CICOR

Cooperative Institute for Climate and Ocean Research

of the Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

Annual Progress Report

July 1, 2007- June 30, 2008

Dr. Robert A. Weller, Director

submitted to
National Oceanic and Atmostpheric Administration
Ocean and Atmospheric Research (OAR)
September 2008

The Cooperative Institute for Climate and Ocean Research at the Woods Hole Oceanographic Institution prepared this report under award #NA17RJ1223 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

Please direct comments or request for copies to: cicor@whoi.edu

Robert A. Weller, Director, CICOR
Patricia White, CICOR Administrator

On the cover: Photo of the SHOA surface buoy with a WHOI technician servicing the WHOI self-contained, internally recording meteorological sensor. At that time, the mooring was not recovered. In October 2008, the buoy and mooring will be recovered. (Photo by Sean Whelan, WHOI)

Contents

CICOR EXECUTIVE SUMMARY

6 Executive Summary

7 Research Highlights

CICOR ADMINISTRATIVE OVERVIEW

10 CICOR – Administrative Overview

12 Personnel Summary

13 Personnel Support Overview

CICOR EDUCATION AND OUTREACH

14 CICOR Postdoctoral Scholar Summary Report
Dr. Tobias Kukulka – CICOR Postdoctoral Scholar 2007-2008

16 CICOR Postdoctoral Scholar Summary Report
Dr. Ricardo De Pol-Holz - CICOR Postdoctoral Scholar 2006-2008

18 CICOR Summer Student Fellows

18 Christopher 'Max' Castorani

19 Jennifer Clinton

20 Jess McNally

21 Teacher At Sea Program Involvement 2007-08

23 Cicor Workshops, Meeting Support, and Outreach

CICOR ANNUAL RESEARCH SUMMARIES

30 U.S. Program In Marine Biotoxins And Harmful Algae
Donald Anderson
NOAA Program Manager: Dr. Quay Dortch, NOAA/NOS/CSCOR

32 Bowhead Whale Feeding in the Western Beaufort Sea: Oceanographic Conditions, Whale Prey Distributions, and Whale Feeding and Foraging Behavior
Carin J. Ashjian and Mark F. Baumgartner
NOAA Program Manager: Dave Rugh NOAA/NMFS/AFSC/NMML

35 Wind-Driven Transport Indices for Cod and Haddock Recruitment on Georges Bank
Dr. Philip Bogden
Program Manager: David Mountain NOAA/NMFS/NEFSC

39 Multi-Sensor Improved SST (MISST) for GODAE
Dr. Sandra Castro and Dr. William Emery
NOAA Program Manager: Dr. Stan Wilson, NOAA/NESDIS.

43 Vents New Millennium Observatory (NeMO) 2007
Robert S. Detrick
NOAA Program Manager: Robert W. Embly, NOAA/OAR/PMEL/NOAA PROGRAM: CIPO

44 **Implementing QA/QC Standards for In Situ Ocean Sensors using OGC-Sensor Web Enablement**
Janet Fredericks
NOAA Program Manager: James Boyd, NOAA/NOS/CSC (Coastal Services Center)

47 **An Intercalibration and Quality Assurance Program using a Stand-Alone Wireless IMET System**
David Hosom
NOAA Program Manager: Dr. Sidney Thurston, NOAA/CPO/OCO

49 **Marine Resource Industries, Regulation, and Waterfront Land Use Change in New England Fishing Communities**
Di Jin
NOAA Program Manager: Dr. Eric Thunberg, NMFS/NEFSC/Social Sciences Branch, Woods Hole, MA

51 **Development of Commercial Fishing Vessel Cost Models**
Di Jin
NOAA Program Manager: Andrew Kitts, NMFS/NEFSC/Social Science Branch

53 **Economics of Ocean Surface Vector Winds Observation**
Hauke Kite-Powell
NOAA Program Manager: Joseph Sienkiewic, NOAA/NWS/Ocean Applications Branch

55 **Assessment of Air-Sea CO_2 Exchange Rates in the World's Ocean Using Bomb ^{14}C Inventories Derived from WOCE Global Survey**
Dr. Alison Macdonald
NOAA Program Manager: Dr. Kathy Tedesco, NOAA/OAR/OGP/GCC

57 **Coupled Biological/Physical Models in the Coastal Ocean: Skill Assessment and Planning for Regional Testbed Projects**
Dr. Dennis J. McGillicuddy, Jr.
Program Manager: Dr. Elizabeth Turner, NOAA/NOS/COP

60 **The Argo Float Program**
Dr. Brechner Owens
Program Manager: Dr. Steve Piotrowicz, NOAA/OAR

62 **Dynamics of the Flow of Pacific Water Through the Western Chukchi: Analysis of the 2004 RUSALCA Herald Canyon Hydrographic Data.**
Dr. Robert S. Pickart
NOAA Program Manager: Dr. John Calder, NOAA/OAR/ARCTIC

66 **State of the Arctic Report**
Dr. Andrey Proshutinsky
Program Manager: Dr John A. Calder, NOAA/OAR Arctic Research Office

69 **POGO Cruise Database Support**
Shubha Sathyendranath
NOAA Program Manager: Mike Johnson, NOAA/OAR/CPO/Climate Observations.

71 **U.S. Research Vessel Surface Meteorology Data Assembly Center**
Dr. Eric Chassignet, Mr. Shawn R. Smith, and Dr. Mark A. Bourassa
NOAA Program Manager: Michael Johnson, NOAA/OAR/CPO/Climate Observing Division

74 **A re-Analysis and Testing of Trends of Tropical Cyclone Data during the Aircraft Reconnaissance and Saatellite Era**
Andrew Solow
NOAA Program Manager: Christopher D. Miller, OAR/CPO

76 **NOAA/PMEL ICEALOT Cruise on *R/V Knorr***
Albert F. Suchy
NOAA Program Manager: Tim Bates, NOAA/OAR/PMEL

78 **Movements, Diving Behavior, and Characterization of Foraging Habitat of Deep Diving Odontocete Cetaceans, and Potential Responses to a Sonar Exercise Near the Hawaiian Islands**
Peter L. Tyack & Robin W. Baird
NOAA Program Manager: Brandon L. Southall, NMFS/Office of Protected Species, Ocean Acoustics Program

81 **Air-Sea Interaction in the Eastern Tropical Pacific ITCZ/Cold Tongue Complex**
Dr. Robert A. Weller
NOAA Program Manager: Dr. Jin Huang, OAR/CPO/Climate Prediction Program for the Americas

86 **Volunteer Observing Ship Program**
Robert A. Weller , Albert J. Plueddemann and David S. Hosom
NOAA Program Manager: Dr. Michael Johnson NOAA/OAR/CPO/Climate Observations

89 **Long-Term Evolution and Coupling of the Boundary Layers in the STRATUS Deck Regions of the Eastern Pacific**
Dr. Robert A. Weller
Program Manager: Dr. Jin Huang NOAA/CPO

92 **Ocean Reference Stations**
Robert A. Weller and Albert J. Plueddemann
NOAA Program Manager: Dr. Michael Johnson NOAA/OAR/CPO/Climate Observations

97 **A FIFTY-YEAR ANALYSIS OF GLOBAL OCEAN SURFACE HEAT FLUX**
Drs. Lisan Yu and Robert Weller
Program Managers: Dr. Mike Johnson, NOAA/OCO

102 **Honors and Awards**

103 **Presentations and Outreach Activities**

108 **Appendix I: Publication Statistics**

109 **Publications**

Executive Summary

CICOR

Cooperative Institute for Climate and Ocean Research
Annual Report 2007-08

Dr. Robert A. Weller, CICOR Director

CICOR is a Cooperative Institute between the National Oceanic and Atmospheric Administration (NOAA) and the Woods Hole Oceanographic Institution (WHOI). CICOR's specific research themes are:

- The coastal ocean and near-shore processes,
- The ocean's participation in climate and climate variability, and
- Marine ecosystem processes analysis.

CICOR brings to NOAA research excellence in oceanographic research and marine policy as well as access to research ships and submersibles, remotely operated and autonomous vehicles, and state of the art ocean observing systems.

Education and Outreach activities are key priorities for CICOR. This year CICOR has continued its support of postdoctoral scholars, graduate research assistants, and Summer Student Fellows as well as its participation in a local science fair. It also continues its sponsorship of a multi-media Harmful Algal Bloom exhibit in the WHOI Exhibit Center, which along with the Information Center hosts over 30,000 visitors per year. The Cooperative Institute is in the process of developing further educational and outreach activities with regional partners.

NOAA's Teacher At Sea program has continued to be an important component of CICOR outreach. Again this year CICOR research cruises hosted several teachers on NOAA-funded Ocean Reference Station cruises in Chile and Hawaii. We also heard from a prior Teacher At Sea, Debra Brice, who shared her statistical evidence that indicated that enrichment opportunities, such as the Teacher At Sea program, had a positive correlation with her students' higher test scores compared to others in the district.

CICOR continues to stimulate interaction with the external community and act as an incubator for activities on the cutting edge of regional and global science. For example, CICOR held talks and a round-table discussion entitled, 'Change in the Global Freshwater Cycle: The Ocean's Role' which hosted atmospheric scientist Graeme Stephens from Colorado State University. CICOR is sponsoring a workshop on Connecticut River Science in conjunction with the Connecticut River Museum which will provide a forum for scientists active in the Connecticut River basin to share their work and ideas, and to foster collaborations for future research on the Connecticut River and its drainage basin. CICOR and WHOI scientists are working with NOAA and regional and international partners on regional ocean observing and ecosystems science planning efforts. They will be leading a discussion on the topic at the upcoming OCEAN INNOVATION 2008 World Summit: Ocean Observing Systems meeting to be held in St. John's Newfoundland in October 2008 and are planning a symposium dedicated to the topic for early 2009.

In July 2008, CICOR entered its tenth year of activity dedicated to connecting WHOI resources to NOAA's goals. CICOR has a strong track record of moving forward NOAA-funded research and operations in climate observations with the Argo Float Program and the Ocean Reference Station activity as well as climate modeling. In the coastal and ecosystems goals, CICOR scientists have been leaders in a variety of areas including marine policy research on fisheries management, marine mammal acoustic tagging, and harmful algal bloom research and the related invaluable modeling work that has alerted local authorities and fishermen of events which were instrumental in protecting human life and health. CICOR is a global and regional resource that is well poised to broaden and deepen its scope over the coming years by its commitment to strengthening its global partnerships and fostering robust regional collaborations.

CICOR Annual Research Highlights

HIGHLIGHTS

The U.S. Program In Marine Biotoxins And Harmful Algae office administers HAB event response funds to provide rapid reaction to unexpected or unusual outbreaks in different parts of the country. This year, these include the first documented presence of diarrhetic shellfish poisoning (DSP) toxins in shellfish within the US, and a massive regional red tide in New England. D.M. Anderson, Director of the National Office provided testimony to the Subcommittee on Energy and Environment Hearing, "Harmful Algal Blooms: The Challenges on the Nation's Coastline", Washington, DC, July 2008. The completely revised Harmful Algae website was launched in October 2008 and remains one of the top 5 visited websites at WHOI; in fact, visits are up 25% from the previous year. All of the activity under this project relates to HABs, a serious and growing threat to the nation's fisheries, coastal ecosystem and human coastal communities.

Carin Ashjian and Mark Baumgartner observed considerable interannual variability in physical and biological oceanography between the three years of their observations (this work and the two years of the SNACS project). The researchers found that the oceanography and whale prey distribution on the shelf near Barrow are intimately tied to wind forcing. Their work helps us define and understand the interannual variability in ocean conditions and whale prey and how it is associated with larger scale atmospheric and oceanographic conditions which is critical to achieving a better understanding of the importance and persistence of the western Beaufort Shelf as a feeding environment for the bowhead whales during their fall migration. This in turn has implications to the success and resilience of Iñupiat subsistence whaling at Barrow as well as to a better understanding of how to protect and manage the Western Arctic bowhead whale population.

GOMOOS scientists Philip Bogden and Tom Shyka led the development of a product to enhance weather and wave forecasting which will improve public safety and provides enhanced support for marine commerce and transportation. The product was designed after similar products available through sailing and airline websites. Code was developed to extract desired data from the wind forecast model (NCEP) from NOAA OPeNDAP servers with the help of James Manning from NEFSC. Data is stored on the GoMOOS server and the product is automatically updated twice daily. Since the release in July 2007, the application is the third most used application on GoMOOS.org after the hourly buoy data and home page.

Drs. Sandra Castro and William Emery generated a revised turbulence-closure based diurnal warming model that smoothly blends fundamental turbulence and enhanced mixing schemes. This leads to enhanced SST analyses for improved weather forecasting and monitoring of climate change.

Janet Fredericks has led a community of data providers, IT specialists and domain experts needed to work together to provide meaningful descriptions of sensors, processing and other relevant information on the sensors set-up and care. Towards that end, a community of people, both from the public domain and private institutions, have become engaged in implementing QA/QC practices for waves, in situ currents, CTD and dissolved oxygen into the OGC-SWE framework. As we move towards dealing with machine-to-machine exchange of information, a common expectation in data quality will assure a broader trust in the abundance of data that will result in the ability to more readily discover and harvest data from disparate sources. This will enable interdisciplinary research with enhanced confidence levels using data funded for perhaps different applications, enhancing the value of any funded collection of data.

The UOP group led by Weller, Plueddemann and Hosom have led the new development and implementation of hardware and software that greatly increases memory capacity while simultaneously reducing memory cost for the ASIMET (Air-Sea Interaction Metorological) systems. A new ASIMET module processor/controller board was designed to improve low-temperature operation for the next generation of ASIMET electronics. The long-term goal

of the "portable standard" ASIMET package is to provide climate quality meteorology from the oceanographic research fleet. This will result in a unique database of in-situ observations in regions of the world's oceans where access by commercial and volunteer observing ships is limited or non-existent.

In his work on marine resource industries, regulation and waterfront land use change in New England Fishing communities Dr. Di Jin found a strong spatial relationship between local fish stocks and local employment in the fishing and related industries. The study will improve our understanding of the interactions between changes in fish stocks and waterfront land uses and fishing communities' economic conditions.

In another study on the development of commercial fishing vessel cost models, Dr. Jin developed a general framework for constructing dependent and independent variables using results from recent NMFS surveys, and for reviewing a large number of independent variables for different cost models. We developed three sets of models: annual vessel fixed cost, annual labor cost, and vessel trip variable cost. Within each set, separate models were estimated for different gear groups. Analysts often work on similar issues, but in different contexts; vessel types often overlap across Fisheries Management Plans (FMPs) and protected species actions. As such, having standardized and pre-tested cost models by gear and other strata would create a number of benefits. It would increase the likelihood of cost models being used in regulatory analyses, it would reduce the work load on analysts, and it would foster an agreed-upon "best practice" approach to this aspect of fisheries modeling.

Hauke Kite-Powell's research on the economics of ocean surface vector winds observations indicates that a significant fraction of the approximately $500 million/year risk to commercial maritime transportation from severe storms in the North Atlantic and North Pacific oceans can be avoided with ocean surface vector wind observations and forecasts. This research contributes to the understanding of the economic value of ocean observing systems, specifically ocean surface vector wind observing instruments on satellites. This kind of information is important in the analysis of tradeoffs between alternative public earth observing system investments, and in ensuring that the nation builds and maintains an efficient and effective ocean observing infrastructure.

Dr. Alison MacDonald's research found that the ocean inventory of bomb-produced radiocarbon (^{14}C) is directly related to air-sea CO_2 exchange and thereby provides a powerful constraint on the exchange rates. The large amount of high-quality radiocarbon data collected during the WOCE program provides the opportunity to improve our estimate of these air-sea CO_2 exchange rates and make the results available to the modeling community.

Dr. Robert S. Pickart's work investigated for the first time the dynamics of the flow of Pacific water through Herald Canyon. Winter water entered the canyon on the western side, but switched to the eastern wall of the canyon as it flowed northward. The RUSALCA program represented a fruitful collaboration of Russian and US scientists, making use of shared resources and expertise. The results from the study enhanced our knowledge of a critical part of the Arctic system, enabling us to better predict the impacts of variable inflow through Bering Strait as a result of climate change.

The U.S. Research Vessel Meteorology Data Assembly Center Recruited 5 additional vessels to the SAMOS initiative, including the WHOI RV *Oceanus*. An increase from 992 to 2279 ship days of underway meteorological and thermosalinograph data was collected, run through automated quality control, and distributed. The Data Assembly Center provides quality-evaluated marine meteorological data to the satellite and air-sea flux communities. Using these data, improvements are made in satellite retrieval algorithms that, in turn, will improve our ability to monitor the atmosphere near the ocean surface from space-based platforms. Similarly, the flux community achieves a better understanding of the variability in heat and moisture exchange between the ocean and atmosphere, which will improve future atmospheric and ocean models (potentially improving future forecasting capabilities).

Dr. Andrew Solow's work provides further evidence that at least part of the long-term increase in the observed number of North Atlantic tropical cyclones can be attributed to incompleteness in the early part of the record. In order to manage risks associated with long-term changes in hurricane activity and intensity, society needs to understand how such risks are changing and are likely to change in response to on-going climate change. A central problem in using the observational record of hurricanes to advance this understanding is bias due to under-sampling. The work conducted under this project is aimed at developing and applying methods that can account for such under-sampling.

Led by Robert A. Weller , Albert J. Plueddemann and David S. Hosom, the Volunteer Observing Ship Program continued field operations to maintain AutoIMET systems on two VOS routes in the Pacific and provided documentation and engineering consulting to STAR Engineering (licensee for IMET fabrication and sales) for the transfer of an ASIMET sonic anemometer wind module from development to production.
Also designed, fabricated, and tested was a 3rd generation Iridium communication controller, Seabird SIM interface, and Benthos acoustic modem interface for inductive and acoustic telemetry of underwater instruments. The long-term goals of this work are to improve in-situ observations of marine boundary layer meteorology and air sea fluxes in order to improve understanding and prediction of the earth's climate.

Dr. Brechner Owens reports that the WHOI contribution to the Argo Float Program has continued to significantly accelerate and improve the performance of the floats. Improvements in both the communications system and the calibration procedures have been implemented. A significant error in the data reported from these floats has been indentified and the procedures to correct the data have been developed and implemented. The through-flow of data to the final quality controlled values has also significantly increased.

Work on the Ocean Reference Stations led by Drs. Plueddemann and Weller report that two Ocean Reference Stations (Stratus, WHOTS) are now collecting pCO_2 data in addition to surface meteorology. One of these (Stratus) is also collecting surface wave data. One Ocean Reference Station (NTAS) serves as the development site for near real-time delivery of surface meteorology and upper-ocean properties via Iridium telemetry. The Upper Ocean Processes Group web site, which serves the ORS meteorological data, has been extensively revised and re-organized. Near real-time WHOI ORS data are also available through NDBC. Six years of surface heat fluxes from the Stratus ORS site were merged and evaluated, suggesting significant discrepancies in the ECMWF ERA-40 and NCEP-2 reanalyses The long-term goals of this work are to improve in-situ observations of marine boundary layer meteorology and air-sea fluxes in order to improve understanding and prediction of the earth's climate.

CICOR – Administrative Overview

(Cooperative Institute for Climate and Ocean Research)

CICOR is a Cooperative Institute between National Oceanic and Atmospheric Administration (NOAA) and the Woods Hole Oceanographic Institution (WHOI).

CICOR's primary mission is to facilitate and build interaction between NOAA and academia through sponsored research organized around three broad themes. Historically, the Great Lakes Environmental Research Laboratory (GLERL) was CICOR's formal partner within the NOAA OAR structure, but several years ago the cooperative institute has been partnered directly with the Climate Program Office within OAR. In addition to close ties to the arctic and climate observations and modeling programs within CPO, CICOR investigators also have research partnerships with other NOAA laboratories and line offices, including several NMFSC labs on the east and west coasts, NESDIS, AOML (Atlantic Oceanographic and Meteorological Laboratory) in Miami, PMEL (Pacific Marine Environmental Laboratory) in Seattle, the Environmental Technology Laboratory (ETL) in Boulder, and NOS and its IOOS and Coastal Ocean Program offices.

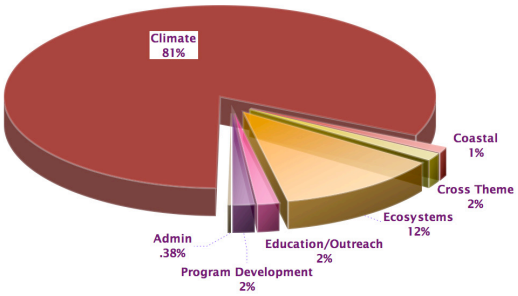
As of July 2008, CICOR entered its tenth year of operations. The first cooperative agreement with NOAA OAR, lasted 3 years, and began in the summer of 2001. A 5-year cooperative agreement was signed July 2001. In 2006, the agreement was extended until June, 2008. Another one-year extension until June '09 was granted so that a new competition for a regional CI could be coordinated within NOAA over the 2008-09 funding period.

Under the cooperative agreement CICOR research is organized around three **science themes**. At the same time, for administrative purposes budgets are organized around four **tasks**.

CICOR's three research themes are:

- The coastal ocean and near shore processes,
- The ocean's participation in climate and climate variability and
- Marine ecosystem processes analysis.

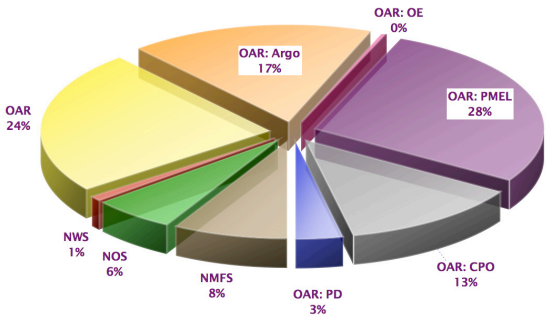
2007-08 Funding by Theme



These theme areas, each of which has significant implications for human society, are interrelated and scientific progress requires collaborations by scientists within and between disciplines. In each case, progress depends on a combination of fundamental process studies, the development and deployment of technological systems for sustained observation, and the development of predictive models that are based on an understanding of the underlying processes and that assimilate information from the observational systems.

CICOR has been in existence for nine years. During the first 3-year Cooperative Agreement it assisted WHOI Scientists with 26 funded projects totaling a budget of $5,817,000. The total amount funded for projects undertaken during the present 7-year Cooperative Agreement through June '08 is $36,543,460. For the reporting year July 2007 – June 2008, the total amount awarded for projects was $8,239,790

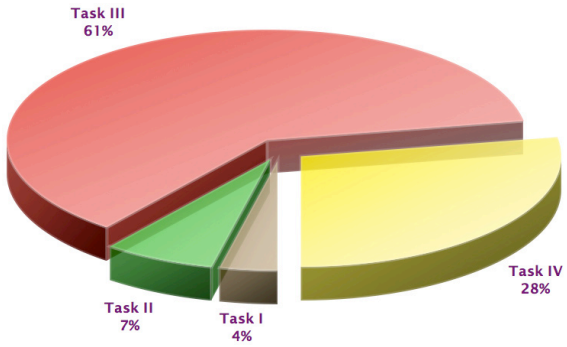
2007-08 Funding By NOAA Office



The bulk of the NOAA funds come from the Office of Oceanic and Atmospheric Research and the Climate Program Office including the Climate Observations Division and Arctic Programming with additional funds from the National Marine Fisheries Service, the National Ocean Service and NESDIS, the National Environmental Satellite and Data Service. Funding to CICOR from NOAA is categorized as falling into four Tasks:

• **Task I**, with a total of $297,706 in 2007-8, included all funding for administration and supporting program development, including educational programming. CICOR program development fees during this reporting year covered two post-docs, a graduate student, three summer student fellows, educational outreach, travel support for CICOR PIs and post-docs to attend meetings with NOAA personnel as well as support for short term visitors for seminars and workshops. For more information see the CICOR website: http://www.whoi.edu/science/cicor.

2007-08 Funding by Task



• **Task II** is research funding with explicit participation by a NOAA investigator ($576.4K);

• **Task III** is research that is in support of NOAA's strategic goals and funds work done by WHOI or other academic investigators without NOAA scientists as co-principal investigators ($5.1M), and

• **Task IV** is support for use of WHOI research vessels and submersibles by NOAA and other NOAA-funded investigators ($2.3M.).

It is important to bring to the reader's attention that CICOR is an administrative, planning, and facilitation structure serving NOAA, WHOI, and other external investigators funded by NOAA. CICOR investigators respond to NOAA Announcements of Opportunity, submit proposals, and if successful are awarded funds by NOAA through CICOR. The $110K base funds from NOAA OAR and the program development funds are devoted to Task I activities including education, outreach, and increasing engagement in planning and execution of NOAA research. That the principal mode of research is competitive grants funded in response to NOAA announcements is the context for how CICOR manages its science.

Although NOAA funds CICOR Research, the Woods Hole Oceanographic Institution contributes substantial fiscal and administrative support to the Institute. It does this in a number of significant ways, for example, by supplementing lower overhead rates, which are afforded CICOR research and by providing $100K for overhead support. The current cooperative agreement was proposed and awarded with indirect costs that were less than the 2001 overhead rates negotiated with our cognizant agency, ONR, with the exception that the rate would remain fixed at 44% and 30% of salaries (for lab and G&A respectively) for the duration of the five-year Cooperative Agreement. Since WHOI overhead rates have typically increased each year, the difference between the overhead rates on CICOR proposals (2001 rates) and the WHOI rate continues to increase. WHOI however, is required to charge all grants and contracts regardless of funding agency the same overhead rate. This is accomplished by WHOI contributing from its unrestricted funds the difference in overhead on CICOR projects. CICOR's current cooperative agreement was extended two years from June 30, 2006 to June 30, 2008 and again from 2008 - 2009 with no increase or change to the overhead structure. As of June 2008, WHOI's contribution to overhead for the current cooperative agreement totals over $1,167,796, an average of $146,000 per year and over $252,582 in this reporting year.

Over the past year CICOR has developed several new integrated databases that link projects and initiatives with people and themes. For example, we can easily search who has been involved with ecosystem research and any related ecosystem workshops or meetings that have been organized through the office. Thus far, the use has been confined only to CICOR PIs, projects and people who have been on the variety of mailing lists for the numerous events the office has organized. However, the tools can be put to use on a broader scale. It is anticipated that these new tools will be useful for integrating the work of multiple partners as we look toward a future with a stronger regional focus.

Personnel Summary

July 1, 2007 – June 30, 2008

Task I Support

Employees	Appt. Dates
Bob Weller, CICOR Director	1999 - present
Patricia White, CICOR Administrator	2004 - present

Task I and Development Costs Supporting Post-Docs and Joint Program Students

Post-Doc	CICOR Theme	Appt. Dates	Advisor(s)
Ricardo De Pol Holz	Climate	2006-2007	Lloyd Keigwin
Tobias Kukulka	Coastal & Ecosystems	2007-2008	Al Plueddemann & John Trowbridge

Graduate Student	CICOR Theme	Appt. Dates	Advisor
Carlos Moffat	Climate	2005-2007	Robert Beardsley

Summer Student Fellows	CICOR Theme	Advisor
Max Castriani	Ecosystems	Scott Gallagher (BIO)
Jennifer Clinton	Coastal	Porter Hoagland (MPC)
Jess McNally	Coastal	Carin Ashjian & Rubao Ji

Personnel Support Overview:

Through CICOR NOAA supported 114 people in 2007-08: Twenty people were supported for half time or more eighty-four were supported for less than half time. (The summary below does not include summer student fellows or joint program students.)

Personnel				
Category	Number	B.S.	M.S.	Ph.D.
Research Scientist	24	0	1	23
Visiting Scientist	0	0	0	0
Postdoctoral Fellow	2	0	0	2
Research Support Staff	58	21	13	4
Administrative	20	15	2	0
Undergraduate Students	6	0	0	0
Graduate Students	2	2	0	0
Employees (< 50%) NOAA Funding	109	47	14	23
Total (≥50% support)	5	2	1	1
Obtained NOAA employment within the last year	1			

2008 NOAA/CICOR Post Doctoral Scholar Progress Report

Post Doctoral Scholar: Tobias Kukulka
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-3455 E-mail: kukulka@whoi.edu

Related NOAA Strategic Plan Goal*:*
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
Goal 3. Serve society's needs for weather and water information.

OVERVIEW

Tobias Kukulka started his appointment at the Woods Hole Oceanographic Institution (WHOI) in September 2007, after completing his PhD from the University of Rhode Island (URI). During his PhD training, Tobias investigated the role of breaking waves on wave statistics and air-sea momentum exchange by developing a coupled model of wind and waves. This new model will advance Tobias' ongoing research at WHOI of upper ocean turbulence, which is driven by ocean surface waves. Such turbulence accomplishes vertical transport of passive scalars (e.g., nutrients); influences horizontal mixing; and controls the velocity, temperature, as well as density distributions. Because upper ocean turbulence cannot be resolved in numerical ocean models that are used for climate and weather projections, it has to be parameterized in these models. However, such parameterizations do not represent realistically the effects of ocean surface waves. The goal of Tobias' research is to assess quantitatively the role of surface waves in upper ocean turbulence dynamics, in order to come up with improved, physics-based parameterization of subsurface turbulence.

To accomplish this research goal, Tobias collaborates at WHOI with Albert Plueddemann from the Department of Physical Oceanography and John Trowbridge from the Department of Applied Ocean Physics and Engineering. Utilizing new state-of-the-art turbulence measurements and numerical models, Tobias systematically compares observations and models of the wave-influenced ocean surface boundary layer. The numerical simulations are based on a high resolution model ("large eddy simulations") capable of resolving turbulence and wave effects. To incorporate wave effects more realistically for diverse wind conditions, Tobias is coupling the numerical model with the wind and wave model developed during his PhD. Field observations are based on data from special purpose sonars that allow estimates of turbulent kinetic energy budgets, as well as dominant turbulence length scales. In the long term, the results of this investigation will be essential in incorporating wave effects in upper ocean turbulence parameterizations that can be used to enhance weather and climate models.

During his tenure as Cooperative Institute for Climate and Ocean Research (CICOR) Postdoctoral Scholar, Tobias has published two papers in the Journal of Physical Oceanography, has submitted two further manuscripts, presented two public seminars at WHOI, and gave a lecture on air-sea interactions for WHOI's Summer Student Fellows. Furthermore, CICOR has supported his travel to the European Geosciences Union General Assembly in Vienna, Austria, where he presented a paper titled "Air-sea momentum flux over breaking and non-breaking waves".

PRESENTATIONS & OUTREACH ACTIVITIES

Kukulka, T., T. Hara. Wave effects on subsurface turbulence, COFDL-Talk, Woods Hole Oceanographic Institution, Woods Hole, MA, 2008.

Kukulka, T., T. Hara. Air-sea momentum flux over breaking and non-breaking surface waves, Physical Oceanography seminar series, Woods Hole Oceanographic Institution, Woods Hole, MA, 2008.

Kukulka, T., Hara, T., Belcher, S.E., Air-sea momentum flux over breaking and non-breaking surface waves, EGU General Assembly, 2008.

Kukulka, T., and T. Hara, Effects of breaking waves on a coupled wind-wave model and air-sea momentum flux, ASLO/AGU Ocean Science Meeting, 2008.

2008 Lectured for Woods Hole Oceanographic Institute Summer Student Fellows on "Air-sea interactions"

PUBLICATIONS

Kukulka, T., T. Hara, The effect of breaking waves on a coupled model of wind and ocean surface waves: I. Mature seas, *J. Phys. Oceanogr.*, published 2008.

Kukulka, T., T. Hara, The effect of breaking waves on a coupled model of wind and ocean surface waves: II. Growing seas, *J. Phys. Oceanogr.*, published 2008.

Kukulka, T., T. Hara, L. Wu, A Newton-collocation method for solving nonlinear advance-delay differential equations, *submitted to J. Applied Numerical Mathematics*.

Gerbi, G.P., J.H. Trowbridge, E.A. Terray, A.J. Plueddemann, T. Kukulka, Observations of turbulence in the ocean surface boundary layer: energetics and diffusivity, submitted to *Journal of Physical Oceanography*, 2008.

CICOR Postdoctoral Scholar Summary Report

Summary of Accomplishment

Dr. Ricardo De Pol-Holz – CICOR Postdoctoral Scholar 2006-2008

Dr. De Pol-Holz arrived at the Woods Hole Oceanographic Institution (WHOI) in November of 2006, after completing his Ph.D. in Oceanography at the University of Concepcion, Chile. During his Ph.D. training, Dr. De Pol-Holz studied the biogeochemistry of nitrogen isotopes in the eastern South Pacific and used this information to assess the variability of the intensity of denitrification during the Late Quaternary. Dr. De Pol-Holz's Ph.D. training provided him with a strong background in stable isotope analysis, nitrogen biogeochemistry and Paleoclimatology. At WHOI, Dr. De Pol-Holz seeks to become familiar with radiocarbon techniques, and to assess the past variability of intermediate water mass ventilation in the South Pacific. Dr. De Pol-Holz's project at WHOI, in collaboration with faculty advisor Lloyd D. Keigwin, is to use paired radiocarbon analyses in benthic and planktonic foraminifera to investigate the deglacial changes in Antarctic Intermediate Water (AAIW) ventilation using cores from the Chile margin.

During last year (2007-2008), Dr. De Pol-Holz wrote a research proposal in collaboration with his advisor Dr. Keigwin and submitted it to the National Science Foundation for evaluation. In December 2007 they received the funding confirmation, securing his affiliation with WHOI as a postdoctoral Investigator for one more year after the CICOR support is over.

Dr. De Pol-Holz's research project is to use the radiocarbon data to determine the apparent ventilation age of a selected depth range in the eastern South Pacific. The N isotope information that he generated in his Ph.D. provided the evidence that during the last deglaciation, there was a collapse in the ventilation of the South Pacific subsurface (onset of the modern Oxygen Minimum Zone) which has been associated with changes in intermediate water formation. The radiocarbon data that is being analyzed at WHOI constitutes the first attempt to directly assess the changes in AAIW near its formation zone west of the Drake Passage. Dr. De Pol-Holz hopes that the radiocarbon data will confirm the growing evidence of the existence of a deep and radiocarbon depleted water reservoir in the Pacific and that it was its ventilation and the spread of its signal to other basins by way of AAIW formation, that was the responsible mechanism for the deglacial increase in CO_2 in the atmosphere.

Using stable isotope analysis on benthic foraminifera, Dr. De Pol-Holz will also try to identify hydrological changes that could have altered AAIW characteristics during the last glacial-interglacial transition (18,000-11,000 years ago). The methodology lies in the identification of peaks in abundance of selected species of benthic foraminifera like *Uvegerina peregrina*, *Cibicidoides sp.* and *Bulimina sp.* in several cores from intermediate depths along the Chilean margin. His results confirm the existence of such peaks where he has already sampled enough material for 10 paired plantik-benthic radiocarbon analyses from one core to the NOSAMS laboratory at WHOI.

CICOR sponsored Dr. De Pol-Holz's travel to Chile for an international Summer Institute in Climate Change organized by the Universidad de Concepcion as well as a trip to the University of California at Irvine where he participated in a short course on Radiocarbon in the Earth system.

In the last year (2007-2008), Dr. De Pol-Holz has had one publication published, and an additional one submitted:

De Pol-Holz**,** R., R. Robinson, D. Hebbeln, D. M. Sigman and O. Ulloa. Controls of sedimentary N isotopes along the Chile margin. 2007. Submitted to *Deep-Sea Res II.*

De Pol-Holz, R., O. Ulloa, F. Lamy, L. Dezileau, P. Sabatierr, D. Hebbeln. Late Quaternary variability of sedimentary nitrogen isotopes in the eastern South Pacific Ocean. 2007. *Paleoceanography,* 22, PA2207, doi:10.1029/2006PA001308.

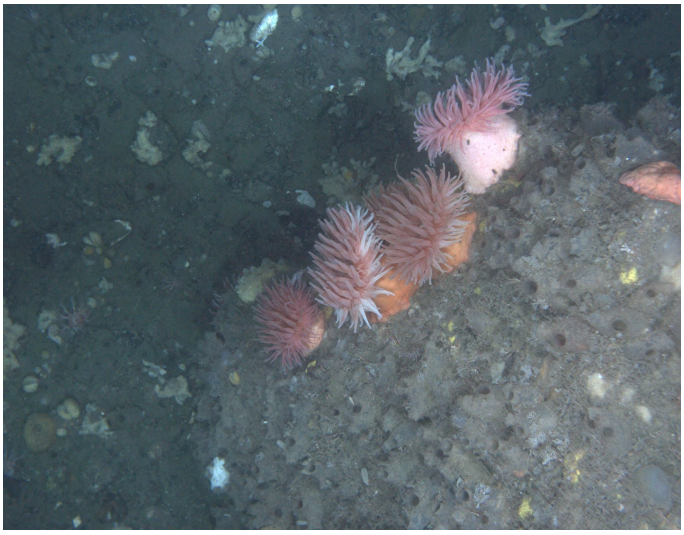
CICOR Summer Student Fellow

Christopher "Max" N. Castorani
Summer Student Fellow

PhD Candidate
San Diego State University
University of California, Davis

Summer Student Fellow
WHOI Biology Department
Advisor: Scott Gallager
"Benthic Marine Ecology at the
Stellwagen Bank National Marine Sanctuary"

Related NOAA Strategic Plan Goal:
Ecosystem Goal: To protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management.



ACTIVITY REPORT

The Stellwagen Bank National Marine Sanctuary is region of high physical heterogeneity and is thought to have great biological productivity. It is an economically important area for fisheries, tourism, and recreation. However, few studies have examined the benthic composition of the sanctuary. We use images gathered by a towed underwater camera (HabCam) to evaluate the benthic community structure and biodiversity across a trench east of Tillies Bank. We also measure changes in community structure as a function of region, depth, and sediment characteristics. Community assemblages were found to be significantly different between the sides of the Trench and within the Trench. Diversity and species richness were lower in the trench than on either ridge. However, diversity was not found to be significantly different between the East Ridge and the West Ridge. Abundance for all species decreased as a function of depth and community structure was different at depth. There were also observed differences in community composition by sediment type. Softer substrates were dominated by annelids and siphoning bivalves, while in regions with harder substrates tunicates and, to a lesser degree, brachiopods prevailed. In all regions, depths, and sediments, communities were overwhelmed by individuals from a relatively small number of species. This study was part of a larger project known as the Northeastern Bentho-Pelagic Observatory (NEBO). NEBO has the goals of producing unique data for fisheries and marine protected area (MPA) managers, and developing ecosystem-based approaches to management. There is still much work to be done within the Stellwagen Bank National Marine Sanctuary. We would like to further investigate the distributions of organisms through spatial statistics, quantify species associations, and determine the trophic roles being played by the most abundant species within the sanctuary.

CICOR Summer Student Fellow

Jennifer Clinton
Summer Student Fellow

Summer Student Fellow
Fairfield University, Dept. of Political Science
WHOI Dept. of Marine Policy

Advisor: Porter Hoagland
The market as an institution for zoning the ocean.

Related NOAA Strategic Plan Goal:
Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

ACTIVITY REPORT:

In recent years, spatial conflicts among ocean users have increased significantly, particularly in the coastal ocean. Ocean zoning has been proposed as a promising solution to these conflicts. Strikingly, most ocean zoning proponents focus on a centralized approach, involving government oversight, planning, and spatial allocations. We hypothesize that a market may be more efficient for allocating ocean space, because it tends to put ocean space in the hands of the highest valued uses, and it does not require public decision-makers to compile and analyze large amounts of information. Importantly, where external costs arise, a market in ocean space may need government oversight or regulation. We develop four case studies demonstrating that private allocations of ocean space are taking place already. This evidence suggests that a regulated market in ocean space may perform well as an allocative institution. We find that the proper functioning of a market in ocean space depends positively upon the strength of legal property rights and supportive public policies and negatively upon the number of users and the size of transaction costs.

CICOR Summer Student Fellow

Jess McNally
Summer Student Fellow

Summer Student Fellow
Stanford University, class of 2009
Expected B.S. Earth Systems, Oceans track

WHOI Department: Biology
Advisors: Dr. Carin Ashjian and Dr. Rubao Ji
Topic of Study: Modeling the development of Arctic Calanus copepods

Related NOAA Strategic Plan Goal:
Goal 3: Protect, restore and manage the use of coastal and ocean resources.

ACTIVITY REPORT

Belehrádek functions for the temperature-dependent development of three *Calanus* species—*C. finmarchicus, C. glacialis*, and *C. hyperboreus*—were parameterized from existing literature, in some cases using the equiproportional rule for development. A biological model for copepod development was then integrated with the Finite-Volume Coastal Ocean Model (FV-COM) based *i-state* Configuration Model (FISCM). 0D sensitivity testing for variations in growth season length and ocean warming was conducted using ice-tethered profiler data gathered from the Beaufort Sea. At Arctic temperatures, *C. glacialis* is by far the fastest developing of the three species, followed by *C. hyperboreus* and *C. finmarchicus*. Sensitivity testing supports the hypothesis that two or three weeks difference in the length of the growing season could have a significant impact on the number of *C. finmarchicus* and *C. hyperboreus* that make it to a stage where diapause is possible. We can also not reject the hypothesis that one or two degrees of warming could be the difference between *C. finmarchicus* making it to a stage where it could overwinter or not, which supports the hypothesis that warming in the Arctic could significantly alter the biogeographical range of this North Atlantic species.

Teacher At Sea Program Involvement 2007-08

Two Teachers at Sea participated on CICOR – funded cruises during the 2007-08 funding period. Megan O'Leary who teaches 5th Grade at a Massachusetts school participated in the Stratus cruise which went through the Panama Canal and traveled to the coast of Chile where the Stratus buoy was recovered and a new one deployed. Megan had an on-line blog and kept in touch with her students via e-mail. Patricia Kassis, a math teacher in Hawaii participated in the WHOTS cruise off the coast of Hawaii in the summer of 2007.

The teachers in this program are responsible for providing daily logs which get posted to a NOAA Teacher at Sea website. Megan's final log included the following:

TEACHER AT SEA: MEGAN O'LEARY:

The Stratus 8 Cruise on the *Ronald H. Brown*
Monday, November 5, 2007

THE FINAL ENTRY FROM THE OCEAN

It's difficult to believe that this will be my final entry from the equatorial Pacific! We are packing up the main lab and are scheduled to disembark tomorrow morning in the Galapagos Islands to begin our journey home. It has been a truly remarkable 30 days for me out here on the open waters, a unique adventure and one that I'll never forget. The scientists on the trip were so willing to include me in their experiments and conversations, and so willing to answer all of my questions. The officers and crew of the *Ronald H. Brown* opened up their home so that I could join this amazing group to observe, participate, listen and learn--many thanks and best of luck on your next four very long legs!! Many thanks also go NOAA's Teacher at Sea Program!! If you have any interest at all in oceanography, marine fisheries, or our amazing atmosphere I would suggest making a visit to their site and thinking about applying for next year!! http://teacheratsea.noaa.gov/

I'll leave you with an interesting quotation from Jacques Cousteau—"The sea, once it casts its spell, holds on in its net of wonder forever."

Before and After: Styrofoam cups decorated by Megan's students before and after they were shrunk by ocean pressure on a decent via CTD apparatus.

TEACHER AT SEA: PATRICIA KASSIS:

Patricia's Blog was utilized by students in Hawaii and elsewhere. One of her entries about the CTD casting included this:

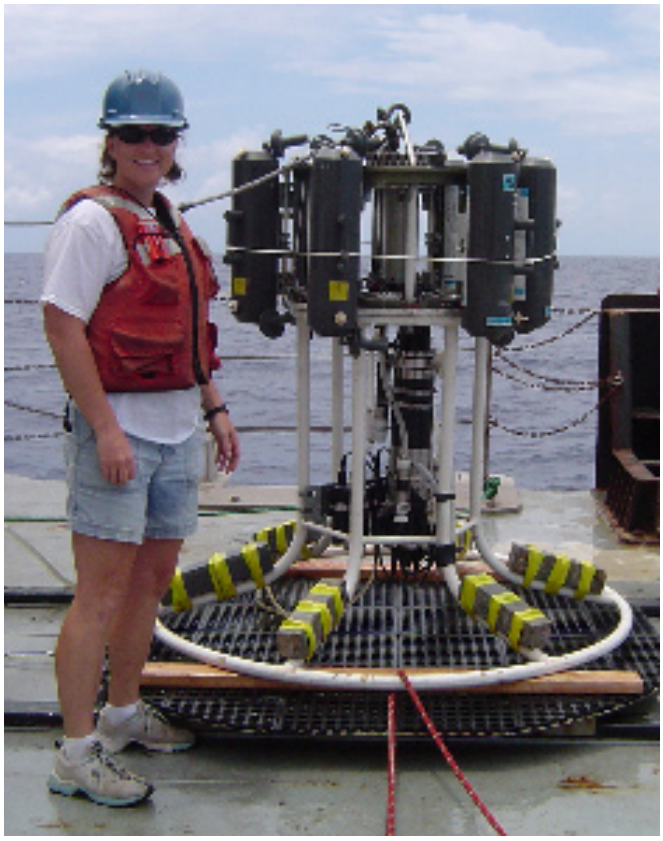
CTD scans while both buoys are deployed
NOAA Teacher at Sea: Patricia Kassis

Aboard the R/V *Kilo Moana*
Mission: WHOTS (Woods Hole and Hawaii Ocean Time Series)
Date: 5 June 2008
Geographical Area: Central Pacific, North of O'ahu

Science Log
The deployment of the buoy went fine yesterday, and now we're monitoring data from both buoys while we take some extra measurements of the water in the neighborhood of the buoy.

The new buoy has two of everything, and for the most part duplicate pairs agree.

The extra measurements I mentioned involve lowering a rosette with a CTD (remember? it determines salinity and temperature at different depths) and some bottles for collecting water directly. Here's me in front of the suite of instruments.



CICOR Workshops, Meetings Support and Outreach

CICOR continues to stimulate interaction with the external community and act as an incubator for activities on the cutting edge of regional and global science. Several of these initiatives are reported on here, but it should be acknowledged, that much of the important work of engagement with the external entities is conducted on a less formal basis and over time by ongoing exchanges and the building of relationships. For example, CICOR and WHOI scientists are working with NOAA and regional and international partners on regional ocean observing and ecosystems science planning efforts. They will be leading a discussion on the topic at the upcoming OCEAN INNOVATION 2008 World Summit: Ocean Observing Systems meeting to be held in St. John's Newfoundland in October 2008 and are planning a symposium dedicated to the topic for early 2009. In addition to fostering coordinated science efforts, CICOR also recognizes the importance of collaboration with the private sector to forward NOAA's goals in the region. CICOR engages with the private sector primarily through, MOTN, the Marine and Oceanography Technology Network and WHOI's Office of Applied Oceanography which is the Institution's formal link to MOTN. A MOTN event at UMASS Dartmouth in recent months prompted connections between CICOR and UMASS students and faculty which are expected to develop into more formal activities which will foster exchanges between the two institutions.

Other initiatives that have been cultivated through the CICOR office over the 2007-08 funding year include the following:

CICOR Fellows Ecosystems Initiative Scoping Workshop
November 18 – 20 2007

GOAL: To develop the scientific understanding and operational capability to sustain healthy marine ecosystems and the fisheries they support.

BACKGROUND: NOAA fisheries is transitioning from single-species fisheries management to ecosystem based management. The expectation is a requirement for regional Integrated Ecosystem Assessment (IEA) that synthesizes information on relevant physical, biochemical, ecological and human processes in relation to specified resource management objectives. A consortium approach will be needed to coordinate observing, analysis, and modeling activities for the Northeast US Continental Shelf Large Marine Ecosystem (LME; Cape Hatteras to Nova Scotia) in support of IEA.

OBJECTIVES
- Accelerate development of an ocean observing system in the northeast region
- Develop the understanding and capability to forecast ocean processes relevant to marine ecosystem management
- Provide the scientific information needed to support an ecosystem approach to management. Specifically, to incorporate ecosystem science, based on coordinated regional observing, into an IEA for the Northeast US LME

DRIVERS
- Pew Oceans Commission Reports (2003)
- U.S. Commission on Ocean Policy, "Ocean Blueprint for the 21st Century" (2004)
- U.S. Ocean Action Plan, Committee on Ocean Policy (2004)
- ICSORMI Ocean Research Priorities Plan

INITIATIVE ELEMENTS:
- Integrated Regional Observing
- Comprehensive Modeling Strategy
- Process Studies for Enhancing Ecosystem Predictability

PLANNING PROCESS
- Describe the ecosystem to be assessed and the topics to be examined

- Describe the ecosystem attributes of concern (physical, biological, and chemical)
- Review the relevant management objectives
- Describe the relevant ecosystem stressors such as nutrients, invasive species, etc.

WORK PLAN CONCEPT

- Identify steering committee
- Complete initiative scoping process
- Develop and test indicators reflecting ecosystem attributes specified in the scoping process
- Perform analysis of the risks posed by human activities and natural processes
- Integrate results from the risk analysis for each ecosystem
- Quantify the status of the ecosystem relative to historical status and prescribed targets using statistical models, the multivariate assessment.
- Evaluate the potential of different management strategies to influence the status of natural and human system indicators using an ecosystem modeling frameworks (e.g., the Atlantis ecosystem model).

Scope

- Geographic: Continental shelf and slope from Cape Hatteras to Nova Scotia, with overlay of principal eco-regions
- Temporal: Processes affecting interannual to decadal variability of marine ecosystems; Relationship of ecosystem processes to key climate indicators
- Space-Time Resolution: Requirements TBD
- Degree of connectivity (e.g. between eco-regions) and complexity (e.g. modeling component requirements): TBD
- Management time frame: Resource management plan updated on ~5 year intervals based on results from ongoing IEA

Assessment Needs

- Operational ocean observing system that integrates physics, biology, chemistry, and air-sea interaction
- Access to advanced observing capabilities to complement traditional fisheries surveys
- Systematic reporting on the status of ecosystems via IEAs and "key indicators"
- Modeling of regional ecology linked to goals of sustainable use
- Linking human activities to incremental change in ecosystems

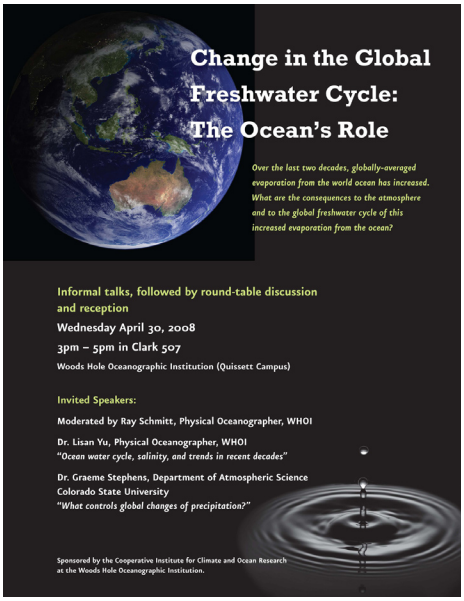
Talks and round-table discussion on 'Change in the Global Freshwater Cycle: The Ocean's Role'.

Over the last two decades, globally-averaged evaporation from the world ocean has increased. What are the consequences to the atmosphere and to the global freshwater cycle of this increceased evaporation from the ocean?

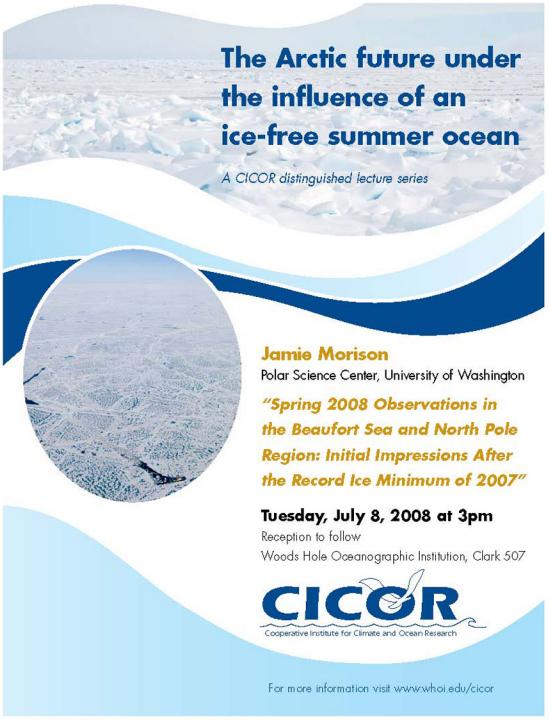
Informal talks, followed by round-table discussion and reception.
Moderated by Ray Schmitt, Physical Oceanographer, WHOI

Invited Speakers:
Dr. Graeme Stephens, Department of Atmospheric Science
What controls global changes of precipitation?

Dr. Lisan Yu, Physical Oceanographer, WHOI
Ocean water cycle, salinity, and trends in recent decades



The Arctic Future under the Influence of an Ice-free Summer Ocean Distinguished Lecture Series



Senior Scientist, Andrey Proshutinsky, who has been funded by NOAA through CICOR for his part of the collaborative work on assembling the State of the Arctic Report has hosted a Distinguished Lecture Series on the Arctic Future under the Influence of an Ice-free Summer. To date there have been four guest speakers with a fifth by Dr. Lawson Brigham scheduled for October 2008.

The major motivation for this series of lectures is an increased attention to the Arctic related with a continuing warming and melting of sea ice, disappearance of glaciers, increase of river runoff, thawing of permafrost, and changes in biological conditions. The coincidence of rapid change in Arctic climate (extreme 2007 decline in sea ice and recent unprecedented warming) and enhanced observational activities during the International Polar Year (2007-2009) offers hope that these changes will be documented in great detail but it is also important to explain these changes and predict future climatic states. In order to do this we have to investigate deeply observed changes, develop new approaches, theories and ideas and involve a new generation of scientists for these purposes.

The major goal of proposed lectures is to provide regional scientists and students with the basic knowledge about most important problems of climate variability in the Arctic and to enhance their participation and collaboration in the solution of these problems. WHOI scientists and colleagues can successfully contribute to Arctic science in two ways: Via development and implementation of new instruments allowing year-round observations of arctic processes under sea ice and via theoretical and numerical studies, formulating and solving fundamental questions of arctic climate variability based on WHOI experience and knowledge gained at the temperate oceans.

The objectives of these events include:

* To identify key scientists able to formulate and describe the most important and critical problems of arctic climatology associated with ice disappearance;
* To invite these scientists to give lectures and to personally discuss with WHOI and regional scientists the most interesting hypotheses and ideas; and
* To organize arctic group meetings that promote further dialogue and lead to the development of proposals and other arctic research related activity.

» Marika M. Holland. The forcings and feedbacks of rapid Arctic sea ice loss, May 1, 2008.
» Vladimir Romanovsky: State of Fate of Permafrost on a Changing Planet, May 22, 2008.
» Harper Simmons: Penetration of wind energy into the Arctic Ocean: impact of a changing ice cover, June 12, 2008.
» Jamie Morison: Arctic Ocean conditions after the 2007 record ice minimum with implications and questions regarding an ice free Arctic, July 8, 2008.

The Connecticut River Science Workshop
Monday, October 27, 2008

Bernhard Peucker-Ehrenbrink (WHOI), Rocky Geyer (WHOI), and Peter Raymond (Yale) are coordinating an upcoming workshop on the Connecticut River that will host over twenty-five individuals from more than 16 institutions in the region including: NOAA (NWS), USGS, CT Dept. of Marine Fisheries, EPA, Dartmouth College, Mt. Holyoke College, Rutgers, UConn, WHOI, and Yale.

Background:
The Connecticut River Basin is one of the largest and most diverse river basins in New England and along the U.S. East Coast. The significant environmental changes that are being forecast for the next decades offer a unique opportunity to gain fundamental insights into the processes that control transport of land-derived matter to the coastal ocean, and investigate the effects on the coastal ocean, specifically Long Island Sound. The impending changes also require improved predictive capabilities that cannot be achieved without better observations and models. Changes in average runoff and runoff intensity, nutrient and sediment loading, aquatic species diversity and abundance, land-use characteristics and related organic and inorganic pollutants, as well as sea level rise have important implications for the population in the Connecticut River basin and the coastal communities of Long Island Sound.

Format:
This workshop is intended to bring together researchers interested in the Connecticut River basin. We also invite the participation of state and federal agencies that are active in the basin, as well as representatives of non-governmental organizations who are stakeholders in matters important to the health of the river basin.

The one-day workshop will feature several invited keynote speakers. Presentation and discussion of scientific results and ideas for future research via a poster session and a follow-up plenary discussion will dominate the workshop.

Purpose:
To provide a forum for scientists active in the Connecticut River basin to share their work and ideas, and to foster collaborations for future research on the Connecticut River and its drainage basin.

Registration:

* Participants should register online for the workshop at no later than September 30, 2008.
* Participants interested in presenting their research in the poster session should send the poster title, names and affiliations of authors and a brief abstract to Dr. Bernhard Peucker-Ehrenbrink (behrenbrink@whoi.edu).
* No registration or abstract fee is required as the workshop is jointly sponsored by the Woods Hole Oceanographic Institution's Cooperative Institute of Climate and Ocean Research and the Connecticut River Museum.

Location:
The workshop will be held on Monday, October 27, 2008 at that Connecticut River Museum, 67 Main Street, Essex, CT 06426.

The CICOR office has signed on to split the cost of sponsorship of this workshop with Conservation International through the efforts of Scott Doney, WHOI PI and chair of the Ocean Carbon and Biogeochemistry Scientific Steering Committee. The OCCC-SSG group was established by the U.S. Carbon Cycle Science Program with a specific charge to address coordination across the multi-agency U.S. ocean carbon effort. The OCB-SSC was created jointly by NSF, NASA and NOAA and will more broadly focus on marine biogeochemistry (including carbon) and a variety of ocean science research communities.

Workshop Proposal:
Current conservation efforts addressing the climate change on marine biodiversity and human welfare are almost exclusively focused on building species, ecosystem and human resilience to the expected impacts on the ocean environment. However, the physical impacts of climate change - ocean warming; sea level rise; changing ocean systems including upwelling, currents and fronts; ocean acidification – are already resulting in shifting species distributions, changes in species populations, changes in ecosystem composition and localized extinctions.

Conservation strategies that maximize biodiversity and ensure human welfare must now be designed to allow for and incorporate these changes in ecosystem structure, location and function. Approaches such as Ecosystem Based Management (EBM) that focus on multi-disciplinary broad ecological approaches are especially suited to integrating these issues as they are not limited by specific geographic locations or habitat structures. However, currently there is very little work addressing the practicalities of how conservation might explicitly address the impacts of (and marine responses to) climate change – how will in-the-field management account for the new 'normal' state climate change will bring about in a given marine ecosystem? For example, MPAs and coastal development planning must now account for a future in which species will shift and/or become more and less viable at their current locations.

Development of the needed new conservation strategies will necessarily require the integration of 4 key elements:

1. estimates of the future state of the oceans, specifically including regional oceanographic conditions under different climate change scenarios;
2. ecological and species responses, including ecological models of species at all trophic levels;
3. human responses to both the physical changes and ecological responses;
4. conservation and management strategies, including an expansion of EBM, that manage for these ecosystem changes.

To date, very little work has been undertaken on developing these new conservation strategies for the marine environment. The workshop described here will coordinate the first essential steps to driving the science necessary by bringing together experts from each of the elements described above to assess

- how existing knowledge and modeling efforts can be used immediately to advise management and conservation;
- what physical, ecological and socio economic research could be immediately (2 year time frame) applied to conservation or is needed to facilitate the synthesis of the physical, ecological, and socio economic responses to climate change with marine management;
- What longterm research agenda is needed to support the development of conservation strategies that can address the transitional nature of marine ecosystems under climate change.

Key workshop outputs:
The workshop will be designed to consider what conservation actions are possible given current knowledge and to stimulate integrated research in physical modeling, biological research and conservation so that conservation actions can be specifically address climate change. Key workshop outputs will include:

- Recommendations for where and how existing ocean models (and outputs) can be immediately integrated with ecosystem response models into conservation action, particularly through approaches such as EBM.

- Recommendations for immediate and future research on ocean climate modeling, ecosystem response and socio economic response needed to support the creation of new tools for conservation (or needed for inclusion in current conservation approaches such as Ecosystem Based Management).
- Exploration of mechanisms for effectively integrating ocean modeling with conservation outcomes.
- Collaborations between physical, ecological, socio economic and conservation research to enact the recommendations of the workshop. (It is anticipated that collaborative research proposals will be generated by this workshop.)
- Analysis (particularly through case studies) to facilitate the evolution in conservation approach and thinking that is needed to address the ecosystem transitions that will now unavoidably occur as a result of climate change.

The workshop is designed to be a starting point for integrating model outputs with conservation approaches that explicitly address and allow for ecosystem responses to climate change. As such, a significant output of the workshop will be fostering collaborations between physical, ecological, socio economic and conservation research, including possible follow-up discussions. It is expected that the results of the workshop will be presented at meetings – suggested venues include a session at the American Geophysical Union Conference, San Francisco, December 2008 and an AAAS symposium at the annual meeting in Chicago, February 2009. Seaweb has already expressed an interest in supporting a symposium at the AAAS meeting. These will also act as venues for continued development of the results of the workshop and present an opportunity to include the wider scientific community. In addition at least one peer reviewed paper will result from the workshop.

The workshop outputs will be immediately integrated into conservation activities and strategic planning at Conservation International and its extensive network of partnerships. Further, the workshop directly builds on and contributes to work currently ongoing at Boston University and Duke University, particularly:

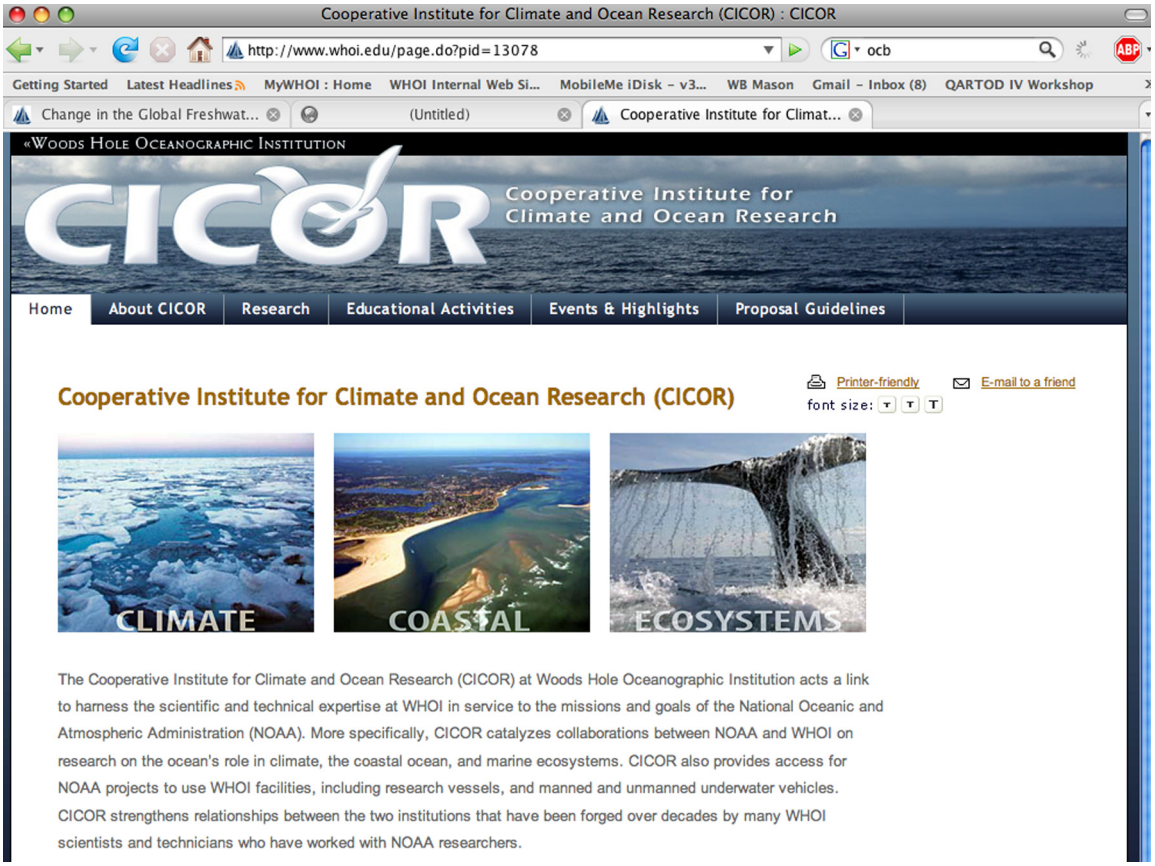
- The Multiscale Integrated Models of Ecosystem Services (MIMES) Project which is developing spatially explicit dynamic modeling, and particularly integrating the linkages between social and natural ecosystem processes in nearshore marine environments (Boston University is leading the marine component of MIMES);
- Development of an end-user graphic decision tool called MIDAS (Marine Integrated Decision Analysis System) which will translate science-based predictions of the effects of alternative marine management decisions (such as altering fishing access) and hence demonstrates the dynamics of decision trade-offs. (Partnership between Boston University and the Marine Management Area Science Program at Conservation International).
- Ongoing work at Boston University detailing climate change impacts on tropical marine species and ecological processes.
- Marine connectivity modeling using graph theory network models to evaluate the potential connectivity between patchy ocean environments under different ocean climate regimes. (Ongoing at the Marine Geospatial Ecology Lab, Duke University)
- Marine mammal habitat modeling initiative and the Marine Ecosystem-Based Management Tool Fund program. (Ongoing at the Marine Geospatial Ecology Lab, Duke University)

Participants

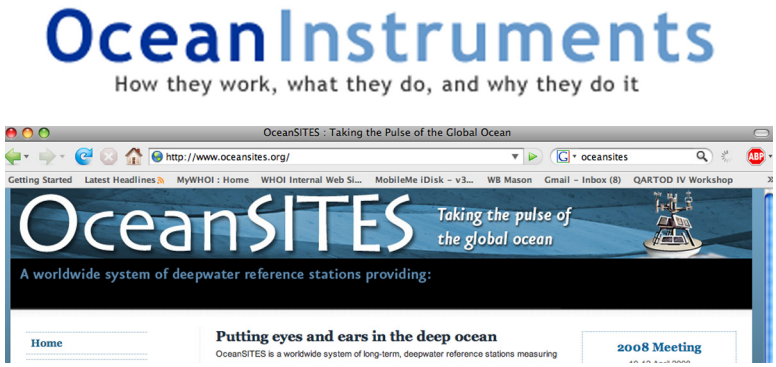
The workshop will be overseen by Dr Emily Pidgeon of the marine climate change program at Conservation International. Conservation International has extensive experience conducting workshops with multi-disciplinary conservation science outcomes. An advisory group with expertise in each of the key elements (physical modeling, ecological processes and management) will lead planning including identifying key participants, developing an agenda, and ensuring the completion of necessary preparatory work.

CICOR Websites

CICOR maintains three active websites, one for the office itself and two others for projects which have fallen under our stewardship. Having been created almost ten years ago, the CICOR website was long in need of an overhaul, which it finally received this year. The site has been integrated into the WHOI content management system and allows research projects to be searched by scientist or theme. It is the main communications tool for the office and is always a work in progress. Suggestions are welcome.



CICOR also maintains the Ocean Instruments website one of the most often visited sections of the whoi.edu web domain providing information on ocean instruments to reporters, students and colleagues alike. The OceanSITES website and publication distribution is also managed through the CICOR office. OceanSITES is a group of international scientists who maintain long-term observing stations in the world's oceans which are considered part of GEOSS, the Global Earth Observing System of Systems.



U.S. Program In Marine Biotoxins And Harmful Algae

NOAA Cooperative Agreement No. NA17RJ1223 sub-points 09, 10, 11, 36 and 88
July 1, 2007 through June 30, 2008

Donald Anderson
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2351 E-mail: danderson@whoi.edu

NOAA Program Manager: Dr. Quay Dortch, NOAA/NOS/CSCOR

Related NOAA Strategic Plan Goal
Goal 1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

PROJECT OVERVIEW

This project supports operation of the U.S. National Office for Marine Biotoxins and Harmful Algal Blooms at the Woods Hole Oceanographic Institution. The Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) authorizes several components that constitute a National Program for Harmful Algal Bloom (HAB) Research. The National Program for Harmful Algal Bloom Research is currently implemented through two competitive extramural research programs of NOAA's Center for Sponsored Coastal Ocean Research (CSCOR), the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) and the Monitoring and Event Response for Harmful Algal Blooms (MERHAB). CSCOR has established the U. S. National Office for Harmful Algal Blooms to provide critical coordination and technical support capabilities that enhance the Nation's ability to respond to and manage the growing threat posed by HABs. It also provides liaison with the scientific community and related programs nationally and internationally.

ACCOMPLISHMENTS

- In October, 2008, the redesigned National Office website, "Harmful Algae" (http://www.whoi.edu/redtide), was launched. Considerable effort was devoted to the complete redesign of this site – which includes significant new content as well, especially on freshwater HABs, which were previously not covered. We are continuing to add content to this site, currently working on a FAQs page and updating our photo gallery.
- A major focus during the past year was the organization of the 4th U.S. HAB Symposium, held October 29 – November 1, 2007 in Woods Hole, Massachusetts. 260 scientists, students and agency personnel attended this symposium. Efforts included soliciting, collecting and compiling abstracts for oral presentations and posters; program development – topics for presentations and discussions sessions; conference site organization and arranging facilities; obtaining funding for travel awards for students and Postdocs, reviewing applications, and making and processing subsequent awards; We also created and maintain the website for the symposium and disseminated information to the US HAB community and other interested groups. Work has begun in planning the 5th US HAB Symposium to be held November 2009 in Ocean Shores, WA and the National Office will provide significant support for this meeting as well.
- The National Office presently undertakes the unique role of compiling information on HAB events in the U.S. as the ICES *National Coordinating Center for Exchange of Information on Harmful Algal Blooms.* This involves annual efforts interacting with colleagues around the U.S. to compile reports of all national HAB events each year. These raw data are entered into standard forms and supplied to the ICES Science and Communications Center in Vigo, Spain for inclusion in the Harmful Algal Event Database (HAEDAT). A summary of the US bloom reports was given at the March 2008 ICES Working Group on Harmful Algal Bloom Dynamics, held in

Galway, Ireland. National and international bloom reports are also provided to all U.S. network participants, as well as to other interested parties. This is the only compilation of U.S. HAB incidents.

- The National Office also administers a Rapid Response Program for HAB Events in the U.S. in cooperation with CSCOR administrators. This involves advertising availability of funds to the HAB community as well as accepting requests for funds and administering their dispersal. The National Office works with NOAA Program Managers to decide who receives funds and how much will be needed in each case. Additionally, we make arrangements and process travel associated with these rapid response activities as well as other budget issues, including vessel charters, equipment rental, etc. This year, events included: a *Dinophysis* event in Texas and an *Alexandrium* event in the Gulf of Maine.
- The National Office is supporting the recently formed National HAB Committee (NHC) which is overseeing coordination and implementation of the new US National Plan for HABs. In October 2007, we organized the second meeting of this group; held in Woods Hole. We continued to maintain an NHC webpage (http://www.whoi.edu/nationalhab/; ran several conference calls; organized and ran the 2008 election for new members; set up ad hoc subcommittees; and will organize the third on-site meeting to be held in Ocean Shores, WA prior to the 5th US HAB symposium (November, 2009).

HIGHLIGHTS

- This office administers HAB event response funds to provide rapid reaction to unexpected or unusual outbreaks in different parts of the country. This year, these include the first documented presence of diarrhetic shellfish poisoning (DSP) toxins in shellfish within the US, and a massive regional red tide in New England.
- D.M. Anderson, Director of the National Office provided testimony to the Subcommittee on Energy and Environment Hearing, “Harmful Algal Blooms: The Challenges on the Nation’s Coastline”, Washington, DC, July 2008.
- The completely revised Harmful Algae website was launched in October 2008 and remains one of the top 5 visited websites at WHOI; in fact, visits are up 25% from the previous year.

SOCIETAL BENEFITS

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

EDUCATION AND OUTREACH ACHIEVEMENTS

Anderson, D.M., invited talk,“Don’t eat the clams: Managing the threat from the New England red tide”, Frontiers in Environmental Sciences, Weekly Series on Emerging Issues in Environmental Health Sciences, National Institute of Environmental Health Sciences, Research Triangle Park, NC, 08/07.

Contribution to Encyclopedia of Life for *Alexandrium* entry.

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

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 420
July 1, 2007 through June 30, 2008

Carin J. Ashjian and Mark F. Baumgartner
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-3457 E-mail: cashjian@whoi.edu, mbaumgartner@whoi.edu

NOAA Program Manager: Dave Rugh NOAA/NMFS/AFSC/NMML

Related NOAA Strategic Plan Goal:
Goal 1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
Goal 4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

Note: Funding for the Bowhead Whale Feeding Ecology Study (BOWFEST) originates from the Department of Interior's Minerals Management Service (MMS) and is provided via an Interagency Agreement (MMS 4500000120) between MMS and the National Marine Mammal Laboratory (NMML) at the Alaska Fisheries Science Center (AFSC), National Marine Fisheries Service (NMFS), National Oceanographic and Atmospheric Administration (NOAA). David Rugh is the Program Coordinator for BOWFEST at NMML.

PROJECT OVERVIEW

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

The specific objective of the WHOI project was to sample on the Beaufort Sea shelf from Barrow, AK east to ~152 °E during mid-August to mid-September 2007 using several approaches: (1) High vertical-resolution oceanographic sampling along several shore-shelfbreak transects using a 43' boat; (2) Short-term (hours) suction cup tagging of feeding bowhead whales to characterize diving behavior, with whale tagging accomplished from a 20' boat; and (3) fine scale oceanographic and prey sampling following a nested sampling design adjacent to tagged feeding bowhead whales using two boats (43' and 32') (tagged whale tracking will be conducted simultaneously the 20' boat).

No significant changes to objectives, approach, methodology, or rationale.

ACCOMPLISHMENTS AND PRELIMINARY RESULTS

Fieldwork was conducted from Aug. 15-Sept. 12, 2007. Bad weather precluded sampling for 16 of the 29 days. For the high-vertical resolution oceanographic surveys, four transect lines were surveyed (Figure 1); three of the lines were surveyed twice (seven working days). Additional sampling off of the transect lines was conducted on two days. No bowhead whales were observed during the field season so that no whale tagging or fine-scale oceanographic and prey sampling could be conducted.

Overall, the oceanographic sampling was highly successful despite the poor weather. Sixty-four stations were conducted, including many with multiple types of instrument deployments or collections. The Acrobat towed vehicle (temperature, salinity, chlorophyll and CDOM fluorescence, optical backscatter) and the acoustic Doppler current profiler (ADCP) were towed along most lines except where weather precluded their use. The repeated sampling of transect lines permitted us to better identify the role of wind in defining the oceanography on the shelf and in providing a favorable prey environment for bowhead whales. Since the field season, analysis of the oceanographic data is ongoing.

Multiple water masses were observed each year 2005-2007, with close coupling between water mass and biological characteristics. Considerable inter-annual variability was observed. Both 2005 and 2007 were characterized by little or no sea ice and warm surface water (~11°C in 2007) while melting sea ice in 2006 contributed to colder surface waters (<4°C). Shorter-term variability in conditions on the shelf was intimately tied to the direction and strength of the wind. Based on stomach content analysis from harvested bowhead whales, the whales near Barrow feed primarily on Arctic copepods or on krill (euphausiids) that are advected from the Pacific in the prevailing currents of the Chukchi Sea. Krill and copepods are upwelled onto the Beaufort Shelf from Barrow Canyon or the Beaufort Sea when winds are from the E or SE. A favorable feeding environment is produced when these krill and copepods are concentrated on the shelf near Barrow as the prevailing westward shelf currents converge with the strong Alaska Coastal Current that flows to the northeast along the eastern side of Barrow Canyon. In addition, krill may be retained in Elson Lagoon under upwelling winds and subsequently flushed out along the barrier islands, providing local krill aggregations as prey for the whales. To date, feeding bowhead whales were observed in association with elevated abundances of krill along the barrier islands of Elson Lagoon (2005) and on the shelf to the east of Barrow Canyon (2006) following wind conditions consistent with the proposed mechanism of prey aggregation.

HIGHLIGHTS

- Considerable interannual variability in physical and biological oceanography has been observed between the three years of our observations (this work and the two years of the SNACS project).
- The oceanography and whale prey distribution on the shelf near Barrow are intimately tied to wind forcing
- A favorable feeding environment for bowhead whales near Barrow is created when krill are upwelled onto the shelf from along the Beaufort Shelf break and subsequently trapped and aggregated there by ocean currents

SOCIETAL BENEFITS

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

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT

Mooring deployments on the shelf, shelf-break, and in the inlets of Elson Lagoon by S. Okkonen (UAF), K. Stafford (APL-UW)

Aerial surveys of bowhead whale distributions (D. Rugh, NOAA)

EDUCATION AND OUTREACH ACHIEVEMENTS

Ashjian, C.J. Briefing on project to congressional staffers, August. 31, 2007, Barrow, AK

Ashjian, C.J. Barrow Arctic Science Consortium Schoolyard Saturday (public lecture series), Barrow, AK., Sept. 1, 2007.

Ashjian interviewed by San Francisco Exploratorium team conducting IPY outreach project, Barrow, AK, Sept. 2, 2007

Ashjian, C.J. Description of project to Barrow High School Science Class, Sept. 13, 2007

Ashjian, C.J, Braund, S.R., Campbell, R.G., George, J.C., Moore, S.E., Okkonen, S.R. Sherr, B.F., Sherr, E.B. 2008. Environmental variability and bowhead whale distribution on the Alaskan Beaufort Shelf near Barrow, AK. Ocean Sciences Meeting, March 6, 2008, Orlando, FL. Oral Presentation.

Ashjian, C.J, Campbell, R.G., George, J.C., Moore, S.E., Okkonen, S.R. Sherr, B.F., Sherr, E.B. 2008. Environmental variability and bowhead whale distribution on the Alaskan Beaufort Shelf near Barrow, AK. Alaska Marine Science Symposium, Jan., 21-23, Anchorage, AK. Poster.

Moore, S.E., George, J.C., Ashjian, C.J. Cetacean habitats and Behavior Offshore Northwestern Alaska: Comparisons across Two Decades. Alaska Marine Science Symposium, Jan., 21-23, Anchorage, AK. Poster.

Okkonen, S., Ashjian, C.J., Campbell, R.G. Intrusion of warm Bering/Chukchi Waters onto the Shelf in the Western Beafort Sea. Alaska Marine Science Symposium, Jan., 21-23, Anchorage, AK. Poster.

PUBLICATIONS

Ashjian, C.J, Braund, S.R., Campbell, R.G., George, J.C., Moore, S.E., Okkonen, S.R. Sherr, B.F., Sherr, E.B. 2008. Environmental variability and bowhead whale distribution on the Alaskan Beaufort Shelf near Barrow, AK. Ocean Sciences Meeting, March 6, 2008, Orlando, FL. Oral Presentation.

Ashjian, C.J, Campbell, R.G., George, J.C., Moore, S.E., Okkonen, S.R. Sherr, B.F., Sherr, E.B. 2008. Environmental variability and bowhead whale distribution on the Alaskan Beaufort Shelf near Barrow, AK. Alaska Marine Science Symposium, Jan. 21-23, Anchorage, AK. Poster.

Moore, S.E., George, J.C., Ashjian, C.J. Cetacean habitats and Behavior Offshore Northwestern Alaska: Comparisons across Two Decades. Alaska Marine Science Symposium, Jan. 21-23, Anchorage, AK. Poster.

Okkonen, S., Ashjian, C.J., Campbell, R.G. Intrusion of warm Bering/Chukchi Waters onto the Shelf in the Western Beafort Sea. Alaska Marine Science Symposium, Jan. 21-23, Anchorage, AK. Poster.

Okkonen, S.R., Ashjian, C.J., Campbell, R.G., Potter, R. Intrusion of warm Bering/Chukchi waters onto the shelf in the western Beaufort Sea. In review, J. Geophys. Res.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

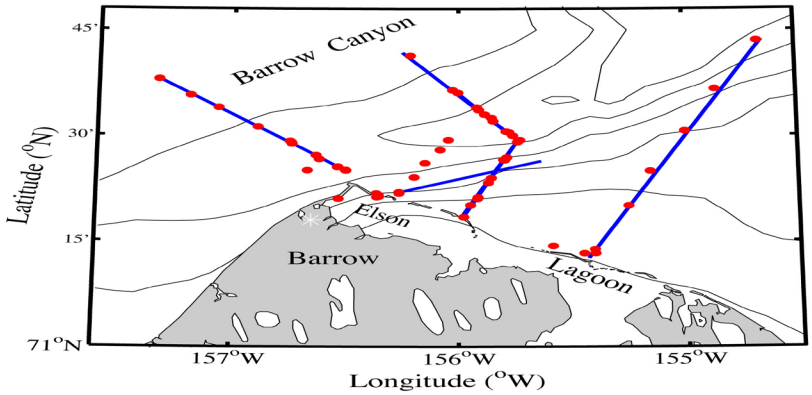


Figure 1. Locations of stations (red dots) and continuous sampling with the Acrobat and ADCP (blue lines). Each of the long lines was surveyed at least twice.

Wind-Driven Transport Indices for Cod and Haddock Recruitment on Georges Bank

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 410
July 1, 2007 through June 30, 2008

Dr. Philip Bogden
GoMOOS (Gulf of Maine Ocean Observing System)
Tel: (207) 773-0423 E-mail: bogden@gomoos.org

Program Manager: David Mountain NOAA/NMFS/NEFSC

Related NOAA Strategic Plan Goal*:*

- Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
- Goal 3. Serve society's needs for weather and water information.
- Goal 4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

PROJECT OVERVIEW

In February 2007, GoMOOS development staff met with project manager David Mountain and James Manning of NOAA NEFSC to discuss how best to address the needs of the project. It was determined that the goals of the project could be met by tailoring the product to improve access to wind observations and predictions over the web. Additionally, GoMOOS learned through end user feedback and survey results that this type of information would be valuable to the greater Gulf of Maine community.

> *Recent inquiry from a GoMOOS user:*
>
> *"I am sailing the Marblehead to Halifax ocean race this summer and would like to follow the winds over the course for the next few weeks. Is there a graphical product that estimates the current surface wind direction and velocity over that ocean area (Gulf of Maine plus east to Halifax) that I can conveniently access? Thanks for your help."*

As a result of that discussion, the team decided to create a wind forecast product that would utilize available wind speed and direction predictions for a 48-hour forecast product on the GoMOOS website. Point forecasts would be extracted from the model data specific to the GoMOOS and NBDC buoy locations in the Gulf of Maine, as well as provide a forecast to observation comparison plot to gauge the accuracy of the forecast.

ACCOMPLISHMENTS

The Wind and Wave Forecast was completed in early June 2007, and is available as a web-delivered product, available 24 hours, 7 days a week on the GoMOOS.org website at http://www.gomoos.org/waveforecasts/windwaveforecast.html. The user communities that benefit from this product include mariners, fishermen, scientists, coastal managers, recreational boaters, sailors, surfers and educators.

See the 2007 Progress Report for more technical details on this project.

HIGHLIGHTS

- The product was designed after similar products available through sailing and airline websites. This approach to layout and design was deemed most useful in displaying a large amount of data to a non-scientific audience.
- The NOAA NCEP wind model was selected as the best source for wind data.
- The product also contains data from the Wave Watch III model for a combined wave/wind forecast – including wave period and primary direction
- Code was developed to extract desired data from the wind forecast model (NCEP) from NOAA OPeNDAP servers with the help of James Manning from NEFSC
- Data is stored on the GoMOOS server and the product is automatically updated twice daily
- Since the release in July 2007, the application is the third most used application on GoMOOS.org after the hourly buoy data and home page.

SOCIETAL BENEFITS

The weather and wave forecast will improve public safety and provides enhanced support for marine commerce and transportation.

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT:

Additionally, it was determined that the wind forecast would be a useful first step in prototyping a product for our work with the NERACOOS (Northeastern Regional Association for Ocean Observing Systems). One of the products identified as a high priority for coastal managers was a tool to determine the likelihood of harmful algal bloom (HAB) formation given certain environmental conditions. Researchers at the University of Maine have discovered that a relationship exists between wind direction, duration and stress that can create downwelling conditions which appears to be favorable to the formation of HABs during the spring and summer months.

Using available NCEP wind forecast model and buoy gathered wind data; we can generate an alert when the HAB favorable conditions are detected in the forecast

Users (HAB managers, HAB scientists) can then log in to the HAB Potential Index Tool (Figure 3) to view the forecast and get more information.

The HAB Potential Index Tool would be a visual indication of forecast for the next 48 hours and would include observed conditions from the GoMOOS buoy array for accuracy. Alerts will be issued when observed data matches forecast data

The forecast was modified programmatically to detect upcoming conditions – wind speed, direction and duration. If the conditions are met, an alert is generated. We are working with HAB scientists to determine the exact conditions that will trigger the alert and with HAB manager to determine the important elements of the forecast.

Additional development of the product is currently on hold pending additional funding opportunities. Possible next steps are to develop notification services so that end users (HAB managers) can be alerted via email or SMS text message that these conditions are likely to occur sometime in the next 48 hours.

EDUCATION AND OUTREACH ACHIEVEMENTS

The Wind and Wave Forecast tool was integrated into the recent release of the upgraded GoMOOS.org website. The website was initially released in beta testing mode in July 2007, and a panel of end users was enlisted to help with testing. Initial feedback on the Wind and Wave Forecast was very positive. The majority of users rated it Good or Excellent for ease of use, value of information presented and relevance to their needs.

Some feedback from the user testing:

"Good service and the Wind and Wave forecast looks like it will be very useful."

"Wind-wave forecast: this would be very useful to me, I would probably use it on a daily basis."

In September 2007, the GoMOOS beta website became the operational website. The new wind and wave product is highlighted as a new site feature and highlighted in our news update. We will be using our outreach tool – the GoMOOS Observer newsletter – to alert our user base of all the new features, including the Wind and Wave Forecast. Additionally, we connected with user groups (e.g. Mass Lobstermen's Association in January 2008 and the Fishermen's Forum in March 2008) to alert them of these new products and services.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

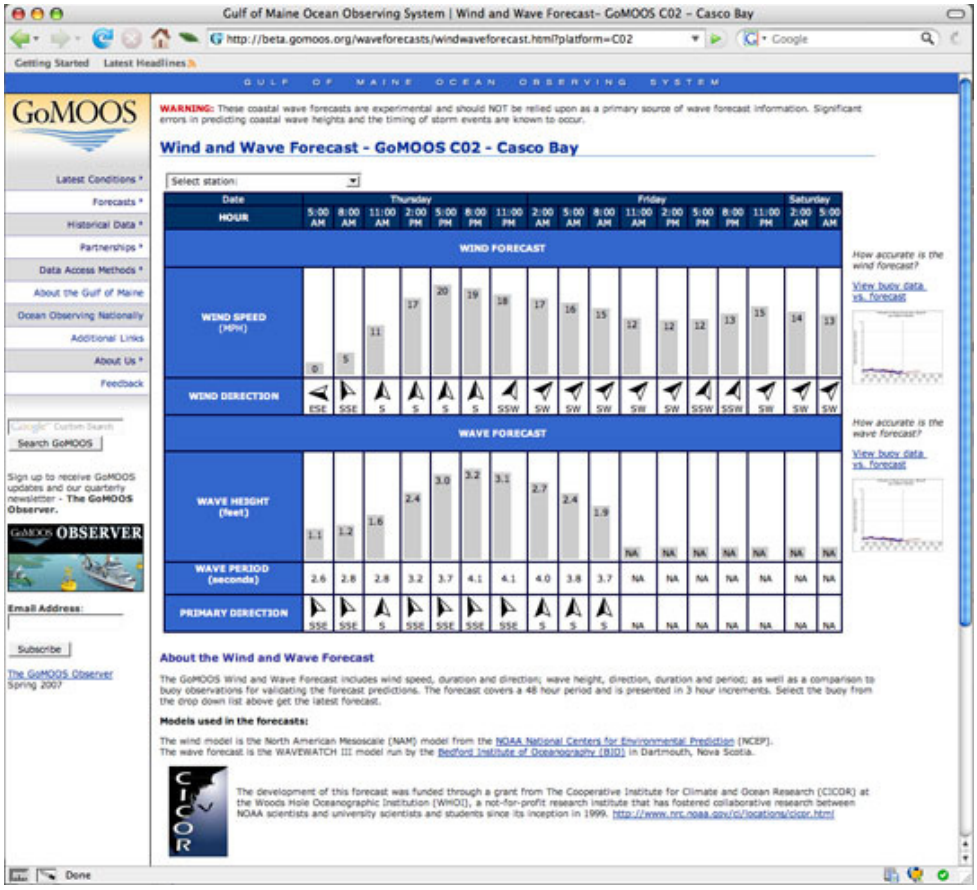


Figure 1. Screenshot of Wind and Wave Forecast

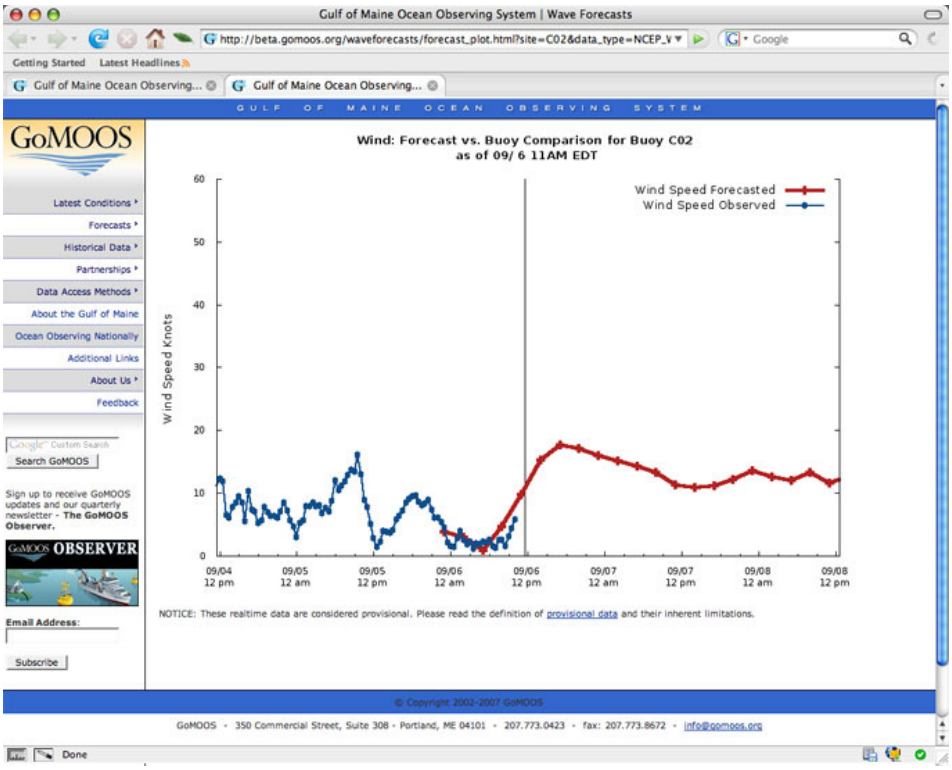


Figure 2. Screenshot of forecast to observation comparison plot.

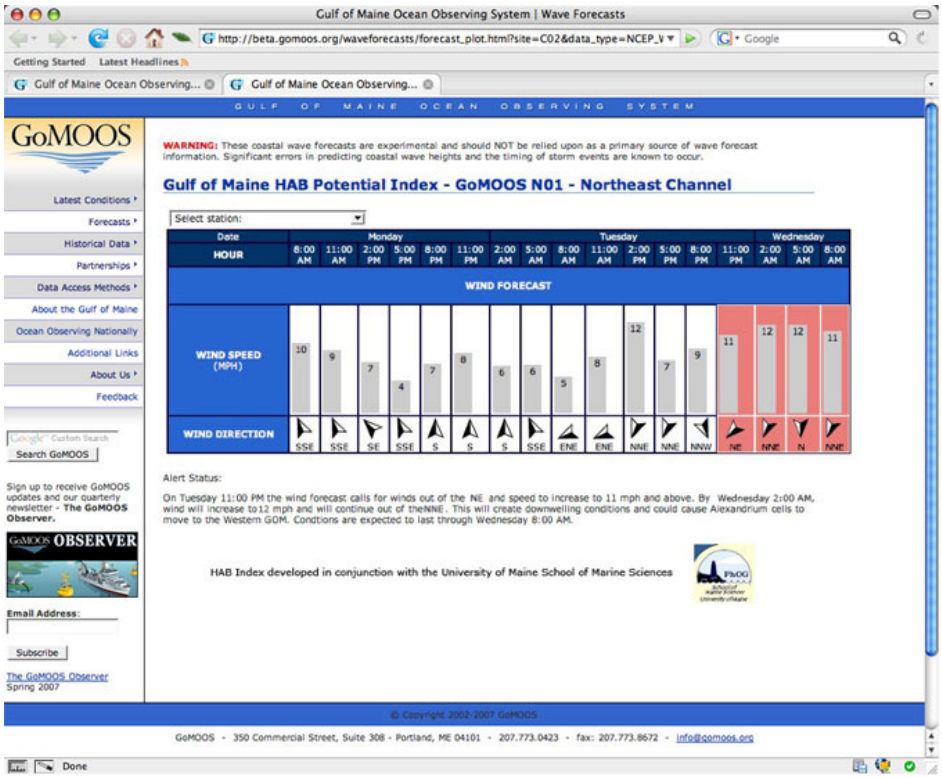


Figure 3. Screenshot HAB Potential Index Prototype.

Multi-Sensor Improved SST (MISST) for GODAE

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 357
July 1, 2007 through June 30, 2008

Dr. Sandra Castro and Dr. William Emery
Colorado Center for Astrodynamics Research, University of Colorado, Boulder, CO 80302
Tel: (303) 492-1241 E-mail: sandrac@colorado.edu

NOAA Program Manager: Dr. Stan Wilson, NOAA/NESDIS.

Related NOAA Strategic Plan Goal*:*
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
Goal 3. Serve society's needs for weather and water information.

PROJECT OVERVIEW

The main objective of this project is the understanding and characterization of uncertainty estimates of satellite retrievals of sea surface temperature (SST) in the presence of diurnal warming (DW). Diurnal warming of the ocean surface layer at low wind speeds and sufficient insolation can lead to significant and highly variable differences between the skin and subsurface temperatures. These differences represent a source of uncertainty in estimates of subsurface (bulk) temperatures derived from satellite retrievals of skin temperatures, as well as in daily multi-sensor SST analyses that combine SST measurements from various satellites at different times through the diurnal cycle.

We explore whether improved accuracy in estimates of subsurface temperatures can be achieved by explicit consideration of diurnal warming effects in satellite retrievals of the skin temperature through the derivation and application of simplified diurnal warming look-up tables (LUT). We select this approach since look-up tables incorporate incompletely known functional dependencies and are easily integrated into operational applications. Simplified LUT are obtained by binning numerical simulations of detailed 2nd moment closure turbulence models on idealized forcing conditions and real observations. Measurements of DW events were gathered by NOAA ETL/ESRL during different flux campaigns (C. Fairall).

SPECIFIC OBJECTIVES ARE:

Detailed simulations with numerical models:
- Assess overall accuracy of models with ideal forcing data
- Identify optimal model configurations
- Provide bounds on expected uncertainty

Use of detailed models to develop simplified LUT
- Compare different forcing parameters for use in LUT
- Establish an approach suitable for operations and application to available satellite (and/or NWP) inputs

Quantify accuracy of simplified LUT formulation in reproducing model warming
- Explore impact of source data on LUT accuracy
- Determine impact of resolution of input data on table accuracy
- Accuracy of predictions to be compared to select final methodology
-

ACCOMPLISHMENTS/PROGRESS/STATUS

Progress to date:

- Turbulence models were forced for 36 hours with idealized insolation and constant wind speed for 3 environmental regimes (Tropics, Mid- and High Latitudes), and 2 turbulence schemes (Fundamental mixing and Enhanced mixing).
- Results from simulations were used to generate look-up tables for diurnal warming as a function of time of day, and instantaneous and/or integrated wind speed and insolation
- Alternative tables were generated from real forcing from cruise data.

Initial sensitivity studies showed that:

- Modeled diurnal warming exhibit a strong dependence on the turbulence formulation. More specifically, the enhanced mixing scheme develops instabilities at very low wind speeds, whereas the fundamental mixing scheme is stable but tends to overestimate the amplitudes of the DW (see Figure 1). Currently we are completing the evaluation of a blended LUT that combines the fundamental mixing for wind speeds up to 2 m/s and the enhanced mixing for winds greater than 3 m/s with an added transition between regimes (Figure 2). To accomplish this, a detailed turbulence-closure based diurnal warming model was modified to smoothly transition between the fundamental and enhanced mixing schemes.
- It is unclear whether instantaneous values of wind speed and insolation are the optimal choices of input parameters in the LUT. We are currently exploring alternative formulations regarding the treatment of the wind and insolation, including:

  Use of daily integrated insolation and wind speed
  Use of dynamic bins
  Methods to account for wind speed fluctuations

- While instantaneous wind speed and insolation inputs worked well in reproducing idealized results, tests with application to real data achieved the best results using the combination of instantaneous wind speed and daily integrated insolation. Dynamic bins were required to preserve adequate discretization when using integrated quantities. At lower wind speeds, finer bin sizes in the look-up tables were required to properly treat the rapid variation in warming with wind speed.
- Relative to the detailed source model used in the derivation, rms errors introduced by the LUT approach 0.3 K at the peak of diurnal warming.

HIGHLIGHTS

- Generated a revised turbulence-closure based diurnal warming model that smoothly blends fundamental turbulence and enhanced mixing schemes.
- Developed and evaluated simplified look-up tables for diurnal warming based on revised, full-turbulence models (Figure 2).

SOCIETAL BENEFITS

Enhanced SST analyses for improved weather forecasting and monitoring of climate change.

AWARDS & HONORS TO PIS AND PARTICIPATING RESEARCHERS

Sandra Castro attended the 9th GHRSST-PP (Global Ocean Data Assimilation Experiment High Resolution Sea Surface Temperature – Pilot Project) Science Team Meeting in Perros-Guirec, Brittany, France, June 9-13, 2008, and was appointed Science Team member of GHRSST.

EDUCATION AND OUTREACH ACHIEVEMENTS

Sandra Castro gave the following Conference Presentations:

The joint 2007 EUMETSAT Meteorological Satellite Conference and the 15th American Meteorological Society (AMS) Satellite Meteorology & Oceanography Conference, Amsterdam, The Netherlands, September 24-28, 2007: Application of Numerical Diurnal Warming Models to the Computation of Bulk Sea Surface Temperature from Infrared Satellite Reference Measurements by Sandra Castro, Gary Wick, and William Emery.

2008 Ocean Sciences Meeting, Orlando, Florida, March, 2-7, 2008: Evaluation of Modeled Derived Look-up Tables for Estimation of Diurnal Warming in Satellite-Derived Sea Surface Temperature Products by Sandra Castro, Gary Wick, and William Emery.

These results were also presented at the Diurnal Variability Working Group (DVWG) workshops held in Edinburgh, Scotland in September 2007 and Orlando, Florida in March 2008, which preceded the previous meetings.

PERSONNEL OBTAINING NOAA EMPLOYMENT WITHIN THE LAST YEAR

This work was done in close partnership with Dr. Gary Wick and Mr. Darren Jackson from NOAA/OAR/ESRL/PSD.

Additional project partners that we interacted with included scientists of the Office of Research and Applications within NOAA/NESDIS (Dr. Andy Harris and Ms. Eileen Maturi). Future planed impact studies incorporating our results will be conducted by NOAA/EMC within NESDIS.

PUBLICATIONS

Castro, S. L., G. A. Wick, D. L. Jackson, and W. J. Emery, Error characterization of infrared and microwave satellite sea surface temperature products for merging and analysis, *Journal of Geophysical Research*, 113, C03010, doi:10.1029/2006JC003829, 2008.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

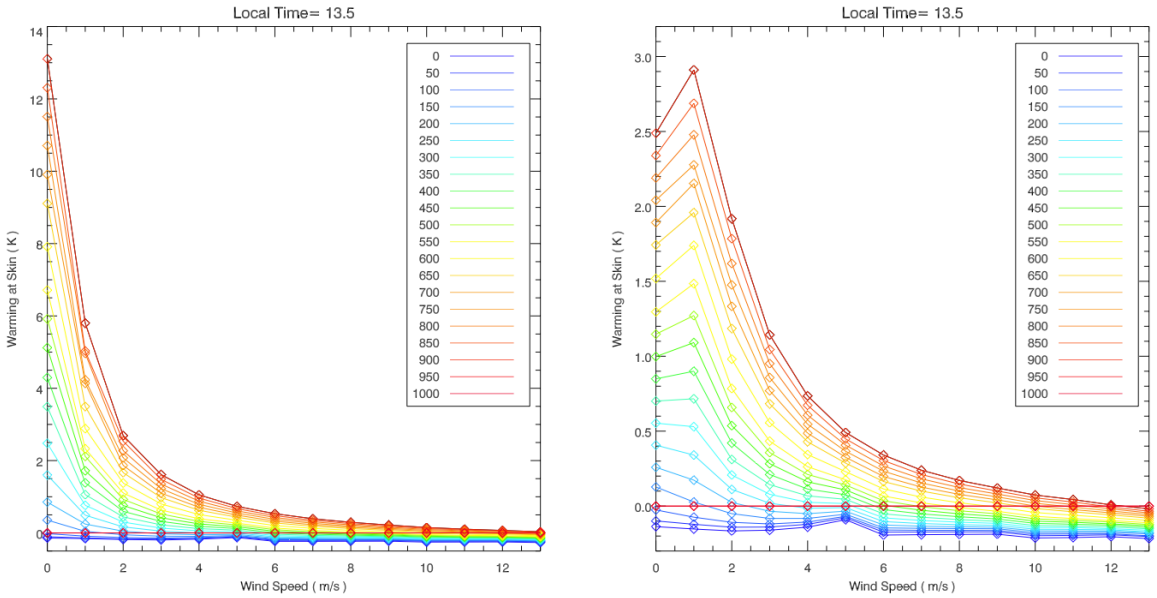


Figure 1: Sensitivity of detailed diurnal warming model to wind speed for a) Fundamental mixing and b) Enhanced turbulence scheme.

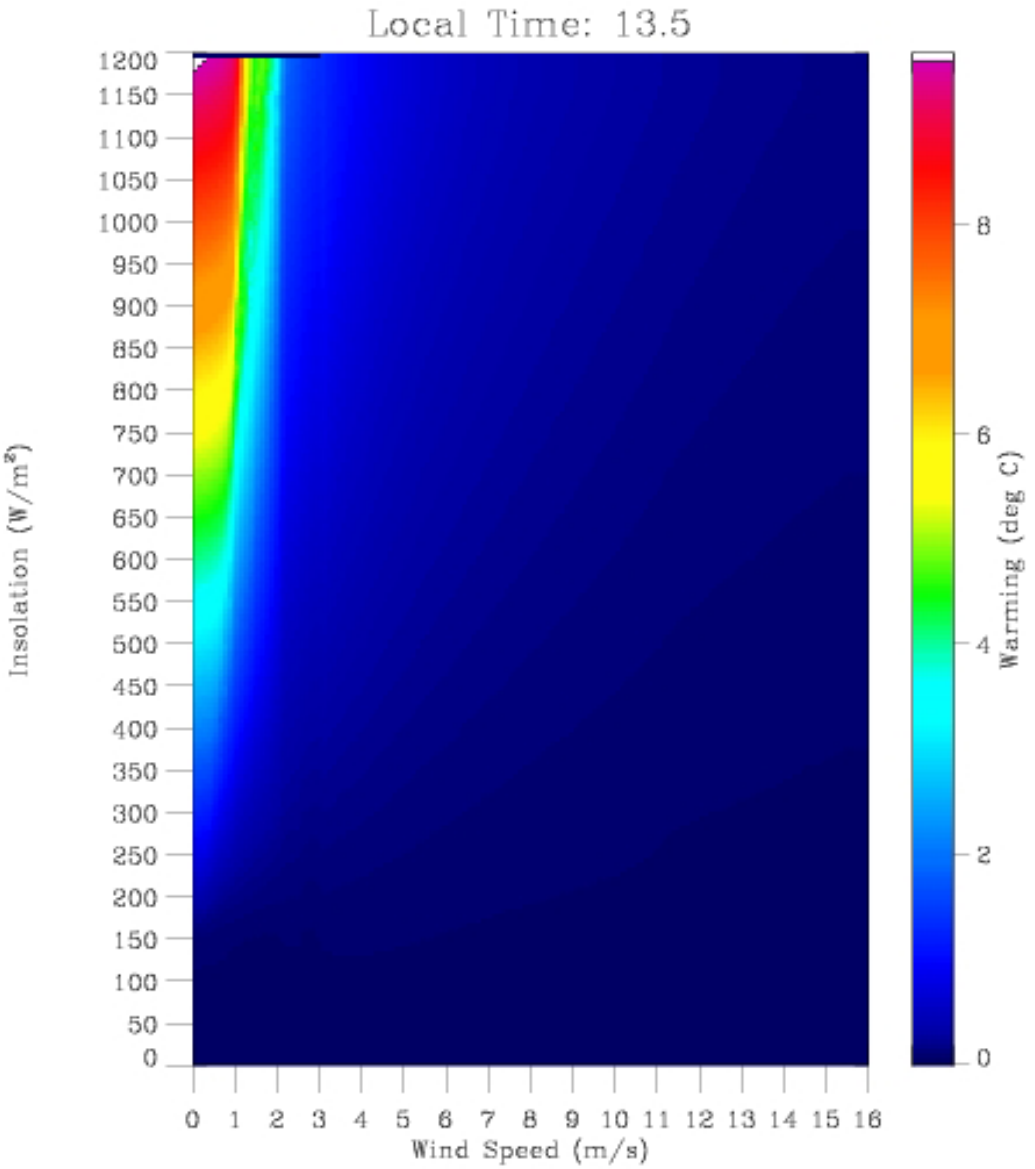


Figure 2: Blended look-up table of diurnal warming corresponding to 1:30 pm as a function of wind speed and insolation.

Vents New Millennium Observatory (NeMO) 2007

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 427
July 1, 2007 through June 30, 2008

Robert S. Detrick
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-3335 E-mail: rdetrick@whoi.edu

NOAA Program Manager: Robert W. Embly, NOAA/OAR/PMEL/NOAA PROGRAM: CIPO

Related NOAA Strategic Plan Goal*:*
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The R/V *Atlantis* and ROV *Jason* were provided by the Woods Hole Oceanographic Institution to study the dynamic interactions between submarine volcanic activity and seafloor hotsprings at an observatory, Axial seamount. A volcanic eruption occurred at Axial in January 1998, destroyed some hygrothermal vent sites and creating new ones. Since then NeMo scientists have been assessing the impact of the eruption and documenting the on-going changes in Axial's summit caldera.

ACCOMPLISHMENTS/PROGRESS/STATUS

Scientific accomplishments provided to NOAA by Chief Scientist as part of their reporting requirement.

The R/V *Atlantis* and ROV *Jason* were provided for 18 days in August of 2007. The final rates for these systems resulted in an unexpended balance of $45,725 which was approved for use for a survey conducted for Robert Embly in August 2009. See WHOI proposal 12777.00 and CICOR award NA17RJ1223 amendment 102

PHOTOGRAPHS

Remotely Operated Vehicle (ROV) *Jason*

The research vessel (R/V) *Atlantis*

Implementing QA/QC Standards for In Situ Ocean Sensors using OGC-Sensor Web Enablement

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 434
July 1, 2007 through June June 30, 2008

Janet Fredericks
Woods Hole Oceanographic Institution, , MS #9 Woods Hole, MA 02543
Tel: (508) 289-2573, E-mail: jfredericks@whoi.edu

Julie Bosch, NOAA/NESDIS/National Coastal Data Development Center, Stennis, MS
Michael Botts, University of Alabama, Huntsville, AL
Harvey Seim, University of North Carolina, Chapel Hill, NC
Philip Bogden, Gulf of Maine Ocean Observing System, Portland, ME

NOAA Program Manager: James Boyd, NOAA/NOS/CSC (Coastal Services Center)

Related NOAA Strategic Plan Goal:
Goal 1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
Goal 3. Serve society's needs for weather and water information.

PROJECT OVERVIEW

To ensure a solid foundation for developing ocean observing systems, this project was funded by the NOAA Coastal Services Center (Regional Integrated Ocean Observing System) to enable implementation of QA/QC standards, developed as part of the QARTOD (Quality Assurance in Real Time Oceanographic Data: http://qartod.org), into the evolving Open Geospatial Consortium (OGC) – Sensor Web Enablement (SWE) framework. For four focus areas (wave, in situ currents, CTD and dissolved oxygen), the project enables the development of specifications, generation of data dictionaries and ontologies and the definition of relevant SensorML profiles to capture and convey data quality. The long-term goals are to provide tutorials and tools for implementation by local data nodes and to support implementation on existing local observing system data nodes, through OOSTethys SOS services (http://oostethys.org). The project deliverables will be publicized by cooperation with existing community-building programs, such as MMI, CICOR, ACT and QARTOD. The project start date was January 1, 2008.

Objectives for the current reporting period were to establish a community of IT specialists and focus area domain experts willing to address the issues of building a vocabulary and integrating QC tests within the OGC-SWE framework. Towards that end, two workshops were scheduled to bring together the communities. The first workshop was developed to begin planning with the QARTOD community leaders, who provide the QA/QC standards for this project. A second workshop was conducted to educate domain experts for waves and currents in the enabling technologies and review the information required to develop the framework which is needed to incorporate data from their area of interest.

There was no change in objectives, approach, methodology or rationale since the revised proposal was submitted.

Kick-off meeting attendees at Stennis Space Center (MS) February 2008.

ACCOMPLISHMENTS/PROGRESS/STATUS

A web-site was set up to share information on our effort: http://q2o.whoi.edu

PI Fredericks attended a "grantees" workshop in Charleston, SC, February, 2008, which brought together most of those who received awards under the NOAA-CSC RIOOS program. Although this was an unexpected trip, it was extremely productive in connecting people with complementary projects. Fredericks is now engaging the members of the GCOOS data portal project in our Q2O (QARTOD to OGC) effort and members of our project team are communicating with the NOAA IOOS Program Office Data Interoperability Framework (DIF) project team.

A "kick-off" meeting was held at the Stennis Space Center (MS), February 26-28, 2008. The meeting was attended by 25 participants including two representatives from the QARTOD waves group; two representatives from the QARTOD currents group; one representative from the QARTOD CTD group; and, two representatives from the QARTOD dissolved oxygen group. The attendees also included two SensorML (Sensor Modeling Language) authors, two representatives from the Marine Metadata Interoperability (MMI) project (a community funded to work on general issues of marine metadata and interoperability – http://marinemetadata.org) and other selected participants who have shown a willingness and ability to demonstrate interoperability on their respective ocean observing systems. The outcome of this meeting was a list of guidelines for QARTOD leaders to consider which would enable the most complete SWE implementation of QA/QC for each of the domains. Unfortunately, the QARTOD effort was "orphaned" when the NOAA IOOS Program Office was formed. (QARTOD had been supported by the NOAA NDBC and the NOS offices.) This limits the progress that can be made as part of our Q2O (QARTOD to OGC) project, but we believe that the examples that can be demonstrated with the existing QARTOD documented practices will serve as a framework for future QARTOD work.

In June, two one-day domain workshops (one for waves and the other for in situ currents) were held at the Woods Hole Oceanographic Institution and followed by a half-day planning workshop for Q2O project leaders. The 22 participants were chosen for their knowledge of sensors and processing methods. The concepts of Sensor Web Enablement were introduced along with the goals of the Q2O project. A list of minimum requirements in metadata, recommended QC tests, as specified by QARTOD, and a brief description of the requirements of developing a data dictionary were presented. Discussion on the need to properly reference processing methods to unambiguously describe them was invaluable to our development of meaningful dictionaries. We also discussed potential use-cases to stimulate interest and develop relationships that will allow us to exercise our implementation.

HIGHLIGHTS

A community of data providers, IT specialists and domain experts need to work together to provide meaningful descriptions of sensors, processing and other relevant information on the sensors set-up and care. Towards that end, a community of people, both from the public domain and private institutions, have become engaged in implementing QA/QC practices for waves, *in situ* currents, CTD and dissolved oxygen into the OGC-SWE framework.

SOCIETAL BENEFITS

As we move towards dealing with machine-to-machine exchange of information, a common expectation in data quality will assure a broader trust in the abundance of data that will result in the ability to more readily discover and harvest data from disparate sources. This will enable interdisciplinary research with enhanced confidence levels using data funded for perhaps different applications, enhancing the value of any funded collection of data. Education and outreach achievements

The activities underway through this award were presented at a GEOSS workshop in May, 2008, in Geneva, Switzerland. Travel for this activity was provided through the Woods Hole Oceanographic Institution Center for Ocean, Seafloor and Marine Observations. The GEOSS participants were supportive of common (international) development of standards in the integration of oceanographic data into the SWE framework and recognized the importance of registries for services and vocabularies.

These activities were presented as part of discussion of data quality standards at the JCOMM/IODE Forum for Oceanographic Data Management and Exchange Standards, held in Belgium in January, 2008. This outreach effort was supported by the Forum's key sponsor, the NOAA IOOS Program Office.

An Intercalibration and Quality Assurance Program using a Stand-Alone Wireless IMET System

NOAA Cooperative Agreement No. NA17RJ1223
Sub-points 368 & 382
July 1, 2007 through June 30, 2008

David Hosom
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2666, E-mail: dhosom@whoi.edu

NOAA Program Manager: Dr. Sidney Thurston, NOAA/CPO/OCO

Related NOAA Strategic Plan Goal*:*
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

This project is directed at the long term development of a system to ensure that shipboard observations of air-sea fluxes are of the highest quality, as needed by research programs such as CLIVAR and SOLAS, and as needed so that the shipboard systems can provide in-situ calibrations of the ocean observatories under development by NSF. The goal of the project is to improve the quality and quantify the accuracy of shipboard meteorological and air-sea flux observations to the point that the data will meet the requirements of the science programs and provide the means to do in situ calibrations of the time series stations that will be maintained by some of these same ships.

At present, observations from scientific research vessels have well-documented problems and may not be routinely recorded when the vessel is at sea; and because of accuracy limitations, many VOS data require cumbersome correction procedures and are still not useful in some applications. To address these problems, this project will develop a transportable instrument suite to provide a standard for evaluating and improving ship-based observations of variables used in near-surface bulk meteorology and fluxes. The concept is for a central controller to collect one minute data from multiple ASIMET modules each hour and relay that data to the bridge for processing and merging with data from the ship's standard sensors for comparison purposes. The bridge would use a radio modem and bridge computer operating on ship's power. The central controller and all of the modules would be battery powered for up to a month at a time. This "portable standard marine meteorology kit" would be installed on the NOAA ship *Ron Brown* as an engineering test and later deployed on UNOLS and NOAA research vessels in a sequence of studies of each vessel.

ACCOMPLISHMENTS

The project focused on design and prototyping of the "portable standard marine meteorology kit" based on a IMET system with wireless communications. Future proposals will address the fabrication and field deployment of the system on multiple ships. Accomplishments are listed for each of the five principal tasks of the project.

1. Portable standard kit: The mechanical configuration of the portable standard ASIMET system was completed. Prototyping and evaluation were not completed.

2. Data storage: The PCMCIA memory card in existing ASIMET modules can now be replaced by a standard

Compact Flash (CF) card for lower cost and greatly increased storage capacity. A new module controller board is in progress that will use the CF and will have improved low temperature operation. This task is critical to the long term availability and use of ASIMET components, and was given highest priority. Unfortunately, this task was more demanding than anticipated and precluded progress on prototyping the central controller (Task 4) and integrating the system with the bridge computer (Task 5).

3. Mounting System: A prototype mounting system, similar to the VOS system presently used, was configured and deployed on the Kilo Moana during the WHOTS ORS mooring service cruise.

4. Central Controller: The design and prototyping of the central controller was not completed due to unexpected effort spent on Task 2.

5. Bridge Computer: The bridge computer was purchased in preparation for system integration.

HIGHLIGHTS

1. Hardware and software were developed and implemented to allow replacement of PCMCIA memory with Compact Flash in all existing ASIMET modules and loggers. This greatly increases memory capacity while simultaneously reducing memory cost.

2. A new ASIMET module processor/controller board was designed to provide native Compact Flash compatibility and improved low-temperature operation for the next generation of ASIMET electronics.

SOCIETAL BENEFITS

The long-term goal of the “portable standard” ASIMET package is to provide climate quality meteorology from the oceanographic research fleet. This will result in a unique database of in-situ observations in regions of the world’s oceans where access by commercial and volunteer observing ships is limited or non-existent.

Marine Resource Industries, Regulation, and Waterfront Land Use Change in New England Fishing Communities

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 437
July 1, 2007 through June 30, 2008

Di Jin
Marine Policy Center, MS 41
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: 508-289-2874, E-mail: djin@whoi.edu

NOAA Program Manager: Dr. Eric Thunberg, NMFS/NEFSC/Social Sciences Branch, Woods Hole, MA 02543

Related NOAA Strategic Plan Goal*:* Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

PROJECT OVERVIEW

Since the implementation of the interim New England multispecies fishery management plan in 1982, there has been a dramatic increase in regulatory activity (e.g., area closures and limits on days at sea). Industry participants usually perceive these regulations as imposing additional costs, and they seek to adjust to each new set of regulations in order to lessen their financial impact. In many cases, industry adjustments require relocating business operations and switching to other stocks or species. Geographic shifts in harvesting capacity may have implications for the location of associated industries that supply the harvesting sector as well as those in the processing, distribution, and other downstream sectors, leading to broader societal impacts.

Federal laws such as the National Environmental Policy Act of 1969 and the Sustainable Fisheries Act of 1996 require that conservation and management measures take into consideration the importance of fishery resources to fishing communities, with the goals of providing for the sustained participation of those communities and minimizing adverse economic impacts. One of the challenges in gauging the long-term and cumulative impacts of management regulations on coastal fishing communities is the lack of clear understanding of the interactions between changes in fish stocks and waterfront land uses. The main objectives of the research are to examine the impact of changing fish stock abundance on the structure of fishing and related industries in New England using county level data, and to examine changes in waterfront land uses in Massachusetts fishing communities using parcel level data and GIS tools.

PROGRESS

Using the NMFS stock assessment data for the northeastern region, we have constructed biomass estimate for each state in the region. We have developed time series cross section models for marine fishing, marine seafood, seafood dealers, and seafood processing industries, using data from the 11 northeastern states between 1989 and 2004.

HIGHLIGHTS

Our model results indicate a strong spatial relationship between local fish stocks and local employment in the fishing and related industries. Agglomeration of fishing-related industries in particular locations is driven by proximity to fish stocks.

SOCIETAL BENEFITS

The study will improve our understanding of the interactions between changes in fish stocks and waterfront land uses and fishing communities' economic conditions.

Development of Commercial Fishing Vessel Cost Models

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 423
July 1, 2007 through June 30, 2008

Di Jin
Marine Policy Center, MS 41
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Tel: 508-289-2874, E-mail: djin@whoi.edu

NOAA Program Manager: Andrew Kitts, NMFS/NEFSC/Social Science Branch

Related NOAA Strategic Plan Goal*:* Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

PROJECT OVERVIEW

Economists at the Northeast Fisheries Science Center (NEFSC) perform a wide variety of economic analyses of regulatory actions, including proposals under New England and Mid-Atlantic Fishery Management Plans and for Protected Species actions. Some actions are best evaluated by the use of behavioral models of fishing vessels which includes a cost component. These behavioral models are usually built by individual analysts to address specific regulatory actions. However, incorporating cost models can be time consuming and often average costs by gear, vessel size, and region are used instead.

The objective of the proposed project is to develop a set of cost models by cost component, gear type, vessel size, region, and other appropriate strata. Since cost data is constantly up-dated, this project focuses primarily on procedures and functional form issues. A goal would be to produce "off the shelf" models; however, since they may become obsolete over time, the main goal is to develop tools (such as SAS codes and procedure manuals) for use by analysts. The end product is a set of documents that describe the data, methods, results and SAS codes with explanations.

This project is highly relevant, as the collection of cost data in the Northeast has evolved to the point where the data available for econometric estimation is rich. While trip cost data has been collected through the observer program since 1995, the coverage by gear type in the first five to eight years was limited. Recently, coverage has expanded significantly due to bycatch and other management concerns as well as NEFSC Social Sciences Branch funding for under-represented fisheries. In addition, a new fixed cost survey implemented in early 2007 will further improve the quality and quantity of available data.

ACCOMPLISHMENTS

In preparing the two 2006 data sets for regression analysis, we tried to be inclusive in constructing independent variables, to avoid potential losses of useful information collected by the NMFS cost surveys. As a result, we had long lists of variables in both the trip cost and fixed cost data sets. We developed three sets of models: annual vessel fixed cost, annual labor cost, and vessel trip variable cost. Within each set, separate models were estimated for different gear groups. For the fixed and labor costs, we developed models for fixed gear, lobster gear, and mobile gear. For the trip cost, gill net, longline, otter trawl, scallop dredge, and paired otter trawl.

Given the large number of variables in the data sets, an efficient way to identify a set of independent variables for

a specific dependent variable is to use the SAS model selection (stepwise regression) procedure. The result of the stepwise regression is a short list of variables that are most significant in explaining variations in the dependent variable. Utilizing the short lists, we re-estimated individual cost models using GMM (Generalized Method of Moments) estimation in the SAS Model Procedure.

The study has developed a general framework for (1) constructing dependent and independent variables using results from recent NMFS surveys, (2) reviewing a large number of independent variables for different cost models, and (3) developing estimation procedures that can be used to address the issue of heteroscedasticity.

The results of the study are consistent with those of earlier studies in the literature. Generally, costs of fishing are affected by gear type, vessel characteristics (e.g., size, horsepower, and age), vessel operation (e.g., days at sea and location), and value of landings. However, there are several new findings with respect to new variables that have been constructed using results of recent NMFS surveys. For example, ownership type and vessel estimated value are significant variables in some fixed cost models.

HIGHLIGHTS

The study has developed a general framework for constructing dependent and independent variables using results from recent NMFS surveys, and for reviewing a large number of independent variables for different cost models. We developed three sets of models: annual vessel fixed cost, annual labor cost, and vessel trip variable cost. Within each set, separate models were estimated for different gear groups.

SOCIETAL BENEFITS

Analysts often work on similar issues, but in different contexts; vessel types often overlap across Fisheries Management Plans (FMPs) and protected species actions. As such, having standardized and pre-tested cost models by gear and other strata would create a number of benefits. It would increase the likelihood of cost models being used in regulatory analyses, it would reduce the work load on analysts, and it would foster an agreed-upon “best practice” approach to this aspect of fisheries modeling.

PUBLICATIONS

Jin, D. 2008. Development of Commercial Fishing Vessel Cost Models. Project Report to NOAA-NMFS. May. Marine Policy Center, Woods Hole Oceanographic Institution.

Economics of Ocean Surface Vector Winds Observation

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 433
July 1, 2007 through June 30, 2008

Hauke Kite-Powell
Marine Policy Center
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2938 E-mail: hauke@whoi.edu

NOAA Program Manager: Joseph Sienkiewic, NOAA/NWS/Ocean Applications Branch

Related NOAA Strategic Plan Goal*:*

Goal 3. Serve society's needs for weather and water information.

Goal 4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

PROJECT OVERVIEW

Objective: To develop an estimate of the annual economic value of ocean surface vector winds observation.

Major Tasks: This project was designed to build on prior research on the value of ocean surface vector winds observation to commercial shipping (storm warnings and ocean routing) by expanding the range of applications and users beyond the shipping industry. We selected four other user sectors for particular attention: offshore energy production, recreational boating, commercial fishing, and detection/prediction of Pacific tropical cyclones. To assess the likely benefits to these users from ocean surface wind information, we have

- characterized the difference in nowcasts and forecasts with and without the scatterometer information (forecast horizon, accuracy, temporal and spatial resolution, etc.); and
- estimated the economic implications of these improved nowcasts/forecasts to develop a lower bound estimate of the total economic value of scatterometer-based ocean surface vector winds data.

STATUS

The assessment of the value of ocean surface vector winds data to maritime transportation has been completed. Work on other user sectors (offshore energy production, recreational boating, commercial fishing, and detection/prediction of Pacific tropical cyclones) is nearly complete. An overview of results to date follows:

Severe wind and wave conditions associated with extratropical storms in the North Pacific and North Atlantic impose costs on maritime commerce by delaying and sometimes damaging vessels that encounter these storms. In particular, container ship traffic in these regions is at increased risk of losing containers overboard in severe weather conditions; and dry bulk ships carrying grain (Pacific and Atlantic) and coal (Pacific) face increased risk of structural damage from these conditions.

We estimate that average expected annual losses to container shipping (lost containers and associated damage to vessels) in the absence of good information about extratropical storm conditions would be on the order of $250 million/year in the North Pacific and $120 million/year in the North Atlantic; and we estimate average expected annual losses to bulk shipping operations from extratropical storm exposure in these regions to be on the order of $150 million/year.

A significant fraction of this risk can be avoided with ocean surface vector wind observations and forecasts. We

model the change in storm conditions exposure that becomes possible with nowcasts and forecasts of ocean surface vector wind fields under information scenarios representing the present QuikSCAT data, the European ASCAT radar, and a hypothetical Extended Ocean Vector Wind Mission (XOVWM) instrument. Model results suggest that the present QuikSCAT information and associated forecasts enable a reduction in annual exposure for shipping traffic in the North Atlantic and North Pacific of about 44%, with total annual net savings of $135 million. This is due mostly to avoided losses in the container ship trades, with $77 million/year in net avoided losses on the Pacific and $47 million/year on the Atlantic. The combined estimate of net annual benefits to shipping operations from ASCAT is $58 million, and hypothetical net benefits from XOVWM are $207 million. A perfect long-term forecast (not feasible with present technology) could deliver expected annual benefits of $520 million from all shipping by allowing for the virtual elimination of storm conditions exposure with no significant increase in operating costs.

In addition to maritime transportation, the offshore energy, commercial fishing, and recreational boating communities are exposed to risk from severe marine conditions. Although the risk of potential losses from severe storm events is considerable for offshore energy activities ranging from exploration to development and production, the extent to which this risk can be mitigated with better nowcasts and forecasts is limited. The total value of marine conditions forecasts for the US offshore energy industry in the Gulf of Mexico has been estimated on the order of $20-50 million/year; and the incremental value provided by QuikSCAT or similar information is likely to be less than 10% of that. Commercial fishermen and recreational boaters use marine conditions reports and forecasts to limit exposure to dangerous conditions; the total value to these user sectors of coastal ocean observing information in US waters is estimated to be in the $100s of millions/year. The contribution to this total value of QuikSCAT or similar data is likely to be on the order of $10 million/year. For recreational boater in particular, the value will be greatest for vector wind observing systems that are capable of resolving wind fields well in the immediate vicinity of the coast.

HIGHLIGHTS

- Our results indicate that a significant fraction of the approximately $500 million/year risk to commercial maritime transportation from severe storms in the North Atlantic and North Pacific oceans can be avoided with ocean surface vector wind observations and forecasts.
- Benefits to other user sectors from ocean surface vector wind observations and forecasts are likely to be smaller, on the order of $10s of millions/year.

SOCIETAL BENEFITS

This research contributes to the understanding of the economic value of ocean observing systems, specifically ocean surface vector wind observing instruments on satellites. This kind of information is important in the analysis of tradeoffs between alternative public earth observing system investments, and to ensuring that the nation builds and maintains an efficient and effective ocean observing infrastructure.

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT

The project PI is conducting an ongoing project, with funding from NOAA, to better characterize the economic value generated by coastal ocean observing systems in the New England region, and to develop tools to incorporate economic information in ocean observing system planning and design.

EDUCATION AND OUTREACH ACHIEVEMENTS

Education: Carolyn Clarkin (Bucknell University) worked as a Summer Student Fellow at the WHOI Marine Policy Center from June – August 2007, focusing on the value of ocean surface vector wind information to maritime shipping.
Outreach: No formal presentations to date; PI plans to present results of this work at the NOAA IOOS meeting in Baltimore in December 2008.

PUBLICATIONS

Paper on value of ocean surface wind information to maritime shipping is in preparation, for submission to *Marine Policy.*

Assessment of Air-Sea CO_2 Exchange Rates in the World's Ocean Using Bomb ^{14}C Inventories Derived from WOCE Global Survey

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 350
July 1, 2007 through June 30, 2008

Dr. Alison Macdonald
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
(508) 289-3507, amacdonald@whoi.edu
Dr. Tsung-Hung Peng, NOAA/AOML, Tsung-Hung.Peng@noaa.gov
Dr. Rik Wanninkhof, NOAA/AOML, Rik.Wanninkhof@noaa.gov
Dr. Robert M. Key, Princeton University, key@Princeton.edu

NOAA Program Manager: Dr. Kathy Tedesco, NOAA/OAR/OGP/GCC

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

Determining the spatial patterns and variability of carbon sources and sinks at global to regional scales, and documenting the fate of anthropogenic CO_2 in the atmosphere and ocean are main goals of the NOAA contribution to the U.S. Interagency Carbon Cycle Science Program (CCSP). Quantifying air-sea CO_2 exchange rates is critical to these goals because this exchange is the primary mechanism for CO_2 transfer between the atmospheric and oceanic carbon reservoirs.

This project has three main objectives:

1. To determine air-sea CO_2 exchange rates in the world oceans based on the bomb ^{14}C distribution observed during the WOCE global survey in the 1990s,
2. To re-evaluate the air-sea CO_2 exchange rates based upon the bomb ^{14}C inventory estimated from the 1970s-GEOSECS data using an improved method of separating natural ^{14}C from the observed ^{14}C, and
3. To use inverse methods to derive the air-sea CO_2 exchange rates from the WOCE era oceanic bomb ^{14}C distribution and ocean circulation.

ACCOMPLISHMENTS/PROGRESS/STATUS

Project goals one and two were completed prior to the time period of interest. The last goal was determined to not be possible given the intended methods and the available funding. Over the past year an effort was made to convert the lateral model software to Matlab for all three ocean basins and to make a number of test runs to create results to be used in a publication. Given other recent advances in the field (that is the use of assimilative models), it is not yet certain whether enough new information can be gleaned from the updated lateral model to warrant publication beyond the presentations already made.

SOCIETAL BENEFITS

The ocean inventory of bomb-produced radiocarbon (^{14}C) is directly related to air-sea CO_2 exchange and thereby provides a powerful constraint on the exchange rates. The large amount of high-quality radiocarbon data collected during the WOCE program provides the opportunity to improve our estimate of these air-sea CO_2 exchange rates and make the results available to the modeling community.

EDUCATION AND OUTREACH ACHIEVEMENTS

Peng T.-H., R. Wanninkhof, R. Key and A. Macdonald. Assessment of the Air-Sea CO2 Exchange Rates in the World's Oceans Using Bomb 14C Inventories, poster ICDC7, Boulder, Colorado, 2005 and NOAA PI meeting Fall 2007.

A. Macdonald, T.-H. Peng, R. Wanninkhof and R. Key, Ocean Bomb Radio-Carbon (14C) GEOSECS-WOCE, WHOI seminar, Dec, 2005.

Web Links: (http://cdiac.esd.ornl.gov/oceans/glodap/Glodap_home.htm)

Coupled Biological/Physical Models in the Coastal Ocean: Skill Assessment and Planning for Regional Testbed Projects

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 377
July 1, 2007 through June 30, 2008

Dr. Dennis J. McGillicuddy, Jr.
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
(508) 289-2683, dmcgillicuddy@whoi.edu

Program Manager: Dr. Elizabeth Turner, NOAA/NOS/COP

Related NOAA Strategic Plan Goals:
Goal 1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The goal of this project is to provide the scientific and technical basis for quantitative evaluation of coupled physical-biological models relevant to NOAA's Ecosystem Based Management activities.

We conducted an initial workshop in July, 2006 with practitioners drawn from carbon cycle, marine ecosystems, population dynamics, harmful algal bloom, and water quality modeling, as well as those interested in ecosystem-based management. Participants defined a set of papers to be composed for a refereed journal. A second workshop in March, 2007 reconvened the participants to present the papers and synthesize the results.

ACCOMPLISHMENTS

This year's activity was focused on completion of a special issue of JMS entitled "Skill Assessment for Coupled Biological/Physical Models of Marine Systems." Papers were contributed from several sources reflective of the state-of-the-art in coupled marine modeling in four different application areas: plankton ecosystems and biogeochemistry, harmful algal blooms, food webs, and water quality. Interaction amongst the groups resulted in papers focused on the cross-cutting themes of skill metrics (Stow et al., in press) and skill assessment in the context of data assimilation (Gregg et al., in press). Rose et al. (in press) introduce some new tools for quantitative comparison of spatial maps using simulated data and identical twin experiments to evaluate their effectiveness.

Plankton ecosystems and biogeochemistry

Applications related to the area of ocean biogeochemistry were quite diverse, including an assessment of a radiative transfer model used as forcing for coupled physical-biogeochemical models (Gregg and Casey, in press). Jolliff et al. (in press) introduce a new tool for skill assessment, the "target error diagram," using it to test an ocean ecosystem model with satellite-based ocean color data. Allen and Somerfield (in press) describe principal component analysis and nonparametric multivariate approaches to assessing an ecosystem model of the North Sea. Doney et al. (in press) present a generalized framework for assessing the skill of global upper ocean ecosystem-biogeochemical models, utilizing a variety of metrics including model-data residuals, time-space correlation, root mean square error, and Taylor diagrams. Advanced methods for skill assessment were applied in two different regional studies. Friedrichs et al. (in press) tested a set of thirty primary production models with an extensive data set in the Equatorial Pacific. Wallhead et al. (in press) use data subsetting and Monte Carlo simulation to test statistical and dynamical models of areal-mean chlorophyll on Georges Bank.

Harmful algal blooms
Stumpf et al. (in press) evaluate the skill of an operational harmful algal bloom forecast model for *Karenia brevis* on the west Florida shelf, using quantitative metrics to assess how well the system performs in five aspects: identification, intensification, transport, extent, and impact. A harmful algal bloom issue in the Gulf of Maine is addressed by Smith et al. (in press), who use a Monte Carlo ensemble smoother approach to inverting for initial conditions and mortality in a spatially explicit physical-biological model of the toxic dinoflagellate *Alexandrium fundyense*.

Food webs
Fennel (in press) grapples with the issue of coupling plankton ecosystem models with models of fish production, examining the impact of model truncation and parameterization on skill. Steele (in press) uses inverse methods to fit a linear food web model to observations, critically evaluating the ecological assumptions underlying these optimization strategies via comparison to application in nonlinear dynamic models.

Water quality
Fitzpatrick (in press) provides a review of metrics used to assess the skill of water quality models, which are becoming increasingly important in setting policy on total maximum daily loads of nutrient discharge in many areas of the coastal ocean. Sheng and Kim (in press) use a variety of quantitative metrics to evaluate a water quality model of the Indian River Lagoon. Stow and Scavia (in press) utilize a Bayesian framework for parameter estimation that yields both model forecasts and probabilistic estimates of forecast uncertainty, a key input into policy decision-making.

PUBLICATIONS

Lynch, D.R., McGillicuddy, D.J., and F.E. Werner. Introduction to the Volume: Skill Assessment for Coupled Biological/Physical Models of Marine Systems. In press, Journal of Marine Systems.

Gregg, W.W. and N.W. Casey. Skill assessment of a spectral ocean-atmosphere radiative model. In press, Journal of Marine Systems.

Jolliff, J.K., Kindle, J.C., Shulman, I., Penta, B., Friedrichs, M.A.M., Helber, R., and R.A. Arnone. Summary diagrams for coupled hydrodynamic-ecosystem model skill assessment. In press, Journal of Marine Systems.

Wallhead, P.J., Martin, A.P., Srokosz, M.A., and P.J.S. Franks. Skill Assessment via Cross Validation and Monte Carlo Simulation: An Application to George's Bank Plankton Models. In press, Journal of Marine Systems.

Stow, C.A, and D. Scavia. Modeling Hypoxia in the Chesapeake Bay: Ensemble Estimation Using a Bayesian Hierarchical Model. In press, Journal of Marine Systems.

Allen, J.I. and P.J. Somerfield. A multivariate approach to model skill assessment. In press, Journal of Marine Systems.

Fennel, W. Parameterizations of truncated food web models from the perspective of an end-to-end model approach. In press, *Journal of Marine Systems*.

Steele, J. H. Assessment of some linear food web methods. In press, *Journal of Marine Systems*.

Sheng Y.P. and T. Kim. Skill assessment of an integrated modeling system for shallow coastal and estuarine ecosystems. In press, Journal of Marine Systems.

Stumpf, R.P., Tomlinson, M.C., Calkins, J.A., Kirkpatrick, B., Nierenberg, K., Currier, R., Wynne, T.T., and K. Fisher. Skill assessment for an operational algal bloom forecast system. In press, Journal of Marine Systems.

Stow, C.A., Jolliff, J., McGillicuddy, D.J., Doney, S.C., Allen, J.I., Friedrichs, M.A., Rose, K.A., and P. Wallhead. Skill assessment for coupled biological/physical models of marine systems. In press, Journal of Marine Systems.

Smith, K.W., McGillicuddy, D.J., and D.R. Lynch. Parameter estimation using an ensemble smoother: the effect of the circulation in biological estimation. In press, Journal of Marine Systems.

Rose, K.A., Roth, B.M. and E.P. Smith. Skill assessment of spatial maps for oceanographic modeling. In press, Journal of Marine Systems.

Gregg, W.W., Freidrichs, M.A.M., Robinson, A.R., Rose, K.A., Schlitzer, R., Thompson, K.R., and S.C. Doney. Skill assessment in ocean biological data assimilation. In press, Journal of Marine Systems.

Fitzpatrick, J. Assessing skill of estuarine and coastal eutrophication models for water quality managers. In press, Journal of Marine Systems.

Doney, S.C., Lima, I., Moore, J.K., Lindsay, K., Behrenfeld, M., Westberry, T.K., Mahowald, N., Glover, D.M., McGillicuddy, D.J. and T. Takahashi. Skill metrics for confronting global upper ocean ecosystem-biogeochemistry models against field and remote sensing data. In press, Journal of Marine Systems.

Friedrichs, M.A.M., Carr, M.E., Barber, R.T., Scardi, M. and the PPARR team. Assessing the Uncertainties of Model Estimates of Primary Productivity in the Tropical Pacific Ocean. In press, Journal of Marine Systems.

Summary of Interaction with NOAA

There was active participation of NOAA scientists in the second workshop, several of which contributed to the special volume.

SUMMARY OF EDUCATION AND OUTREACH ACTIVITY

Web-based outreach:

http://www-nml.thayer.dartmouth.edu/Publications/internal_reports/NML-06-Skill/

http://www.whoi.edu/sbl/liteSite.do?litesiteid=18052

The Argo Float Program

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 304 & 305
July 1, 2004 through June 30, 2005

Dr. Brechner Owens
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
(508) 289-2811, bowens@whoi.edu

Program Manager: Dr. Steve Piotrowicz, NOAA/OAR

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT BACKGROUND

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 expects to reach this goal in October, 2007. Once this coverage has been achieved the further objective is to sustain this array indefinitely. The US is expected to provide half the array and the WHOI component of the Argo float program that has been funded through CICOR represents approximately 15% of the array. The duration of present grant is 5 years, starting in July 2006.

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

OBJECTIVES

This grant covers WHOI's contribution to phase III of the Argo float program. The activities carried out in the final year of this grant include manufacturing of floats for the Argo array, quality-control of the data, and contributions to the scientific management of the Argo Float program. Further analyses of the data from an array of over 200 floats from the northern North Atlantic are being carried out to investigate the seasonally varying heat and salt content for the region as a demonstration of the types of analyses that can also be applied to the Argo float array.

STATUS

Over the period from 1 July, 2007 to 30 June, 2008 a total of 90 floats have been manufactured and deployed, primarily in the Atlantic Ocean. Our coordination with AOML to deploy these floats primarily from VOS cruises has developed so that we can anticipate cruises and make deliveries on a timely basis, but there continue to be occasional problems. As compared to the deployments in other oceans, the relatively small size of the Atlantic requires that we only deploy 6-8 floats per VOS cruise and these cruises change or are cancelled. This means that the time per float spent organizing for its delivery is higher than is the case when a cruise involves 30 or more floats as is the case in the Pacific and Indian Oceans. Most of the deployments have been in the Atlantic and Southern Ocean, with a few floats launched in the eastern tropical Pacific. An additional 10 floats have been deployed in the Bellinghausen Sea both within and adjacent to the seasonal ice cover. These latter floats were equipped with an algorithm to detect open leads, which has proven to be quite successful given that several floats have missed one or

more transmissions and then found open water to send back all the data.

Due to the unavailability of some electronic components, our supplier of the electronic float controller has been forced to develop a new hardware design. We have taken advantage of this opportunity to streamline the design and develop new software that has been written in C and to make a more flexible hardware and software interface both for the user and to communicate with sensors that are integrated into the float. This new float has been fully tested in a new 10 m deep tank built at WHOI specifically to test floats. Five of the new designed floats will be deployed in the Fall of 2008. Assuming that these first deployments go well, we will migrate over to the new design in the near future. This new controller has also been designed so that it has the proper input/output lines so that it can be used with the new SOLO II float that is being developed at Scripps Institution of Oceanography.

During the previous year, an analysis of Argo float data identified that the WHOI FSI equipped floats had data that had a signficiantly cold bias. After extensive examination of the problem, it was determined that the error occurred because the FSI CTD was carrying out the bin averaging from the bottom of the profile, rather than from the sea surface downward. This error caused the pressure values to be incorrectly reported in the netcdf files. For approximately half of these floats, there is engineering data that will allow the data to be corrected unambiguously. For the other fraction, a least-squares procedure combined with a visual inspection has been developed to best estimate the pressures. This procedure will increase the pressure uncertainty to order 10 dbars. Although all these floats have been processed to estimate the actual pressure, it was decided, in consultation with members of the Argo Science Team, that this large uncertainty in pressure made this data of dubious quality. As a result, we have decided to label all this data as bad and are in the process of uploading these files to the Global Data Acquisition Centers.

Owens has continued to work with A. Wong (U of Washington) to improve the procedures for calibration of the conductivity sensors against historical CTD data. We had implemented a piece-wise linear fitting procedure that chooses the statistically simplest model of the drift and have developed a new procedure to make the comparison between the float and climatological data within intermediate layer mode waters and deep homogeneous layers. This new procedure has been evaluated by the Argo community and has been accepted as the method to carry out the calibration of conductivity sensors. The procedure was thoroughly vetted at the recent Argo Delayed Mode Quality Control workshop (DMQC-3) held in Seattle, 10-12 October. A manuscript describing the procedure has been accepted for publication in *Deep-Sea Research*.

In order to improve the throughput of delayed mode data, Paul Robbins was hired this year to work on evaluating and implementing the delayed mode quality control procedures. He has made significant contributions to the overall procedures and also has started to push though a significant number of profile so that they are in their final form useful for climate research.

Owens has continued to spend some time involved with the International Argo Steering Team and the Argo Advisory panel. This has included AST-8 which met at the British Met Office in March, 2007.

In summary, the WHOI contribution to the Argo Float Program has continued significantly accelerated and improved the performance of the floats. Improvements in both the communications system and the calibration procedures have been implemented. A significant error in the data reported from these floats has been indentified and the procedures to correct the data have been developed and implemented. The through-flow of data to the final quality controlled values has also significantly increased.

PUBLICATIONS

W. Brechner Owens and Annie P. S. Wong, 2008. An Improved Calibration Method for the Drift of the Conductivity Sensor on Autonomous CTD Profiling Floats by θ-S Climatology, *Deep-Sea Research*, (In Press).

D. Roemmich, S. Riser, R. Davis, W.B. Owens, G. Johnson, S. Garzoli, M. Ignaszewski, 2008. The Argo Program: Observing the Global Oceans with Profiling Floats, NOPP special issue, *Oceanography Magazine*, Accepted

Dynamics of the Flow of Pacific Water Through the Western Chukchi: Analysis of the 2004 RUSALCA Herald Canyon Hydrographic Data.

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 371
June 1, 2005 through May 31, 2006 (Extended to December 31, 2008)

Dr. Robert S. Pickart
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2858 E-mail: rpickart@whoi.edu

NOAA Program Manager: Dr. John Calder, NOAA/OAR/ARCTIC

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

In summer 2004 the Russian icebreaker *Khromov* carried out the inaugural cruise of the Russia-US Long-term Census of the Arctic (RUSALCA) program. The expedition was a great success, consisting of multi-disciplinary sampling from Bering Strait northward into the Chukchi Sea. Part of the hydrographic component consisted of a detailed survey of the flow through Herald Canyon (Fig 1). This was the first time that the canyon had been sampled at high cross-stream resolution (station spacing less than the Rossby radius of deformation), enabling the currents and water masses to be fully resolved. Using the hydrographic and velocity data obtained from the survey, the dynamics of the flow of dense water through the canyon, and the potential impact that this has on the ventilation of the western Arctic, was investigated.

ACCOMPLISHMENTS

The focus of the study was on the dynamics of the flow of Pacific water (both summer water and winter water) through Herald Canyon (Fig 1). During the RUSALCA survey the two water masses entered the south side of the canyon flowing side by side, but the winter water switched to the eastern side of the canyon as it progressed northward, while the summer water disappeared from the canyon (Fig 2). In place of the summer water, an intermediate water mass mode was present at the mouth of the canyon (Fig 3). Why did the dense water cross to the eastern side of the canyon, and what caused the creation of the intermediate water mass mode? There is indication in the hydrographic and velocity data that hydraulic adjustment was active during the time of the survey. A three-layer non-rotating hydraulic theory, applied to the measured parameters of the flow and the topography, suggests that the current was supercritical. This can explain the west-to-east transposition of the dense water. The small value of the Richardson number implies that strong mixing was also occurring, which likely formed the intermediate water mass. Finally, it was demonstrated that the source of dense water entering the canyon was likely a combination of winter water originating from Bering Strait, with a contribution from the polynya located west of Wrangel Island that opened up regularly during the previous winter.

HIGHLIGHTS

The dynamics of the flow of Pacific water through Herald Canyon were investigated for the first time.
Winter water entered the canyon on the western side, but switched to the eastern wall of the canyon as it flowed northward.

The transposition of winter water can be explained by hydraulic theory applied to the flow.
Mixing of the winter and summer water masses in the canyon created an intermediate water mass mode.
Polynya activity west of Wrangel Island during the previous winter likely contributed to the influx of dense water into Herald Canyon.

SOCIETAL BENEFITS

The RUSALCA program represented a fruitful collaboration of Russian and US scientists, making use of shared resources and expertise. The results from the study enhanced our knowledge of a critical part of the Arctic system, enabling us to better predict the impacts of variable inflow through Bering Strait as a result of climate change.

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT

The hydrographic data collected during the cruise was used by numerous other RUSALCA researchers.

EDUCATION AND OUTREACH ACHIEVEMENTS

The work was presented at the 2008 Ocean Sciences Meeting.

PUBLICATIONS

Pickart, R.S., L.J. Pratt, D.J. Torres, T.E. Whitledge, A.Y. Proshutinsky, K. Aagaard, T.A. Agnew, G.W.K. Moore, H.J. Dail. Evolution and dynamics of the flow through Herald Canyon in the Western Chukchi Sea. *Deep-Sea Research*, accepted.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

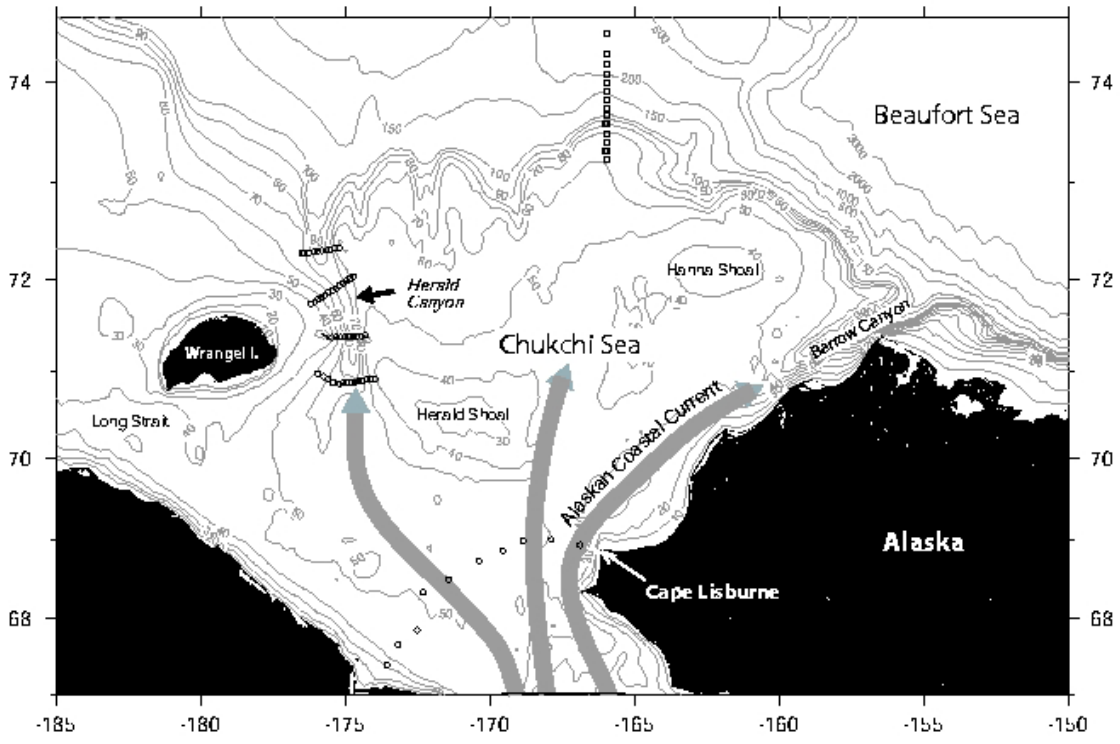


Figure 1: Study area of the Chukchi Sea, including names of geographical features. Three branches of the Bering Strait inflow are represented schematically, the western-most of which feeds Herald Canyon. Circles denote stations occupied as part of the RUSALCA program in August 2004. The four transects in Herald Canyon were the focus of the study.

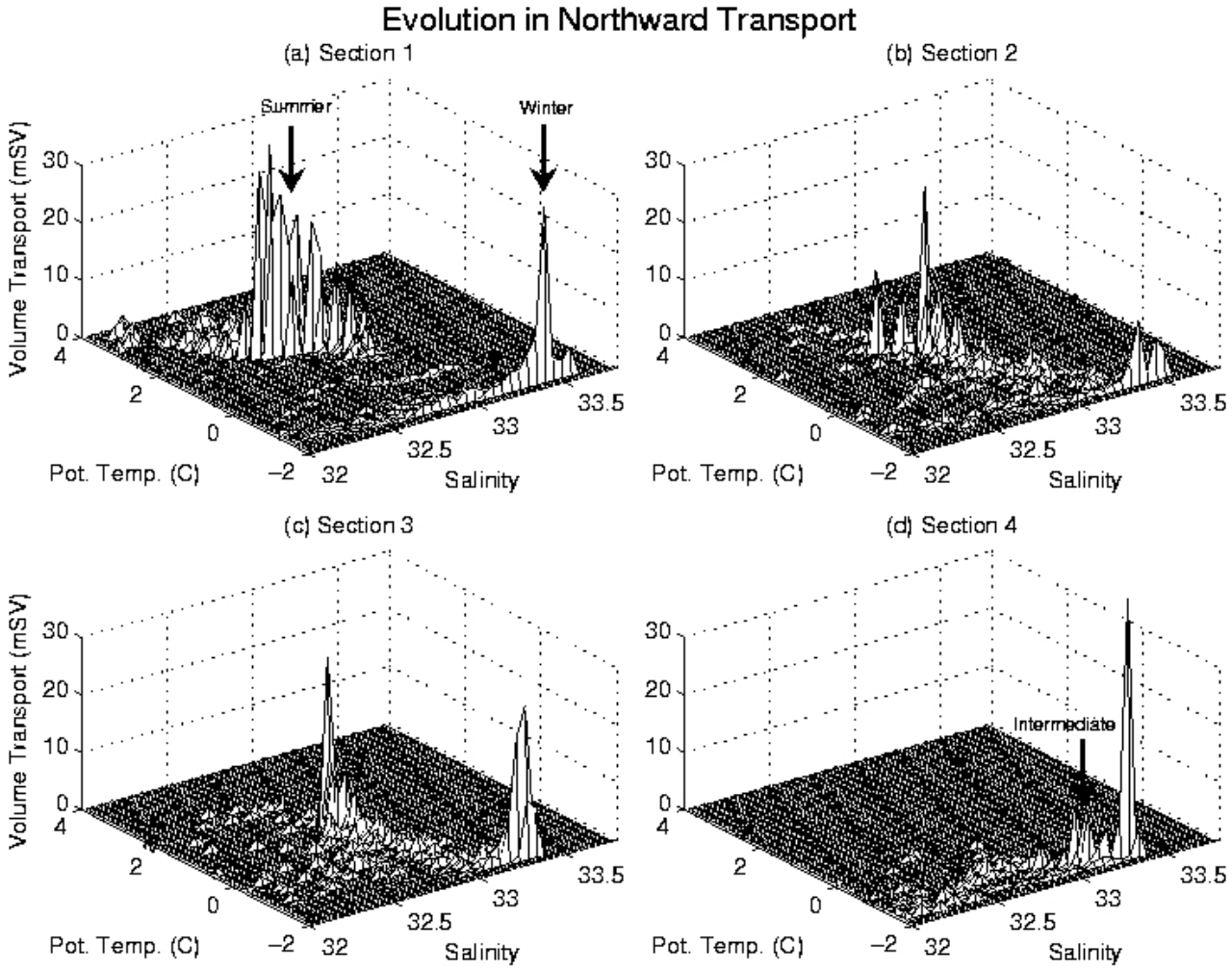


Figure 2: Evolution of the water masses and flow field from south to north in Herald Canyon. The vertical sections are oriented such that the viewer is looking north, and the sections are positioned so that the center of the canyon is aligned (as indicated by the arrows). (a) Locations of the four transects. The contours in (b)-(e) are absolute geostrophic velocity (positive denotes northward flow). The core of the poleward flow at section 3, used in the hydraulic analysis, is marked by the bar along the horizontal axis in (d).

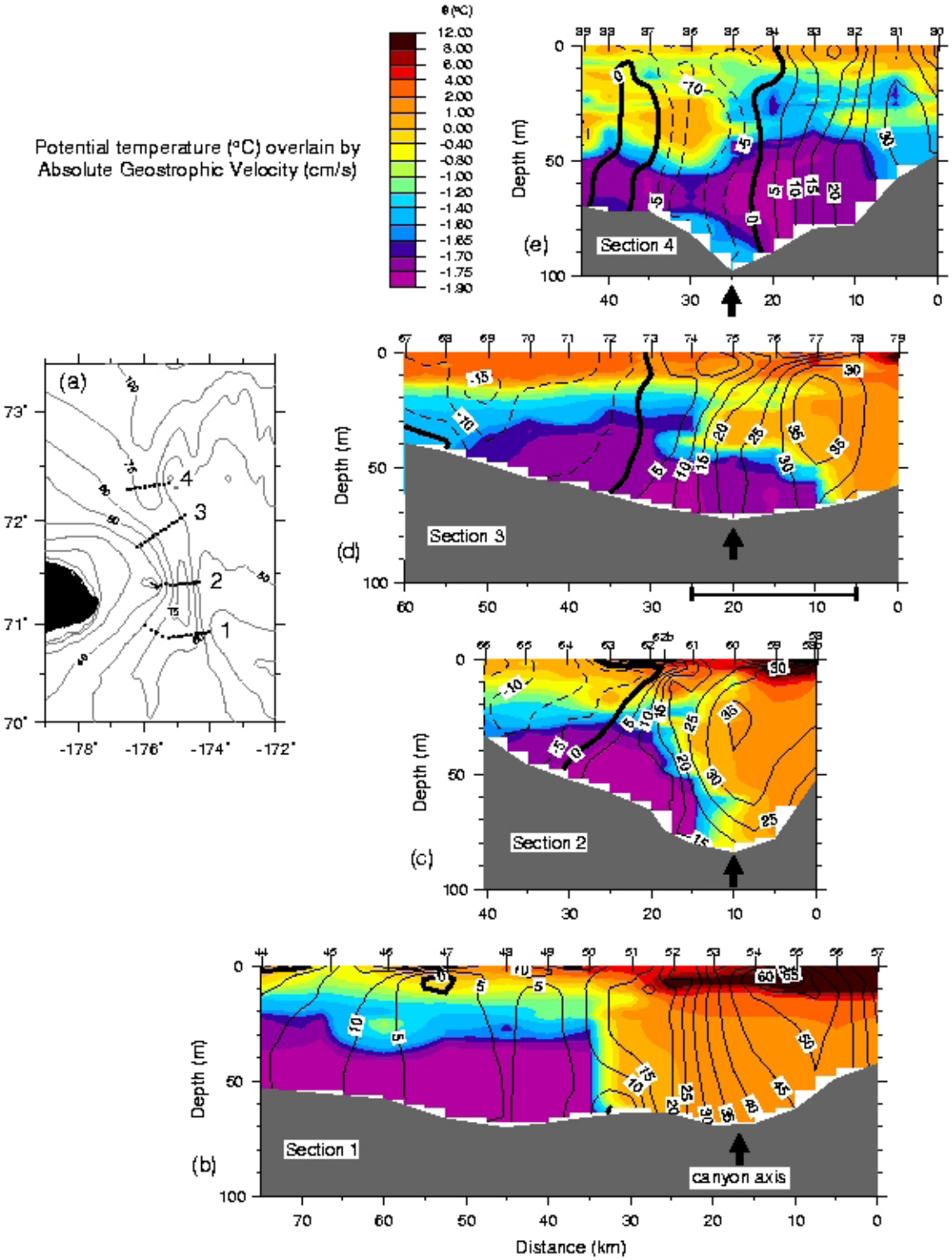


Figure 3: Volume transport in milli-Sverdrups (mSv) as a function of potential temperature and salinity for the four transects. The three transport modes are marked by the arrows.

State of the Arctic Report

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 378
July 1, 2007 through June 30, 2008

Dr. Andrey Proshutinsky
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
(508) 289-2796, aproshutinsky@whoi.edu

Program Manager: Dr John A. Calder, NOAA/OAR Arctic Research Office

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The overall goal of the proposed task is to produce an annual report fully assessing the state of the Arctic Ocean. Specific objectives include:

- Preparing a baseline report on the state of the Arctic.
- Developing a methodology for an annual reassessment
- Widely disseminating the report.

The annual assessment was based on data obtained from U.S. and international sources and covers:
Atmospheric circulation
Surface air temperature and barometric pressure
Sea ice concentration, thickness, concentration, and mass balance.
Sea ice drift
Arctic Ocean circulation, thermohaline structure, and heat content
Ocean transport of freshwater, heat and nutrients through major Arctic gateways
Sea level
Biological activity from primarily productivity to fish to marine mammmals.

The report was produced by a team of experts lead by Jacqueline Richter-Menge (sea ice), James Overland (atmosphere), and Andrey Proshutinsky (ocean). The science advisory team consisted of national and international Arctic experts from universities and government laboratories.

The information in this report was disseminated in several ways. It was presented as a peer-reviewed article as part of the American Meteorological Society annual climate summary. We also developed a Web site with an electronic version of the report plus an easily accessible, complete representation of all of the reporting activities. Highlights from the annual assessment were and will also be presented at major conferences.

ACCOMPLISHMENTS

The major project accomplishment is the report describing the Arctic climate. The 2007 NOAA global climate report includes a section with a review of recent Arctic data by an international group of scientists who developed a consensus on the arctic environment information content and reliability. Of particular note:
In 2007 there continued to be wide-spread evidence of the impact of a general warming trend in the Arctic region, where surface air temperatures reaching their highest recorded level. One of the most dramatic signals was the significant reduction in the extent of the summer sea ice cover and in the relative amount of older, thicker ice, both

showing signs of an increase in the relative rate of reduction. Accompanying the reduction in the sea ice cover was an increase in the temperature and decrease in the salinity of the surface ocean layer. Water temperatures in deeper ocean layers also increased due to the influx of warmer waters into the Arctic Basin. On land, there was a general greening of tundra and browning of forested areas. Permafrost temperatures tended to increase and snow extent tended to decrease. Measurements of the mass balance of glaciers and ice caps indicate that in most of the world, glaciers are shrinking in mass. The largest of these, Greenland, experienced records in both the duration and extent of the summer surface melt.

FIGURES AND IMAGES

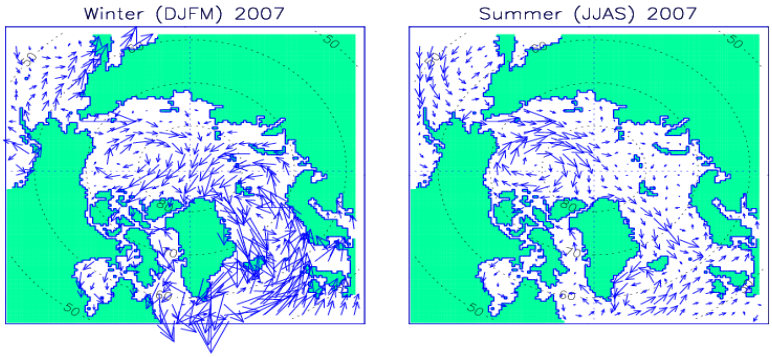


Figure 1 *Circulation patterns of the simulated upper ocean wind-driven circulation in winter (left) and summer (right) of 2007. Updated following to Proshutinsky and Johnson, 1997.*

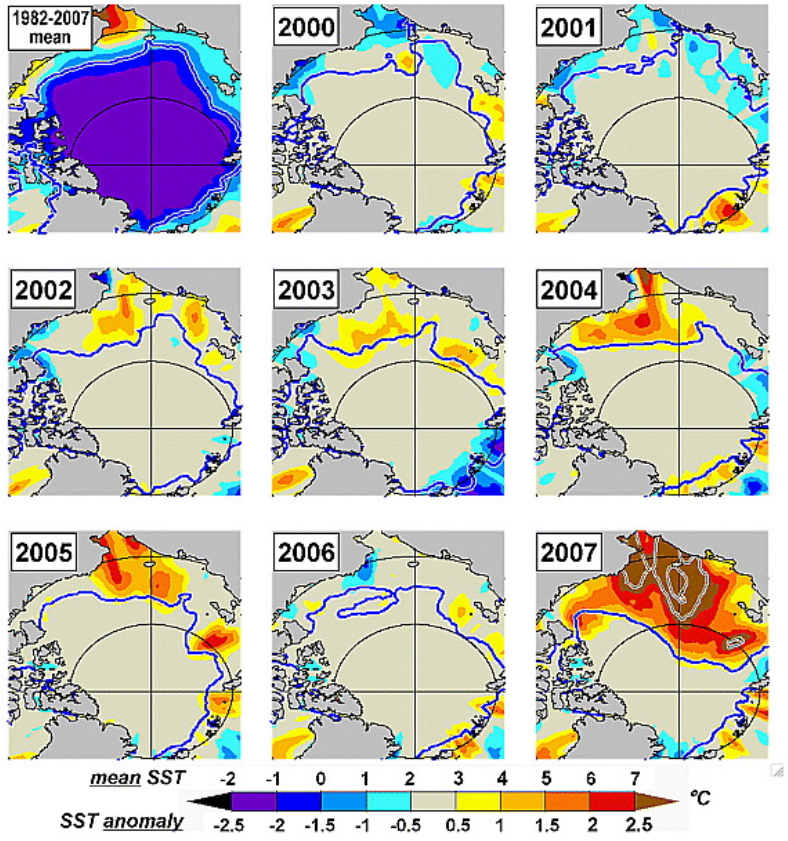


Figure 2 (top left) Mean satellite-derived summer (July- Aug) sea surface temperature (SST) [Reynolds et al., 2002] and anomalies from this mean over 2000–2007. Latitudes 70_N and 80_N and longitudes 0°/180°E and 90°/270°E are shown. For 2007, extra contours for 3°C and 4°C are provided. Also shown is the September-mean ice edge (blue contour) (from Steele et al., 2008).

PUBLICATIONS

J. Richter-Menge, J. Overland, A. Proshutinsky, V. Romanovsky, J. C. Gascard, M. Karcher, J. Maslanik, D. Perovich, A. Shiklomanov, and D. Walker (2007), Arctic, In: State of the climate report in 2007, Eds D.H Levinson and J.H. Lawrimore, Special supplement to the Bulletin of the American Meteorlogical Society, vol. 89, No 7, July 2008.

J. Richter-Menge, J.Overland, A. Proshutinsky, V. Romanovsky, L. Bengtsson, L. Brigham, M. Dyurgerov, J.C. Gascard, S. Gerland, R. Graversen, C. Haas, M. Karcher, P. Kuhry, J. Maslanik, H. Melling, W. Maslowski, J. Morison, D. Perovich, R. Przybylak, V. Rachold, I. Rigor, A. Shiklomanov, J. Stroeve, R. Volker, D. Walker and J. Walsh (2007), State of the Arctic Report, NOAA web site (submitted)

SUMMARY OF INTERACTION WITH NOAA

The report was produced under supervision of J. Calder and we have successfully and efficiently interacted in order to complete this work in time and successfully.

SUMMARY OF EDUCATION AND OUTREACH ACTIVITY

The major project results were prepared by a group of experts from USA, Germany, France, Russia, Poland, Canada, and Sweden and the project results were respectively disseminated in these countries. The major project results will be also presented at the AGU 2008 Fall meeting, and AAAS meeting at University of Alaska Fairbanks.

POGO Cruise Database Support

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 428
July 1, 2007 through June 30, 2008

Shubha Sathyendranath
Partnership for Observation of the Global Oceans (POGO)
Bedford Institute of Oceanography
Dartmouth, Nova Scotia, Canada B2Y 4A2
Phone:1-902-426-8044 E-mail: shubha@dal.ca

NOAA Program Manager: Mike Johnson, NOAA/OAR/CPO/Climate Observations.

Related NOAA Strategic Plan Goals:
Goal 1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
Goal 3. Serve society's needs for weather and water information.
Goal 4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

PROJECT OVERVIEW

To develop an international cruise information database to facilitate resource sharing and information exchange related to past and planned research cruises

ACCOMPLISHMENTS/PROGRESS/STATUS

Present status
The website www.pogo-oceancruises.org was launched in 2007 and gradually each of the 3 planned databases is becoming available. The SeaDataNet partners are actively developing the applications for adding new entries, updating existing entries and for searching and retrieving information. In parallel active surveys are underway to populate each of the 3 databases with entries of all RV's worldwide > 60 meters.

The **International Research Vessel Cruise Programmes** database has been operational since 2007 and provides the facility to search and present an increasing number of planned cruises. The compilation of this database is coordinated by the British Oceanographic Data Centre (BODC). A survey format has been defined, which forms the basis of the database. Users can retrieve information from the database using the versatile User Interface, which supports combined geographical – alpha numerical searching, that has been developed by MARIS.

The **Global directory of ocean-going Research Vessels** has been operational since early July 2007. It has been developed by EurOcean with support of MARIS and it contains characteristics, owners and operators' information for ocean-going research vessels. The content format is in conformance to the Oceanic database, that was operated and kept up-to-date till 2005 by the University of Delaware. EurOcean previously developed an online RV Directory for all European vessels, which can be found at the EurOcean portal (www.eurocean.org). The global directory has been developed as a special version on behalf of the POGO-CoML initiative. It contains up-to-date information on ocean-going Research Vessels, operated worldwide, and is now accessible from the www.pogo-oceancruises.org website. In cooperation with ISOM, BODC, MARIS and the University of Delaware, by searching

the internet and using the position paper of the ESF Marine Board on European Ocean Research Fleets an initial list and database was composed of known existing ocean-going RV's, their operators and specifications.
The **Cruise Summary Report (CSR) database** for the POGO-CoML initiative is being developed by BSH/ DOD, Germany. It focuses on details of completed cruises and providing a first level inventory of oceanographic measurements made and samples taken.

HIGHLIGHTS

The website www.pogo-oceancruises.org was launched in 2007 and gradually each of the 3 planned databases is becoming available. The SeaDataNet partners are actively developing the applications for adding new entries, updating existing entries and for searching and retrieving information. In parallel active surveys are underway to populate each of the 3 databases with entries of all RV's worldwide > 60 metres.

SOCIETAL BENEFITS

The project was undertaken to enhance resource sharing and information exchange related to past and planned research cruises. Benefits include:

-
- Helping scientists from different countries coordinate future funded research through information about research vessels of opportunity;
- Aiding in retrospective ability to find data in regions of interest;
- Making it possible for projects to conduct joint work and to fill empty berths;
- Creating capacity-building and training opportunities;
- Aiding in tracking and distributing data;
- Allowing cost sharing among institutions, projects, and nations;
- Making possible intercomparisons, intercalibrations, and validation among different data types (e.g. CTD vs. Argo, in situ vs. remote sensing)

U.S. Research Vessel Surface Meteorology Data Assembly Center

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 356
July 1, 2007 through June 30, 2008

Dr. Eric Chassignet, Mr. Shawn R. Smith, and Dr. Mark A. Bourassa
Center for Ocean-Atmospheric Prediction Studies
The Florida State University
Tallahassee, FL 32306-2840
Phone: 850-644-4581, email: echassignet@coaps.fsu.edu
Phone: 850-644-6918, email: smith@coaps.fsu.edu
Phone: 850-644-6923, email: bourassa@coaps.fsu.edu

NOAA Program Manager: Michael Johnson, NOAA/OAR/CPO/Climate Observing Division

Related NOAA Strategic Plan Goal*:*
- Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
- Goal 3. Serve society's needs for weather and water information.

PROJECT OVERVIEW

The central activity of the U.S. Research Vessel Surface Meteorology Data Assembly Center (DAC) is the implementation of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative. The SAMOS initiative focuses on improving the quality of and access to surface marine meteorological and oceanographic data collected *in-situ* by automated instrumentation on research and merchant vessels. The DAC activities focus primarily on NOAA Strategic Plan Goals 2 and 3 by providing high quality weather and near surface ocean data for use in validating satellite products, global air-sea flux analyses, and model fields.

The DAC was established at the Florida State University specifically to coordinate the collection, quality evaluation, distribution, and future archival of underway-meteorological data. The DAC has steadily moved away from cruise-by-cruise delayed-mode quality evaluation towards the near-real time examination of automated observations from SAMOS. A SAMOS is typically some form of a computerized data logging system that continuously records navigation (ship's position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near ocean surface (sea temperature and salinity) parameters while the vessel is at sea. Measurements are recorded at high-temporal sampling rates (typically 1 minute or less). The move towards near-real time QC has been ongoing and was not fully envisioned during the earlier years of our CICOR agreement. The data acquisition and QC objectives of the DAC are now centered on the near-real time SAMOS activities and, with additional NOAA funds provided directly to COAPS, the SAMOS data stewardship activity is nearing full implementation. Details of the SAMOS data flow, vessel recruitment, and data access are available on the SAMOS web site: (http://samos.coaps.fsu.edu/).

STATUS

Over the past year our efforts primarily have focused on the recruitment of additional vessels to the SAMOS initiative and the implementation of the data quality procedures. The increased load of data to evaluate has limited development of new QC techniques.

Recruitment of additional vessels to participate in the SAMOS Initiative was very successful during the reporting period. Five new vessels were recruited (Table 1) in the past year, including the WHOI RV *Oceanus*. Combined with

previously recruited vessels, the total of 17 RVs resulted in 2279 ship days of data for the year (an 130% increase from the previous year). A continued collaboration with NOAA OMAO added four new NOAA vessels. Through continued liaison activities, the DAC has identified additional vessels for recruitment. Although many UNOLS vessels expressed interest in participating in SAMOS, initiating new data transfers is still difficult in these times of tight operational budgets for research vessels.

Table 1: Ships transmitting observations to SAMOS DAC.

Vessel	Call Sign	Operator	No. of ship days of data 7/1/2006 – 6/30/2007	No. of ship days of data 7/1/2007 – 6/30/2008
Atlantis	KAQP	WHOI	290	299
David Star Jordan	WTDK	NOAA	-	4
Fairweather	WTEB	NOAA	-	20
Gordon Gunter	WTEO	NOAA	2	19
Healy	NEPP	USCG	6	132
Henry Bigelow	WTDF	NOAA	21	137
Hi'Ialakai	WTEY	NOAA	45	206
Ka'Imimoana	WTEU	NOAA	7	190
Knorr	KCEJ	WHOI	229	304
Lawrence Gould	WCX7445	NSF/Raytheon	32	131
Miller Freeman	WTDM	NOAA	122	200
Nancy Foster	WTER	NOAA	74	103
Oceanus	WXAQ	WHOI	-	36
Oregon	WTDO	NOAA	-	18
Oscar Dyson	WTEP	NOAA	93	207
Ronald Brown	WTEC	NOAA	71	232
Rainier	WTEF	NOAA	-	41
			992	2279

All data received undergo two levels of quality control. The process begins with the ship sending all the one-minute data reports for an individual day via an ASCII text file attached to an email. Preliminary processing includes metadata augmentation and converting the file to the SAMOS netCDF format. These preliminary files undergo fully automated QC and are then posted to our web site for distribution. A delayed-mode, visual quality control is scheduled to occur on a 10-day delay from the original date of receipt. This delay allows for late data transmissions. At present, the volume of data to undergo visual inspection exceeds our staffing level, so the research quality data release is several months behind schedule.

Many upgrades have been made to both our public access web site (http://samos.coaps.fsu.edu/) and our internal data base tools. We have implemented a series of web-based forms to allow ship operators to upload and modify the ship and instrument metadata for their vessels. A data mapping tool is also available using Google Earth technology. Users can select vessels and time periods of interest and view interactive track maps. To facilitate this mapping tool, the SAMOS ship database has been populated with hourly sub-samples from the one-minute underway data. This requires some extensive restructuring of the database, but will allow more advanced data searches on the web in the near future.

Throughout the year, DAC personnel have been actively promoting the SAMOS Initiative and the importance of underway meteorological and thermosalinograph measurements through meetings and working groups.

HIGHLIGHTS

Recruitment of 5 additional vessels to the SAMOS initiative, including the WHOI RV *Oceanus*.
An increase from 992 to 2279 ship days of underway meteorological and thermosalinograph data collected, run through automated quality control, and distributed.

SOCIETAL BENEFITS

The Data Assembly Center provides quality-evaluated marine meteorological data to the satellite and air-sea flux communities. Using these data, improvements are made in satellite retrieval algorithms that, in turn, will improve our ability to monitor the atmosphere near the ocean surface from space-based platforms. Similarly, the flux community achieves a better understanding of the variability in heat and moisture exchange between the ocean and atmosphere, which will improve future atmospheric and ocean models (potentially improving future forecasting capabilities).

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT:

The activities of the DAC receive additional support from the NOAA Climate Observation Division (COD) through a NOAA Applied Research Center at COAPS. In addition, NOAA COD provided support for the 2nd Joint GOSUD/SAMOS Workshop that was held in Seattle, WA, USA from 10-12 June 2008. The workshop reviewed the progress of the SAMOS initiative and provided a series of recommendations and actions for the next 2 years. In addition, the workshop provided and opportunity to expand international cooperation in the area of underway meteorological and thermosalinograph measurements.

EDUCATION AND OUTREACH ACHIEVEMENTS

The DAC initiated discussion with the ocean workforce education community at the 2008 Ocean Sciences meeting in Orlando. The focus of the discussion was on the need for additional training in the collection and handling of underway data by research vessel technicians. This is an ongoing education and outreach effort of the DAC and the SAMOS Initiative. In addition, DAC personnel made several presentations at national and international meetings:

Bourassa, M. A., L. Bucci, C. A. Clayson, C. Forgue, M. Onderlinde and B. Roberts, 2008: The Influences of Differing Temperature and Moisture Roughness Length Parameterizations on Height Adjustment and Turbulent Surface Fluxes. *Third JCOMM Workshop on Advances in Marine Climatology*, 6-9 May 2008, Gdynia, Poland.
Bourassa, M. A., L. Bucci, C. A. Clayson, C. Forgue, M. Onderlinde and B. Roberts, 2008: The Influences of Differing Temperature and Moisture Roughness Length Parameterizations on Height Adjustment and Turbulent Surface Fluxes. *2nd Joint GOSUD/SAMOS Workshop*, 10-12 June 2008, Seattle, Washington.
Rolph, J., S. R. Smith, and M. A. Bourassa, 2008: Quality evaluation of marine meteorological observations. *2nd Joint GOSUD/SAMOS Workshop*, Seattle, WA, 10-12 June 2008.
Smith, S. R., M. A. Bourassa, and J. R. Rolph, 2008: Data flow through the Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) Data Assembly Center. *2nd Joint GOSUD/SAMOS Workhop*, Seattle, WA, 10-12 June 2008.
Rolph, J., S. R. Smith, and M. A. Bourassa, 2008: Quality evaluation of marine meteorological observations. *2008 Northern Gulf Institute Annual Conference*, Biloxi, MS, 13-14 May 2008.
Smith, S. R., M. A. Bourassa, and J. R. Rolph, 2008: The Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) Initiative. *Third JCOMM Workshop on Advances in Marine Climatology (CLIMAR-III)*, Gdynia, Poland, 6-9 May 2008.
Smith, S. R., J. Rolph, and M. A. Bourassa, 2008: The Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative. *2008 Ocean Sciences Meeting*, Orlando, FL. 2-7 March 2008.
Smith, S. R., 2007: Metadata automation: Survey Results and Ideas. *UNOLS Research Vessel Technical Enhancement Committee 2007 Annual Meeting*, Moss Landing, CA, 6-8 November 2007.
Smith, S. R., and J. Rolph, 2007: The SAMOS Initiative. *UNOLS Research Vessel Technical Enhancement Committee 2007 Annual Meeting*, Moss Landing, CA, 6-8 November 2007.

A re-Analysis and Testing of Trends of Tropical Cyclone Data during the Aircraft Reconnaissance and Saatellite Era

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 421
July 1, 2007 through June 30, 2008

Andrew Solow
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2746 E-mail: asolow@whoi.edu

NOAA Program Manager: Christopher D. Miller, OAR/CPO

Related NOAA Strategic Plan Goal*:*
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The overall goal of this project is to extend and revise the North Atlantic hurricane database and to use the revised database to advance the understanding of long-term changes in hurricane activity and their connection to the broader climate system.

ACCOMPLISHMENTS

The accomplishments to date are summarized in the abstracts of the following two papers:

Solow AR & Beet AR. 2008. On the incompleteness of the historical record of North Atlantic tropical cyclones. *Geophysical Research Letters*.

There is some question as to whether the historical record of observed North Atlantic tropical cyclones is complete prior to the advent of satellite coverage. This question is central for understanding the historical trend in cyclone activity and the effect of environmental factors on it. To address this question, a statistical model of the relationship between annual cyclone counts between 1870 and 2004 and sea surface temperature and the state of the Southern Oscillation is extended to allow for non-decreasing observation probability prior to 1966. The estimated observation probabilities increase from 0.72 in 1870 to 1 in 1964. Allowing for record incompleteness reduces the estimated effect of sea surface temperature on annual cyclone activity.

Solow AR. 2008. On the maximum observed wind speed in a randomly sampled hurricane. *Journal of Climate*, submitted.

There is considerable interest in detecting a long-term trend in hurricane intensity possibly related to large-scale ocean warming. This effort is complicated by the paucity of wind speed measurements for hurricanes in the early part of the observational record. Here, results are presented regarding the maximum observed wind speed in a sparsely randomly sampled hurricane based on a model of the evolution of wind speed over the lifetime of a hurricane.

HIGHLIGHTS

This work provides further evidence that at least part of the long-term increase in the observed number of North Atlantic tropical cyclones can be attributed to incompleteness in the early part of the record.

This work shows that the sparse sampling of a hurricane can lead to a substantial underestimation in lifetime maximum wind speed. This calls into question some estimates of a long-term increase in hurricane intensity.

SOCIETAL RELEVANCE

In order to manage risks associated with long-term changes in hurricane activity and intensity, society needs to understand how such risks are changing and are likely to change in response to on-going climate change. A central problem in using the observational record of hurricanes to advance this understanding is bias due to under-sampling. The work conducted under this project is aimed at developing and applying methods that can account for such under-sampling.

PUBLICATIONS

Solow AR & Beet AR. 2008. On the incompleteness of the historical record of North Atlantic tropical cyclones. *Geophysical Research Letters*.

Solow AR. 2008. On the maximum observed wind speed in a randomly sampled hurricane. *Journal of Climate*, submitted.

NOAA/PMEL ICEALOT Cruise on *R/V Knorr*

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 435
July 1, 2007 through June 30, 2008

Albert F. Suchy
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2624 E-mail: asuchy@whoi.edu

NOAA Program Manager: Tim Bates, NOAA/OAR/PMEL

Related NOAA Strategic Plan Goal*:*
- Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The International Chemistry Experiment in the Arctic LOwer Troposphere (ICEALOT) is a springtime study of aerosol properties and atmospheric chemistry over the ice-free region of the Arctic. The project is a component of the International Polar Year (IPY) coordinated through a related international program for Polar Study using Aircraft, Remote Sensing, Surface Measurements and Models, of Climate, Chemistry, Aerosols, and Transport. (POLARCAT - http://www.polarcat.no/polarcat). As a part of POLARCAT, this project undertook a research cruise in an ice-free region of the Arctic during March-April, 2008. The study area was to include the Greenland, Norwegian, and Barents Seas. Scientific issues to be addressed included springtime sources and transport of pollutants to the Arctic, evolution of aerosols and gases into and within the Arctic, and climate impacts of haze and ozone in the Arctic. An additional activity to be undertaken while en route to the Arctic was to augment data collected on prior cruises supporting the New England Air Quality Study (NEAQS), a regional air quality assessment program initiated by NOAA to conduct research on atmospheric processes in near-coastal urban areas for evaluating and improving NOAA's air quality forecasting capability. This study of processes that control particulate matter formation, transport, and fate in the near-coastal environment is essential for creating accurate air quality forecast models and more accurate forecasts.

Significant changes in objectives, approach, methodology, or rationale provided to NOAA by Chief Scientist as part of their reporting requirement.

ACCOMPLISHMENTS

The R/V *Knorr* departed Woods Hole on 19 March 2008, after completion of pre-cruise staging to include shipyard modifications required for accommodating the mission load on the forward deck of the ship. Underway observations (time- and weather-dependent) were made for several days off the coast of New England, collecting data for the NEAQS project. The ship then proceeded to the working grounds in the Arctic where coordinated observations with aircraft and other platforms were operating in support of an intensive observation period for POLARCAT/IPY. An overnight port stop took place on April 12-13 in Tromso, Norway, followed by a second leg of cruise operations ending in Reykjavik, Iceland on April 24. Samples, equipment and personnel were offloaded April 25-26.

Scientific accomplishments provided to NOAA by Chief Scientist as part of their reporting requirement.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

The Research Vessel *Knorr*

Movements, Diving Behavior, and Characterization of Foraging Habitat of Deep Diving Odontocete Cetaceans, and Potential Responses to a Sonar Exercise Near the Hawaiian Islands

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 436
1 May 2008 – 15 September 2008

Peter L. Tyack & Robin W. Baird

Peter Tyack
Woods Hole Oceanographic Institution, MS 50, Woods Hole, MA 02543
Tel: (508) 289-2818, E-mail: ptyack@whoi.edu

Robin Baird
Cascadia Research Collective
218 1/2 W 4th Ave., Olympia, WA 98501 USA
Tel: 360-943-7325, E-mail: RWBaird@cascadiaresearch.org

NOAA Program Manager: Brandon L. Southall, NMFS/Office of Protected Species, Ocean Acoustics Program

Related NOAA Strategic Plan Goal:
Goal 1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

PROJECT OVERVIEW

We proposed a research cruise off the Hawaiian Islands using the NOAA RV OSCAR ELTON SETTE and smaller vessels to tag deep diving odontocetes, observe their responses to anthropogenic sound, and characterize their foraging habitat. NOAA provided the large vessel support for this project, including marine mammal observations from the flying bridge and a suite of ecosystem observations. Two different types of tags were used – a medium term satellite tag that can track movements over periods of weeks to months and shorter term acoustic and behavior recording tag (Dtags or Bprobes). Cascadia Research Collective performed the satellite and Bprobe tagging and WHOI and Duke supported the Dtagging. The period of performance of the research cruise overlapped with the Rim of the Pacific (RIMPAC) naval exercise. Satellite and acoustic and behavior recording tags were deployed before and during the RIMPAC exercise to allow monitoring of potential responses to sonar transmissions. We coordinated as much as possible with the Navy to determine when sonar sounds were transmitted within audible range of tagged whales, we attempted to tag at times and areas to optimize documenting effects. The Dtagging was the first such tagging attempted in Hawaiian waters and will emphasize baseline tag data collected in tandem with characterization of the foraging habitat.

ACCOMPLISHMENTS

Five pilot whales were tagged with archival sound and behavior recording tags using a tagging boat deployed from the RV *Sette*. Tagging efforts by Cascadia Research resulted in the deployment of 33 medium-service life satellite tags on four species of odontocetes over 31 field days, the largest number of satellite tags ever deployed on multiple species of cetaceans in this short a time period. As well as demonstrating the feasibility of this approach to examine movements of individuals in relation to a large scale naval exercise, these tags are continuing to provide unprecedented information on movements of individuals of several species in relation to the main Hawaiian Islands (with one tag still transmitting as of September 29, 2008, with an average transmission life of 37 days,

n =33). Tagging was undertaken in two general areas, off the island of Kaua‘i and Hawai‘i, and movements of tagged individuals have spanned an area greater than 13,000 km2. Analyses of movements are ongoing, and this data set will allow for an assessment of movements in relation to mid-frequency sonar use when sonar data are provided by the Navy. Species tagged were: Blainville's beaked whales (five individuals), melon-headed whales (five individuals), false killer whales (seven individuals) and short-finned pilot whales (16 individuals). Three of the four species remained associated with the main Hawaiian Islands over the duration of tag attachments. Only melon-headed whales exhibited large scale directional movements away from the islands, with two individuals moving greater than 400 km from the initial tagging locations in 18 days, one of which reached a maximum distance from the main islands of 430 km 10 days after tagging. Blainville's beaked whales and false killer whales remained associated with the island off which they were tagged for periods of over 50 days. One short-finned pilot whale tagged off Kaua‘i largely remained associated with the island with one week-long transit to/from O‘ahu over a 44-day period. Short-finned pilot whales tagged off the island of Hawaii remained generally associated with the island.

Cascadia Research small-boat operations covered 3,637 km of trackline and resulted in 109 sightings of 13 species of cetaceans. In addition to the satellite tag deployments, dive data (using suction-cup attached data logging tags) were collected from two Blainville's beaked whales and one false killer whale, and acoustic data were collected from two short-finned pilot whales tagged with Burgess BioAcoustic Probes. Over 48,000 photographs were taken for contribution to individual photo-identification catalogs of 10 different species, and 30 skin samples were obtained for contribution to stock structure analyses.

HIGHLIGHTS

- Proved capability to tag sufficient sample size of whales before and during exercise to monitor effects
- Proved capability to Dtag odontocetes by deploying tag boat from the NOAA RV *Sette*
- Proved sufficient attachment duration for study design
- Simultaneously gathered sighting and genetic data critical for long-term understanding of populations

SOCIETAL BENEFITS

This research project was the first to attempt large scale tagging to monitor effects on whales of an actual sonar exercise. The number of whales tagged and the duration of attachments exceeded our expectations, and more than satisfied the requirements of the study design. This research project thus opens the door to a new way to study effects of sound-producing activities lasting on the order of a week.

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT:

- Dive data were obtained from two Blainville's beaked whales and one false killer whale using time-depth recorders.
- Photographs (>48,000) were obtained of 10 species of odontocetes for contribution to individual photo-identification catalogs being curated by Cascadia Research Collective.
- Thirty skin samples were obtained for contribution to stock structure analyses being undertaken by the Southwest Fisheries Science Center, NOAA Fisheries.

EDUCATION AND OUTREACH ACHIEVEMENTS

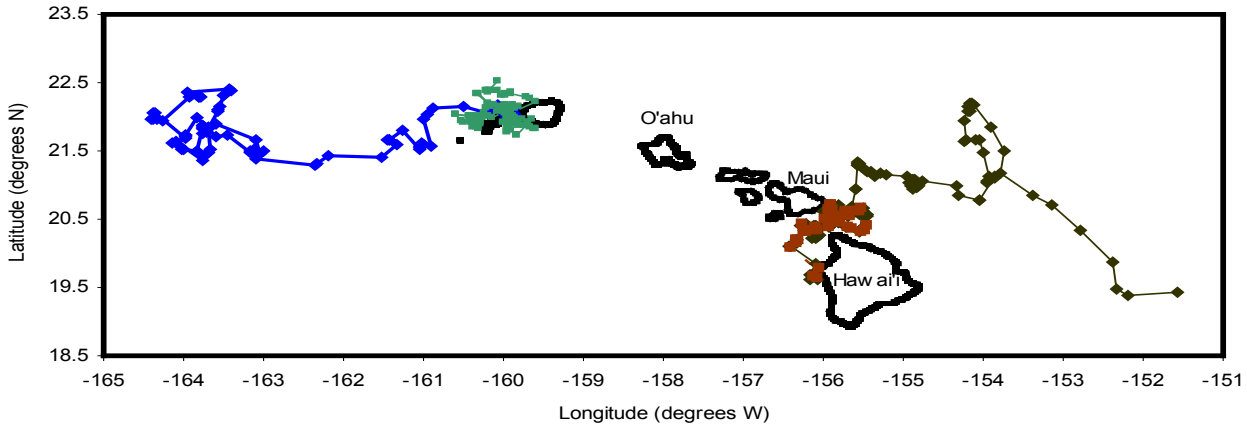
- Regular updates during the field project were provided on-line through the web site of Cascadia Research, one of the participating research organizations (www.cascadiaresearch.org/robin/JunJul2008.htm).
- A press release for this project was also published.

PUBLICATIONS

Manuscripts for scientific articles will be submitted by end of February 2009

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

The above photos show the tagging of a pilot whale with a DTAG off Hawaii. Research was conducted under permit # 731-1774-04 issued by NMFS under the authority of the MMPA and the EPA. Photo Credit: PIFSC.



Tracks of satellite tagged melon-headed whales around the main Hawaiian Islands during June/July 2008. Information from four individuals tagged between 25 June and 2 July are included, with attachment durations from 6 to 18 days (n = 388 locations).

Air-Sea Interaction in the Eastern Tropical Pacific ITCZ/Cold Tongue Complex

NOAA Cooperative Agreement No. NA17RJ1223, sub-point 325 (continuation from NA87RJ0445)
July 1, 2007 - June 30, 2008

Dr. Robert A. Weller
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: 508-289-2508, email: rweller@whoi.edu

NOAA Program Manager: Dr. Jin Huang, OAR/CPO/Climate Prediction Program for the Americas

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

PROJECT OVERVIEW

As part of the NOAA funded Pan American Climate Study (PACS), two surface moorings were deployed on 125º W, one at 3° S (cold tongue) and one at 10° N near the northernmost climatological position of the Inter-Tropical Convergence Zone (ITCZ). Each surface buoy carried two complete sets of meteorological sensors (wind velocity, air and sea temperature, incoming shortwave and longwave radiation, humidity, barometric pressure, precipitation, surface currents), and the heat, mass, and momentum fluxes have been computed using state-of-the-art bulk formulae (Fairall et al., 1996). The mooring lines carried temperature, conductivity, and velocity sensors to observe upper ocean variability in the upper 200 m. The data from the northern mooring returned the first accurate and complete time series of the air-sea fluxes of heat, freshwater, and momentum in the eastern Pacific warm pool beneath the northernmost climatological position of the Inter-Tropical Convergence Zone (ITCZ). This data set is also unique because it spans the strong El Niño event of 1997-98 and the onset of the subsequent La Niña. Analysis of this data has had two principle foci: (1) Understanding of the balance of processes that set SST, and (2) Characterization of air-sea fluxes of heat, momentum, and freshwater in these two climatically and meteorologically important regions. Other recent analysis has used the well-resolved upper-ocean measurements and air-sea fluxes to study the diurnal cycle of upper-ocean temperature, salinity, and velocity and to test parameterizations of the diurnal cycle.

STATUS

Work on this project is nearing completion. Two manuscripts, based on the Ph.D. thesis research of Tom Farrar, are being prepared for submission to research journals. Other work this past year has focused on preparation of a final, archival version of the data set.

HIGHLIGHTS

1. Processes affecting SST at two contrasting sites in the eastern tropical Pacific

The well-resolved time series of upper-ocean temperature and velocity, together with the accurate estimates of air-sea heat fluxes and satellite observations of SST, allow examination of the relative importance of surface heat fluxes and horizontal advection in setting the local SST. The residual of the temperature balance equation can be used to assess the role of vertical mixing and other unresolved processes. Analysis of the surface layer temperature balance (e.g., Cronin and McPhaden, 1997) has been carried out at both mooring sites, and results are being prepared for publication.

At the southern site, horizontal advection was important throughout most of the mooring deployment. In particular, southward advection from the equatorial cold tongue by wind-driven Ekman transport was important in bringing about the local establishment of the equatorial cold tongue during the transition from El Niño to La Niña states. At the northern site, the surface temperature balance was primarily between surface heating and vertical mixing during the 1997 ITCZ season (July-December), but the balance shifted to one of surface heating and horizontal advection during the trade-wind season (January-May; Figure 2).

2. Mesoscale variability in SST, velocity, and sea surface height in the east Pacific warm pool
Prominent meridional current fluctuations with a period of about 2 months (Figure 2) were observed in the mooring data at the northern site, and these current fluctuations exerted a strong influence on the local SST through horizontal advection (Figure 1), causing SST to fluctuate with about a 2 month period from January-June of 1998. The SST fluctuations associated with this signal were substantial, with peak-to-peak amplitudes ranging from 0.5-0.8ºC. The two month signal in meridional currents was linked to a previously recognized sea surface height signal that is strongest in the latitude band 9-13ºN east of 120ºW (Miller et al., 1985; Perigaud, 1990; Giese et al., 1994). To resolve discrepancies in prior studies of the signal (Perigaud, 1990; Giese et al., 1994), an effort was undertaken to characterize the signal observed at the mooring within its larger spatial and temporal context using satellite SST and sea surface height measurements (Figure 3). The signal was found to be associated with relatively short (5-15º wavelength) baroclinic Rossby waves. There is evidence that the intraseasonal velocity variability and its annual cycle are associated with instability of the westward flowing North Equatorial Current as it intensifies in the spring of each year. The mooring observations were instrumental in this study, because they allowed establishment and understanding of the link between the intraseasonal SSH and SST fluctuations. These findings were published in the Journal of Geophysical Research (Farrar and Weller, 2006).

3. Impact of mesoscale SST variability on atmospheric convection and clouds at intraseasonal timescales
The PACS buoy observations from the 10°N site further indicate that there is variability in surface solar radiation coupled to the sea surface temperature (SST) signal of the Rossby wave, which suggests that oceanic Rossby waves may affect atmospheric convection by modulating SST. This hypothesis was investigated using satellite measurements of SST, columnar cloud liquid water (CLW), cloud reflectivity, and surface solar radiation. A statistically significant relationship between SST and these cloud properties was identified within the wavenumber-frequency band of oceanic Rossby waves (e.g., Figure 4a). For example, analysis of seven years of data indicates that 10-20% of the variance in the logarithm of CLW at intraseasonal periods and zonal scales on the order of 10° longitude can be ascribed to SST signals driven by oceanic Rossby waves (Figure 4b). The robust relationship identified in multiple data sets suggests that the oceanic mesoscale SST variability in the region modulates the likelihood and/or intensity of atmospheric convection.

SOCIETAL BENEFITS

The measurements and analysis provide new information on air-sea interaction and upper-ocean dynamics in regions important to weather and climate. The measurements played a central role in the Ph.D. thesis work of Tom Farrar, a graduate student under the PI's supervision, and much of Farrar's support was provided by this grant.

PUBLICATIONS

Farrar, J.T. 2008. Observations of the dispersion characteristics and meridional sea-level structure of equatorial waves in the Pacific Ocean. J. Phys. Oceanogr. 38, 1669-1689.

PRESENTATIONS/CONFERENCE ABSTRACTS

Farrar, J.T. and Weller, R.A. Oceanic mesoscale variability and atmospheric convection on 10°N in the eastern Pacific. University of Oklahoma, Seminar series in convection and numerical weather prediction, October 2007.

Farrar, J.T. Oceanic mesoscale variability and atmospheric convection on 10°N in the eastern Pacific. Oregon State University, Joint Physical Oceanography and Atmospheric Sciences Seminar, November 2007.

Weller, R.A. and Farrar, J.T. Buoy-based observations of the diurnal cycle in upper-ocean and surface meteorological properties. Ocean Sciences Meeting Abstract Book, p. 489. 2008.

Farrar, J.T. Observations of the dispersion characteristics and meridional sea-level structure of Pacific equatorial waves. Ocean Sciences Meeting Abstract Book, p. 121. 2008.

SUMMARY OF EDUCATION AND OUTREACH ACTIVITY

Tom Farrar, who was a postdoc under the PI's supervision, gave a presentation to undergraduate physics majors at the University of Oklahoma in October 2007 on career pathways in physical oceanography.

Works cited:

Cronin, M.F. and McPhaden, M.J. 1997. The upper ocean heat balance in the western equatorial Pacific warm pool during September-December 1992. J. Geophys. Res., 102:8533-8553.

Fairall, C.W., Bradley, C.W., Rogers, D.P., Edson, J.B. and Young, G.S. 1996. Bulk parameterization of air-sea fluxes during TOGA COARE. J. Geophys. Res., 101:3747-3764.

Giese, B.S., Carton, J.A., and Holl, L.J. 1994. Sea level variability in the eastern tropical Pacific as observed by TOPEX and the Tropical Ocean-Global Atmosphere Tropical Atmosphere-Ocean Experiment. J. Geophys. Res., 99:24,739-24,748.

Miller, L., Watts, D.R., and Wimbush, M. 1985. Oscillations in dynamic topography in the eastern Pacific. J. Phys. Oceanogr., 15:1759-1770.

Perigaud, C. 1990. Sea level oscillations observed with Geosat along the two shear fronts of the North Equatorial Counter Current. J. Geophys. Res., 95:7239-7248.

FIGURES

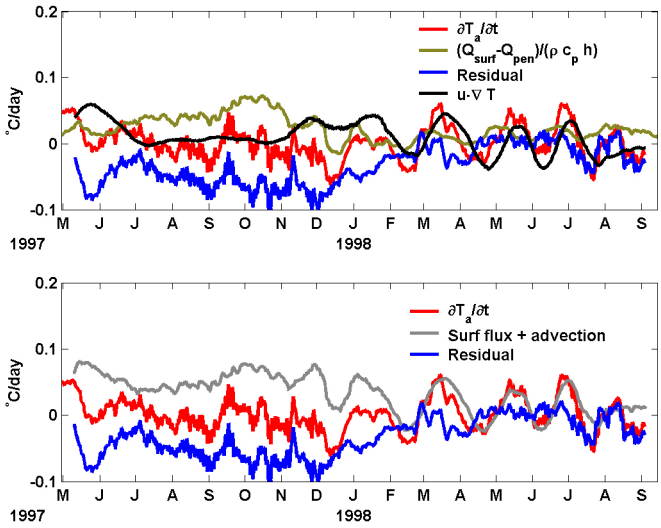


Figure 1. Terms in surface layer temperature balance at the 10ºN, 125ºW site. The terms estimated are: rate of change of layer-averaged temperature ($\partial Ta/\partial t$), heating of the layer associated with surface heat flux ((Q_{surf}-Q_{pen})/(ρcph)), and horizontal advection ($-u \bullet \nabla T$). In the lower panel, the surface heating term and horizontal advection term have been combined to more clearly show their contribution to rate of change of temperature.

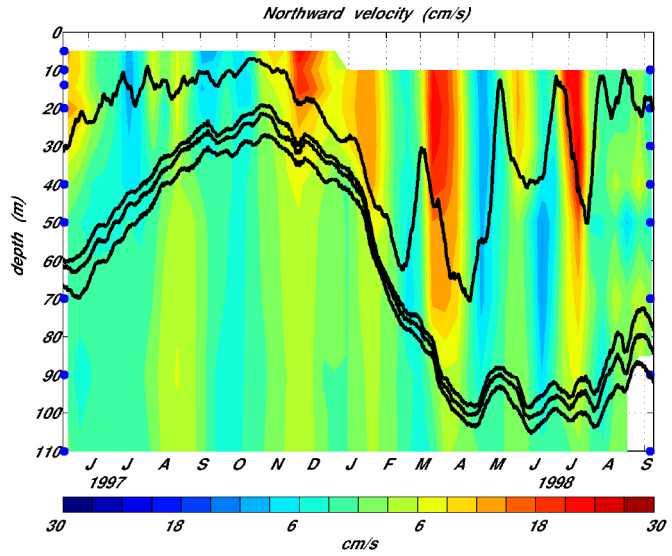


Figure 2. Northward velocity observed at 10ºN, 125ºW (10 day averages). The upper black line marks the mixed layer depth, and the lower three black lines mark isotherms in the thermocline (19, 22, and 24º C). The blue circles on the left and right edges of the figure indicate current meter depths.

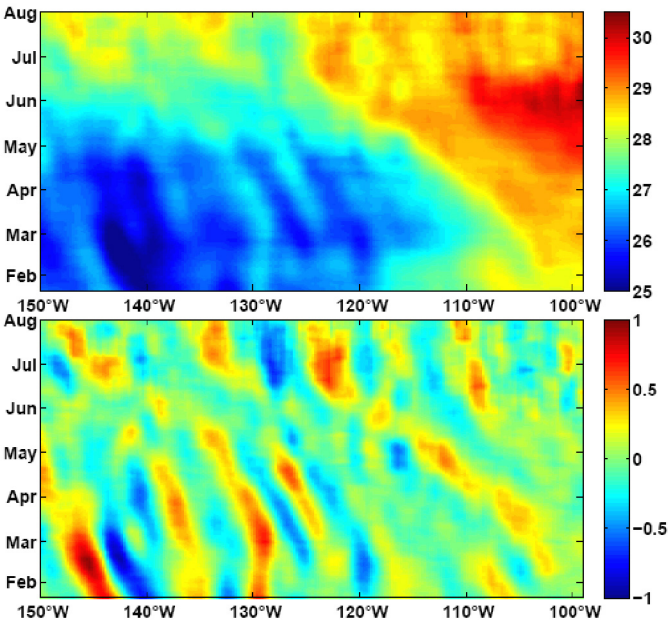


Figure 3. Upper panel: Longitude-time plot of SST (°C) along 10ºN during 1998 from the TMI instrument aboard the TRMM satellite. Lower panel: The same, except a 10° longitudinal running average has been removed to emphasize the mesoscale variability. The westward propagation of the SST signals is caused by advection associated with Rossby waves.

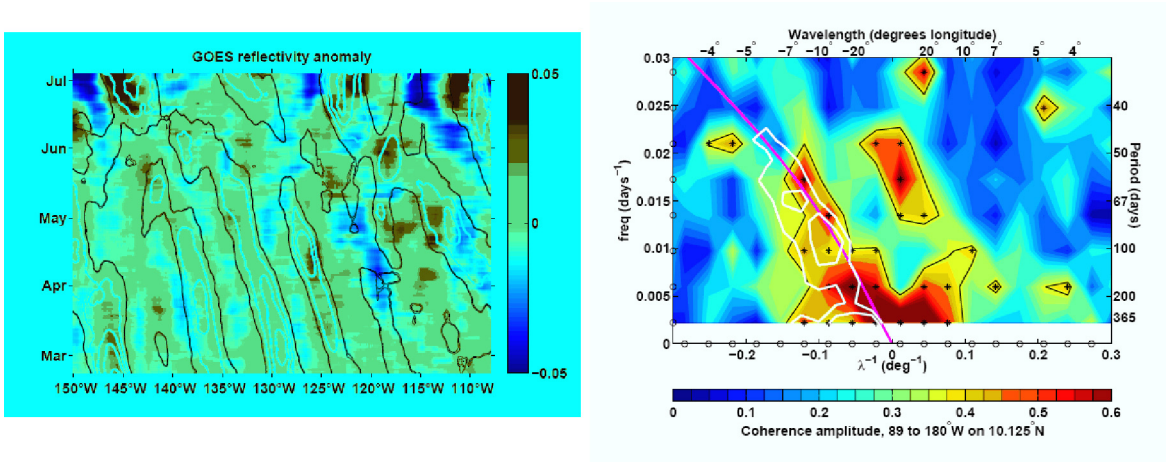


Figure 4. Left panel: Longitude-time plot of visible (cloud) reflectivity along 10ºN during 1998 from the GOES-9 satellite (colored, in %), filtered as in Figure 3b. Mesoscale SST anomalies (Figure 3b) are contoured in white at 0.1°C intervals, and the zero contour is black. Right panel: Coherence amplitude of SST and the base-ten logarithm of cloud liquid water. Points where the coherence is significant at 99% confidence are marked by asterisks and surrounded by a black contour. The white contours show the peak power spectral density in north-south velocity (measured by the zonal slope of sea surface height), and the pink line is a theoretical estimate of the Rossby wave dispersion relation that accounts for Doppler shifting by the westward-flowing North Equatorial Current.

Volunteer Observing Ship Program

NOAA Cooperative Agreement No. NA17RJ1223
sub-points 376, 400, 401, 402, 430, 431, 432
July 1, 2007 through June 30, 2008

Robert A. Weller , Albert J. Plueddemann and David S. Hosom
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Tel: (508) 289-2508, (508) 289-2789, (508) 289-2666
E-mail: rweller@whoi.edu, aplueddemann@whoi.edu, dhosom@whoi.edu

NOAA Program Manager: Dr. Michael Johnson NOAA/OAR/CPO/Climate Observations

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

Central to present efforts to improve the predictability of climate is the need to understand the physics of how the atmosphere and ocean exchange heat, freshwater, and momentum and, in turn, to accurately represent that understanding in the models to be used to make predictions. At present, over much of the globe, our quantitative maps of these air-sea exchanges, derived either from ship reports, numerical model analyses or satellites, have errors that are large compared to the size of climatically significant signals. Observations made using the IMET technology from Volunteer Observing Ships (VOS) on routes that span the ocean basins are essential to providing the accurate, in-situ observations needed to:

1. identify errors in existing climatological, model-based, and remotely-sensed surface meteorological and air-sea flux fields,
2. motivate improvements to existing parameterizations and algorithms,
3. provide the data needed to correct existing climatologies,
4. validate new model codes and remote sensing methods.

AutoIMET was developed by the Woods Hole Oceanographic Institution to meet the need for improved marine weather and climate forecasting. It is a wireless, climate-quality system for making upper-ocean and atmospheric boundary layer measurements. This interfaces to the NOAA SEAS 2000 (Shipboard Environmental (Data) Acquisition System) that sends in automated one hour satellite reports via Inmarsat C. The AutoIMET system documents heat uptake, transport, and release by the ocean as well as the air-sea exchange of water and the ocean's overturning circulation.

This report for the WHOI VOS Program includes information on two tasks: 1) Field Operations and 2) Instrumentation Development and Upgrades. VOS Field Operations under Task 1 are being discontinued, which will allow us to concentrate on processing existing data. Since the core AutoIMET sensors and electronics are common to the buoy-based Ocean Reference Stations program, effort under Task 2 will address present ORS meteorological sensor and electronics problems and to build toward the future where the Ocean Reference Stations will provide upper ocean heat content in real time in addition to the surface meteorology and air-sea fluxes.

ACCOMPLISHMENTS

1) *VOS Field Operations*

Operations were focused on two ships. The first is our longest running vessel the *Horizon Enterprise*, presently running from Oakland to Hawaii. The second was a new ship, the *Horizon Hawk* doing the Oakland -Hawaii-Guam-Taiwan-Tacoma run. Ship selection and interface to the NOAA SEAS system was done via AOML and SIO. We note that the VOS Field Program will be phased out this fall. A chronological list of activities managed by Frank Bahr during the reporting period includes:

September/October 07, Tacoma, WA and Oakland, CA: Met the *Horizon Hawk* in Tacoma for new AutoIMET installation; sailed with the *Hawk* to Oakland to complete the installation. Returned to Tacoma to meet the *Horizon Enterprise* for AutoIMET calibration turn-around.

November/December 07, Oakland CA: Met the *Enterprise* and the *Hawk* to repair AutoIMET humidity and wind sensors, respectively.

January 08, Tacoma, WA and Oakland, CA: Met the *Hawk* in Tacoma for AutoIMET repairs; sailed with the ship to Oakland for evaluation.

March 08, Honolulu, HI: Met the R/V *Kilo Moana* to install an AutoIMET system for the WHOTS mooring recovery cruise; partially uninstalled AutoIMET on the Enterprise in preparation for shipyard period;

April 08, Oakland CA: Met the *Hawk* for a standard AutoIMET calibration turn-around.

June 08, Oakland CA: Met the *Enterprise* after the shipyard period to re-install AutoIMET.

July/August 08, Tacoma, WA: Met *Enterprise* and *Hawk* for wind sensor repairs.

2*) Instrumentation Development and Upgrades*

Efforts are focused on addressing shortcomings in sensors and electronics as well as design revisions to cope with obsolete parts and cold sensitivities. Since VOS (AutoIMET) and ORS (ASIMET) sensors and electronics are shared, these developments represent improvement to operation of the Ocean Reference Stations. A related development task is technology development for Iridium telemetry of subsurface data on ORS moorings. The activities managed by Geoff Allsup include:

Ongoing revision of ASIMET logger and module software to add Compact FLASH storage on existing logger hardware in place of original custom PCMCIA FLASH storage

Ongoing revision and additions to documentation on the DGE website at frodo.whoi.edu; provided documentation VOS instruments produced by Star Engineering.

Software development for IRIDIUM communications controller, Seabird inductive modem interface, and Benthos acoustic modem interface.

Updated sonic wind module interface software for GILL sensor front-end board.

Designed next-generation ASIMET board sets with internal FLASH memory, Compact FLASH data storage, and improved cold tolerance.

New and updated LinuxPC software to perform initial processing of binary files from various ASIMET instruments, data loggers, system controllers

HIGHLIGHTS

Continued field operations to maintain AutoIMET systems on two VOS routes in the Pacific.

Provided documentation and engineering consulting to STAR Engineering (licensee for IMET fabrication and sales) for the transfer of an ASIMET sonic anemometer wind module from development to production.

Designed, fabricated, and tested 3rd generation Iridium communication controller, Seabird SIM interface, and Benthos acoustic modem interface for inductive and acoustic telemetry of underwater instruments.

SOCIETAL BENEFITS

The long-term goals of this work are to improve in-situ observations of marine boundary layer meteorology and air sea fluxes in order to improve understanding and prediction of the earth's climate.

EDUCATION AND OUTREACH ACHIEVEMENTS

"Inductive telemetry for UOP Ocean Reference Station Moorings", presentation at WHOI Buoy Lunch by Al Plueddemann

"Inductive telemetry for UOP Ocean Reference Station Moorings", Upper Ocean Processes Technical Note, August, 2007, see http://uop.whoi.edu/techdocs/technotes.html

Bouchard, P., J. Lord, N. Galbraith, G. Allsup, S. Whelan, A. Plueddemann and R. Weller, 2008, Inductive Telemetry for UOP Ocean Reference Station Moorings, ONR/MTS Buoy Workshop, 4-6 March, Bay St. Louis, MS.

Plueddemann, A., F. Bahr, L. Yu and R. Weller, 2008, "Observed and Modeled Longwave Radiation in the North Pacific During 2004", NOAA Office of Climate Observation Annual System Review, Silver Spring, MD, 3-5 Sept 2008.

Long-Term Evolution and Coupling of the Boundary Layers in the STRATUS Deck Regions of the Eastern Pacific

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 308
July 1, 2007 through June 30, 2008

Dr. Robert A. Weller
Woods Hole Oceanographic Institution
E-mail: rweller @whoi.edu

Program Manager: Dr. Jin Huang NOAA/CPO

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The stratus project has been successful at initiating an effort to elucidate the physical processes that maintain the observed cool surface waters of the Peru-Chile stratus region. In this region of persistent stratus cloud cover, there is a poor understanding of the upper ocean heat budget, of the air-sea fluxes, and of the coupling between the ocean and the clouds. This project uses data collected from a long-term, climate quality surface mooring and the annual cruises that service the mooring and works to quantify the air sea fluxes and upper ocean processes in the region.

PROGRESS

Colbo and Weller (2007) synthesized the mooring data with historical hydrographic and satellite data to show that the upper ocean heat and salt budgets had a large component that was contributed by the divergence of the "eddy" flux. This large transport of cool, fresh water from the coastal upwelling region to the deep ocean through the eddy field has not been noted before. It also helps explain the deficiencies observed in many global models of the region, which are not eddy resolving, and hence cannot adequately capture this important oceanic transport.

In using the ocean reference station data for this project, as well as others, it was necessary to understand the accuracy of the basic surface meteorology and the derived flux products. We have explored this is a submitted manuscript (Colbo and Weller 2008). It lays out the expected accuracy of all the individual meteorological sensors in detail, and shows how those errors propagate into the heat, freshwater and momentum fluxes. This is a crucial step in validating the observations and is necessary for any future climate studies involving the Ocean Reference Station data.

The surface meteorological and air-sea flux data collected at the Stratus mooring together with the shipboard data collected by Chris Fairall's group are being used to describe and characterize the surface forcing and atmosphere-ocean coupling observed under the stratus cloud deck at a site close to the region of climatological maximum low cloud cover (Weller et al., in prep.). This site is data sparse, and these buoy data provide the first accurate long time series that can be used to characterize the site. Both model and climatological values are found to differ significantly from the observations. Though the regime is basically a trade wind regime, with very stable wind direction, wind speed at times drops to low enough values to allow strong diurnal warming in sea surface temperature. Strong diurnal variability is also found in other variables, including the incoming longwave radiation. Links between local variability at diurnal and synoptic time scales to regional synoptic variability are being explored. At the same time significant interannual variability and work is underway to examine whether or

not this is tied to change in the South Pacific subtropical circulation in the atmosphere and to other causes.

A new effort this year has been to use the collected data sets from past cruises to the Stratus region to both develop a description of the oceanic variability in the region and guide the development of sampling to be conducted during the VOCALS (VAMOS Ocean Cloud Atmosphere Land Study) field campaign to be conducted in October-November 2008.

HIGHLIGHTS

- Development of upper ocean heat and salt budgets for the stratus site.
- Quantification of the accuracy of the basic surface meteorology and the derived flux products provided by the buoy at the stratus site and other subtropical buoy sites.

SOCIETAL BENEFITS

The stratus deck region site is data sparse. At the same time it has impact on regional and global climate. Both model and climatological values are found to be in error, differing significantly from our observations. These improved observations and understanding of the process controlling SST and the upper ocean in the region will improve models and predictive capabilties.

OTHER RESEARCH ASSOCIATED WITH THIS PROJECT:

This work is linked to the ongoing occupation of the Stratus side under the NOAA Climate Observation Program and to participation jointly with Dr. Fiamma Straneo (WHOI) in VOCALS.

EDUCATION AND OUTREACH ACHIEVEMENTS

European Geophysical Union, April, Vienna. Weller, R.A. Air-sea coupling under the persistent stratus deck in the Southeast Pacific.

Inclusion of NOAA Teacher at Sea on October 9-November 9, 2007, NOAA ship *Ronald H. Brown*, Charleston, SC –Galapagos Islands, mooring recovery and redeployment cruise.

PUBLICATIONS

Colbo, K and R. A. Weller, 2007: The variability and heat budget of the upper ocean under the Chile-Peru stratus. J. Mar. Res., 65, 607-637, doi:10.1357/002224007783649510.

Colbo, K. and R. A. Weller, 2008: The accuracy of the IMET sensor package in the subtropics. *J. Atmos. Oceanic Technol.*, in review.

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS –

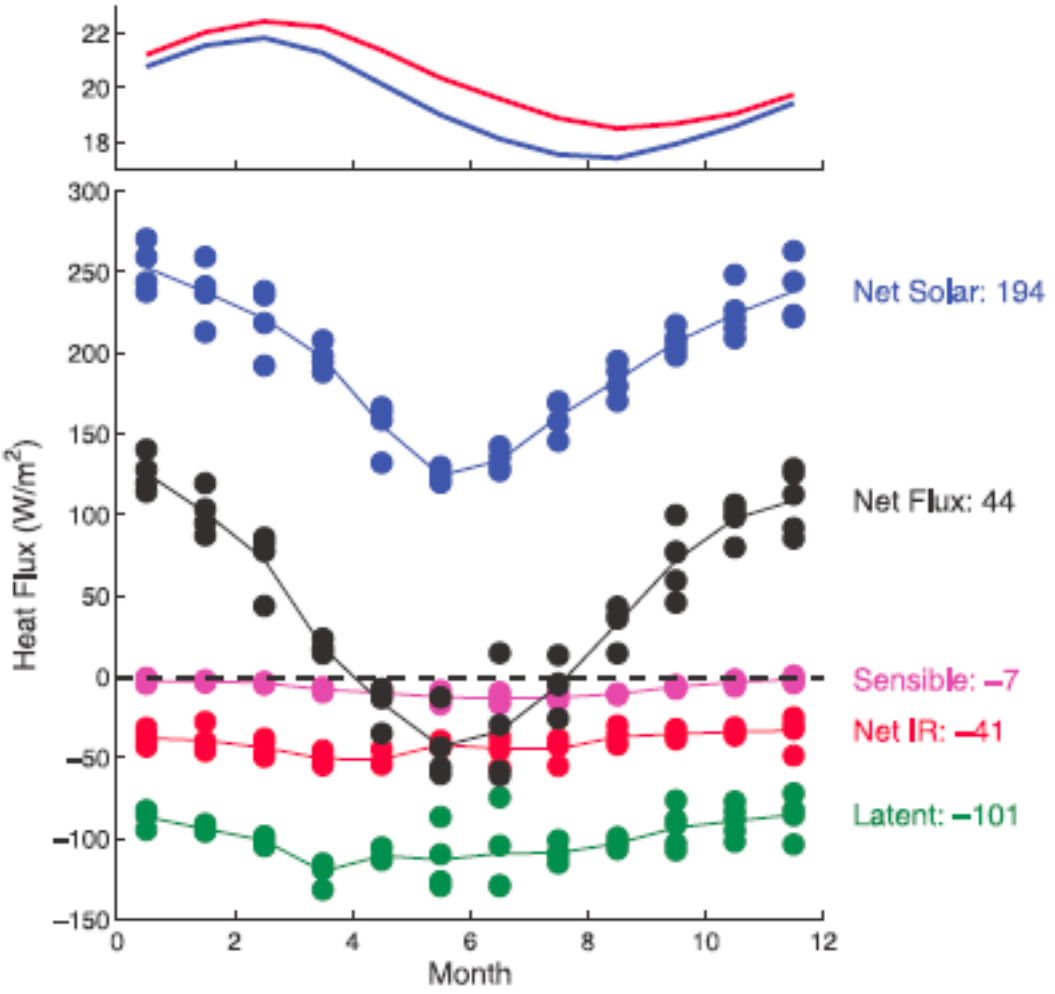


Figure 1. Surface heat fluxes (lower panel), and the air (blue) and sea-surface (red) temperatures (upper panel) for four years of data. The heat flux components show monthly averages (dots), the multi-year mean (line) and are labeled with the corresponding four year annual average value on the right (in W/m^2). From Colbo and Weller (2007).

Ocean Reference Stations

NOAA Cooperative Agreement No. NA17RJ1223
Sub-points 302, 327, 328, 329, 359, 383, 403, 404, 405, 406, 407
July 1, 2007 through June 30, 2008

Robert A. Weller and Albert J. Plueddemann
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
Phone: 508 289-2508, FAX: 508 457-2163,
E-mail: rweller@whoi.edu , aplueddemann@whoi.edu

NOAA Program Manager: Dr. Michael Johnson NOAA/OAR/CPO/Climate Observations

Related NOAA Strategic Plan Goal*:*
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.

PROJECT OVERVIEW

The goal of these related observational projects is to maintain long-term surface moorings, known as Ocean Reference Stations, as part of the integrated ocean observing system. Ocean Reference Stations collect long time series of observations of surface meteorology and upper ocean variability in regions of key interest to climate studies. The resulting meteorological and oceanographic observations provide a set of high quality air-sea fluxes of heat, freshwater and momentum as well as upper ocean heat and salt content. The scientific rationale for the collection of these flux products is manifold: 1) to describe the upper ocean variability and the local response to atmospheric forcing; 2) to motivate and guide improvement to atmospheric, oceanic, and coupled models; 3) to calibrate and guide improvement to remote sensing products and capabilities; and 4) to provide anchor points for the development of new, basin scale fields of the air-sea fluxes. Model, satellite, and climatological fields of surface meteorology and air-sea fluxes have large errors; high quality, in-situ time series are the essential data needed to improve our understanding of atmosphere-ocean coupling and to create more accurate global fields.
Three Ocean Reference Stations are being maintained: A site at 20°S, 85°W under the stratus cloud deck off northern Chile (Stratus), the Northwest Tropical Atlantic Station (NTAS) at 15°N, 51°W, and a site north of Hawaii near the Hawaii Ocean Time-series (HOT) site at 22.75°N, 158°W known as the WHOI Hawaii Ocean Time-series Station or WHOTS. Moorings at the Stratus and NTAS sites were initially deployed and serviced annually under NOAA OGP support; these sites have now transitioned to long-term Ocean Reference Stations. WHOTS was established in 2004, in collaboration with investigators that have made shipboard and moored observations in that region in recent years.

The Ocean Reference Stations project is managed under four task areas: 1) Engineering, oversight, and data management, 2) Maintenance of the Stratus site, for which the seventh year of operation was successfully completed, 3) Maintenance of the NTAS site, for which the seventh year of operation was completed, 4) Maintenance of the WHOTS site, for which the fourth year of operation was completed. Progress on each of the task areas is reported in more detail below.

ACCOMPLISHMENTS

Task I: Engineering, oversight and data management

The WHOI ORS program takes advantage of developments within the closely related WHOI VOS program to provide continuous upgrades in capability. Over the past year we began to transition ORS ASIMET modules from

PCMCIA to Compact Flash memory, based on hardware and software development in the VOS program. We are also phasing in a new wind module based on a Gill sonic anemometer. Finally, the WHOTS and NTAS programs benefited from use of a prototype portable ASIMET standard developed under the WHOI wireless IMET program. This allowed calibrated sensors with known performance characteristics to be placed aboard the *Kilo Moana* and *Oceanus* during mooring service cruises.

We have continued the development of an Iridium telemetry system, including mooring controllers and an automated, shore-based decoding and processing system. This modular system allows storage, buffering and transmission of ASIMET surface meteorology, subsurface data transmitted via inductive link, subsurface data transmitted via acoustic modem, or all three. The system is built around a newly developed Iridium Communication Module (ICM) and a modified ASIMET controller board, and can now be integrated with both a Seabird inductive modem and a Benthos acoustic modem. The ASIMET controller uses only a few milliwatts, and runs continuously, while the ICM and modems, which use considerably more power, are turned on intermittently. In its present configuration, the system transmits 1 hr averages of surface meteorology and subsurface temperature, salinity and currents once every 4 hr and is implemented as a prototype system on the NTAS ORS (Argos telemetry of surface meteorology remains the primary system). Note that at present we bear the costs of the Iridium telemetry, and cost constraints prevent us from implementing Iridium on an operational basis. Should NOAA arrange for a tariff agreement for Iridium as for Argos, we would be able to shift to Iridium for all ORS sites.

We continue to add complementary instrumentation to ORS installations to the extent possible. For example, we are now incorporating pCO_2 instrumentation developed by Chris Sabine (NOAA PMEL) on both Stratus and WHOTS buoys. The Stratus buoy is also being used for testing of sensors to measure surface waves. This is being done in collaboration with the National Data Buoy Center (NDBC), who provide hardware and guidance on how to install and operate the wave sensors.

Oceanographic (velocity, temperature, salinity) and surface meteorological data (wind speed and direction, air and sea surface temperature, rain, incoming shortwave and longwave, relative humidity, and barometric pressure) are processed and stored on disks attached to our workstations. Hourly meteorological data are transmitted via Argos telemetry and made available via an FTP server and a website with download capability. We maintain a public access archive of historical Upper Ocean Processes (UOP) Group data from mooring deployments. The UOP web site was extensively revised and re-organized this year, providing a more modern look and better access to data and documentation.

We have worked with the National Data Buoy Center (NDBC) to exchange WHOI ORS data in a format that can be utilized by standard NDBC processing and display tools. As a result, the three ORS sites are now accessible as stations within the NDBC buoy network (see Stations 32ST0, 41NT0 and 51WH0, at http://www.ndbc.noaa.gov).

Task II: Stratus Ocean Reference Station

The Stratus ORS was originally deployed under a previous grant (from the Pan American Climate Studies) in October 2000. It has been annually serviced (recovered and redeployed) since that time. During the deployments, hourly-averaged surface meteorology is available in near real time via Service ARGOS and the UOP web site. Data are routinely exchanged with ECMWF, NCEP and others to examine numerical weather prediction model performance and examine air-sea fluxes under the stratus clouds. The telemetered meteorological data are also available via the website maintained for this site (http://uop.whoi.edu/projects/Stratus/stratus.html). Internally recorded 1-minute meteorological data as well as the oceanographic data, which are only internally recorded, were downloaded from the recovered instrumentation. Data recovery was good, post-calibrations are being done, and data files have been shared with colleagues. Preliminary cruise reports are filed with the State Department soon after the cruise; final documentation that goes to foreign observers and the State Department includes copies of the underway data and a cruise report.

Field operations this year included deploying the new Stratus mooring and recovering the old mooring, doing calibrations (both pre and post-deployment), data processing, writing cruise reports, preparing mooring hardware and instrumentation for the new deployment and cleaning and assessing the recovered equipment. The mooring service cruise was carried out aboard the *Ronald H. Brown* during the period 9 October to 8 November 2007. Data

recovery this year was good, post-calibrations are being done, and data files have been shared with colleagues.

On the Stratus buoy we measure air temperature, sea surface temperature, relative humidity, incoming shortwave and longwave radiation, wind speed and direction, rain rate, and barometric pressure. On the mooring line the instrumentation is concentrated in the upper 300m and measures temperature, salinity, and velocity. During the deployment, high data rate (up to 1 sample per minute) data are stored in each instrument. The internally recorded data goes through processing, has calibration information applied, and is subject to preliminary analyses before being made publicly available on our website. Hourly surface meteorological data are being shared with OceanSITES (http://www.oceansites.org), with the Chilean Navy (SHOA), with CLIVAR modelers interested in the Stratus region, with VAMOS investigators in the U.S. and in South America, and with Peter Glecker at PCMDI for use in the SURFA project. Once per minute as well as hourly surface meteorological time series are provided to VOCALS PIs and others (including Sandra Yuter, Chris Bretherton, Meghan Cronin) after recovery. Data have also been made available to the satellite community (including NASA-Langley, JPL, NCEP/NCDC and SEAFLUX). The oceanographic data are being used by Weller to investigate air-sea coupling and upper ocean variability under the stratus deck.

The Stratus cruises serve the wider scientific community by providing a platform on which to study the regional ocean. Researchers who participated in collaborative research or benefited from shared ship time in FY2008 have come from many institutions: NOAA Earth System Research Laboratory, Servicio Hydrografico y Oceanografico de la Armada (SHOA, Chile), the NOAA National Data Buoy Center, INOCAR (Institute of Naval Oceanography, Ecuadorian Navy), the Argo float program, the NOAA surface drifter program, the Peruvian Navy Hydrographic Service, and IMARPE (Institute of Marine Research, Peru). Ten Argo floats, 13 surface drifters, and 4 French profiling floats were deployed during the cruise. A new NDBC DART buoy was deployed. During the transit from Rodman, Panama, sampling was done Ecuadorian and Peruvian waters in collaboration with these countries to investigate the La Niña event then underway. A teacher from NOAA's Teachers-at-Sea program (Meghan O'Leary) participated in the cruise. WHOI meteorological sensors on the Chilean Navy tsunami warning buoy at 20°S, 75°W were serviced as part of a growing partnership between the ORS project and SHOA. The first 6 years of Stratus data were quality controlled and shared in support of VOCALS (VAMOS Ocean Cloud Atmosphere Land Study) to be conducted in conjunction with the October 2008 Stratus cruise.

Task III: NTAS Ocean Reference Station

The NTAS ORS was originally deployed in 2001 and has been annually serviced (recovered and redeployed) since that time. NTAS surface meteorological data are archived on the UOP web site (http://uop.whoi.edu/projects/NTAS/ntas.htm) and also available in near real time from the NDBC web server. Data are exchanged with ECMWF and NCEP, and they in turn provide operational model output at the grid point nearest the buoy. NTAS data are also available through OceanSITES and are shared with the Baseline Surface Radiation Network (BSRN) and the GEWEX (Global Energy and Water Cycle Experiment) Radiation Panel.

The NTAS mooring service cruise was conducted on the R/V *Oceanus* during the period 14 July to 1 August 2008 in order to retrieve the existing mooring (NTAS-7) and replace it with a new mooring (NTAS-8). In preparation for this cruise, three ASIMET systems were calibrated and tested, and two systems, comprised of the best performing sensors, were prepared for deployment. The NTAS-8 mooring was deployed on 28 July 2008 and the NTAS-7 mooring was recovered on 29 July. The period between deployment and recovery was dedicated to a comparison of the two buoy systems, with the shipboard system as an independent benchmark. Data return from NTAS-7 was very good during the first 14 months, with all meteorological sensors showing complete records except for SST, for which one system had 72% return. Since the second system had a complete record, no data will be missing in the final (combined) data set. However, because the service cruise was delayed by several months due to mechanical problems with the NOAA ship *Ronald H Brown*, the ASIMET logging system, designed for 12-14 months of operation, terminated data acquisition about 20 days prior to servicing. This will result in a data gap between NTAS-7 and NTAS-8.

The 2008 NTAS cruise represented the second year of collaboration with the Meridional Overturning Variability Experiment (MOVE). The MOVE effort involved deployment servicing of three subsurface mooring sites and data collection from four Pressure/Inverted Echo Sounders (PIES).

The NTAS-8 mooring represented the second year of development for real-time telemetry of subsurface data. Engineering work undertaken as part of the WHOI VOS project resulted in a 3rd generation telemetry system, including an Iridium communication controller, Seabird SIM interface, and Benthos acoustic modem interface. Using these new electronics along with hardware developed for NTAS-7, the mooring was outfitted with a prototype system for both inductive and acoustic telemetry of underwater instruments. Unfortunately, despite successful testing of all system components prior to assembly, the fully assembled system did not function as expected at sea prior to deployment. Several rounds of debugging were executed at sea, but ultimately the NTAS-8 mooring was deployed without a functional subsurface telemetry system. A similar system has since been assembled and successfully tested for another project, and we expect the NTAS-9 system to be fully functional.

Task IV: Hawaii Ocean Reference Station

The Hawaii Ocean Time-series (HOT) site, 100 km north of Oahu, Hawaii, has been occupied since 1988 as a part of the World Ocean Circulation Experiment (WOCE) and the Joint Global Ocean Flux Study (JGOFS). The primary intent of the WHOI Hawaii Ocean Time-series Station (WHOTS) mooring is to provide long-term, high-quality air-sea fluxes as a coordinated part of the HOT program and contribute to the goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The WHOTS ORS was originally deployed in 2004 and has been annually serviced (recovered and redeployed) since that time.

WHOTS surface meteorological data are archived on the UOP web site (http://uop.whoi.edu/projects/WHOTS/whots.htm) and also available in near real time from the NDBC web server. Data are exchanged with ECMWF and NCEP, and they in turn provide operational model output at the grid point nearest the buoy. WHOTS data are also available through OceanSITES and are shared with the Baseline Surface Radiation Network (BSRN) and the GEWEX (Global Energy and Water Cycle Experiment) Radiation Panel. Subsurface oceanographic sensors on the mooring are being provided through cooperation with Roger Lukas (U. Hawaii; funded by the National Science Foundation). In cooperation with C. Sabine (PMEL), and with the assistance of D. Sadler (U. Hawaii), a pCO2 system was incorporated in the WHOTS-5 buoy. Incorporation of CO_2 measurements on the WHOTS buoy provides continuation of the time series begun in 2004 from the MOSEAN buoy.

The WHOTS mooring service cruise was conducted on the R/V *Kilo Moana* during the period 3 to 10 June 2008 in order to retrieve the existing mooring (WHOTS-4) and replace it with a new mooring (WHOTS-5). In preparation for this cruise, three ASIMET systems were calibrated and tested, and two systems, comprised of the best performing sensors, were prepared for deployment. The WHOTS-5 mooring was deployed on 5 June 2008 and the WHOTS-4 mooring was recovered on 6 June. The period between deployment and recovery was dedicated to a comparison of the two buoy systems, with the shipboard system as an independent benchmark. Data return from WHOTS-4 was good, with most meteorological sensors showing complete records. Exceptions were AT/RH, and WND, for which one system had only partial records. Since the second system had complete records, no data will be missing in the final (combined) data set. Meteorological data and computed fluxes for the first 4 years of WHOTS are being quality controlled and merged, and will be made available on the UOP web site.

HIGHLIGHTS

Two Ocean Reference Station (Stratus, WHOTS) are now collecting and pCO2 data in addition to surface meteorology. One of these (Stratus) is also collecting surface wave data.

One Ocean Reference Station (NTAS) serves as the development site for near real-time delivery of surface meteorology and upper-ocean properties via Iridium telemetry.

The Upper Ocean Processes Group web site, which serves the ORS meteorological data, has been extensively revised and re-organized. Near real-time WHOI ORS data are also available through NDBC.

The Stratus ORS site was successfully serviced, initiating the eighth year of continuous operation.

Six years of surface heat fluxes from the Stratus ORS site were merged and evaluated, suggesting significant discrepancies in the ECMWF ERA-40 and NCEP-2 reanalyses (see Table 1 and Figure 1).

The NTAS ORS site was successfully serviced, initiating the eighth year of continuous operation.

The WHOTS ORS site was successfully serviced, initiating the fifth year of continuous operation.

SOCIETAL BENEFITS

The long-term goals of this work are to improve in-situ observations of marine boundary layer meteorology and air-sea fluxes in order to improve understanding and prediction of the earth's climate.

EDUCATION AND OUTREACH ACHIEVEMENTS (outreach and conference results are presently being compiled)

FIGURES/PHOTOGRAPHS/ILLUSTRATIONS

Variable	Stratus 1	Stratus 2	Stratus 3	Stratus 4	Stratus 5	ECMWF
Latent	-103.1	-118.0	-107.3	-99.0	-99.5	-124.6
Sensible	-7.0	-10.3	-7.1	-7.1	-5.0	-15.2
Longwave	-40.6	-49.2	-36.6	-21.7	-44.6	-55.0
Shortwave	202.0	199.5	190.4	191.3	183.5	220.2
Net	51.4	22.1	39.4	63.4	34.3	25.5

Table 1. Annual means of heat flux components and net heat flux (W/m^2) from Stratus 1-5 compared with comparable variables from the 40-year mean ECMWF ERA-40 reanalysis. It is evident that the ocean receives more net heat than ERA-40 suggests, yet the lower observed shortwave indicates that the sky is cloudier. The larger net gain comes from observed latent, sensible and longwave losses being less than indicated by ERA-40.

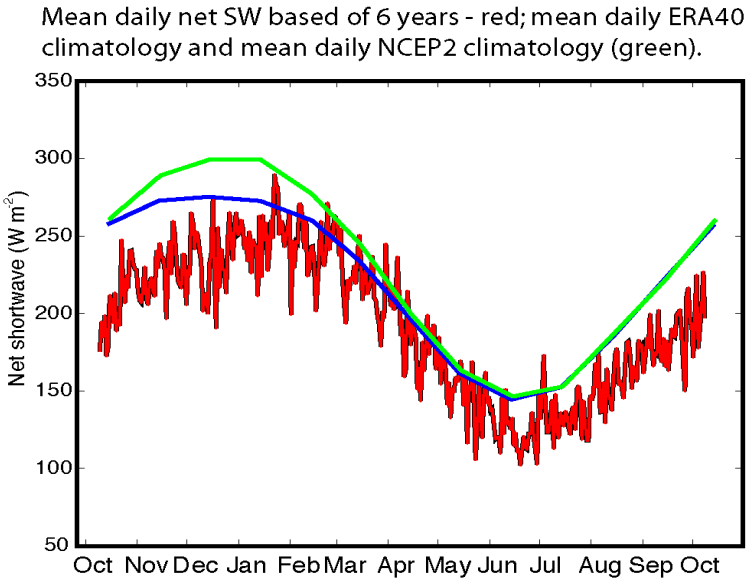


Figure 1. Comparison of observed incoming shortwave radiation at the Stratus Ocean Reference Station (daily means, averaged over 6 years, in red) with the monthly climatological incoming shortwave radiation from ERA40 (blue) and NCEP2 (green). During October to December, the models produce too few clouds, and as a consequence supply too much insolation to the sea surface.

A FIFTY-YEAR ANALYSIS OF GLOBAL OCEAN SURFACE HEAT FLUX

NOAA Cooperative Agreement No. NA17RJ1223 sub-point 351
July 1, 2007 through June 30, 2008

Drs. Lisan Yu and Robert Weller
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
(508) 289-2504, lyu@whoi.edu
(508) 289-2580, rweller@whoi.edu

Program Managers: Dr. Mike Johnson, NOAA/OCO

Related NOAA Strategic Plan Goal:
Goal 2. Understand climate variability and change to enhance society's ability to plan and respond.
Goal 3. Serve society's needs for weather and water information.

PROJECT OVERVIEW

The ocean and the atmosphere exchange heat at their interface via a number of processes: solar radiation, longwave radiation, sensible heat transfer by conduction and convection, and latent heat transfer by evaporation of sea surface water. The amount of heat being exchanged is called heat flux. The distribution of heat flux over the global oceans is a key element for climate studies, as it is required to establish air-sea feedback mechanisms, to provide guidance and motivation for modeling studies, to verify individual or coupled atmosphere-ocean general circulation model simulations, and to serve as forcing functions for ocean model exercises. However, direct flux measurements are sparse. Our present knowledge of the global air-sea heat flux distribution stems primarily from the bulk parameterizations of air-sea fluxes as functions of surface meteorological variables (e.g., wind speed, temperature, humidity, cloud cover, etc). The source of observations for those flux-related variables includes marine surface weather reports from Voluntary Observing Ships (VOS) collected by Comprehensive Ocean-Atmosphere Data Set (COADS) and satellite remote sensing from various platforms. Atmospheric reanalyses from numerical weather prediction (NWP) centers such as National Centers for Environmental Prediction (NCEP) and the European Centre for Medium-Range Weather Forecasts (ECMWF) provide additional model-based database. Nonetheless, none of the three data sources is perfect as each suffers from at least one of the four deficiencies: (1) incomplete global coverage, (2) relatively short time series, (3) systematic bias, and (4) random error.
While improving the quality of each data source is a necessary step toward improving the estimates of surface heat fluxes, this project takes an alternative approach, i.e., to improve the quality of the flux estimates through objectively synthesizing the advantages of the three data sources. The synthesis approach has been applied successfully to generate gridded products of surface vector wind, SST, and precipitation. This project, which is termed "Objectively Analyzed air-sea heat Fluxes (OAFlux)", develops an equivalent global synthesis product for surface heat fluxes by utilizing the methodology developed and experience learnt from a previous pilot study for the Atlantic Ocean.

The project has two main objectives. The first objective is to produce a 50-year (from the mid 1950s onward) analysis of surface latent, sensible, net shortwave and net longwave radiation fluxes over the global oceans with improved accuracy. This is to be achieved by an appropriate combination of COADS data, NWP reanalysis outputs, and satellite retrievals using advanced objective analysis. The target resolution is 1° longitude by 1° latitude and monthly. Daily flux fields are produced when satellite data are available. The second objective is to use the data to study the heat flux variability on seasonal, annual, interannual, decadal and longer timescales and their relation

to global climate change. The scientific investigation helps to assess the quality and reliability of the dataset in depicting the multi-decade climate record since 1950s and to provide physical insights into the dataset.
A nearly 50-year (1958-present) analysis of global surface latent and sensible heat fluxes with monthly and daily resolutions has been completed. The datasets are to be released by the end of 2007 and are freely available to the community via the project website (http://oaflux.whoi.edu). The proposed study contributes to CLIVAR programs including CLIVAR Atlantic, Pacific and PACS, and benefits the CLIVAR and other research communities on studies of climate variability and predictability.

ACCOMPLISHMENTS

(i) Global climate datasets of air-sea latent and sensible heat fluxes (1958-2006)

We have completed the global analysis of air-sea latent and sensible heat fluxes along with error field estimates for the years from 1958 to 2006 (Fig.1).

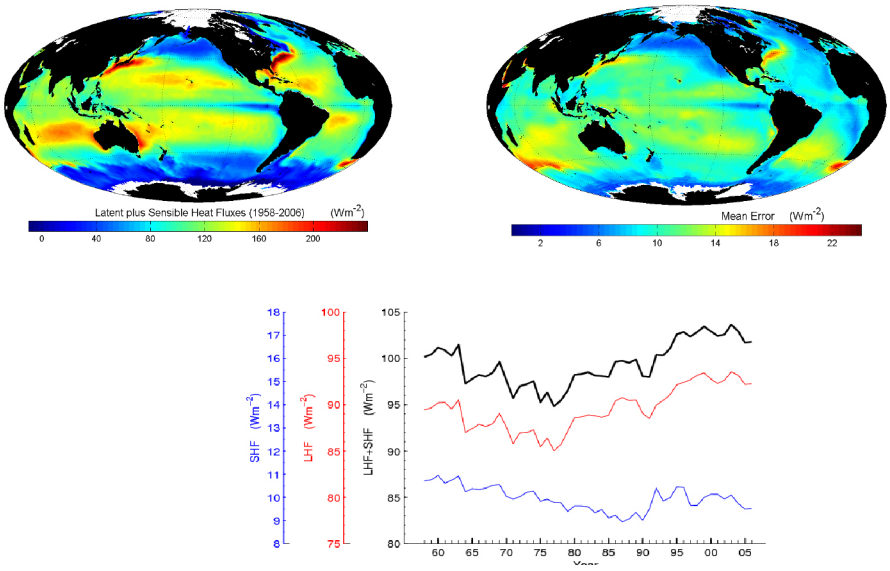


Fig.1 (a) Annual mean latent plus sensible heat fluxes averaged over the 49 year period (1958-2006). (b) Mean error (standard deviation) of the latent plus sensible heat fluxes. (c) Time series of annual-mean latent (red), sensible (blue), and latent plus sensible heat fluxes averaged over global oceans.

(ii) Validation with 100+ in situ air-sea buoy measurements

We have conducted long-term mean comparison using COADS-based (1950-2005) climatological flux atlases, and validated the OAFlux daily time series with in situ daily flux measurements at 107 locations (105 buoys plus 2 ships). The OAFlux estimates have good agreement with long-term means of COADS-based climatologies. Daily latent plus sensible heat flux estimates are unbiased and have the smallest mean error: the mean OAFlux-buoy difference is of 1.0 Wm-2 and the mean OAFlux-buoy difference in absolute measure is of 7.4 Wm-2. By comparison, NWP reanalyzed fluxes are largely overestimated (Fig.2).

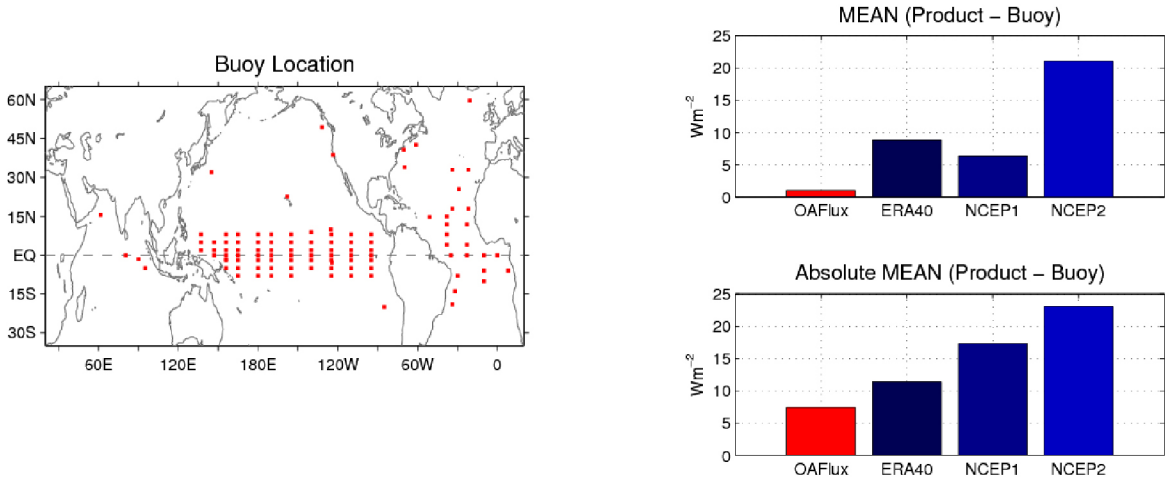


Fig.2 (a) Location of the 105 buoys used in validation analysis. (b) Differences in latent-plus-sensible heat fluxes between product (OAFlux, ERA40, NCEP1, and NCEP2) and buoy averaged over the 107 (105 buoys pus 2 ships) in situ locations. Top panel: mean average (positive and negative signs cancel each other; a measure of bias); Bottom panel: mean average in absolute measure (signs are ignored; a measure of mean variance).

(iii) Understanding the long-term variability of global heat and water cycle

The 49-year time series (Fig. 1c) shows that the decadal change of the global latent heat flux is marked by a distinct transition from a downward trend to an upward trend around 1977-78. The upward trend coincided with the rapid rise of global sea surface temperature in the 1980s–1990s, suggesting a response of the atmosphere to oceanic forcing (Yu and Weller 2007).

The air-sea latent heat exchange releases not only heat energy but also water vapor to the atmosphere. The ocean evaporation accounts for 86% of global evaporation and is a key component of global water cycle. An increased latent heat flux means increased ocean evaporation and is indicative of a changing global water cycle (Yu 2007). Evidence of a changing water cycle has been shown in seawater salinity variations. The saltier northern and southern subtropics of the Atlantic Ocean from the 1950s to the 1990s implied a 5–10% increase in net evaporation (i.e., evaporation minus precipitation). Our time series from 1958 to 2006 shows that the ocean evaporation in 1990s is higher than that in early 1960s, consistent with the pattern of change projected by salinity observations.

HIGHLIGHTS

- We have produced global datasets of air-sea latent and sensible heat fluxes from 1958 to 2006 by synthesizing satellite observations and numerical weather prediction outputs.
- We have released the OAFlux datasets (global latent and sensible heat fluxes and flux-related surface meteorological variables and their error estimates) via the project website http://oaflux.whoi.edu
- We have established a ground-truth database by integrating 100+ air-sea buoy time series measurements for validating the quality of flux products.
- We have shown that the global ocean evaporation time series are a major dataset for understanding the long-term variability of global water cycle.

SOCIETAL BENEFITS

The project investigates variability of air-sea heat exchanges on seasonal, annual, interannual, decadal and longer timescales and its relation to global climate change. The project aims at understanding climate variability and change to enhance society's ability to plan and respond.

EDUCATION AND OUTREACH ACHIEVEMENTS

- February 2008: Improving global ocean heat budget: A use of PIRATA measurements. Oral presentation given at the PIRATA-XIII science workshop. Natal, Brazil. (invited)
- March 2008: Salinity and water cycle. Oral presentation given at the AGU Ocean Sciences meeting. Orlando, Florida.
- April 2008: Ocean water cycle, salinity, and trends in recent decades. Oral presentation given at the WHOI CICOR discussion on "Changes in the Global Water Cycle: The Ocean's Role". Woods Hole, Massachusetts. (invited)

PUBLICATIONS

- Yu, L., X. Jin, and R. A. Weller, 2008: Air-sea turbulent heat flux estimates at the global buoy sites. J. Climate. Sub judice.
- Yu, L., 2008: Sea surface exchanges of momentum, heat, and freshwater determined by satellite remote sensing. Encyclopedia of Ocean Sciences, Steve A. Thorpe and Karl K. Turekian, Eds. In press.
- Yu, L., 2007: Global variations in oceanic evaporation (1958-2005): The role of the changing wind speed. J.Climate, 20, 5376–5390.
- Levinson, D.H., J.H. Lawrimore, et al., 2008: State of the Climate in 2007. Bull. Amer. Meteor. Soc., 89, S1–S179.
- Bourlès, B., R. Lumpkin, M.J. McPhaden, F. Hernandez, P. Nobre, E. Campos, L. Yu, S. Planton, A. Busalacchi, A.D. Moura, J. Servain, and J. Trotte, 2008: The Pirata Program: History, Accomplishments, and Future Directions. Bull. Amer. Meteor. Soc., 89, 1111–1125.
- McPhaden, M. J., G. Meyers, K. Ando, Y. Masumoto, V. S. N. Murty, M. Ravichandran, F. Syamsudin, J. Vialard, L. Yu, and W. Yu, 2008: RAMA: The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction. Bull. Ameri. Meteor. Soc. Accepted.
- Joyce, T., Y-O. Kwon, and L. Yu, 2008: On the relationship between path shifts in the Gulf Stream and the Kuroshio Extension and synoptic wintertime atmospheric variability. J. Climate. Accepted.

Honors and Awards:

Sandra Castro attended the 9th GHRSST-PP (Global Ocean Data Assimilation Experiment High Resolution Sea Surface Temperature – Pilot Project) Science Team Meeting in Perros-Guirec, Brittany, France, June 9-13, 2008, and was appointed Science Team member of GHRSST.

Dennis McGillicuddy received the 27th Annual Rosenstiel Award from the The University of Miami's Rosenstiel School of Marine and Atmospheric Science. McGillicuddy, a senior scientist in the Department of Applied Ocean Physics and Engineering at the Woods Hole Oceanographic Institution (WHOI), is a pioneer in the study of physical-biological interactions in the ocean. His multidisciplinary studies of plankton and ocean currents are helping to decipher what controls the productivity of marine ecosystems and how this affects the global carbon cycle. The Rosenstiel Award is designed to honor scientists who, in the past decade, have made significant and growing impacts in their field. It's an award targeted for researchers who, in their early to mid-career stages, are already making outstanding scientific contributions.

Presentations, Meetings, Committees, and Outreach Activities

US Office on Harmful Algal Blooms:
Anderson, D.M., invited talk, "Don't eat the clams: Managing the threat from the New England red tide", Frontiers in Environmental Sciences, Weekly Series on Emerging Issues in Environmental Health Sciences, National Institute of Environmental Health Sciences, Research Triangle Park, NC, 08/07.

Anderson, D.M., Contribution to Encyclopedia of Life for *Alexandrium* entry

Wind-Driven Transport Indices for Cod and Haddock Recruitment on Georges Bank:
Bogden, P., The Wind and Wave Forecast tool was integrated into the recent release of the upgraded GoMOOS.org website. The website was initially released in beta testing mode in July 2007, and a panel of end users was enlisted to help with testing. Initial feedback on the Wind and Wave Forecast was very positive. The majority of users rated it Good or Excellent for ease of use, value of information presented and relevance to their needs.

Some feedback from the user testing:

"Good service and the Wind and Wave forecast looks like it will be very useful."

"Wind-wave forecast: this would be very useful to me, I would probably use it on a daily basis."

In September 2007, the GoMOOS beta website became the operational website. The new wind and wave product is highlighted as a new site feature and highlighted in our news update. We will be using our outreach tool – the GoMOOS Observer newsletter – to alert our user base of all the new features, including the Wind and Wave Forecast. Additionally, we connected with user groups (e.g. Mass Lobstermen's Association in January 2008 and the Fishermen's Forum in March 2008) to alert them of these new products and services.

The website www.pogo-oceancruises.org was launched in 2007 and gradually each of the 3 planned databases is becoming available. The SeaDataNet partners are actively developing the applications for adding new entries, updating existing entries and for searching and retrieving information. In parallel active surveys are underway to populate each of the 3 databases with entries of all RV's worldwide > 60 metres.

The activities underway through the award, Implementing QA/QC Standards for In Situ Ocean Sensors using OGC-Sensor Web Enablement were presented at a GEOSS workshop in May, 2008, in Geneva, Switzerland. Travel for this activity was provided through the Woods Hole Oceanographic Institution Center for Ocean, Seafloor and Marine Observations. The GEOSS participants were supportive of common (international) development of standards in the integration of oceanographic data into the SWE framework and recognized the importance of registries for services and vocabularies.

These activities were presented as part of discussion of data quality standards at the JCOMM/IODE Forum for Oceanographic Data Management and Exchange Standards, held in Belgium in January, 2008. This outreach effort was supported by the Forum's key sponsor, the NOAA IOOS Program Office.

Multi-Sensor Improved SST (MISST) for GODAE
Castro, S., gave the following Conference Presentations:

The joint 2007 EUMETSAT Meteorological Satellite Conference and the 15th American Meteorological Society (AMS) Satellite Meteorology & Oceanography Conference, Amsterdam, The Netherlands, September 24-28, 2007: Application of Numerical Diurnal Warming Models to the Computation of Bulk Sea Surface Temperature from Infrared Satellite Reference Measurements by Sandra Castro, Gary Wick, and William Emery.

2008 Ocean Sciences Meeting, Orlando, Florida, March, 2-7, 2008: Evaluation of Modeled Derived Look-up Tables for Estimation of Diurnal Warming in Satellite-Derived Sea Surface Temperature Products by Sandra Castro, Gary Wick, and William Emery.

These results were also presented at the Diurnal Variability Working Group (DVWG) workshops held in Edinburgh, Scotland in September 2007 and Orlando, Florida in March 2008, which preceded the previous meetings.

Farrar, J.T.:

Farrar, J.T. and Weller, R.A. Oceanic mesoscale variability and atmospheric convection on 10°N in the eastern Pacific. University of Oklahoma, Seminar series in convection and numerical weather prediction, October 2007.

Farrar, J.T. Oceanic mesoscale variability and atmospheric convection on 10°N in the eastern Pacific. Oregon State University, Joint Physical Oceanography and Atmospheric Sciences Seminar, November 2007.

Farrar, J.T. Observations of the dispersion characteristics and meridional sea-level structure of Pacific equatorial waves. Ocean Sciences Meeting Abstract Book, p. 121. 2008.

Tom Farrar, who was a postdoc under the PI's supervision, gave a presentation to undergraduate physics majors at the University of Oklahoma in October 2007 on career pathways in physical oceanography.

Macdonald, A., T.-H. Peng, R. Wanninkhof and R. Key, Ocean Bomb Radio-Carbon (14C) GEOSECS-WOCE, WHOI seminar, Dec, 2005. Related Web Links: (http://cdiac.esd.ornl.gov/oceans/glodap/Glodap_home.htm)

McGuillicuddy, D.:

Web-based outreach for Dennis McGuillicuddy's project, Coupled Biological/Physical Models in the Coastal Ocean: Skill Assessment and Planning for Regional Testbed Projects, includes:

http://www-nml.thayer.dartmouth.edu/Publications/internal_reports/NML-06-Skill/
http://www.whoi.edu/sbl/liteSite.do?litesiteid=18052

Peng T.-H., R. Wanninkhof, R. Key and A. Macdonald. Assessment of the Air-Sea CO2 Exchange Rates in the World's Oceans Using Bomb 14C Inventories, poster ICDC7, Boulder, Colorado, 2005 and NOAA PI meeting Fall 2007.

Pickart, R.,: Work on, "Dynamics of the Flow of Pacific Water Through the Western Chukchi: Analysis of the 2004 RUSALCA Herald Canyon Hydrographic Data", was presented at the 2008 Ocean Sciences Meeting.

Plueddemann, A.:

"Inductive telemetry for UOP Ocean Reference Station Moorings", presentation at WHOI Buoy Lunch by Al Plueddemann

"Inductive telemetry for UOP Ocean Reference Station Moorings", Upper Ocean Processes Technical Note, August, 2007, see http://uop.whoi.edu/techdocs/technotes.html

Bouchard, P., J. Lord, N. Galbraith, G. Allsup, S. Whelan, A. Plueddemann and R. Weller, 2008, Inductive Telemetry for UOP Ocean Reference Station Moorings, ONR/MTS Buoy Workshop, 4-6 March, Bay St. Louis, MS.

Plueddemann, A., F. Bahr, L. Yu and R. Weller, 2008, "Observed and Modeled Longwave Radiation in the North Pacific During 2004", NOAA Office of Climate Observation Annual System Review, Silver Spring, MD, 3-5 Sept 2008.

Presentations and Conference Proceedings

Bouchard, P., J. Lord, N. Galbraith, G. Allsup, S. Whelan, A. Plueddemann and R. Weller, 2008. "Inductive telemetry for UOP Ocean Reference Station Moorings", ONR/MTS Buoy Workshop, 4-6 March 2008, Bay St. Louis, MS.

Plueddemann, A., F. Bahr, L. Yu and R. Weller, 2008. "Observed and Modeled Longwave Radiation in the North Pacific During 2004", NOAA Office of Climate Observation Annual System Review, Silver Spring, MD, 3-5 Sept 2008.
Upper Ocean Processes Group, 2007. "The Oceanscience underway CTD", UOP Tech Note, August 2007, contributed by S. Whelan and Jochen Klinke. http://uop.whoi.edu/techdocs/technotes.html
Upper Ocean Processes Group, 2007. "Inductive telemetry for UOP Ocean Reference Station Moorings", UOP Tech Note, December 2007, contributed by A. Plueddemann, J. Lord, G. Allsup and N. Galbraith. http://uop.whoi.edu/techdocs/technotes.html
Weller, R.A., 2007. "The status and needs of long time series observations", POGO-9 Meeting, Bermuda, January 2008.
Weller, R.A. and J. T. Farrar, 2008. "Buoy-based observations of the diurnal cycle in upper-ocean and surface meteorological properties", Ocean Sciences Meeting, Orlando, FL.
Bigorre, S. and R.A. Weller, 2008. "Long -Term Air-Sea In-Situ Observations in the Gulf Stream", Ocean Sciences Meeting, Orlando, FL.
Weller, R.A., 2007. "The Air-sea coupling under the persistent stratus deck in the Southeast Pacific", European Geophysical Union, Vienna, Austria.
Bigorre, S. and R.A. Weller, 2008. "Long -Term Air-Sea In-Situ Observations in the Gulf Stream", European Geophysical Union, Vienna, Austria.
Farrar, J.T. 2008. "Observations of the dispersion characteristics and meridional sea-level structure of Pacific equatorial waves", Ocean Sciences Meeting, Orlando, FL.
Upper Ocean Processes Group web site at http://uop.whoi.edu

Committees, panels, societies, etc
Co-Chair, Science Supporting an Ecosystem Approach to Management Working Group
Coordinator, OOI Project Scientist Group
Member, Marine Metadata Initiative (MMI) Technical Team
Member, Marine Metadata Initiative (MMI) Steering Committee
Member, National Data Buoy Center Advisory Group
Panelist, Canada – New England Business Forum

Meetings attended:
OOI SE/PM Interface Meeting, WHOI, 10 October 2007
OOI Blue Ribbon Panel Review, Wash. DC, 22 October 2007
Atlantic Canada – New England Business Forum, Quincy, MA, 11 November 2007
CICOR Ecosystem Initiative Scoping Session, Woods Hole, 19 November 2007
OOI Preliminary Design Review, Wash. DC, 4-7 December 2007
OOI National Security Meeting, Wash. DC, 29 January 2008
Ocean Sciences Meeting, Orlando, FL, 3-6 March 2008
OSSE Workshop, AOML, Virginia Key, FL, 14-17 April 2008
OOI Engineering Program Review, Wash, DC, 30 April – 1 May 2008
OOI Requirements Development Workshop, Denver, CO, 7-9 May 2008
OOI Cyberinfrastructure Requirements Workshop, WHOI, 13-14 May 2008
OOI SE/PM/PI Program Review, Boston, MA, 8-11 July 2008

Proshutinsky, A.
The major project results for the State of the Arctic Report were prepared by a group of experts from USA, Germany, France, Russia, Poland, Canada, and Sweden and the project results were respectively disseminated in these countries. The major project results will be also presented at the AGU 2008 Fall meeting, and AAAS meeting at University of Alaska Fairbanks.

Smith, S.R., et al.
The DAC initiated discussion with the ocean workforce education community at the 2008 Ocean Sciences meeting in Orlando. The focus of the discussion was on the need for additional training in the collection and handling of underway data by research vessel technicians. This is an ongoing education and outreach effort of the DAC and the SAMOS Initiative. In addition, DAC personnel made several presentations at national and international meetings:

Bourassa, M. A., L. Bucci, C. A. Clayson, C. Forgue, M. Onderlinde and B. Roberts, 2008: The Influences of Differing Temperature and Moisture Roughness Length Parameterizations on Height Adjustment and Turbulent Surface Fluxes. Third JCOMM Workshop on Advances in Marine Climatology, 6-9 May 2008, Gdynia, Poland.

Bourassa, M. A., L. Bucci, C. A. Clayson, C. Forgue, M. Onderlinde and B. Roberts, 2008: The Influences of Differing Temperature and Moisture Roughness Length Parameterizations on Height Adjustment and Turbulent Surface Fluxes. 2nd Joint GOSUD/SAMOS Workshop, 10-12 June 2008, Seattle, Washington.
Rolph, J., S. R. Smith, and M. A. Bourassa, 2008: Quality evaluation of marine meteorological observations. 2nd Joint GOSUD/SAMOS Workshop, Seattle, WA, 10-12 June 2008.

Smith, S. R., M. A. Bourassa, and J. R. Rolph, 2008: Data flow through the Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) Data Assembly Center. 2nd Joint GOSUD/SAMOS Workhop, Seattle, WA, 10-12 June 2008.

Rolph, J., S. R. Smith, and M. A. Bourassa, 2008: Quality evaluation of marine meteorological observations. 2008 Northern Gulf Institute Annual Conference, Biloxi, MS, 13-14 May 2008.

Smith, S. R., M. A. Bourassa, and J. R. Rolph, 2008: The Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) Initiative. Third JCOMM Workshop on Advances in Marine Climatology (CLIMAR-III), Gdynia, Poland, 6-9 May 2008.

Smith, S. R., J. Rolph, and M. A. Bourassa, 2008: The Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative. 2008 Ocean Sciences Meeting, Orlando, FL. 2-7 March 2008.

Smith, S. R., 2007: Metadata automation: Survey Results and Ideas. UNOLS Research Vessel Technical Enhancement Committee 2007 Annual Meeting, Moss Landing, CA, 6-8 November 2007.

Smith, S. R., and J. Rolph, 2007: The SAMOS Initiative. UNOLS Research Vessel Technical Enhancement Committee 2007 Annual Meeting, Moss Landing, CA, 6-8 November 2007.

Tyack, P., Regular updates during the field project for the project, "Movements, Diving Behavior, and Characterization of Foraging Habitat of Deep Diving Odontocete Cetaceans, and Potential Responses to a Sonar Exercise Near the Hawaiian Islands", were provided on-line through the web site of Cascadia Research, one of the participating research organizations (www.cascadiaresearch.org/robin/JunJul2008.htm).

Weller, R.A.:

Presentations:
Weller, R.A. and Farrar, J.T. Buoy-based observations of the diurnal cycle in upper-ocean and surface meteorological properties. Ocean Sciences Meeting Abstract Book, p. 489. 2008.

Weller, R.A., 2007. "The status and needs of long time series observations", POGO-9 Meeting, Bermuda, January 2008.

Committees, panels, societies, etc
AMS, Awards Committee, AMS Council (ends 2008)
Member CLIVAR VAMOS VOCALS Science Working Group

Weller, R.A.:

Committees, panels, societies, etc (cont'd.)

Member, UNESCO/IOC Ocean Observations Panel for Climate (OOPC).
Member, UNESCO/WMO GOOS Capacity Building Panel
Member, GEOSS Capacity Building Panel
Member, GEOSS Science and Technology Advisory Panel
Member, NRC Committee on NPOESS and Climate, starting 2007
Discipline Expert, Group on Earth Observations (GEO)
Discipline Expert, Interagency Working Group on Earth Observations (IWGEO)
NOAA: Climate Observing System Council, Climate Working Group
Co-chair, International Time Series Science Team (OceanSITES)
Member, NCAR Facilities Assessment, Surface Fluxes and Soils Subcommittee
Chair, UCAR Membership Committee
National data Buoy Center (NDBC) Advisory Group, starting 2007

Meetings attended:

January - POGO (Partnership Ocean Global Observations) in Bermuda
January- OOI PI meeting, Washington DC
January- AMS annual meeting, New Orleans
January- OOI CGSN senior management, Denver
February – NOAA Cooperative Institute Annual Mtg, Silver Spring
February – Ocean week briefings, Washington DC
March – Ocean Sciences Mug
March – Meeting with Chief of Naval Research, Washington DC
March – VOCALS Science Mug , Boulder
March – VOCALS Science Steering Committee Mug, Boulder
March – OOI PI mug, DC
March – NOAA Climate Working Group, review of NOAA modeling activities, Princeton NJ
May – Ecosystems discussion, U Mass Dartmouth
May – OOI CGSN management trip to SIO, San Diego
June – US Navy, 2008 Discovery and Invention Review
June – NOAA Climate Working Group, National Climate Service Review, Vail, Colorado
July – OOI meeting, MIT
July – CGSN management trip to Corvallis, Seattle
July – meet in Narragansett with Rutgers, NE Fisheries staff
August – Pre-cruise planning meeting, Stratus/VOCALS, Charleston
August – OOI PI's brief GEO directorate at NSF
Sept – NOAA Climate Observing Program, Ann Review, Silver Spring
Sept- NOAA Climate Observing System Council, Silver Spring
Sept – OOI mug, Dallas
Nov – OOI Review, DC
Nov – OOI Final Design Review, DC
Nov – NOAA Climate Working Group. Maryland
Dec – NOAA Climate Observing System Council, Seattle

Appendix I: Publication Statistics

	JI Lead Author						
	FY01	FY02	FY03	FY04	FY05	FY06	FY07
Peer-Reviewed	26	40	37	13	23	20	19
Non-Peer-Reviewed	0	23	15	12	6	14	3

	Other Lead Author						
	FY01	FY02	FY03	FY04	FY05	FY 06	FY07
Peer-Reviewed	0	0	0	5	2	5	20
Non-Peer-Reviewed	0	0	0	0	0	15	3

Publications

Allen, J.I. and P.J. Somerfield. A multivariate approach to model skill assessment. In press, Journal of Marine Systems.

Ashjian, C.J, Braund, S.R., Campbell, R.G., George, J.C., Moore, S.E., Okkonen, S.R. Sherr, B.F., Sherr, E.B. 2008. Environmental variability and bowhead whale distribution on the Alaskan Beaufort Shelf near Barrow, AK. Ocean Sciences Meeting, March 6, 2008, Orlando, FL. Oral Presentation.

Ashjian, C.J, Campbell, R.G., George, J.C., Moore, S.E., Okkonen, S.R. Sherr, B.F., Sherr, E.B. 2008. Environmental variability and bowhead whale distribution on the Alaskan Beaufort Shelf near Barrow, AK. Alaska Marine Science Symposium, Jan. 21-23, Anchorage, AK. Poster.

Castro, S. L., G. A. Wick, D. L. Jackson, and W. J. Emery, Error characterization of infrared and microwave satellite sea surface temperature products for merging and analysis, Journal of Geophysical Research, 113, C03010, doi:10.1029/2006JC003829, 2008.

De Pol-Holz, R., R. Robinson, D. Hebbeln, D. M. Sigman and O. Ulloa. Controls of sedimentary N isotopes along the Chile margin. 2007. Submitted to Deep-Sea Res II.

De Pol-Holz, R., O. Ulloa, F. Lamy, L. Dezileau, P. Sabatierr, D. Hebbeln. Late Quaternary variability of sedimentary nitrogen isotopes in the eastern South Pacific Ocean. 2007. Paleoceanography, 22, PA2207, doi:10.1029/2006PA001308.

Doney, S.C., Lima, I., Moore, J.K., Lindsay, K., Behrenfeld, M., Westberry, T.K., Mahowald, N., Glover, D.M., McGillicuddy, D.J. and T. Takahashi. Skill metrics for confronting global upper ocean ecosystem-biogeochemistry models against field and remote sensing data. In press, Journal of Marine Systems.

Farrar, J.T. 2008. Observations of the dispersion characteristics and meridional sea-level structure of equatorial waves in the Pacific Ocean. J. Phys. Oceanogr. 38, 1669-1689.

Fennel, W. Parameterizations of truncated food web models from the perspective of an end-to-end model approach. In press, Journal of Marine Systems.

Fitzpatrick, J. Assessing skill of estuarine and coastal eutrophication models for water quality managers. In press, Journal of Marine Systems.

Friedrichs, M.A.M., Carr, M.E., Barber, R.T., Scardi, M. and the PPARR team. Assessing the Uncertainties of Model Estimates of Primary Productivity in the Tropical Pacific Ocean. In press, Journal of Marine Systems.

Gregg, W.W. and N.W. Casey. Skill assessment of a spectral ocean-atmosphere radiative model. In press, Journal of Marine Systems.

Gregg, W.W., Freidrichs, M.A.M., Robinson, A.R., Rose, K.A., Schlitzer, R., Thompson, K.R., and S.C. Doney. Skill assessment in ocean biological data assimilation. In press, Journal of Marine Systems.

Jin, D. 2008. Development of Commercial Fishing Vessel Cost Models. Project Report to NOAA-NMFS. May. Marine Policy Center, Woods Hole Oceanographic Institution.

Jolliff, J.K., Kindle, J.C., Shulman, I., Penta, B., Friedrichs, M.A.M., Helber, R., and R.A. Arnone. Summary diagrams for coupled hydrodynamic-ecosystem model skill assessment. In press, Journal of Marine Systems.

Kite-Powell, H., Paper on value of ocean surface wind information to maritime shipping is in preparation, for submission to Marine Policy.

Lynch, D.R., McGillicuddy, D.J., and F.E. Werner. Introduction to the Volume: Skill Assessment for Coupled Biological/Physical Models of Marine Systems. In press, Journal of Marine Systems.

Moore, S.E., George, J.C., Ashjian, C.J. Cetacean habitats and Behavior Offshore Northwestern Alaska: Comparisons across Two Decades. Alaska Marine Science Symposium, Jan. 21-23, Anchorage, AK. Poster.

Okkonen, S., Ashjian, C.J., Campbell, R.G. Intrusion of warm Bering/Chukchi Waters onto the Shelf in the Western Beafort Sea. Alaska Marine Science Symposium, Jan. 21-23, Anchorage, AK. Poster.

Okkonen, S.R., Ashjian, C.J., Campbell, R.G., Potter, R. Intrusion of warm Bering/Chukchi waters onto the shelf in the western Beaufort Sea. In review, J. Geophys. Res.

Pickart, R.S., L.J. Pratt, D.J. Torres, T.E. Whitledge, A.Y. Proshutinsky, K. Aagaard, T.A. Agnew, G.W.K. Moore, H.J. Dail. Evolution and dynamics of the flow through Herald Canyon in the Western Chukchi Sea. Deep-Sea Research, accepted.

J. Richter-Menge, J. Overland, A. Proshutinsky, V. Romanovsky, J. C. Gascard, M. Karcher, J. Maslanik, D. Perovich, A. Shiklomanov, and D. Walker (2007), Arctic, In: State of the climate report in 2007, Eds D.H Levinson and J.H. Lawrimore, Special supplement to the Bulletin of the American Meteorlogical Society, vol. 89, No 7, July 2008.

J. Richter-Menge, J.Overland, A. Proshutinsky, V. Romanovsky, L. Bengtsson, L. Brigham, M. Dyurgerov, J.C. Gascard, S. Gerland, R. Graversen, C. Haas, M. Karcher, P. Kuhry, J. Maslanik, H. Melling, W. Maslowski, J. Morison, D. Perovich, R. Przybylak, V. Rachold, I. Rigor, A. Shiklomanov, J. Stroeve, R. Volker, D. Walker and J. Walsh (2007), State of the Arctic Report, NOAA web site (submitted)

Rose, K.A., Roth, B.M. and E.P. Smith. Skill assessment of spatial maps for oceanographic modeling. In press, Journal of Marine Systems.

Sheng Y.P. and T. Kim. Skill assessment of an integrated modeling system for shallow coastal and estuarine ecosystems. In press, Journal of Marine Systems.

Solow AR & Beet AR. 2008. On the incompleteness of the historical record of North Atlantic tropical cyclones. Geophysical Research Letters.

Solow AR. 2008. On the maximum observed wind speed in a randomly sampled hurricane. Journal of Climate, submitted.

Steele, J. H. Assessment of some linear food web methods. In press, Journal of Marine Systems.

Stumpf, R.P., Tomlinson, M.C., Calkins, J.A., Kirkpatrick, B., Nierenberg, K., Currier, R., Wynne, T.T., and K. Fisher. Skill assessment for an operational algal bloom forecast system. In press, Journal of Marine Systems.

Stow, C.A., Jolliff, J., McGillicuddy, D.J., Doney, S.C., Allen, J.I., Friedrichs, M.A., Rose, K.A., and P. Wallhead. Skill assessment for coupled biological/physical models of marine systems. In press, Journal of Marine Systems.

Stow, C.A, and D. Scavia. Modeling Hypoxia in the Chesapeake Bay: Ensemble Estimation Using a Bayesian Hierarchical Model. In press, Journal of Marine Systems. Smith, K.W., McGillicuddy, D.J., and D.R. Lynch. Parameter estimation using an ensemble smoother: the effect of the circulation in biological estimation. In press, Journal of Marine Systems.

Tyack, P., Manuscripts for scientific articles on Movements, Diving Behavior, and Characterization of Foraging Habitat of Deep Diving Odontocete Cetaceans, and Potential Responses to a Sonar Exercise Near the Hawaiian Islands will be submitted by end of February 2009

Vialard, J., J. P. Duvel, M. J. McPhaden, P. Bouret-Aubertot, B. Ward, E. Keys, D. Bourass, R. Weller, P. Minnett, A. Weils, C. Cassous, L. Yard, T. Fristedt, F. Marsac, C. Menkes, S, Kennan, 2008. CIRENE: Air-sea interactions in the Seychelles-Chagos thermocline ridge region. Bull. Amer, Meteor. Soc.,, in press

Wallhead, P.J., Martin, A.P., Srokosz, M.A., and P.J.S. Franks. Skill Assessment via Cross Validation and Monte Carlo Simulation: An Application to George's Bank Plankton Models. In press, Journal of Marine Systems.

Weller, R. A., Bradley, E. F., Edson, J., Fairall, C., Brooks, I., Yelland, M. J., and Pascal, R. W.: Sensors for physical fluxes at the sea surface: energy, heat, water, salt, Ocean Sci. Discuss., 5, 327-373, 2008.

Yu, L., R. A. Weller, 2008. Objectively Analyzed air-sea heat Fluxes (OAFlux) for the global ice-free oceans. Bull. Amer. Meteor. Soc., 88(4), 527-533.

Yu, L., X. Jin, and R. A. Weller, 2008. Air-sea turbulent heat flux estimates at the global buoy sites. J. Geophysics. Res, submitted.