bay, and the Great Lakes. The workshop was very productive, and many questions were addressed and solved during the open discussion.

As required by the NOAA Great Lakes Environmental Research Laboratory (GLERL), we have coded the GLERL heat flux algorithm into the FVCOM v3.2 and delivered it to NOAA CSDL and GLERL. GLERL has tested this new heat flux code and has successfully used it in the 24/7 Great Lake FVCOM forecast system operations.

We have arranged several conference calls with CSDL and GLERL scientists to help them solve several code issues. To improve the efficiency of the forecast operation, we also modified the FVCOM code to make the WRF forcing input independent of the number of computational nodes being used.

We have modified the FVCOM code to meet the NOAA CSDL requirements for 24/7 forecast operations in the NOAA new supercomputer system. We have worked together with CSDL scientists and NOAA IT staff to fix the NaN issues; modified the river input code to make the

controller of temperature the same as salinity; modified the temperature calculation at river node or cell using the same algorithm as salinity; added the exchange of heat flux data in MPI domains for the NetCDF output; added the GLERL heat flux forcing for the NetCDF output, etc. We have fixed the code bugs in the dike-groyne module in FVCOM for calculation of the vertical velocity and temperature/salinity. We also fixed several other bugs that were identified by the CSDL and GLERL.

HIGHLIGHTS

- Provided regular technical support for CSDL and GLERL in development of the FVCOM-based forecast systems in the northern Gulf of Mexico (NGOM), San Francisco Bay, and the Great Lakes.
- Helped develop and modify the FVCOM modules to meet the NOAA CSDL and GLERL needs in the forecast system development.
- Provided an example for multi-domain nesting and guided the technical approach to nesting the CSDL forecast system in global and regional models.
- Developed several new modules in FVCOM for the NOAA CSDL and GLERL.

SOCIETAL BENEFITS

We shared FVCOM development with academic and public users, which helped other coastal regions in the world utilize FVCOM applications.

The continued development of the FVCOM forecast system and its application in NECOFS provided state and federal government agencies and the public with real-time oceanic environmental conditions via the web for use in marine ecosystem and health evaluation, navigation, ocean search and rescue operation planning, storm-induced coastal inundation, and river flooding.
Updated the existing NOAA forecast system to the new technical level with better resolution of coastal geometry.

EDUCATION AND OUTREACH ACTIVITIES

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

Estimating early mortality for reference points for the Atlantic menhaden stock

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Hongshen Bi - UMCES

NOAA Sponsor – Jonathan Hare - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

- In the past two decades, Atlantic menhaden (*Brevoortia tyrannus*) has experienced a notable decline in recruitment to the Chesapeake Bay. The primary objective of this study is to examine the coast-wide larval menhaden abundance and identify possible causes for the observed decline.
- Larval data were obtained from two major ichthyoplankton surveys conducted by the NOAA Northeast Fisheries Science Center, MARMAP, and ECOMON. MARMAP, the Marine Resources Monitoring, Assessment, and Prediction Program, was conducted from 1977-1987, and ECOMON, the Ecosystem Monitoring Program, was conducted from 1992-present.
- The goal of this project is to understand the relationship between larval menhaden abundance and recruitment. Using data on larval abundance and size, we developed a larval abundance index. This index was used to examine changes in larval abundance over time, and was also incorporated into a survival model to examine how environmental conditions affect interannual variation in early life survival.

ACCOMPLISHMENTS

- We used the larval index paired with the juvenile abundance index constructed for the 2015 Atlantic Menhaden stock assessment to estimate relative early life survival (Fig. 1), and then fit our survival model with environmental variables.
- We were interested in examining the effects of large-scale ocean variability, temperature, wind, and freshwater flow on Atlantic Menhaden early survival. To examine long-term environmental effects, we collected data sets that spanned the entire span of the study, beginning in 1977. We used surface temperature information collected with larval observations during the ECOMON and MARMAP surveys. We also used temperature data collected from the Patuxent River in the Chesapeake Bay by the Chesapeake Biological Lab as an index of nursery temperature conditions. Wind and flow data were collected for the Chesapeake Bay as well. We used AMO (the Atlantic Multidecadal Oscillation index) to characterize changes in large-scale ocean conditions (Fig. 2).
- We used AIC selection and found the best fit model estimates of survival from larval abundance, coastal temperature, wind speed, and wind direction. Southeastward wind appeared to be coincidental with higher survival.

- We also identified several interesting spatial patterns: highest larval abundance was observed near the coast (within ~25 km) and in the southern portion of the survey off the coast of North Carolina. Larvae were, on average, also largest near the coast and in the central portion of the survey, between the Chesapeake and Delaware Bays.
- Future analysis will focus on these spatial trends as well as the fine-scale analysis of environmental variables that affect larval abundance and survival.

HIGHLIGHTS

- We observed a declining trend in larval survival.
- Interesting patterns related to the effects of wind and temperature on survival were observed; in particular, strong southeastward winds were associated with higher survival.
- Larvae were larger and in higher abundance near the coast.

SOCIETAL BENEFITS

Atlantic menhaden support the largest fishery on the U.S. east coast. This analysis provides a fishery independent index of Atlantic menhaden abundance with broad spatial and temporal coverage. Modeling the changes in larval mortality improves the scientific information used to manage this stock by incorporating environmental processes into stock assessments and the determination of stock status.

EDUCATION AND OUTREACH ACTIVITIES

- Simpson*, C.A., M. J. Wilberg, A. M. Schueller, G. M. Nesslage, H. J. Walsh, H. Bi. 2014. Estimating Atlantic menhaden larval abundance along the Atlantic coast of the United States. American Fisheries Society. 144th Annual Meeting. August 17-21. Quebec City, Quebec.
- Simpson*, C.A., M. J. Wilberg, H. Bi, A. M. Schueller, G. M. Nesslage, and H. J. Walsh. 2014. Mysterious early lives of Atlantic menhaden. Tidewater Chapter American Fisheries Society. 29th Annual Meeting. March 5-7. Pine Knoll Shores, North Carolina.
- Bi, H., C. Simpson, M. Wilberge, A. Schueller, G. Nesslage, H. Walsh, 2015, Estimating early mortality for reference points for the Atlantic menhaden stock, FATE annual meeting, San Diego, CA

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

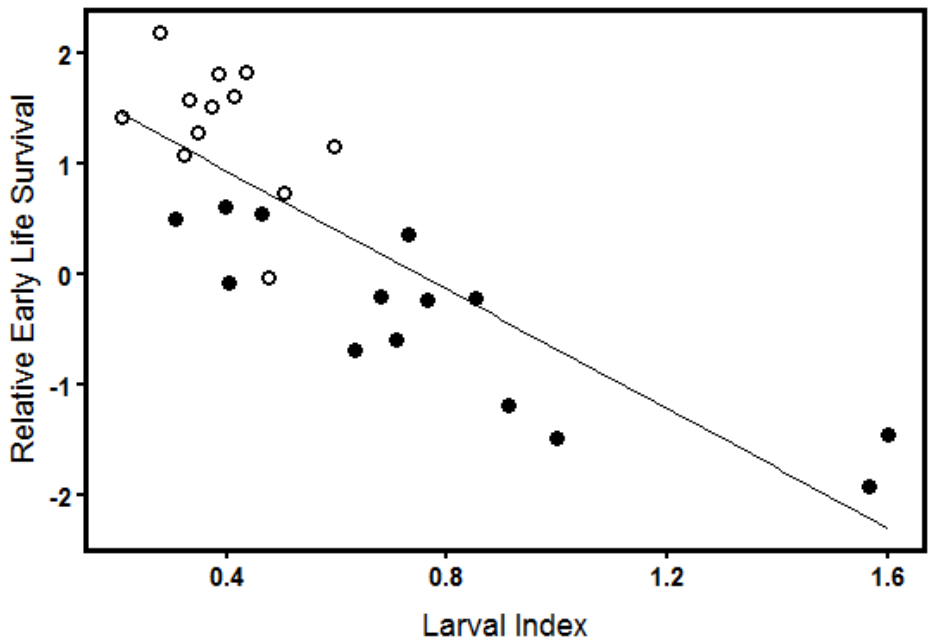


Figure 1. Relative early survival and larval index with solid black dots indicating ECOMON period, and open circles indicating MARMAP period.

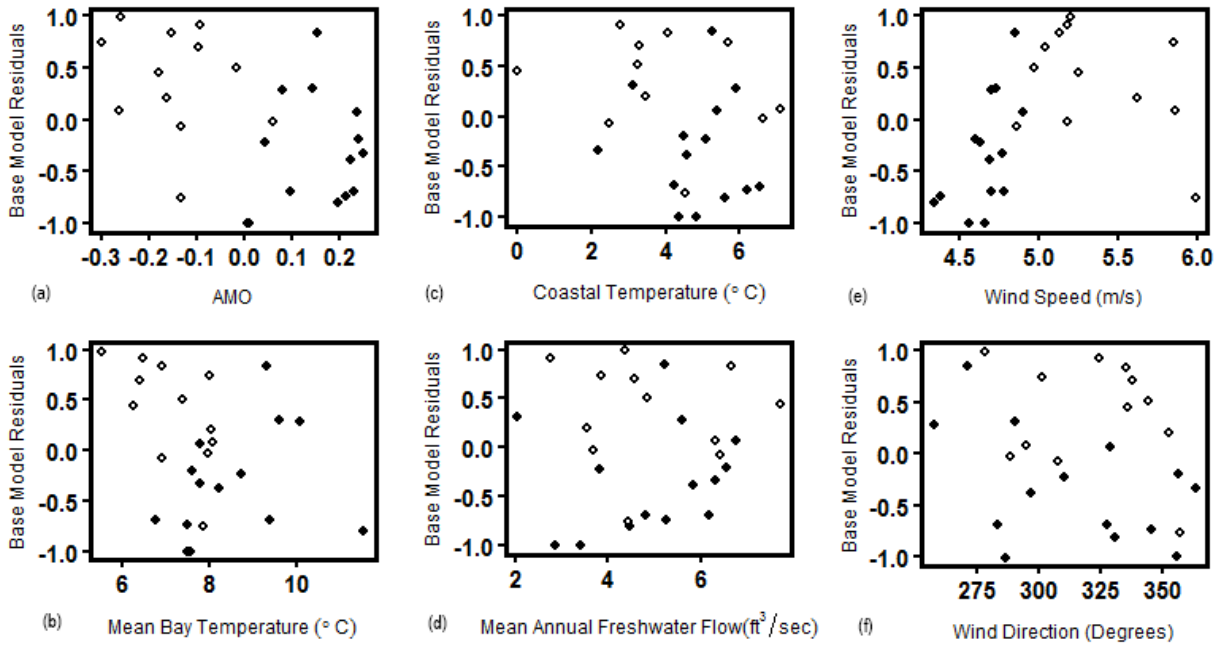


Figure 2. Scatter plots showing base model residuals from Figure 1 and environmental variables: (a) Atlantic multi-decadal oscillation (AMO), (b) coastal surface temperature from field data, (c)

wind speed at Chesapeake Bay mouth, (d) temperature in the Chesapeake Bay, (e) mean annual freshwater flow to the Chesapeake Bay, and (f) wind direction at the Chesapeake Bay mouth.

Nutrient dynamics on the NE continental shelf: Sample analyses

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – David Townsend - UMaine

NOAA Sponsor – Jonathan Hare - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

This project was initiated in 2011 in response to the need for better data coverage for dissolved inorganic nutrient concentrations in waters of the Gulf of Maine (GOM) and adjacent regions of the Northeast U.S. continental shelf. In a study we published in 2010 we speculated that changes in the concentrations of silicate and nitrate in the interior GOM over the past several decades might be driven by larger scale changes in shelf and slope currents farther "upstream" from the Gulf, in the Labrador Sea, and off Nova Scoria. Accelerated melting of the Greenland ice sheet and the Arctic ice cap in recent decades may have changed the dynamics of the baroclinic transport of low salinity shelf waters to regions farther south, in an episodic fashion. Our 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, but that those proportions of nutrients in the Gulf are highly variable among years. In addition, there is growing evidence that those changes in the nutrient regime may also be forcing changes in the structure of the planktonic ecosystem. Most recently, we have shown that shelf water flows into the GOM (Scotian Shelf Water) alternate with deep Slope Water flows into the Gulf, with periods from several months to several years (Townsend et al., in revision).

We have recently been funded by the NOAA IOOS Program to deploy *in situ* optical nitrate sensors (Satlantic, Inc., SUNAs) on GOM buoys (UMOOS, the University of Maine Ocean Observing System, a subset of NERACOOS, The Northeast Regional Associate of Coastal Ocean Observing Systems). Along with the continuation of this CINAR project analyzing nutrient samples collected on ECOMON cruises, we hope to better understand the nature of water mass variability in the GOM and its influence on the nutrient field, which is of fundamental importance to our understanding of basic biological phenomena from red tides to changing fish abundances and distributions.

We report here progress made on our CINAR-funded project to analyze samples collected as part of the ***NOAA Northeast Fishery Science Center's Ecosystem Monitoring Program*** (ECOMON Program) in collaboration with Dr. Jon Hare. The ECOMON Program conducts survey cruises approximately four times each year in shelf and slope waters of the GOM – Georges Bank – Mid-Atlantic Bight. As part of their standard sampling, they perform a CTD cast at each station, and when possible (given constraints for water sample allocation), they collect water samples for

nutrient analyses. Samples are filtered and frozen at sea and then delivered by overnight courier to the University of Maine where they are analyzed for nitrate plus nitrite, silicate, phosphate, and ammonium using standard autoanalyzer techniques. Those data are delivered to NOAA following each cruise.

ACCOMPLISHMENTS

As of this writing (April 2, 2015), we have received and processed samples from 17 ECOMON cruises, summarized in Figure 1, which shows station locations for each cruise. In addition, Townsend's Research Associate, Ms. Maura Thomas from the University of Maine, participated in the three-week Fall 2014 ECOMON cruise aboard the *R/V Pisces*.

Once we have analyzed the water samples in our nutrient analysis laboratory here at the University of Maine for concentrations of nitrate plus nitrite, silicate, phosphate, and ammonium, we combine the resulting data with the CTD data and produce profiles of the hydrography and nutrient properties. Those processed data and profile plots are then sent to NOAA Narragansett (c/o Dr. Jon Hare). 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.

HIGHLIGHTS

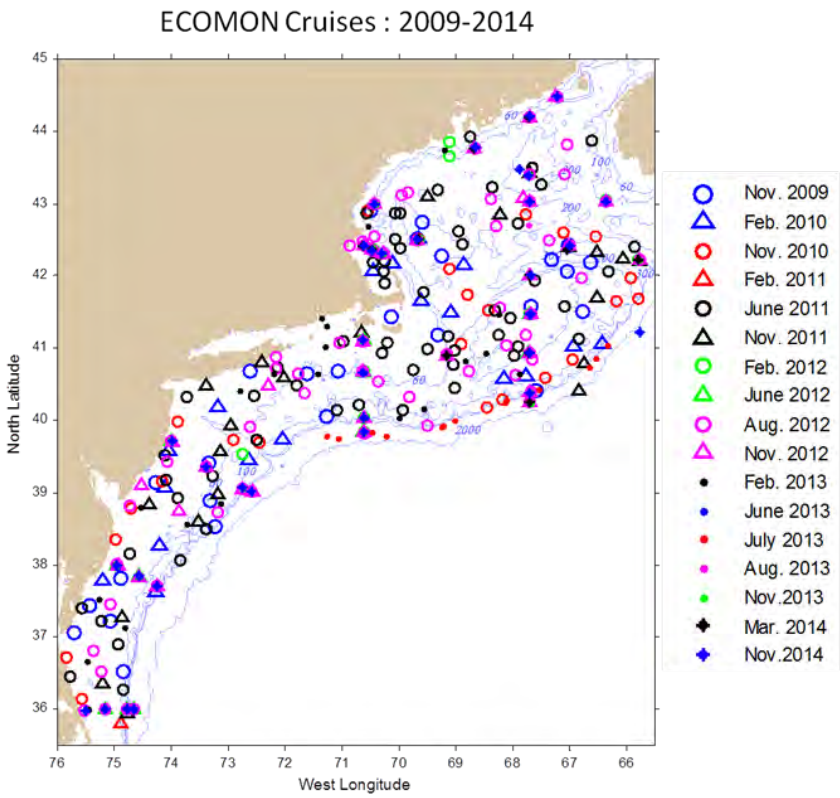
- Fall 2014 samples collected in Jordan Basin in the eastern offshore Gulf of Maine captured the fall phytoplankton bloom, showing how *in situ* chlorophyll was elevated in waters above a rather deep pycnocline. With accompanying nutrient data, this is a first: I am unaware of any other account of a fall phytoplankton bloom in the Gulf of Maine, apart from satellite images. With these data, we have a first-of-its-kind snapshot of the bloom.

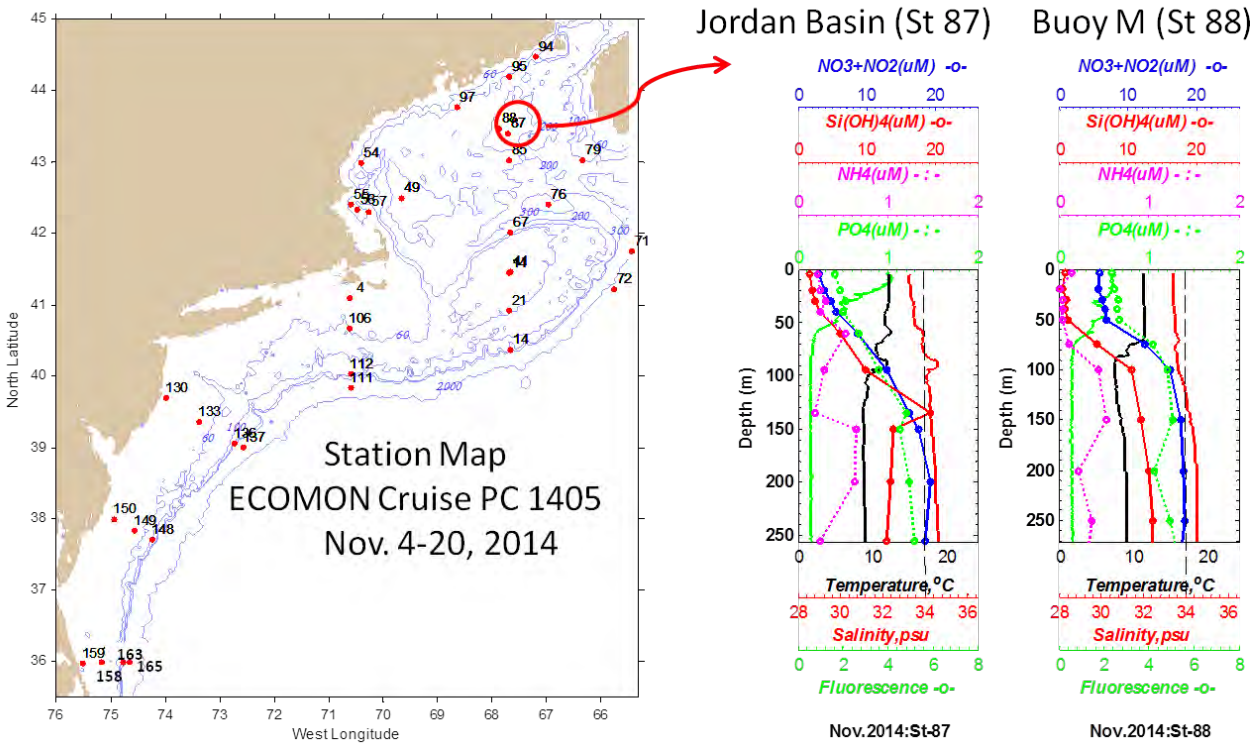
SOCIETAL BENEFITS

- Our continued analyses of the nutrient samples collected on the ECOMON cruises will be extremely important in our interpretations of conditions of Paralytic Shellfish Poisoning (PSP) from *Alexandrium* populations, and are already being used to help initiate simulation models to forecast the severity of GOM “red tides” months in advance.
- This research is providing baseline data for future interpretations of climate change-induced alterations to the marine environment of the Northwest Atlantic continental shelf. Our data have already provided evidence in support of earlier expressed concerns about far-field effects of Arctic melting.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Figure 1. Station Map: NOAA ECOMON Surveys (2009 to Fall 2014).





Nov. 11, 2014: Buoy M: 100m SUNA concentration @ 2000 = 15.46uM (NO_3)
100m Ground Truth concentration @ 2146=16.12uM (NO_3)

Figure 2. Hydrographic profiles in Jordan Basin in the Fall of 2014, adjacent to NERACOOS Buoy B, where we have an *in situ* optical nitrate sensor (Satlantic, Inc. SUNA) mounted at 100 m depth. CTD profiles and nutrient concentrations are plotted, and the "calibration" sample results are given.

Using the American lobster settlement index and environmental indicators to forecast lobster fishery recruitment

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Richard Wahle - UMaine

NOAA Sponsor – Larry Jacobson - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

We proposed to complete four objectives related to the predictive links between parallel time series generated by the American Lobster Settlement Index and state/federal trawl surveys, and additional environmental indicators. These objectives were to: (1) Evaluate spawner-to-settler relationships; (2) Evaluate cohort fate over first years of benthic life; (3) Forecast fishery recruitment; and (4) Make stock level data available for use in the stock assessment model.

Our original timetable had us completing Objectives 1 and 2 in year 1, and Objectives 3 and 4 in year 2. In practice, we initiated work on Objectives 1, 2, and 3 during year 1, and made the most progress on 2 and 3. This summary therefore focuses on the accomplishments for those two objectives. We used the approach largely as described in the proposal, except that for objective 3 we validated the settler to fishery recruit hindcasts by using commercial landings data rather than fishery-independent trawl survey data. The rationale for this approach is that the lobster fishery is a recruitment fishery, that is, the volume of landings largely depends on what recruits to the fishery in a given year, notwithstanding changes in fishing effort. Also, trawl surveys in state waters only began in Maine in 2000, reducing the number of years available to validate our recruitment hindcasts.

ACCOMPLISHMENTS

Objective 2: First year survival.

Methods: This objective looked within the ALSI database to characterize the functional relationship between “young -of-year” (YoY or age 0+) recruitment to subsequent early juvenile stages still residing within the nursery habitat. This allows us to evaluate the fate of cohorts over their first few years of life, before they emerge from nursery habitats. In the process we also refined our size definitions for age 0+ and 1+ lobsters. We conducted a length frequency analysis using MULITFAN software to estimate the mean and 95% confidence interval of the age 0+ and 1+ groups. Next, we conducted regression analyses using different non-overlapping size definitions of 0+ and 1+ age groups in an iterative process to find the best fitting relationship. Here we evaluated both linear and power functions. This analysis served two purposes: (1) to refine the regionally specified size definitions used for the two age groups that

likely result from regional environmental differences, and (2) to provide a first indication of how well settlement predicts the abundance of 1-year olds, thereby providing an estimate of first year survival.

Results: Both the length frequency and regression analyses have helped refine the size definitions for 0+ and 1+ lobsters in the different regions. Our best estimates of the size definitions for age 0+ and 1+ lobsters for eight study areas by these methods are compared to current definitions that have been based simply on visual inspection of length frequency distributions (Table 1). The results of the two analyses were fairly consistent in suggesting that size definitions should be upwardly revised in most cases. This is especially true for southern study areas where the more subjective estimates fell considerably short. For example, the upper limit for 0+ lobsters in the eastern Gulf of Maine (GOM)/Bay of Fundy region (Beaver Harbour, Lobster Bay) ranges from 9-11 mm, whereas in Rhode Island it ranges from 14-17 mm.

As for first year survival estimates, we focused on three sentinel study areas with the longest time series and contrasting environments - Beaver Harbour, NB, Midcoast ME, and Rhode Island (Fig. 1). Despite differing ranges of settlement densities in the three locations, the relationship between 0+ and resulting 1+ lobsters is essentially linear. Beaver Harbour stands out, though, for two reasons: (1) first-year survival there is almost twice as high as at the other two areas, and (2) the exceptionally strong 2005 settlement year class did not result in as high of numbers of 1+ lobsters as predicted by the linear equation, suggesting that survival was disproportionally low, perhaps a result of crowding (Fig. 2).

Objective 3: Evaluating the power of ALSI as a tool to forecast fishery recruitment

Methods: This objective evaluated the accuracy of a predictive model designed to forecast fishery recruitment from settlement and to account for variable growth and the influence of temperature. The original version of the model without temperature effects was developed by Wahle et al. (2004), and referenced in the original proposal. The consequence of variable growth is to spread fishery recruitment of a single settlement year class over several years. To account for this variability in the model we employed a logistic equation giving the proportion of a cohort recruiting to the fishery at age. We used previously estimated values of median age at recruitment to the fishery (a_{50}) for Rhode Island, Midcoast Maine, and Beaver Harbour, NB, determined from mark-recapture data (Bergeron 2011). These locations contrast considerably with respect to summer temperatures. Estimates of a_{50} were regressed against average bottom temperature for the corresponding region to give a functional relationship between temperature and a50 that we could use in our recruitment forecasting model. Bottom temperatures for each area were acquired from the Northeast Ocean Forecast System (NECOFS) bottom temperature hindcast model (http://fvcom.smast.umassd.edu/research_projects/NECOFS/). We tested two modeling scenarios, one in which temperature was held constant at the time series mean from 1990 to 2014 for the given location. In the second scenario temperature changed annually. Finally, the recruitment index was taken as the sum of the fractions of all settlement year classes contributing to recruitment in a given year. Linear regression was then used to validate recruitment hindcasts against observed fishery landings.

Results: Hindcasts of fishery recruitment generally agreed with landings trends in the seven study areas that allowed a comparison over 10 or more years (Fig. 2). We found statistically

significant ($p < 0.05$) or marginally significant ($p < 0.10$) positive correlations between modeled hindcasts and observed landings for five of the seven ALSI study areas with at least one of the two modeling scenarios (Table 2).

The locations for which the hindcasts best fit observed landings were those where the magnitude of change has been the greatest over time (e.g., RI, Beverly-Salem, Mt. Desert, Beaver Harbour) with 3-5-fold differences in abundance over the time series. The forecasts did not perform as well in locations with more stable recruitment (e.g., Cape Cod Bay, Midcoast ME) where the magnitude of change was considerably smaller (<2-fold). In these cases the forecasting tool did not accurately predict more subtle changes in landings. The variable and constant temperature models performed similarly well, but adding yearly variability did not consistently improve the prediction. The model hindcasts generally captured the trend of increasing landings in the GOM and declining landings since the late 1990s in southern New England (Fig. 2). Model forecasts suggest a few more years of increasing recruitment in the northeastern GOM followed by a considerable downturn. Further south in the GOM, such as in Beverly-Salem, forecasts suggest that the downturn will begin sooner. In Rhode Island, forecasts suggest continued low levels of recruitment in the near future.

HIGHLIGHTS

Preliminary results suggest that:

- Refining our size definitions for young-of-year and one-year-old lobster enables us to move forward with estimates of first year survival and the development of forecasting tools for fishery recruitment.
- We estimate first year survival to range from 45-85% of the settling cohort and to vary regionally. These provide the first empirical data enabling estimates of early juvenile natural mortality for the American lobster.
- Only in the most densely populated locations did we find evidence of density-dependent mortality over the first year. We cannot rule out emigration as a component of the losses, although prior evidence suggests movements to be minimal during the first year.
- Our initial effort to test the predictive power of the settlement index for fishery recruitment is promising. We found statistically significant relationships between our settlement based hindcasts and lobster landings for 5 of 7 regions analyzed. The two non-significant results were for locations that had relatively stable landings over the period.
- If our forecasts are accurate, the eastern GOM should be expecting a downturn in the next few years from its decade-long boom in landings.

SOCIETAL BENEFITS

Forecasting buys us the time we need to make choices about how to adapt to change in the environment. The fishing industry, fishery managers and policy makers, and residents and businesses of the working waterfront are the key stakeholders.

EDUCATION AND OUTREACH

Oppenheim, N. and R.A. Wahle. 2015. Forecasting lobster fishery recruitment from a larval settlement index. Invited presentation. Maine Fishermen's Forum. Mar 5, 2015. Rockland, ME

Wahle, R.A. 2015. The American Lobster: Developing Forecasting Tools in a Changing Ecosystem. Invited presentation. Maine Fishermen's Forum. Mar 5, 2015. Rockland, ME

Wahle, R.A. 2015. Sparse spawners & crowded cannibals:pushing the limits of density-dependence in a heavily exploited marine food web. Invited presentation. India Institute of Science. Center for Ecological Sciences. Feb 26, 2015. Bangalore, India.

White, M.M., A.C. Candelmo, R. C. Chambers, C.J. Gobler, A.L. King, N.N. Price, R.A. Wahle, J.D. Waller* 2015. The biological response of multiple northeast taxa to ocean acidification. Oral presentation by first author. Northeast Aquaculture Conference and Exposition. Jan 14-16, 2015. Portland, ME.

Wahle, R.A. 2015. The American lobster in a changing ecosystem. Invited presentation. Maine Legislators Bus Tour. Jan 14, 2015. Orono, ME

Incze, L. S., R.A. Wahle, H. Xue, and C. Wilson. 2014. Understanding a complex regional fishery in the context of changing global-scale drivers and the need for sustainability. Xiamen Marine Science Conference. Jan. 3, 2015. Xiamen University, China.

Wahle, R.A. and N. Oppenheim*. 2014. Developing forecasting tools from a larval settlement index. Invited panel presentation. Workshop on Fishery Forecasting and Prediction. Dec. 18, 2014. Univ. Southern Maine, Portland, ME

Wahle, R.A., W. Ambrose, R. Kilada. 2014. The American lobster: Developing forecasting tools in a changing ecosystem. Invited presentation. Workshop on Crustacean age determination. Nov. 11, 2014. Institute for Marine Research, Tromsø, Norway.

Wahle, R.A. and N. Oppenheim. 2014. Applied research in focus: Long-term investment in the American lobster settlement index. Invited presentation. Sea Grant Site visit, UMaine President's Residence. Oct 7, 2014. Orono, ME

Wahle, R.A. 2014. Ocean acidification and the challenges facing the American lobster fishery in a changing ecosystem. Invited presentation. Maine Ocean Acidification Commission Meeting. Aug. 5, 2014. Darling Marine Center, Walpole, ME.

Wahle, R.A. 2014. The American lobster in a changing ecosystem. Invited presentation. The Lobster Institute, board of advisors meeting. June 11, 2014. Orono, ME

Wahle, R.A. 2014. The American lobster in a changing ecosystem. Invited presentation. Maine Legislators visit to the Darling Marine Center. June 5, 2014. Orono, ME

Wahle, R.A. 2014. The American lobster: Poster child of a changing ecosystem. Keynote Address. 10th International Conference and Workshop on Lobsters. May 18 -23, 2014. Cancún, Mexico.

Wahle, R.A., L. Delinger, S. Olszewski, P. Jekielek, C. Bergeron. 2014. Lobster nurseries of southern New England recede in the face of climate change. Oral presentation. 10th International Conference and Workshop on Lobsters. May 18 -23, 2014. Cancún, Mexico.

Oppenheim, N., R.A. Wahle. 2014. A new forecasting model for the American lobster fishery using the American Lobster Settlement Index. Oral presentation. 10th International Conference and Workshop on Lobsters. May 18 -23, 2014. Cancún, Mexico.

Pershing, A.J., K.E. Mills, Y. Chen, A.C. Thomas, and R.A. Wahle. 2014. Impact of the 2012 Ocean Heat Wave on Fish and Fisheries. Poster presentation. ASLO Ocean Sciences Meeting. February 23-28. Honolulu, HI

Oppenheim, N.G.*, R.A. Wahle, D.C. Brady. 2014. Can we forecast the future of the American lobster fishery from a larval settlement index? Poster presentation. ASLO Ocean Sciences Meeting. February 23-28. Honolulu, HI

Wahle, R.A. and P. Jekielek. 2014. The American Lobster Settlement Index: a US-Canada collaborative for ecological and fishery monitoring. Poster presentation. ASLO Ocean Sciences Meeting. February 23-28. Honolulu, HI

Wahle, R. 2014. The American lobster in a changing climate. Invited Webinar presentation. Northeast Coastal Acidification Network (NECAN). Hosted by NERACOOS. January 21, 2014. http://www.neracoos.org/necan

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

Table 1. Current and revised size definitions of 0+ and 1+ lobsters from linear and non--- linear regression and length frequency analysis for the eight study areas. Regression statistics (r^2 and p) given for the best fitting relationship between age 0+ and resulting 1+ lobsters a year later.

	Lobster Bay, NS	Beaver Harbour, NB	Mt Desert. ME	Mid-coast, ME	Casco Bay, ME	York, ME	Beverly-Salem, MA*^	Rhode Island
Time series>	2007-2011	1991-2011	1999-2011	1989-2011	2000-2011	2000-2011	1997-2011	1992-2011
Current Definitions								
0+ upper limit (mm)	13	13	13	10.5	10.5	10.5	12	13
1+ upper limit (mm)				16				25
Linear Fit								
0+ upper limit (mm)	9	11	10	11	12	13	17	17
1+ upper limit (mm)	14	16	18	17	22	16	24	25
r^2	0.9981	0.5424	0.7451	0.6564	0.4229	0.629	0.8277	0.7159
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.01	< 0.001	< 0.001
Power function Fit								
0+ upper limit (mm)	9	11	12	13	14	13	17	17
1+ upper limit (mm)	14	16	17	17	20	16	24	25
r^2	0.6773	0.7461	0.745	0.7118	0.5058	0.7144	0.8226	0.8299
p	NS	< 0.001	< 0.001	< 0.001	< 0.05	< 0.01	< 0.001	< 0.001
MULTIFAN Fit								
0+ mean size (mm)	8.81	7.59	9.59	9.32	9.44	9.17	9.85	9.87
1+ mean size (mm)	14.3	12.43	14.63	14.76	14.64	14.85	19.08	21.3
0+ upper limit (mm) 95% CI	11.24	10.67	12.73	12.42	12.87	12.54	14.38	14.44
1+ upper limit (mm) 95% CI	16.75	15.59	17.73	18.09	18.17	18.28	23.88	26.75

Table 2. Model validation: result of correlation analysis between model predicted and observed landings for the seven ALSI study areas depicted in Fig. 2. Asterisks indicate degree of statistical significance, with *, **, and * corresponding to p < 0.05, 0.01, and 0.001, respectively.**

Region	Constant Temperature		Variable Temperature		Number of forecast years
	r2	p	r2	p	
Rhode Island	0.472	0.00231**	0.299	0.0231*	17
Buzzards Bay	0.097	0.351	0.28	0.0887	11
Cape Cod Bay	0.217	0.149	0.059	0.47	11
Beverly/Salem	0.939	0.0000000913***	0.807	0.000171***	11
Midcoast	0.117	0.195	0.123	0.182	16
Mt. Desert Island	0.93	0.00000272***	0.96	0.000000292***	10
Beaver Harbour	0.658	0.000764**	0.808	0.00000362***	13

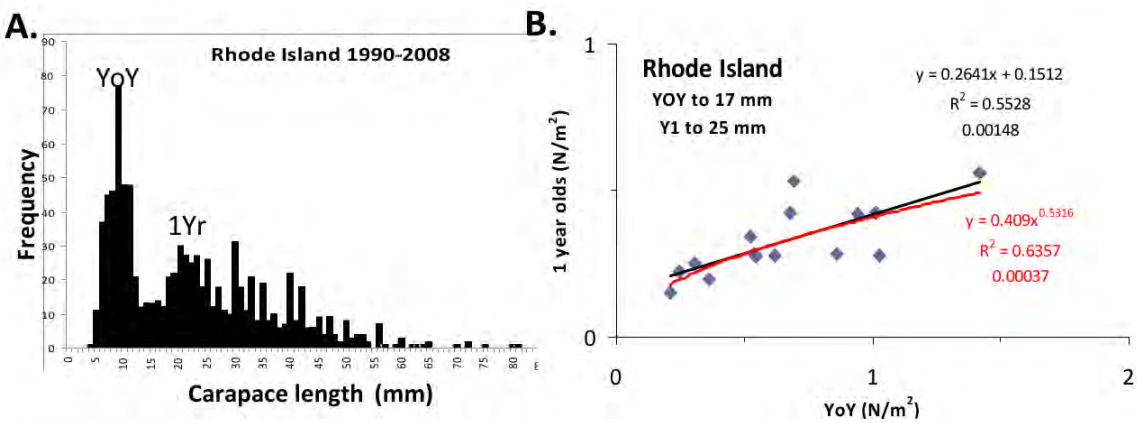


Figure 1. Example of a size frequency distribution of juvenile lobsters from the American Lobster Settlement Index. The first two modes in the distribution correspond to young of year (age 0+) and one---year old lobsters (age 1+). Research objective 1 served to refine our size definitions of these age groups for the purposes of forecasting the fate of year classes.

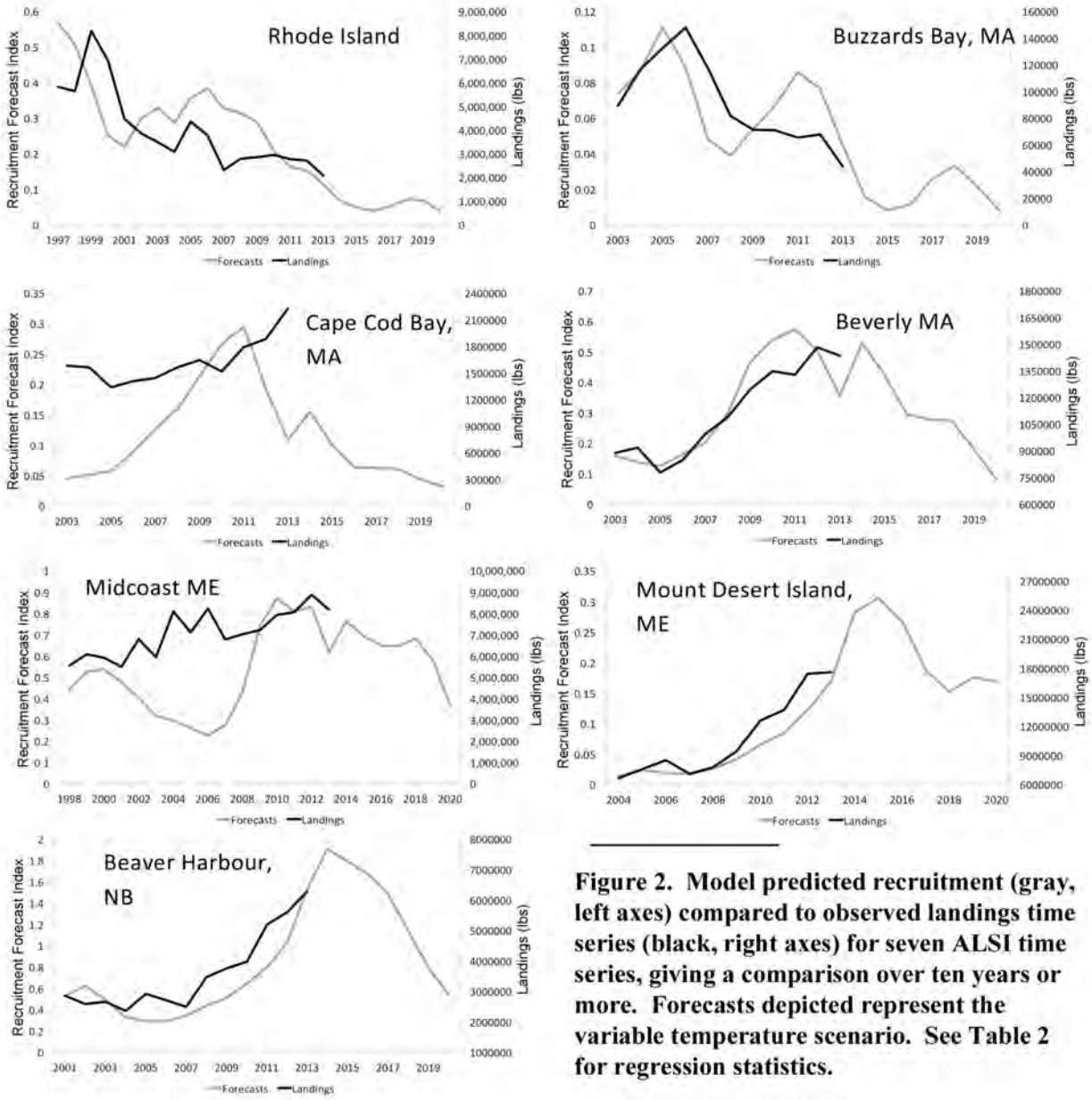


Figure 2. Model predicted recruitment (gray, left axes) compared to observed landings time series (black, right axes) for seven ALSI time series, giving a comparison over ten years or more. Forecasts depicted represent the variable temperature scenario. See Table 2 for regression statistics.

Development and testing of a new method for selecting among stock assessment models

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Michael Wilberg - UMCES

NOAA Sponsor – Brian Linton - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

The objectives of this project are to develop and test a new method for selecting among complex stock assessment models. There have been no changes to the objectives of the project.

ACCOMPLISHMENTS

- Two alternative model selection methods were developed. The first method evaluates the accuracy of a candidate model's terminal year predictions, while the second method evaluates the accuracy of a candidate model's short term forecasts.
- A simulation study was designed to test the performance of the two model selection methods. The estimation models to be used in the study will represent different classes of age-structured statistical models used in real world stock assessments. The underlying data-generating model for the study will possess greater complexity (e.g., multiple time-varying biological and fishery processes) than any one of the candidate estimation models. An initial suite of simulation scenarios have been selected for testing. Additional simulation scenarios will be developed based on the results of the initial simulation runs.
- Programming of the simulation study models is in progress, and nearing completion.

HIGHLIGHTS

We have designed two new model selection methods for complex stock assessment models. We are in the process of simulation testing the two methods to compare them with previously developed methods.

SOCIETAL BENEFITS

Stock assessments provide much of the information to guide catch limits and other fishery management decisions. Because of their importance, the most accurate information possible is desired. We are testing several techniques to improve the quality of estimates from stock assessments by developing objective metrics that can be used to select models providing the most accurate estimates of stock size, fishing mortality rates, and catch limits.

Sustaining development of National Ocean Service operational forecast systems based on the Regional Ocean Modeling System

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – John Wilkin - Rutgers

NOAA Sponsor – Aijun Zhang - NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: I. Ecosystem Forecasting

PROJECT OVERVIEW

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

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

The specific objectives of this project are to facilitate exchange of information between the ROMS developer group and the ROMS users at NOS so as to ensure that: (1) NOS has access to and is aware of the most recent developments in the ROMS source code; (2) NOS follows ROMS best practices; and (3) NOS needs and recommendations for code modifications are conveyed to the developers and implemented in the community to make the NOS user experience accessible to the broader ROMS user community.

ACCOMPLISHMENTS

On June 10-11, 2014, the Rutgers project team met with NOS scientists in Silver Spring to present an overview of recent enhancements to the ROMS variational data assimilation capabilities, and the introduction of synchronous 2-way nesting to the model kernel. Wilkin and Arango addressed issues NOS was encountering with the Cook Inlet model configuration, and provided guidance on the CBOFS and DBOFS systems upgrades to the most recent version of ROMS. Discussion amongst the meeting attendees considered outstanding development issues

for implementing the He and McGillicuddy “redtide” model for Gulf of Maine Harmful Algal Blooms. These issues have since been resolved and a completed version of “redtide” was released in December 2014 via a restricted access SubVersion branch of the ROMS source code at the www.myroms.org portal. This is being implemented in the latest NCSU Gulf of Maine 3-D model and evaluated by WHOI and NCSU. Future development will see this code, once accepted, ported to the GOM OFS currently under development at NOS.

HIGHLIGHTS

- A completed version of “redtide” was released in via a restricted access SubVersion branch of the ROMS source code at the www.myroms.org portal.
- This is being implemented in the latest NCSU Gulf of Maine 3-D model and evaluated by WHOI and NCSU.

SOCIETAL BENEFITS

Improved quality of the model-based scientific information conveyed to maritime industry and resource managers operating in the Chesapeake, Delaware, and Tampa Bay ports. Development of an operational ecosystem prediction for Harmful Algal Blooms in the Gulf of Maine.

THEME II. ECOSYSTEM MONITORING

Publication of a special issue of Oceanography magazine on emerging themes in ocean acidification science

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Heather Benway - WHOI

NOAA Sponsor – Elizabeth Jewett - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The Oceanography Society (TOS) proposes to publish a special issue of *Oceanography* magazine in June 2015 entitled "Emerging Themes in Ocean Acidification Science." The proposed issue will contain peer-reviewed articles that synthesize the outcomes from breakout discussion sessions at the 2013 Ocean Acidification Principal Investigators' (OAPI) Meeting, and review subtopics of ocean acidification science that were not deeply explored at the OAPI meeting, yet are of broad interdisciplinary interest. Breakout discussions addressed overarching questions that sought to: 1) document the state of ocean acidification knowledge in an interdisciplinary context; 2) start synthesizing trends and themes in the science across environments and processes; 3) explore how enhanced interdisciplinary activity can address knowledge gaps; and 4) identify logical short-term steps and longer-term goals for the research community. Additional papers are being submitted by meeting attendees to cover the full scope of ocean acidification research at present.

ACCOMPLISHMENTS

We have submitted the majority (~80-90%) of the papers to Oceanography for a June publication date. The rest are going through final revisions, and will be submitted shortly. We are currently preparing the introductory paper and working on selecting a cover image for the special volume.

HIGHLIGHTS

- The Oceanography Society will publish a special issue of *Oceanography* magazine in June 2015 entitled "Emerging Themes in Ocean Acidification Science."
- Breakout discussions at the 2013 OAPI meeting sought to synthesize the state of ocean acidification knowledge in an interdisciplinary context, address knowledge gaps and identify research goals, and review subtopics of ocean acidification science that were not deeply explored at the OAPI meeting.
- The special issue will contain peer-reviewed articles based on the outcomes from these breakout discussion sessions at the 2013 OAPI Meeting.

SOCIETAL BENEFITS

The proposed special issue of *Oceanography* magazine (http://www.tos.org/oceanography) is intended to synthesize the state of ocean acidification knowledge and research activities so that they are readily understandable to the lay public, undergraduate and graduate students, and a wide range of scientists and policy makers.

Characterizing the Penobscot River estuarine transition zone to determine environmental challenges for Atlantic salmon, their prey, and other sea-run species

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Damian Brady - UMaine

NOAA Sponsor – John Kocik - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The abundance of Atlantic salmon *Salmo salar* has precipitously declined in recent decades, despite considerable conservation efforts. One reason for this decline is high mortality and smolt loss during their seaward migration through estuaries, which is higher than monthly mortality in open ocean systems. High mortality rates may be due to a combination of physiological stressors, variable prey concentrations, and elevated predation pressure. Salmon migration success is influenced by physical conditions in the estuarine transition zone such as salinity, temperature, and turbidity. Especially important is the nature of the saltwater intrusion and how gradually smolts are exposed to seawater and thermal shifts. Another important factor is the strength of the turbidity maximum, which affects both smolt foraging success and predation risk. Despite the importance of such variables to smolt migration, a thorough characterization of the estuarine transition zone is lacking in the Penobscot estuary. The location and intensity of the salt intrusion and turbidity maximum is dually affected by riverine and tidal forcing. We plan to conduct vertical profiles of temperature, salinity, and turbidity throughout the estuarine transition zone during smolt migration. We will specifically target dates to sample a broad range of discharge values and various tidal stages. Additionally, we will collect zooplankton (including mysids and fish larvae) samples to characterize the prey field available to migrating smolts. These data can be combined with ongoing NOAA efforts to determine which combination of physical variables contributes to smolt migration success in the Penobscot estuary.

ACCOMPLISHMENTS

While we have not started the actual surveys, we have compiled relevant data collected to date in the Penobscot estuary. These data include surveys of the physical variables such as temperature, salinity, chlorophyll, and zooplankton abundance, as well as data collected previously from acoustic receivers that detect tagged smolts during their migration. These previous surveys were not temporally coupled, but we are using these preliminary data to guide our survey design. We have met with NOAA scientists (including the program manager, John Kocik) on numerous occasions to discuss our sampling protocol and data management plan. We have also attended an Atlantic salmon meeting, where fisheries biologists from academic, non-governmental, as well as

state and federal organizations meet to discuss current research efforts and challenges related to Atlantic salmon recovery.

HIGHLIGHTS

- Together with NOAA, we are creating an ecosystem-based framework for monitoring the U.S.'s largest river restoration program. In addition to current sampling for anadromous fish, we are expanding the monitoring protocol to include measurements of water quality and prey abundance along important migration corridors.

SOCIETAL BENEFITS

Historically, Atlantic salmon were a very important part of New England's culture by providing food for local communities and export, recreational fishing opportunities, and performing an essential ecosystem service of exporting nutrients through their migration behavior. Despite significant conservation efforts, Atlantic salmon stocks have declined considerably in recent decades, with the highest mortality taking place as smolts migrate through estuarine and inshore waters. This project will provide a rare survey of migrating smolts along with spatially-coupled measurements of physical variables and available prey to elucidate the major obstacles hindering smolt migration and salmon recovery.

Annual Eastern Gulf of Maine sentinel jigging/longline survey/fishery

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Yong Chen – UMaine

NOAA Sponsor – John Hoey - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The Eastern Gulf of Maine Sentinel Survey/Fishery is a groundfish survey conducted in the summer from the western edge of Penobscot Bay to the eastern border with Canada. The survey consists of stratified random stations that are sampled with both demersal longline gear and jigging gear. A portion of the stations is also allocated for fishermen to select where they want to fish based on their knowledge of historic fishing grounds and suitable habitat. The primary objective of the survey is to provide an annual index of abundance as well as habitat preference information for groundfish species (including Atlantic cod, cusk, white hake and Atlantic halibut) in an area that was traditionally important for the commercial groundfish fishery but is not currently well covered by either commercial fisheries or other bottom-trawl –based monitoring programs. The yearly report focuses on the most recent year of the sentinel survey/fishery (2014), but also includes an analysis of all the survey/fishery catch data since the inception of the sentinel survey/fishery in 2010 to the most recent year 2014.

In 2014, the overall allocation of sampling effort was divided into longline and jig components that were stratified by depth. Within these two gear types, random longline stations (LL) and Fishermen's Choice longline stations (LF) comprised the longline portion, while Jigging at Jigging only stations (JJ) comprised the jig portion. There were 30 LL stations stratified by three separate depths (50-80m, 80-150m, and 150m+), 16 LF stations, and 47 JJ stations (Figure 1). The JJ stations were also stratified by depth, and consisted of 36 JJ at Stratum 0 (0-50m) stations and 15 JJ at strata 1-3 (50-80m, 80-150m, and 150m+). Each LL and LF station also had a jigging component included to continue modifications made in 2013 as per suggestion by the Northeast Fisheries Science Center. There were 30 jigging at random longline stations (JL) and 16 jigging at fishermen's choice stations (JF). The JL stations were therefore stratified by depth as well; all falling into strata 1-3. Therefore an additional 46 stations were sampled with jigging gear at LF and LL stations, creating a total of 93 stations sampled by jig gear. Atlantic cod were the only targeted groundfish species for the JJ, JL and JF, though other species including pollock and mackerel were also caught. There are no LL stations in Stratum 0 (0-50 m) because of the large number of fixed gear in summer in the Maine coastal waters.

This study suggests that the longline/jig sentinel survey fishery can become an important monitoring program to collect abundance and biological data of important groundfish species in

an area not well covered by other survey programs. Such information can fill the data gap in stock assessment and will become more valuable with the increased length of data time series.

ACCOMPLISHMENTS

In 2014 Atlantic cod were caught by longline at 16.7% of stratified random stations (LL); by longline at 31.2% of fishermen's choice stations (LF); by jig at 29.8% of random jig stations (JJ); by jig at 10.0% of random longline stations (JL); and by jig at 25.0% of fishermen's choice stations (JF) (Table 1). Cusk were caught at 6.7% random longline (LL) survey stations, and at 31.2% of fishermen's choice longline (LF) stations (Table 1). White hake were caught at 63.3% of random longline (LL) survey stations and at 43.8% of fishermen's choice (LF) stations (Table 1). Halibut were caught at 56.7% of random longline (LL) survey stations and 37.5% of fishermen's choice (LF) stations (Table 1). Dogfish were caught at 43.3% of random longline (LL) survey stations and 37.5% of fishermen's choice (LF) stations (Table 1).

In contrast, in 2013 there was a lower percentage of species of interest seen at each of the station types (Table 2).

Overall, in 2014 there was a higher percentage of LL, LF, and JJ stations where Atlantic cod were caught. Similarly, in 2014 there was a higher percentage of LL and LF stations where Atlantic halibut were caught. This could indicate a greater dispersal and wider distribution of the groundfish species of interest in the sampling areas in 2014 compared to 2013.

The stratified random survey was only conducted between 2012 and 2014. Thus we only had three years of survey abundance indices for longline and jigging. Each abundance index was calculated per station type. For longline (LL), the mean abundance index of cod increased from 2012 to 2013 and decreased from 2013 to 2014 (Table 3). The estimates of all three years had large CVs, making the interpretation of between-year difference difficult. The mean abundance of cusk at LL stations decreased from 2012 to 2013, and decreased from 2013 to 2014 (Table 3). All three years had large CVs. Mean abundance of white hake decreased from 2012 to 2013, and then decreased again from 2013 to 2014 (Table 3). The CV in 2012 was large, slightly decreased in 2013, and then greatly decreased in 2014 (Table 3). The mean abundance of Atlantic halibut at LL stations decreased from 2012 to 2013, but then more than doubled from 2013 to 2014 (Table 3). All CVs for halibut were very small. The CVs for jigging were much smaller than those for the longline.

Analysis for jigging stations in 2014 was conducted slightly differently than in previous years; the inshore jigging (JJ at Stratum 0) stations were separated from offshore jigging at strata 1-3 (JJO) and mean abundance and CV was calculated for each. To remain consistent with previous years' analysis, however, mean abundance and CV for Atlantic cod were still calculated for each jigging component. Mean abundance of cod at random jig stations (JJ) decreased from 2013 to 2014 (Table 3). The CV for cod at JJ stations decreased by a large amount from 2013 to 2014 (Table 3). The random jigging stations were then divided into inshore and offshore components for analysis. The JJ stations at stratum 0 sites were referred to inshore station, while JJ stations in strata 1-3 were referred to offshore stations (JJO). The JJO and jigging at random longline stations were combined because they both encapsulated strata 1-3, and combining the two station types increased sample size of Atlantic cod. Mean abundance of cod at JJ Stratum 0 decreased

from 2012-2013, then sharply increased from 2013-2014 (Table 3). While the CV was large in 2012, it decreased dramatically in 2013 and 2014 (Table 3). For the offshore jigging stations (JJO+JL) mean cod abundance decreased from 2013 to 2014; the CV also decreased from 2013 to 2014 (Table 3). Finally, all random jigging stations for strata 0-3 were combined and assessed (JJ+JJO+JL). Mean abundance of cod for all random jigging stations decreased from 2013 to 2014; the CV also decreased (Table 3). Although cod abundance decreased over all the area from 2013 to 2014, this analysis suggests that cod abundance tended to have a different temporal pattern between inshore and offshore with cod increasing significantly inshore, but decreasing offshore from 2013 to 2014.

The abundance indices show that jigging was highly efficient at coastal waters (i.e., Stratum 0) where fixed gear congestion makes it almost impossible for other sampling gear types (including trawl and longline). The increase in mean abundance of cod at JJ Stratum 0 stations between 2012 and 2014 is important information not previously obtainable by other survey programs in the Gulf of Maine. In addition, the CVs were relatively low, indicating a good confidence of abundance index data obtained.

To analyze the mean abundance of species at fishermen's choice (LF) stations, we used standardized catch per unit effort (CPUE). Trends in standardized CPUE of fishermen's choice stations between 2010 and 2014 show a slight increase for white hake from 2010 to 2012, but a slight decrease from 2012 to 2013, followed by a decrease from 2013 to 2014 (Figure 2). There was a small decrease from 2010 to 2012, a large decrease from 2012 to 2013, and a large increase from 2013 to 2014 for Atlantic halibut (Figure 2). Standardized CPUE for cusk showed a decrease from 2010 to 2012 followed by an increase in 2013 and slight increase in 2014 (Figure 2). Finally, there was an increase from 2010 to 2012, a decrease in 2013, and then a large increase in 2014 for Atlantic cod (Figure 2). However, large standard errors were associated with most standardized CPUEs.

Depth was repeatedly and consistently found to be one of the most important environmental variables influencing the survey catch rates of Atlantic cod, cusk, white hake and Atlantic halibut. This justifies the design of the survey as stratified by depth. Sediment and sea surface temperature were also an important factor for some species.

HIGHLIGHTS

- An abundance index was created for targeted groundfish species of interest including Atlantic cod, cusk, white hake, and Atlantic halibut.
- The inshore jig component wasseparated from other strata and analyzed; it was then added to the abundance index to show importance of inshore areas not covered by existing monitering programs.
- Catch-per-unit-effort (CPUE) at fishermen's choice stations for targeted groundfish species of interest analyzed from 2010-2014, and found to fluctuate between years. However, the highest CPUE to date for cod and halibut was in 2014.
- Percentage of stations where targeted groundfish species of interest assessed for 2014; then compared with 2014, and found to indicate higher dispersal of groundfish in the sampling area.

- Depth was repeatedly and consistently found to be one of the most important variables influencing survey catch rates of Atlantic cod, cusk, white hake, Atlantic halibut, and spiny dogfish. Sediment and sea surface temperature were also important for some species.

SOCIETAL BENEFITS

The Eastern Gulf of Maine Sentinel survey exists to evaluate the abundance an habitat preferences of groundfish species in an area not covered by existing monitoring programs. The survey is beneficial to scientists studying the dwindling stocks in the area, but also valuable information for fishermen within the no longer commercially viable groundfish industry. Because fishermen are directly involved in the scientific process through the Sentinel survey, this research strengthens fishermen-scientist collaboration while collecting fine-scale sampling information in the eastern Gulf of Maine.

EDUCATION AND OUTREACH ACTIVITIES

A summary of results for the 2014 sampling season as well as data from the combined five survey years was presented at the Fishermen's Forum in March of 2015.

FIGURES/PHOTOS/ILLUSTRATIONS

Table 1. Breakdown of station allocations and number of stations where groundfish species of interest were caught in the 2014 survey.

			Stations where species present									
Station Type	Stations		Cod		Cusk		White Hake		Halibut		Dogfish	
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Random longline (LL)	30	22.1	5	16.7	2	6.7	19	63.3	17	56.7	13	43.3
Stratum1 (50-80)	9	6.5	0	0.0	0	0.0	0	0.0	4	44.0	0	0.0
Stratum2 (80-150)	10	7.2	2	20.0	1	10.0	7	70.0	10	100.0	3	30.0
Stratum3 (150+)	11	7.9	3	27.2	1	9.0	10	90.9	1	9.09	10	90.9
Fishermen's Choice (LF)	16	11.5	5	31.2	5	31.20	7	43.8	6	37.5	6	37.5
Jigging at jigging only station(JJ)	47	33.8	14	29.8								
Stratum 0 (0-50)	36	25.9	14	38.9								
Stratum1 (50-80)	4	2.9	0	0								
Stratum2 (80-150)	4	2.9	0	0								
Stratum3 (150+)	3	2.2	0	0								
Jigging at random longline (JL)	30	21.6	3	10.0								
Jigging at fisherman's choice(JF)	16	11.5	4	25.0								
All (cod/other species)	139/44	100.0	31	22.3	7	5.03	26	18.7	23	16.5	19	41.3

Table 2. Breakdown of station allocations and number of stations where groundfish species of interest were caught in the 2013 survey.

			Stations where species present									
Station Type	Stations		Cod		Cusk		White Hake		Halibut		Dogfish	
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Random longline (LL)	30	22.1	2	6.7	2	6.7	17	56.7	11	36.7	22	73.3
Stratum1 (50-80)	5	3.7	0	0.0	0	0.0	0	0.0	4	80.0	2	40.0
Stratum2 (80-150)	12	8.8	0	0.0	2	16.7	4	33.3	5	41.7	7	58.3
Stratum3 (150+)	13	9.6	2	15.4	0	0.0	13	100.0	2	15.4	13	100.0
Fishermen's Choice (LF)	14	10.3	2	14.3	4	28.6	6	42.9	2	14.3	6	42.9
Jigging at jigging only station(JJ)	48	35.3	9	19								
Stratum 0 (0-50)	36	26.5	8	22								
Stratum1 (50-80)	4	2.9	0	0								
Stratum2 (80-150)	4	2.9	1	25								
Stratum3 (150+)	4	2.9	0	0								
Jigging at random longline (JL)	30	22.1	2	6.7								
Jigging at fisherman's choice(JF)	14	10.3	0	0								
All (cod/other species)	136/44	100.0	15	11.0	6	13.6	23	52.3	13	29.5	28	63.6

Table 3. Mean abundance and coefficient of variation (CV) of groundfish species of interest.

Year/Station Type	Species							
	Cod		Cusk		White Hake		Halibut	
	mean	CV	mean	CV	mean	CV	mean	CV
2012 LL	0.11	0.17	0.56	0.19	39.00	0.14	3.90	0.095
2013 LL	0.35	0.78	0.07	0.19	32.28	0.11	1.05	0.090
2014 LL	0.20	0.24	0.04	0.96	16.01	0.09	2.30	0.097
2013 JJ	0.34	0.71						
2014 JJ	0.14	0.04						
2012 JJ Stratum 0	0.50	0.27						
2013 JJ Stratum 0	0.44	0.06						
2014 JJ Stratum 0	0.64	0.06						
2013 JJO+JL	0.21	0.57						
2014 JJO+JL	0.04	0.36						
2013 JJ+JJO+JL	0.23	0.45						
2014 JJ+JJO+JL	0.11	0.13						

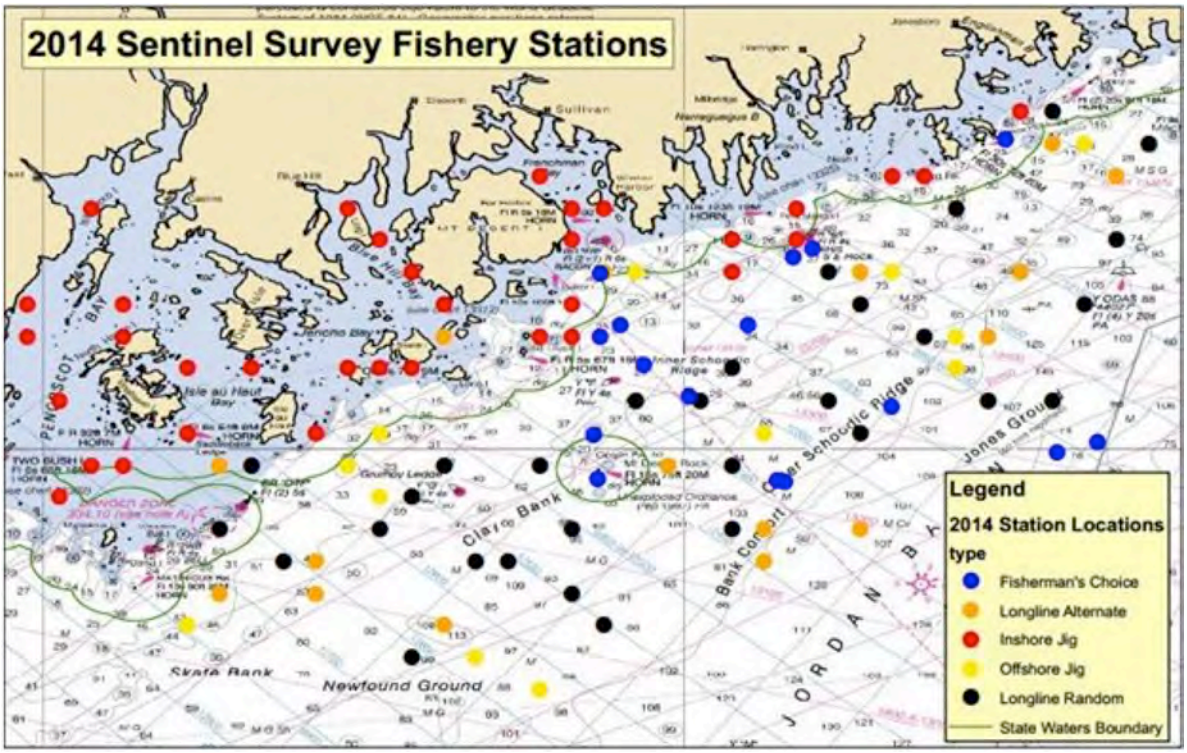


Figure 1. Survey area including 2014 sampling locations.

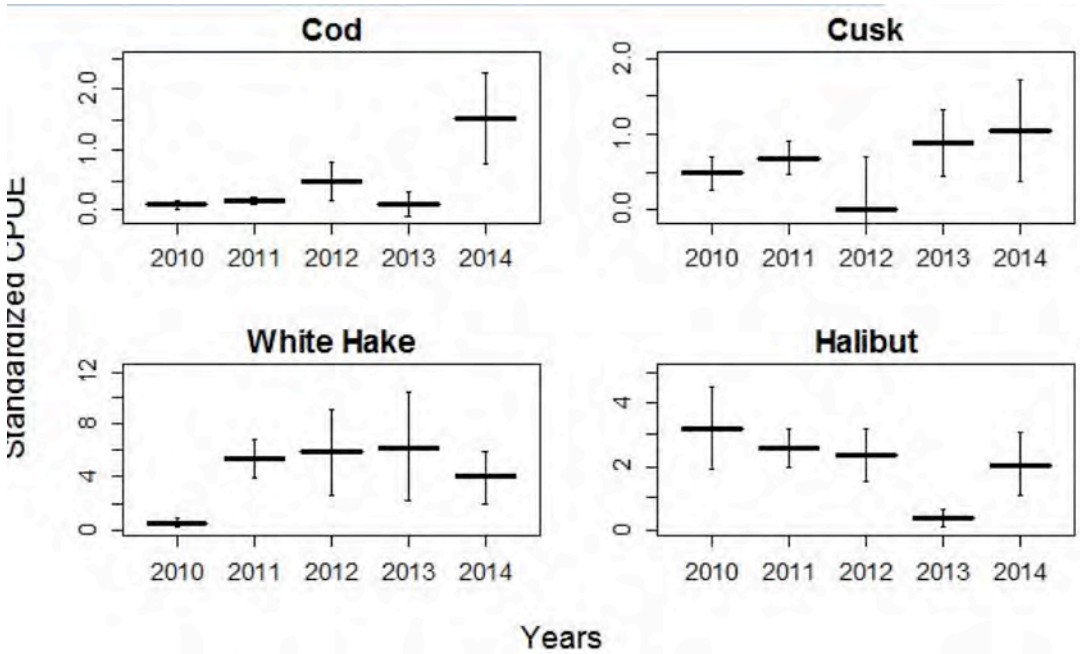


Figure 2. Standardized CPUE for groundfish species of interest between 2010-2014.

Operational support for Habcam V4 on scallop surveys, post-cruise processing, machine vision efforts, habitat classification, yellowtail surveys, and lobster habitat

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Scott Gallager - WHOI

NOAA Sponsor – Dvora Hart - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The use of underwater stereo imagery in stock assessment and ecosystem analysis is becoming a widespread alternative to pelagic and benthic trawling. We have been collaborating with NOAA for the past five years in developing new, non-invasive technologies for the cost effective survey of sea scallops and ground fish. As such we have developed a stereo optical and acoustic imaging system that is currently being used by NOAA to survey scallops along the entire northeast continental shelf. This project is in support of six WHOI/NOAA initiatives that directly relate to either the further development of this technology or to its application in enhancing stock assessment of sea scallops and ground fish.

Major project objectives included the following:

1) WHOI participation in the annual scallop survey and post cruise data processing;
2) WHOI participation in the development of habitat characterization methods and data products using data from HabCamV4;
3) Support for development and testing of image processing and machine vision tools for segmentation and classification of yellowtail flounder and other difficult targets (in collaboration with Lakshman Prasad, Los Alamos National Laboratory);
4) Support for RPI/WHOI student Peter Honig to develop machine vision tools for classifying substrate and other targets;
5) Support for WHOI participation in a new initiative to develop a yellowtail flounder survey using HabCamV4 and implementation of the machine vision tools for processing the imagery; and
6) Support for participating in and processing data from a lobster habitat cruise along the northeast continental slope.

ACCOMPLISHMENTS

Objective 1: WHOI participation in the annual scallop survey and post cruise data processing.

This objective supported WHOI's participation in the 2014 Scallop Survey (Leg 3), we well as follow up data processing and training.
In addition to the objectives set out for Legs 1 and 2, this year we also included real-time image processing, substrate classification, scallop classification, and automated stereo measurement of scallops and other targets off the seafloor. This new software required some additional training to show NOAA personnel how it works and how to interpret the results.

Objective 2: WHOI participation in the development of habitat characterization methods and data products using data from HabCamV4.

This project provided stock assessment managers with the ability to assess the impact of changing habitats on the following specific elements: 1) abundance uncertainty of key commercially important stocks, 2) improved projection of biomass estimates in areas with minimal or no sampling effort, 3) impact of habitat disturbance on the abundance of target species specifically and biodiversity in general, 4) the ability to increase the efficacy of sampling design and maximizing precision of a survey by stratifying on habitat, 5) minimizing bycatch of key species, and 6) assessing the impact of invasive species.

Objective 3: Support for development and testing of image processing and machine vision tools for segmentation and classification of yellowtail flounder and other difficult targets (in collaboration with Lakshman Prasad, Los Alamos National Laboratory).

Multiscale Image Decomposition and Shape Analysis Capability to NOAA Fisheries Image and Video Data Analysis
In this project we adapted the broad-based marine image analysis capability using the NOAA representative datasets as benchmark imagery to test and evaluate performance of algorithmic workflows that are being developed to address core functionalities of fish detection and delineation. Specifically, we are using edge-based polygonal image decomposition to achieve feature extraction that is relatively robust to color and contrast variations. The edge-based features will be subject to shape characterization and parts-based decomposition (Fig. 1), with attributes customized to identify and recognize fish type and size by their distinguishing features. This will ultimately enable the development of annotated shape databases against which matching and recognition can be performed. Multiscale image decomposition will also be used to develop methods to evaluate the fine-scale composition of larger-scale features and statistically discriminate fish against complex, textured backgrounds.

These activities ultimately will produce a platform with an easy to use Python/Matlab API that exposes functionalities of the capability and the project's algorithmic workflow for NOAA and WHOI researchers.

Objective 4: Support for RPI/WHOI student Peter Honig to develop machine vision tools for classifying substrate and other targets.

CMECS categories were identified and the automated classifier trained to provide percentage cover of each substrate category along the entire track of Legs 1-3.

This approach will continue into the segmentation of images at a pixel-level granularity using the cell classification probabilities as weights in conjunction with directed-edge graph-cuts, with the goal of real-time image processing at sea to provide the basis for a robust scallop and occluded target identification system. We will implement a prototype of this classifier on the scallop and yellowtail cruises scheduled for this summer.

Objective 5: Support for WHOI participation in a new initiative to develop a yellowtail flounder survey using HabCamV4 and implementation of the machine vision tools for processing the imagery.

Objective 5 comprises four tasks: 1) Set up (mobilize) and demobilize the HabCamV4 vehicle on the R/V Connecticut for a cruise in October, 2014; 2) Participate in a HabCamV4 survey to the Closed Area II region on Georges Bank and conduct a six day survey to assess Yellowtail Flounder abundance and distribution; 3) Process data for lightfield and color stereo disparity, and provide access to the images through the HabCam database and web services; 4) Provide assistance in identifying Yellowtail Flounder during image annotation by NOAA personnel, process distributional and substrate data extracted from the database, and build a projected population distribution model based on habitat suitability to evaluate total Yellowtail number and biomass. This project was executed without a hitch and we are currently processing all images for the presence of yellowtail flounder.

Objective 6: Support for participating in and processing data from a lobster habitat cruise along the northeast continental slope.

In collaboration with NOAA investigator Burton Shank, we participated in a two day add-on cruise to the scallop survey in which we towed HabCamV4 into some of the deep trenches and the rim of Hudson Canyon out to about 200m depth. Data was processed for sidescan acoustics and multibeam acoustics to achieve a rugosity index of lobster habitat, along with manual and automated substrate classification.

HIGHLIGHTS

- Operated image acquisition, light-field correction, and color correction in real-time at sea.
- Maintained an at-sea database for metadata associated with imagery so that manual annotations could be performed by NOAA and WHOI personnel as time permitted.
- Ran scallop and substrate classification software in parallel with data acquisition and transferred results to the database while at sea.
- Upon transfer of imagery from the ship to the NOAA RAID drives in Gallager's lab by the end of the cruises (around July 15, 2014), we were able to complete all assignments for scallop annotations as well as data processing and plotting in time for the August 15, 2014 deadline for presentation to the scallop SARC.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

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

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

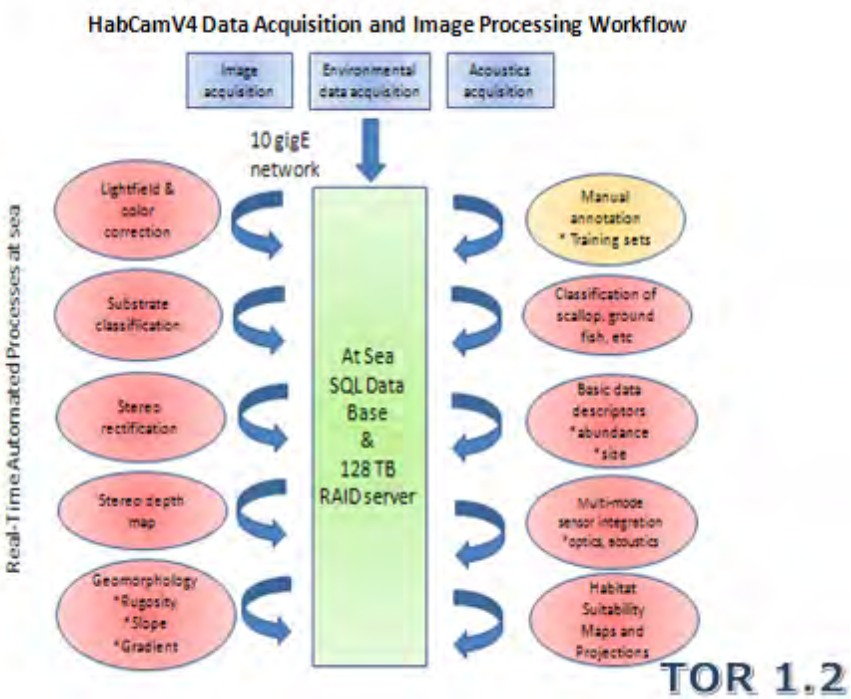


Figure 1. Hardware and database as configured on the R/V Sharp for the annual scallop survey.

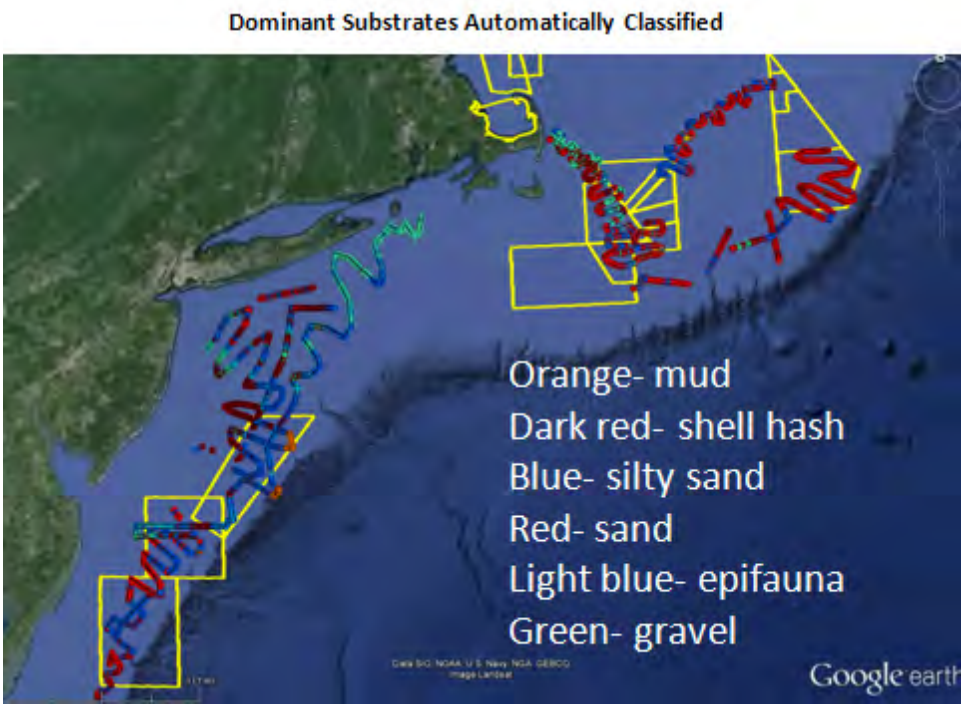


Figure 2. Legs 1-3 of the 2014 scallop survey. Dots are color codes by substrate as measured automatically using machine vision software (Honig, York and Gallager, submitted).

Impacts of a changing ecosystem on Atlantic salmon marine productivity

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Kathy Mills - GMRI

NOAA Sponsor – Timothy Sheehan - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

This study will evaluate the hypothesis that Atlantic salmon marine growth provides a mechanism that links changing ecosystem conditions to Atlantic salmon survival and productivity. Statistical analyses and modeling will be used to investigate: (1) how changes in marine survival and productivity are related to changes in marine growth of Atlantic salmon, and (2) how changes in marine growth are related to ecosystem conditions that affect salmon marine energetic requirements and energetic resources available via salmon prey. Specifically, it will accomplish three main objectives:

1. Document how patterns of marine growth and survival have changed over time for populations of Atlantic salmon;
2. Evaluate how changing ecosystem characteristics affect Atlantic salmon marine growth and survival; and
3. Model how ecosystem changes are affecting energy flow to Atlantic salmon and the impacts of these changes to salmon growth, survival, and productivity.

In year 1, we had planned to analyze changes in growth of Penobscot salmon and relationships between growth and survival. Progress towards this goal was slowed by initial shortfalls in sample sizes of scales read from Penobscot fish. (In some cases, scales were not readable due to decay, regeneration, or other factors.) We are re-evaluating whether additional scales are available to fill the current data gaps, and where possible, NMFS is re-reading scales to expand our sample size. We had also planned to hire a postdoctoral associate in year 1, but this was delayed due to uncertainty about continued funding in year 2. Now that a portion of the funding for year 2 is in place, we will start recruiting for a postdoc this month.

ACCOMPLISHMENTS

To date, we have obtained archived scales of Atlantic salmon that returned to the Penobscot River from the ME Department of Marine Resources, and NMFS has read scales to measure circuli and seasonal growth increments from 1SW and 2SW in three clusters of smolt years (1978-1980, 1986-1988, and 1998-2000) that align with periods of high, medium, and low marine survival. Our initial plan had been to have samples sizes of 50 scales from each sea age/smolt year combination. However, due to unreadable scales in the initial target and back-up

sets, some years have fallen as much as 20% below the target sample size. We are currently trying to identify readable scales from those that remain in the archive to fill these shortfalls, and as usable scales are identified, NMFS is reading them to collect growth data.

In the meantime, we have begun compiling data on oceanographic conditions that may affect Atlantic salmon growth, energy requirements, and survival while they are at sea. Data sets we have begun to develop from the Extended Reconstruction Sea Surface Temperature (SST) data set include spatially-explicit growing degree days (accumulated temperature exposure), rates of change in SST, and distance to waters of specific temperatures. We have also begun a review of data and analyses on chlorophyll and primary productivity patterns in the Labrador Sea.

An intern will be joining the project this summer to assist with some of the oceanographic dataset compilation work and with initial analyses of the Penobscot River salmon growth data. In addition, now that a portion of funds for year 2 have been put towards the project, we plan to begin recruiting for a postdoctoral research associate later this month.

HIGHLIGHTS

- Growth data have been obtained from Atlantic salmon from the Penobscot River, and current data gaps are in the process of being filled.
- Oceanographic datasets needed to evaluate how ecosystem conditions that affect Atlantic salmon energetic requirements while they are at sea are being compiled.

SOCIETAL BENEFITS

This project will broadly expand our scientific capacity to understand how marine ecosystem changes can affect the vital rates (e.g., growth, mortality, fecundity) of fish species—information that is essential for effectively assessing the population status and trajectories of fish populations that NMFS manages. In this case, our focus is Atlantic salmon—a protected species—so understanding factors that influence its population trajectory is important for evaluating the recovery potential of the species and for planning effective recovery strategies, particularly in the context of ongoing climate change in its marine habitat range.

Field experimentation to determine catchability of advanced technologies

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Hanumant Singh - WHOI

NOAA Sponsor – Elizabeth Clarke - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW

The goal of this project was to instrument platforms with Long Base Line (LBL) transponders to allow intercomparisons between technologies. Our work has included doing the navigation as well as post processing the imagery collected by the fixed cameras on the seafloor.

ACCOMPLISHMENTS

The untrawlable habitat strategic initiative at NOAA aims to understand the role of different imaging platforms for measuring fish abundance in untrawlable habitats. To explore these issues a field campaign was conducted at a coral sponge reef in the middle grounds in the Gulf of Mexico off Florida's east coast. Over the course of two weeks aboard the R/V Pelican (August 4-21, 2014), we were part of an expedition that deployed a small ROV, the Seabed AUV, and the CBASS towed vehicle to look at quantifying fish avoidance and attraction behaviors to such gear. Our group's particular role was to work on the navigation methodologies as well as to support the self-recording cameras that were placed on the seafloor to ground truth the effects of the other sampling gear.

Over the course of the cruise we collected a very high volume of data (several terabytes) that is currently being analyzed. The preliminary analysis highlights the complexity of the data and the complexity of the response, which varies considerable according to the sampling gear and the particular species of fish.

While the analysis is still ongoing, plans are underway to repeat this experiment at the same site this year, and to extend it to other sites with different habitat, species, and depths.

HIGHLIGHTS

- Part of the Untrawlable Habitat Strategic Initiative
- Technology deployed to study the fish attraction and avoidance behavior for different platforms

SOCIETAL BENEFITS

This work is critical to building a system for sustainable fisheries management. Understanding the biases of different sampling gear is crucial for working towards the goal of species-specific fish abundance measurements.

EDUCATION AND OUTREACH ACTIVITIES

Campbell, M., et al., Towards quantifying displacement and attraction of fish to mobile sampling platforms. *Submitted to the Annual Meeting of the American Fisheries Society.*

Clarke, M.E., et al., Experiences Using Autonomous Technologies to Survey Fish Populations. *Submitted to the Annual Meeting of the American Fisheries Society.*

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

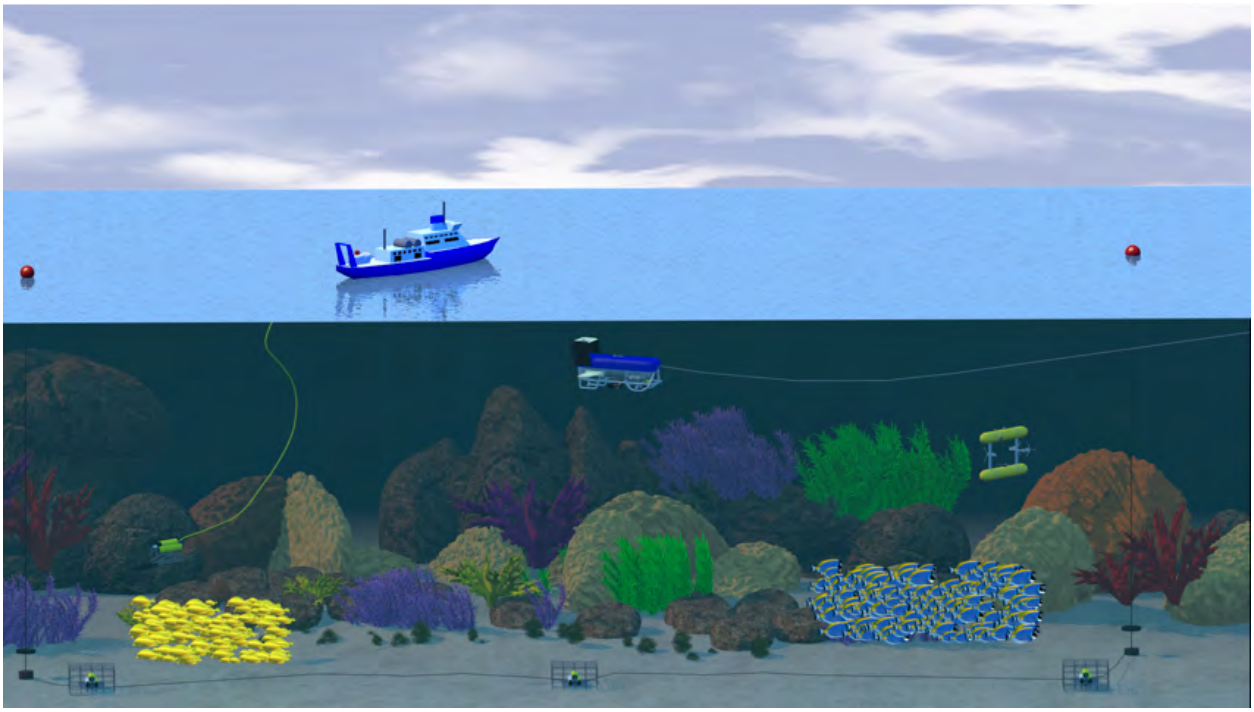


Figure 1. The concept behind the untrawlable habitat strategic initiative. Different sampling gear (ROV, Towed, AUV) are used to look at fish populations, and are groundtruthed with *in-situ* camera platforms to try and understand biases in our sampling due to fish avoidance and attraction.

Investigating coral communities in the Gulf of Maine

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Rhian Waller - UMaine

NOAA Sponsor – Martha Nizinski - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: II. Ecosystem Monitoring

PROJECT OVERVIEW:

Beginning in 2012 we embarked on a collaboration with personnel at the Northeast Fisheries Science Center to focus on regional DSC research requirements. Briefly, this included joint participation in an MV Scarlett Isabella cruise with a Waitt Institute AUV to Physalia Seamount in 2012 (PJA), planning and research for the Okeanos Explorer ROV cruise to Georges Bank submarine canyons and New England Seamounts in 2013 (RGW and PJA), a RV Connecticut cruise with the ISIS2 camera system to the northern Gulf of Maine region in 2013 (RGW and PJA), and a collaboration with the NEFSC ECOMON group to obtain multibeam sonar maps of Gulf of Maine dive sites during a subsequent Okeanos Explorer cruise in 2013 (PJA). This project continues collaborative studies through 2014 and 2015 to advance knowledge of DSC resources in the Northeast Region and to inform management.

ACCOMPLISHMENTS:

Auster coordinated with other project scientists and collaborators securing map products and collections data to inform dive site selection, coordinated with the other project scientists and Kraken II pilots and technicians to insure vehicle capabilities and configuration comports with research requirements (e.g., includes imaging, sample collection and navigation requirements), and served as Chief Scientist on the RV Connecticut deep sea coral cruise to northern Gulf of Maine.

Post cruise Auster and Waller collaborated with UMaine and NEFSC scientists to address cruise reporting to the DSC program, archiving video and coral aging samples. Samples for genetic and reproduction studies were archived at the University of Maine, and Auster worked with IMAG to initiate first order video analysis focused on abundance and diversity of coral taxa. We also began a search (and identified) for a graduate student who will be based at University of Maine during year 2. This graduate student will start in summer 2015 as an intern, and transfer to a MS program in the fall.

Auster led development of a white paper summarizing aggregate cruise results (2013 and 2014) for submission to the NEFMC to inform ongoing habitat conservation actions by the Council (as well as work by NAFO and ICES).

HIGHLIGHTS

- **White Paper** - *Imaging Surveys of Select Areas in the Northern Gulf of Maine for Deep-sea Corals and Sponges during 2013-2014. Report to the New England Fishery Management Council - 30 October 2014.* Peter J. Auster, David Packer, Rhian Waller, Steven Auscavitch, Les Watling, Martha S. Nizinski, Ivar Babb, Donna Johnson, Jeffrey Pessutti, Amy Drohan, Brian Kinlan

- Press - Interviewed by NPR for Cold Water Corals in the Gulf of Maine - http://news.mpbn.net/post/gulf-maine-coral-formations-dazzle-scientists

SOCIETAL BENEFITS

Research to inform managers is needed to refine alternatives previously developed for the NEFMC region. The deep sea coral alternatives originally integrated into the Omnibus Habitat Amendment 2 were removed in 2012 and are scheduled to be to used in a separate Omnibus Deep Sea Coral Amendment in late 2014 or early 2015 (a deep sea coral amendment is currently underway in the MAFMC region). This study aids in this process by providing acurate data on where corals are, and what ecological impacts are occurring.

EDUCATION AND OUTREACH ACTIVITIES

Press - Interviewed by NPR for Cold Water Corals in the Gulf of Maine - http://news.mpbn.net/post/gulf-maine-coral-formations-dazzle-scientists

PUBLICATIONS

White Paper - *Imaging Surveys of Select Areas in the Northern Gulf of Maine for Deep-sea Corals and Sponges during 2013-2014. Report to the New England Fishery Management Council - 30 October 2014.* Peter J. Auster, David Packer, Rhian Waller, Steven Auscavitch, Les Watling, Martha S. Nizinski, Ivar Babb, Donna Johnson, Jeffrey Pessutti, Amy Drohan, Brian Kinlan

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Coral hanging gardens in the Gulf of Maine.

THEME III. ECOSYSTEM MANAGEMENT

Chesapeake Bay National Estuarine Research Reserves (CBNERRS): An integrated system of sentinel sites to understand baywide climate impacts for stakeholders

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Raleigh Hood - UMCES

NOAA Sponsor – Bob Wood - NOS

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

In a collaborative venture, CBNERRS, NOAA, and UMCES have partnered to use the CBNERRS long-term environmental monitoring data to assess how changes in climate variability and extreme events affect the ecosystem services, vulnerability, and resiliency of Chesapeake Bay's shallow water habitats. Our focus is on the use of past events and event distributions and frequency. This will allow us to investigate system resiliency and environmental and ecological tipping points that may lead to nonlinear future ecosystem responses. This approach focuses on the use of observations to investigate system and organismal responses to recent climate variability in a manner that leverages stakeholder's memories of past events to enhance public outreach efforts. The final outcome of this collaboration will be a set of web-based, interactive products and peer-reviewed publications with active participation from the CBNERRS managers, which can be used to address educational and managerial questions throughout the Chesapeake Bay watershed.

Traditional climate change research has mainly focused on speculative simulations of what *could happen* to global ecosystems in the distant future. This CBNERRS project is unique in that it is using historical time series data to assess climate change impacts from the view of "this *is* what happened, this *is* what very well might happen again due to climate change, and this *is* what it means directly to the Chesapeake Bay ecosystem and for you."

In short, the goal of this proposed work is to show how climate and anthropogenic changes beyond (but inclusive of) sea level rise will affect the ecosystems of Chesapeake Bay. We are using observations and the expertise of the CBNERRS personnel to establish responses to events, and describe the present state and how it could change in the near future at our current climate trajectory. Figure 2 outlines the major milestones of this work that will result in useable products (quantified data, reports, and interactive web tools) for the CBNERRS stakeholders and the interested public.
The following problem statement, specific CBNERRS challenges, and research approach were developed in response to an initial meeting between the CBNERRS, NOAA, and UMCES personnel. We cooperatively aim to address the overall needs of the CBNERRS network as well as the concerns at each unique CBNERRS reserve.

Problem Statement

Climate variability and change is a complex but pressing concern for coastal ecosystems within Chesapeake Bay. Both organismal and ecological responses to climate variability reflect nonlinear interactions with the environment that may lead to tipping points, thresholds, or highly resilient systems. Past investigations of climate sensitivity have largely focused on modeled mean changes in temperature and sea level; however, these are highly uncertain, and may not include the nonlinearities that often characterize ecological and organismal responses.

The proposed research approach to this collaborative investigation follows the DPSIR framework (Driver, Pressure, State, Impact, and Response) as outlined in Figure 3. This work plan has a flexible framework so that the calculated meteorological *Driving Forces* and environmental *Pressures* will influence which organisms and ecological "stories" we will collaboratively choose to investigate in the *State* and *Impact* sections. We also note that this work plan ends at the *Impact* section and will leave the *Response* to the stakeholders of individual communities.

Final Products

This collaborative, comprehensive, and multi-dimensional investigation is developing usable products including, but not limited to: technical, peer-reviewed articles, reader-friendly news articles, enhancements to well-reviewed a K-12 learning tool e-book, and an educational, interactive web-based experience. The needs of the NERRS management teams vary with state, site, anthropogenic pressures, stakeholder needs and biases, and past history of climate studies. Thus we do not propose to generate a single, one-size-fits-all product. Since this is a collaborative effort, we will communicate with the CBNERRS managers on a regular basis to exchange data analysis tools, datasets, ideas, and to interact with other NERRS research programs.

One product and forum for communication we have recently established is an on-going Wordpress blog called SciencePensieve (http://www.sciencepensieve.org/). This blog will be updated weekly to show the public (including the CBNERRS managers) what we are doing. This approach will demonstrate the raw, scientific method, allowing a viewer the chance to see our progress and provide comments, concerns, or ideas in real time.

Overall, with the combined efforts of the CBNERRS, this project will develop products to demonstrate the effects of climate variability on Chesapeake Bay from a past, present, and future perspective that can provide insights for future mitigation efforts.

Timeline and Accomplishments to Date

See Figures 4 and 5

ACCOMPLISHMENTS

We have assessed and identified historical trends for 26 climate indices to establish how extreme climate change and variability has already manifested in Chesapeake Bay over the last century. These climate indices, established by the Expert Team on Climate Change Detection and Indices, use precipitation- and temperature-based extreme weather events, such as the annual growing

season length or the maximum intensity of a single precipitation event, to track climate changes (http://www.clivar.org/). We have focused our meteorological analyses at the seven CBNERRS sites within Maryland and Virginia, where the System-Wide Monitoring Program data sets and other research activities provide a place-based lens on climate variability for the Chesapeake Bay as a whole. Our project will use these findings to develop educational materials and exhibits that connect historic and contemporary climate changes and events to future climate change, in order to support and encourage coastal communities, decision-makers, and the general public to contemplate and create adaptation plans and mitigation strategies that will enhance their resilience to future climate and ecosystem changes and events.

HIGHLIGHTS

- We convened two workshops with Maryland and Virginia program managers to define specific project objectives and review analyses that have been undertaken to date.
- We have identified seven potential "story" themes:
  1. Climate: How are large precipitation events changing in frequency and intensity? How have recurrence intervals (return periods) changed over the last 100 years? What could increased precipitation events mean to shorelines and ecosystems?
  2. Benthic: How vulnerable are Chesapeake Bay (CB) benthic habitats, including submerged aquatic vegetation (SAV) and oysters beds? How will this affect iconic organisms like the blue crab? What does this mean for the bioenergetics of the CB food web?
  3. Shallow water: How often do cold stuns and hypoxic fish kills occur in shallow water habitats? How likely are these events to re-occur? What effects could fish kills have on the ecosystem and on the local communities?
  4. Open bay/epipelagic: How are changes in the growing season affecting the phenology (such as timing and magnitude of spring bloom)? How does increased precipitation affect anchovy recruitment, thus the food web? How often do HABs occur and could that change in the future?
  5. Salinity: How often will decreases in salinity occur and how will that affect oyster recruitment? How will salinity changes effect the distribution and occurrence of *Vibrio*? How will salinity variability alter SAV species?
  6. Temperature: How will increases in extreme temperatures and variability cause heat or cold related organism kills? What effects will these events have on ecosystems? How will mean temperature changes cause shifts in non-native species?
  7. Agriculture: How will changes in precipitation and temperature effect best agricultural practices, such as pesticide use, nutrient application, effectiveness of buffer zones, and need for irrigation. How will these listed agricultural changes influence near-shore ecosystem dynamics, such as eutrophication?

SOCIETAL BENEFITS

Using the extensive NERR datasets, along with external ancillary data-streams, we will characterize and quantify the sensitivity of these sentinel species and properties to stressors related to projected regional climate changes. Leveraging the ensemble of sites, we will determine how these sensitivities relate to other tributaries and ecosystems of Chesapeake Bay so

that measurements at the NERR sites can be scaled up to the entire Chesapeake Bay system. With these insights, we will predict Bay-wide physical and biogeochemical changes under climate change scenarios using a coupled physical-biogeochemical model, and project anticipated impacts of climate change on the NERR sites. Working with NERR stakeholders to ensure that products meet their needs, we will develop visualizations to illustrate anticipated changes, ranging from a K-12 i-pad based e-book to web served dynamic animations of climate change impacts.

EDUCATION AND OUTREACH ACTIVITIES

We have developed a blog for the general public that is updated weekly. See: http://www.sciencepensieve.org.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

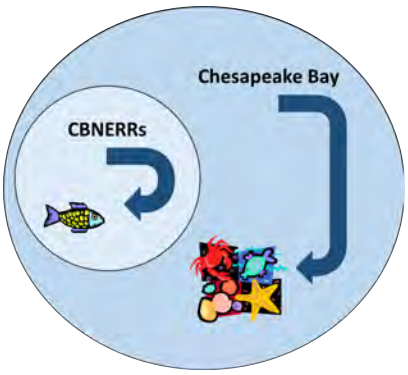


Figure 1: Simple schematic showing that the CBNERRS data will be used to assess climate-induced changes at each reserve. Each CBNERRS site will be used as a "lens" that is projected to ecosystem-types within Chesapeake Bay using statistical models.

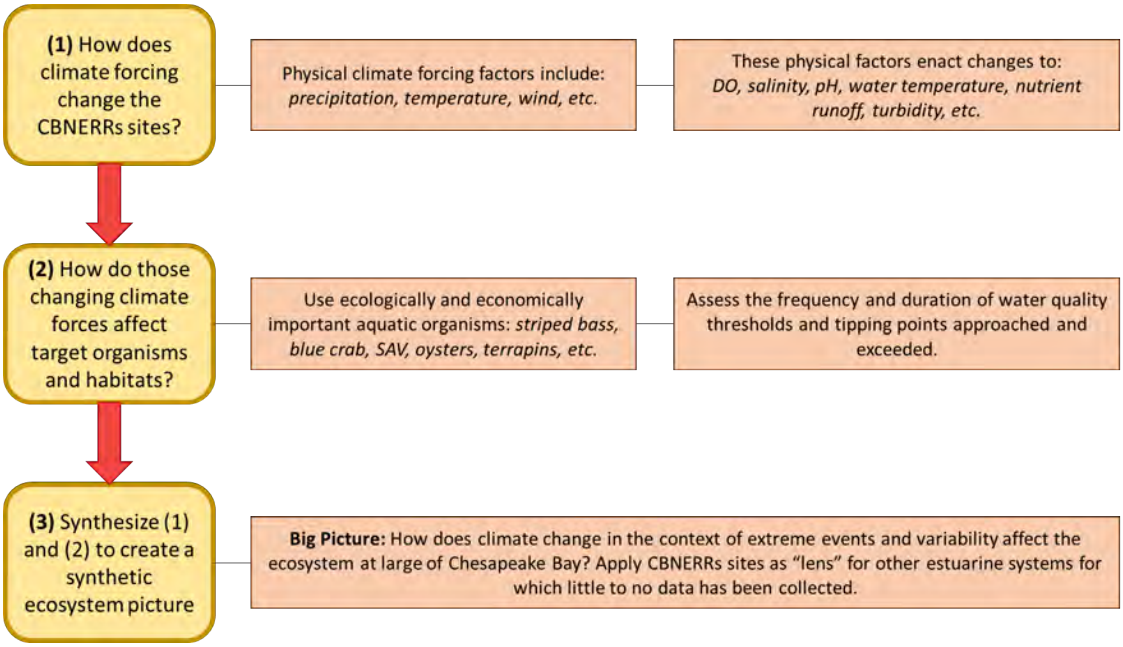


Figure 2: A brief outline of this project's proposed approach. Each yellow box represents a useful informational product that will be produced for the CBNERRS stakeholders. (1) We will first assess the physical forcing and environmental quality changes using the NERRS data. (2) Next, we will apply these analyses to predict and assess impacts on iconic Chesapeake Bay organisms and habitats. (3) Lastly, we will synthesize all these findings into a complete ecosystem "story" of the Chesapeake Bay watershed.

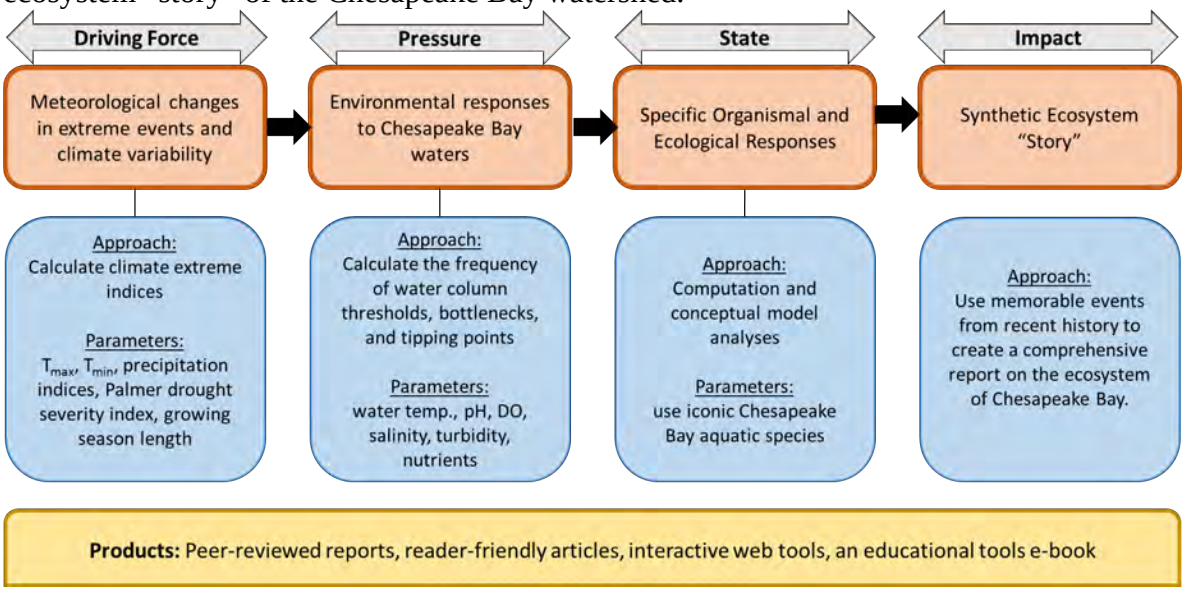


Figure 3: Conceptual model of the DPSIR framework used to approach this project. Each main box (orange) is described in more detail below, with a provided example. Note that the scope of this proposed project ends at the *Impact* section.

Timelines and Meeting Outline

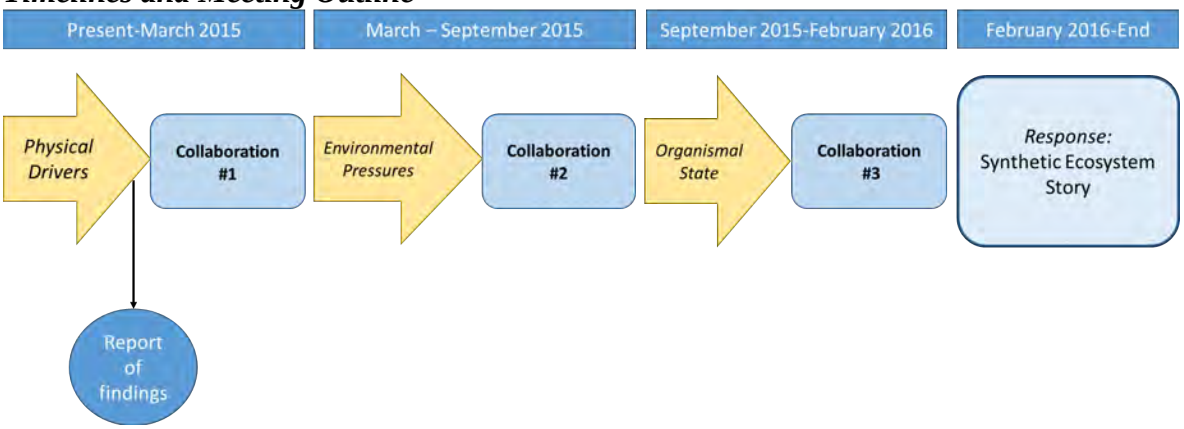


Figure 4: Flexible timeline of this investigation. Note that each **collaboration** is required to proceed to the next step. Verbal communication and onsite visits beyond the scheduled collaborations will be given on a monthly frequency, in addition to regular updates on the SciencePensieve blog.

Statistical analysis of trip cost data collected by the Northeast Observer Program

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Di Jin - WHOI

NOAA Sponsor – Andrew Kitts - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

The objective of the study is to investigate the statistical properties of fishing vessel trip costs estimated from the sea sampling data collected through the Standardized Bycatch Reporting Methodology (SBRM) program. The main tasks involve data processing, estimation of sampling fractions by stratum, and developing recommendations for future uses of the cost data for economic analyses.

ACCOMPLISHMENTS

The raw data from the Social Sciences Branch (SSB) of the Northeast Fisheries Science Center (NEFSC) include 2011-2015 annual SBRM data files (used to estimate the number of sea days required for bycatch sampling), a VTR (vessel trip report) data file, a trip cost data file (data collected by onboard observers), and several related data files.

The SBRM, VTR and cost data files have been merged to form a project data set that covers July 1, 2009 - June 30, 2014. Using this project data set, we have developed estimates for:

- Accomplishment rates of the sea sampling program for SBRM years 2010-2013 (April 1, 2010 - March 31, 2014);
- Sampling fractions by SBRM fleet stratum (by gear, mesh and fishing area) for 2009-2014; and
- Sampling fractions by vessel cost stratum (by vessel size and gear) for 2009-2014.

The sampling fractions will be used to assess the statistical properties of fishing vessel trip costs estimates.

HIGHLIGHTS

Although the sea sampling program has been in place for over twenty years, its data collection process has not been evaluated retrospectively. In this study, we developed estimates of the accomplishment rates of the sea sampling program across 56 SBRM fleets for 2010-2013. The accomplishment rate is calculated as the number of sea days actually observed divided by the number of sea days scheduled for observers.

SOCIETAL BENEFITS

Economists at NMFS perform a wide variety of economic analyses of management and regulatory actions, using behavioral models of fishing vessels that include cost components. Trip cost estimates based the sea sampling data have been used in many of these analyses. Potential biases in the cost estimates, if they exist, may lead to erroneous conclusions. This study focuses on understanding the statistical properties of the sea sampling data to ensure that the cost data are properly used in economic models and other analyses.

Indicators of marine climate impacts in North America

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Malin Pinsky - Rutgers

NOAA Sponsor – Jonathan Hare - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

The objectives of the project are to:

1. Acquire the latest bottom trawl survey data from the Eastern Bering Sea, Aleutian Islands, Gulf of Alaska, West Coast US, and Northeast US.
2. Process these new data and integrate them into the fish distribution indicator website.
3. Develop a data analysis pipeline and methods for the SEAMAP-SA survey.
4. Expand the existing website to include the SEAMAP-SA survey.
5. Add maps of species distribution shifts to the existing website
6. Develop outreach materials about shifting species distributions, and the website targeted for fisheries management and stakeholders groups

Our work to date has focused on Objective 3.

ACCOMPLISHMENTS

- We have acquired the SEAMAP-SA bottom trawl survey data from the South Carolina DNR and are quality checking it. We have found numerous data errors, and are working with the original data stewards to correct these in the database. In addition, we are developing a data analysis pipeline to correct a number of the remaining errors.
- The OceanAdapt website was launched in December (http://oceanadapt.rutgers.edu) to present data on shifts in species distributions around North America.
- Jon Hare and Malin Pinsky presented a NOAA Fisheries Webinar on the OceanAdapt website.

HIGHLIGHTS

- The OceanAdapt website is now live (http://oceanadapt.rutgers.edu) and provides readily accessible information on shifts in marine species distributions. The website also provides access to NOAA bottom trawl survey data.

SOCIETAL BENEFITS

- This research helps to inform society about the impacts of climate, fishing, and other factors on marine life.

EDUCATION AND OUTREACH ACTIVITIES

- NOAA Fisheries Webinar on December 16, 2014. An EBM Tools Webinar is scheduled for April 21, 2015.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

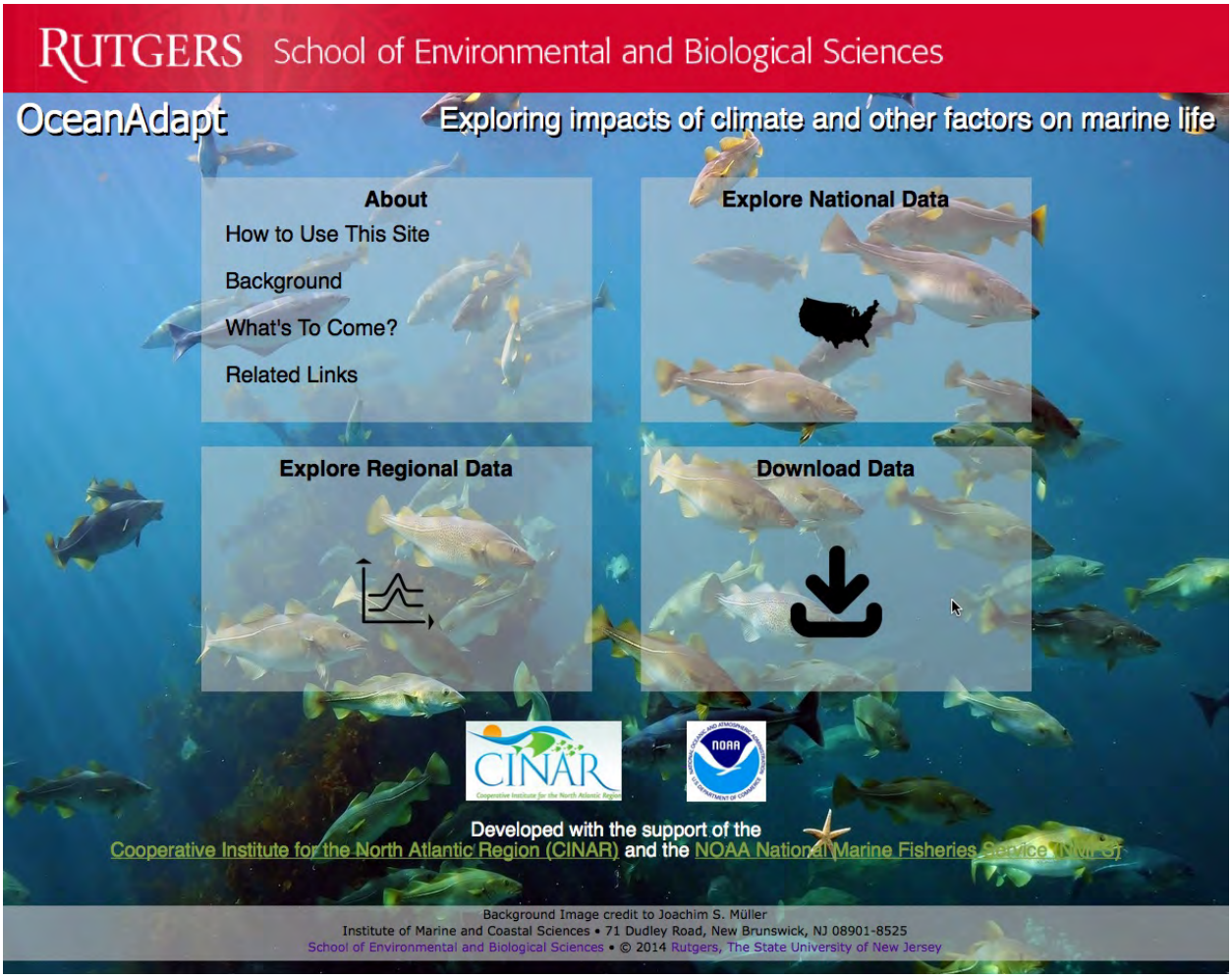


Figure 1. The OceanAdapt webpage provides information on shifts in marine species distributions, many of which are influenced by climate change and variability.

Physiological ecology and habitat suitability: Combining experiments and surveys to inform stock assessments

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Grace Saba - Rutgers

NOAA Sponsor – Jonathan Hare - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Inclusion of habitat information into stock assessment models is increasingly important, as stock dynamics and observations of stock abundance are impacted by habitat characteristics. Part of the difficulty in accomplishing this is due to the scale of most habitat studies, which is often not matched to the scale of most assessments. While more than fifteen models are used for stock assessments at the Northeast Fisheries Science Center (NEFSC), only a few have the ability to directly include habitat information. One recent success was the development of a habitat suitability model, coupled with a circulation model hindcast, for the assessment of pelagic forage fish, Atlantic Butterfish (*Peprilus triacanthus*). The model is parameterized using catch densities and temperatures from multiple fishery-independent surveys. However, extracting niche dimensions from field survey collections can be problematic. Another approach is to develop niche dimensions experimentally, by determining the metabolic functional response of target species to a range of temperatures. These laboratory-based studies can then be used to calibrate species niche models.

This project tests this premise. We proposed to parameterize mechanistic thermal niche models by measuring temperature and size-dependent metabolic rates for butterfish, compare habitat suitability models based on field and experimental data, then evaluate the effect of parameterization on catchability estimates for butterfish along the U.S. east coast in the context of the stock assessment model. This will allow us to identify priority habitat areas for butterfish. All experimental work in this first year of our project was conducted by a joint NOAA (Rich Bell, Chris Taylor) and Rutgers (Grace Saba) team aboard the NOAA vessel *Pisces* during EcoMon cruise PC1405 from November 3, 2014 through November 20, 2014.

ACCOMPLISHMENTS

We developed the techniques to determine basal and active metabolic rates in butterfish. The process required capturing live fish, maintaining them in a holding tank, determining individual characteristics, and running the experiments in a swim tunnel and respirometry chambers. In total, twelve individual experiments with six species (butterfish, Atlantic sea herring, lumpfish, sandlance, lookdown, paper nautilus) were conducted. The set-up of the Loligo respirometry systems was successful. The majority of the potential issues were documented and a general

procedure for running experiments has been developed and detailed in written protocols by both the NOAA team and Rutgers teams. Major bugs were worked out, enabling us to pose more detailed questions through this experimental design in year two experiments. Important questions include whether the experiments should be conducted at constant temperature or follow in situ patterns, and how that affects the results. Additionally, the size of the chamber limits the experiments to age-1 fish and younger. Therefore, another question is how does juvenile habitat differ from adult habitat, and how does this scale up to help define optimal butterfish habitat?

While the first year of this project was valuable in establishing the respirometry systems and understanding the feasibility of conducting these experiments at sea, there were several challenges that we are currently addressing in order to conduct experiments this year. The biggest challenge for this project was acquiring and maintaining healthy fish. Over thirty mid-water tows were conducted, but butterfish were only captured in three tows. This was attributed first to the collection gear (trawl net; no cod end), and second to low overall abundance of butterfish. The first challenge was recognized during the first week of the cruise, and a cod end aquarium was constructed on board the *Pisces* that allowed organisms caught to be retained in water when brought on board. Unfortunately, the cod end aquarium was placed in the net too late (no butterfish were caught in the trawls after that). The commercial fishery typically catch butterfish with a bottom trawl, and butterfish are generally more concentrated on the bottom during the day. We may have been a little late in the season, as the species moves offshore in the colder months, or we could have simply been fishing in the wrong locations.

When the fish were healthy, or appeared healthy, the experiments were successful. The butterfish and herring collected were not in good condition due to the method of collection. The use of a well designed cod end aquarium and increasing the number of butterfish caught with fishing gear designed for and proven successful at catching butterfish would significantly improve the health of the fish and the potential for success. Additionally, capturing fish from pound nets in Narragansett Bay or from day trawlers could be useful for running experiments in the laboratory. Our approach for the upcoming summer is to collect fish using these improved methods, and conduct more thorough experiments at the NOAA Sandy Hook Laboratory.

HIGHLIGHTS

- At sea respirometry is feasible with proper set-up and maintenance, and can provide valuable physiological information under controlled conditions (i.e., temperature) for target fish species.
- The major challenge in conducting experiments at sea (and physiological experiments in general) is the ability to collect and maintain healthy fish; thus, collection gear and methods need to be appropriate for the specific target fish species.
- Follow-up experiments planned for the upcoming summer at the NOAA Sandy Hook Laboratory will benefit greatly from improved fishing gear and methods, and will provide temperature- and size-dependent butterfish physiological data needed for habitat suitability models.

SOCIETAL BENEFITS

Physiological results from this proposed work will be incorporated into the butterfish stock assessment and will provide information for estimating catch efficiency based on a habitat suitability model and identification of priority habitat areas for butterfish. In addition, our results will provide a direct comparison between habitat suitability models developed with three very different kinds of data. If there is agreement, this will bolster the use of survey-based models; if there is disagreement, the magnitude of the effect will be demonstrated and hypotheses will be developed for future research.

Advancing the 6th International Deep-Sea Coral Symposium

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Timothy Shank - WHOI

NOAA Sponsor – Martha Nizinski - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

Understanding the role, function, and value of deep-sea coral ecosystems has become a priority topic for many national governments and international regional resource management bodies. Continuing in the tradition of past Symposia in Halifax, Canada and Erlangen, Germany (see Table below), the 6th International Symposium on Deep-Sea Corals (ISDSC) will facilitate global exchange of current scientific knowledge and rapidly developing hypotheses on deep-water corals and their associated fauna and to discuss potential statutory means available to conserve and protect deep-sea habitat.

In the last decade, the global presence of deep sea, cold-water corals in a range of ocean margin settings has been established, and is still being expanded. Associated with the corals is the presence of huge carbonate mound structures and deep-sea reefs, which contain unique records and a detailed history of ambient ocean water conditions over periods of rapid climate change. The coral reefs and mounds form very rich benthic habitats of spectacular biodiversity, housing more coral species in deep cold-waters than in tropical coral reefs. Because of their function as a nursery for commercially important fisheries, in combination with increasing environmental pressures, the cold-water corals, reefs, and mounds are seriously threatened and management and policy making is a must. The 6th ISDSC addresses new developments and knowledge through a range of themes and topics, and will take place in Boston, USA in the Fall of 2016.

The 6th International Symposium will provide attendees from around the world with an opportunity to share their research results, identify information gaps, and discuss if deep-sea corals need special protection and if so, the statutory means available to do so. Being international and inter-institutional in nature, the symposium also allows scientists to develop collaborative partnerships for future projects. A public forum presented by selected deep-sea coral researchers will be held one evening. Given the Northeast US location for this Symposium, we anticipate potentially more than 500 participants (the last US ISDSC in Miami in 2005 hosted more than 300 attendees) and covering a broad range of ongoing and upcoming topics.

Specifically, funding ($10,000) was requested to mediate costs associated with acquiring a venue sufficient for more than 500 potential attendees. The 6th ISDSC addresses new developments

and knowledge through a range of themes and topics, and will take place over a five day period in Boston, USA in the Fall of 2016.

ACCOMPLISHMENTS

Andy Daly and Tim Shank visited and surveyed more than a dozen possible venues in Boston in early 2015. Through comparisons of available facilities, proximity to Boson resources, and costs, it was decided that The Marriot Long Wharf Conference Hotel will be the site of the Symposium, and as of April 1, 2015, a contract was being finalized.

HIGHLIGHTS

- The 6th International Deep Sea Coral Symposium, addressing new developments and knowledge through a range of themes and topics, will take place at The Marriot Long Wharf Conference Hotel over a five day period, most likely September 5-9, in Boston, USA.

SOCIETAL BENEFITS

The vast majority of deep-ocean resources, specifically coral ecosystems that support commercially-important fisheries and endemic biological diversity, are currently unknown. only through the communication, exchange, and advancement of scientific information will the first order discovery and characterization of these resources be known for the subsequent and effective ability to protect and manage such resources, and the impacts of climate change on these resources and their stewardship.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

Figure 1. The Boston Marriot Long Wharf venue for the 6th International Deep Sea Coral Conference.

Accessing and visualizing satellite data for use by fisheries managers in the Northeast

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Riley Young Morse - GMRI

NOAA Sponsor – Walter Glance - NESDIS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: III. Ecosystem Management

PROJECT OVERVIEW

The primary goal of the first year of this project is to assess, understand, and document the current structure and accessibility of data sets available through the National Climate Data Center/Climate Data Record (NCDC/CDR) program that are relevant to fisheries and other marine resource issues.

Our goals outlined in the proposal were to:

- Identify target data services from NODC (e.g., NCDC Climate Data Record)
- Determine data filters (temporal/spatial)
- Develop and test web services
- Documentation of web services
- Integrate data into applications (e.g. the related Fisheries Dashboard project)

ACCOMPLISHMENTS

To date, we are making tremendous progress on this effort. Eric Bridger, Senior Programmer with the Ocean Data Products group, has taken the lead on the technical implementation. He has been working with the data feeds available through the Climate Data Records Program: http://www.ncdc.noaa.gov/cdr/operationalcdrs.html

We have identified the preliminary data sets to access, which include the Oceanic Climate Data Records for Sea Surface Temperature Optimum Interpolation (OISST) time series and anomaly data sets from 1981-present: http://www1.ncdc.noaa.gov/pub/data/sds/cdr/CDRs/Sea_Surface_Temperature_Optimum_Interpolation/Overview.pdf.

Bridger developed scripts (using the programming language python) to query, parse, and acquire data utilizing the available subset service (THREDDS). The scripts return a spatial subset of the time series data using coordinates from the NERACOOS buoys as reference points.

These scripts are the foundation of the web services that will be used to dynamically access the

data and integrate into the fisheries dashboard application. The scripts are automated and run nightly to pull the most recent data from the NCDC data servers and amend to the subset time series.

Bridger is currently working on the necessary modifications of these web services to acquire the gridded data from a spatial subset (for the Northeast Shelf Large Marine Ecosystem - NES LME) in order to produce map visualizations for the data dashboard.

HIGHLIGHTS

- Successfully developed automated web services for the NCDC global OISST time series:
  - web services can be geospatially subset by coordinates (currently using lat/long for NERACOSS buoy array as reference points) and temporally subset by years; and
  - web services provide the initial acquisition of full time series and are updated daily.
- Developed post-processing scripts to convert data on the fly into the format necessary for the development of visualizations to be used in the fisheries dashboard.

SOCIETAL BENEFITS

This project contributes to the CINAR theme of sustained ocean observations and climate, and to improved integration and availability of ocean observations from global to local scales. Additionally, this project contributes to the NOAA research goal of understanding climate variability and change to enhance society's ability to plan and respond.

THEME IV. PROTECTION AND RESTORATION OF RESOURCES

Passive acoustic monitoring from autonomous platforms

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Mark Baumgartner - WHOI

NOAA Sponsor – Sofie Van Parijs - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

This project is designed to (1) demonstrate the utility of real-time passive acoustic monitoring from autonomous platforms using the digital acoustic monitoring (DMON) instrument and the low-frequency detection and classification system (LFDCS), (2) validate the accuracy of in-situ detection and classification capability when used on a variety of stationary and mobile autonomous platforms, and (3) incorporate this new technology into NMFS whale and fish monitoring efforts. The project will provide flexible tools for long-term reduction in analytical effort and improved efficiency of existing monitoring technologies (e.g., visual surveys). We anticipate that NOAA will be able to significantly enhance its monitoring efforts using real-time detection information to identify areas of persistent whale occurrence, and to direct airplane- or ship-based surveys to regions that require additional visual surveillance.

Several objectives involving passive acoustic monitoring from autonomous platforms will be met during the project. These objectives and plans are as follows:

1. Demonstration and validation of DMON/LFDCS from a moored buoy, Slocum glider, and wave glider in the Gulf of Maine (*ESTCP demonstration and evaluation*).

    - Deploy a moored buoy near Mount Desert Rock in the northern Gulf of Maine (GOM) and conduct proximate visual surveys from the Mount Desert Rock lighthouse during summer 2015 and 2016.
    - Deploy a Slocum glider in the Great South Channel of the southwestern GOM and conduct proximate visual surveys from the NOAA Ship *Gordon Gunter* during spring 2015 and 2016.
    - Deploy a wave glider in the GOM to do broadscale surveys and coordinate visual surveys with the NOAA aerial survey team.

2. Persistent real-time detection, classification, and reporting of baleen whales near a Coast Guard gunnery range (*Nomans Land moored buoy*).
    - Deploy a moored buoy near Nomans Land Island and report real-time detections to the Coast Guard to help them minimize impacts to whales during gunnery exercises in the area.

3. Passive acoustic surveys for Atlantic cod in the Stellwagen Bank National Marine Sanctuary (*Cod glider surveys*).
   - Deploy two gliders (jointly funded by NOAA/CINAR and The Nature Conservancy) in Stellwagen Basin during December 2014 and 2015 to acoustically survey for Atlantic cod.
4. Real-time passive acoustic surveys for baleen whales in the GOM (*GOM glider surveys*).
   - Conduct Slocum glider surveys in areas of ecological or conservation importance to baleen whales in the GOM.
5. Real-time passive acoustic surveys for baleen whales in the New York Bight (*NYB wave glider surveys*).
   - Deploy a wave glider in the New York Bight during 2015 and 2016 to survey for baleen whales.
6. Development of improved detection and classification software (*DCS development*).
   - Support use of the desktop LFDCS by NEFSC and other users.
   - Modify DMON/LFDCS as needed to improve performance.
   - Develop wide-band detection and classification system to monitor sounds from blue whales to dolphin whistles.

ACCOMPLISHMENTS

1) *ESTCP demonstration and evaluation:* During the reporting period, a new Slocum G2 glider and wave glider were procured, and all platforms (Slocum glider, wave glider, and moored buoy) were prepared for deployment in spring 2015. Baumgartner participated in the preparation of the Demonstration Plan for the Department of Defense, and attended an ESTCP In-Progress Review meeting in preparation for fieldwork.

2) *Nomans Land moored buoy:* The moored buoy was prepared for deployment, including fabrication of a new DMON faired housing for the multi-function node (MFN) bottom mooring. Improvements in the electronics to warehouse DMON data and transmit these via Iridium satellite were completed. The buoy was deployed on March 24, 2015, and detection data for fin, sei, right, and humpback whales are being reviewed in near real time.

3) *Cod glider surveys:* Two G1 Slocum gliders were outfitted with two DMONs each, including an internally mounted DMON (the same setup as was used in past years) that transmitted detection data in near real time via Iridium, and an externally mounted DMON that recorded both low- and mid-frequency audio. Each glider was also equipped with a Vemco VR2W acoustic receiver to detect tagged cod, and sensors to measure temperature, conductivity (from which salinity is derived), chlorophyll fluorescence, and optical backscatter. The gliders were deployed in Stellwagen Basin on December 1, 2014, and they operated for three weeks (recovered on December 22, 2014). Glider data has been disseminated to all project participants.

4) *GOM glider surveys:* No funds were disbursed for this objective during the reporting period, so no work was accomplished.

5) *NYB wave glider surveys:* A wave glider was procured, modified with noise abatement mechanisms, and outfitted with a DMON. Testing has been conducted on the wave glider to

reduce platform noise and verify expected operation. Baumgartner attended wave glider pilot training in Hawaii during February 2015 in preparation for wave glider surveys.

6) *DCS development:* An LFDCS wiki (online manual) was developed and implemented during the reporting period (http://dcs.whoi.edu/mediawiki/index.php/Main_Page). A three-day training course on both the LFDCS and DMON/LFDCS was held for NEFSC personnel as well as participants from NAVFAC Atlantic, Dalhousie University, and DFO Canada during March 2015. Improvements in the LFDCS have been made to accommodate virtually any filename convention. Conceptual work has been conducted on the wide-band detection and classification system (WBDCS), including comparisons of wavelet versus constant-Q implementations of log-frequency spectrograms.

HIGHLIGHTS

- Deployment of the Nomans Land moored buoy for incorporating near real-time whale acoustic detections in Coast Guard gunnery exercise scheduling to reduce impacts to endangered baleen whales.
- Passive acoustic detection of Atlantic cod, baleen whales, and dolphins from two Slocum gliders in Stellwagen Basin, with simultaneous detection of tagged Atlantic cod and measurement of oceanographic conditions for three weeks.
- Implementation of near real-time passive acoustic monitoring capability from wave gliders.

SOCIETAL BENEFITS

This project supports the NOAA goal of "Healthy Oceans: Marine fisheries, habitats, and biodiversity sustained within healthy and productive ecosystems" by providing tools with which NMFS can monitor endangered populations of baleen whales. Continuous, long-term and real-time monitoring will improve mitigation of a variety of anthropogenic stressors in these endangered populations, including ship strikes and fishing gear entanglements.

EDUCATION AND OUTREACH ACTIVITIES

No education and outreach has been conducted as yet. Only one conference presentation has been made:

Baumgartner, M.F. 2015. Real-time passive acoustic monitoring of marine mammals from autonomous vehicles and moored platforms: development and applications. William Watkins Memorial Bioacoustic Symposium, New Bedford, MA, March 27-29, 2015.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

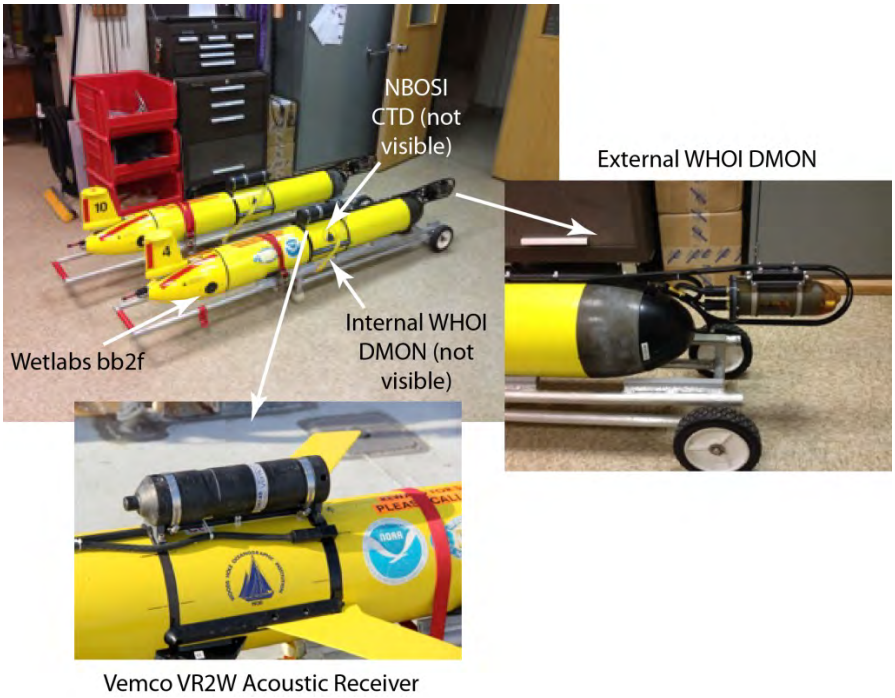


Figure 1. Gliders deployed for the December 2014 cod glider survey.

Figure 2. Mount Desert Rock (left) and Nomans Land (right) buoys prior to deployment.

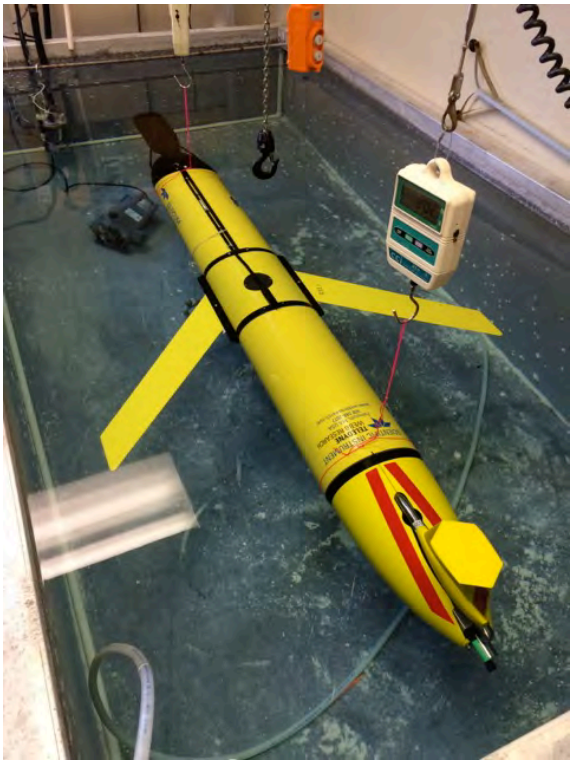


Figure 3. Slocum G2 glider in ballast tank prior to March 2015 test deployment in preparation for Great South Channel survey (*ESTCP demonstration and evaluation*).

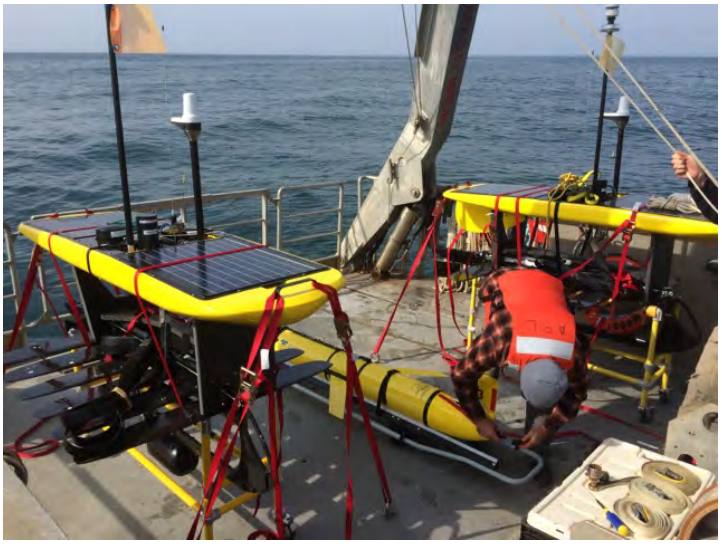


Figure 4. Wave gliders (*ESTCP demonstration and evaluation, NYB wave glider surveys*) and Slocum G2 glider (*ESTCP demonstration and evaluation*) prior to test deployment near Nomans Land buoy in March 2015.

Carbonate mineralogy of Alaskan corals

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Anne Cohen - WHOI

NOAA Sponsor – Dwight Gledhill - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

This project seeks to determine skeletal mineralogy and composition of Alaskan corals belonging to a range of coral taxa. Skeletal mineralogy and magnesium (Mg) content of skeletal carbonates are considered important criteria in evaluating the vulnerability of deep and cold-water taxa to ocean acidification.

Deep-sea corals are widespread throughout Alaska, including the continental shelf and upper slope of the Gulf of Alaska, the Aleutian Islands, the eastern Bering Sea, and extending as far north as the Beaufort Sea. Ocean acidification threatens coral reefs by reducing rates of biogenic calcification and accelerating dissolution and bioerosion. Effects of ocean acidification on deep-sea coral habitats in the North Pacific Ocean could be pronounced given the particularly shallow depth of the calcite and aragonite saturation horizons and the predictions that they will become shallower in the near future.

Dissolution depends in part on the mineralogy of the skeletons (i.e. calcite, aragonite, high Mg-calcite) of marine organisms. As pCO_2 increases, very high Mg-calcite (>15 mol% Mg) will dissolve first, followed by aragonite and then low Mg-calcite.

The skeletal composition is unknown for most species of deep-sea corals worldwide and for only a handful of the 136 taxa documented in Alaskan waters. Our goal was to determine the skeletal composition for corals from each major taxonomic group and for species of particular ecological importance (i.e. those that form single species assemblages) to identify those taxa that could be most at risk from ocean acidification. We looked for evidence of intraspecific variation in skeletal mineralogy across broad geographic scales and depth.

ACCOMPLISHMENTS

During this study we obtained skeletal ratios (aragonite, calcite, high Mg-calcite) for a total of 108 samples including Gorgonians, Hydrozoans, and Scleractinians. Additionally we obtained Mg contents in the high Mg-calcite for all samples with >2.4 vol% of high Mg-calcite (79 samples).

Sample description

The diverse collections of archived specimens at the Auke Bay Laboratories and Smithsonian Institution were carefully sorted through and 108 specimens from all major groups of corals were selected for laboratory analyses. Corals were selected to cover major taxonomic groups, species of particular ecological importance (i.e., those that form large single species assemblages), and specimens of the same species from multiple depth and geographic zones. Samples from Alaskan waters were not available for analyses for some species (N = 9 samples) and in those cases we examined archived specimens from elsewhere in the species' range (e.g., Russia, British Columbia, Washington, Oregon, and California).

Samples consisted of whole corals (scleractinians) or selected sections of corals (all other groups). We selected sections of gorgonians with obviously calcified parts and the axial rods of pennatulaceans. Samples were carefully examined under a dissecting microscope (1–6 X) identify and remove contaminants (e.g., epibionts and sediment). Sections were superficially crushed with a mortar and pestle if necessary to expose contaminants lodged in corallites.

Samples were crushed in a platinum mortar or in a manual agate mortar (when necessary) and then ground in an agate ball mill for 10 minutes. Samples with large grain size differences were passed through a sieve with 425 µm mesh and the remainder re-ground in the agate ball mill for 2 to 10 minutes. This step (sieving / grinding in agate ball mill) was repeated until all material passed the 425 µm mesh.

Some powders produced in the first batch using the Dremel tool and a manual agate mortar and pestle were re-ground for 2 to 5 minutes in the agate ball mill to increase homogeneity and decrease grain size.

Tools (platinum and agate mortar and pestle, agate ball mill) were cleaned using water and a scouring pad, then thoroughly rinsed with distilled water and ethanol. The 425 µm mesh sieve was cleaned in an ultrasound bath and inspected under a microscope.

Technique: X-Ray Diffraction and Rietveld Refinement Method

Per definition calcite contains 0–4 mol% Mg, high Mg-calcite contains >4 mol% Mg. (We call what is usually called Mg-calcite "high Mg" here for easy distinction) Very high Mg-calcite contains >15 mol% Mg.

X-ray power diffractometry (XRD) coupled with the Rietveld refinement method for XRD data analysis provides means to quickly and precisely determine the ratios of any mineral phases present. The method gains mineralogical information, i.e. chemical and structural data, which is necessary to distinguish chemically identical phases, like aragonite and calcite. Moreover, Rietveld refinement can be used to determine the Mg contents for each phase individually, which is of great advantage. We used a PANalytical X'Pert Pro diffractometer with High-Speed Bragg-Brentano optics and the commercial PANalytical software HighScore Plus v3. The Rietveld method uses fundamental calculations from crystal structure models to produce a calculated pattern, which is compared to the pattern produced by the analyzed phase (experimental pattern).

The calculated pattern is then refined by varying model parameters until the best fit between the calculated and the experimental pattern is obtained.

According to Titschak et al. (2011) Mg-determination by XRD and Rietveld refinement is 0.8 mol%. Element ratios are determined up to 1%-point in precision.
High–resolution XRD was performed using a PANalytical X'Pert Pro diffractometer at the Center for Material Sciences and Engineering (CMSE), a NSF-funded shared user facility located at MIT (Massachusetts Institute of Technology).

The PANalytical X'Pert Pro diffractometer with High-Speed Bragg-Brentano optics is equipped with a Cu source (generator: 40 mA, 45 kV) and has a goniometer radius of 240 mm. The angular range observed was 16 to 90°2Th, with a step size of 0.017°2Th, and a counting time of 120 s/step. Samples that were expected to contain substantial of organic material (e.g. gorgonin, tissue) were run with a counting time of 240s/step to compensate for the signal loss due to the organics. Sample holders with 16 mm powder wells were used with powder thicknesses between 2.5 mm and 0.1 mm.

Phase quantification and Riedveld refinement with lattice parameter determination with was performed using the commercial PANalytical software HighScore Plus v3.

The Rietveld method uses fundamental calculations from crystal structure models to produce a calculated pattern, which is compared to the pattern produced by the analyzed phase (experimental pattern). The calculated pattern is refined by varying model parameters until the best fit between the calculated and the experimental pattern is obtained.

Mg contents for Mg-calcites were calculated from the lattice parameters using calibration for unit cell parameter a by Titschak et al. (2011). The accuracy of the determination of Mg is better than 0.8 mol% between 0 and 15.5 mol%.

Using Riedveld refinement for the determination of both, mineral ratios and Mg contents of high-Mg calcite, has a large advantage over other methods often used (RIR, and single peak displacement), as all available peaks are taken into account, as well as peak intensities influenced by preferred orientation, peak broadening due to particle-size effects, and equipment specific influences (diffractometer symmetry; monochromator, soller slits, etc.), preparation effects, such as sample displacement errors, and most importantly the method is suitable for strongly overlapping reflections, like the ones produced by calcite and Mg-calcite.

HIGHLIGHTS

- The Mg concentration in high Mg-calcite is high (ranging from 7.4±0.8 mol% Mg to 14.8±0.8 mol% Mg), especially given the cold temperatures and low *pH* of sample locations. Nine of the analyzed samples are above the threshold of 12 mol% Mg.
- Some samples of Scleractinia (*Caryophylllia alaskensis*) from the Aleutian Islands and Bering Sea (very cold and very acidic) showed 5 and 7 vol.% calcite. Scleractinia are by definition, aragonitic, so the presence of not insignificant amounts of calcite is surprising

and hugely interesting, and may indicate an adaptive response by these corals to the extreme conditions in which they live.

- Some corals have varying skeletal components in different structural positions, e.g. the woody core of *Arthorgorgia kinoshitae* (sample #39) is 100% aragonite, polyps and coencheme are nearly exclusively high-Mg calcite (98.8%), samples containing both, woody core, and polyps and coencheme, show a mixture of aragonite and high Mg calcite.
- In contrast, for, both the woody core of *Fanellia fraseri* (WC, sample #42) and polyps and coencheme (PC, sample # 43) are nearly exclusively high-Mg calcite. The skleleton of *Fanellia fraseri* shows no variation in different structural positions.
- Skeletal compositions vary within orders, e.g. in Anthoathecatae: Cryphthelia, Sytlantheca, and Stylaster (except for *Stylaster repandus* and *Stylaster verrillii*) are largely aragonitic, while *Distichopora* and *Errinopora* are mostly high Mg-calcite.
- Skeletal compositions vary within families, e.g. in Primnoidae: *Plumarella* is aragonitic, *Parastenella ramosa* is largely aragonitic (~70%), while *Fanellia fraseri* (both woody core (WC) and, polyps and coencheme (PC)), *Thouarella*, and all but one *Primnoa* samples are high Mg-calcite.
- Skeletal compositions vary within genera, e.g. for *Stylaster*: most analyzed species are mostly aragonic, while *Stylaster repandus* and *Stylaster verrillii* are mostly high Mg-calcite.

SOCIETAL BENEFITS

This study aims to help address the effects of ocean acidification on coral reefs.

EDUCATION AND OUTREACH ACTIVITIES

Angela H. Helbling, Anne L. Cohen, Robert P. Stone, Christopher Doropoulos, Scott A. Speakman: Mineralogy and Composition of Calcium Carbonate Skeletons determined by High-Resolution X-Ray Powder Diffraction and Rietveld Refinement
(Poster presentation at Ocean Sciences Meeting 2014, Honolulu, Hawai'i)

Robert P. Stone, John Guinotte, Anne Cohen, Stephen D. Cairns, and Angela Helbling: "Calcium Carbonate Mineralogy of Alaskan Corals: the foundation for a risk assessment to the effects of Ocean Acidification"
(Poster presentation at the U.S. Ocean Acidification Principal Investigators' Meeting 2013, Washington, DC).

Robert P. Stone, Angela Helbling , John Guinotte, Stephen D. Cairns, and Anne Cohen: "Calcium Carbonate Mineralogy of Alaskan Corals"
(paper in preparation)

East coast marine mammal health assessment

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Michael Moore - WHOI

NOAA Sponsor – Teresa Rowles - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

This project consists of two parts:

Part 1 - East Coast Marine Mammal Health Mapping

The objectives of this project include: assist the NOAA Fisheries Office of Protected Resources with health assessments of marine mammal populations impacted by Unusual Mortality Events (UMEs) and in areas of high concern; assist with integrating health assessment protocols on population studies of east coast stocks conducted by NMFS biologists; provide assistance to on-site coordinators with data compilation and reports in order to enhance the ability to monitor and predict national marine mammal health trends; and coordinate with regional stranding coordinators and representatives of the Integrated Ocean Observing system to incorporate marine mammal health into the observing system.

Part 2 – Large Whale Stranding Response and Human Impact Investigation

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

ACCOMPLISHMENTS

Part 1

During the first six months of this project A. Bogomolni participated and contributed to the development of the Marine Mammal HealthMap, provided support for the Office of Protected Species during the ongoing California Sea Lion UME, and has worked on publishing several manuscripts related to the 2006 Northeast US seal UME. She has also contributed to ongoing discussions to synthesize past UMEs, including the 2011 seal/avian influenza event in the Northeast US. Over the next six months, further evaluation and analysis will be done as data

becomes available for this, and other UMEs. Follow-up on the Marine Mammal HealthMAP workshop through post workshop webinars will take place, as well as the development of specific case definitions identified during the workshop. In January 2015, A. Bogomolni assisted in establishing health assessment protocols and sampling during population studies of gray seal pups with the Northeast Fisheries Science Center.

Part 2 activities are summarized in the table below

Date	Species	Case	Location	Summary
7/12/2014	Right whale	IFAW14-122Eg	18nm SE Tuckernuck Island	Floating at sea exam. No cause of death determined
8/22/2014	Sei Whale	VAQS 20141077	Portsmouth, VA	Emaciated from plastic ingestion with subsequent vessel strike
8/24/2014	Right whale	IFAW14-142Eg	Newport, RI	Very decomposed
10/4/2014	Right whale	IFAW14-156Eg	Anchored in gear S on Nantucket	Not sampled
11/30/2014	Humpback whale	IFAW14-180Mn	Miacomet Beach, Nantucket, MA	Renal disease

HIGHLIGHTS

Part 1

- Contributed to the development of the vision document for Marine Mammal HealthMAP.
- Contributed to the design and presentation of two HealthMAP pre-workshop Webinars.
- Assisted with the implementation, coordination and presentation of the HealthMAP Workshop, March 3-5, 2015.
- Assisted at the Marine Mammal Center at Fort Macarthur San Pedro, CA and the Pacific Marine Mammal Center during the 2015 Sea Lion UME.
- Implemented health assessment protocols and sampling of gray seals with the NMFS NEFSC.
- Presented at the 3rd International One Health Congress, March 15-18, 2015, Amsterdam, the Netherlands.

Part 2

- The major outcome from the large whale cases relates to the difficulty of transporting large whale mortalities to the beach to undertake thorough necropsies to determine cause of death. These difficulties are a combination of the distance to shore, weather precluding prompt response, and lack of sites to tow carcasses to in the Northeast US.

SOCIETAL BENEFITS

Part 1

Marine Mammals are considered sentinels of ocean and human health. Understanding the health of marine mammals may ultimately help understand the threats posed to humans dependent on the same environment. The mission and vision of the Marine Mammal HealthMAP is to bring together measures of ocean and marine mammal health using a web-based data management platform. This platform will give the public and resource managers the ability to detect potential public and animal health risks in our changing ocean environment and will help to prioritize management and conservation efforts.

Part 2

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

EDUCATION AND OUTREACH ACTIVITIES

Part 1

Presented at the 3rd One Health Congress in Amsterdam, the Netherlands. March 15-18, 2015 "Saxitoxin Increases Phocine Distemper Virus Replication Upon *In-Vitro* infection in Harbor Seal Immune Cells".
Presented and participated as a panelist at the Falmouth Historical Society "Sealposium" March 24th, 2015. "Seals as Sentinels of Ocean Health".

Part 2

A presentation was made at the 2014 annual meeting of the North Atlantic Right Whale Consortium, at the New Bedford Whaling Museum, November 5, 2014. Extensive interviews were given to the Boston Globe, which resulted in a major review of this and related work in print and online at
http://www.bostonglobe.com/metro/2014/10/25/chasing-bayla/tJuazyjBOsdKQTRVnAbh7K/story.html.
The right whale skull collected from Newport RI was accessioned at the Cape Cod Museum of Natural History for public display.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

Figure 1. Partial right whale skull from IFAW14-142Eg. This skull had fallen out of the decomposing carcass as it came into shallow water under the cliff Walk in Newport. It was still covered at low tide. On August 24, 2014 the responding crew was able to roll it onto an inflatable raft, and tow it to the nearest road head for transport to WHOI. It has now been accessioned at the Cape Cod Museum of Natural History in Brewster MA. Photo credit: Michael Moore, WHOI. NOAA permit # 932-1905-00/MA-009526.

Figure 2. Aerial image of right whale IFAW14-156Eg anchored in fishing gear. Weather precluded a vessel based examination attempt for seven days, at which time the carcass was no longer present. Image courtesy of USCG.

Effects of drag from entanglement in fishing gear in right whales

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Michael Moore - WHOI

NOAA Sponsor – Peter Corkeron - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

Entanglement is the leading cause of death in large whales in the Northwest Atlantic. Entanglement may become protracted when individuals break free and carry a portion of the entangling gear, often for months to years. Emaciation is common in entanglement mortalities due to drag-induced increases in energetic costs, and reduced mobility and foraging ability significantly alter energy balance. Sub-lethal entanglement trauma is close to ubiquitous in North Atlantic right whales: in a recent survey, 83% had been entangled at least once, and 26% acquired new wounds and scars annually. It therefore could be a major concern in terms of population level productivity.

Energetic consequences associated with drag from towing entangling gear have only recently begun to be quantified. Evidence acquired thus far from one right whale entanglement case has suggested that entanglement imposes significant energy drain, requiring 70 to 102% more energy to maintain a preferred swimming speed. Quantifying drag imposed by entangling gear as well as the potential for survival or recovery is critical. Such an exercise assists predictive efforts to estimate the drag imposed by gear towed by free-swimming individuals at the time of their detection.

Even following disentanglement by humans, or self-disentanglement, energy reserves may remain sufficiently impacted so as to lead to death. Combining empirically derived drag estimates with individual life history information from the North Atlantic Right Whale catalog, we will investigate the energetic impact of 15 specific entanglement cases to determine the predictability of lethality and post-disentanglement survival.

Research Objectives:

1. Assess the energetic impact of specific North Atlantic right whale entanglements to determine the predictability of lethality or post-disentanglement survival.
2. Quantify the incremental energetic gains achieved by partial disentanglement.
3. Compare measured versus estimated drag from gear sets, to enable a predictive capacity to estimate drag for free-swimming entangled individuals at their time of detection.

ACCOMPLISHMENTS

In this study we quantified the amount of drag at different speeds and depths measured from fishing gear removed from entangled whales, and examined how these factors changed with different gear configurations (Fig. 1). We established predictive relationships between drag and (1) the weight of a gear set, and (2) the length of a gear set, and whether or not it includes buoys or floats (Figure 2). We found that on average, entanglement doubles the drag on a swimming whale, and hence the propulsion required for a given speed. We also examined the reduction of drag achieved by partial gear removal, which is particularly beneficial at slow swim speeds. Finally we have begun to account for the impact entanglement may have on the energetic budget of these animals in the context of their reproductive success.

HIGHLIGHTS

This project has:

- Increased our understanding of the magnitude and variability of drag imposed from different entangling gear scenarios (Fig. 2).
- Shown that at a minimum, entanglement doubles the drag experienced by a whale, and doubles the power required to swim.
- Provided formulae from which we can confidently estimate the drag on an entangled whale based on the length of the gear and whether or not floats or buoys are involved (Fig. 3).
- Reinforced the existing disentanglement practice of reducing trailing lines and the tether to the telemetry buoy to ~20 m.
- Informed disentanglement operations in terms of how much drag is reduced as trailing gear are removed, to be balanced with maintaining an acceptable amount of gear that would enable individuals to self-disentangle or for follow-up disentanglement attempts to occur.
- Illustrated the extent to which entanglement onset and duration, as well as added energetic burden, come into play when trying to predict the outcome of a given entanglement event (Fig. 4).
- Estimated the potential for entanglement in fishing gear to affect the reproductive output of North Atlantic right whales. Thus, for the first time there is the potential to introduce the concern of entanglement reducing fecundity, in how the U.S. Government accounts for fisheries impacts on this endangered species.

SOCIETAL BENEFITS

Understanding the role of drag from entanglement of North Atlantic right whales in fishing gear is an essential component of the overall management of protected species such as right whales in the broader context of ecosystem based management of commercially important fisheries, especially those that interact with protected species.

EDUCATION AND OUTREACH ACTIVITIES

North Atlantic Right Whale Consortium Meeting, New Bedford MA. November 2014.
"Drag on Marine Mammals" Lecture, Nauset Regional High School Physics Class, March 2015
International Whaling Commission Meeting on Large Whale Entanglement Issues, Provincetown MA. April 2015.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

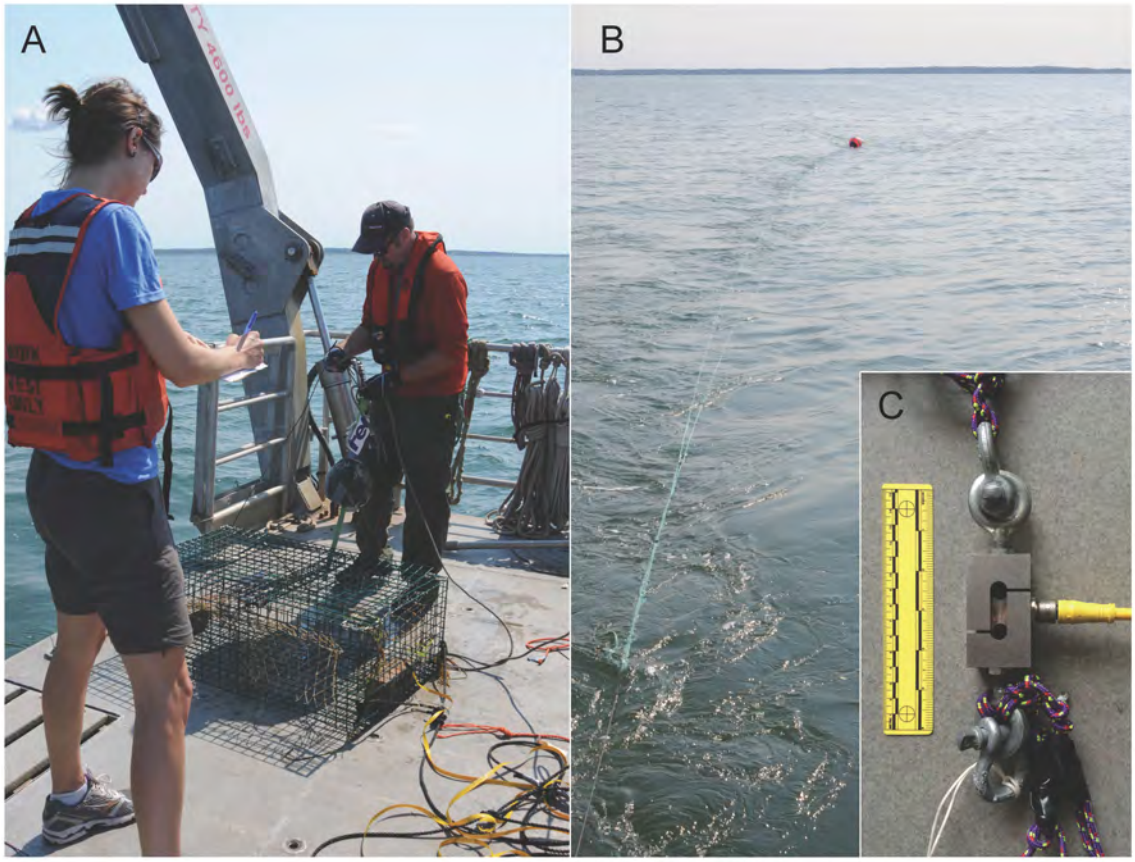


Figure 1. (A) Julie van der Hoop (MIT, WHOI; left) and David Morin (NOAA Fisheries; right) prepare to measure drag on a set of fishing gear, including a 15.7 Kg lobster trap, removed from an entangled right whale. (**B)** A set of fishing gear being towed behind a boat, attached to (**C)** the tensiometer used to measure its drag through the water.

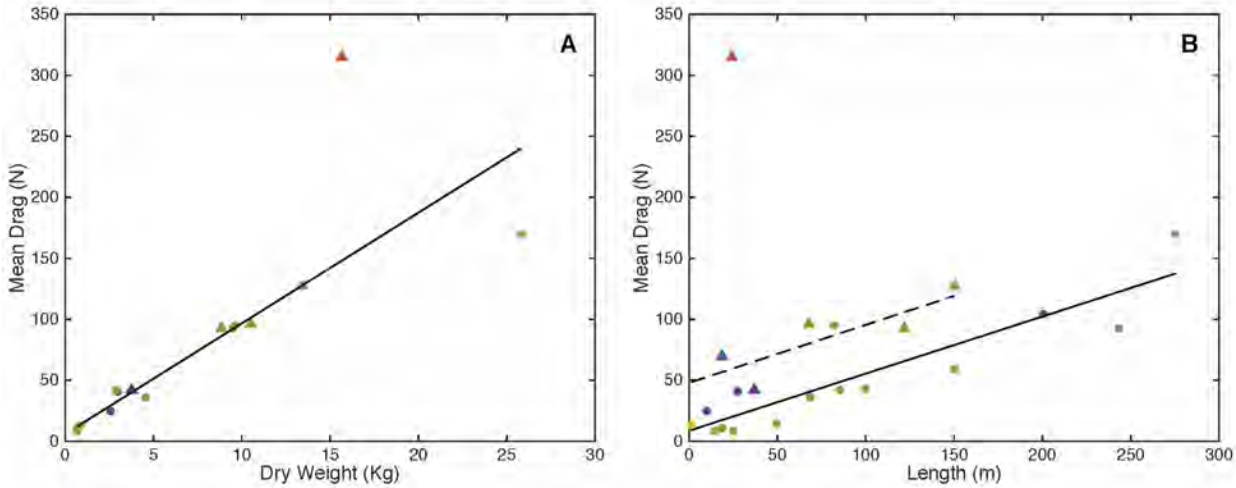


Figure 2. Mean drag (N) measured across speeds and depths can be predicted by the dry weight (Kg; A) or length (m; B) of a gear set. Colors represent different types of gears, as identified by hierarchical clustering. Gear sets made up of line only are represented as circles, and gear sets with floats or buoys as triangles. Black lines illustrate linear model fits of mean drag and (A) weight; and (B) length, with the presence of floats (dashed line) as a categorical covariate.

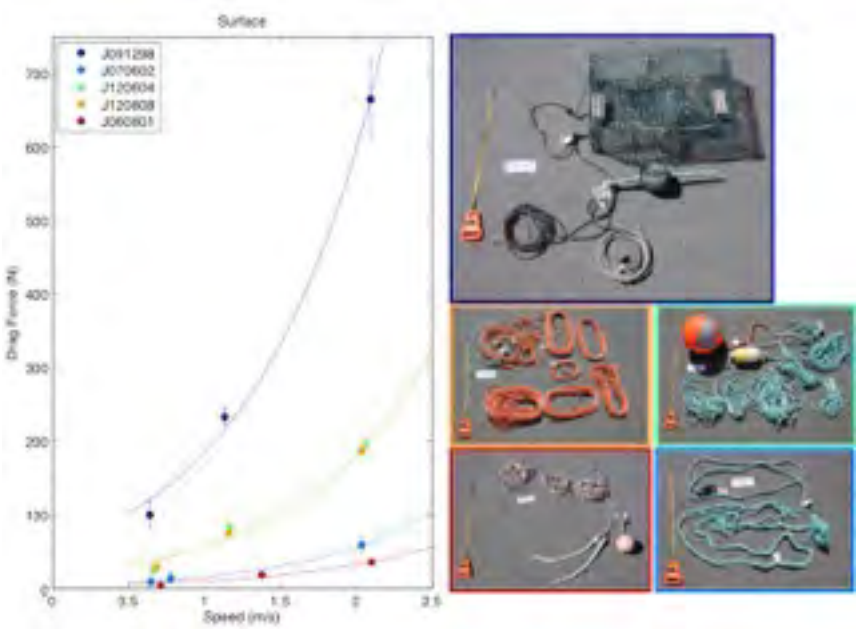


Figure 3. Drag force (N) of five example sets of fishing gear (shown at right) removed from North Atlantic right whales, measured by tensiometer at multiple depths across a range of speeds.

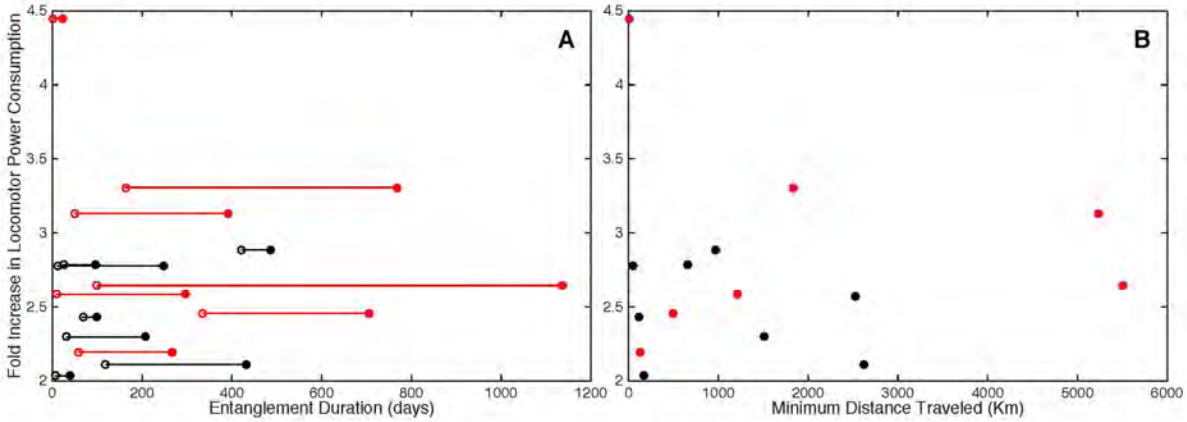


Figure 4. Fold increase in locomotor power consumption of 15 entangled right whales and (**A**) the minimum (open circle) and maximum (closed circle) entanglement duration (days) and (**B**) the minimum distance traveled with this entanglement. Colors represent the fate of the whales (red = died; black = alive).

A passive acoustic ocean observing system for monitoring and mapping marine mammals and noise in the Chukchi Sea ecosystem

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Donald Peters - WHOI

NOAA Sponsor – Julie Ann Mocklin - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

This project was a continuation to the ongoing Chukchi Acoustic, Oceanography, and Zooplankton (CHAOZ) project, which finished its final field season in 2012, and was a component of the Chukchi Acoustic, Oceanography and Zooplankton Extension study, referred to as CHAOZ-X. This work was a collaboration between Woods Hole Oceanographic Institution (WHOI) and the Bioacoustics Research Program (BRP) at the Cornell Laboratory of Ornithology (Cornell) over the period April 1, 2014 through June 30, 2014.

In the period of July 1-December 31, 2014, WHOI proposed to ship the Autodetection Buoy (AB) mooring system, prepared under the earlier grant, from Woods Hole, MA, to Seattle, WA; stage and load onto the deployment vessel; deploy and recover the mooring; and ship it back to WHOI for refurbishment.

The Cornell subcontract for this period included costs for AB and marine autonomous seafloor recording units (MARU) array field work, MARU array data analysis, continued development and application of a web-based GUI for AB acoustic data, and continued development of a system to quantify the contributions and influences of anthropogenic sound-generating activities (e.g., seismic survey, drilling operation, support vessels) on the natural acoustic environments of selected acoustically active marine mammal species.

ACCOMPLISHMENTS

The AB system prepared by WHOI was shipped from Woods Hole and loaded aboard R/V Westward Wind.

With considerable logistical and project management assistance from Sheyna Wisdom (Arctic Program Manager, Olgoonik Fairweather) and generous support from Michael Macrander (Shell, chief scientist, Alaska), Fred Channel (Field Operations Specialist, Cornell-BRP) deployed five MARUs from the R/V *Westward Wind* on August 4, 2014 (Fig. 1). Before departing from the ship on August 7, Fred briefed and trained the deck crew for the deployment of the AB and two double-bubble MARUs (Dbs). On August 20, the R/V *Westward Wind*'s deck crew deployed the AB at 70.9999.57 N by -163.676712W, and the two Dbs within close proximity (Fig. 1). On

October 13, 2014, Fred Channel, aboard the R/V *Westward Wind*, successfully recovered all five MARUs, the single Db that was deployed in 2013 (Db-2013), and the AB. The two Dbs that were deployed in August 2014 will operate through the next 12 months and be recovered in summer 2015. All the equipment was shipped back to Cornell, and the acoustic data were extracted from the five MARUs, Db-2013, and the AB. One of the five MARUs failed to record data, but the data from the four other MARUs, Db-2013, and the AB were all extracted successfully.

During its deployment period, the AB ran real-time software that detected bowhead whale calls and calculated background noise spectral distributions. A total of 342 audio detection clips as well as spectral measurements were transmitted back via Iridium satellite. The AB audio data were recorded to FLASH memory throughout the deployment.
Cornell continued to make significant progress with the acoustic ecology software system such that the MatLab code can be run on either single systems (e.g., a laptop) or Cornell's high-performance oDeLMA computer system. Initial performance metrics of this system were evaluated and used to resolve file naming inconsistencies or periods of time with data drop-out. These features are intended to enable collaborative coordination of data processing tools and results between Cornell BRP and NOAA-AFSC.
Post-doctoral Fellow, Yu Shiu, focused on auto-detection software for post-processing the acoustic data from the Db-2013 and the four 2014 MARUs, and becoming facile with concepts, algorithms, and software related to translating acoustic occurrence data into animal density estimates. This is a primary reason why the five MARUs were deployed as a set of distributed recorders, with only partial overlap in individual acoustic detection areas.

HIGHLIGHTS

- Five MARUs were deployed from the R/V *Westward Wind* on August 4, 2014.
- During its deployment period, the AB ran real-time software that detected bowhead whale calls and calculated background noise spectral distributions.
- Significant progress was made in the development of a system to quantify the contributions and influences of anthropogenic sound-generating activities (e.g., seismic survey, drilling operation, support vessels) on the natural acoustic environments of selected acoustically active marine mammal species.

Figure 1. Deployment geometry of the five Cornell MARUs, the auto-detection buoy (AB-2014) and the two double-bubbles (Db-1 and Db-2). MARU-5 failed to record data.

Habitat suitability modeling for deep-sea corals and sponges in the Northeast and Mid-Atlantic regions – version 2 and ground trothing of potential deep-sea coral areas

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Timothy Shank - WHOI

NOAA Sponsor – Martha Nizinski - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: IV. Protection and Restoration of Resources

PROJECT OVERVIEW

Submarine canyons can contain the most productive non-chemosynthetic habitats described in the deep sea and may enhance local and regional species diversity, including those vulnerable to anthropogenic activities. Using recently collected fine-scale bathymetry data and regional deep-sea coral presence records, we propose to locate, document, and characterize deep-sea coral and sponge ecosystems in virtually unexplored northeast and mid-Atlantic canyons. We will utilize WHOI's *TowCam* system to ground-truth some deep-sea coral "hotspots" predicted by the existing model/maps. The future development of coral-habitat predictive models and habitat suitability maps depends on new records and ground-truthed coral/sponge occurrence data obtained from towed camera surveys. Data collected will be used to: 1) support the NE Regional Deep-Sea Coral and Sponge Initiative; 2) provide guidance to the NEFMC and MAFMC to designate deep-sea coral management alternatives in the northeast and mid-Atlantic; and 3) support the northeast's Habitat Blueprint regional initiative. In addition, the new deep-sea coral/sponge data obtained from the *TowCam* surveys will be compiled and analyzed for integration into the existing national Deep-Sea Coral and Sponge database as well as guide critical sampling of whole specimens and tissue collections for future taxonomic and genetic (phylogenetic and population genetic) analysis.

The specific objective for the past year was to locate, document, and characterize canyon coral, sponge, and fish locations through the use of a towed camera system during a F/V Bigelow cruise to ground-truth areas highlighted on the bathymetric maps, and provide these data to regional fisheries management councils for their deliberation of fisheries efforts and conservation measures.

ACCOMPLISHMENTS

We conducted 28 towed imaging surveys across 8 canyons, specifically, Washington, Accomac, Leonard, Wilmington, Spencer, Lindenkohl, and Carteret Canyons in August 2014.

Our proposed approach is, as has been for the last two years, to ground-truth areas predicted to be coral hotspots based on available collected multibeam, data provided from habitat suitability

models, and historical coral records. Specifically, we will utilize high-quality multibeam data from recent ACUMEN mapping expeditions (including those conducted by NOAA Ships *Okeanos Explorer* and *Ferdinand Hassler*) to locate high-relief bottom features that appeared to be likely coral habitat. We will consult results (as appropriate) from our recently developed habitat suitability model (Brian Kinlan, lead). This model uses various physical and biological data to predict where corals are likely to occur based on conditions found in locations where corals were previously reported.

Images were taken every 10-15 seconds at an altitude between 2-6 meters from the seafloor with a 16-megapixel camera. *TowCam* was equipped with two vertical lasers separated by 20 cm for scale and co-registered to a Seabird CTD sensor (seabird SBE25) and altimeter to provide accurate depth and altitude for each image. The images from the *TowCam* system were recorded internally and simultaneously transmitted to the surface through 0.68" CTD cable.

Images were downloaded from the camera's 32 GB compact flash card for analysis upon return to the ship. Each bottom image was visually screened for hard and soft corals, sponges, and fish fauna. Presence/absence information was logged for each image using iView Media Pro through which data catalogues indicating faunal occurrence were constructed. Fauna was identified to the lowest possible taxon. Density estimates were obtained where possible, substrate and topographical information was noted, and habitats classified using pre-existing definitions from the literature. Text data files from each *TowCam* lowering were exported from the iView MediaPro catalog and merged with navigation files using the time-date stamp from the image file names. Coral/fish/sponge location data were geo-referenced in ArcGIS and mapped.

HIGHLIGHTS

- We completed the imaging surveys and the georeferencing analysis of deep-water coral, sponge, and fish locations.
- We provided these georefernced data to NOAA (Brian Kinlan, NOS) who correlated the locations with coral habitat (bottom slope angles in predictive models of bathymetric slope as coral habitat) to reveal strong correlations across different coral species.
- We provided these data to the Mid-Atlantic Regional Fisheries Council who voted to protect 38,000 square miles (98,420 sq km) from all bottom fishing (with one limited exemption for a very small red crab fishery focusing on soft sediment/mud areas in less than 1% of the closed area for 2 years while impacts are assessed). This was the first use of discretionary authority granted to fishery Councils under the 2007 reauthorization of Magnuson to protect deep sea corals purely for conservation and habitat protection reasons, rather than for any specific fishery management or sustainability goals.
- If approved by NOAA as seems likely, this will be the largest single area protected from all bottom fishing in the continental U.S. (eg the Rockfish Conservation Area, which extends the entire length of the Pacific coast, is only 12,620 sq mi - 32,685 sq km - and it is not permanent but part of a fishery rebuilding plan). If considered a marine protected area, the new Mid-Atlantic Deep-sea Coral Protection Area would be the 12th largest in the world, just below the Galápagos Marine Reserve, and the largest in the continental U.S. EEZ. In comparison to land-based protected areas, it is substantially larger (by

>25%) than the entire Arctic National Wildlife Refuge. It is more than 3.5 times the combined size of the recently expanded Cordell Bank, Greater Gulf of Farallones and Monterey Bay contiguous Sanctuary complex.

SOCIETAL BENEFITS

- This work has resulted in the protection of expansive yet little known marine resources for society.

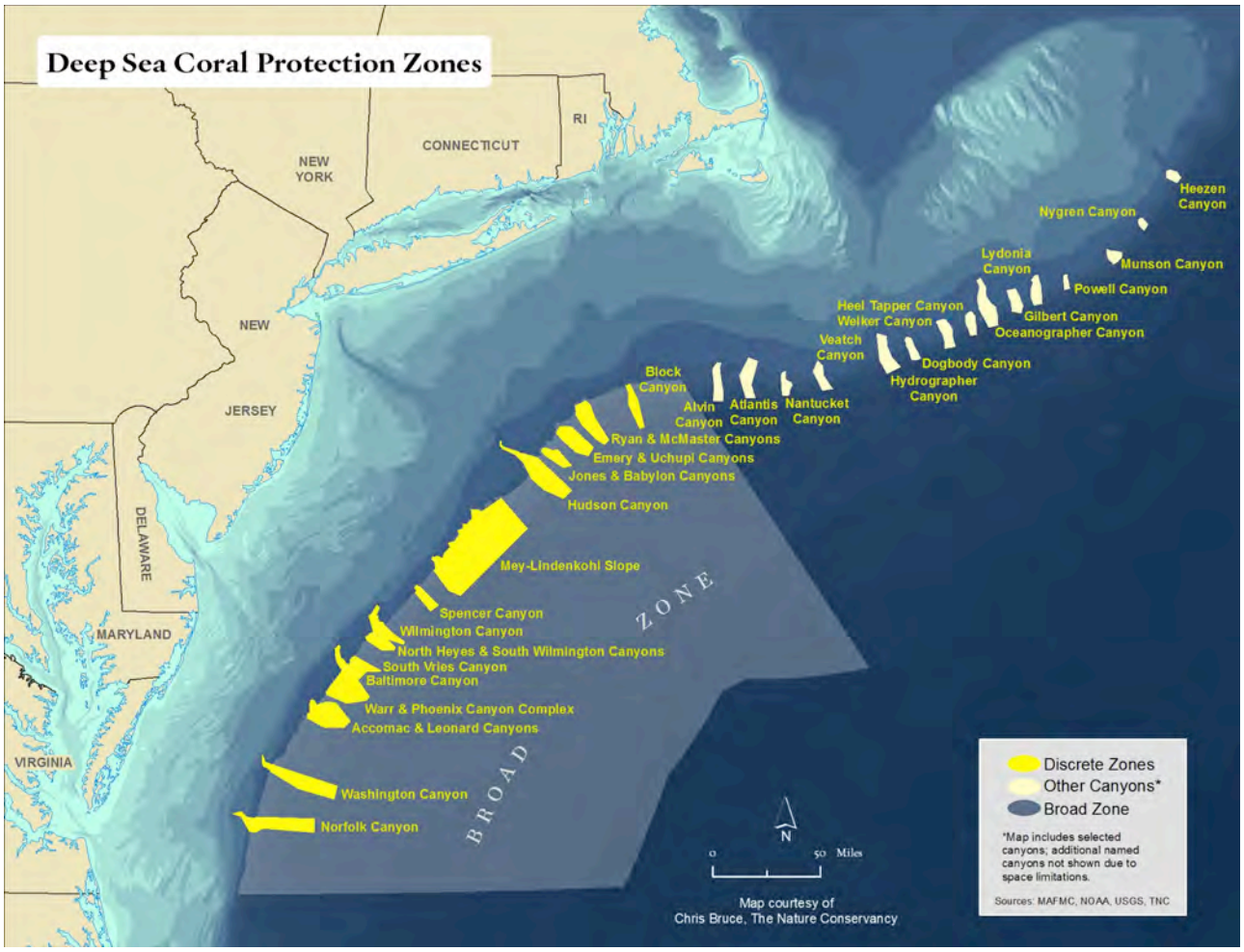
- This work has resulted in some of the first open dialogues and agreements among the fishing industry and the US Government for the protection of societal resources.

EDUCATION AND OUTREACH ACTIVITIES

This work resulted in the numerous newspaper an online articles in the New York Times, Baltimore Times, The Asbury Park Press, etc., and National Television for the education of the global public our on deepwater resources and assets (and the importance of understanding and learning more about them).

This work was featured at a WHOI Public Event, connecting with more than 80 people (lay public) including new interactive bathymetric data displays of the Atlantic Canyons, imagery and video from the canyons, and a preserved specimen display.

FIGURES/PHOTOS/ILLUSTRATIONS



The Northwest Atlantic Canyons surveyed during this research program (yellow and white canyons, excluding Hudson Canyon). Yellow Canyons indicated those recommended for protection by the Mid-Atlantic Regional Fisheries Council in June 2015, as a result of the data and ground-truthing of predictive models generated and provided by this research program.

THEME V. SUSTAINED OCEAN OBSERVATIONS AND CLIMATE

CINAR

Cooperative Institute for the North Atlantic Region

Global ocean observing coordination activities

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Donald Anderson - WHOI

NOAA Sponsor – Stephen Piotrowicz - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

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

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

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

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

ACCOMPLISHMENTS

Data Buoy Cooperation Panel

Support was provided to the DBCP via Kelly Stroker (working remotely from the USA) until she resigned in September 2014. Champika Gallage (Canada) was then recruited in November 2014, directly in Brest, where the whole JCOMMOPS office would be re-establish (in March 2015).

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

Latest maps where made available in September 2014, together with the required documentation for the DBCP yearly meeting by the former TC. With no TC in place for a while, JCOMMOPS loses track on the status of the drifter and moorings array. The resuming of maps/stats production has been a challenge for the new TC and the office. Hence, the new TC had to start a review from scratch on all components of the DBCP and did work closely with the I.T. engineer to fuel the new Information System with proper metadata. On another end, the new TC has been travelling a lot to meet with her new community and understand its requirements.

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

The complete work plan and its evaluation for the DBCP Technical Coordinator is available at: https://docs.google.com/spreadsheets/d/1YKHcazfVfArR9pdKGjLdKF12Im9mr9Wv6ws22zRzCy4/edit#gid=1025089654

OceanSITES

Support is given to the OceanSITES science team, who is working to develop requirements for each of the several networks embedded with the OceanSITES programme (www.oceansites.org). The overall JCOMMOPS infrastructure is providing integrated monitoring tools, including for OceanSITES. The TC has been establishing links with the community, checking the quality of the OceanSITES metadata and requirements to include these in the new Information System Here is available the complete work plan and its evaluation for the OceanSITES Technical Coordinator:https://docs.google.com/spreadsheets/d/1YKHcazfVfArR9pdKGjLdKF12Im9mr9Wv6ws22zRzCy4/edit#gid=1504673413

Argo

Support to the Argo programme is provided via a dedicated TC and Argo Information Centre activities and website. Mathieu Belbeoch has been providing such support to Argo since Feb. 2001. Status maps and charts are regularly provided to the Argo Steering and Data teams (e.g.).

See http://argo.jcommops.org/maps.html). New analysis tools are regularly designed and added. EEZ notification and warning system is gradually improved and maintained operational, to facilitate program managers tasks. Guidance is regularly provided to the community on the international regulations and best practices.

The AIC maintains appropriate tools to facilitate the implementation planning and optimize the network distribution. A scoring system of deployment plans has been designed. In depth analysis and report son delays have permitted to dramatically improved them and discover weaknesses in the data flow for some national centers . The AIC is also fostering the review of the Argo design to define and dimension rationally the requirements (number of floats required per year, distribution, etc.). A new design is proposed each year to the AST meeting in March as discussion base. A set of performance indicators are then built on these targets.

Proper density maps are designed to track the spatial distribution of the network and guide implementation. Instruments performance is extensively tracked through various reliability charts and statistics. The TC works closely with the Argo Teams to harmonize the vocabulary across JCOMMOPS matadata, Argo netCDF format and WIGOS/GTS code tables.
See: https://docs.google.com/spreadsheets/d/1Aw8B7FFUjG4e9MveD5qqvI7ZbB-z_x32IQnpHZbXVZA/edit#gid=1

Argo metadata are already available in the new Information System and the two systems are run in parallel to check potential problems. The new AIC/JCOMMOPS website is to be released in September 2015 for an internal review (with representatives of AST/ADMT) and publicly late 2015.

Given the transitional period (early 2015, see below section on JCOMMOPS move from Toulouse to Brest), and the management role of M. Belbeoch for the office, the routine production of monitoring tools was slow down. All services provided on-line for Argo will be fully operationalized through the new system and backup staff by the end of 2015.

The complete work plan of the Argo TC is available at:
https://docs.google.com/spreadsheets/d/1YKHcazfVfArR9pdKGjLdKF12Im9mr9Wv6ws22zRzCy4/edit#gid=0

Ships

For SOT, the production of maps was maintained and various new maps developed, which include statistics on participating countries, data quality, automatization and timeliness or masking schemes. A set of performance indicators where designed and made available through a score card (see http://sot.jcommops.org/maps).

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

VOS metadata, gathered in WMO publication No. 47, are continuously monitored and incoherencies reported to the responsible national focal points, with the request to review and update their data. A large number of wrongly registered platforms was successfully identified, reported and modified.

For GO-SHIP, information on planned or recently accomplished cruises were gathered and compiled in a global cruise plan. Where no national focal points existed, appropriate scientists were identified and recruited for almost all active countries by the TC.

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

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

The complete work plan of the Ship Coordinator is available at:
https://docs.google.com/spreadsheets/d/1YKHcazfVfArR9pdKGjLdKF12Im9mr9Wv6ws22zRzCy4/edit#gid=358096762

JCOMMOPS

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

To be noted the optimistic options offered by a potential move of the office in Brest.
This move has been completed on March 18, 2015 in Ifremer/Brest where the local ocean community together with AST members inaugurated the new office in presence of elected officials, IOC, WMO and JCOMM representatives. The local authorities have provided a 3 years grant at the level of 100keuros per year to help the centre installation and development.

The funding, justification and recruitment of a new TC, to focus on ship information was definitely a real progress, applauded by the community, as well as the firm establishment of a dedicated software engineer in support of all JCOMMOPS activities. Martin Kramp has shown some solid skills for the position and team work.

A dedicated engineer (Anthonin Lizé) was recruited in August 2014 after a period of turnover and shown immediately appropriate technical skills, interest for the development of services to the OOS community and a strong potential and motivation for the job. In addition to the active development of the Information System he will act as backup resource for the TC and make sure core deliverables are operationalized.

A work plan was set up to clarify each staff priorities, duties, and deliverables. Such tool will allow the networks and panels to change TC priorities according to their requirements. Regular teleconferences with the governance (JCOMM Observations Coordination Group) track the progress of the Centre and gather direct guidance from the panels.

An important work on designing integrated key performance indicators common to all programmes was initiated in April 2014. The new generation of the JCOMMOPS Information System, websites and web services will be exposed to the community in September 2015.

It has to be noted that the Argo Technical Coordinator and de facto office manager for the office has succeeded after many years in:

- completing the physical transition of the office from a satellite based company (CLS) to an ocean pole (Brest/Ifremer) in excellent conditions
- creating, (identifying funding, documenting the requirements, and recruiting) two full time positions at the service of the JCOMM/GOOS networks
- identifying some new funding sources and support with local authorities which will allow the recruitment of a fifth permanent staff (assistant management/communication)
- Shaping the architecture of a new information system and webservices that will be used by the community in the next decade, and drive the ambitious developments using internal and external resources to boost productivity.

See: http://www.unesco.org/new/en/media-services/single-view/news/inauguration_of_the_operational_centre_for_ocean_observation_in_brest/

The TC was commended for those efforts and tenacity at the inauguration of the new office in March 2015. 2015. Many challenges are still on JCOMMOPS plate, in a rather complex governance model, and very diverse community. A decade of integrated services is in sight, including a new set of website and web based services, a new integrated ship time service, via a strengthened team. JCOMMOPS has finally the means to achieve its full potential.

OOPC

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

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

variables for GOOS, while defining sustained ocean observing requirements for WCRP, especially in regard to the WCRP Climate Variability and Predictability Project (CLIVAR).

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

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

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

To refine and adjust the TPOS to monitor, observe and predict the state of ENSO, and advance scientific understanding of its causes.
To determine the most efficient and effective methods for sustained observations to support prediction systems for ocean, weather and climate services of high societal and economic utility, including underpinning research.

To advance and refine the knowledge of the predictability horizon of the Tropical Pacific variability (physical and biogeochemical), as well as its impact in global climate.
To determine how inter-annual to multi-decadal variability and human activities impact the relation between marine biogeochemistry and biology to carbon budgets, food security and biodiversity.

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

EDUCATION AND OUTREACH

Outreach and education is an issue in the long run for all JCOMMOPS programs, in the context of sustained networks. This is a growing activity given the demand and potential. A number of technical developments have been made to democratize this access to information (e.g. Google Earth layers) and JCOMMOPS is participating in a number of training workshops, or specific actions (e.g. school visits, collaboration with aquariums, teacher, etc). Some others tools based on social Medias are gradually being set up (e.g.: picasa albums, twitter news).
An important outreach initiative led by JCOMMOPS is to have the sailing community (individuals, adventurers, navy schools, sailing races, NGOs) participating in the deployment (and soon the funding) of the GOOS networks. Famous skippers can attract medias much more than scientists and tell the whole story. In November 2014, the Barcelona World Race skippers participated to the race with a new challenge: deploying one Argo floats in the South Atlantic. All floats were successfully deployed and work well. This generated a large international media coverage. Plans are to renew this with other world round races (all passing through the Southern Ocean) and if possible have the instrument self-funded by the race sponsors.

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

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

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

PUBLICATIONS AND REPORTS

Publications by Principal Investigators

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

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

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

JCOMMOPS monitoring products such as maps and charts are often used in scientific publications, and national reports or proposals.

Other Relevant Publications

OOPC (2014): The Tropical Pacific Observing System 2020 Workshop – Volume I: Workshop Report and Recommendations.
OOPC (2014): The Tropical Pacific Observing System 2020 Workshop – Volume II: White Papers.

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

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Carin Ashjian - WHOI

NOAA Sponsor – Kathleen Crane - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

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

ACCOMPLISHMENTS

During the past year progress has been made on the synthesis effort led by M. Pisareva and R. Pickart. The paper will include data collected using the VPR in Herald Canyon in 2009.

HIGHLIGHTS

- The vertical distributions of copepods and diatoms and marine snow particles were closely associated with the vertical structure of the water column and with different water mass types (Figure 1).
- Herald Canyon was very dynamic, with multiple water masses and complex velocity patterns. Plankton and particles were spatially heterogeneous. Along- or cross-canyon flux of plankton and particles in this region revealed that most types were primarily
- advected to the north while on the western side of the canyon substantial flux of algal mats was observed. (Figure 2)
- The VPR was an effective means to obtain high-resolution vertical distributions of plankton and particles that can be coupled to hydrography and to velocity in achieving a better understanding of the complex interaction between biology and physics that structures this ecosystem.

SOCIETAL BENEFITS

Predicting the impact of climate on ecosystems requires an understanding of the important components and interactions in the ecosystem, both to identify change and to develop a predictive modeling capability for the ecosystem. Such information can ultimately be used to help us better conserve Arctic ecosystems and, in the future, potentially manage Arctic fisheries. Information on the high-resolution distributions of plankton in association with hydrography and currents can enhance our understanding of the ecosystem and contribute ultimately to better modeling of the system.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

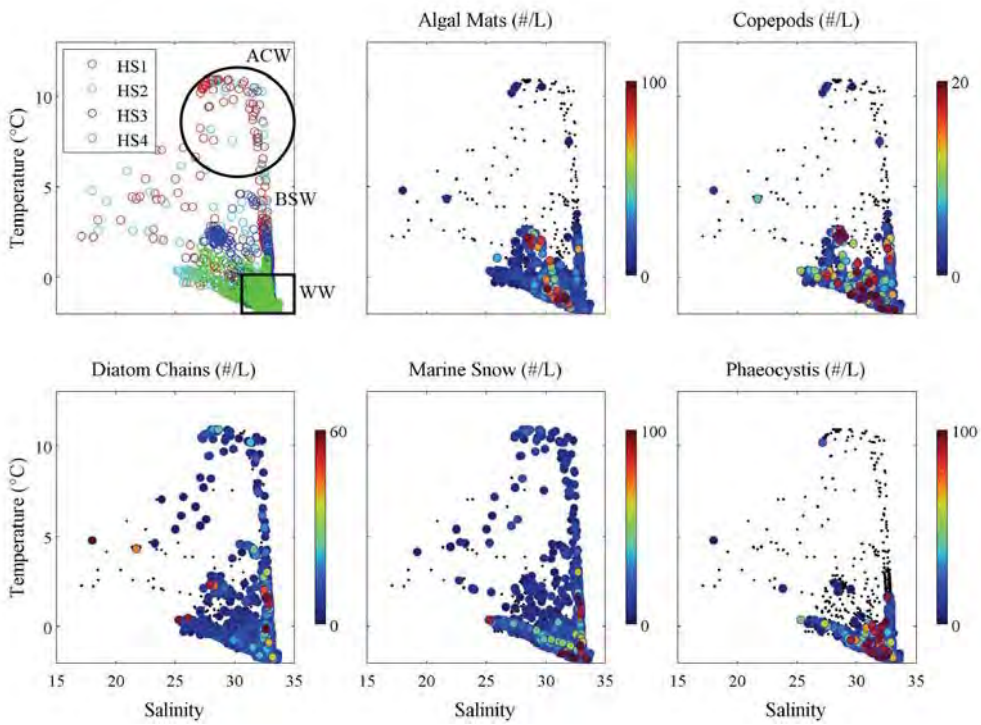


Figure 1. Temperature-salinity-plankton diagrams for Herald Canyon in August 2004. Upper left panel shows the TS for all of the tows with the different transects indicated in different colors and dominant water types indicated. The remaining panels shows TSP plots for dominant plankton/particles. Strong affinities of some types to different water masses were seen. In particular, algal mats, phaeocystis, and copepods were in highest abundance in the upper water column, above the cold, salty remnant Winter Water (WW). Marine snow and diatom chains were found in all water mass types, including the warm Alaska Coastal Water (ACW) seen primarily on transects HS1 and HS2 and in the Bering Sea Water (BSW).

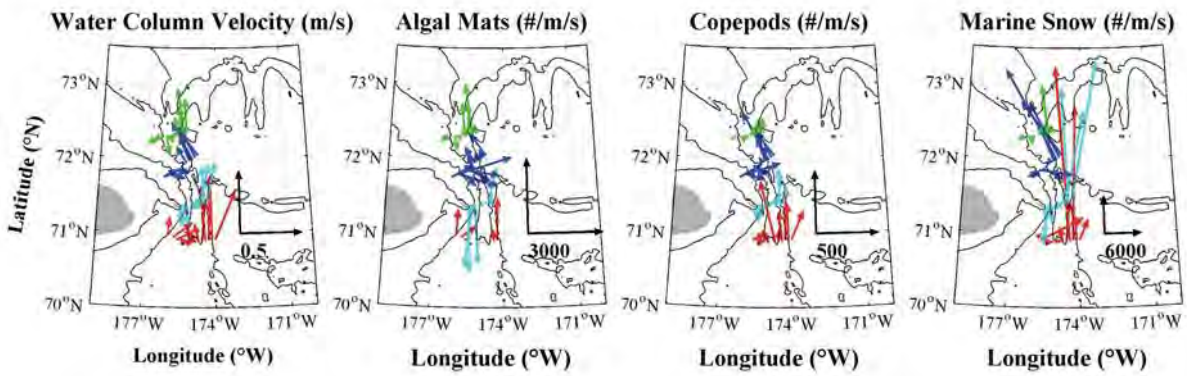


Figure 2. Mean water column velocity (m/sec) and the mean water column flux (#/m/sec) of algal mats, copepods, and marine snow through Herald Canyon in the western Chukchi Sea in August 2004. Flux was calculated by combining the water column abundance of plankton or particles with the mean water column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

2014 ROV Jason use for Chadwick Moyer cruise

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Andrew Bowen - WHOI

NOAA Sponsor – Thomas Peltzer - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

An expedition to NW Eifuku and NW Rota Seamounts in the Mariana Arc was carried out on the *R/V Revelle* with ROV *Jason* in November-December 2014, funded by the National Science Foundation with Dr. Craig Moyer of Western Washington University (WWU) as Chief Scientist. Personnel from the NOAA/PMEL Earth-Ocean Interactions (EOI) group participated in the cruise and provided geological and chemical expertise on the local hydrothermal environments. NW Eifuku is unique because it vents liquid CO_2 (the only known arc-seamount where this occurs), its CO_2 output is the highest of any submarine hydrothermal site in the world, and because it hosts a surprisingly dense biomass of chemosynthetic mussels and other organisms. This combination makes it an extraordinary natural laboratory where the effects of natural ocean acidification on marine ecosystems can be studied. NW Rota is also unusual as it is a site where submarine volcanic eruptions and landslides were previously observed, and therefore presents an extraordinary opportunity to study active processes. Both seamounts are part of the Mariana Trench Marine National Monument (MTMNM).
This request added four additional days of operation of ROV *Jason* to the previous NSF-funded Moyer cruise on *R/V Revelle*.

ACCOMPLISHMENTS

ROV *Jason* was used for operations by Moyer (NSF) and Chadwick (NOAA) from November 29 to December 21, 2014 on board the *R/V Revelle*. The location of these operations was the Urashima vent site (12 55.28°N 143 38.70°E). The four NOAA days covered by this award were used for Jason to recover samples using the Beast, Majors, gas tights, scoop samplers, Optode, BIOMAT sampler, and other small samplers. Samples were obtained from the Golden Horn chimney site, which was one of the main cruise objectives. ROV Jason reached depths of 2,938 meters with bottom time operations varying from 6.8 to 31.6 hours.

HIGHLIGHTS

- The four NOAA days covered by this award were used for Jason to recover samples from NW Eifuku and NW Rota Seamounts in the Mariana Arc.
- Both seamounts are unique, and present extraordinary opportunities to study the effects of natural ocean acidification on marine ecosystems as well as active processes related to submarine volcanic eruptions and landslides.

- Samples were obtained from the Golden Horn chimney site, which was one of the main cruise objectives.

Assessing regional sea-ice predictability in the US Arctic: A multi-model approach

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Enrique Curchitser - Rutgers

NOAA Sponsor – Jessie Carman - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

Predictability of pan-Arctic sea ice extent and volume has been examined in a number of studies. In comparison, *regional* sea ice predictability is less explored despite its significance for a suite of stakeholders - coastal communities, shipping and oil industry, and marine ecosystem management. The goal of this study is to assess regional sea ice predictability in the US Arctic: the Beaufort Sea, Chukchi Sea, and Bering Sea. This effort is in part motivated by PMEL/EcoFOCI (Ecosystem and Fishery Oceanography Coordinated Investigations) group's *in situ* knowledge of the role of sea ice on the regional oceanography and marine ecosystem. To assess predictability, we will utilize existing output from the NCAR CESM Large Ensemble simulations and the NOAA CFSv2 forecast system. In addition, we will carry out ocean-sea ice experiments using a pan-Arctic grid of the Regional Ocean Modeling System (ROMS) at nominal 10-km horizontal resolution, driven by these global models. We will analyze both diagnostic (lagged correlation) and prognostic (from initialization ensemble runs) sea ice predictability on regional scales. For the latter, root-mean-square error, anomaly correlation coefficient, and potential prognostic predictability will be calculated. We will begin our analyses on the regional sea ice area and thickness and, time permitting, expand to other properties such as ice edge locations and spring retreat timing. Moreover, we will examine cross-model differences in regional predictability and assess what factors (e.g., spatial resolution and coupling) and physical mechanisms contribute to such differences. Results from this study are anticipated to improve our understanding of processes controlling regional sea ice predictability in the US Arctic, a necessary step towards developing cross-scale earth system prediction capability. This effort will be in close coordination with scientists working on the ESPC Arctic sea ice focus project, directly contributing to the goals of the latter.

ACCOMPLISHMENTS

During the first six months of this effort, we implemented a high-resolution regional model for the Arctic and sub-Arctic regions. The model is based on the Regional Ocean Modeling System (ROMS) at nominal 10-km horizontal resolution, with enhanced resolution in the Chukchi and Beaufort and Bering Seas. Figure 1 shows the implemented pan-Arctic grid bathymetry and corresponding resolution. The coupled ice-ocean model is being implemented in a pure hindcast mode first to test the model setup and parameters.

We have started analyzing sea ice predictability in the regional seas of the Arctic – Bering Sea, Chukchi Sea, and Beaufort Sea (Fig. 2) using the NCAR CESM large ensemble runs output. Seasonal ice area persistency is examined through lagged autocorrelations. We compare the seasonal persistency in the regional seas to that of the Arctic. During the freezing season (Fig. 3; November, January and March), ice area persistency in the regional seas is generally lower than that of the entire Arctic, but there are also regional variations. For example, the Bering Sea autocorrelations starting in January and March closely follow their Arctic counterparts until sea ice melts away at the end of spring (blue and black lines in Fig. 3). Meanwhile ice area in the Chukchi and Beaufort Seas shows a faster drop in their autocorrelations than ice area in the Arctic and Bering Sea. In comparison, in the spring and fall seasons (Fig. 3, May and September), the Arctic and regional ice areas show similar magnitude of autocorrelation until lag 4 months. We will continue examining the mechanisms that contribute to such regional and seasonal differences in the ice area autocorrelation, and their implications on regional sea ice predictions.

HIGHLIGHTS

- During the freezing season, ice area persistency in the regional seas is generally lower than that of the entire Arctic, but there are also regional variations.
- In comparison, in the spring and fall seasons, the Arctic and regional ice areas show similar magnitude of autocorrelation until lag 4 months.

SOCIETAL BENEFITS

Results from this study are anticipated to improve our understanding of processes controlling regional sea ice predictability in the US Arctic, a necessary step towards developing cross-scale earth system prediction capability.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

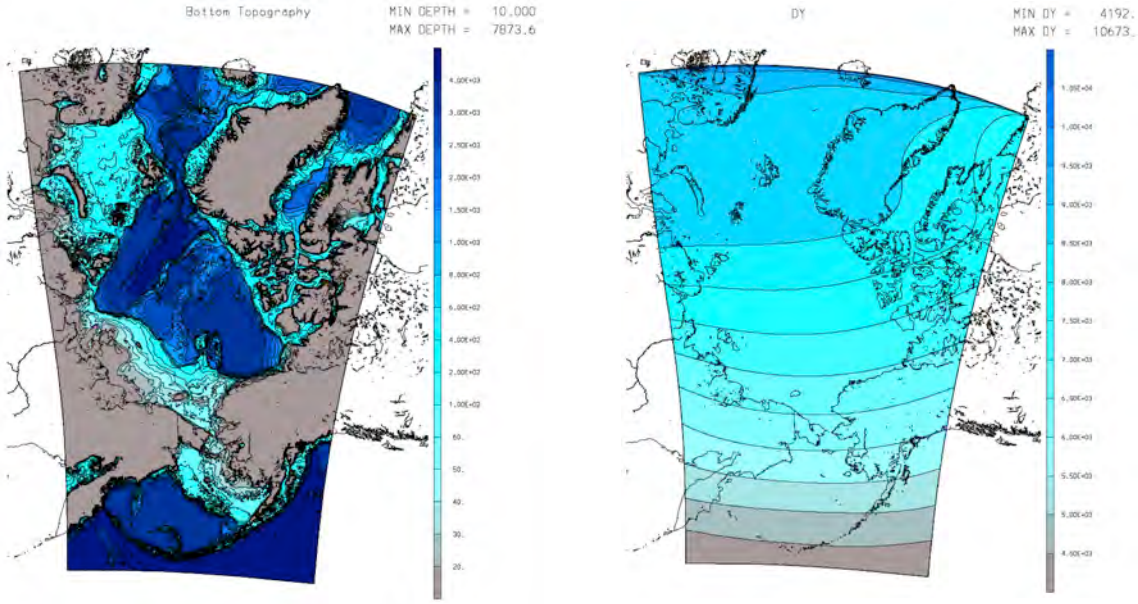


Figure 1. Model bathymetry (left) and resolution (right) for the Pan-Arctic grid. Resolution is enhanced in the oceans surrounding Alaska.

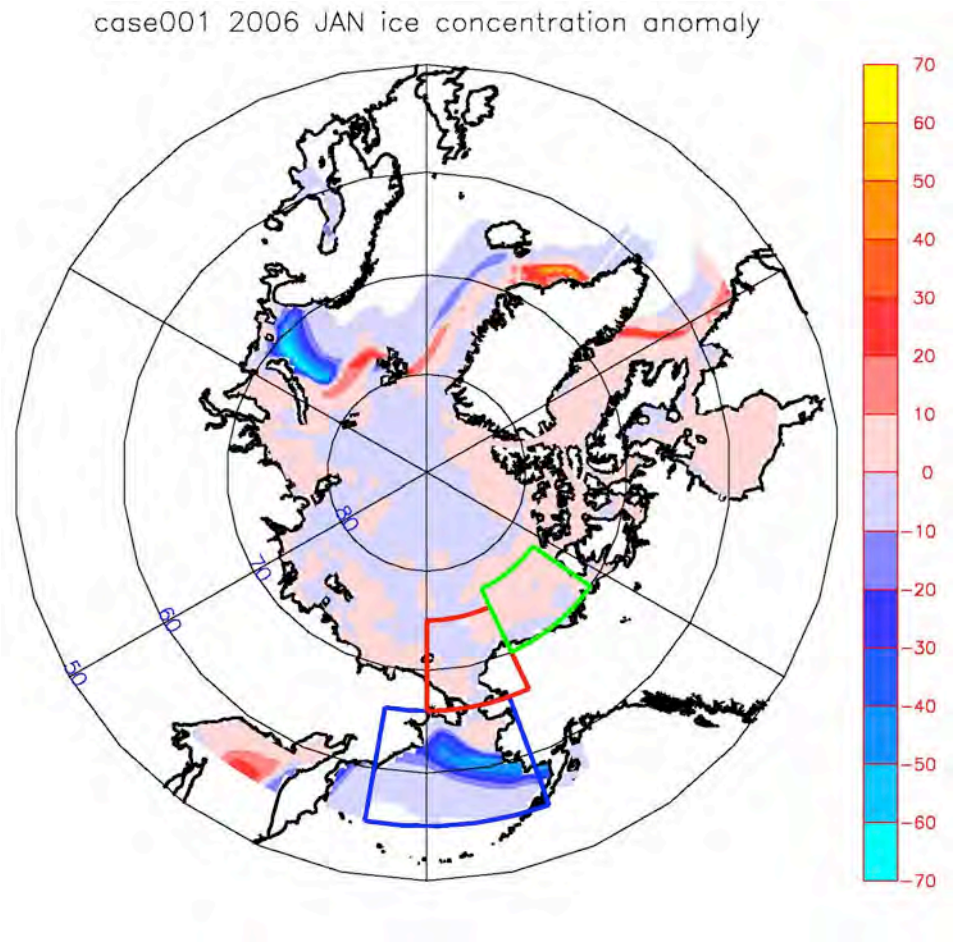


Figure 2. Blue, Red, and green boxes indicate the Bering, Chukchi, and Beaufort Sea domains respectively. Color shading shows ice area anomalies (percentage) in January 2006 of run member 001. The NCAR CESM large ensemble runs consist of 30 members for years 2006-2080 with monthly mean output data. Monthly anomalies for all members are obtained by removing the ensemble mean of each month from the monthly data.

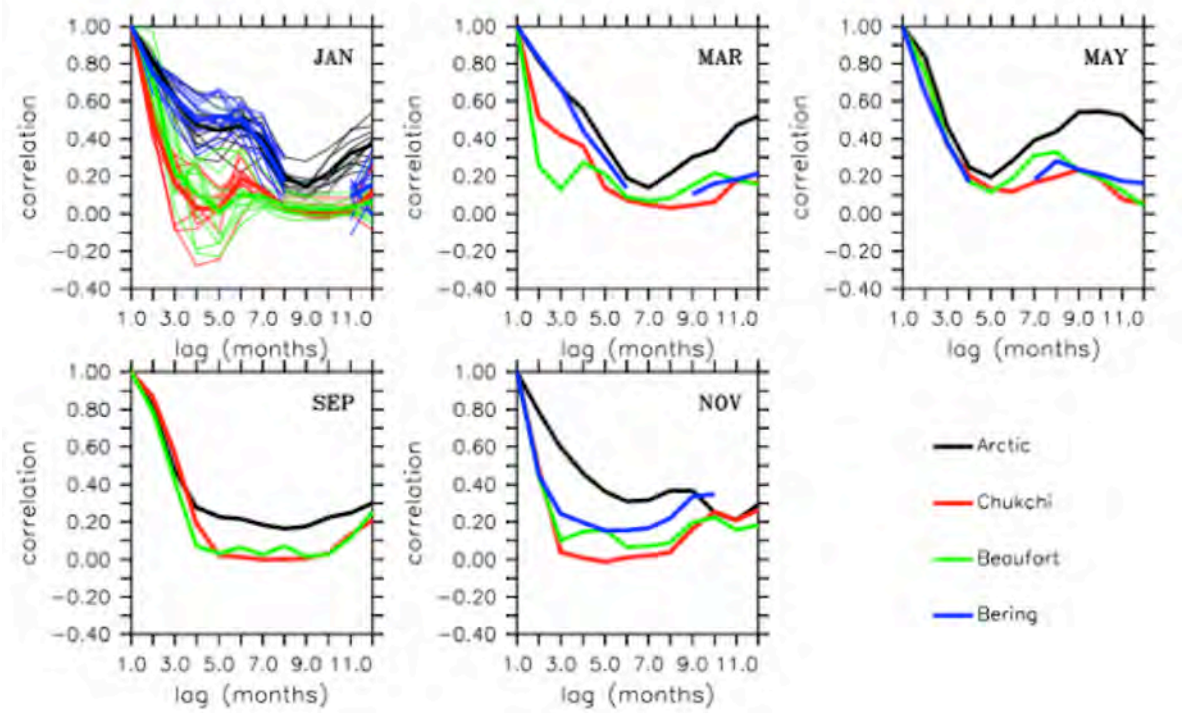


Figure 3. Autocorrelations of ice area averaged over the entire Arctic (north of 55°N) and the regional seas. The starting month of the calculation is marked on the panels, and the x-axis indicates the lag (in month) relative to the starting month. Colors correspond to different regions and the legend is shown on the bottom right. Thin lines in January plot correspond to the ensemble members and the thick lines correspond to the ensemble means. For clarity, individual ensemble member results are skipped in months other than January.

Satellite-derived climate data records of ocean-atmosphere exchange: Ocean surface bundle CDR

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Carol Anne Clayson - WHOI

NOAA Sponsor – Xuepeng Zhao - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

In this project we are developing the following CDR products: surface and near-surface parameters of wind speed, temperature, and humidity. These are derived from a combination of satellite observations, with a focus on the use of these variables towards determination of the air-sea turbulent heat fluxes.

This dataset is a follow-on to the CDR SeaFlux v 1 dataset, which currently covers the time period of 1988 through 2008, and the variables of sea surface temperature and 10-m temperature, wind speed, and specific humidity at a 3-hourly, 0.25º resolution over the global oceans. The current project is bringing the product short latency by adding in Special Sensor Microwave Imager/Sounder (SSMIS) data. Our goals include the completion of the colocation of the SSMIS and *in situ* data, testing issues relating to the channel changes, and resolving issues relating to changes in channel and resolution.

ACCOMPLISHMENTS

Under this funding, we have extended the original SeaFlux satellite data set, which was based on the SSM/I satellite data sets, to make use of the SSMIS satellite data. This required a number of adaptations of the original algorithm. In order to gain enough data for determination of the appropriate neural net weights, we used the ICOADS Value Added Dataset (IVAD). This dataset has greater error than the original research-quality measurements used for the SSM/I-based CDR, and required reanalysis. This included a new colocation analysis. We also had to develop a new methodology for addressing the channel change in the SSMIS (91 GHz) as compared to the SSM/I (85 GHz). This issue arises because the SSM/I had all channels at the same or reducible to the same resolution; SSMIS has samples for different channels at completely different locations that are not regularly spaced. These issues have been addressed.

In addition, we have updated the rain data and surface radiation data, as the datasets used with the SSM/I only dataset did not extend due to the current time period. As part of this we have replaced the HOAPS data with GPCP data and the previously used GEWEX radiation data have been exchanged for the CERES data. Given the new analysis methods and input data, we have produced a data set that is current through the end of 2014. This includes all the near-surface

properties of air temperature, humidity and winds, and sea surface temperature. Final fields of latent and sensible heat flux have also been produced.

HIGHLIGHTS

We have created a satellite-based dataset that is current through 2014. This is the first SSMIS-based dataset, which allows us to determine the air-sea state parameters and fluxes past 2008, to within six months of the current time.

SOCIETAL BENEFITS

Evaporation between the ocean and the atmosphere is the single largest source of water to the atmosphere, and drives the global scale atmosphere circulation. The flux of heat and momentum between the ocean to the atmosphere also drives the surface ocean circulation. They are also key in understanding changes in the upper ocean heat content. Determining the variability of these fluxes are important to understanding storms, atmospheric rivers, and other short and long-term weather and climate variability.

EDUCATION AND OUTREACH ACTIVITIES

Most notably, I highlighted the projection of this dataset into the near-real time at my plenary talk during the pan-GEWEX 7th International Scientific Conference on the Global Water and Energy Cycle. I (and others) have referred to the extension of the dataset in multiple talks at the recent AGU Fall Meeting and the AMS Annual Meeting.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

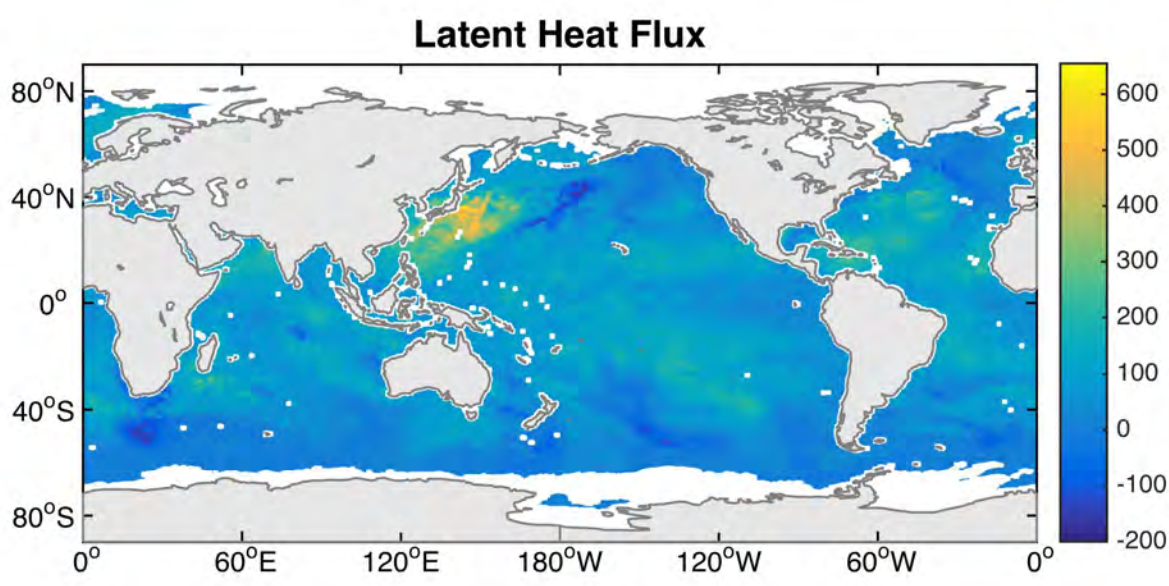


Figure 1. Sample field of latent heat flux from January 1, 2011 using initial (not final) neural network.

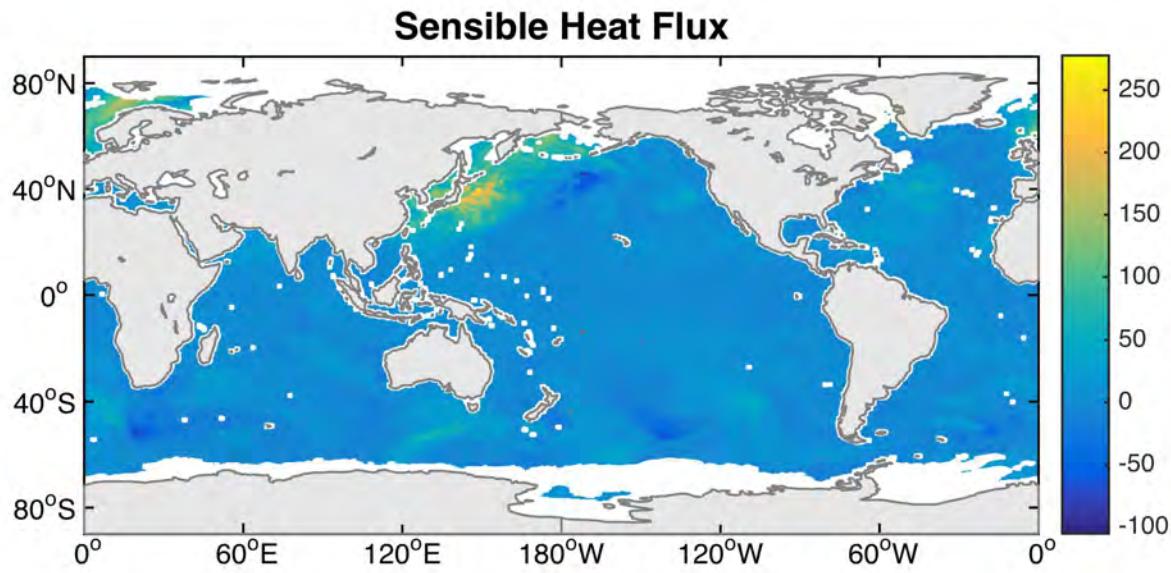


Figure 2. Sample field of sensible heat flux from January 1, 2011 using initial (not final) neural network.

Exploration of the Arctic Ocean with the Nereid under-ice vehicle

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Christopher German - WHOI

NOAA Sponsor – John McDonough - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The primary objectives of this proposal were two-fold: first, to conduct the first under-ice dives of the new hybrid ROV Nereid Under Ice (NUI) to evaluate its capabilities for polar ocean exploration and research - the work to be undertaken during a cruise of the German ship FS Polarstern to the Gakkel Ridge, Arctic Ocean, in July 2014; second, to use existing technologies provided by our German colleagues, while on station at the Gakkel Ridge, to explore for, and ideally locate, the first high temperature "black smoker" hydrothermal vents to be tracked to source in this ice-covered ocean. The project was implemented exactly as intended.

ACCOMPLISHMENTS

During the FS Polarstern cruise, four complete NUI dives were completed, ranging from a purely engineering dive NUI001 to fully scientific dives NUI 003 and NUI 004. During the course of the cruise, we demonstrated the viability of operating the vehicle under ice in both ROV and AUV mode (AUV based recoveries were achieved [required!] on three of the four dives when the optical fibre broke with the vehicle off-set from the ship and beneath multi-year ice cover). Other important engineering goals included the demonstration of operating the vehicle in fly-away mode from a research ship of opportunity and our ability to navigate under ice, including while conducting complex navigational surveys, so that data collected from beneath the sea-ice using NUI could be co-registered with on-ice and helicopter based surveys of key parameters from above the ice. Important scientific data sets were also collected from the NUI vehicle, using: the ROV's video and still image cameras (not least to record spectacular and surprisingly abundant animal life feeding off photosynthetic algae); the CTD and associated optical and biogeochemical *in situ* sensors to quantify the biogeochemical cycling processes driven by photosynthesis; radiance and irradiance measurements to quantify and characterize the amount and quality of light penetrating through the sea-ice to drive photosynthesis; and multibeam mapping of the under-side of the ice for co-registration with photo-mosaicing efforts. Results from this part of the work have already been presented at the AGU Fall Meeting in December 2014 and at a Gordon Research Conference on Polar Research (March 2015). Two peer-reviewed papers are already underway from the NUI work - one submitted to JGR Oceans discussing the through ice penetration and the other in preparation for submission to Deep Sea Research discussing the broader capabilities of the NUI vehicle for future science users.

The second part of our program was equally successful. Over the course of >20 CTD "drift-yo" casts and a further 16 deployments of the OFOS TV Camera (each of ~6h duration), we were able to successfully identify the presence of active submarine venting close to the summit of an axial volcanic ridge at the Aurora Field (near 6°W on the Gakkel Ridge), and with approximately 2h to spare at the end of the very final cast of the whole cruise, to obtain first video and still-camera documentation of active black-smoker venting - the first data of its kind anywhere in the Arctic. These results were also reported at the AGU Fall Meeting in December 2014 and are now being worked up, including data from the post-cruise shore based analyses conducted in Germany, for publication in a high impact peer-review journal.

HIGHLIGHTS

- First dives of the NUI vehicle under ice, in both ROV and AUV form, for engineering and science.
- Surprising discovery of abundant and diverse life immediately at/beneath the ice-ocean interface.
- Documentation of a spring bloom evolution over the course of four dives.
- Co-registered helicopter- and NUI-based lateral surveys of light transmission variability through ice.
- Discovery of first black smoker hydrothermal vents in the ice-covered Arctic Ocean.

SOCIETAL BENEFITS

The Arctic is changing rapidly, including shrinking of the ocean's multi-year ice cover. To better understand the impact that this will have on ocean biogeochemistry, we first need to understand the processes active in the pristine, undisturbed ice-ocean system - but this is impossible from an ice-breaker, which perturbs the natural environment faster than instrumentation can be deployed to study it. With the development of NUI we have demonstrated the potential to study the pristine environment, undisturbed and away from the support-ship ice-breaker, and in the very first deployments we made scientific observations that were new and surprising, and which could never have been made without the use of such a vehicle.

EDUCATION AND OUTREACH ACTIVITIES

Three presentations were made at the AGU Fall Meeting (L. Whitcomb et al. = engineering; C. German et al. = science capabilities of NUI; A. Boetius et al. = first hydrothermal vent discoveries), and a further presentation of all these results was subsequently made at the Gordon Research Conference on Polar Research in Italy in March 2015 by cruise Chief Scientist A. Boetius, AWI, Germany)

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

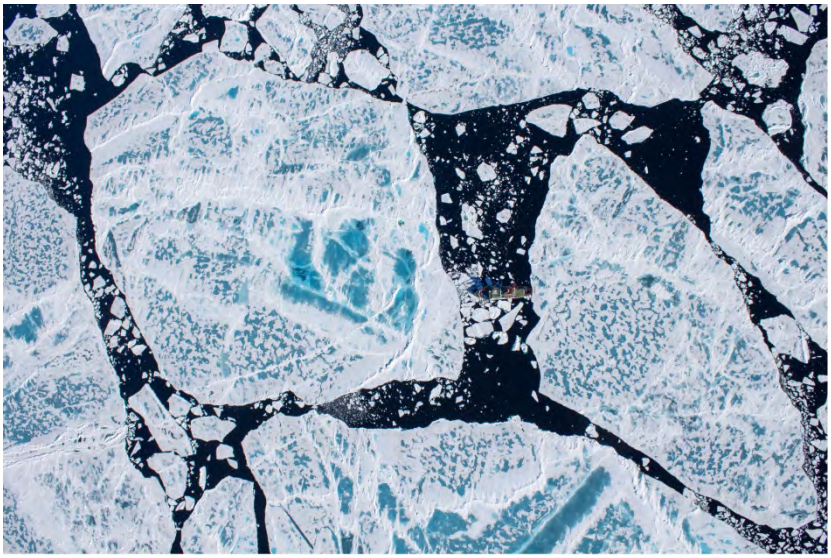


Figure 1. Aerial photograph of FS Polarstern on Station in the Arctic Ocean, July 2014. Photo credit: S. Arndt (AWI, Germany).

Figure 2. The NUI hybrid-ROV deployed in the ice-covered Arctic. Photo credit: C. German (copyright WHOI).

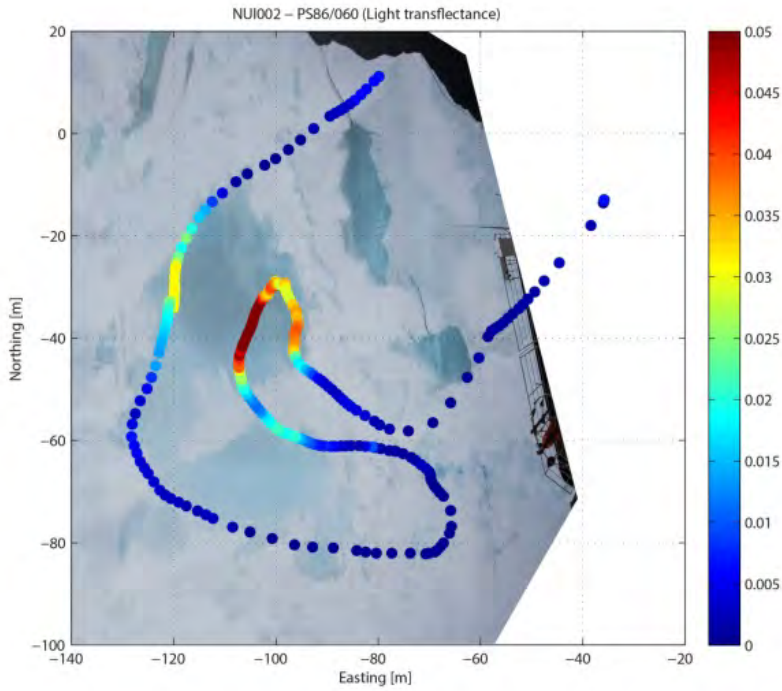


Figure 3. Co-registered aerial photograph of ice cover (white) and melt ponds (pale blue), together with co-registered light transmission data recorded by NUI, along co-registered under-ice dive-track during Dive 002. Note that light transmission increases beneath melt-ponds due to lensing effects. Image credit: C. Katlein (AWI, Germany).

Figure 4. Upward looking photograph of algal bloom accreted to the underside of the ice-ocean interface, and fuelled via through-ice photosynthesis. Image credit: NUI (copyright WHOI).

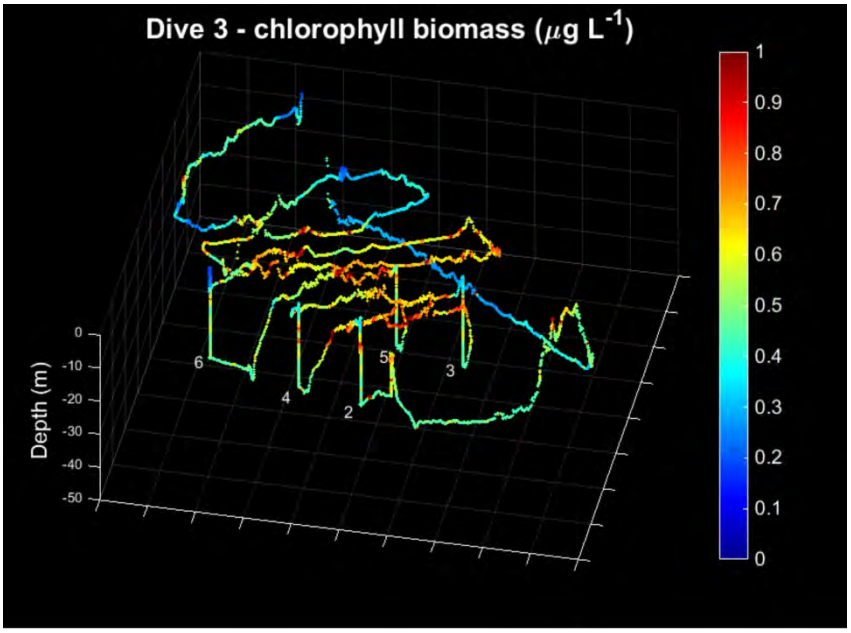


Figure 5. 3-D distributions of biomass mapped by chlorophyll sensor, NUI dive 003. Image credit: S. Laney (WHOI).

Figure 6. Video frame grab of abundant larvaceans, also during NUI dive 003. Image credit: NUI (copyright WHOI).

Pacific Arctic Group (PAG) Secretariat Office 2014-2015

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Jacqueline Grebmeier - UMCES

NOAA Sponsor – Kathy Crane - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Pacific Arctic Group (PAG) is a networked group of international institutes and individuals having a Pacific perspective on Arctic science. Originally organized under the International Arctic Science Committee (IASC), the now independent PAG has as its mission to serve as a Pacific Arctic regional partnership to plan, coordinate, and collaborate on science activities of mutual interest. The current PAG science themes are focused on the structure and function of Arctic ecosystems, including atmosphere, sea ice, oceanography, and modeling. NOAA is supporting efforts to maintain the PAG Secretariat Office at the Chesapeake Biological Laboratory/UMCES, and PI Grebmeier was elected Chair of the PAG in fall 2012 for a two-year term (until fall 2014). She currently continues on the PAG Executive Committee. The PAG Secretariat maintains a PAG list server of participants, organizes biannual PAG international meetings, and updates and maintains a PAG website (http://pag.arcticportal.org). The PAG activities are centered around networking oceanographic field activities in the Pacific Arctic region, coordinating the Distributed Biological Observatory (DBO) as an international time-series array of latitudinal transects in the region, and undertaking various synthesis activities to better understand and track ecosystem status and trends in the Pacific Arctic marine region. Currently the PAG is developing a networked Pacific Arctic Climate Ecosystem Observatory in the northern slope to basin regions of the Pacific Arctic undergoing the most rapid seasonal sea ice retreat.

ACCOMPLISHMENTS

- The PAG Secretariat provided logistical support for both the spring 2014 PAG meeting in Helsinki, Finland during the 2014 Arctic Science Summit Week and the fall 2014 PAG meeting in Seattle, WA for ~65 participants from the six countries focused on marine work in the Pacific Arctic: Canada, China, Japan, Korea, Russia, and the U.S. The PAG Secretariat prepared final meeting reports for these meetings that are publically available on the PAG website hosted by the Arctic Portal in Iceland (http://pag.arcticportal.org).
- The PAG has leadership for coordinating national and international sampling on the DBO that was developed as a “change detection array” to track biological response to sea ice retreat and environmental change. Repeat collections on standard transect lines from the northern Bering Sea to the northern Chukchi Sea include hydrography, plankton, benthic, and upper tropic level parameters, sampled opportunistically by multiple ships from May-

October. In addition, the DBO includes satellite and mooring data results to understand the full system.

- The PAG Secretariat personnel (Grebmeier and Bayard) organized the 2nd DBO Data Workshop that was held at the PMEL/NOAA in Seattle, Washington, October 29-31, 2014, with assistance from the local host, Dr. Sue Moore of NOAA. Over 50 participants from all PAG member countries participated in the workshop, with meeting presentations and final workshop report posted on the NOAA DBO website http://www.arctic.noaa.gov/dbo.
- PI Grebmeier was the lead editor for the PAG Synthesis volume entitled "*The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment*, 2014", published Springer, Dordrecht in June 2014, which included over 50 international authors.
- PI Grebmeier is currently co-editor for two PAG-endorsed scientific journal special issues: (1) the Korean Polar Research Institute (KOPRI) special issue of Deep Sea Research II describing scientific results of the RV ARAON Arctic program, and (2) the Japanese Arctic research special issue of *Biogeosciences* on Japanese Arctic research results in Pacific Arctic regions with rapid sea ice retreat.

HIGHLIGHTS

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

- The PAG Secretariat sponsored the 2nd DBO Data Workshop from October 29-31, 2014 at the PMEL/NOAA in Seattle, Washington in coordination with Dr. Sue Moore of NOAA. Over 50 participants from all the PAG member countries at the workshop, with the final report and presentations posted on the NOAA DBO website http://www.arctic.noaa.gov/dbo

- PI Grebmeier was the lead editor for the PAG Synthesis volume entitled "*The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment*, 2014", published Springer, Dordrecht in June 2014, which included over 50 international authors.

- The DBO is highlighted in NOAA's 2011 Arctic Vision and Strategy report, the 2013 U.S. National Strategy for the Arctic Region (NSAR) and 2014 NSAR Implementation Plans, the 2013 U.S. National Ocean Policy Implementation Plan, and is a task project within the Sustaining Arctic Observing Network (SAON) of the Arctic Council.

SOCIETAL BENEFITS

The PAG activities are focused on understanding the marine system in the Pacific Arctic sector in order to better understand the status and trends of the rapid sea ice change and ecosystem

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

EDUCATION AND OUTREACH ACTIVITIES

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

- Spring and fall 2014 PAG international meetings;
- December 2014, AGU invited talk on the DBO;
- April 2014, invited presentation on the PAG status and directions to the Forum of Arctic Research Operators (FARO) and European Polar Board (EPB) during the April 2014 Arctic Science Summit Week in Krakow, Poland, and on the DBO to the Marine Working Group of the IASC;
- April 2015, invited PAG presentations to FARO and on the DBO to the IASC Marine Working Group during the 2015 ASSW in Toyama, Japan; and
- PI Grebmeier was awarded the 2015 IASC Medal by the 23 member countries for her leadership in international science planning and overall science activities. She gave a 30 min lecture on her research during the April 2015 ASSW in Toyama, Japan.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

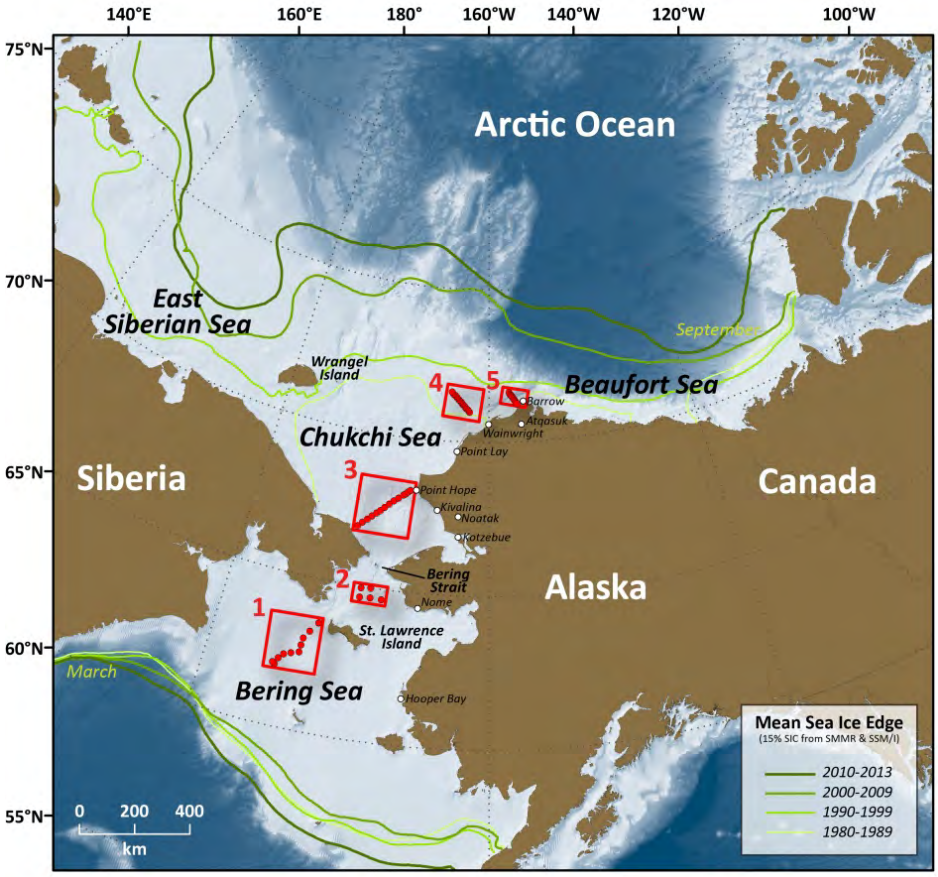


Figure 1. The Distributed Biological Observatory (DBO; http://www.arctic.noaa.gov/dbo) is a time series, biologically focused observatory in the Pacific Arctic region where international ships agree to sample standard measurements seasonally. The DBO is being coordinated through the Pacific Arctic Group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

Figure 2. Participants of the 2nd DBO Data Workshop held at PMEL/NOAA October 29-31, 2014 in Seattle, WA. The full workshop report is available on the PAG website http://pag.arcticportal.org.

Synthesis activities within the RUSALCA Program 2014-2015

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Jacqueline Grebmeier - UMCES

NOAA Sponsor – Kathleen Crane - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The Russian-American Long-term Census of the Arctic (RUSALCA) is a NOAA-sponsored program to document the long-term ecosystem health of the Pacific Arctic ecosystem, particularly as changes in various components are observed associated with climate forcing. Three full-scale ecosystem cruises were undertaken in August 2004**,** and August-September 2009 and 2012 in the Chukchi Sea (plus East Siberian Sea in 2009 only). Within the RUSALCA program our project objectives are to evaluate the benthic community structure and carbon cycling in the Pacific-influenced waters in the Amerasian Arctic. Our work is particularly focused on benthic biological communities and associated sediment chemistry. Some of our benthic findings indicate higher export of carbon in the southeast Chukchi Sea in areas of high primary production, and in areas around Wrangell Island and on the western side of Herald Canyon. We are also observing decadal changes in organic carbon processing and regional decline in benthic biomass at some time series sites in the southeast Chukchi Sea. As part of the RUSALCA effort, we have been involved in synthesis and publication activities. Currently we have multiple publications in progress with Russian colleagues that were developed during our recent trip to Moscow and St. Petersburg, Russia in February 2015.

ACCOMPLISHMENTS

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

with Russian collaborators for the special RUSALCA issue in Oceanography Magazine.

The following is a brief summary of select findings from field and synthesis activities that are part of ongoing manuscript preparations. First, the highest carbon export to benthos is coincident with highest areas of infaunal biomass (gC m-^{2}), indicating strong pelagic-benthic coupling. The dominant macrofauna are bivalves and polychaetes that are important prey to walrus, gray whales, and bearded seals. Highest macroinfaunal benthic abundance and biomass for all cruises was observed at the head of Herald Valley in the southeast Chukchi Sea in the known DBO3 "hotspot" of *Macoma* bivalves that extends across the US-Russian boundary, with biomasses ranging from 30 to ~100 gC m^{-2} (Fig. 1, left and right panels).
The southeast Chukchi Sea provides important foraging areas for both walrus and gray whales that are known to forage in this hotspot seasonally due to high biomass levels of benthic prey (Grebmeier et al. 2015). This hotspot is maintained by export of high chlorophyll *a* that is produced locally as well as advected by Pacific water masses transiting northward through the system. Notably, the center of the highest benthic biomass regions has shifted northward in the DBO3 line occupied during the RUSALCA program (Grebmeier, pers. obs.). This northward shift has coincided with changing sediment grain size, an indicator of current speed, and is also likely a response to changes in primary production in the region.
Sediment metabolism studies that measured sediment community oxygen respiration indicate that the highest rates of oxygen utilization (and related organic carbon export to the benthos) consistently occurred in the southeast Chukchi Sea hotspot site, where we also have observed high biomasses of bivalves and polychaetes (Fig. 2). Seawater O-18 measurements indicate an increased level of sea ice melt in surface waters in 2012, with the coincident observed major sea ice retreat compared to more riverine influenced surface waters in 2004 (Fig. 3). Sediment stable carbon isotopes indicate marine (offshore) versus terrestrial (inshore) influenced carbon content. In addition, sedimentation rates vary from low values in high current regimes (Herald Canyon) to moderate deposition rate in Long Strait; bioturbation also impacts the profiles.

HIGHLIGHTS

- Highest observed infaunal benthic biomass was observed at the head of Herald Valley in the southeast Chukchi Sea, in the known "hotspot" of *Macoma* bivalves that extends from across the U.S.-Russian boundary, with values ranging from 30 to ~100 gC m^{-2} (Fig. 1).
- Lowest observed macroinfaunal biomass (0-10 gC m^{-2}) occurred towards the northwest and offshore to the northern most stations, with the lowest biomass in coastal areas (Fig. 1).
- Dominant infauna: bivalves and polychaetes are important prey to walruses, gray whales, and bearded seals.
- Persistent productivity of the Anadyr Water north of Bering Strait is tied to tight pelagic-benthic coupling between the upper water column production zone and underlying benthos during annual primary production and deposition events (Fig. 2).
- Sediment stable carbon isotopes indicate marine versus terrestrial influenced carbon on the Chukchi continental shelves.
- Sedimentation rates vary from low values in high current regimes (Herald Canyon) to moderate deposition rate in Long Strait; bioturbation has an impact on profile shape.
- Sediment grain size data can act as an indicator of current speed. Results from the three RUSALCA cruises indicate a reduction of current speed and coincident deposition of fine

silt and clay sediment (high %≥5 phi) in a northwest direction from the Bering Strait down the Herald Valley and the Herald Canyon northward to the slope in all cruises.
- Sandy sediments (low % silt/clay) are found along the Alaskan and Chukotka coastline.
- Shift is O-18 values in seawater from 2004 to 2012 related to increasing sea ice melt in the surface water (Fig. 3).

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

Reports from the cruises of research activities and photos are available for both the 2009 and 2012 cruises through NOAA's Ocean Exploration program: http://oceanexplorer.noaa.gov/explorations/12arctic/logs/sept13/sept13.html

Results of all aspects of the RUSALCA program were presented at the 2014 RUSALCA PI meeting in Honolulu, Hawaii, U.S., and new summaries of activities and findings across all RUSALCA cruises are available on the NOAA RUSALCA website: http://www.arctic.noaa.gov/aro/russian-american/. We are also cross-linking RUSALCA data at the southeast Chukchi Sea DBO3 line for the DBO observing project http://www.arctic.noaa.gov/dbo/. We have also made presentations at the 2014 ASLO Ocean Sciences meeting and AGU fall meeting that included RUSALCA data.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

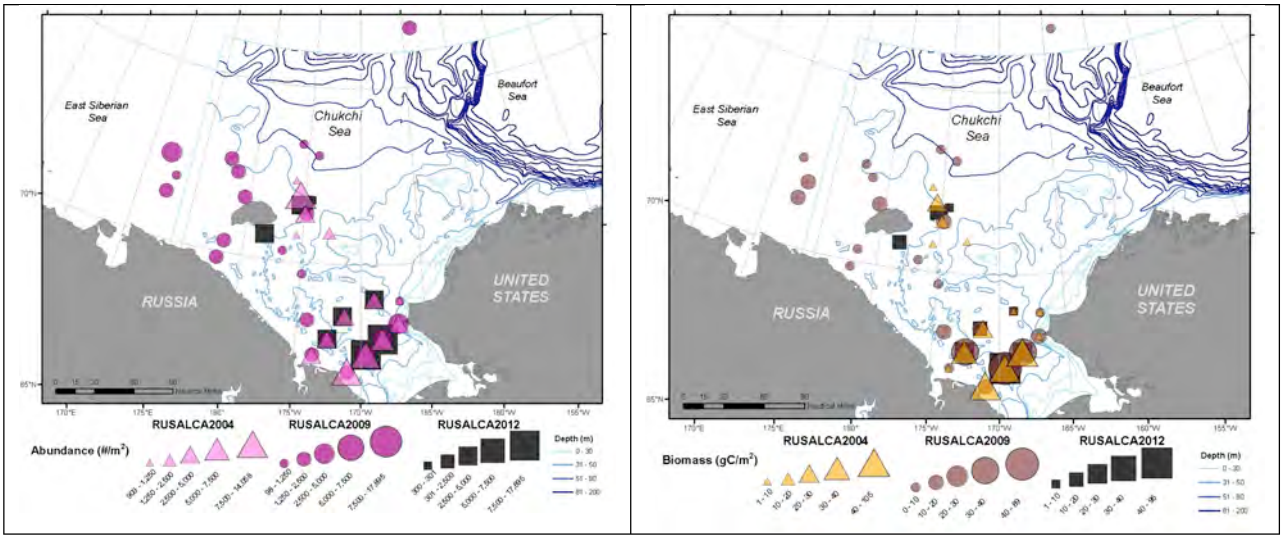


Figure 1. Distribution of benthic macroinfaunal abundance (left panel) and biomass (right panel) during the RUSALCA 2004, 2009, and 2012 cruises.

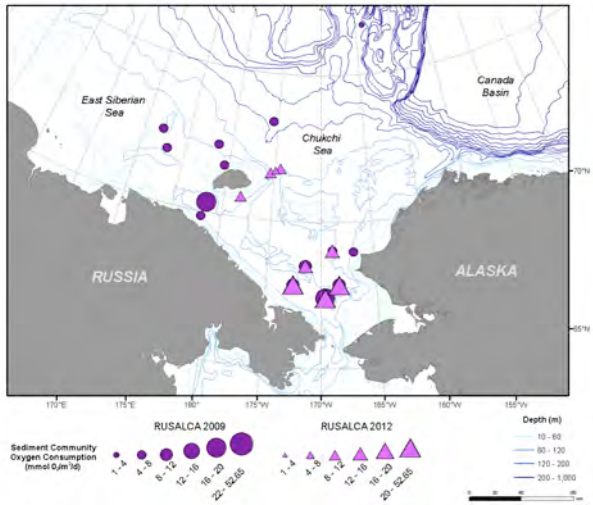


Figure 2. Sediment community oxygen consumption (mmol O_2 m^{-2} d^{-1}) from RUSALCA 2009 and 2012.

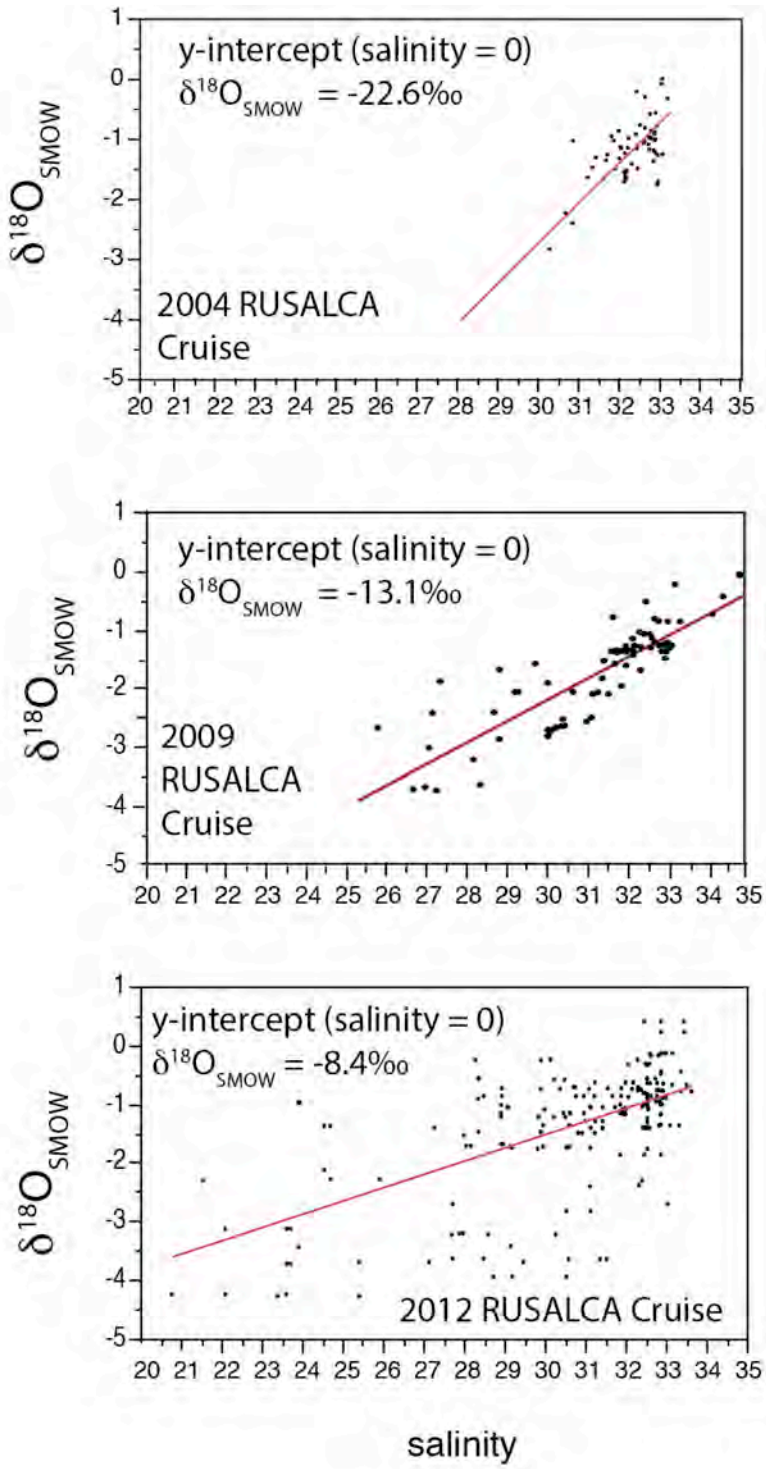


Figure 3. Oxygen-18 versus salinity relationships for the 2004, 2009, and 2012 RUSALCA cruises showing a shift in the freshwater end-member from a runoff-dominated system in 2004 (freshwater $d^{18}O$ = ~-22.6‰) to one dominated by melted sea ice in 2012 (freshwater $d^{18}O$ = ~ -8.4‰).

WHOI contribution to the ARGO Float Program (2014-2015)

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Steven Jayne - WHOI

NOAA Sponsor – Steven Piotrowicz - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

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

The U.S. is expected to provide one-half of the array, and the WHOI component of the Argo float program represents approximately 15% of the array.

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

ACCOMPLISHMENTS

This project covers WHOI's contribution to the Argo float program. During the project period, 67 WHOI floats were launched. We presently have an inventory of 9 SOLO-I floats and an inventory of 10 SOLO-2 floats. During the past year, a maximum of 328 and a minimum of 303 WHOI floats have been active, and 134,681 profiles have been inserted into the Argo data system. In the past year, we also continued our efforts to increase the number of Argo floats in the Gulf of Mexico and Caribbean.

Of the over 134,000 profiles provided by the WHOI floats, more than 75% have been reviewed, quality controlled, and had their salinity adjusted. In addition, a new GUI editor has been developed for carrying out quality control on the float profiles. This new editor, which uses MATLAB, is a significant improvement over an earlier one used by the Argo community, and uses the embedded NetCDF function calls that are now available in the latest versions of MATLAB. This code has been migrated to other Argo delayed mode quality control

operators. In collaboration with Annie Wong from the University of Washington, we also continue to maintain the software that is used by the Argo community to calibrate the conductivity sensors on the floats.

HIGHLIGHTS

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

SOCIETAL BENEFITS

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

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

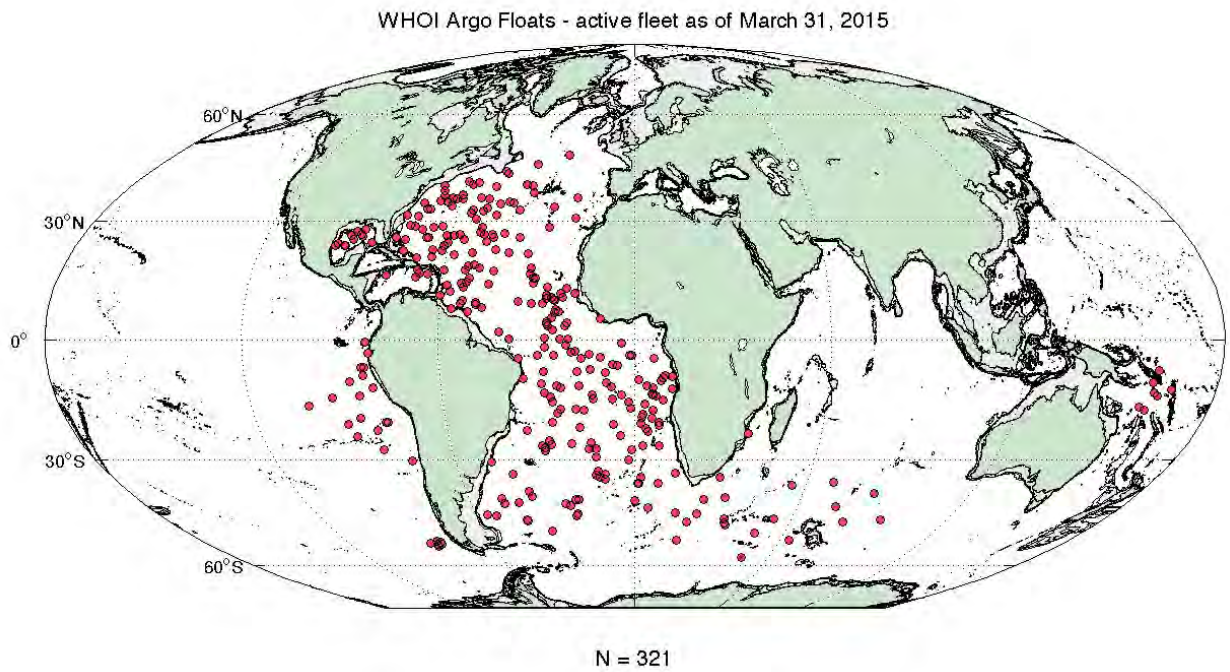


Figure 1. WHOI active floats as of March 31, 2015.

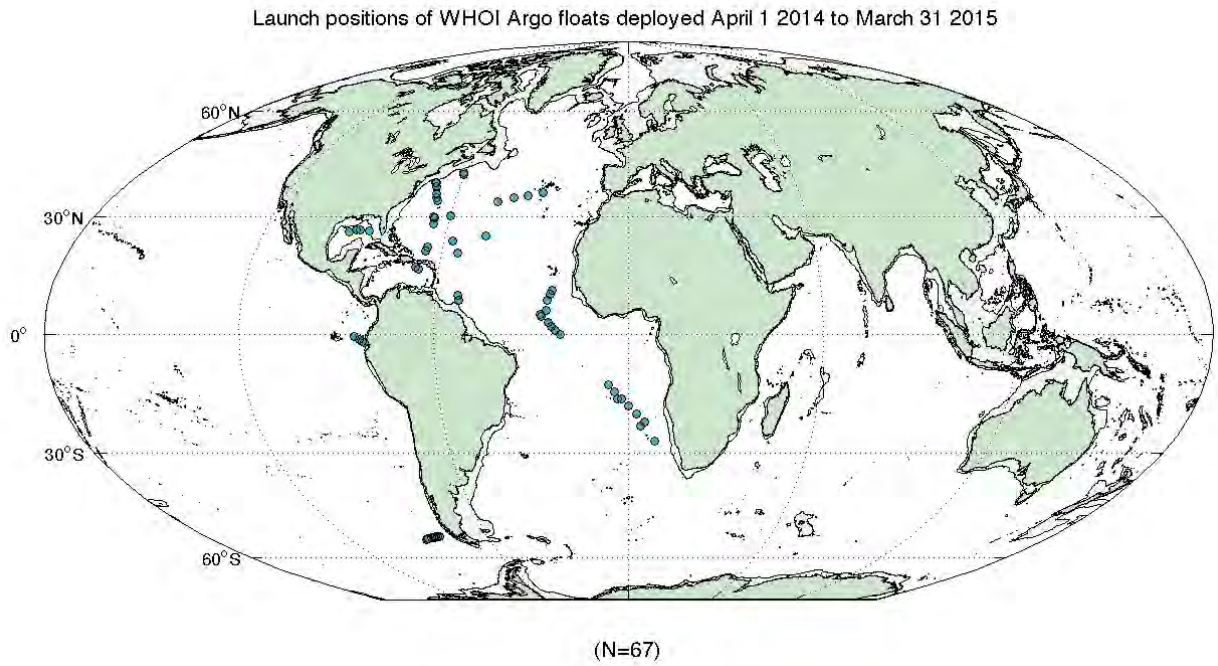


Figure 2. Launch positions of WHOI floats during the past year.

The impact of ocean acidification on larval sea scallops (Placopecten magellanicus) and possible mitigation by feeding: An initial experimental study

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Daniel McCorkle - WHOI

NOAA Sponsor – Elizabeth Jewett - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

Original objectives and plans

We proposed an experimental study at WHOI, in collaboration with colleagues at the NOAA-NMFS Milford, CT lab, to quantify the impact of ocean acidification (OA) on the early development of the sea scallop, and to assess the influence of food availability on this OA impact. Our goal was to build on our previous work with other species, and test two hypotheses for *Placopecten magellanicus*:

1. Lower pH and aragonite saturation state will elevate mortality, and reduce the growth rate of surviving larvae, and
2. Well-fed larvae in low-pH, low-Ωar conditions will experience reduced mortality and elevated growth rates compared with less well-fed larvae reared in the same CO_2 conditions.

The experiment was to run for approximately two weeks, and to use two CO_2 levels (ambient and enriched, targeting Ωar values of 2.2 and 0.8, to span the saturation state levels observed in sea scallop habitat today and projected levels in the coming decades), and three feeding levels.

Changes in actual 2014 research

It was determined that the available adult sea scallops would not be ready to spawn until August, 2014. In order to provide a research project for an undergraduate Summer Student Fellow (Cailan Sugano, UC Santa Barbara), we carried out a bay scallop (*Argopecten irradians*) $CO_2 \times$ feeding rate experiment in June and July, and then carried out an initial sea scallop $CO_2 \times$ feeding experiment in August. The bay scallop experiment built on our previous $CO_2 \times$ feeding experiments with surf clams, and on previous CO_2-only experiments (without a feeding rate treatment) that had been carried out by Meredith White, a graduate student in our lab. In addition to shell size data (determined from SEM images), Sugano also developed a "shell deformity" index, which revealed a strong impact of CO_2 on the early development of bay scallops.

ACCOMPLISHMENTS

Both 2014 experiments were successful. The bay scallop experiment was exciting because the impact of elevated CO_2 on the frequency of shell deformities was striking; this had not been observed in our previous work with surf clams. The sea scallop experiment was also exciting, first simply because this species is notoriously difficult to culture, and second because we observed significant CO_2 effects and feeding rate effects on early sea scallop growth. Details regarding these experiments are provided below.

In the first experiment, we investigated the impact of ocean acidification (OA) and food supply on larval development of the bay scallop *Argopecten irradians*. Bay scallop larvae were reared from three hours post-fertilization to seven days old under a combination of two CO_2 levels and two feeding rates. Elevated pCO_2 had significant negative impacts on growth (shell length and prodissoconch II growth) at both low and high feeding rates, and a low feeding rate reduced growth at both CO_2 levels. The two stressors showed no interaction – low food supply did not cause increased sensitivity to elevated pCO_2. However, well-nourished larvae reared in high CO_2 conditions grew as fast as undernourished larvae reared at ambient CO_2 levels, and grew faster than larvae from the low-food high-CO_2 treatment. The frequency and severity of shell deformities increased dramatically with elevated CO_2, and this effect *was* moderated by feeding rate; high food supply reduced the frequency of shell deformities by a factor of two. Our results confirm the negative impact of acidification on early development of bivalve larvae and highlight the role of nutritional status on larval growth. Efforts to improve forecasting of near-shore OA and net primary productivity (NPP) changes over the course of this century, combined with laboratory manipulation experiments, will greatly improve projections of shellfish futures. These results were presented in a talk by Cailan Sugano at the National Shellfisheries Association meeting in Monterey, CA, in March 2015.

The sea scallop experiment also had two CO_2 levels and two feeding rates. Mortality was relatively high, and the experiment was terminated after four days in order to guarantee sufficient specimens for imaging and analysis. Even after that relatively short exposure to the treatments, significant differences in shell length were observed: analysis of variance (ANOVA) suggests significant CO_2 and feeding rate effects on shell size at four days, and a marginally significant interaction of CO_2 and feeding rate. This first experiment was far from definitive, but it demonstrates that this species can be cultured under the range of conditions needed to assess the likely impacts of climate-change related stressors in the 21st century.

HIGHLIGHTS

Experiments using bay scallops demonstrated that:

- High food supply resulted in increased shell size at both pCO_2 levels;
- Elevated pCO_2 significantly reduced shell size at both feeding rates; and
- The frequency of shell-shape deformities was strongly linked to pCO_2 (high deformities at high pCO_2), and only weakly linked to feeding rate.

Experiments using sea scallops demonstrated that:

- We were able to successfully spawn this species, and grew larvae to 93 hours post-fertilization;
- Elevated pCO_2 has a significant negative impact on shell size; and
- High feeding rates have a positive impact on shell size.

The bay scallop works suggests that quantifiable shell-development data (e.g., frequency of deformities) will be a valuable metric for the impact of stressors such as elevated pCO_2 levels and reduced food supply, and perhaps elevated temperature.

SOCIETAL BENEFITS

The larval stages of two commercially important shellfish species, bay scallops and sea scallops, showed significant negative responses (growth, shell development) to elevated CO_2, and also showed a positive response to feeding rate. Both of these environmental factors are likely to shift in the decades ahead (higher CO_2, and in some regions, lower food supply), and both need to be considered in models of recruitment and fisheries yield.

EDUCATION AND OUTREACH ACTIVITIES

- Research project for WHOI summer student fellow Cailan Sugano (UC Santa Barbara).
- Research project for NOAA-NMFS undergraduate intern Brittany Flittner (University of Rochester, mentored by NOAA-NMFS colleague Dr. Lisa Milke).
- Sugano presented his results at the National Shellfisheries Association meeting in Monterey, CA, in March 2015. (Oral presentation; student first author)
- McCorkle presented a talk on our 2012 surfclam $CO_2 \times$ feeding rate experiments at that same meeting (NSA, March 2015).
- McCorkle presented a talk on coastal acidification at a briefing for congressional staff members, sponsored by the National Association of Marine Laboratories (October 2014).
- Cohen and McCorkle both appeared in a recent NOVA program on ocean acidification, “Lethal Seas” (May 2015).

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS

Figure 2. SEM images of 3-day-old sea scallop larvae from our 2014 test experiment; top, ambient pCO_2 high food; bottom, 2200 ppmv pCO_2 high food.

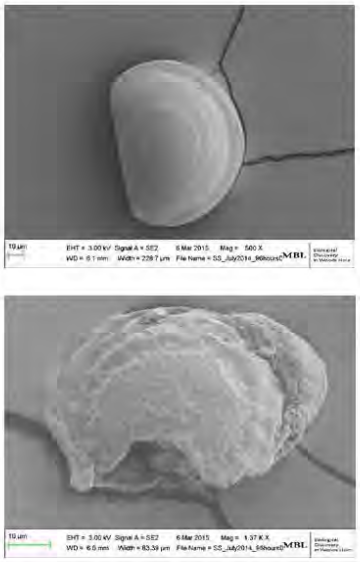
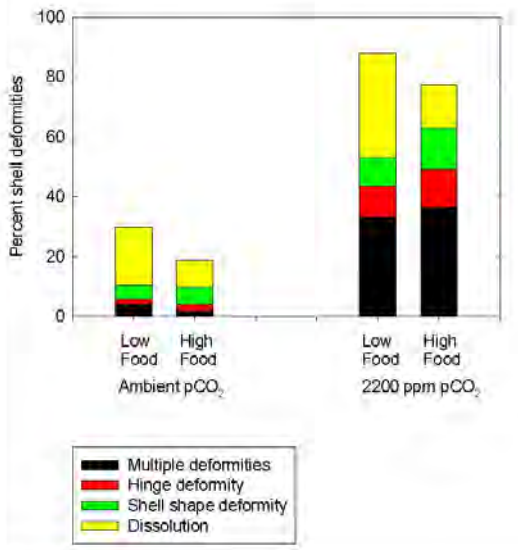


Figure 3. Shell deformities in 7 day old larval bay scallops (Sugano et al., 2015). Elevated pCO_2 causes a dramatic increase in shell deformities.



Climate adaptation in fishery ecosystems

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigators – Andrew Pershing and Kathy Mills - GMRI

NOAA Sponsor – Roger Griffis - NMFS

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

As the impacts of climate change and variability become apparent in fishery ecosystems, there is a critical need for strategies that enable climate adaptation in marine fisheries. Advances towards climate adaptation have been less developed for fisheries than for other sectors, such as agriculture, water resources, and coastal management. Our project is developing frameworks for climate adaptation that will enable fishery managers, fishing industry, and fishing communities to plan for future risks and opportunities.

The project will work towards this goal through two specific objectives:

1. Organizing an international working group on Climate Adaptation in Fisheries Ecosystems (CAFE) to compare climate impacts and adaptation approaches with rapidly changing ecosystems with different fisheries and fishery management regimes.
2. Piloting and refining a social-ecological vulnerability assessment and adaptation planning framework for marine fisheries.

We have taken a major step towards work associated with Objective 1 by running a workshop at the 3rd international symposium on the Effects of Climate Change on the World's Oceans, as further described below. We will be using insights gained from this workshop as we begin our work towards Objective 2 of this project in the next month.

ACCOMPLISHMENTS

To date, this project has made progress on Objective 1 by organizing and facilitating a workshop on "Moving Towards Climate-Ready Fishery Systems" at the 3rd international symposium on the Effects of Climate Change on the World's Oceans (March 21-22, 2015). The workshop brought together 44 scientists from the US, Australia, New Zealand, Norway, the UK, Canada, Brazil, and Cambodia to compare experiences in climate impacts and adaptation across four fishery ecosystems (eastern Australia, Gulf of Alaska, Gulf of Maine, and Nordic Seas) that are experiencing rapid changes. Specifically, discussions identified:

1. key elements of climate change adaptation,

2. How these elements as well as other contextual factors shape adaptation approaches in different situations and at different scales, and advances that are needed to support climate adaptation in marine fisheries.

We are now developing a synthesis paper that integrates insights into these topics gained from the workshop and that we hope will serve as a road map for future climate adaptation efforts. Specific take-away messages include:

- Increasing temperatures are impacting fisheries around the world, and we are starting to see examples of fishermen, management bodies, and governments adapting to these changes. Most examples are reactionary or autonomous, not directed or strategic. We also see examples where adaptation has not kept pace with the rate of environmental change.
- We are now living in a world where the past is not a suitable analogue for the future, and we need to begin climate adaptation planning with an eye towards near-term and long-term objectives and needs of scientists, managers, fishermen, and the fishing industry. The pressing challenges mean that we cannot wait for perfect tools, but need to work with our existing tools while building towards improvements.
- There is a critical need to identify and test drive some key tools and approaches for climate-ready fisheries management. We need to identify the core ingredients for effective fisheries management under a variety of climate scenarios - and develop the science and communication tools to have these accepted and used by fisheries managers and fishery-dependent sectors and communities.
- Movement of fish across jurisdictional or management boundaries is especially challenging. There is considerable work to do to ensure sustainable management of emerging fisheries and to help develop allocation strategies that meet conservation and social goals.
- Successful adaptation requires strong participation and collaboration from all stakeholders. It will be critical to assess impacts and solutions across the entire fishing system: fishers, managers, processors and other stakeholders at local, regional, and international scales.
- As global population increases, discussions of adaptation will increasingly take place in the context of food security, in addition to the current focus on sustaining fisheries as we know them and preserving their economic value.

HIGHLIGHTS

- CINAR supported GMRI scientists Kathy Mills and Andy Pershing to organize a workshop on "Moving Towards Climate-Ready Fishery Systems" at the 3rd international symposium on the Effects of Climate Change on the World's Oceans. The workshop used a comparative approach to identify ingredients, approaches, and advances needed to support climate adaptation in marine fisheries. The results will appear in an upcoming synthesis paper.

SOCIETAL BENEFITS:

This project will advance the capacity to understand climate-related risks and adaptation strategies for marine fisheries. Our work to date has developed a global perspective on approaches to climate adaptation in marine fisheries and advances that are needed to support further adaptation and preparedness. We will now apply these global insights to develop a framework that can be applied locally to enable fishery managers, industry participants, and fishing communities in the Northeast to understand climate-related risks and to plan for how they will respond to climate impacts.

EDUCATION AND OUTREACH ACTIVITIES

Mills, K. E. and A. J. Pershing. 2015. Cross-scale interactions in coupled social-ecological systems: An organizing framework for assessing climate impacts and adaptation in marine fisheries. Third international symposium on the Effects of Climate Change on the World's Oceans. Santos, Brazil. March 21, 2015.

Pershing, A. J., K. E. Mills, C. M. Hernandez, L. Kerr, and G. Sherwood. 2015. Slow management during rapid ecosystem change or how rapid warming drove the collapse of Gulf of Maine cod. Third international symposium on the Effects of Climate Change on the World's Oceans. Santos, Brazil. March 21, 2015.

Mills, K. E. and A. J. Pershing. 2015. Fisheries adaptation spurred by the 2012 Northwest Atlantic ocean heat wave. Third international symposium on the Effects of Climate Change on the World's Oceans. Santos, Brazil. March 21, 2015.

FIGURES/PHOTOS/ILLUSTRATIONS

Participants in workshop "Moving Towards Climate-Ready Fishery Systems" at the 3rd international symposium on the Effects of Climate Change on the World's Oceans, March 21-22 in Santos, Brazil. Workshop leads, Roger Griffis (NMFS), Andy Pershing (GMRI), Alan Haynie (Alaska Fisheries Science Center), Gretta Pecl University of Tasmania), and Kathy Mills (GMRI) are in the front row.

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

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Robert Pickart - WHOI

NOAA Sponsor – Kathleen Crane - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

In 2012 a program called the Distributed Biological Observatory (DBO) was started in the Pacific sector of the Arctic Ocean. The goal of the DBO is to document and understand the changing ecosystem in the Bering and Chukchi Seas and determine the physical drivers responsible for those changes. Five priority regions were identified across the latitudinal extent of the domain, and ships of opportunity occupy transects within the regions and collect measurements in the water column, sediments, and sea-ice as time and logistics permit. The implementation of the DBO has required significant coordination and communication, and the Pacific Arctic Group (PAG) continues to help lead this effort. To date, five years of DBO data have been collected (2010-14) and NOAA is funding the initial scientific analysis of a portion of the data. The goal of the present project is to analyze the collection of DBO transects across Barrow Canyon (DBO line 5) to characterize the water masses in the canyon, document the seasonal evolution, and determine the role of wind forcing in dictating the conditions in the canyon.

ACCOMPLISHMENTS

The study focuses on the DBO-5 transects collected between 2010-14. The seasonal coverage of data is roughly evenly distributed over the months of July to October, and the interannual distribution of occupations is also fairly uniform. The conductivity-temperature-depth (CTD) data have been used to identify the different water masses in the canyon and how they vary geographically through the summer and fall. Vertical sections of various properties (potential temperature, salinity, potential density, buoyancy frequency) were constructed on a standard grid and are presently being analyzed. Using the wind record from the Pt. Barrow meteorological station, together with water column data from the adjacent basin, we are exploring the relationship between the atmospheric forcing and the manner in which Atlantic water is upwelled into the canyon. We are also investigating the injection of Pacific-origin water into the basin.

HIGHLIGHTS

- There is a pronounced seasonality in the water masses found in Barrow Canyon through the summer and fall. Newly ventilated winter water (the coldest and densest Pacific water

mass observed in the canyon) is present predominantly in August. This is a reflection of the slow pathway on the central shelf that brings this high-nutrient water into the canyon.

- The Alaskan coastal water, which is responsible for melting ice in the basin, becomes warmer through September, then abruptly cools in October likely because of atmospheric cooling and wind mixing.
- Atlantic water is found in the canyon almost exclusively in September. This is likely due to wind-driven upwelling, although it is not obvious why this process should diminish in October. This is presently being investigated.

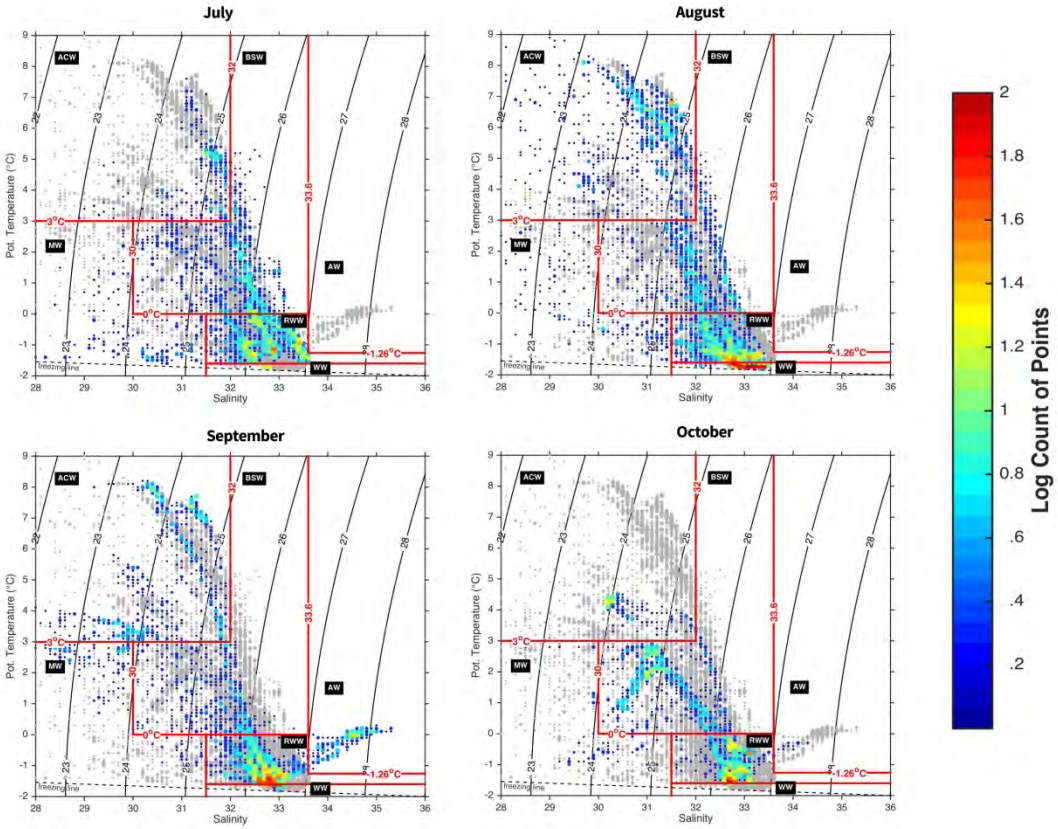
SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

The results (to date) of this study were presented at the 2014 Pacific Arctic Group meeting.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS



This figure shows the evolution of water masses in Barrow Canyon from July to October using the DBO-5 transect data. The colored dots denote the amount of each water mass present (in counts). The grey dots show all the data. The different water masses are delineated by the red lines. ACW = Alaskan coastal water; BSW = Bering Sea water; WW = newly ventilated Pacific winter water; RWW = remnant Pacific winter water; AW = Atlantic water; MW = sea ice melt water.

The western Chukchi Sea: Physical drivers and biological and geochemical responses

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Robert Pickart - WHOI

NOAA Sponsor – Kathleen Crane - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

The overall goal of the Russian-American Long-term Census of the Arctic (RUSALCA) program is to document and understand the ecosystem response of the Pacific sector of the Arctic Ocean to the pronounced recent changes in climatic forcing. The broad-scale component of RUSALCA included a series of multi-disciplinary cruises sampling the water column and benthos of the Chukchi Sea (and eastern portion of the East Siberian Sea). To date there have been three broad-scale surveys: in August 2004, September 2009, and September 2012. Presently we are in the synthesis stage, bringing together the various data sets to understand how this important ecosystem functions – and how it might react to the changing environmental conditions. Our study aims to relate the physical drivers on the shelf, including the circulation, atmospheric forcing, and sea-ice concentration, to different components of the biological system, including the benthic community and water column distributions of nutrients, chlorophyll, and zooplankton.

ACCOMPLISHMENTS

A study of the circulation of the western Chukchi Sea was completed. The 2009 RUSALCA hydrographic, chemical, and velocity data were used to characterize the water masses and flow paths during the survey period. This was then compared to historical data from the World Ocean Data Base to assess to degree to which September 2009 was representative. Reanalysis fields from NARR along with mooring data from Bering Strait were used to assess the atmospheric forcing and upstream influences from the Bering Sea. It turns out that September 2009 was an exceptionally windy month, which resulted in anomalous hydrographic conditions over a large portion of the western shelf (Figure 1). A simple numerical model was used to shed light on the dynamics of the flow that led to the observed water mass distributions. This work was submitted for publication in Deep-Sea Research I.

In addition to the above analysis, a synthesis study was initiated to better understand the relationship between the physical drivers on the shelf and the observed patterns of sediment grain size, benthic diversity/biomass, and water column zooplankton. During the fall, the lead investigators for each of the above components visited WHOI, shared their data, and together we delved into the various relationships among these different parts of the ecosystem. We are also

using numerical model output from RUSALCA PIs to help flesh out the links between the physics and biology.

HIGHLIGHTS

The strong northeasterly winds in September 2009 caused a transposition of the water masses in Bering Strait, such that Alaskan coastal water switched to the Russian side of the strait and subsequently flooded the western portion of the shelf, all the way into Herald Canyon. By considering the cumulative Ekman Flux and invoking a simple numerical model, it was shown how the secondary circulation in the strait caused this transposition and why the entire shelf was impacted. Among other things, this process alters the distribution of heat and freshwater in the Chukchi Sea, which in turn will influence sea ice melt and freshwater export to the basin.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

The study of the Chukchi shelf using the 2009 data was presented at the annual Pacific Arctic Group meeting and in a seminar at WHOI.

A guest student, Maria Pisareva from Shirshov Institute of Oceanology in Moscow, visited WHOI for seven months to complete the Chukchi shelf study and begin the synthesis study.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

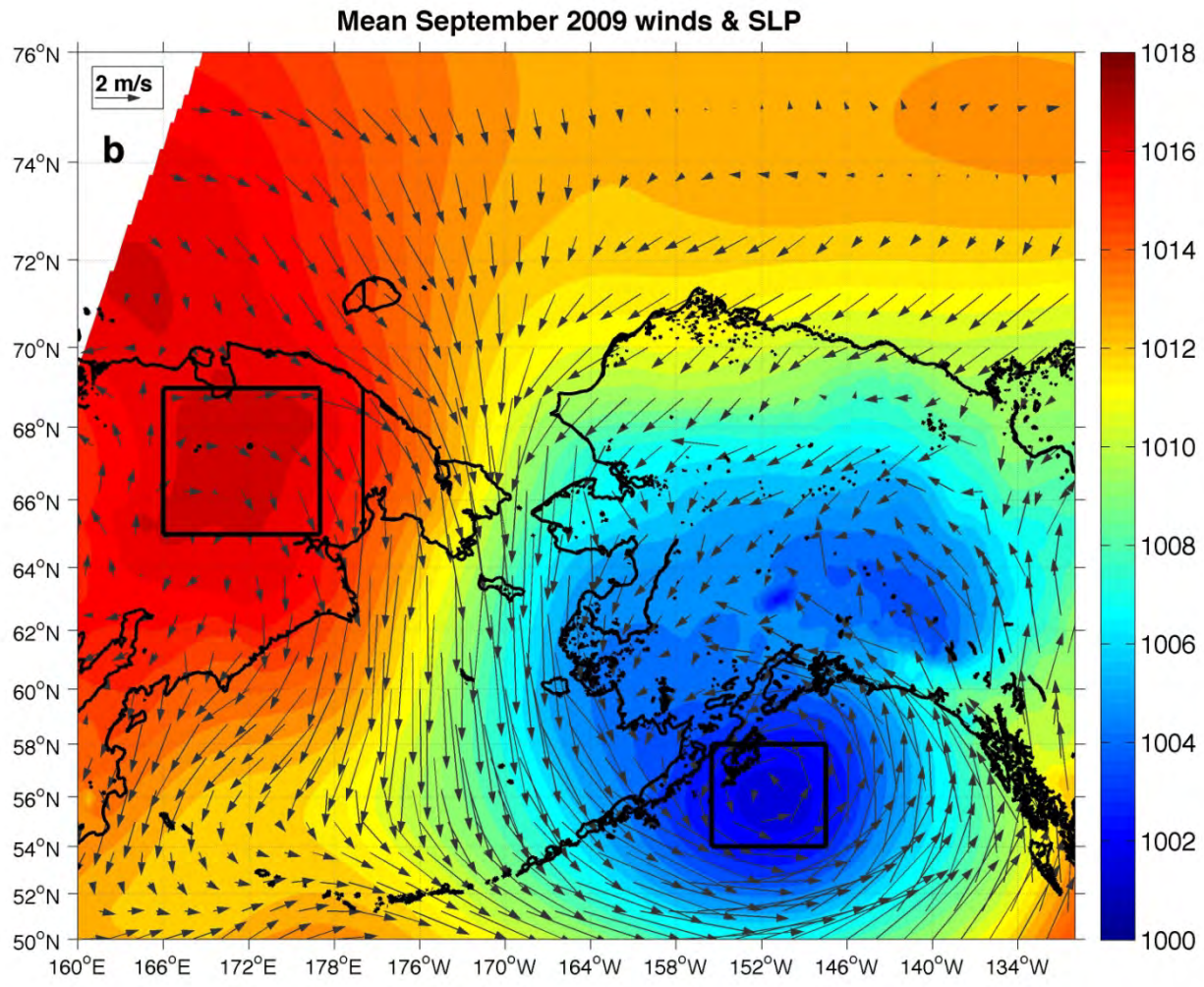


Figure 1. This figure shows the atmospheric conditions that led to the enhanced winds in September 2009 on the Chukchi shelf, which in turn caused the transposition of water masses in Bering Strait. The vectors are the mean winds for the month, and the mean sea level pressure is shown in color. One sees a deep Aleutian Low and the presence of the Siberian High (centered within the two black boxes, respectively), which together caused the strong northerly winds. The climatology for the decade indicates that the Siberian High is normally not present during the month of September.

Building tools for applying climate science to fisheries management

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Riley Young Morse - GMRI

NOAA Sponsor – Ellen Mecray - NESDIS

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

Working in partnership with the NOAA NCDC Northeast Regional Climate Center, The Gulf of Maine Research Institute (GMRI) is developing an online dashboard to make a variety of information available to fisheries management community.

The high level goals and objectives are:

- Summarize outcomes from June 2014 meeting
- Create mockup of outlook product to review with project team and stakeholders
- Identify priority data streams and data products to include in dashboard
- Develop online dashboard product
- Integrate data sources
- Launch dashboard

ACCOMPLISHMENTS

PI Young Morse co-hosted and participated in a June 2014 workshop at WHOI with program sponsor and project collaborator Ellen Mecray of NCDC. The participants included fisheries scientists, industry representatives and fisheries managers. The outcome of the meeting was a common understanding of the dashboard effort and the priority data sets, advisories, and outlooks to acquire and deliver through the tool.

As a follow up to this meeting, a smaller “content advisory team” was recruited to review the selection of priority data sets and participate in the development of the dashboard. This group had a kickoff call in early March, and plans to communicate monthly to review progress and provide feedback.

The GMRI Ocean Data Products team has been working on the mockup and technology that will drive the development of the dashboard. With a close connection to the “Accessing and Visualizing Satellite Data for Use by Fisheries Managers in the Northeast Large Marine Ecosystem” CINAR project, the team has begun working with the Optimally Interpolated Sea Surface Temperature (OISST) data set.

Preliminary visualizations representing the time series have been developed for specific

coordinates that match the NERACOOS buoy array locations for reference points. The time series, trends and anomaly data have been developed, as well as a mapping component for visualizing the gridded data for the NESLME (Northeast Shelf Large Marine Ecosystem).

Working mockups of the full dashboard (that include the interactive display for the OISST) will be developed over the next month and shared with the advisory team.

Upon finalizing the priority data sets (based on the data identified from the workshop and vetted by the content advisory team), GMRI will identify the appropriate paths and mechanisms to integrate and make the data available through the dashboard.

HIGHLIGHTS

- Fisheries stakeholder workshop was held in June 2014 to identify priority datasets for inclusion in the fisheries dashboard.
- Assembled a “content advisory team” made up of a core group of stakeholders to finalize datasets and help develop dashboard functional requirements.
- Developed preliminary visualizations from the OISST time series to demonstrate the capacity of the dashboard to show dynamic data updated automatically in near real time.

SOCIETAL BENEFITS

This project contributes to the CINAR themes of sustained ocean observations and climate, and to conduct research and develop decision-support tools for sustainable fisheries management. Additionally, this project contributes to the NOAA research goal of understanding climate variability and change to enhance society’s ability to plan and respond.

EDUCATION AND OUTREACH ACTIVITIES

PI Riley Young Morse presented the fisheries dashboard project in a session on climate data tools at the 2015 Fishermen's Forum in Rockport, Maine.

NCDC project sponsor and collaborator Ellen Mecrey spoke at an Island Institute hosted climate change meeting held in Portland, Maine in December 2014. Young Morse also attended this meeting.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

The two figures are representative images of the preliminary interactive charts, with slightly different presentations.

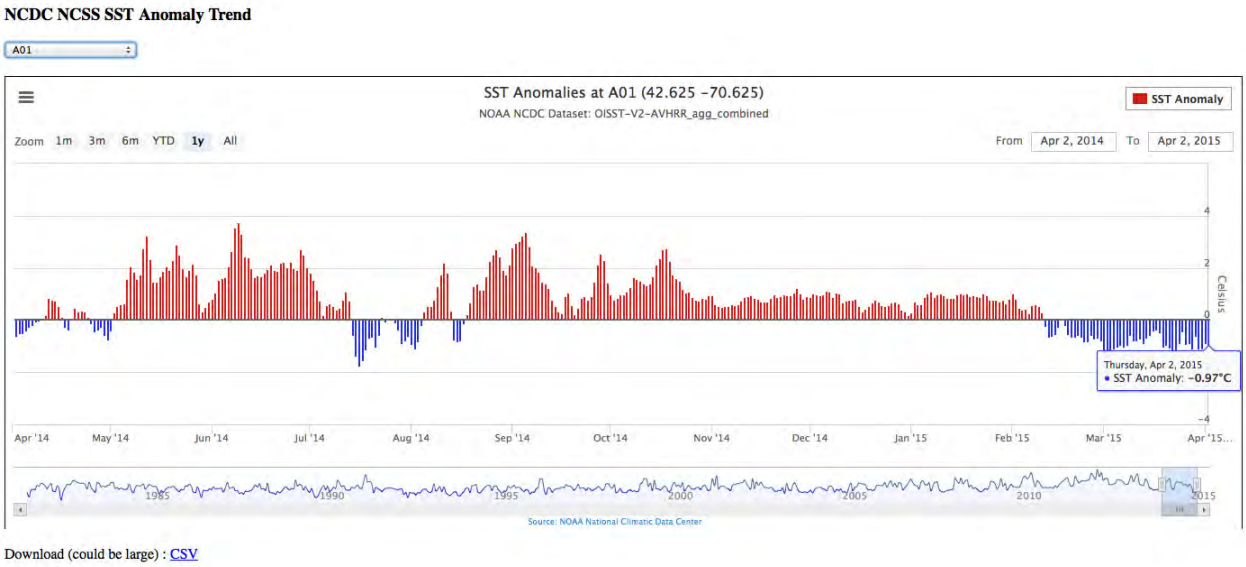


Figure 1. This is a screen shot of the OISST anomaly data for the full time series of the climate data record (1981-2015). A new chart is rendered from data for each of the geographic reference points (in this case, the NERACOOS buoys). In the interactive chart, users can zoom in by month, year, or view the full time series.

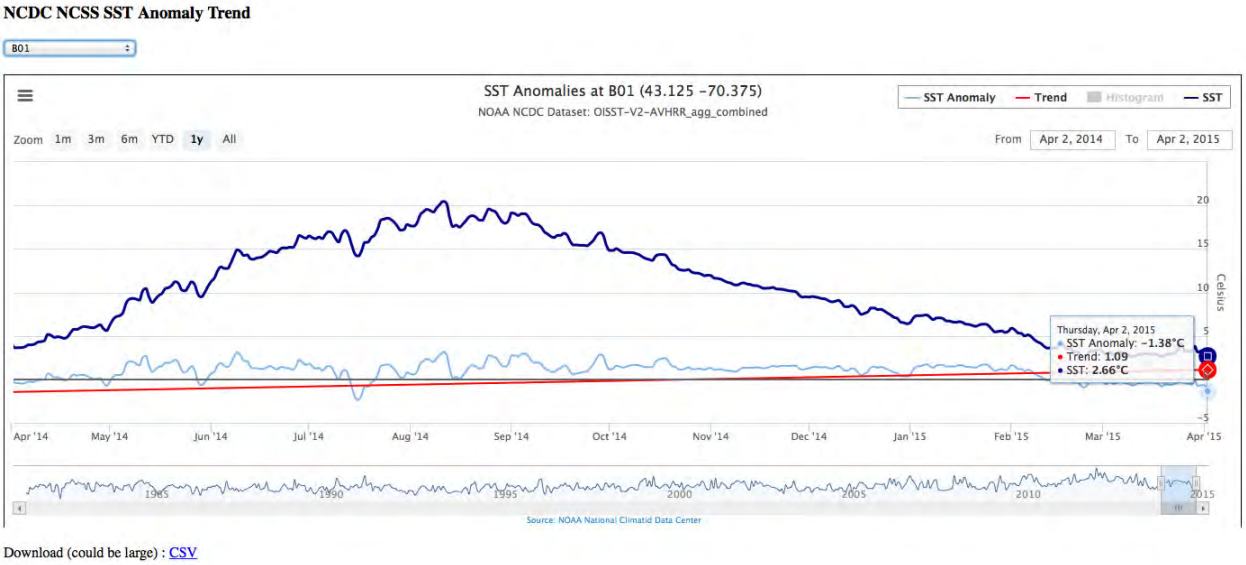


Figure 2. This is a screen shot of the OISST, anomaly and trend lines for the full time series of the climate data record (1981-2015). A new chart is rendered from data for each of the geographic reference points (in this case, the NERACOOS buoys). In the interactive chart, users can zoom in by month, year, or view the full time series.

Ocean climate observations and analyses (2014-2015)

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Robert Weller and Albert Plueddemann - WHOI

NOAA Sponsor – Diane Stanitski - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

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

In FY2014, the WHOI Ocean Reference Station project carried out cruises to the three sites to recover moorings that had been in service for a year or more, and deploy new moorings. NTAS was serviced by the NOAA Ship RH Brown in October 2013. Stratus was serviced by the NOAA Ship RH Brown during a February-March 2014 cruise. WHOTS was recovered and redeployed in July, 2014 on the NOAA Ship Hi'ialakai. Each cruise resulted in the collection of the internally recorded data from the instrumentation on the buoy and the mooring line, and supporting data sets from the ships, such as meteorological data for comparison with the buoy meteorological data. From the deployment of a new buoy onward, the surface meteorological data are available in near real-time, with hourly averages typically telemetered via Service Argos. The WHOI Ocean Reference Station data are not placed on the global telecommunications system (GTS); instead they are used as independent data for model validation by users such as ECMWF (European Centre for Medium Range Weather Forecasts) and NCEP (National Centers for Environmental Prediction), and for quantification of error in fields such as the surface fluxes by investigators working in coordination with the CLIVAR Global Synthesis and Observations Panel (GSOP).

ACCOMPLISHMENTS

The basic deliverables from the ORS are the high quality data, supported by the documentation of the methods. The directly observed data fall into three main categories: 1) Surface meteorology and air-sea fluxes. The surface wind speed and direction, air temperature, relative humidity, barometric pressure, incoming shortwave radiation, incoming long wave radiation, and rain rate are measured at a once per minute rate. Logged at the same time are buoy bridle temperature and salinity; 2) Surface oceanographic data; 3) Ocean observations of temperature,

salinity, and velocity along the mooring line - Stratus has recently added dissolved oxygen measurements. The surface meteorology, surface temperature, and surface current are used with the bulk formulae to compute the following fourth product; 4) Air-sea fluxes of heat, freshwater, and momentum; 5) Deep T and S - All of the ORS moorings include additional sensors to obtain deep ocean temperature and salinity. Ancillary observations by cooperating investigators add product six; 6) Surface wave data by NDBC at Stratus and NTAS; 7) pCO_2 by NOAA PMEL at Stratus and WHOTS; 8) Dissolved oxygen observations at Stratus by Lothar Stramma from Kiel, Germany; and 9) In water radiance observations at WHOTS by Sam Laney of WHOI. Surface meteorology is available in real-time and the remaining data follow in delayed mode.

The surface moorings have proven to be a very effective methodology. The WHOTS mooring has been on station 100%. Stratus and NTAS have provided 94% and 95% of the planned station time. This is a very important statistic, as record length is a key determinant of statistical significance in examining trends. Our methodology of deploying meteorological instrumentation with sufficient redundancy to ensure close to 100% return of high quality surface meteorological and air-sea flux time series has been particularly effective.

The ORS in particular address the following ocean observing system program deliverables:

- **Sea surface temperature (SST) and surface currents**. The ORS surface buoys have been instrumented to provide improved sea surface temperature observations. Because they sample surface and near-surface ocean temperature and because they have collocated, high quality air-sea fluxes, ORS data sets are sought by investigators working on diurnal warm layer dynamics and remote sensing of SST.
- **Ocean heat content and transport.** The ORS buoys are equipped with temperature, salinity, and velocity sensors from the upper thermocline to the surface (at Stratus, these go deeper, to 1,800 m). As a result, the temporal evolution of the mixed layer and its heat storage can be tracked as well as the heat content of the upper ocean.
- **Air-Sea Exchanges of Heat Momentum and Freshwater.** The ORS are equipped to make state of the art, sustained air-sea flux observations, providing the air-sea exchanges of heat, freshwater, and momentum. The ORS surface meteorological and air-sea flux data, uniquely, are both high quality and withheld from real-time assimilation into weather and climate models.
- **Ocean Carbon Uptake and Content**. Collaboration with Chris Sabine at NOAA PMEL has added pCO_2 observations to Stratus and WHOTS.

HIGHLIGHTS

- Eastern South Pacific Heat and Salt Budgets. The longer Stratus record now available allowed re-examination of the heat and salt budgets of the upper ocean in the Stratus region and improve upon the earlier work. In this work, the data from Argo floats in the region are included in the synthesis (Fig. 1). The major new finding is that horizontal advection plays the major role in cooling and freshening the upper ocean. This greatly improves our understanding of the dynamics of the region and provides a basis for validation/verification of ocean models.

- Variability and Trends. Weller (2014) reports finding long-term trends in surface meteorology and air-sea fluxes at the Stratus ORS. Using the first ten years of Stratus data, which provide nine full calendar years, statistically significant trends were found in wind speed, wind stress, latent heat flux, and het heat flux. Increases in wind speed, wind stress, and latent heat flux over nine years were 0.8 m s^{-1}, 0.022 N m^{-2}, and 20 W m^{-2} or 13, 29, and 20% of the respective nine-year means. The decrease in the annual mean net heat flux was 39 W m^{-2} or 104% of the mean.
- Hawaii Region Hydrological Cycle. Our partnership with the University of Hawaii (R. Lukas with NSF funding) has provided key insights in the regional hydrological cycle. Recent work by Lukas points to several processes acting to control the local ocean state, including changes in the balance between surface rainfall and evaporation, and transports by eddies of water masses from distant locations. Salinity in the mixed layer is increasing in association with a negative freshwater flux (loss of freshwater from the ocean) while temperature is decreasing, resulting in a density increase that is statistically significant over the first eight years of the WHOTS record. Comparisons with global models show that the WHOTS observations are regionally representative, yet the models do not necessarily show seasonal to decadal variability in surface fluxes consistent with those of the observations.
- Atlantic Trade Wind Region Dynamics. The NTAS ORS is in a region where the mechanisms controlling SST and upper ocean heat content are of interest. A decade of data (2001-2011) allows a typical year to be characterized from observations. The seasonal cycle dominates the net heat flux, with the migration of the Inter Tropical Convergence Zone (ITCZ) modulating cloud cover and rainfall. Interannual variability is evident in the minimum and maximum seasonal values as well as the timing of seasonal transitions. The extent to which NWP forecasts and reanalyses reproduce the amplitude and timing of the annual cycle and seasonal transitions is being evaluated. NTAS is a region where interactions among wind, evaporation, and SST are important, and there is interest in the role of advective cooling during periods of wind relaxation when evaporative cooling is reduced, and thus there is a tendency for local SST increase (without advection).

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

- Whenever possible, ORS cruises involved NOAA Teachers at Sea, undergraduate, and graduate students.
- "Sustained Observations of Air-Sea Fluxes and Air-Sea Interaction at the Stratus Ocean Reference Station", EGU, Vienna, May 2014.

- "A ten-year look at the trade wind regime off Northern Chile", invited talk, Oregon State Univ, Corvallis, May 2014.
- "In-Situ Observations of Air-Sea Interaction in the South East Pacific", AMS annual meeting, January 2015, Phoenix AZ

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

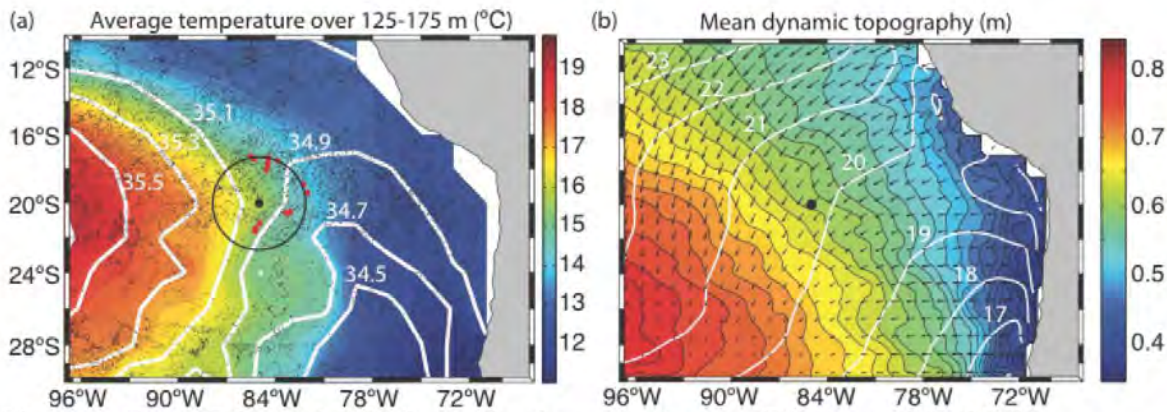


Figure 1. From Holte et al. (2014), panel a shows the Stratus ORS site at 20°S, 85°W and the small black dots are 12,628 Argo float profiles used to map the temperature (color) and salinity (white contours) fields in the region. Panel b shows the Ekman transport (arrows), mean SST contours (white), and dynamic topography (color).

50 year analysis: global ocean surface heat flux

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Lisan Yu - WHOI

NOAA Sponsor – Kathy Tedesco - OAR

Related NOAA Strategic Plan Goal: Climate Adaptation and Mitigation

CINAR Theme: V. Sustained Ocean Observations and Climate

PROJECT OVERVIEW

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

The OAFlux project was established on the basis that quality global flux fields can be obtained only when data errors are properly treated. This is due to the fact that global air-sea flux fields are commonly constructed from flux bulk parameterizations that require surface meteorological observables (e.g., wind speed, temperature, humidity, cloud cover, etc.) as inputs. However, no surface meteorological observables are free from errors/biases regardless of whether they are ship-based measurements or space-born satellite retrievals. To take into account these data errors, the OAFlux project developed an objective synthesis to include error information in the formulation, and to improve the flux estimates through synthesizing measurements/estimates from various sources. The error information of input data is determined from air-sea measurements from surface moorings. The OAFlux established a validation database consisting of more than 130 flux buoys from the ocean climate observing system.

The OAFlux project produced the global 1° resolution, daily/monthly analysis (1958- present) of ocean evaporation, air-sea latent and sensible heat fluxes, and related surface meteorological variables. The products are distributed online through the project website at http://oaflux.whoi.edu/data.html and updated twice per year. The project continues its efforts to develop a high-resolution (0.25°) global analysis of surface heat fluxes to improve the representation of the coupling between the atmosphere and ocean fronts/eddies, to develop surface radiative fluxes with improved accuracy, and to progress toward a net heat flux dataset.

The OAFlux project demonstrates the important role of integrating air-sea measurements from the global ocean climate observing system in constraining the global flux products. At the same time, the OAFlux global products broaden, strengthen, and enrich the use of in situ flux measurements. The buoy-validated, completely global, gridded, and temporally homogeneous products spanning several decades can help the ocean and climate diagnostic and modeling

studies in many ways that the irregularly spaced and sparse buoy time series cannot. The OAFlux user base has been growing rapidly. Since the access counter was installed on May 1, 2013, the project home page has been accessed 8,482 times, and the data download page 7,901 times. The products were used as a base dataset in 670 publications since their 2007 release. This product was cited 141 times in peer-reviewed journals in FY2014, compared to 149 citations in FY2013.

ACCOMPLISHMENTS

We provide near real-time online updates of the OAFlux analysis to maintain timely dissemination of the flux time series from 1958 to the present. The 50-year OAFlux products are known for quality, reliability, near real-time updates, and easy access. They are being used in a broad range of applications, including characterization, attribution, modeling, and understanding of variability and long-term change in the atmosphere and ocean. The OAFlux products provide the observational support for the State of the Climate annual assessment report led by NOAA Climate Data Center.

We have implemented an innovative regression algorithm to determine near-surface air humidity and temperature from AMSU-A and AMSU-B humidity/temperature profiles and the SSMI/I and SSMIS total integrated water vapor using buoys as a training database. The new time series depicts a slowdown or “pause” in global temperature and humidity since 2000, which followed a period of rapid acceleration in the 1990s.

The OAFlux products are used as a reference dataset to validate climate model simulations and atmospheric reanalysis products, in particular, to identify the biases in reanalysis flux products. In FY2014, we used the OAFlux wind analysis to assist the National Centers for Environmental Prediction (NCEP) climate prediction center isolate the bias source in the NCEP2 surface winds. The NCEP’s prediction of ENSO conditions in spring 2014 showed inconsistency with the predictions from other weather prediction centers, as the central equatorial Pacific was anomalously cold in the NCEP ocean model. We determined that the cold sea surface temperature (SST) anomalies were caused by peculiarly strong easterlies (negative anomalies in Figure 3a) in the NCEP2 winds that were used in forcing the NCEP prediction model. The stronger westward winds produced stronger equatorial upwelling that cooled down the surface temperatures and inhibited the generation of the warming conditions as seen in other prediction models. Our investigation also suggested that the NCEP2 easterly anomalies were centered at 170W, due perhaps to the poor Tropical Atmosphere Ocean (TAO) buoy data returns in recent years. Unlike the Climate Forecast System Reanalysis (CFSR), which assimilates satellite WindSat observations, NCEP2 assimilates only TAO buoy array data, making it extremely vulnerable to the reduction of the TAO buoy reports. Our analysis helped the CPC in understanding the surface wind conditions in the spring of 2014, and the oceanic consequences during the CPC Monthly Ocean Briefing in June/July.

HIGHLIGHTS

- We provide near real-time online updates of the OAFlux analysis to maintain timely dissemination of climate records of global air-sea fluxes of heat, moisture, and momentum from 1958 to the present, and to meet the communities’ need for accurate, multi-decadal datasets for research on the global energy and water cycle.

- The OAFlux products are used as a reference dataset to validate climate model simulations and atmospheric reanalysis products; in particular, to identify the biases in reanalysis flux products.
- The new time series depicts a slowdown or “pause” in global temperature and humidity since 2000, which followed a period of rapid acceleration in the 1990s. Similarly, the rate of ocean evaporation has been trending downward since 2000, reversing the upward trend that was dominant during the 1980s and 1990s.

SOCIETAL BENEFITS

The OAFlux time series of 57 years help to analyze and quantify the changes in the surface forcing functions and contribute to our understanding of the role of the ocean in the global climate system and change.

EDUCATION AND OUTREACH ACTIVITIES

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

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

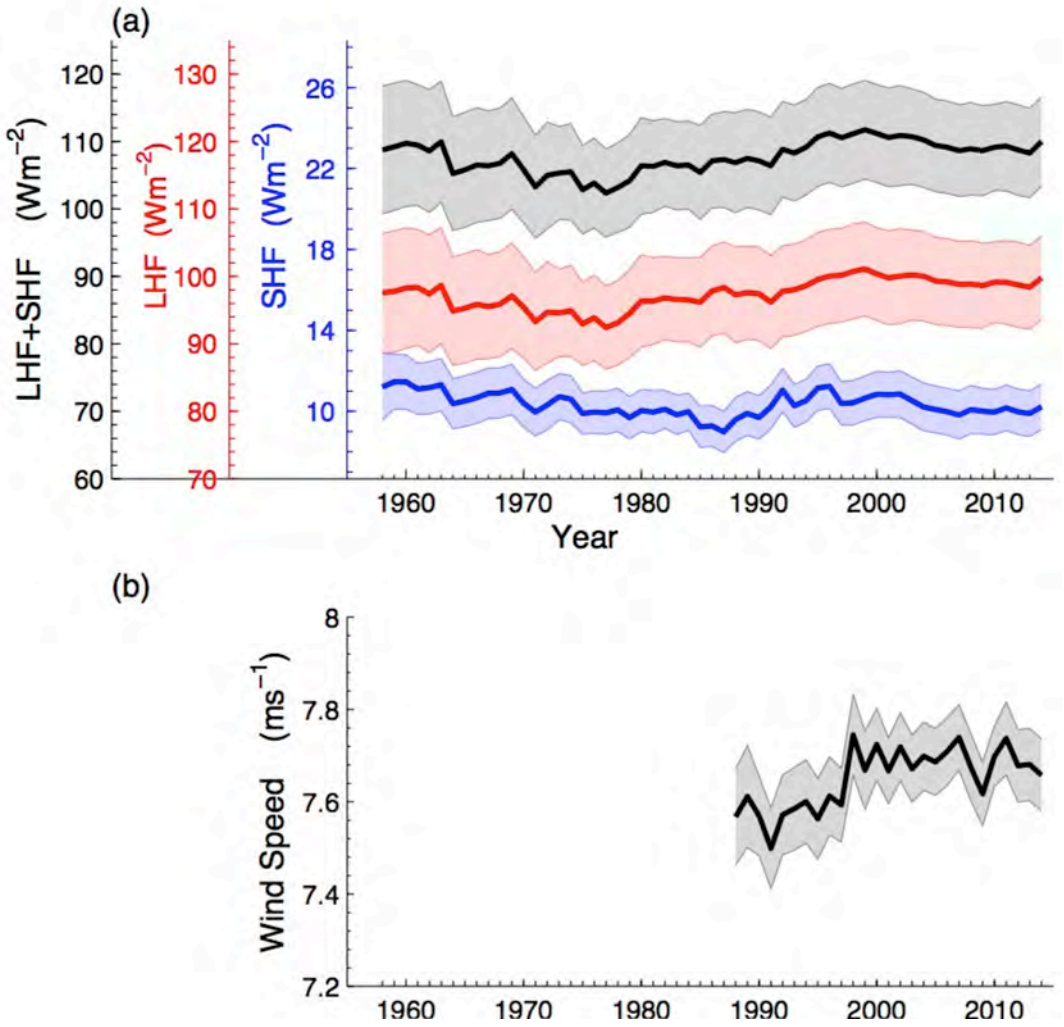


Figure 1. Year-to-year variations of global averaged annual mean latent plus sensible heat flux (LHF+SHF) (black curve), latent heat flux (LHF) (red curve), and sensible heat flux (SHF) (blue curve) from OAFlux. (b) Year-to-year variations of global averaged annual mean wind speed from OAFlux. The shaded areas indicate the error bars of the fluxes and wind speed estimates at the 95% confidence level.

THEME VI. EDUCATION AND OUTREACH

CINAR

Cooperative Institute for the North Atlantic Region

Research and education in quantitative fisheries and ecosystem science

NOAA Cooperative Agreement No. NA14OAR4320158
April 01, 2014 – March 31, 2015

CINAR Investigator - Donald Anderson - WHOI

NOAA Sponsor – Russell Brown - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

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

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

ACCOMPLISHMENTS

This program began in 2012. The first CINAR Fellows were appointed during in early 2013. Progress reports on their activities during 2014-2015 are given in the attached Appendix.

Rubao Ji, Associate Scientist, Biology Department. Dr. Ji's CINAR Fellowship is allowing him to work on transferring the modeling tools and data products developed in his previous and on-going research projects for fisheries stock assessment and management, and to enhance/expand his existing education and training activities with NOAA and SMAST.

Porter Hoagland, Senior Research Specialist, Marine Policy Center. As a CINAR Fellow, Porter Hoagland is continuing work with colleagues on the development of a conceptual framework for the contribution of the social sciences to ecosystem-based fisheries management (EBFM). Further, he is studying the implications of competing models of the US northeast shelf ecosystem for the economic and welfare impacts of alternative fishery conservation and management strategies. Of particular interest is the identification of strategies that perform well under different ecological models and are, therefore, robust against model uncertainty.

Gareth Lawson, Assistant Scientist, Biology Department. In collaboration with colleagues at the NEFSC, Dr. Lawson is focusing on the development of acoustic techniques for sampling zooplankton and micronekton for the purpose of ecosystem assessment. He will also apply such techniques to the study of euphausiid ecology in the Gulf of Maine region and ecosystem dynamics at the New England continental shelf break.

SMAST Faculty. Assistant professor Dr. Gavin Fay joined the Department of Fisheries Oceanography in the fall 2014 semester. Dr. Fay is using marine ecosystem models to evaluate the performance of ecosystem-based fisheries management strategies for the northeast U.S. continental shelf. As he develops his research program at SMAST, he is expected to use interdisciplinary multi-model approaches to extend the scope of applications for fisheries and ecosystem assessment.

SOCIETAL BENEFITS

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

Please see individual reports (Appendix A) for highlights, education and outreach activities, and publications.

APPENDIX A
CINAR Fellow Progress Reports

CINAR Fellow: Porter Hoagland

PROJECT OVERVIEW

R**esearch**: Linking economic and ecological models for ecosystem based fisheries management (EBFM) with a focus on their relationship to and use in coastal and marine spatial planning.

Teaching: Teaching graduate and undergraduate students in the Department of Marine Affairs, University of Rhode Island.

Mentoring: Mentoring graduate students at WHOI.

ACCOMPLISHMENTS:

Submitted paper: Hoagland P., Dalton TM, Jin D, Dwyer J. 2014. An approach for assessing the spatial welfare and distributional effects of siting wind energy in the ocean: the Rhode Island/ Massachusetts "Area of Mutual Interest." *Marine Policy* (submitted).

Workshop Participation: Participated in a workshop on fisheries science and management entitled "Seeking Synergy: Social & Natural Science" sponsored by the MIT Sea Grant College Program (May 5, 2014)

Accepted abstract and presentation: One abstract has been accepted for presentation at the American Fisheries Society meeting Portland, Oregon: Jin D, DePiper G, Hoagland P. 2015. An empirical analysis of portfolio management as a tool for implementing ecosystem-based fishery management. Symposium of Multispecies Modeling. *Proc. American Fisheries Society 145th Annual Meeting*, Portland, OR (August 16-20, 2015).

HIGHLIGHTS:

- Marine spatial planning (MSP) involves characterizing the potential socio-economic consequences of locating one or more human uses in place of others in the coastal ocean. Most commonly, the focus of MSP is on the juxtapositions of activities across ocean space. When implementing MSP, we argues that it is critically important to characterize not only the distribution of effects over the coastal ocean but also the distribution of impacts on coupled human communities onshore, including those communities that may not be considered strictly coastal (Hoagland *et al*. 2014; submitted manuscript).
- We examined the broader economic and distributional effects of the potential siting of a renewable energy facility (wind power) in a southern New England offshore area that also is used intensively for commercial fishing (Hoagland *et al*. 2014; submitted manuscript). For a leading siting alternative, we found that the complete displacement of commercial fishing would result in estimated direct output impacts to the regional economy of $5 million, leading to $11 million in direct, indirect, and induced impacts and a corresponding loss of about 150 jobs. Total economic welfare losses were estimated at $14 million, reflecting not only output reductions but also the effects of price increases in the relevant markets. The welfare losses would be progressively distributed, such that households in mid- to high-income categories would likely bear the most

significant impacts. Adjusting these welfare losses for society's aversion to income inequality, we found that inequality-adjusted impacts would be more pronounced in areas that are not necessarily located in close proximity to the coastline. Individual low-income households located in five non-coastal census tracts would bear estimated median impacts (≥ $140/yr), which would be an order of magnitude larger than those borne by the next group of impacted households.

- We have developed an ecosystem-based fisheries management (EBFM) portfolio model for the US northeastern region, using empirical data from NMFS for 1964-2012 and species grouping used in food web models of the same region (Jin *et al*. 2015; accepted abstract). We developed annual performance measures of the northeast fisheries over five decades to capture the inefficiencies (in terms of risk level for a given level of revenue) in the fisheries, and thus the potential for improvements. We demonstrated the usefulness of the model and results through case studies of different portfolios by ecological production unit (EPU) and by fishing port. Results of our research will further improve understanding of the potential for portfolio management as a practical approach to help achieve EBFM in the northeastern region.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

Teaching: Department of Marine Affairs, University of Rhode Island: Taught two courses: MAF 511 Ocean Uses and Marine Sciences (Fall 2014); MAF 482: Quantitative Methods in Marine Affairs (Spring 2015).

Mentoring: Mentoring of students working on related research:

Drew Bush, Ph.D. Candidate, School of the Environment, McGill University

Joseph Dwyer, Ph.D. Candidate, Department of Marine Affairs, University of Rhode Island

Kelly Heber, Ph.D. Candidate, Department of Urban Planning, Massachusetts Institute of Technology

PUBLICATIONS

Hoagland P., Dalton TM, Jin D, Dwyer J. 2014. An approach for assessing the spatial welfare and distributional effects of siting wind energy in the ocean: the Rhode Island/Massachusetts

"Area of Mutual Interest." *Marine Policy* (submitted).

Jin D, DePiper G, Hoagland P. 2015. An empirical analysis of portfolio management as a tool for implementing ecosystem-based fishery management. Symposium of Multispecies Modeling. *Proc. American Fisheries Society 145th Annual Meeting*, Portland, OR (August 16-20, 2015).

FIGURES

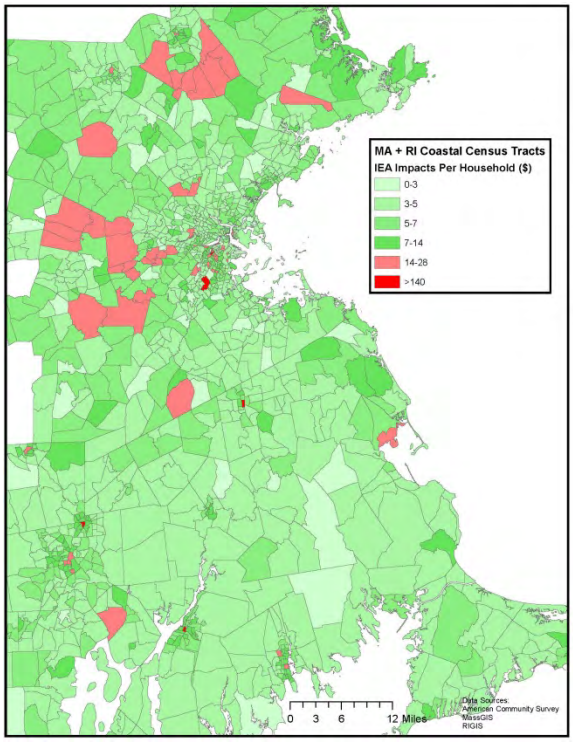


Fig. 1: Hypothetical spatial distribution of inequality-adjusted welfare losses resulting from the displacement of commercial fishing from the siting of a wind generating facility in the Area of Mutual Interest in Rhode Island Sound (Hoagland *et al*. submitted).

CINAR Fellow: Rubao Ji

PROJECT OVERVIEW

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

1) Research: develop research proposals for the Northeast US Continental Shelf region; write research papers with scientists from NOAA and CINAR partner institutes.

2) Education/training: Advise students from the MIT-WHOI joint program and from School for Marine Sciences and Technology (SMAST) at University of Massachusetts. Advise a Postdoc investigator working on a NOAA-WHOI joint Fisheries And The Environment (FATE) project.

3) Outreach: disseminate research results through international meeting; play a leadership role in research community activities.

ACCOMPLISHMENTS

1. Developed 4 proposals that are related to the CINAR region, including 1) NSF BioOce proposal to examine the zooplankton population connectivity and persistency along the Northwest Atlantic Shelf (Co-PIs include Jeff Runge from UMaine and Changsheng Chen from University of Massachusetts). This proposal has been awarded for funding by NSF. 2) NOAA proposal "Looking back to understand the future: resolving the mechanisms driving past impacts of climate and ecosystem variability on fish populations on the NE US continental shelf" (Lead PI: Simon Thorrold, with multiple NOAA NMFS co-PIs). 3) NOAA proposal "Analysis and use of a global-to-local scale climate-ocean physical-biological model of the NESLME as an operational tool for ecosystem-based fishery management" (Lead PI: Cabell Davis, with multiple NOAA NMFS co-PIs). 4) WHOI Ocean and Climate Change Institute (OCCI) proposal on multi-decadal simulation of food-web dynamics on the Northwest Atlantic Shelf.
2. Worked on 7 papers with scientists from NOAA and/or CINAR collaborators, with 4 papers being published and 3 papers being prepared. The topics of the papers cover hydrodynamics, lower-trophic level food web and zooplankton population dynamics on the Northeast US Continental Shelf.
3. Advised two PhD students and one Postdoc investigator. Served as an advisor for one MIT-WHOI Joint program student (Ben Jones) and as a committee member for one UMass student (Yu Zhang). Advised one NOAA Postdoc (Dr. Yun Li) who has been working in my lab on a FATE project with Drs. Paula Fratantoni and Jon Hare from NMFS and Dr. Changsheng Chen from UMass.
4. Continue to co-chair an ICES Working Group; Lecturer for a PICES summer school on end-to-end modeling; co-chair sessions for IMBER Open Science Meeting and PIES/ICES international symposium.

HIGHLIGHTS

- Developed four research proposals focusing on the CINAR region. All proposals involve CINAR partner institutes and NOAA collaborators.
- Published 6 papers and working on one more paper focusing on the CINAR region through collaboration with NOAA and CINAR partner institutes.

SOCIETAL BENEFITS

- Provided training for next generation fisheries oceanographer
- Produced oceanography products that can help stock assessment and ecosystem-based management

EDUCATION AND OUTREACH ACTIVITIES:

1) Co-chair ICES Working Group on Integrated, Physical-biological and Ecosystem Modelling (*WGIPEM*). Organized annual working group meeting in Plymouth, UK in March 2015.
2) Co-convene a session in the 2014 IMBER Open Science Meeting in Bergen, Norway (C3 - Integrated studies of the impact of climate change on marine ecosystems).
3) Co-convene a session in the 3rd International Symposium on the "Effects of Climate Change on the World's Oceans".
4) Selected presentation 1: Rubao Ji, Yun Li, Stephanie Jenouvrier, Meibing Jin, Julienne Stroeve, Garrett Campbell, Øystein Varpe 2015. Spatio-temporal variability of synchronicity between ice retreat and phytoplankton blooms in the polar regions. 3rd International Symposium on the "Effects of Climate Change on the World's Oceans". Santos, Brazil.
5) Selected presentation 2: Yun Li, Rubao Ji, Paula S. Fratantoni, Changsheng Chen, Yunfang Sun and Jonathan A. Hare, 2015. Changing rhythm of stratification on the Northwest Atlantic shelf: interannual variability and its biological implications (Poster). 3rd International Symposium on the "Effects of Climate Change on the World's Oceans". Santos, Brazil.
6) Selected presentation 3: Rubao Ji. Modeling zooplankton: frontiers and WGIPEM activities. 2015. ICES Working Group meeting (WGIPEM-WGZE Joint Session). Plymouth, UK.

PUBLICATIONS

Petrik, C.M. **R. Ji**, C. Davis, 2014. Interannual differences in larval haddock survival: hypothesis testing with a 3D biophysical model of Georges Bank. Fisheries Oceanography, *23(6): 521-553.*

Runge, J.A., **R. Ji**, C. Thompson, N. Record, F. Maps, C. Chen, J. Salisbury, D. Vandemark, 2014. Persistence of Calanus finmarchicus in the western Gulf of Maine under strong environmental forcing. Journal of Plankton Research, DOI: 10.1093/plankt/fbu098.

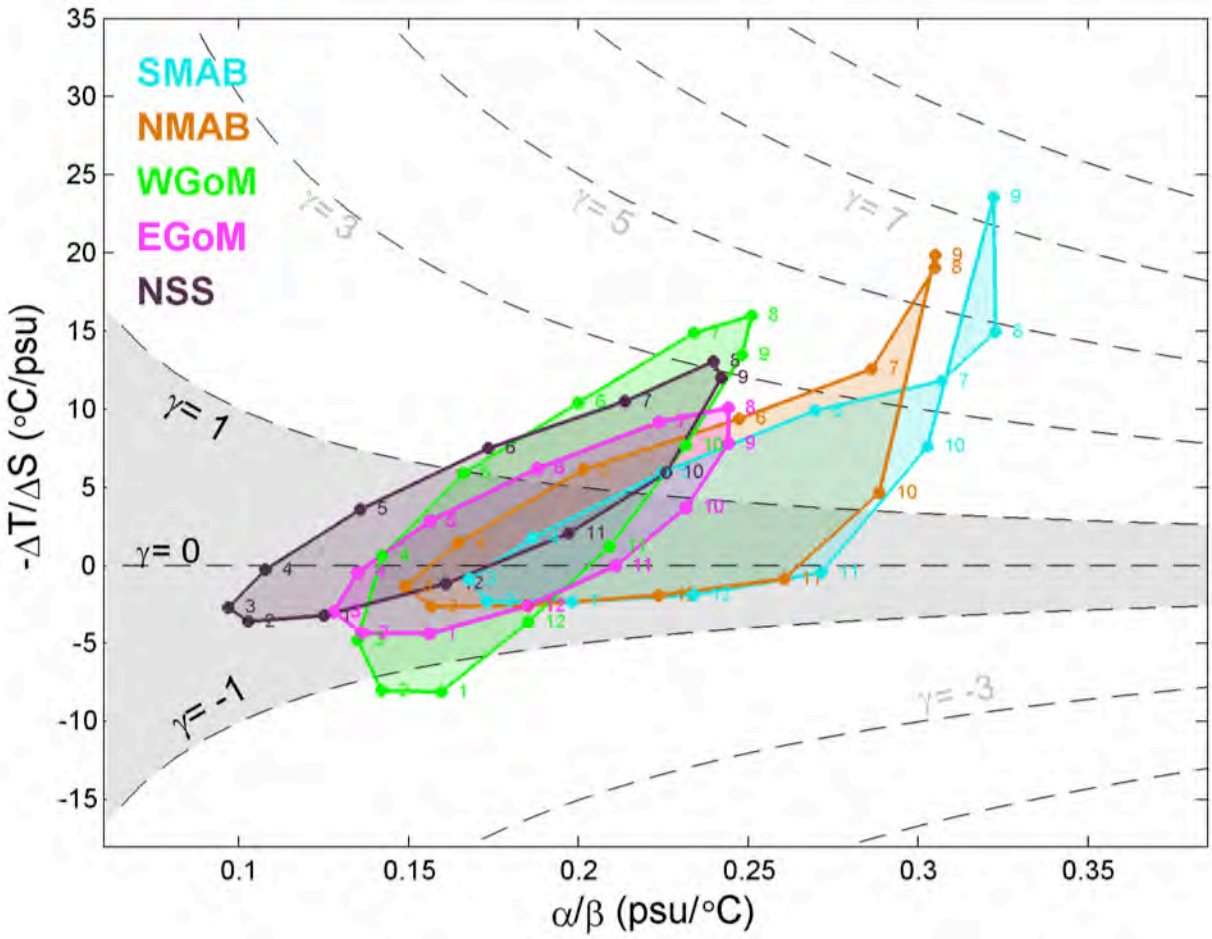
Li, Y. P. Fratantoni, C. Chen, J. Hare, R. C. Beardsley, **R. Ji**. 2014. Spatio-temporal patterns of stratification on the Northwest Atlantic shelf. Progress in Oceanography 134:123-137

Tian, R., C. Chen, J. Qi, **R. Ji**, R. C. Beardsley and C. S. Davis, 2014. Model Study of Nutrient and Phytoplankton Dynamics in the Gulf of Maine: Patterns and Drivers for Seasonal and Interannual Variability. ICES Journal of Marine Sciences, 72(2): 388-402.

Llopiz, J.K., R.K. Cowen, M.J. Hauff, **R. Ji**, P.L. Munday, B.A. Muhling, M.A. Peck, D.E. Richardson, S. Sogard, and S. Sponaugle. 2014. Early life history and fisheries oceanography: New questions in a changing world. *Oceanography* 27(4):26–41, http://dx.doi.org/10.5670/oceanog.2014.84.

Friedland, K. D., R. T. Leaf, J. Kane, D. Tommasi, R. G. Asch, N. Rebuck, **R. Ji**, S. I. Large, C. Stock, V. S. Saba, 2015. Spring Bloom Dynamics and Zooplankton Biomass Response on the US Northeast Continental Shelf. Continental Shelf Research 102:47-61.

Record, N. R., **R. Ji**, F. Maps, Ø. Varpe, 2015. Computing the global biogeography of copepodid diapause. Submitted to Journal of Plankton Research.



This figure is a result of a NOAA FATE project in which I am the leading PI. It was published in 2014 (Li, Y. P. Fratantoni, C. Chen, J. Hare, R. C. Beardsley, R. Ji. 2014. Spatio-temporal patterns of stratification on the Northwest Atlantic shelf. Progress in Oceanography 134:123-137). We studied the stratification patterns in the Northwest Atlantic shelf. The data product can be used for fisheries stock assessment purposes. The figure shows aregime diagram of annual cycle of stratification in the five subregions on the NW Atlantic Shelf. The horizontal axis α/β represent the ratio between thermal and haline coefficients; the vertical axis –ΔT/ΔS represents the ratio between surface-to-50m temperature and salinity differences (see details in Section 2.3). The gray and while zones delineate regimes dominant by haline and thermal controls respectively. Each dot represents the monthly mean computed using the daily climatology, and the corresponding month is marked in numbers.

CINAR Fellow: Gareth Lawson

PROJECT OVERVIEW

My CINAR fellowship activities focus on research and education concerning two overarching topics: (1) Development of acoustic methods for sampling zooplankton and micronekton for the purpose of stock and ecosystem assessment, (2) Application of acoustic techniques for the study of euphausiid ecology and fisheries interactions in the Gulf of Maine region and ecosystem dynamics at the New England continental shelf break. This research program is highly collaborative, involving colleagues from the Northeast Fisheries Science Center (NEFSC) and the commercial fishing and acoustic manufacturing industries, as well as multiple students and postdocs.

For my CINAR fellowship I have been working on three inter-related research projects:

1. Assessing the use of multi-frequency acoustic data collected ancillary to routine, non-acoustic, NEFSC assessment surveys (e.g., the ECOMON and marine mammal surveys) as indices of zooplankton and micronekton abundance and for use in Integrated Ecosystem Assessment, spatial planning, and ecosystem-based management. This is a collaboration with Debra Palka, Michael Jech, and Jonathan Hare (NEFSC).

2. Exploring the potential of broadband acoustic technologies for fish stock and ecosystem assessment through collection of preliminary field and laboratory data. With Michael Jech (NEFSC), Andone Lavery (WHOI), Jeffrey Condiotty, Lars Andersen (Kongsberg Simrad), and Captain Christopher Roebuck (Commercial fisherman).

3. Examining spatial and inter-annual variability in the distribution of euphausiids along the northern flank of Georges Bank using existing multi-frequency acoustic data collected during herring assessment surveys (1999-2012) and quantifying the interaction of euphausiids with herring and other predators. With Michael Jech (NEFSC).

My educational activities mostly focus on training in acoustics, which I am achieving through course-based instruction and by working with students and postdocs with specific interest in the use of active acoustics for ecosystem assessment.

ACCOMPLISHMENTS

With NEFSC collaborators I am deriving indices of zooplankton and micronekton abundance from multi-frequency acoustic and ancillary data collected during marine mammal surveys (2009-2014). Efforts to discriminate different kinds of organisms in these data are ongoing, after which they will be incorporated into marine mammal habitat models and used to examine the concentrating effects of submarine canyons. A doctoral student involved in this work will shortly defend her dissertation and has two manuscripts in development.

Together with WHOI, NEFSC, and industry collaborators I have conducted tests and field deployments of a prototype broadband acoustic system for stock and ecosystem assessment. Analyses of data from a 2014 cruise suggest that the acoustic spectra of Atlantic butterfish, spiny

dogfish, and Northern krill can be resolved and used to discriminate among species. Tank experiments have examined questions of calibration and resolving targets near boundaries. These findings will be presented at the upcoming ICES Symposium on Marine Ecosystem Acoustics and manuscripts will be submitted for publication in the conference proceedings. This broadband work has led to a new collaboration with the Norwegian IMR examining groundfish, and processing code, methods, and ideas have been exchanged with collaborators at the AFSC, NWFSC, NOAA NOS Center for Coastal Fisheries and Habitat Research, and UNH Center for Coastal and Ocean Mapping.

Michael Jech (NEFSC) and I have combined multi-frequency analysis of acoustic data collected during herring assessment surveys (1999-2012) with models of euphausiid scattering to estimate euphausiid biomass in the southern Gulf of Maine. In the coming year we will verify these estimates relative to other information, examine spatial variability in euphausiid distribution, and examine the importance of euphausiids to herring population dynamics.

Stemming from a successful session on ecosystem applications of acoustic methods that I convened with Kelly Benoit-Bird (OSU) at the ASLO-AGU Ocean Sciences 2014 meeting, we co-authored an invited review for the Annual Review of Marine Science.

Glen Gawarkiewicz (WHOI), Margaret Petruny-Parker (Commercial Fisheries Research Foundation), and I have been seeking to develop a federally-funded cooperative research program examining the New England shelf break ecosystem, stemming from a CINAR workshop we co-convened. In the past year we made a successful visit to Washington D.C. to promote this idea at NSF, and also had productive meetings and email discussions with NOAA administrators.

EDUCATION AND OUTREACH ACTIVITIES

I co-founded a new WHOI-NEFSC seminar series on Fisheries and Ecosystem Acoustics, which convenes every two months at NEFSC and is also distributed as a webinar. I developed a new inter-disciplinary oceanography course for the MIT-WHOI Joint Program, which included a module on fisheries. I have been involved in the development of a CINAR seminar course on ecosystem-based management, planned for fall 2015. I have involved multiple graduate students and postdocs in my research program, providing training in acoustics and ecosystem science. I have continued my participation in the ICES Working Group on Fisheries Acoustics Science and Technology, convened a session on ecosystem applications at the 2014 WG-FAST meeting, and joined the new Working Group on Target Classification.

HIGHLIGHTS

- Analyses are being conducted of multi-frequency acoustic data collected ancillary to routine NEFSC surveys in order to generate indices of zooplankton and micronekton abundance as indices for Integrated Ecosystem Assessment, spatial planning, and ecosystem-based management, including indices of zooplankton and micronekton abundance from shelf-break marine mammal surveys (2009-2014) and estimates of euphausiid biomass from herring assessment surveys (1999-2012).

- Successful calibrations, tests, and analyses of field data have been conducted with a prototype broadband echosounder, investigating the potential of this technology for stock and ecosystem assessment. Publications are in development.

- Co-authored a review paper on ecosystem applications of active acoustic methods recently submitted to the Annual Review of Marine Science.

- Co-founded a new WHOI-NEFSC seminar series on Fisheries and Ecosystem Acoustics; attendance has been high, including online participation via webinar.

- Multiple educational activities were conducted, including course-based activities and involvement of students in acoustic research.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

Education

- WHOI host and advisor for Robert Levine, a graduate student in the Cornell-WHOI Master's program working on krill at the New England shelf break. Mr. Levine defended his thesis in May 2014 and accepted a contract position in the acoustics group at the NMFS AFSC.

- WHOI host for Erin LaBrecque and Julia Burrows, Ph.D. students at Duke University working on acoustic methods for assessing marine mammal prey fields via the WHOI-Duke Fellowship in Marine Mammal Conservation.

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

- WHOI host for guest postdoc Timothy White (CUNY), a seabird ecologist relating bird distribution to concurrent acoustic observations of prey made during cruises conducted by my lab in 2010. In fall of 2014 Dr. White accepted a contract position with the NOAA Biogeography Branch.

- I have worked closely with Christopher Bassett, a WHOI post-doctoral scholar advised by my collaborator Andone Lavery, including on methods for processing broadband acoustic data and discriminating targets near boundaries (e.g., groundfish near the bottom). Dr. Bassett presently has a job application pending with NOAA AFSC.

Outreach

- **Lawson, G.L.**, J.M. Jech, A.C. Lavery, V. Price, N. Charriere, and C. Roebuck. 2014. Field Measurements of Volume Backscattering Strength From Fish and Zooplankton Over a Wide Frequency Band (15 - 400 kHz). ICES Working Group on Fisheries Acoustics Science and Technology, New Bedford, MA.

- Lavery, A.C., **G.L. Lawson**, J.M. Jech, D. Chu, L.N. Andersen, J. Condiotty, T. Weber, C. Lanzoni, and G. Macaulay. 2014. Standard Target Calibration of Simrad EK80 Wide Band Transceivers (WBTs). ICES Working Group on Fisheries Acoustics Science and Technology, New Bedford, MA.

- Lowe, M., **G.L. Lawson**, M. Fogarty, J. Link, and B. Smith. 2014. Using Trophic Interactions to Better Understand the Ecology of Latent Resources of the Northwest Atlantic Shelf Break Ecosystem. AFS Annual Meeting, Symposium on Are We Still Fishing Down the Food Web, Quebec City.

- White, T.P., **G.L. Lawson**, and P.H. Wiebe. 2015. Seabird and cetacean associations with prey, bathymetry, and hydrographic features in Northwest Atlantic submarine canyons during summer 2010. Pacific Seabird Group Annual Meeting, San Jose, CA.

- Convened a session on ‘Applications of acoustic methods to characterize ecosystems’ at the ICES Working Group on Fisheries Acoustics Science and Technology, New Bedford, MA.

- Invited Participant, Northeast Coastal Acidification Network State of Science Workshop, Portsmouth NH, April 2014.

PUBLICATIONS

- Benoit-Bird, K.J. and **G.L. Lawson**. Ecological insights from pelagic systems acquired using active acoustic techniques. Submitted to *Annual Review of Marine Science*.

FIGURES/ PHOTOGRAPHS / ILLUSTRATIONS

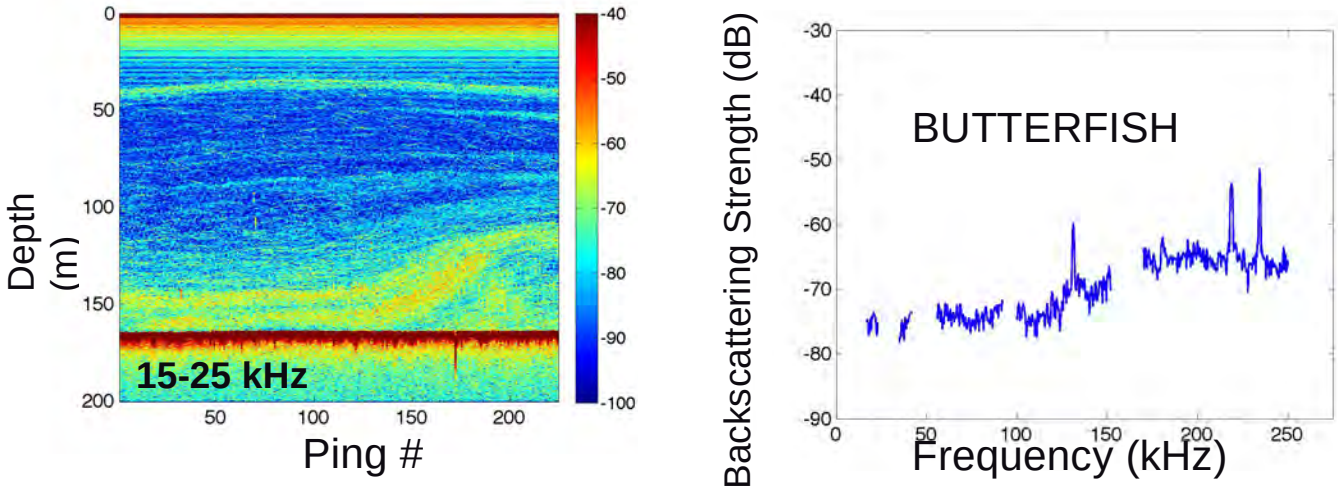


Figure 1. Left: Echogram of acoustic data collected with a prototype broadband acoustic system at the continental shelf break south of New England showing a layer of butterfish migrating up from the bottom at dusk. Right: Acoustic spectrum (i.e., backscattering relative to frequency) derived from these broadband data resolving the characteristic frequency response for butterfish, of substantial utility in discriminating this species from other animals present during acoustic surveys.

CINAR Faculty Gavin Fay

PROJECT OVERVIEW

- Develop capability for graduate student education and training for the next generation of stock assessment scientists, ecosystem scientists, and economists, as part of NOAA Fisheries' Quantitative Ecology and Socioeconomics Training (QUEST) program. Fund new hire of full-time faculty position at the University of Massachusetts Dartmouth's School for Marine Science and Technology (SMAST) in line with NOAA QUEST goals.
- Support graduate students with research relevance to the QUEST program

ACCOMPLISHMENTS

Dr. Gavin Fay was hired as a new tenure-track assistant professor at SMAST. Dr. Fay started at SMAST 09/01/15.

Dr. Fay was supported through the grant through: salary (09/01/14-3/31/15), conference travel (ICES Annual Science Conference, September 2014; CAPAM/NOAA stock assessment workshop, November 2014), and graduate student support (2 students, 01/15-03/31/15).

Dr. Fay was able to use time on CINAR funds in the initial semester to develop and submit 6 grant proposals. One of these has been funded. Three are still currently pending. 2 were unsuccessful. Funded proposal:

McGilliard, C.R. & G. Fay. Incorporating recruitment-environment linkages into stock assessment models for Alaskan groundfish with application to population projections in a changing climate. NOAA Fisheries and the Environment (FATE) program. Total project funds $154,031. UMass Dartmouth funds $110,194.

At 2014 ICES Annual Conference, Dr. Fay co-chaired a Theme Session "Practical advice for implementing marine policy: combining ecosystem and societal indicators in stock and ecosystem assessments". Dr. Fay also gave three oral presentations. At the 2014 NOAA/CAPAM workshop on "Growth: theory, estimation, and application in fishery stock assessment models", Fay gave 1 oral presentation.

Fay developed 2 graduate courses, 1 taught in spring semester 2015 (Jan 2015 – May 2015): "Ecosystem-Based Fisheries Management". The following course (co-taught with S. Cadrin) will be offered at SMAST in fall 2015: "Advanced Population Modeling for Management of Living Marine Resources". Fay and Cadrin have also been re-structuring and redeveloping an existing graduate biostatistics course that will be offered in spring 2016 and intended to be opened to senior level undergraduate students.

Professional activities:
Dr. Fay also served on the review panel for 2015 applications to the national NOAA-SeaGrant Graduate Fellowship Program in Population and Ecosystem Dynamics.

Dr. Fay invited co-chair, ICES The Workshop on guidance for the review of MSFD decision descriptor 4 – foodwebs II. Working group to provide advice for implementation of Europe's Marine Strategy Framework Directive.

Project funds were used to support the following PhD students:

1. Daniel Goethel (Partial support: 60.45%): 4/1/14 -5/24/14
2. Owen Nichols (Partial support: 60.45%): 4/1/14 -6/28/14
3. Owen Nichols (100%): 9/1/14 -12/31/14
4. Megan Winton (100%): 1/4/15 -3/31/15
5. Robert Wildermuth (100%): 1/18/15 -3/31/15

Megan Winton (Advisor: G. Fay) started her PhD program Jan 2015. Her dissertation topic is: Evaluating mehtods for incorporating electronic tagging information in models for assessment and management of highly migratory species. Megan is collaborating with Heather Haas (NEFSC) on sea turtle distribution modeling.

Robert Wildermuth (Advisor: G. Fay) started his PhD program Jan 2015. His dissertation topic is: "Comparing qualitative and quantitative modeling approaches for evaluating tradeoffs for ecosystem-based management". Robert is collaborating with Sarah Gaichas (NEFSC), who will serve as a thesis committee member.

Daniel Goethel completed his dissertation on "Development and simulation testing of a spatially explicit tag-integrated model with application to yellowtail flounder off New England." Chris Legault (NEFSC) served as a graduate committee member and provided essential guidance on advanced modeling and simulation. Three final publications from the dissertation were produced during the period.

Goethel Dissertation Summary - Fisheries management generally attempts to achieve optimal yield, which depends on conserving population structure. However, stock assessment models typically assume spatial homogeneity and that the assessed unit is closed to immigration and emigration. Although many fishery resources have complex spatial population dynamics, such complexity is rarely incorporated into stock assessment models. The purpose of this dissertation was to explore how ignoring population structure impacts stock assessments. The two stage estimation-simulation procedure that was developed in this dissertation to evaluate closed population model interpretations of population dynamics might be a more valuable application of the tag-integrated framework than using it as the sole basis for stock assessment of a species. Although spatially explicit techniques may not be warranted even when complex population structure exists, it is important to carefully consider the implicit spatial assumptions in all stock assessment applications.

Owen Nichols continued his dissertation research on "Environmental effects on longfin inshore squid distribution in Nantucket Sound at multiple spatiotemporal scales". Jon Hare (NEFSC) is

on the graduate committee and is offering guidance on environmental effects. A publication and a technical report were produced during the period:

Nichols Dissertation Summary - The longfin inshore squid (*Doryteuthis pealeii*) is distributed in continental shelf and slope waters of the northwest Atlantic Ocean from Newfoundland to the Gulf of Venezuela. There is no accepted stock assessment model for the species. Poor performance of existing stock assessment models is due in part to variability in survey-derived biomass indices, which is likely in part a product of environmental effects on distribution and catchability. That same environmental variability likely influences the boom-or-bust nature of the fishery, and an overall decline in inshore landings and survey-derived biomass indices in Nantucket Sound is a cause for concern. The goal of the dissertation is to improve understanding of environmental effects on longfin inshore squid distribution at multiple scales, which has direct implications for stock assessment, ecosystem-based fishery management, and adaptation to global climate change.

HIGHLIGHTS

- Hire of tenure-track faculty in quantitative fisheries and ecosystem assessment and management.
- 5 peer-reviewed publications published or in press. 1 technical report.
- Two graduate courses developed (one taught) in topics relevant to NOAA QUEST program priorities.
- Startup funds for Dr. Fay supported proposal development to help establish research program at UMass Dartmouth
- Partial or full support for 4 Ph.D. students at University of Massachusetts Dartmouth. 1 student defended thesis and is now employed as a stock assessment scientist at NOAA Fisheries Southeast Fisheries Science Center.

SOCIETAL BENEFITS

Research supported has direct application to improving the stock assessment and management of commercially important fish species. Dr. Fay worked as invited expert to provide advice to ICES implementation of integrated ecosystem assessments. Project supported the graduate education of four PhD students and also established a new faculty position at the University of Massachusetts Dartmouth who will train future NOAA stock and ecosystem assessment scientists.

EDUCATION AND OUTREACH ACTIVITIES

Fay developed 2 graduate courses, 1 taught in spring semester 2015 (Jan 2015 – May 2015): “Ecosystem-Based Fisheries Management”. The following course (co-taught with S. Cadrin) will be offered at SMAST in fall 2015: “Advanced Population Modeling for Management of Living Marine Resources”. Fay and Cadrin have also been re-structuring and redeveloping an existing graduate biostatistics course that will be offered in spring 2016 and intended to be opened to

senior level undergraduate students: “Introduction to statistics and programming for the biological sciences”.

Fay also organized UMassD Department of Fisheries Oceanography seminar series (Jan 2015-May 2015), lectures from invited experts in fisheries science. Seminar schedule at http://ow.ly/KU60e

Conference presentations:

Fay, G. 2014. Using size increment data in age-structured stock assessment models. CAPAM growth in stock assessment workshop. La Jolla, CA, USA.

Fay, G., and J.S. Link. 2014. Distilling complex information for Integrated Ecosystem Assessments. ICES Annual Science Conference. La Coruna, Spain.

Fay, G., J.S. Link, R.J. Gamble, R. Gorton, S.I. Large, and E.A. Fulton. 2014. Management performance of ecological indicators in the Northeast US: evaluation using ecosystem models. ICES Annual Science Conference. La Coruna, Spain.

Large, S.I., G. Fay, K.D. Friedland, and J.S. Link. 2014. Incorporating ecological and societal indicators to identify ecosystem reference points in response to multiple pressures. ICES Annual Science Conference. La Coruna, Spain.

Other presentations:

Fay, G. 2015. Including regime shifts in fisheries assessments and harvest recommendations using Markov switching models. DTU Aqua Seminar. Charlottenlund, Denmark.

Fay, G. 2014. Including regime shifts in fisheries assessments and harvest recommendations using Markov switching models. Department of Fisheries Oceanography seminar series. University of Massachusetts Dartmouth. Fairhaven, MA, USA.

PUBLICATIONS

Goethel D, CM Legault & SX Cadrin 2015 Demonstration of a Spatially-Explicit, Tag-Integrated Stock Assessment Model with Application to Three Interconnected Stocks of Yellowtail Flounder off of New England. ICES JMS doi:10.1093/icesjms/fsu014.

Goethel D, CM Legault & SX Cadrin 2015 Testing the performance of a spatially explicit tag-integrated stock assessment model of yellowtail flounder (*Limanda ferruginea*) through simulation analysis. Can J Fish Aquat Sci 10.1139/cjfas-2014-0244.

Goethel D, LA Kerr & SX Cadrin, 2015. Incorporating environment and spatial structure in stock assessment of yellowtail flounder and its management implications. In Management Science in Fisheries: a Practical Introduction to Simulation-Based Methods. Taylor & Francis (in press).

Griffiths, S.P., and G. Fay. 2015. Including recreational fisheries data in stock assessment: implications for model performance and subsequent management strategies. Fisheries Management and Ecology. (in press).

Nichols OC, E Eldredge & SX Cadrin 2014 Gray seal depredation at commercial fish weirs observed using Dual-frequency Identification Sonar (DIDSON). Marine Technology Society Journal Volume 48(4): 72-78.

Nichols OC, JR King, JA Hare & SX Cadrin 2014. Untangling drivers, mechanisms and scales of environmental effects on squid availability to a seasonal inshore fishery. ICES CM 2014/P:05.

U.S. National Office for Harmful Algal Blooms

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Donald Anderson - WHOI

NOAA Sponsor – Quay Dortch - NOS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

Related NOAA Goal Plan:

PROJECT OVERVIEW

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

ACCOMPLISHMENTS

Communication and Outreach:

National HAB Web Site: The *Harmful Algae* Web Site (www.whoi.edu/redtide) serves as a critical resource for the U.S. HAB community. The site receives between 6,500 and 7,500 visits each month. In addition to maintaining the Web Site, conference announcements, funding opportunities, reports, etc. of interest to the HAB community are routinely posted and circulated through our numerous listservers. We post approximately 2-3 announcements per week to our Harmful Algae Facebook account for the National Office – typically these are links to harmful bloom events in the U.S. We have received positive responses from the community about this effort, with 604 "likes" at present.

Information requests: The National Office deals with many direct requests for information that are elicited by the site. These include frequent requests for photographs or other media products,

referrals to experts in particular regions or disciplines, inquiries from students doing reports, and journalist inquiries. Another important type of interaction is with victims of HAB poisonings who are seeking help in the form of information and referrals to appropriate physicians. In many of these cases, direct personal interactions are needed, requiring considerable time commitments, but also providing a necessary and valuable service to the public.

International Council for the Exploration of the Seas (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 for posting on the Harmful Algae Web Site (see www.whoi.edu/redtide/page.do?pid=14898&tid=542&cid=47899&c=3 for an example).
At the 2015 WGHABD meeting, PI Anderson presented a summary of U.S. events for 2014. In addition, time was devoted to correcting errors in the HAEDAT database and preparing information on U.S. HAB trends through time (since the beginning of the HAEDAT database in the early 1980s).

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 the availability of funds to the HAB community as well as accepting requests for funds and administering their dispersal. The National Office works with NOAA Program Managers who decide who receives funds and how much will be needed in each case. Additionally, we make arrangements and process travel, vessel charters, analyses, and other expenses associated with these rapid response activities. During the past year we arranged funding for the following events: *Karenia* event, Florida; cyanoHABs, Toledo, OH; loggerhead sea turtles (*Karenia*), Florida; and mapping of a *Karenia* bloom, Florida.

Scientific Meetings/Workshops

The National Office often assists with the formulation of scientific agendas, arranging for financial and administrative support, and providing expert representation for national and international HAB workshops, symposia, and conferences. The National Office also assists in selection and disbursement of funds for student travel to national and international conferences, workshops, and training courses. During the project year, meetings we were involved with include the *16th International Conference on Harmful Algae* (Korea) and the *Eighth Symposium on Harmful Algae in the U.S.* (California).

U.S. HAB symposia. Kleindinst served on the Steering Committees for the *Eighth Symposium on Harmful Algae in the U.S.*, to be held November, 2015 in Long Beach, CA. She is working closely with the organizers to plan the meeting, and to communicate updates and announcements to the U.S. HAB community. The National Office will also solicit and process travel awards for students and managers for the HAB symposium.

International HAB Conferences. Anderson served on the Steering Committee for the *16th International Conference on Harmful Algae,* which was held in New Zealand, October 2014. The National Office handled travel reimbursements for nine students receiving support to attend the meeting.

National HAB Committee (NHC)

The National HAB Committee was formed in 2005, and is charged with overseeing coordination and implementation of the revised U.S. National Plan. The National Office provides support to the NHC. Each year we request nominations for the 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, which facilitates communication by this group. Kleindinst provides administrative support to this group, and both she and Anderson serve as *ex officio* members. Kleindinst also serves on the subcommittee on Education and Outreach. The National Office arranges and leads conference calls for the group as well as in-person meetings.

HIGHLIGHTS

- Assisted with the planning and organization of the *16th International Conference on Harmful Algae* (Korea) and the *Eighth Symposium on Harmful Algae in the U.S.* (California), including soliciting and processing travel awards for students and managers.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACTIVITIES

- Anderson, D.M., Plenary, "Harmful algal blooms", International Conference on Harmful Algal Blooms and Desalination, Muscat, Oman (April, 2014)
- Anderson, D.M., U.S. Summary of HAB Events – 2014, ICES WGHABD, Lisbon, Portugal, April, 2015)
- Harmful algae website: http://www.whoi.edu/redtide
- National HAB Committee Web Site: www.whoi.edu/nationalhab/
- Northeast PSP website: http://www.whoi.edu/northeastpsp/

Marine Resources Education Program: Northeast region

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Alexa Dayton - GMRI

NOAA Sponsor – John Hoey - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

For the project period, the Marine Resources Education Program (MREP) Implementation Team proposed to carry out five initiatives:

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

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

ACCOMPLISHMENTS

We delivered the following workshops as outlined in our proposed scope of work:

- MREP 200 Science – 2 Days, Woods Hole, MA (October 27 - 28, 2014)
- MREP 100 Science workshop – 3 Days**,** Warwick, RI (Jan 13 – 15, 2015)
- MREP 100 Management – 3 Days**,** Warwick, RI (March 10 -12)

Following informal consultation with community members in the growing MREP network, the Implementation Team determined that greatest demand is currently from a spectrum of fisheries operating primarily in Southern New England and the Mid-Atlantic Bight, and the MREP 200 Insights into the stock assessment workshop continues to be highly relevant.

The team hosted the MREP 200 workshop in Woods Hole, MA, with a tour of the Bigelow at her berth in Newport, RI. Gloucester, MA fishermen, who have been highly articulate about voicing their ongoing concerns over stock assessments for Gulf of Maine Cod, remarked on the extraordinary access they had to leading scientists who addressed their issues in a straightforward manner. The culmination of the two-day workshop came during a tour of the NOAA fishing gear warehouse, when tribal leader Sam Novello had opportunity to talk with the Bigelow gear technicians and examine the trawl survey net and ground gear. "It's good," said Sam, and others in the party agreed. Since this workshop, interaction with the industry on the topic of stock assessments continues to reveal lack of trust in the outcome, but this is accompanied with a greater degree of respect for NOAA fisheries, and appreciation for the Survey sampling branch. Industry has focused on the spatial and temporal coverage of the Bigelow and fishery independent surveys, and suggested that more sampling is needed to understanding impacts associated with changing climate.

Fishermen in the Southern New England area very often are targeting a mix of species, some of which are managed by the Mid-Atlantic Fishery Management Council, and some by the New England Council. The decision was to locate the 2015 Science 100 and Management 100 modules in Warwick, RI, within easy driving distance of New Bedford and Montauk, and a short flight from Baltimore and Philadelphia. Though the roster of participants for both modules contained attendees from across the eleven-state Northeast Region, the majority hailed from ports in New Jersey, New York, Rhode Island, and New Bedford, MA. This new mix of interests challenged us to reevaluate the modules' curricula content, to add species managed by both Councils, and to recruit science and management presenters from both New England and "The Mid". An additional twist is the growing participation of recreational fishermen, primarily from the for-hire fisheries between Rhode Island to New Jersey.

To encourage this emerging recreational sector participation, we enlisted charterboat captain Rick Bellavance to moderate the Science 100 module, added a component on near-shore ecosystems, expanded a presentation from the Atlantic States Marine Fisheries Commission (ASMFC) staff, and added a discussion of monitoring and data-collection issues in the management of Black Sea Bass.

The Super Fish Case Study continues as a highlight of the Management Module, with improvements planned for each upcoming iteration; this year's exercise employed staff members from both Fishery Management Councils serving as advisors on the process as participants negotiated a hypothetical resource allocation. To accommodate the larger numbers, the class was divided into two separate negotiations, with additional roles assigned. Individuals were given detailed instructions on their unique negotiation parameters, and people with similar assignments were allowed to caucus in advance to explore and share options for pursuing their assigned objectives. Individual role instructions have been further refined based on input from previous Case Study exercises. Participants demonstrated an enthusiastic response to the Case Study, and the post-negotiation discussion of "lessons learned" was animated, with participants, Councils' staff and NMFS professionals sharing experiences.

A new Science 200 curriculum on marine ecosystems and fishery productivity is under development by the Implementation Team. Initial conversations with NMFS personnel in Sandy

Hook, Narragansett, and Woods Hole have yielded an outline of possible topics; curriculum discussions are continuing with key agency personnel and others in the greater community to explore ecosystem-based management principles. A central challenge is to identify ways to make this, as much as possible, a hands-on learning experience.

HIGHLIGHTS

In the 2014-2015 presentation cycle, MREP made substantial progress in three areas, by:

- Expanding our network structure to incorporate new and underserved communities;
- Integrating workshop recruiting, delivery, and curricula to attract fishermen across the Mid-Atlantic and New England regions; and
- Adapting module delivery to allow larger, more diverse classes, reaching more fishermen.
- Delivering three workshops total, attracting 54 total unique participants.
- Expanding speaker's bureau and program content to meet evolving industry needs and increased geographic breadth.

SOCIETAL BENEFITS

- MREP workshops provide a foundation for improved trust in the Fishery Management process.
- MREP has prepared industry members for meaningful engagement as articulated and envisioned by Magnusson Stevens Act.
- MREP has provided a critical platform for dialog around Gulf of Maine stock assessment.

EDUCATION AND OUTREACH ACTIVITIES

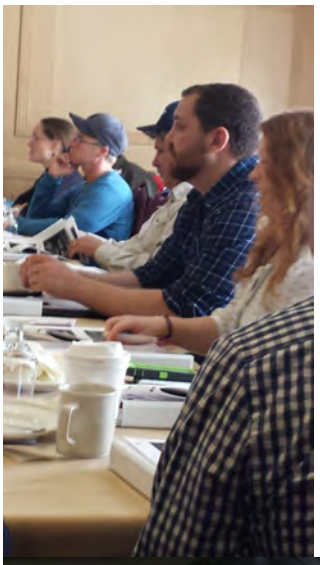
Building on our experience with a condensed "introductory" MREP workshop delivered in 2014 in the ports of Gloucester and Chatham, we made it a priority to recruit participation of Cape Ann fishermen for the advanced MREP 200, Insights into Stock Assessments, offered in Woods Hole in October 2014. Recruiting participants was a coordinated effort by the Northeast Sector Services Network (NESSN), the Northeast Seafood Coalition, and Gloucester Fishermen's Wives, resulting in eight prominent figures from the Gloucester waterfront attending.

We further leveraged the MREP alumni networks and proactively approached several key figures in the mid-Atlantic and southern New England areas to assist with targeted recruiting. The turning point for recruiting participants from the recreational sector for the MREP 100 workshops came during a Mid-Atlantic Fishery Management Council regulatory action on Black Sea Bass in November. Attending were party boat owners (whose clientele target the species), including MREP alumni Monty Hawkins and Skip Feller. Over lunch with a dozen of their colleagues at the table, Skip described the MREP curriculum to his fellow captains and invited a short presentation from the MREP Team. Skip and Monty then followed up in recruiting efforts.

Roster size for the three modules in this cycle ranged from 22 to 28, up from a typical 18-person class size in past modules. We believe the new approach to networking into new areas of the

industry have huge merit, and have a revealed a significant and untapped audience for the MREP program, further deepening our impact.

FIGURES/PHOTOGRAPHS/ ILLUSTRATIONS



DRINK WHAT ALES YOU.

Marine Resources Education Program: Southeast fisheries region

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Alexa Dayton - GMRI

NOAA Sponsor – Kim Amendola - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

The Gulf of Maine Research Institute (GMRI) proposed to continue the collaboration with partners in the Southeast fisheries region to refine and implement another set of Marine Resource Education Program (MREP) Southeast workshops, a fishery science and management education program for commercial and recreational fishermen, tailored to the region by an 18-member Steering Committee. This education enables fishermen and others to participate productively in the fisheries science and management processes, and leads to improved cooperation and trust between fishermen, and scientists and managers. Fundamentally, a co-learning approach is used in this program, where program developers, program participants, and program presenters all learn from one another through their interactions and collaborations.

GMRI proposed to recruit twenty program participants for the Management workshop during the reporting period, and also recruit an additional 20 participants for a Science workshop, with class compositions that reflect a high degree of diversity. Program implementation consists of a series of two workshops, which build upon each other: a multi-day fishery science workshop, followed by a multi-day fishery management workshop. The format of the workshop creates an open dialogue among participants and presenters in which they explore ways of fostering cooperation among fishermen, scientists, and managers.

GMRI further proposed to reconvene the regional Steering Committee for a third annual meeting, and engage them in a program review and evaluation of the second year.

ACCOMPLISHMENTS

Fisheries Science Workshop

The second MREP Southeast Science Workshop was held April 4 - 6, 2014 in St. Petersburg, Florida. The three-day workshop was held at the Florida Fish and Wildlife Conservation Commission's Fish & Wildlife Research Institute (FWRI) facility. Participants in the workshop included fishermen, industry representatives, and a few others such as a port agent from the South Atlantic, Gulf of Mexico, and the Caribbean. A total of 28 industry members participated, along with 12 presenters and other staff.

All of the program attendees, including the twelve program presenters plus other fisheries technicians from the research labs, joined in the program and discussions with fishing industry participants for multiple days, and the networking resulted in increased understanding of the challenges facing each of the represented sectors. The personal interactions helped to build mutual trust, and break down barriers to communication between the fishing industry, and scientists and managers.
Regional Administrator, Dr. Roy Crabtree, and his staff also joined the program for the bulk of the three days, and new and productive dialog has been initiated with many new fishing industry members. Their staff reported that this was an unparalleled opportunity for them, bridging the gap between NOAA and fishing industry in a way that no other program has yet demonstrated.

Fisheries Management Workshop
The second of the two-part workshop series, the MREP Management Workshop, was held in Tampa, Florida from September 30 - October 2, 2014, and also included participants from the South Atlantic, Gulf of Mexico, and Caribbean. A total of 28 participants attended the workshop, representing commercial, recreational, and charter fishermen, as well as fish house owners/dealers and media. Most of our attendees had also taken the science workshop, but due to scheduling conflicts not all of them took part in Management. We added new attendees from the waiting list as we were able.

In addition to the presentations and the very popular Council Case Study Scenario and role-play, we also included small energizer activities, designed to reinforce the learning, liven up the discussion, and provide a bit of movement to the day. In particular, we developed a power-point based game of Fisheries Management "Jeopardy", and had groups of 4 to 5 people on a team, using different buzzers if they wanted to answer the question, with each team awarded points for correct answers.

Meals and break times continued to be invaluable moments for networking, asking questions, and allowing casual interaction among the presenters and attendees. There were times when we decided to allow a slightly longer break in the presentations than planned, for the discussions were so relevant and engaging that all attendees felt it was a very good use of their time. We observed that phone numbers were exchanged and follow-ups for post workshop contact were developed on an individual basis.

HIGHLIGHTS

- Fisheries science and management education programs refined based on prior year evaluations.
- Speaker's bureau was expanded and enhanced for science and management workshops.
- Fisheries science education program delivered for 28 fishermen and an additional 18 speakers and other guests in St Petersburg, FL, April, 2014.
- Fisheries management education program delivered for 26 fishermen and an additional 18 speakers and other guests in Tampa, FL, September, 2014.
- Reconvened Steering Committee in November 2014, and with four new members selected from prior year workshop attendees.

- Identified Steering Committee meeting feedback and suggested modifications to program approach based on evaluations.
- Performed extensive outreach and networking to generate a second year of program applicants.
- Launched MREP Puerto Rico, led by MREP graduates from prior year and in collaboration with NOAA fisheries, Caribbean Fishery Management Council, Dept. of Natural Resources, and local stakeholders and interested parties such as Fisheries Associations and TNC.
- Held three-day combined fishery science, management, and law enforcement MREP Puerto Rico workshop for 37 participants in January 2015. Program was offered in Spanish, and all workshop materials and website were translated by the project team.

Workshop evaluations were universally positive and indicated a significant increase in participants' likelihood to participate in fisheries science and management activities, such as cooperative research, data collection, and fishery management council activities. Five fishermen applied for Council Advisory Panel positions, and of these three were appointed. Two fishermen have engaged in new cooperative research projects. Two fishermen also initiated a spin-off effort, MREP Puerto Rico, evidence of the program's replicability in other regions.

SOCIETAL BENEFITS

- We delivered the MREP Southeast Fisheries Science and Management workshops, as a foundation for improved trust in the Fishery Management process.
- We delivered the MREP Puerto Rico, as a foundation for local engagement in Fisheries Management and building trust among commercial and recreational sectors.
- We fostered industry leadership through the Steering Committee construct, and workshop moderator opportunities, and saw new individuals become engaged in fisheries discussions, delivering increased leadership capacity for the region.
- MREP Southeast has prepared industry members for meaningful engagement as articulated and envisioned by Magnusson Stevens Act.

EDUCATION AND OUTREACH ACTIVITIES

- The full Steering Committee was provided with periodic updates on curriculum development progress, which written and sent by GMRI staff. They were invited to work in sub-committees and the planning team as a way to directly shape the program content.
- Program awareness and recruiting for attendees for the science program took place primarily during the months January - March 2015.
- We enlisted the Steering Committee members and prior years program attendees as program ambassadors, and the response was tremendous. They reached out to their networks and helped spread the word.
- July 2014 – South Atlantic Council staff provided a brief overview of the MREP Southeast Science Workshop, and sought input and comment from Education Advisory Panel.
- August 2014 – Gulf of Mexico Council staff provided a brief overview of the MREP Southeast Science Workshop.

- September 2014 – At the Caribbean Council Meeting, MREP science workshop attendees Carlos Velasquez and Helena Antoun provided a summary of local steering committee recommendations and a program plan for delivery in 2014-2015.
- We developed another colorful postcard that could be easily circulated and handed out by Steering Committee, and councils alike and provided each person with 20 to hand out, and each council with 250.
- We obtained a mailing list of all Federal permit holders in the Southeast region, and another list of dealers and seafood processors. The total potential mailing list size was 18,000, from which we randomly selected 5,000 names to receive the postcard via bulk mail.
- We employed a combination of tactics whereby we requested that the councils include an announcement in their council meeting updates, and communications to their lists, on behalf of the program. In addition, individual Steering Committee members engaged in social media such as Facebook posts to reach a younger audience.
- A unique website page was developed for this effort. We used photos provided by Steering Committee members and NOAA staff to ensure the proper look and feel for the Southeast region.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Industry leadership capacity is fostered through program participation, engagement with the Steering Committee, and through program moderator opportunities. We gained four new Steering Committee members who have provided additional perspective to the curriculum planning and outreach efforts.

Fisheries stakeholders from a variety of regions and sectors (Recreational, Commercial, Charter) work together in small groups during hands-on otolith ageing activity.

One-on-one conversations during meals and the social hour allow participants and presenters to establish relationships, and build trust with fisheries stakeholders outside the regulatory arena.

Science and Management workshop presenters, drawn from NOAA fisheries' most senior leadership and leading local academic and research institutions, devote time to presenting at MREP, answering questions, and enable application of concepts learned into real world situations.

UMaine Cooperative Education

NOAA Cooperative Agreement No. NA14OAR4320158
July 1, 2014-March 31, 2015

CINAR Investigator – Gayle Zydlewski - UMaine

NOAA Sponsor – Richard Langton - NMFS

Related NOAA Strategic Plan Goal: Healthy Oceans

CINAR Theme: VI. Education and Outreach

PROJECT OVERVIEW

The main objective in Year 1 was to hire four undergraduate students to conduct new internships with the local NOAA-Fisheries Office. One previously established undergraduate continued with these project funds.

Internship advertisements:
Project Title: Improving data sharing in acoustic telemetry networks
The University of Maine, Delaware State University, National Marine Fisheries Service, and Washington Department of Fish and Wildlife scientists intend to work together to understand and describe the groups of current users and determine what they deem as important factors when deciding to join or be involved with a network. In particular, what data are they willing to share, under what circumstances. This could inform future interactions and data sharing across the network and possibly inform a National Policy on acoustic telemetry data sharing. The intern will be participating in designing the survey and compiling and evaluating survey results.

Project Title: Examining Smolt Timing and Spring Water Temperatures
Gulf of Maine Atlantic salmon are the last wild populations in the USA. NOAA biologists have been monitoring smolt migrations in Maine since 1996 in the Narraguagus River. Median run dates of smolts leaving Maine rivers to the waters off Greenland has shifted by nearly two weeks, which has been attributed to lesser snowpack and earlier ice out. In addition, temperatures in the Gulf of Maine are among the most rapidly changing in our world's oceans, which is affecting salmon behavior and survival. A better understanding of changing freshwater and marine temperature regimes is needed. This intern will help assemble data and information to further this ongoing research.

Project Title: Diadromous Fish in Diets of Gulf of Maine Predators
The iconic Atlantic salmon is one of a dozen sea-run fish that spend part of their life in Maine Rivers and the remainder of their life in the Gulf of Maine and beyond. To better understand the role of these diadromous fish in the diet of coastal and Northeast Shelf predators, NOAA Fisheries began studying the diets of groundfish and pelagic predators in 2010. Recently, efforts have been coordinated with Maine Department of Marine Resources to take advantage of their trawl survey. By assisting the DMR with sampling, NOAA is able to collect stomach samples in coastal waters. Examination of the diet of fish in these two regions will document the changing

role of the forage base in these regions with the rebuilding of diadromous fish stocks resulting from dam removals and improved passage.

Project Title: Tomcod in Maine Estuaries
Tomcod are a year-round inhabitant of estuaries, occurring along the entire coast of Maine and ranging from upstream freshwater to full salinity seawater at the river mouth. They are often similar in size and co-occur with Atlantic salmon smolts. Because NOAA staff would like to better understand all diadromous fish in the system, a dedicated synthesis of tomcod data would contribute to this basic knowledge of the Penobscot River before the removal of the Veazie and Great Works dams. These data would then be available for post-dam removal comparisons.

ACCOMPLISHMENTS

- One student continued from a previous internship at the Maine Field Office.
- Four internships were developed between UMaine and NOAA-Fisheries
- Applicant solicitation occurred in at the end of November.
- Applicants were interviewed at the beginning of December; nine applicants representing two different Departments at the University of Maine were interviewed.
- Four interns were hired

HIGHLIGHTS

Summaries

Shane Carey
I have been organizing multiple data sets on stomach contents of diadromous predators from fall and spring Maine Inshore Trawls in 2013 and 2014. The stomach of each fish caught in the trawl was removed and analyzed to determine the diet of the fish in different seasons, and we are entering the data into an MS Access database to examine how these diets may be changing. Once all data is entered we will be able to determine what the fish prefer to eat and how population structure may be changing. Along with data entry, we are preparing equipment for the upcoming spring inshore trawl.

Dylan Whitaker
I have been working on summarizing smolt run data and temperature data collected from 2000-2014 from watersheds in the down east regions of Maine to assess the correlation between smolt run timing and Accumulated Thermal Units (ATU). We have summarized both hatchery and wild smolt data according to the number of fish caught on each day of the year to show when the run was initiated and terminated. The dates that correspond to the percent of the run have been matched with respective ATUs and their daily average temperature to investigate the effects of temperature on run timing. We are analyzing data and finding interesting trends that differ between rivers, and between hatchery and wild fish. Overall this experience has been very fulfilling and I am excited to see what we learn next.

Jamie Fisher
Over this semester I have been working with Atlantic tomcod data. From 2010 to 2013, Atlantic tomcod were collected at various sites along the Penobscot River using four different gear types: a one meter fyke net, two meter fyke net, forty-five meter seine, and a pelagic trawl. The total

length of each fish was measured and the total count of fish was recorded. I sorted through the data and created graphs based on each gear type to determine the size range of fish caught with a particular gear type. I also plotted the total length of the fish by month, to see how the size of tomcod changed over time. I performed a literature review on Atlantic tomcod, and am writing a paper to summarize my findings, and to compare my data with those from other studies on Atlantic tomcod.

Erin Mercer
Over the past several weeks Gayle Zydlewski and I have been revising and preparing a survey evaluating data sharing among acoustic telemetry users. A previous survey conducted in 2010 focused on informal interactions on the East Coast. Since then, new formal networks provide an efficient way to share data nationwide. However, some researchers do not participate. Our survey asks researchers about their involvement with data sharing and the factors determining whether or not they are willing to collaborate with others. I have completed the training required to work with human subjects and the University's Institutional Review Board approved our survey. We hope to distribute the survey soon so we can begin to analyze results.

Audrey Dean
A large-scale marking program for U.S. Atlantic salmon was undertaken from 1962-1996, in which over 1.5 million tagged smolts (primarily Carlin tags) were released in U.S. rivers. Over 8500 fish were recovered on the high seas, and approximately half were from international fisheries in Canada and Greenland. All associated release and recapture data were archived electronically. However, many of the original tag returns also contained scale samples from the recaptured fish. These historical samples have never been properly archived or analyzed. NOAA Fisheries Service has initiated a project to extract growth measurements from these archived scales samples to supplement ongoing investigations into the drivers of marine growth and survival of Atlantic salmon. Initial steps in this process were to inventory the archive scale samples and begin preparing them for growth measurement extraction (Fall 2014).

SOCIETAL BENEFITS

These internships are giving undergraduate students the opportunity to interact with NOAA-scientists concerning societally-relevant marine science issues. These experiences could be instrumental in the students' career paths and their active involvement in fisheries issues.

APPENDIX 1: CINAR Personnel Summary:

July 1, 2014 – March 31, 2015

Task 1 Support

Employees	**Appt. Dates**
Don Anderson, CINAR Director	7/1/14 - present
Judy Kleindinst, CINAR Administrator	7/1/14 - present
Ann Stone, CINAR Administrative Professional	7/1/14 - present

APPENDIX 2 : CINAR Personnel Summary Chart :

April 1, 2013 – March 31, 2014

Category	Number	B.S	M.S	PhD.
Employees who receive ≥ 50% NOAA Funding (not including Students)				
Research Scientist	2	1	1	0
Visiting Scientist	0	0	0	0
Post Doctoral Fellow	2	0	0	2
Research Support Staff	10	5	5	0
Administrative	0	0	0	0
Total	14	6	6	2

Category	Number	B.S	M.S	PhD.
Employees who receive < 50% NOAA Funding (not including Students)				
Research Scientist	38	4	9	25
Visiting Scientist	1	0	0	1
Post Doctoral Fellow	1	0	0	1
Research Support Staff	45	24	16	5
Administrative	14	7	1	0
Total	99	35	26	32

Students	-	-	-	-
Undergraduate Students	5	0	0	0
Graduate Students	4	0	2	2
Total	9	0	2	2

Obtained NOAA employment within the last year	0	0	0	0

APPENDIX 3: CINAR Publications for Reporting Period:

	2014-15
CI Lead Author	8 peer-reviewed 3 non peer-reviewed
NOAA Lead Author	0 peer-reviewed 0 non peer-reviewed
Other Lead Author	3 peer-reviewed 0 non peer-reviewed

Benoit-Bird, K.J. and G.L. Lawson. Ecological insights from pelagic systems acquired using active acoustic techniques. Submitted to Annual Review of Marine Science.

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Bogomolni, A., Frasca Jr S., Levin M., Matassa K., Nielsen O., Waring G., De Guise S. In-Vitro Exposure of Harbor Seal Immune Cells to Aroclor 1260 Alters Phocine Distemper Virus Replication. In review, submitted to Archives of Environmental Toxicology.

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