Annual Report

1 July 2008–30 June 2009

Year 8 of Cooperative Agreement NA17RJ1224

CIFAR

Cooperative Institute for Arctic Research
University of Alaska Fairbanks

Report from CIFAR to NOAA on the eighth year (No-Cost Extension) of Cooperative Agreement No. NA17RJ1224

1 July 2008–30 June 2009

Progress reported during Fiscal Year 2009

(including some activity that occurred in but was not reported during previous periods)

September 2009
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Cover art: "Pancake Ice and Arctic Cod," a painting by Susan Farnham from an exhibit held October 2008 at the Well Street Art Company in Fairbanks, Alaska. The exhibit, based on the findings of the Arctic Ocean Diversity project, featured paintings by Farnham as well as photographs by several marine researchers, including CIFAR PIs Bodil Bluhm, Rolf Gradinger and Russ Hopcroft. More works from this exhibit and other art by Farnham can be seen at www.farnham-art.com/susan

Report layout and production by Barb Hameister, CIFAR.

Overview

[*In 2008, following a competitive application process, CIFAR was awarded a new 5-year cooperative agreement as the NOAA Alaska Regional Cooperative Institute. The new cooperative institute is called the "Cooperative Institute for Alaska Research," to better reflect the Alaska regional aspect while retaining the acronym "CIFAR." This report covers year 8, the final, "no-cost" extension year of cooperative agreement NA17RJ1224, of the Cooperative Institute for Arctic Research.*]

The Cooperative Institute for Arctic Research (CIFAR) was established through a Memorandum of Understanding between NOAA and the University of Alaska in April 1994. CIFAR is one of fourteen national NOAA, Office of Oceanic and Atmospheric Research (OAR)–University cooperative institutes. CIFAR is designed to foster collaboration between NOAA, the University of Alaska and others working in the Western Arctic (Alaska and the Bering, Chukchi and Beaufort Seas) and to conduct research relevant to NOAA's mission as encompassed in our research themes. CIFAR cooperates with NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, the NOAA Arctic Research Office, the National Weather Service (NWS), and Alaska Fisheries Science Center (NOAA/National Marine Fisheries Service, NMFS) through the Auke Bay Laboratories (ABL).

CIFAR is staffed by four people: John Walsh, director; Susan Sugai, associate director; Sherry Lynch, financial administrator; and Barb Hameister, publications and meetings manager. Since we are very distant from the closest NOAA lab and do not have in-house scientific staff, we conduct research in a different manner from other cooperative institutes. A primary mechanism is to involve researchers through a competitive process involving announcements of opportunity to the entire scientific community and to select projects by peer review. As a consequence, CIFAR research is conducted not only by the faculty and staff at the University of Alaska, but also at several other U.S. universities. CIFAR also provides an important mechanism for facilitating research collaboration between University of Alaska Fairbanks (UAF) scientists and other NOAA line offices, such as National Ocean Service (NOS), NWS, and NMFS.

Research Themes

Under cooperative agreement NA17RJ1224, research supported by CIFAR falls under several general research themes that characterize the scope of interest of the Institute. Thematic emphasis has changed somewhat from year to year but the themes have remained focused on the big problems of arctic research.

Atmospheric and Climate Research • *Arctic Oscillation* • *Arctic clouds and energy balance* • *Paleoclimates* Marine Ecosystem Studies • *Southeast Bering Sea Carrying Capacity (SEBSCC)* • *Bering Sea productivity* Tsunami Research	Climate Modeling • *Coupled models* • *Model inter-comparisons* Fisheries Oceanography • *Global Ocean Ecosystem Dynamics Program (GLOBEC)* • *Fisheries studies* Contaminant Effects • *Arctic pollution* • *Effects on indicator species*	UV and Arctic Haze Studies • *Ozone and UV radiation* • *Arctic Haze* Hydrographic and Sea Ice Studies • *Sea ice research* • *Tides and currents* • *Ocean fluxes and circulation* Data Archiving and Support

NOAA Mission Goals

CIFAR research addresses all four of NOAA's mission goals enumerated in the NOAA Strategic Plan. Each individual project report identifies which NOAA goal(s) are addressed, as well as a brief statement on societal benefits and/or the relevance of the research results to the needs of NOAA.

1. Protect, Restore, and Manage the Use of Coastal and Ocean Resources through an Ecosystem Approach to Management
2. Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond
3. Serve Society's Needs for Weather and Water Information

4. Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

This report covers activities for the period 1 July 2008 to 30 June 2009 during which no new funding was received for CIFAR under this cooperative agreement. Reports for on-going research projects funded in previous years that were granted no-cost extensions will be presented in this annual report.

Highlights of CIFAR Task I Activities

During this no cost extension year, our Task I administrative activities were focused upon preparing final annual reports and closing out awards under this cooperative agreement while moving forward under our new cooperative agreement NA08OAR4320751. Because there is some overlap in the reporting periods for the new and old cooperative agreements, we are reporting on outcomes like publications from the continuing projects here rather than in the year 1 report for the new cooperative agreement that covered the period 1 July 2008 to 31 March 2009 that we submitted in April 2009. Administrative activities were reported in the first progress report of the new cooperative agreement are not repeated here.

Because CIFAR is located at UAF, we place high priority on our Task I competitively funded student traineeships that help prepare future human resource needs of NOAA and Alaska. During this no-cost extension year, funds that were not spent on other Task 1 activities were directed toward additional student support.

Education/Outreach

CIFAR has placed specific emphasis upon competitively supporting graduate and undergraduate students (in addition to those students supported on CIFAR research projects) whose research addresses issues that may not be limited to one NOAA line office or one academic program or unit. Because CIFAR is positioned within the University of Alaska system, we can bring together faculty and students from various departments and campuses to collaborate with NOAA scientists on research and educational efforts.

To highlight the important role that students play in fulfilling NOAA's mission goals, we have **boldfaced** the **names of students** in this overview of CIFAR accomplishments.

Stock Assessment Training and Improvement

In 2001, the National Marine Fisheries Service completed a Marine Fisheries Stock Assessment Improvement Plan, a comprehensive evaluation of resource needs and strategies for improving the quality and quantity of fisheries assessments nationwide. A central element of this plan was the development of collaborative research programs between NMFS and universities to ensure the training of students and the encouragement of innovative research. Responding to this report, the Alaska Fisheries Science Center in 2002 initiated collaboration with the University of Alaska through the Task III CIFAR project "Graduate Student Stipend Support for Stock Assessment Training and Improvement." Recently, the mandate for ecosystem-based management of the nation's marine fisheries has further increased the critical need to both NOAA and the state of Alaska to enhance the pool of young scientists trained in quantitative fisheries sciences, including population dynamics, management, and stock assessment. Therefore, beginning in FY06, we transferred this project from Task III to Task I, effectively providing 50% more graduate student support for the same NOAA/NMFS investment dollars.

To date, thirteen students have been supported on competitive fellowships under this award and two students have received tuition support. Of these 13 students, 3 Ph.D. and 4 M.S. degrees have been awarded to date. This project has already produced two Ph.D. level quantitative fisheries professionals (**Dana Hanselman**, who recently was awarded a Presidential Early Career Award for Scientists and Engineers, and **Kalei Shotwell**) and one at the M.S. level (**John Moran**), who are now NOAA employees of the Alaska Fisheries Science Center, Auke Bay Laboratories. **Bill Bechtol**, who finished his Ph.D. during this reporting period, has formed a consulting company, and is studying fish distributions in the Aleutians (funding from U.S. Fish and Wildlife Service) and Bering Sea tanner crab (funding by Bering Sea Fisherman's Research Foundation), and continues to serve on the Crab Plan Team of the North Pacific Fishery Management Council. **Haixue Shen**'s Ph.D. defense was successfully held in August and she has been hired by the Alaska Department of Fish and Game effective 15 September 2009.

Because of the success of the "Stock Assessment Training and Improvement" project, in FY07 we used it as a model for the NOAA investment in the "Enhancement of the University of Alaska's Contribution to the International Polar Year (IPY)."

International Polar Year Student Traineeship Awards

In late 2006, following a competitive review process, seventeen CIFAR IPY student projects were selected for funding. Recipients are students at the three major University of Alaska units—UAF, University of Alaska

Anchorage (UAA), and University of Alaska Southeast (UAS)—working on a wide variety of NOAA polar issues in the physical, biological, and social sciences during the current IPY. Some highlights of these student awards are:

- Over the three year duration of this project, 15 graduate students and 15 undergraduate students at the University of Alaska were supported on research addressing NOAA and CIFAR goals.
- Three of the undergraduate students were Alaska Native. Because of their research experiences, the two students (**Dominic Hondolero, Alice Smith**) who have since graduated have enrolled or plan to enroll in graduate programs related to their IPY student projects.
- **Jason Addison**, a Ph.D. geology student at UAF, has been examining multiple paleoclimate proxies in sediment cores from the Gulf of Alaska. He has found that the Gulf of Alaska marine ecosystem is sensitive to past abrupt climate change events, more so than the adjacent Alaskan terrestrial margin, yet it is also capable of rapidly attaining a new equilibrium with the altered environment. A major period of high-productivity conditions occured between 15,200–13,500 years ago along the Gulf of Alaska continental slope, and appears to be related to an increase in water column stability, and a concomitant enhanced flux of iron bound in glacially derived sediment.
- **Tyler Linderoth**, an undergraduate student at UAS working on a B.S. in marine biology, has examined 5 microsatellite loci to determine the population structure of Alaska red king crab. Thus far, results suggest that there is little divergence among red king crab populations. This has important implications for efforts to boost diminishing red king crab numbers through artificial propagation.
- **Jennifer Newton**, a Ph.D. student in anthropology at UAF, has collected historical narrative data on sea ice conditions in the Bering, Beaufort and Chukchi seas from British Naval records accessed from archival repositories at the Scott Polar Research Institute. Her project database contains hundreds of records of air temperatures, wind direction and strength, precipitation, atmospheric observations, sea surface temperatures, and observations on fauna and other natural phenomena.
- As part of his IPY project on sea-ice system services, UAF Ph.D. student **Matt Druckenmiller** has been conducting sea-ice thickness surveys of landfast ice off Barrow and Wales, Alaska using an electromagnetic induction sounding device while also documenting Barrow whaling trails using differential GPS data and local interviews with hunters. Education and outreach are significant components of Druckenmiller's project: he performed the interview component for the comparative sea-ice photography project in Wales and assisted with the editing of the Wales Iñupiaq Sea Ice Dictionary.
- **Jason Amundson**, a Ph.D. geophysics student at UAF, has been examining the iceberg calving processes at Jakobshavn Isbræ, a large ocean-terminating outlet glacier in West Greenland. He helped process and analyze a lengthy time-series of GPS ice motion data. This data has revealed that the flow of Jakobshavn Isbræ, unlike smaller mountain glaciers, is mostly insensitive to changes in surface melting and precipitation.

Student Research Grant Program (Graduate and Undergraduate Support)

CIFAR is a major partner in the Global Change Student Research Grant Competition, established by the UAF Center for Global Change in 1992. In 2009, the competition was expanded to provide support to UAF and UAA students for research on global change presented in an interdisciplinary context, with an arctic or subarctic focus. The work may involve the social, biological, and physical sciences and engineering. This competition is designed to give students experience with proposal writing and the peer review system as practiced by science funding agencies.

CIFAR supports students through indirect cost recovery, through CIFAR match funds contributed by the Vice Chancellor for Research at UAF, and through Task I direct support of projects of relevance to CIFAR's mission. We completed the 2009 competition in May; the newly funded CIFAR projects are:

- **Christopher Barger**, Department of Biology and Wildlife, UAF: Mechanisms determining resilience of common murre (*Uria aalge*) populations to climate variability in the Bering Sea
- **Robert Burgess**, Department of Biology and Wildlife, UAF: Climate change impacts on microbial lignocellulose decomposers in Alaskan boreal forest soil
- **Katrina Knott**, Department of Biology and Wildlife, UAF: Eco-physical biomarkers and contaminants in a changing environment: Using stable isotope analysis to assess the biological significance of maternal transfer of contaminants in polar bears
- **Robert McNabb**, Department of Geology and Geophysics, UAF: Monitoring and analysis of calving events at Franklinbreen, Vestfonna, Svalbard and Columbia Glacier, Alaska
- **Marc Mueller-Stoffels**, Department of Physics, UAF: The ice-albedo feedback from a complex systems point of view
- **Barbara Truessel**, Department of Geology and Geophysics, UAF: Seasonality of snow line retreat on a lake calving glacier

- **Jared Weems**, School of Fisheries and Ocean Sciences, UAF: Stable isotope turnover rates in select invertebrates: Significance to ice-pelagic-benthic coupling in the Bering Sea

Second year support with CIFAR funds were used for a 2-year award made in 2008:

- **Laura Brosius**, Department of Biology & Wildlife: Determining organic matter sources for methane production and bubbling from Alaskan lakes using stable isotopes and radiocarbon ages

Student Support through Individual Awards

Many of the proposals funded through CIFAR involve graduate and undergraduate students. Fifteen students (13 graduate; 2 undergraduate) were supported in full or in part by the research projects covered in this report or by Task I funds (Appendix 1). In addition, many other students benefited from involvement in the research projects, e.g., through sample/data collection and data analysis, even though they did not receive direct salary support through CIFAR.

Highlights of CIFAR Research Activities and Results

Below are highlights from selected projects reported on in this document with a focus on the role CIFAR is playing in supporting graduate student education and training in CIFAR research themes.

Atmospheric and Climate Research

In two related Pacific Region Integrated Data Enterprise (PRIDE) projects, David Atkinson and co-workers seek to improve publicly available NOAA products across a range of temporal and spatial scales to provide coastal stakeholder groups with short- and long-term forecasting information needed for improving emergency response, damage prevention, community planning, and coastal zone management activities. These projects also provide a linkage between NOAA activities and needs in the Alaska region with those in Hawaii and other U.S. Pacific interests. Some results to date include:

- During this reporting year, **Michel dos Santos Mesquita**, a Ph.D. student in atmospheric sciences, had two more papers on storm activity in the North Pacific published or accepted for publication. The first paper (**Mesquita, M.d.S**., D.E. Atkinson and K. Hodges. Characteristics and variability of storm tracks in the North Pacific, Bering Sea, and Alaska, *Journal of Climate*, in press) focuses on seasonal climatological aspects of various storm parameters (track speed, genesis, lysis, lifetime) in the North Pacific. Important aspects of this work include consideration of the autumn season, which almost never appears in other storm analyses but which is a very important time of year for Alaska and its erosion problems, and consideration of storm activity before/after the climatic shift associated with the Pacific Decadal Oscillation.
- The second paper considers the dynamics of one severe storm in particular, and includes an intercomparison of two storm track algorithms, including the one used operationally by NOAA's Climate Prediction Center. Consideration of the nature of a "storm" and of various ways to portray storms is an important issue because a storm's potential is not always felt in the immediate vicinity of the storm center. This work was published as: **Mesquita, M.d.S**., D.E. Atkinson, I. Simmonds, K. Keay and J. Gottschalck. 2009. New perspectives on the synoptic development of the severe October 1992 Nome storm, *Geophysical Research Letters*, 36, L13808, doi:10.1029/2009GL038824.

Climate Modeling

John Walsh and co-workers have examined four reanalysis models: (a) NCEP/NCAR (National Centers for Environmental Prediction/National Center for Atmospheric Research) global reanalysis; (b) ERA-40 global reanalysis by the European Center for Medium-Range Weather Forecasts; (c) NCEP/NCAR North American Regional Reanalysis (NARR) and (d) Japan Meteorological Agency 25-year reanalysis (JRA-25) and documented limitations in the fields of Arctic clouds and their radiative impacts. The deficiencies were a key motivation for a new Arctic regional reanalysis.

- During the past year, John Walsh and co-workers have carried out proof-of-concept simulations of an Arctic regional reanalysis for two full months, August 2007 and December 2007, enabling an assessment of the capabilities and limitations of the reanalysis system in summer and winter months. The test simulations showed that the sea level pressure field is well captured by the reanalysis, but that there are biases in the surface temperatures that are tied to the surface boundary specifications. Because these biases were most apparent in coastal areas, they have implemented a new set of sea ice concentrations and thicknesses, based on year-month fields of sea ice age and areal coverage from passive microwave satellite imagery. The new boundary

conditions represent a significant advance over the single-thickness specifications used in previous global reanalyses.

Fisheries Oceanography

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 mandates improving the science guiding management with new regional programs for ecosystem research. The *Sebastes* rockfishes are an important component of the marine food web and are also economically important. There are more than 100 species worldwide and more than 60 along the Pacific Coast of North America. In addition, they are morphologically similar; and during their embryological development, they pass through several morphological transformations. Consequently, many adults of some species are difficult and many larvae impossible to identify from their morphologies. Genetics provides tools that can be used to learn about population structure and the underlying demographic structures and markers that can be used to delineate species.

- Tony Gharrett and co-workers used 11 microsatellite loci to analyze four collections of 100 northern rockfish (*S. polyspinis*) from the Aleutian Islands and one from the Bering Sea. Available life history and environmental information as well as their genetic analysis are consistent with a population model for northern rockfish that is based on relatively continuous distribution with life-time dispersals that are much smaller than the species range. Their research indicated that populations were somewhat discrete, and indicated a correlation between genetic divergence and geographic distance along the shelf break. By applying assumptions about the distribution of dispersal, they estimated that the effective sizes of local populations (that is, neighborhoods) are about 40,000 and that limits on the span of dispersal are about 55 km. After taking the biases in the analysis into consideration, they conclude that the dispersal for northern rockfish is limited and much smaller than might be suggested from the oceanographic conditions that the rockfish encounter and from their longevity and mobility. Although Gharrett and co-workers caution that their estimate of dispersal is rough, it seems reasonable that geographic scale of management plans would be no more than a few times that size (Riley et al., in prep).

Hydrographic and Sea Ice Studies

- **Shaoqing Ge**, an M.S. student in environmental engineering working with Daqing Yang and co-workers, analyzed long-term hydrologic and climatic data from the period 1977 to 2006 over the Yukon River Basin. Results of analyses at four gauging stations (Eagle, Stevens Village, Nenana, and Pilot) show that the runoff in low-flow season (November to April) is low with small variations. In the high-flow season (May to October), the runoff is high with big variations. Maximum discharge occurs in June due to snowmelt over the basin, except for the Nenana River, which occurs in July due to glacier-melt. The monthly discharge data for the Pilot Station show a positive trend (177,000 ft^3/s) in May, with confidence at 97%. April flow has increased by 4,586 ft^3/s with confidence over 85%. The negative trends (7,502 ft^3/s-12,184 ft^3/s) in other months are not statistically significant. Daily discharge data at 2 gauging stations (Stevens Village and Pilot) indicate that the timing of peak flow has shifted to an earlier time. They also found annual discharge increased during 1977-2006 by 18,213 ft^3/s (8.0%) for the Yukon basin. Over the same time period, basin-mean annual temperature warmed slightly by 0.3 ^oC, while annual precipitation increased by 28 mm.

Marine Ecosystem Studies

- Synthesis of hydrographic, mooring, and ancillary (wind, sea surface temperature satellite imagery) data acquired during 2005-2008 field seasons allowed PI Steve Okkonen and co-workers to identify conditions which regulate the intrusion of Bering/Chukchi origin waters onto the western Beaufort shelf and to publish these results (Okkonen, S., C. Ashjian, R. Campbell, W. Maslowski, J. Clement-Kinney and R. Potter. 2009. Intrusion of warm Bering/Chukchi waters onto the shelf in the western Beaufort Sea, *J. Geophys. Res.,* 114, C00A11, doi:10.1029/2008JC004870). They found that when winds are weak or from the southwest, Bering/Chukchi waters from Barrow Canyon intrude onto the western Beaufort shelf. When winds are from the east/southeast, currents on the inner Beaufort shelf flow northwestward and oppose significant eastward intrusions of Bering/Chukchi waters onto the western Beaufort shelf.
- These two wind-driven current regimes are also components of the mechanism that makes the Barrow area a bowhead whale feeding hotspot. Winds from the eastern quadrant promote upwelling of zooplankton (krill) onto the western Beaufort shelf where wind-driven shelf currents carry the krill westward toward Barrow. When the winds become weak, the krill become concentrated near the southern flank of Barrow Canyon by eastward-intruding Bering/Chukchi waters.

Tsunami Research

Much of the tsunami research conducted Roger Hansen and co-investigators focuses on the assessment of tsunami and seismic hazards to Alaska coastal communities and to transportation networks. In addition, the modeling development and research are of global importance. Parallel code development has accompanied research-derived refinements of the global tsunami model. After testing, the model described below has been transferred to NOAA's National Tsunami Hazard Mitigation Program to be used for prediction and warning purposes.

- Hansen and co-workers have continued working on the benchmarking of the numerical model of tsunami propagation and runup. This model was developed at the Alaska Earthquake Information Center (AEIC) and is used for tsunami inundation mapping of Alaska communities. As one of the NOAA's recommended field benchmarks, they modeled propagation and runup of tsunami waves generated by the 1993 Hokkaido-Nansei-Oki earthquake. Most of the tsunami damage was concentrated around Okushiri Island located west of Hokkaido Island. Suleimani and colleagues have acquired detailed runup measurements and high-resolution bathymetry grids that allowed them to simulate runup of tsunami waves on Okushiri Island and compare results with available field data. The numerical results are in a good agreement with observations, and have demonstrated that the numerical algorithm is stable and successfully models the overland flow.

Publications and Presentations

During the current reporting period, 39 peer-reviewed publications and 12 non-peer-reviewed publications (including 2 Ph.D. dissertations and 5 Master's theses) were reported from projects funded through CIFAR under cooperative agreement NA17RJ1224. An additional 18 papers were reported as accepted or in press, while another 17 were submitted for publication. Fifty-seven manuscripts were reported as under preparation. Fifty-eight conference presentations (both national and international) and seminars were also reported. More than half of these presentations were from the CIFAR IPY student projects.

In addition to these FY09 numbers, we received information on several publications from previous fiscal years that had not been reported previously. The publication matrix in Appendix 2 reflects these additions.

Note: These numbers do not include presentations or publications from Arctic Research Initiative and Steller sea lion projects funded at NOAA laboratories, other federal agencies, or through other cooperative institutes.

See also Appendix 2.

Task I

Education / Outreach

University of Alaska Fairbanks Graduate Student Stipend for Stock Assessment Training and Improvement

Terrance J. Quinn II, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

This project is complete.

Primary objectives

This fellowship, funded by the Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service (NMFS), supports the training of M.S. and Ph.D. students in quantitative fisheries science, including population dynamics, management and stock assessment. This fellowship is open to M.S. and Ph.D. graduate students with solid quantitative ability and achievement. Generally, a student's research focus is related to the mandate of the AFSC, which includes marine and anadromous waters of the Alaska region. However, other interesting projects are considered. A committee of AFSC and School of Fisheries and Ocean Sciences (SFOS) quantitative scientists evaluates applications. Up to three fellowships per year can be awarded. Also, "gap" funding is available to support quantitative students without other financial support to help them complete their research programs.

Clockwise from upper left: Bill Bechtol, Sara Miller, Katie Palof, Kray van Kirk, Haixue Shen, Suzanne Teerlink.

Approach/methodology

Applications are made to the AFSC Scholarship Committee, Fisheries Division, School of Fisheries and Ocean Sciences, 11120 Glacier Highway, Juneau, AK 99801-8677, e-mail: fisheries@sfos.uaf.edu. The applicant is either a UAF professor or a student with sponsorship from a UAF professor. The applicant details research in a quantitative arena of fisheries science, such as mathematics, statistics, or modeling. Applications are evaluated as they are received; there is no formal date of application.

Research accomplishments/highlights/findings

- Dana Hanselman, Kalei Shotwell, John Moran, and Cindy Tribuzio currently work as Research Fishery Biologists with NOAA/NMFS, Ted Stevens Marine Research Institute (TSMRI), Alaska Fisheries Science Center, Juneau, AK, demonstrating the success of this project in providing critical new employees to NOAA.
- During the past year, six students received graduate stipends. Stipend support provided almost a year of research funding for Kray Van Kirk to continue his graduate work in a new Ph.D. program.
- Haixue Shen has completed a draft of her Ph.D. dissertation and will have her defense on August 25, 2009.
- New M.S. student Suzanne Teerlink is receiving gap funding for a project reconstructing historical abundance of humpback whales in Prince William Sound. This will lead to new understanding about the role that humpback whales play in the lack of recovery of the Pacific herring population there.

NOAA relevance/payoff

This joint program between UAF and NOAA/NMFS/AFSC is designed to prepare young scientists for careers in fish stock assessment, a field that requires strong quantitative skills. The NMFS Stock Assessment Improvement Plan requires such scientists for its implementation, and the available pool of qualified applicants is shrinking. This project has already produced two Ph.D. level quantitative fisheries professionals, who were immediately hired by NOAA after graduation and one Ph.D. student who was hired before completing her dissertation. One student has formed a consulting company, is studying fish distributions in the Aleutians (funding from U.S. Fish and Wildlife Service) and Bering Sea tanner crab (funding by Bering Sea Fisherman's Research Foundation), and continues to serve on the Crab Plan Team of the North Pacific Fishery Management Council.

Research linkages/partnerships/collaborators and networking

The Alaska Fisheries Science Center continues to support this program with help from Anne Hollowed and Pat Livingston. Pat served on Kray Van Kirk's M.S. committee and is serving on his Ph.D. committee. Martin Dorn serves on Haixue Shen's Ph.D. committee. Jim Ianelli continues to help quantitative students with programming issues related to computer modeling and analysis. Dana Hanselman (TSMRI) serves on Pete Hulson's Ph.D. committee. Ron Heintz (TSMRI) serves on Suzanne Teerlink's M.S. committee.

Education/outreach

Graduate student support

The following thirteen UAF fisheries graduate students have been supported on fellowships under this award: Ben Williams (M.S.), Colin Schmitz (M.S.), John Moran (M.S.), Sara Miller (M.S.), Peter-John Hulson (M.S.), Suzanne Teerlink (M.S.), Cindy Tribuzio (Ph.D.), Dana Hanselman (Ph.D.), Kalei Shotwell (Ph.D.), William Bechtol (Ph.D., finished this year), Katie Palof (Ph.D.), Kray Van Kirk (Ph.D.) and Haixue Shen (Ph.D.). Williams, Moran, Hanselman, Shotwell, Miller, Bechtol, and Hulson have completed their graduate degrees; Tribuzio, Miller (Ph.D.), Hulson (Ph.D), Teerlink, Palof, Van Kirk (Ph.D.), and Shen are currently pursuing their graduate degrees. Josh Robins (M.S., finished 2006) and Xinxian Zhang (Ph.D.) have received tuition support. For this year, Van Kirk received salary support for 10 months, Teerlink for 2.5 months, and Bechtol, Miller, Palof, and Shen for 1 month or less, respectively.

Presentations

Hulson, P.-J. 2009. Overview of data weighting practices used in stock assessments of age-structured fish populations. Oral presentation to Alaska Crab Stock Assessment Workshop (sponsored by the Crab Plan Team of the North Pacific Fishery Management Council), Seattle, Washington, 13–14 May 2009.

Hulson, P.-J., D.H. Hanselman and T.J. Quinn II. 2009. Effects of process and observation error on multinomial effective sample size from fishery and survey age and length composition data. Oral presentation at 2009 World Conference on Natural Resource Modeling, Juneau, Alaska, 17–19 June 2009. Winner of one of two best student presentation awards.

Van Kirk, K.F., T.J. Quinn II and J.S. Collie. 2009. A multispecies age-structured model for the Gulf of Alaska. Oral presentation at 2009 World Conference on Natural Resource Modeling, Juneau, Alaska, 17–19 June 2009. Winner of one of two best student presentation awards.

Miller, S. 2009. Estimation of age-specific migration in an age-structured population dynamics model of Eastern Bering Sea walleye pollock (*Theragra chalcogramma*). Workshop on Spatial Pollock Assessment Modeling, Seattle, Washington, 7–10 July 2009. (included because this is the final report and includes work done during the last year)

Hulson, P.-J. 2009. Improvement of a spatial age-structured model with mark-recapture data: walleye pollock in the eastern Bering Sea. Workshop on Spatial Pollock Assessment Modeling, Seattle, Washington, 7–10 July 2009. (included because this is the final report and includes work done during the last year)

Publications

Dissertation

Bechtol, W. 2009. Abundance, Recruitment, and Environmental Forcing of Kodiak Red King Crab. Ph.D. Dissertation, University of Alaska Fairbanks.

Peer-reviewed

Bechtol, W.R. and G.H. Kruse. 2009. Analysis of a stock-recruit relationship for red king crab off Kodiak Island, Alaska. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science,* 1:29–44.

Shen, H., M.W. Dorn, V. Wespestad and T.J. Quinn. 2009. Schooling pattern of eastern Bering Sea walleye pollock and its effect on fishing behaviour. *ICES Journal of Marine Science*, 66:1284–1288.

Submitted

Hulson, P.J., T.J. Quinn II and S. Dressel. Estimation of temporal variation in maturity-at-age of Pacific herring (*Clupea pallasi*) in Sitka Sound, Alaska. Submitted to *Alaska Dept. of Fish and Game, Research Report Series*.

Van Kirk, K.F., T.J. Quinn II and J.S. Collie. A multispecies age-structured model for the Gulf of Alaska. Submitted to *Canadian Journal of Fisheries and Aquatic Sciences*.

In preparation

Miller, S.E., **P.J. Hulson**, J.N. Ianelli and T.J. Quinn II. Simulation of an Eastern Bering Sea walleye pollock (*Theragra chalcogramma*) spatially-explicit stock assessment model with and without tagging data. In preparation for submission to *Canadian Journal of Fisheries and Aquatic Sciences*.

Moran, J.R., M.D. Adkison and B.P. Kelly. Counting seals: estimating the unseen fraction using a photographic capture–recapture and covariate model. In preparation for submission to *Canadian Journal of Zoology*.

Williams, B.C., T.J. Quinn II and L.J. Haldorson. Influence of year and year-class effects on growth of juvenile yellowfin sole and northern rock sole in the eastern Bering Sea. In preparation for submission to *Canadian Journal of Fisheries and Aquatic Sciences*.

Williams, B.C., T.J. Quinn II and L.J. Haldorson. Relationships among biomass, recruitment, environmental variation, and growth of juvenile yellowfin sole and northern rock sole in the eastern Bering Sea. In preparation for submission to *Canadian Journal of Fisheries and Aquatic Sciences*.

Enhancement of the University of Alaska's Contribution to the International Polar Year (IPY): Building a "Human Legacy" of Arctic Scholars

John E. Walsh, PI
University of Alaska Fairbanks

NOAA Goals: Understand Climate Variability and Change; Ecosystem-based Management; Serve Society's Needs for Weather and Water Information

This project is complete. Individual project reports follow this introduction.

Primary objectives

This competitive undergraduate scholarship and graduate fellowship supports the participation of B.A., B.S., M.S. and Ph.D. students in International Polar Year (IPY) projects aligned with NOAA's strategic interests in the Arctic. This fellowship is open to degree-seeking undergraduate and graduate students at any University of Alaska campus working with UA faculty on IPY projects oriented towards understanding climate variability and change, enhancing our knowledge of weather and water, providing information for safe transportation and commerce, and moving toward an ecosystem-based approach to management of coastal ocean resources. A committee of University of Alaska Research Advisory Council designees and CIFAR administrators evaluates applications.

Approach/methodology

Applications are made to CIFAR in response to an announcement of opportunity. The applicants are UA professors or student(s) with sponsorship from one or more UA professor(s). The announcement provides submission deadline and application details.

In late 2006, following a competitive review process, seventeen CIFAR IPY student projects were funded including students seeking degrees at the three major University of Alaska units: UAF, University of Alaska Anchorage (UAA), and University of Alaska Southeast (UAS). These projects involve undergraduate and graduate students working on a wide variety of polar issues supporting NOAA mission goals in the physical, biological, and social sciences. As part of the IPY legacy, these awards will help to train the next generation of polar researchers.

Research accomplishments/highlights/findings

- Over its three-year duration, this project supported 15 graduate students and 15 undergraduate students at the University of Alaska doing research addressing NOAA and CIFAR goals.
- Three undergraduate students were Alaska Natives. Because of their research experiences, the two students who have since graduated are enrolled or plan to enroll in graduate programs related to their IPY student projects.
- To date, this project has resulted in nine peer-reviewed publications, in seven of which the IPY student is the senior author. Five additional publications are in press, two have been submitted, and at least 13 are in preparation.

- In addition, 35 oral and 33 poster presentations have resulted from this project to date, of which 58 were presented by one of the students involved. Twelve of the presentations were at international conferences, reflecting the importance of the broader IPY linkage.

NOAA relevance/societal benefits
This joint program between UAF and NOAA is designed to prepare young scientists for careers in areas supporting all four of NOAA's strategic goals.

Research linkages/partnerships/collaborators and networking
The IPY projects involve linkages with the Alaska Department of Fish & Game, Canadian Wildlife Service, U.S. Environmental Protection Agency, National Aeronautics and Space Administration, National Center for Atmospheric Research, National Park Service, NOAA National Weather Service, North Slope Borough, Nunavut Wildlife Division, Scott Polar Research Institute, Smithsonian Institution, U.S. Army Cold Regions Research and Engineering Laboratory, U.S. Forest Service Research Laboratory, U.S. Geological Survey, UA IPY postdoctoral scholars, and investigators at Central Michigan University, Charles Drew University, ETH Zürich, Switzerland, Hokkaido University, Oregon State University, University of Florida, University of Hawaii, University of Massachusetts-Amherst, University of Michigan, University of New Hampshire, University of Tennessee, and University of Virginia.

Education/outreach
Graduate and undergraduate student support
The following fifteen graduate students have been supported on fellowships under this award to date: Jason Addison (Ph.D.), Jason Amundson (Ph.D.), Jessica Beecher (M.S.), Morgan Brown (M.S.), Daniel Carlson (Ph.D.), Matthew Druckenmiller (Ph.D.), Joel Gottschalk (M.S.), David Gustine (Ph.D.), Jennifer Newton (Ph.D.), Stacy Porter (M.S.), Martha Raynolds (Ph.D.), Theresa Rzeczycki (M.S.), Allison Sayer (M.S.), Kalb Stevenson (Ph.D.), and Yiming Wang (Ph.D.).

Fifteen undergraduate students have been supported: Amina Ashraf, Melanie Bakker, Jon Barton, Brenda Bruggeman, Kari Dammerman, Britany Gonzalez, Dominic Hondolero, Brandon Howard, Lily Ann Jordan, Tyler Linderoth, Jeff Mayfield, Micaela Ponce (now Martinez-Bakker), Cortney Pylant, Alice Smith, and Matthew Sutterer.

International Polar Year (IPY) Student Traineeships:
Late Quaternary climate dynamics inferred using stable oxygen isotope composition of aquatic insects (Chironomidae: Diptera) from Idavain Lake, Southwest Alaska

Matthew J. Wooller, UA faculty member, PI
Yiming Wang, UA graduate student
University of Alaska Fairbanks

NOAA Goal: Understand Climate Variability and Change

CIPY-01: This project is complete.

Primary objectives of the project
This project contributes one component to a larger scale IPY project which will aid the Arctic paleoclimate science community in understanding of Holocene climate variability in Alaska derived from lake downcore sediments. This research aims to further develop and apply the stable oxygen isotope analyses of chironomid head capsules preserved in lake sediments (Wooller et al. 2004) from Lake Idavain, Southwest Alaska, and attempts to extend the record of temperature changes beyond the instrumental record. This new approach could: 1) add significantly to the relatively small database of quantitative temperature reconstructions from terrestrial sites in polar regions, 2) help to establish a more cohesive climate model, and therefore 3) enhance understanding of the paleoclimate and paleoenvironmental changes since the Last Glacial Maximum and make a better prediction of climate change in the future.

Approach/methodology
1. Develop the protocols for preparing subfossil chironomid head capsules for stable isotope analyses.
2. Apply stable isotope techniques on chironomid fossil heads preserved in the lake sediments.

3. Study modern chironomid isotopic fractionations using laboratory environment controlled growth experiments; thus, to compare with the fossil records.
4. In addition to the original plan, stable isotope oxygen and hydrogen analyses on bulk sediments have been added to the methods. We wish to use a suite of stable isotope proxies to provide robust information for the past environment change in Southwest Alaska.

Research accomplishments/highlights/findings

- The growth experiment of culturing chironomids was written into a manuscript and published in the international peer-reviewed journal *Oecologia* in January 2009.
- Yiming Wang is working on another manuscript to reconstruct the Holocene history for southwest Alaska using the stable isotope analyses on subfossil chironomid head capsules. The paper will be submitted to a peer-reviewed journal in the near future.

NOAA relevance/societal benefits

This work supports NOAA's goal to "Understand climate variability and change" by contributing to existing knowledge about past climatic changes in Alaska, which in turn will make possible better predictions of climate changes in the future.

Research linkages/partnerships/collaborators and networking

- Bruce Finney from the Institute of Marine Science, UAF, supplied core materials.
- U.S. Environmental Protection Agency (EPA) provided advice on the growth experiment and provided organisms.
- NOAA National Weather Service at King Salmon, Alaska, collected precipitation samples.
- Amanda Booth, a University of Alaska IPY postdoctoral scholar, is working on a closely related project. Wang has assisted in training Booth in the use of the techniques she has developed for the analysis of chironomids from lake sediments.

Education/outreach

Student participation

Yiming Wang was a Ph.D. student in Geology at UAF. She obtained her Ph.D. in August 2008 and is now working as a postdoctoral fellow at the Institute of Geosciences, University of Kiel, Germany.

Presentation

Wang, Y. 2008. The influence of diet and water on the stable oxygen and hydrogen isotope composition of aquatic organisms (*Chironomidae: Diptera*). Oral presentation at the Isotope Ecology (ISOECOL) international conference, Honolulu, Hawaii, August 2008.

Publications

Dissertation

Wang, Y. 2008. The Development and Application of Stable Oxygen and Hydrogen Isotope Analyses of Chironomidae (Diptera) as Indicators of Past Environmental Changes. Ph.D. Dissertation, University of Alaska Fairbanks, August 2008.

Peer-reviewed

Wang, Y., D. O'Brien, J. Jenson, D. Francis and M.J. Wooller. 2009. The influence of diet and water on the stable oxygen and hydrogen isotope composition of chironomids (Diptera) with paleoecological implications. *Oecologia*, 160:225–233.

In preparation

Wang, Y., B. Finney, A. Krumhardt, B. Cohn and M.J. Wooller. Isotope evidence for shifts in atmospheric circulation patterns during the late Quaternary in Southwest Alaska. In preparation.

Reference

Wooller, M.J., D. Francis, M.L. Fogel, G.H. Miller, I.R. Walker and A.P. Wolfe. 2004. Quantitative paleotemperature estimates from $\delta^{18}O$ in chironomid head capsules from arctic lake sediment. *Journal of Paleolimnology*, 31:267–274.

Role that this award played in student's degree program

CIFAR has given the opportunity for Yiming Wang to grow into an independent and confident scientist by providing valuable opportunities in many ways. This CIFAR traineeship not only allowed Yiming to finish her

Ph.D. project in a timely manner, but also gave her a valuable opportunity to practice writing research grants in her early science career stage. With the support of CIFAR, Yiming could work intensively on this very challenging research topic using stable isotope analyses of subfossil chironomid head capsules derived from lake sediments. This CIFAR traineeship sponsored Yiming to participate in an international meeting, the Isotope Ecology (ISOECOL) international conference in August 2008, where she gave an oral presentation of her research. She benefited greatly from this conference, with the opportunity to connect with other scientists and experts in the field of stable isotope ecology. This CIFAR traineeship also allowed Yiming to collaborate with many other scientists and researchers from different institutions and disciplines for her Ph.D. research, which has been a most beneficial asset to her career development.

International Polar Year (IPY) Student Traineeships:
Understanding the causes and future direction of the present rapid thinning of Jakobshavn Isbræ

Martin Truffer, UA faculty member, PI
Jason Amundson, UA graduate student
University of Alaska Fairbanks

NOAA Goal: Understand Climate Variability and Change

CIPY-04: This project is complete.

Primary objectives

Jakobshavn Isbræ, a large ocean-terminating outlet glacier in West Greenland, has recently undergone a major retreat that coincides with accelerated flow and thinning. This project is attempting to understand the causes and future direction of this retreat, with an emphasis on glacier–ocean and glacier–climate interactions.

Approach/methodology

1. Collect and analyze several different types of field data, including surface velocities (from GPS and optical surveys), seismic data, weather station data, time-lapse photos, iceberg motion (from land-based radar and GPS), tidal stage, and audio recordings.
2. Use these data, along with satellite imagery and data from the Global Seismic Network, to (1) describe calving processes and their effect on glacier, fjord, and solid earth (first chapter of thesis; published in *Geophysical Research Letters*), (2) determine how calved icebergs can influence subsequent calving events and glacier behavior (second chapter of thesis; submitted to *Journal of Geophysical Research – Earth Surface*), and (3) build a greater than 25-year history of calving at Jakobshavn Isbræ (third chapter of thesis; work is ongoing).

Research accomplishments/highlights/findings

- Helped process and analyze a lengthy time-series of GPS ice motion data. This data has revealed that the flow of Jakobshavn Isbræ, unlike smaller mountain glaciers, is mostly insensitive to changes in surface melting and precipation.
- Field observations and theoretical arguments have been used to demonstrate that Jakobshavn Isbræ's ice mélange (dense pack of sea ice and calved icebergs) influences the timing and sequence of calving events, thereby affecting the glacier's stability. The theoretical arguments also support the use of a height-above-floatation calving criterion for use in numerical models.
- Using satellite imagery and global seismic data, a methodology has been developed for identifying calving events in the seismic record. These data indicate that the glacier's current retreat has occurred primarily via several very long (> 12 hr) calving events between 2002 and 2004.

NOAA relevance/societal benefits

It is expected that this work will enable researchers to better predict the contribution of sea level rise from retreating glaciers, which directly addresses NOAA's second mission goal: "Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond."

IPY linkages/partnerships/collaborators and networking

This project is a part of the IPY initiative #339: "Measurement and Attribution of Recent Greenland Ice sheet chaNgeS (MARGINS)." Collaborators include Mark Fahnestock at the University of New Hampshire and Martin Lüthi at ETH Zürich, Switzerland.

Education/outreach

Student participation

Jason Amundson is a Ph.D. student in Geophysics at the University of Alaska Fairbanks.

Outreach

Mr. Amundson was interviewed for an article that will appear in an upcoming issue of *Scientific American*.

Presentations

Amundson, J.M., M. Fahnestock, M. Truffer, V. Tsai and M. West. 2008. Analysis of seismic waveforms generated during iceberg calving events, Jakobshavn Isbræ, Greenland. American Geophysical Union Fall Meeting, San Francisco, California, December 2008.

Amundson, J.M., M. Truffer, M. Fahnestock, I. Joughin, M.P. Lü, J. Brown, R.J. Motyka and D. Podrasky. 2008. Effect of melt on the velocity of the main channel of Jakobshavn Isbræ, Greenland. International Glaciological Society Symposium on Dynamics in Glaciology, Limerick, Ireland, 17–22 August 2008.

Publications

Peer-reviewed

Amundson, J.M., M. Truffer, M.P. Lüthi, M. Fahnestock, M. West and R.J. Motyka. 2008. Glacier, fjord, and seismic response to recent large calving events, Jakobshavn Isbræ, Greenland. *Geophysical Research Letters*, 35(L22501), doi:10.1029/2008GL035281

Submitted

Amundson, J.M., M. Fahnestock, M. Truffer, J. Brown, M.P. Lüthi and R.J. Motyka. Ice mélange dynamics and implications for terminus stability, Jakobshavn Isbræ, Greenland. Submitted to *Journal of Geophysical Research – Earth Surface*.

In preparation

Amundson, J.M., M. Fahnestock, M. Truffer, M. West and E. Okal. Regional seismic observations of iceberg calving events at Jakobshavn Isbræ, Greenland, from 1982–2009.

Role that this award played in student's degree program

This award has provided funding for Jason Amundson during much of his Ph.D. program. All three chapters of his thesis have been partially funded by the award; in addition, results from this project will likely result in one or more co-authored manuscripts. Through this work, Amundson has advanced the understanding of glacier–ocean interactions and the use of seismology to study such interactions. These advances are relevant to IPY in that they may help to improve our ability to predict future mass losses (and resulting sea level variations) from the Greenland Ice Sheet due to changes in atmospheric and oceanic conditions.

International Polar Year (IPY) Student Traineeships:
Late Quaternary environmental change in the Gulf of Alaska

Bruce P. Finney, UA faculty member, PI
Jason A. Addison, UA graduate student
University of Alaska Fairbanks

NOAA Goals: Ecosystem-based Management; Understand Climate Variability and Change

CIPY-06: This project is complete.

Primary objectives
Reconstructions of past climate are a vital component for understanding modern climate variability. The subpolar North Pacific Ocean has been identified through both field studies and modeling efforts as a primary driver for global climate. This project focuses on developing paleoclimate proxies over decadal to millennial timescales using high-resolution marine sediment cores recovered from the Gulf of Alaska, the northeastern-most sector of the Pacific Ocean. Oceanic and atmospheric circulation in the Gulf of Alaska is strongly dependent on the interactions between the Aleutian Low and Siberian High pressure systems, which in turn influence regional marine ecosystems via associated upwelling and advection of nutrient-rich water from the Alaska Gyre. As a result of these teleconnections, it is possible to quantify the effects of both short-term regime shifts in the Aleutian Low and sub-Milankovitch orbital modulations using techniques that measure primary paleoproduction preserved in the marine sedimentary record because it integrates atmospheric, oceanic, and biological systems through the biogeochemical composition of its constituent sediments.

Approach/methodology
- Develop an accurate age model for each sedimentary core using ^{210}Pb and ^{14}C dating, secular variations of the paleomagnetic record, foraminiferal δ^{18}O stratigraphy and tephrochronology.
- Measure multiple independent biogeochemical proxies including δ^{13}C and δ^{15}N isotopes, biogenic silica, total organic carbon, excess barium, and redox-sensitive transition metal concentrations.
- Apply statistical time-series analyses to determine the significance and frequency of proxy data.
- Correlate with regional and global datasets of climate change.

Research accomplishments/highlights/findings
- During the Holocene, Gulf of Alaska marine productivity is commonly out-of-phase with reconstructed precipitation records, suggesting the positive feedback mechanism that currently links these systems (observed in records of the Pacific Decadal Oscillation) is insufficient to describe the full potential range of North Pacific Ocean environmental variability.
- A synthesis of North Pacific high-resolution paleoclimate datasets (including data from the Gulf of Alaska) indicates a major reorganization of atmospheric dynamics occurred in direct response to Northern Hemisphere cooling that began at 4000 years ago, and that the modern Pacific Decadal Oscillation is a direct manifestation of this cooling.
- The Gulf of Alaska marine ecosystem is sensitive to past abrupt climate change events, more so than the adjacent Alaskan terrestrial margin, yet it is also capable of rapidly attaining a new equilibrium with the altered environment.
- A major period of high-productivity ecosystem conditions occurs between 15,200–13,500 years ago along the Gulf of Alaska continental slope, and appears to be related to an increase in water column stability, and a concomitant enhanced flux of iron bound in glacially derived sediment.

NOAA relevance/societal benefits
This project is focused on reconstructing past marine ecosystem change, as well as investigating teleconnections between the northeast Pacific Ocean and global datasets of climate change. Results will also prove to be an important component of future modeling attempts due to the importance of Aleutian Low dynamics to Northern Hemisphere climate.

IPY linkages/partnerships/collaborators and networking
This project has benefited from collaborations with researchers at Oregon State University (Joe Stoner and his Ph.D. student Maureen Davies; Alan Mix and Fred Prahl), the U.S. Geological Survey (Tom Ager, John Barron and Walt

Dean), the University of Florida (John Jaeger and his Ph.D. student Gillian Rosen), as well as the Advanced Instrumentation Laboratory (Ken Severin) and the Alaska Stable Isotope Facility (Mat Wooller) at UAF.

Education/outreach

Student participation

Jason Addison – Ph.D. student, Department of Geology and Geophysics, UAF; Ph.D. dissertation presentation July 24, 2009. Anticipated graduation December 2009.

Presentations

Addison, J.A. 2009. Late Quaternary environmental change in the Gulf of Alaska. Oral presentation to the Center for Global Change & Arctic System Research Science Steering Committee, 13 April 2009.

Addison, J.A., B.P. Finney, W.E. Dean and M.H. Davies. 2008. High-resolution records of mid-Holocene paleoceanographic change from the Subarctic Northeast Pacific Ocean. Poster presentation at American Geophysical Union, Fall Meeting, San Francisco, California, 15–19 December 2008. (abstract #PP41B-1458)

Addison, J.A. 2008. Tephrochronology as a tool for establishing basin-scale correlations in marine sediment cores: Arctic Ocean potential and examples from the Subarctic Northeast Pacific margin. Poster presentation at Consortium for Ocean Leadership Workshop "Arctic Ocean history, from speculation to reality," Bremerhaven, Germany, 3–5 November 2008.

Addison, J.A., W.E. Dean and B.P. Finney. 2008. Sedimentary trace metal and stable isotope trends in fjord and shelf environments along the southeast Alaska margin. Oral presentation at Geological Society of America Annual Meeting, 5–9 October 2008. (abstract #181-14)

Addison, J.A., B.P. Finney and J.M. Jaeger. 2008. The Subarctic Northeast Pacific Ocean since the LGM: a natural laboratory for describing decadal- to millennial-scale atmosphere-ocean-ecosystem interactions. Poster presentation at Integrated Ocean Drilling Program (IODP) workshop "Acquiring high to ultra-high resolution records of past climate change by scientific drilling," Potsdam, Germany, 29 September–1 October 2008.

Addison, J.A., N. Misarti and B.P. Finney. 2008. Paleoproductivity of the Northeast Pacific Ocean during the LGM-Holocene transition: evaluating the possible role of the marine ecosystem in the peopling of the Americas. Oral presentation at American Association for the Advancement of Science, Arctic Science Conference, Fairbanks, Alaska, 15–17 September 2008.

Publications

Peer-reviewed

Barron, J.A., D. Bukry, W.E. Dean, **J.A. Addison** and B.P. Finney. 2009. Paleoceanography of the Gulf of Alaska during the past 15,000 years: results from diatoms, silicoflagellates, and geochemistry. *Marine Micropaleontology*, 72:176–195.

Non-peer-reviewed

Addison, J.A. 2009. Tales from the abyss—results from high-resolution studies of past environments in the Gulf of Alaska. *Global Glimpses*, 15(1):8–10. (http://www.cgc.uaf.edu/Newsletter/index.html)

In preparation

Addison, J.A. High-resolution Paleoceanography of the Gulf of Alaska, Subarctic Northeast Pacific Ocean: Insights into a Dynamic Atmosphere–Ocean–Ecosystem Linkage at Decadal Timescales. Ph.D. dissertation, University of Alaska Fairbanks, 220 pp.

Addison, J.A., J.E. Beget, B.P. Finney and T.A. Ager. Marine tephrochronology of the Mt. Edgecumbe Volcanic Field, southeast Alaska. In preparation for submission to *Quaternary Science*.

Addison, J.A., B.P. Finney, T.A. Ager, M.H. Davies, J.M. Jaeger, A.C. Mix and J.S. Stoner. Holocene evolution of the Pacific Decadal Oscillation in the Gulf of Alaska. In preparation for submission to *Science*.

Addison, J.A., B.P. Finney, W.E. Dean, T.A. Ager, M.H. Davies, A.C. Mix, J.S. Stoner and J.M. Jaeger. High-resolution paleoproductivity evidence for Holocene evolution of the Aleutian Low Pressure System from coastal fjords in the subarctic northeast Pacific Ocean. In preparation for submission to *Continental Shelf Research*.

Addison, J.A., B.P. Finney, W.E. Dean, M.H. Davies, A.C. Mix, J.S. Stoner and J.M. Jaeger. Decoupling of the coastal marine ecosystem and glacimarine Cordilleran Ice Sheet dynamics in the Gulf of Alaska during the Last Glacial Maximum/Holocene transition. In preparation for submission to *Paleoceanography.*

Role that this award played in student's degree program

The fellowship award made through CIFAR/IPY was instrumental to this PhD research. It provided stipend support to Addison for two full years, during which time he has: (i) prepared four major peer-reviewed publications for

imminent submission; (ii) co-authored a fifth peer-reviewed article; (iii) presented his work in three international meetings; and (iv) presented his research in several local and national venues. Combined with analytical funding through the National Science Foundation and a student award from UAF Center for Global Change, the CIFAR/IPY funding provided virtually full support for Addison.

International Polar Year (IPY) Student Traineeships:
Monitoring winter body condition of barren-ground caribou from the Bering Sea to the Hudson Bay

Perry Barboza, UA faculty member, PI
David Gustine, UA graduate student
University of Alaska Fairbanks

NOAA Goals: Ecosystem-based Management; Understand Climate Variability and Change

CIPY-10: This project is complete.

Primary objectives
We are investigating the relationship between winter diet and nitrogen (N) balance within and between wild caribou (*Rangifer tarandus*) herds. Our "hands off" method will be used to assess the protein status of each herd in winter. The project is cooperating with communities and local, state, national, and international wildlife agencies to sample wild caribou across North America.

Approach/methodology
- We are using a new isotopic method to assess nitrogen balance from $^{15}N/^{14}N$ ratios in compounds isolated from urine and feces. This method determines the proportion of urea N from body tissue (*p*-UN), which is an index of body protein loss.
- Samples of snow urine and feces have been collected from 5 wintering caribou herds across 3 years (2006–2008).
- We used urine samples to estimate the $\delta^{15}N$ of urinary urea and body N and used residues of plant fiber in feces to estimate the $\delta^{15}N$ of the diet.
- We used microhistology of fecal samples to estimate the composition of the winter diets of caribou for each herd.
- We are examining the effects of year, herd, diet composition, and winter severity on our index of protein status.

Research accomplishments/highlights/findings
We have collaborated with wildlife agencies in Alaska and Canada to collect 2,500 snow urine and fecal samples (approx. 1,250 snow urines and 1,250 fecals) between 2006–2008 from the Western Arctic Herd in northwest Alaska, the Central Arctic Herd in northcentral Alaska, the Chisana Caribou Herd in central Alaska, the Bluenose East Caribou Herd in northcentral Canada, the Teshekpuk Caribou Herd in northwest Alaska, and the Denali Caribou Herd in interior Alaska.

We have now completed all the laboratory work for isolating urinary N metabolites (urinary creatinine and urea nitrogen) and residues of plant fiber in feces from all samples collected in 2006–2008. Estimating diet composition as well as measuring the $\delta^{15}N$ of urinary metabolites is a lengthy process due to the amount of samples; the number of isotopic determinations necessary to estimate the protein status of one animal ($\delta^{15}N$ of urea, of body N, and diet N); the nature of the techniques used to isolate the metabolites (i.e., high performance liquid chromatography and steam distillation); and the unexpectedly slow turnaround times on the both the counts of isotopic ratios using isotope ratio mass spectrometry and estimates of diets from fecal microhistology. These delays, unfortunately, continue to hamper the completion of the analysis and subsequent preparation of the manuscripts for this project. We have, however, submitted one manuscript for internal review from the U.S. Geological Survey (USGS) (*An isotopic approach to measuring nitrogen balance in caribou: the Chisana herd*) and, upon completion of that process, this manuscript will be submitted to the *Journal of Wildlife Management*. We also have preliminary results from the protein status of caribou in the Western Arctic herd from 2006–2008.

The Chisana Caribou Herd

The completed dataset and analysis on the Chisana caribou herd (CCH) has forced us to re-evaluate our approach in estimating and comparing the *p*-UN of the penned and wild caribou. As per our report last year, we initially expected that caribou in the pen were primarily consuming the provided formulated ration, but after examining the relative density of plant fragments in the feces of penned caribou, surprisingly, lichens dominated the diets of the

penned as well as the wild caribou. Consequently, we could not use the pelleted ration as the dietary endpoint of the model to estimate protein status and this greatly affected our approach for analysis as well as our estimates of protein status. We also concluded that because all caribou in the pen were pregnant while caribou in the wild sample represented diverse segments of the population (subadults, males, and non-reproductive females), all of which were experiencing different nutritional trajectories throughout the winter, we could not directly compare the protein status of the penned and free-ranging (or wild) segments of this population. However, except for the predictions between the penned and wild caribou, our previous predictions still hold: 1) the diets of penned and wild caribou would differ in the occurrence of major forage items as well as the $\delta^{15}N_{Fiber}$; 2) the $\delta^{15}N_{Fiber}$ would correspond to the proportion of major forages in the diet; 3) pregnant females in the pen would generally be in positive protein status as a result of supplemental feeding (i.e., gain core body tissue and p-UN < 0.46); and 4) wild caribou would decline in body condition (as reflected by protein status) in the last month of winter (i.e., p-UN in April < p-UN in May).

Indeed, our first two predictions regarding our isotopic proxy of diet ($\delta^{15}N_{Fiber}$) were as we expected: the $\delta^{15}N_{Fiber}$ of wild caribou was more depleted than the $\delta^{15}N_{Fiber}$ of penned animals ($\chi^2 = 11.20$, $P < 0.001$) and the $\delta^{15}N_{Fiber}$ decreased as animals consumed more lichens and increased with consumption of the ration. Conversely, the response by caribou in the pen to the availability of the pelleted ration as well as the change in protein status of wild caribou from April to May was unexpected. Approximately 55 and 54% of the pregnant caribou in the exclosure lost core body tissue and body protein, respectively. Alternatively, caribou in the wild may have improved their protein status from April to May.

The improvement in protein status for wild caribou was likely due to favorable snow conditions and increased availability of forage. Snow cover was reduced on 1–2 May when we collected urine samples, as the tops of tussock vegetation were exposed and we therefore confined our urine collections to river crossings where snow was still deep. Estimated diet composition on 1–2 May corroborated the disappearance of snow. The state of body components, particularly for non-reproductive animals that are not growing, may undergo rapid changes as environmental conditions change from late winter to spring (i.e., increased availability and quality of forage).

An estimate of protein status for one year does not reveal any biological mechanism for why the CCH previously declined, but it does offer insights into contributing factors as well as provide a reference for future monitoring efforts of this small herd. A forthcoming multi-herd and year comparison should provide more insight into nutritional factors that contribute to the low recruitment in the CCH as well as other sedentary, montane-dwelling herds of caribou.

The Western Arctic Herd

The Western Arctic herd (WAH) is the largest barren-ground caribou herd in Alaska (~375,000) with a large annual range that encompasses northwest Alaska. Recently, the herd has undergone a shift in its use of winter ranges and this may be due to deterioration of range quality (K. Joly, National Park Service (NPS), unpublished data). Indeed, the WAH appears to be reaching an ecological carrying capacity because degradation of lichen ranges (Joly et al. 2007) has corresponded with increased adult mortality and reduced population growth rates (Dau 2005). Consequently, we will use the p-UN to examine current protein status of this herd as it relates to winter diets (as indexed by microhistology) and to compare WAH with other herds and ecotypes of caribou in North America. Currently, we only have p-UN estimates for this herd, while estimates of diet composition and winter severity will be incorporated into the more complex comparisons with the other herds.

Approximately 20 snow urine and fecal samples were collected at each site in 2006, 2007, and 2008. Although there was high variation among sites within years (all $P < 0.011$) and the isotope data for 2008 is incomplete (40 of 60 balance sets have been analyzed), there were more individuals in negative N balance in 2006. We suspect the difference among years and sites within years is largely due to variation in diets, which we will be able to confirm with microhistology. Winter severity data is highly localized and doesn't capture variation in snow conditions within a year, so this measure will be more valuable as an annual index for the comparisons across herds.

Implications

These are the first applications of a non-invasive, isotopic approach to assess the protein status of wild caribou and a full evaluation of the approach and implications is pending. However, this non-invasive technique can be applied at various spatial and temporal scales to assess trends in the protein status of free-ranging populations of northern ungulates. At a minimum, estimates of p-UN at the individual level provide a discrete index of condition of caribou populations. The p-UN, as an index of protein status, is currently limited by our inability to estimate the sex and reproductive status from urine samples of the sampled population. Different segments of wild populations of caribou undergo different nutritional demands and trajectories in late winter. Therefore, a technique that could identify reproductive and non-reproductive components of the population would greatly enhance the utility and ecological value of the p-UN. In spite of this limitation, the p-UN is a valuable tool to examine intra- and inter-annual changes in nutrient partitioning for caribou. With further research and validation of model parameters and development of

techniques to identify sex and reproductive status in urine samples, estimates of nitrogen status from isotopes of N will provide a useful nutritional index for populations of caribou. Annual estimates of protein status could help managers increase the efficiency and efficacy of management actions, and prepare stakeholders for potential changes in population trends.

NOAA relevance/societal benefits

This research addresses the central mission of NOAA "to understand and predict changes in Earth's environment… to meet our Nation's economic, social, and environmental needs." This project uses physiological approaches to improve our ability to predict responses of caribou to changes in their environment.

IPY linkages/partnerships/collaborators and networking

Jim Lawler, Brad Shults, and Tom Leibscher, National Park Service; Jim Dau and Steve Arthur, Alaska Department of Fish and Game; Layne Adams, U.S. Geological Survey; Brian Person, North Slope Borough; Don Russell and Wendy Nixon, Canadian Wildlife Service; Mathieu Dumond, Nunavut Wildlife Division.

Education/outreach

Student participation

This project is part of the doctoral research of David D. Gustine, which is scheduled to be completed in Summer 2010. Funds from National Park Service and U.S. Geological Survey were used to support Jennifer Addison (B.S. Wildlife Biology, 2007) and Keely Moon (enrolled in nursing school preparatory courses) as undergraduate technical assistants in the laboratory. Renee Parsley completed parts of the validation work as a project supported by the Murdock Foundation for providing research experience to high school science teachers.

Presentations

Gustine, D.D., P.S. Barboza, L.G. Adams, R. Farnell and W. Nixon. 2009. An isotopic approach to measuring nitrogen balance in caribou: the Chisana herd. Poster at the annual meeting of the Northwest Section of the Wildlife Society, Fairbanks, Alaska, 7–8 April 2009.

Gustine, D.D., P.S. Barboza, L.G. Adams, R. Farnell and W. Nixon. 2009. An isotopic approach to measuring nitrogen balance in caribou: the Chisana herd. Unit Review for Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska Fairbanks, March 2009.

Role that this award played in student's degree program

Establishing partnerships with cooperating scientists from the USGS and the NPS was a valuable contribution to the completion of Gustine's formal education as well as his development as a professional scientist. Ecologists and managers with decades of experience working with caribou in Alaska have been eager to share their expertise with him regarding the acquisition, analyses, and interpretation of these data on the protein status of wild populations of caribou. His relationships with these scientists will continue to develop throughout his career.

Publications

In preparation

Gustine, D.D., P.S. Barboza, L.G. Adams and R. Farnell. An isotopic approach to measuring nitrogen balance in caribou: the Chisana herd. In preparation for submission to *Journal of Wildlife Management*.

References

Dau, J. 2005. Units 21D, 22A-E, 23, 24, and 26A caribou management report. Alaska Department of Fish and Game, Report Project 3.0.

Joly, K., M.J. Cole and R.R. Jandt. 2007. Diets of overwintering caribou, *Rangifer tarandus*, track decadal changes in Arctic tundra vegetation. *The Canadian Field-Naturalist*, 121:379–383.

International Polar Year (IPY) Student Traineeships:
Effects of an arctic biological pollutant on rare Alaskan habitats

Matthew Carlson, UA faculty member, PI ***NOAA Goal: Ecosystem-based Management***
Theresa Rzeczycki, Allison Sayer, UA graduate students
Matthew Sutterer, UA undergraduate student
University of Alaska Anchorage

CIPY-11: This project is complete.

Primary objectives
The primary objective of this project is to test how susceptible steppe–bluff habitat, adjacent woodland, and glacier river habitat are to the invasion of *Melilotus alba* (white sweet clover) and investigate how establishment may impact nutrient cycling. An *ex-situ* experiment is being conducted to determine how successfully *M. alba* seeds collected from central Alaska germinate, grow, and reach reproductive age in substrate samples taken from four different habitat sites (river, road, steppe–bluff and spruce–birch forest) along river and roadsides in the Matanuska River Basin. Physical, biological, and chemical characteristics of each substrate sample and each seed genotype are being monitored over a two-year period. Germination, establishment, growth and reproduction of each genotype are being measured to understand how populations across the state differ in their performance on these four habitats.

Approach/methodology
- Sample substrates from four different sites collected in the same geographic area: river, roadside, steppe–bluff, woodland
- 20 square substrate plugs taken from each site, including controls
- Plugs moved to control site in Anchorage, randomly arranged on south-facing slope
- *Melilotus alba* seeds from 53 individuals collected from along Matanuska River/Glenn Hwy and No Name Creek/Dalton Hwy
- One seed from each plant randomly sown into each flat, with exception of controls
- Soil carbon and nitrogen content, and pH of each plug analyzed at seeding, end of first season, and end of second season
- Germination success, growth, death, flowers and seed set measured over two seasons

Research accomplishments/highlights/findings
- *M. alba* seeds collected, flats seeded, and maintained for 3 seasons
- Combustion analysis of soil samples for carbon and nitrogen, taken at seeding and end of second season to detect *M. alba* contribution to soil; C and N were highest in woodland and steppe, lowest in river and roadside
- Third season die back of all seeds germinated in season 1 (biennial); no seedlings found in river and roadside flats
- Identified all third season plant species in flats; documented species richness and cover over time
- Most germination occurred in river and roadside (31.5%), less in steppe (21.9%), and least in woodland (7%)
- All germination in roadside and river occurred 1st year; in steppe and woodland half 1st year and half 2nd year
- No successful reproduction (seedset) in river and steppe flats; highest reproductive success in woodland
- Both Fairbanks and Matanuska area seeds germinated best on river and roadside; Fairbanks had poorest germination rate on steppe
- High mortality rate of seedlings reduced significant nitrogen fixation input by *M. alba* into sample soils
- Overall findings: germination at river and roadside locations was rapid, but slow growth and insects, high mortality impacted seedset; germination on steppe flats was slow with arrested growth (most <2 cm tall), insects and competition with native cover limited successful reproduction; in woodland areas, germination was slow, growth robust (9 plants 29–95 cm tall), and insects and competition did not factor as heavily in seedset.
- If *M. alba* overcomes factors such as herbivory and plant competition, it may establish successfully in woodland environment; in steppe, slow growth reduced competitive ability of *M. alba* and eventually, it was shaded out; however, in steppe, small and slow growing natives suggest disadvantages may lie below ground.

NOAA relevance/societal benefits

The ability of *Melilotus* to spread downstream and establish on river gravel bars threatens numerous coastal resources. Gathering baseline information about susceptibility of invasion in different habitats found along river systems can be used to model the behavior of this species under various global climate change scenarios to reduce environmental and economic consequences. Data from this project will be archived at the state's non-native plant database at the Alaska Natural Heritage Program.

IPY linkages/partnerships/collaborators and networking

Research is being performed at UAA, with support of the Environment and Natural Resources Institute (ENRI). The Alaska Natural Heritage Program, the ENRI Isotope & Applied Science, Engineering, and Technology (ASET) Labs, and the UAF Palmer Research Center Lab, Norman Harris of the UAF Palmer Research Center and Trish Wurtz of the USDA Forest Service Research Lab. Additional seed collection support from Jeff Conn and Erin Carr of the USDA Fairbanks Agriculture and Research Service, and Blaine Spellman, UAF Master's student. IPY-NSF funded research to M.L. Carlson (UAA) on evolution of floral pigmentation in arctic plants has some relevance to this research: pigmentation and defensive compounds in *Melilotus* are likely linked biochemically as in arctic mustards—the interplay between costs of defense and increased competitive ability is a primary hypothesis for invasive species that needs explicit evaluation.

Education/outreach

Student Participation

Theresa Rzeczycki is pursuing an M.S. in Biology at the University of Alaska Anchorage. Additional student participation involved Allison Sayer, M.S. Biology 2008, who assisted in first-season soil analyses, and Matt Sutterer, an undergraduate student in anthropology, who assisted in second-season analyses.

Publications

None to date.

Role that this award played in student's degree program

The International Polar Year (IPY) Student Traineeship award played a significant role in preparing Theresa Rzeczycki for reaching the goal of her master's research at UAA. The funding provided her with the means to carry out the required voluminous task of field work and analyses. The opportunity given has enhanced her critical thinking skills to formulate a hypothesis and lay a foundation for a larger research project which further takes into account the results and many more questions this research raises regarding the impact *Melilotus* is having on Alaska's natural environment. Also, with the funding available to hire students as support, her skills in delegating tasks with focus on vision to complete a project have been developed. Lastly, discussing her findings with her peers and professionals in the field has allowed her to network and prepare for a career in the field of plant ecology. This funding has been critical to the development of ideas, methodology, data collection and analysis. These data are currently being analyzed and will be integrated into papers to be submitted for publication as well as a thesis.

International Polar Year (IPY) Student Traineeships:
Investigation of the impact of western arctic volcanic eruption on weather and climate

Nicole Mölders, UA faculty member, PI
Morgan E. Brown (now M.B. Yarker) and
Stacey E. Porter, UA graduate students
University of Alaska Fairbanks

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

CIPY-16. This project is complete.

Primary objectives

Large volcanic eruptions have been shown to alter large-scale dynamical and physical processes, which impact climate regionally and globally. Alaska has a plethora of active volcanoes, which may impact small-scale, short-term atmospheric processes even if the eruptions are not very large. Four aspects of volcanic eruptions on local weather were explored: 1) heat release, 2) water-vapor release, 3) change in albedo due to plume ash-fall, and 4) release of aerosols. Statistical methods (Student t-test, f-test, ANalysis Of Variance [ANOVA]) were used to determine which of the four aspects has the greatest impact on local weather during an eruption. Evaluation with

observational data was performed to assess whether routine Weather Research and Forecasting (WRF) model data can be used to drive Lagrangian plume models to determine ash propagation.

Approach/methodology

- Sixteen simulations were performed for January 10 to February 2, 2006 using WRF.
- The WRF simulations without consideration of any volcanic eruption aspects served as reference simulations and for model evaluation.
- The 16 simulations combining the variety of volcanic influences (i.e., heat, water vapor, albedo, and aerosols) were analyzed using various statistical methods to identify which of the four or combination thereof have the most impact on local weather.
- The results of all simulations were evaluated by observations.

Research accomplishments/highlights/findings

- Evaluation of the reference simulation for the region around Mount Augustine showed that WRF produces excellent weather forecasts for the 2006 Augustine eruption (e.g., Brown 2008). Overall, WRF adequately captures the synoptic situation during the eruption. On average, WRF overestimates daily mean temperature (0.1ºK), dew-point temperature (2.8ºK), wind speed (1.1m/s), and underestimates pressure (-1.1hPa), but shows better performance when compared with hourly data. WRF dampens the diurnal temperature cycle with daily maximum and minimum temperature being overestimated by 0.1ºK and 2.1ºK. WRF underestimates cloud existence, but captures cloud distribution well most of the time. WRF overestimates daily accumulated precipitation about 1 mm/d on average, and is slightly off capturing the temporal evolution of precipitation when compared to hourly data. WRF marginally misrepresents the strength of the horizontal pressure gradient. Thus, it generally overestimates wind speed by 1 m/s, but acceptably captures the temporal evolution. Sensitivity studies with volcanic forcing scenarios orientated at previous eruptions and available data from the 2006 eruption indicate no significant differences (at the 95% or higher confidence level) to simulations without volcanic forcing except in the first 30 km or so downwind of the volcano. A paper is in preparation (Yarker, Prakash and Molders).
- WRF captures well the mainly southwest and southeast wind directions that prevailed in the region throughout the episode. On average, WRF acceptably captures the temporal evolution of wind speed, but overestimates wind speed. Generally, WRF performs better for coastal sites than inland sites, likely because of the low elevation and absence of complex terrain at the coast. Over the study period, forecasted and observed temperatures generally agree well, but WRF almost always overestimates temperature. This finding is true for both hourly and daily averages. In the daily temperature fluctuations, WRF forecasts are slightly delayed compared to the observations. This delay may have implications for other variables, such as dew-point temperature, cloud cover and precipitation, which also have delayed trends compared to the observational data. WRF predicted diurnal cycles are also slightly dampened compared to observations. Skill-scores are better for daily maximum temperature than daily minimum temperature indicating that WRF has greater difficulties forecasting the minimum than maximum temperature.
- Air traffic is very sensitive to ash plumes from volcanic eruptions. Thus, National Weather Prediction (NWP) models have been used to drive Lagrangian models that determine the ash plume propagation for regulation and restrictions of air traffic under these dangerous situations. Unfortunately at the time of any eruption the external forcing due to the volcanic eruption is unknown. This study evaluates WRF's performance for a complex, sub-arctic region for the period of the 2006 Augustine Volcano eruption by observations from 22 sites with hourly reported data and 25 sites with daily reported data as well as satellite data to assess the reliability of WRF forecasts during an episode of unknown external forcing from the volcanic eruption. Overall, WRF shows very good performance skills when compared with previous model evaluation studies of WRF and other state-of-the-art NWP models. Though WRF may not always simulate the values correctly, it captures the trends very well. In conclusion, this evaluation study shows that WRF is well suited to be used in this sub-arctic region even when moderate unknown volcanic forcing may exist due to a volcanic eruption within the region. The results also suggest that a way to reduce random error and improve the forecast in the area of interest is to locate the boundaries of the model as far away from the area of interest as possible with respect to affordable computational time and turnaround. This means that NWP models intended to provide driving data for Lagrangian ash plume models should be best located with the volcano of interest in the center.
- All simulations were analyzed using ANOVA. The results show that independent consideration of aerosol release, water vapor release, and heat release significantly impacted the weather for the region during the volcano eruption. Interactions between water vapor and aerosol release, heat and aerosol release, aerosol release

and ash fall, and heat and water vapor release significantly impacted the weather for the region during the volcano eruption.

- The impact of volcanic eruptions on local weather and the temporal and spatial cloud and precipitation distributions depends on the emission strength, (combination of) volcanic factors, interaction among impacts of factors if they occur concurrently, and the broader synoptic-scale meteorological environment. ANOVA shows that the assumed volcanic scenarios have the greatest statistically significant (at 95% or higher confidence level) impact on clouds and precipitation on relatively humid days.
- Observational and further theoretical work is required to gain understanding of the full range of interaction of effects in response to the various volcanic factors processes in more complex scenarios than the hypothetical simplified scenarios assumed here.

NOAA relevance/societal benefits

The work has been relevant to NOAA's goals and missions of improving weather forecasts. The results are relevant for NOAA and CIFAR as they elucidate the impact of volcanic eruptions in the western Arctic on weather and climate, and they may contribute to assessing uncertainty in numerical weather prediction. Large volcanic eruptions have an overwhelming impact on society (closure of airports, vog [volcanic smog], evacuation, limitations of surface traffic, etc.) and the atmosphere (additional cloud condensation nuclei, radiative effects, acid precipitation, etc.). The work has helped to evaluate and synthesize knowledge on weather prediction and volcanic eruptions that may enhance our understanding of climate variability, climate change, and aerosol–radiation feedback and their consequences.

Furthermore, the project has helped to educate the next generation of scientists by supporting two graduate students. Both students graduated and went on for a Ph.D. in atmospheric sciences (S.E. Porter) and science education (M.E. Brown, now M.B. Yarker).

IPY linkages/partnerships/collaborators and networking

The Alaska Volcano Observatory (AVO) gave access to the satellite data required to include heat release realistically. The Arctic Region Supercomputing Center (ARSC) provided computational resources. Further networking has existed within the Geophysical Institute (GI) and International Arctic Research Center (IARC) with colleagues who work either with WRF or on IPY-related projects, aerosol or volcanic research. Using the WRF model also has fostered connections with colleagues at the National Weather Service (NWS; T. Fathauer), NOAA (G. Grell) and National Center for Atmospheric Research (NCAR). The project also led to collaboration with A. Prakash and R. Gens from the remote sensing group and the Alaska Satellite Facility.

Education/outreach

Student participation

The project provided Morgan E. Brown (now M.B. Yarker) and Stacy E. Porter, graduate students in the Department of Atmospheric Sciences' (DAS) M.S. program with experience in atmospheric numerical modeling. Some of this work has been part of Brown's M.S. thesis (Brown, 2008).

Stacy E. Porter has worked on sensitivity studies related to interesting aspects that came up in the analysis and by recent eruptions. Thus, this project provided her experience with atmospheric numerical modelling and analysis techniques.

Nicole Mölders has organized a bi-weekly Atmospheric Science Informal Seminar where results from this project were also presented. This seminar has been well attended by students from the Atmospheric Sciences Department. She presented some aspects of this work within the framework of the Geophysical Institute's Research Experience for Undergraduates (REU) outreach activities and at the Science Teacher Education Program (STEP).

Presentations

None during this reporting period.

Publications

Theses

Brown, M.E. 2008. Impact of Local External Forcing of the 2006 Augustine Volcano Eruption on Regional Weather Conditions. M.S. Thesis, University of Alaska Fairbanks. 123 pp. http://www.gi.alaska.edu/~molders/MEBrown_Thesis.pdf

Porter, S.E. 2009. Investigation of the Impact of Ship Emissions on Atmospheric Composition and Deposition into Remote, Coastal Landscapes of Southwest Alaska. M.S. Thesis, University of Alaska Fairbanks. 112 pp. http://www.gi.alaska.edu/~molders/porter_final_thesis.pdf

Non-peer-reviewed

Mölders, N., **M.E. Brown** and **S.E. Porter**. 2009. Investigation of the impact of western arctic volcanic eruption on weather and climate. Final report. 16 pp. http://www.gi.alaska.edu/~molders/FY09-CIPY-16_Molders.pdf

In preparation

Yarker, M.B., A. Prakash and N. Mölders. Evaluation of the Weather Research and Forecasting Model (WRF) for the period of the 2006 Augustine Volcano Eruption.

Yarker, M.B., C.F. Cahill, J. Dehn, D. PaiMazumder and N. Mölders. A theoretical case study on potential impacts of emissions from high-latitude moderate volcanic eruptions on cloud and precipitation formation.

Role that this award played in students' degree program

This award helped two graduate students to get experiences in numerical modeling, evaluating model data, performing and interpreting sensitivity studies, and to gain experience in presenting research results to peers at conferences and workshops. It helped the students of Mölders' research group to be linked to and involved in IPY activities and to participate in this once in a lifetime adventure. The students learned more about IPY and its relevance than they would otherwise have done.

International Polar Year (IPY) Student Traineeships:
Adaptation to cold in the far north

Diana Wolf, UA faculty member, PI
Jessica Beecher, UA graduate student
University of Alaska Fairbanks

NOAA Goals: Ecosystem-based Management; Understand Climate Variability and Change

CIPY-20: This project is complete.

Primary objectives

The student, Jessica Beecher, is looking for latitudinal differences in cold tolerance within *Arabidopsis lyrata kamchatica* using genetic as well as physiological tools. This may allow a better understanding of the overall differences within this species, which ranges from 35°N to 65°N latitude. This comprehensive approach should allow the student to address the following questions: 1) Is there a latitudinal cline in cold tolerance in *A. l. kamchatica*? 2) Is there a latitudinal cline in CBF (C-repeat binding factor) expression? 3) Does a change in the expression of the CBF gene play a role in allowing plants to adapt to extreme cold?

Approach/methodology

1. DNA sequencing of CBF genes in *A. l. kamchatica*
2. Comparison of CBF gene sequences to neutrally evolving genes to look for patterns of selection
3. Measure gene expression levels for CBF genes in populations using Quantitative PCR (polymerase chain reaction)
4. Comparison of damage due to cold exposure using electrolyte leakage measurements (a non-lethal assay of freeze damage) for different populations
5. Common garden experiment in Fairbanks to determine if populations are locally adapted by comparing year-long survival, growth, and seed production

Changes to the original proposal:

- The reciprocal transplant experiment will be replaced with a Fairbanks over-winter common garden with three populations and, depending on germination, 180 plants per population in 2008.

Research accomplishments/highlights/findings

- Plants from one southern Canadian and two Alaskan populations were grown and over-wintered in a common garden experiment. There were differences in fitness among populations ($p<0.005$) but not in over-winter survival.

- Freeze damage, quantified by measuring electrolyte leakage, has been measured in plants from three populations before and after cold acclimation; as well as plants from four other *Arabidopsis* species.
- Electrolyte leakage assays of non-acclimated plants suggest that northern populations are better adapted to the cold than southern populations. In summer growing conditions southern plants are significantly more damaged by cold temperatures than northern plants ($p<0.005$, $\Delta lnL=310.60$).
- After acclimation, freeze damage was tested in plants using a much colder range of temperatures (-5 to -30ºC), this range includes the coldest temperatures the plants are likely to experience in nature under the snow. The freeze damage from these plants also suggests that the three populations also have differing amounts of damage after acclimation ($p<0.005$, $\Delta lnL=408.24$). The north-most population unexpectedly had more freeze damage than the southern Alaska population. This may be attributed to the fact that this population is at the edge of the range, but this will require further study.
- There may be genetic variation in freeze tolerance within these populations (seen as a family effect $p<0.005$, $\Delta lnL=27.22$).
- With the assistance of UAF doctoral student Todd Sformo, non-acclimated and over-wintering plants were tested for the presence of anti-freeze proteins. Solute levels were also measured. There was no evidence for *A. kamchatica* having anti-freeze proteins. However, summer plants had much lower solute levels than winter acclimated plants ($p=0.0001$, $t = 8.7863$), indicating that solutes play a significant role in the over-wintering strategy of *A. kamchatica.*
- Three gene copies for the CBF genes were successfully amplified in both genomes in the polyploidy species *A. kamchatica.* Currently, these sequences are being analyzed and will be used to develop QPCR primers for expression analysis.

NOAA relevance/societal benefits

In the face of changing global climates, plants must be able to adapt to new conditions or suffer extinction. This work may be helpful for determining the potential of this and other cold-adapted species to withstand the rapid climate changes which are currently occurring in Alaska and other northern regions.

IPY linkages/partnerships/collaborators and networking

No linkages established yet.

Education/outreach

Student participation

Master's student Jessica Beecher is working on this project.

Outreach

- Beecher has been involved in mentoring for the Rural Alaskan Honors Institute program and study groups for the Alaskan Native Science and Engineering Program (ANSEP) since 2007. This has allowed her to develop mentoring skills as well as sparking an interest in a career in science with young students. She now coordinates 15–20 weekly study groups and is responsible for recruiting new study group leaders.
- Beecher was also one of five graduate students organizing a semester-long seminar series for research related to the EPSCoR research focus areas. The goal for this seminar series was to promote discussion and interaction among faculty, students and post-docs. The series featured talks from internationally renowned researchers (Anne Yoder, Lacey Knowles, and John Avise) who were selected by the graduate students and post-docs from the Biology and Wildlife Department.

Presentations

Beecher, J., D. Wolf and N. Takebayashi. 2008. Is there a latitudinal cline in cold tolerance in *Arabidopsis lyrata* subspecies *kamchatica*? Poster presentation at Botany Meeting, University of British Columbia, BC, Canada, July 2008.

Beecher, J., D. Wolf and N. Takebayashi. 2009. Is there a latitudinal cline in cold tolerance in *Arabidopsis kamchatica*? Talk given at AAAS Arctic Division Meeting, Juneau, Alaska, 14–16 September 2009.

Publications

None to date.

Role that this award played in student's degree program

This fellowship allowed Beecher to make significant progress on her graduate project that would not have been otherwise possible. During this award, she was able to collect much of the physiological data for her project. She was also able to start to collect the genetic data necessary for Quantitative PCR, which will allow her to complete

her Master's thesis. She was also was able to give much back to the community via the seminar series she helped to organize and the study groups she coordinated; this would not have been possible if she were to have other time obligations such as a teaching assistantship. She has also been able to present her research in poster format at two conferences and will be giving a talk related to the work she did while funded by the CIFAR IPY traineeship at the 2009 AAAS Arctic Division meeting in Juneau in September.

International Polar Year (IPY) Student Traineeships:
Undergraduate involvement in studies of adaptive and neutral genetic variation in Alaskan species sensitive to global climate change

David Tallmon, UA faculty member, PI
Brenda Bruggeman, Amina Ashraf, Micaela Ponce, and other UA undergraduate students
University of Alaska Southeast

NOAA Goals: Ecosystem-based Management; Understand Climate Variability and Change

CIPY-23: This project is complete.

Primary objectives

Among the most critically important and least understood aspects of rapid climate change is how it will alter the biological diversity upon which all human societies depend for food, shelter, and economic well-being. Biodiversity in polar regions will change due to rapid warming, but determining which species will go extinct or adapt is fraught with uncertainty. An important component of within-species biodiversity—the very essence of what allows a species to persist—is the distribution of neutral and adaptive genetic variation. My collaborators and I seek to engage undergraduates in genetic investigations of Alaskan species likely to be impacted by global climate change.

Approach/methodology

We actively engaged undergraduates in the field, lab, and analytical research. Primarily, students have been involved in the lab generating genotypes from species likely to be affected by global climate change. Six students have been involved in genetics lab projects. However, we have also given students opportunities to work on research projects in the field; three of the students who worked in the lab have also worked with us in Glacier Bay National Park and in Auke Creek.

Research accomplishments/highlights/findings

Our best result comes from the study of ringed seals, which is an important subsistence species and largely dependent upon Arctic ice for breeding. We have found evidence that ringed seal populations are not genetically subdivided, but, rather, appear to have large amounts of gene flow among populations. This suggests that high rates of movement of seals among populations will help maintain genetic diversity within populations and provide resilience to these populations in the face of future sea ice loss. We are developing these results into a published manuscript on which UAS graduate Micaela Martinez-Bakker (formerly Micaela Ponce) will be a co-author.

We have also begun to quantify the adaptive value of substrate matching and predator avoidance behaviors by coastrange sculpins that successfully colonize recently deglaciated habitats, using mark-recapture and lab experiments. In addition, we have conducted field and lab studies to examine whether sculpins that adjust their color to match novel backgrounds have higher survival rates. This will provide insights into the importance of phenotypic plasticity in the adaptation of organisms to recently deglaciated habitats. Finally, we have also sequenced candidate genes involved in vertebrate coloration plasticity, which will allow us to determine whether variation in gene sequences or gene expression contribute to variation in coloration of populations. We will use these data in our next NSF proposal.

We have examined 5 microsatellite loci to determine the population structure of Alaska red king crab. Thus far, our results suggest there is little divergence among red king crab populations. This has important implications for efforts to boost diminishing red king crab numbers through artificial propagation. UAS undergrad Tyler Linderoth has worked on this project and may be a co-author if he continues.

NOAA relevance/societal benefits

Our research will improve our ability to predict responses of organisms in a wide range of coastal marine and terrestrial environments to global climate change.

IPY linkages/partnerships/collaborators and networking

We have forged collaborative research partnerships with Brad Swanson, Central Michigan University and with Glacier Bay National Park. In addition, we have set up a collaboration with Andrew Whiteley at the University of Massachusetts–Amherst to work on sculpin genomics.

Education/outreach

Student participation

Amina Ashraf, received B.S. in Biology from UAS. Now at Cleveland Clinic as lab tech.
Jon Barton, pursuing B.A. in Biology at UAS.
Brenda Bruggeman, received B.A. in Biology from UAS. Now employed as chemist.
Kari Dammerman, pursuing B.S. in Marine Biology at UAS.
Britany Gonzalez, received B.A. in Biology from UAS.
Brandon Howard, pursing B.S. in Biology at UAS.
Tyler Linderoth, pursuing B.S. in Marine Biology at UAS.
Micaela Martinez-Bakker (formerly Ponce), received B.S. in Marine Biology and Math from UAS in Spring 2009—Magna Cum Laude in both. Now at University of Georgia as lab tech.

Presentations

Ponce, M.E., B.P. Kelly and D. Tallmon. 2008. Impact of climate change on ice-associated seals: Breeding site fidelity and philopatry in ringed seals (*Phoca hispida*). Poster presentation at Ecological Society of America Annual Conference, Milwaukee, Wisconsin, 5 August 2008.

Vulstek, S., **T. Linderoth** and D.A. Tallmon. 2009. Red king crab genetic mating system. Poster presentation at the Lowell Wakefield Symposium, Anchorage, Alaska, 13 March 2009.

Dammerman, K. 2009. Coastrange sculpin (*Cottus aleuticus*) of Glacier Bay National Park. Poster presentation at EPSCoR All-Hands Meeting, Anchorage, Alaska, 13–15 May 2009. Received $1000 award for best undergraduate poster.

Martinez-Bakker, M., B.P. Kelly, S. Sell, B. Swanson and D. Tallmon. 2009. Population structure of an Arctic ice seal: Support for conservative management. Oral presentation at 89th Annual Meeting of the American Society of Mammalogists, University of Alaska Fairbanks, Fairbanks, Alaska, 24–28 June 2009.

Dammerman, K., C. Bergstrom, and D. Tallmon. 2009. Substrate color preference and adaptive coloration in two populations of freshwater coastrange sculpin (*Cottus aleuticus*). Oral presentation at Joint Meeting of Ichthyologists and Herpetologists: 89th Annual Meeting of the American Society of Ichthyologists and Herpetologists, Portland, Oregon, 22–27 July 2009.

Publications

Non-peer-reviewed

Kelly, B.K., **M.E. Ponce**, D.A. Tallmon, B.J. Swanson and S.K. Sell. 2009. Genetic diversity of ringed seals at breeding sites: implications for population structure and sensitivity to sea ice loss. North Pacific Research Board Final Report, Project 631.

International Polar Year (IPY) Student Traineeships:
Retrospective study of sea ice, marine and human system interactions in the North Pacific and Western North American Arctic

Maribeth S. Murray, UA faculty member, PI
Jennifer I.M. Newton, UA graduate student
University of Alaska Fairbanks

NOAA Goal: Understand Climate Variability and Change

CIPY-27: This project is complete.

Primary objectives
Murray's IPY project builds on currently funded research designed to explore the connections between marine ecosystem change, human activities, climate, contaminants (Hg), and agents of change (AOC) in the Gulf of Alaska (GOA). The IPY project expands the research geographically—north of the GOA into the coastal regions of the Bering, Chukchi and Beaufort Seas. Potential sources of data (archaeological, meteorological, historical) will be identified and located, their suitability for applying new analyses/re-analyses (quantitative, biochemical, and qualitative) assessed, analyses will be conducted where feasible, and synthesis of results bearing on the feedbacks among several important components of the Arctic system (sea ice, marine vertebrates, people, and climate) through the Holocene, begun. Newton's Ph.D. research, reported on here, focuses on the use of historical documentary records to supplement and lengthen the instrumental record of climate, to explain changes in pre-contact, late prehistoric Alaska Native settlement locations. These historical sources can provide high resolution information on particular conditions in certain locations at identifiable points in time. Such data are relevant for the reconstruction and quantification of historical-era daily, seasonal and annual variation in ice and weather conditions, and for understanding of human responses to changes in conditions at local scales over the short term.

Approach/methodology
- Locate and evaluate potential sources of new data bearing on climate, sea ice, marine ecosystems, marine fauna, and people, from historical archives compiled over the past 300–400 years during the process of arctic exploration and development for descriptive, scientific and commercial purposes.
- Extract qualitative and quantitative information from those historical documentary records.
- Content and historical source analysis of the selected archival material and especially of narrative records of English-language ships' logs from expeditions to the Bering, Chukchi and Beaufort Seas.

Research accomplishments/highlights/findings
- Newton has completed collecting historic narrative data on sea ice conditions in the Bering, Beaufort and Chukchi seas from archival repositories at the Scott Polar Research Institute. The focus has been on British Naval records.
- Data analysis is currently underway.
- The project database currently contains hundreds of records of air temperature, wind direction and strength, precipitation, atmospheric observations, sea temperature fauna, Alaskan Natives, other ships, and general comments on natural phenomena.
- The data are being incorporated into a long-term study of changing environmental conditions in the region, including extending the baseline for many categories of information, including at the ecosystem level.

NOAA relevance/societal benefits
Murray's IPY project, including Newton's doctoral research, contributes to efforts to describe and understand the state of the climate system through integrated observations, analysis, and data stewardship, as the project integrates suites of comparatively unstudied climate data with palaeoecological and anthropological data and draws these together in a single venue for synthesis.

IPY linkages/partnerships/collaborators and networking
Newton has made strong working connections at the Scott Polar Research Institute. In addition, through the Association of Polar Early Career Scientists (APECS) she will be connecting with young scholars engaged in similar work. The larger project of which Newton is a part involves collaboration among researchers in Canada, Denmark, and the USA. Newton has also established a good working relationship with researchers in Ethnography, History

and Archaeology at the Danish National Museum and she will evaluate archival materials in those collections in order to supplement the data collected under this award.

Education/Outreach

Student participation

Jennifer I.M. Newton is pursuing a Ph.D. in Anthropology at the University of Alaska Fairbanks.

Presentations

Murray, M.S. and **J.I.M. Newton**. 2008. Human response to recent sea-ice and climate system changes. Arctic Observation Integration Workshop, Palisades, New York, 17–20 March 2008. [not reported last year]

Planned

- Presentation/poster for the upcoming State of the Arctic meeting (16–19 March 2010, Miami, Florida)
- Synthesis data publication for appropriate publication – possibly Climatic Change, of Ecology and Society
- Data generated will be used to supplement a planned NSF proposal for fall 2009

International Polar Year (IPY) Student Traineeships:
Cultural identity, geographical attachment, and indicators of behavioral health among Alaska Native students

Robert J. Boeckmann, UA faculty member, PI
Alice Smith and Lily Jordan, UA undergraduate students
University of Alaska Anchorage

NOAA Goal: Understand Climate Variability and Change

CIPY-31. This project is complete.

Primary objectives

We have aimed to develop a better understanding of how Alaska Native people are responding to cultural changes in their communities. Because of the intimate connection between Alaska Native cultural practice and the geography of Alaska we aimed to examine interrelations between their sense of connection to the land, sense of identity, cultural practice, social dynamics in their communities and indicators of behavioral health. IPY funding was used in part to add to and clean an existing data set examining these variables. To facilitate communication and collaboration between scholars with similar objectives, we sought to present the findings of our research at a national conference. We also sought to design a follow up survey that would include measures of resiliency and suicide risk indicators in addition to a selection of the promising variables from the first study. Finally we planned to collect data from Alaska Native students using this revised survey and analyze it with the goal of presenting the research and publishing it at a later date. The long term aim and application of these research projects is to contribute to better interventions to aid individuals and communities in developing and maintaining resilient responses to rapid cultural changes brought about by contact with other cultures as well as the ongoing and profound climatic and ecological changes going on throughout the Arctic region. Finally, through this project an Alaska Native student, Alice Smith, was mentored into engagement in graduate level scholarship.

Approach/methodology

- Survey One: Developed self report survey consisting primarily of the following variables: demographics, Alaska Native heritage (e.g., Yupik, Tlingit, etc.), strength of identity, strength of connection to land, importance and frequency of interaction with role models, cultural practice indicators, and self esteem.
- Recruited Alaska Native students to add to existing data set and replace incomplete data records.
- Use SPSS to evaluate inter-correlations between measured variables.
- Present findings at a conference using PowerPoint and summary provided by Microsoft Word document.
- Survey Two: Reviewed research literature on construct of resilience and worked on conceptualizing this variable in terms of social dynamics and community functioning/adaptation. Reviewed research literature and consulted with academics on assessing suicide risk in culturally appropriate ways. Developed draft of survey incorporating aspects of survey one and new variables and drafted Institutional Review Board (IRB) proposal.
- Consulted with director of Native Student Services about developing a random sample of all Alaska Native students at UAA for recruitment.
- **Survey Two Implementation**: In fall of 2008 a new undergraduate student, Lily Jordan (also an Alaska Native), was recruited to assist with the implementation of the second survey.

- After final revisions the survey was submitted to the Institutional Review Board at UAA. The IRB required several changes to materials and protocol. Revisions were made and approval given to conduct research.
- The primary change in the protocol was the requirement that research participants provide their data at a given time and location where a clinical psychologist could offer counseling support in the event that completing the suicide risk measure or survey questions about cultural change (associated with climate change) brought up troubling emotions.
- Alaska Native Students were recruited from classes and via a mailing conducted by the Native Student Services office. Native Student Services generously contributed the funds to mail out some 500 reply paid envelopes.
- Regrettably only a total of 10 participants came to the 10-hour-long data collection sessions scheduled from March 18th through April 10th.

Research accomplishments/highlights/findings

- As noted above in "Survey Two Implementation", a revised protocol was submitted to the IRB for a second consideration. Additional revisions were required and after those revisions were evaluated we were given approval to conduct research.
- With the financial and administrative assistance of Native Student Services at UAA we were able to send out recruitment messages to 500 Alaska Native students. To our disappointment and surprise very very few participants responded to our recruitment. We collected data from 10 research participants.
- Data analysis was not conducted as the sample size was considered too small to produce reliable results. We discussed possible reasons why response to recruitment efforts was so poor. Our primary conclusions were 1) that answering a survey about suicide risk may have been stigmatizing for students who had to make a public appearance to complete the survey; 2) the location (in the psychology computer laboratory) may have been inconvenient; and 3) the time of year (mid March to mid April) may not have been the best time of the school year for conducting the research.
- This fall (without the aid of funding from CIFAR) we will continue the research with the support of Native Student Services. We will also seek revisions to our protocol and seek approval from the IRB once again. These revisions to protocol are aimed at reasons 1 & 2 identified above.
- If successful we will collect data using the same survey materials and add the new data to the existing 10 data points. Provided we can increase sample size to a minimum of 30 participants (we are hoping for 50 or more) we will analyze the data as originally intended.

NOAA relevance/societal benefits

By elucidating the important role of cultural practice (including subsistence fishing) in Alaska Native identity and behavioral health we believe we can draw attention to the role stewardship of the coastal environment and maintenance of traditional ways can play in aiding Alaska Native communities in maintaining and enhancing behavioral health.

IPY linkages/partnerships/collaborators and networking

In May 2007, Alice Smith met with researchers at the Indigenous Studies conference in Norman, OK who are interested in research with Canadian Indigenous / First Nations groups. She established informal ties with these researchers. Smith also collaborated with Kathy Graves and Boeckmann on examining the Social Transitions of the North (STN) data set. Graves is now the director of behavioral health for the Alaska Native Tribal Health Consortium. At the time of the collaboration she was a University of Alaska IPY postdoctoral fellow at UAA.

Education/outreach

Student participation

Alice Smith completed her B.A. in Psychology in Fall 2007. She is now working but intends to apply to the UAF / UAA joint Ph.D. program in Clinical and Community Psychology with a Rural and Indigenous emphasis. Lily Jordan, UAA undergraduate student, is working toward a B.A. in Psychology and participated in this project in 2008.

Presentations

The results of our first survey and research protocol and data collection efforts involving the second survey were reported here:

Morales, R., R.J. Boeckmann, **A. Smith** and **L. Jordan**. 2009. Cultural change: Native traditions, Alaska Native identity, self worth and reasons for living. Paper presented at the Alaska Native Health Research Conference, Anchorage, Alaska, March 2009.

Publications

None to date. In May 2007 Smith presented "Correlates of Alaska Native Identity and Self Esteem: Tradition and Place in Times of Change" at the "What's next for Native American and Indigenous Studies?: An International Scholarly Meeting" at the University of Oklahoma, Norman. We plan to write up this research for publication.

International Polar Year (IPY) Student Traineeships:
Do arctic vertebrates defend bone mineral stores during hibernation?

Brian Barnes (UAF) and Ian van Tets (UAA), UA faculty members, PIs
Kalb Stevenson, UAA/UAF graduate student and
Jeffery Mayfield, UAF undergraduate student
University of Alaska Fairbanks/Anchorage

NOAA Goal: Understand Climate Variability and Change

CIPY-33: This project is complete.

Primary objectives

The mammals of arctic and subarctic Alaska employ a variety of different mechanisms to survive the winter. Some species employ true hibernation, some use prolonged but shallower periods of torpor to conserve energy and some maintain a constant body temperature year round. Hibernation is a 5–7 month period of inactivity during which an animal's metabolic rate is severely decreased and no food is consumed. Therefore, maintenance of energy, nutrient, and mineral levels in hibernators is very important. As climate changes in arctic and subarctic regions, nutrients and minerals may change in their availability or accessibility immediately prior to or following hibernation seasons, which could affect the survival and breeding strategies of different hibernating populations. Prolonged inactivity could lead to a loss of minerals from bone or, alternatively, hibernators may have active processes that protect bone mineral density (BMD). There are conflicting reports about whether bone mineral composition changes during hibernation among various vertebrate species. Our aim was to use dual-energy X-ray absorptiometry (DXA) to measure changes in the BMD of a hibernating species, the arctic ground squirrel (*Spermophilus parryii*) and of a species that uses torpor to conserve energy in winter, the black bear (*Ursus americanus*) and to compare the results for these species with earlier measurements from an Alaskan species that maintains a constant high body temperature year-round, the northern red-backed vole (*Myodes rutilus*). Our intent was to improve the current understanding of the effect of hibernation on the bone density levels of arctic and sub-arctic mammals and our ability to assess the likely effects of climate change on bone maintenance in these species.

Approach/methodology

We used as study animals two species that were also subjects of other studies in hibernation physiology at UAF: Arctic ground squirrels and black bears.

Arctic Ground Squirrels

Approximately 50 Arctic ground squirrels (*Spermophilus parryii*) were captured in interior Alaska and were held in UAF animal quarters. We used DXA to measure pre-hibernation measurements of mass and femur BMD in August 2007. They were then euthanized after 30, 60, 90, or 120 days into hibernation, and a second set of measurements were taken. We also measured non-hibernating squirrels as a control.

Black Bears

We used DXA to measure the early hibernation BMD of four captive black bears (*Ursus americanus*) at UAF in October/November 2007 and took a second post-hibernation measurement from each bear when they were euthanized in Spring of 2008.

Research accomplishments/highlights/findings

- We found that, while both squirrels and bears lost body mass during hibernation, their BMD either remained constant (squirrels) or decreased very slowly (bears). This is in contrast to our earlier findings on northern red-backed voles whose BMD decreased substantially and predictably over the winter.
- These results suggest that bone mineral loss is reduced by hibernation, presumably as a result of reduced metabolic activity and that the deeper hibernation pattern employed by arctic ground squirrels reduces any such loss to the extent that it is undetectable.

NOAA relevance/societal benefits

This research benefits NOAA and/or wider society in two ways:

1. It tested and confirmed the applicability of Dual Energy X-ray technology to studies of bone mineral density in two ecologically and physiologically interesting Alaskan species. That is, it successfully applied relatively new technology in a new way to document natural variability.
2. It identified differences in the effect of over-wintering on mammal species that employ different over-wintering strategies: deep hibernation (arctic ground squirrels), shallow hibernation / winter sleep (black bears), and constant winter body temperature (northern red-backed voles). Each of these strategies is used by multiple species in Alaska. From the perspective of bone mineral defense, long, cold winters currently favor true hibernators over non-hibernators. If the current warming trend in the arctic continues, that advantage will be progressively reduced.

Education/outreach

Student participation

Kalb Stevenson—Ph.D. student (UAA/UAF)

Jeff Mayfield—B.S. student (UAF)

Trixie Lee, collaborator/participant—Ph.D. student (UAF)

Don Young Chon, collaborator/participant – high school student (East Anchorage High School)

Presentations

Mayfield, J.M., **K.T. Stevenson**, T.N. Lee, I.G. van Tets and B.M. Barnes. 2008. Bone mineral density is conserved during hibernation in arctic mammals. American Association for the Advancement of Science (Arctic Division) annual conference, Fairbanks, Alaska, 15–17 September 2008.

Mayfield, J.M., **K.T. Stevenson**, T.N. Lee, I.G. van Tets and B.M. Barnes. 2009. Bone mineral density is conserved during hibernation in arctic mammals. Society for Integrative and Comparative Biology annual conference, Boston, Massachusetts, 3–7 January 2009.

Mayfield, J.M., **K.T. Stevenson**, T.N. Lee, I.G. van Tets and B.M. Barnes. 2009. Bone mineral density is conserved during hibernation in arctic mammals. American Society for Mammalogy annual meeting, Fairbanks, Alaska, 24–28 June 2009.

Publications

Peer-reviewed

Stevenson, K.T., I.G. van Tets and D.Y. Chon. 2009. Making no bones about it: Bone mineral density changes seasonally in a nonhibernating Alaskan rodent. *Journal of Mammalogy,* 90(1):25–31.

Submitted

Stevenson, K.T., **J.D. Mayfield**, T.N. Lee, I.G. van Tets, B.M. Barnes and Ø. Tøien. Effect of hibernation on bone density in arctic ground squirrels (*Spermophilus parryii*) and American black bears (*Ursus americanus*). Submitted to *Physiological and Biochemical Zoology*.

Role that this award played in students' degree programs

- J. Mayfield graduated with a bachelor's degree in biology from UAF in December 2008.
- K. Stevenson plans to graduate with his Ph.D. in biological sciences through the joint UAA/UAF Ph.D. program in August 2009. One of the research chapters in his doctoral thesis was based upon work supported by this grant.
- D.Y. Chon graduated from high school in 2008 and is now an undergraduate student at UAA. He is enrolled in a B.S. degree (Biology) program and is supported by a competitive scholarship.

International Polar Year (IPY) Student Traineeships:
Sea-ice use during IPY 2007–2008: Exploring past and present local activities through research and education and outreach in Barrow and Wales, Alaska

Hajo Eicken, UA faculty member, PI
Matthew Druckenmiller, UA graduate student
University of Alaska Fairbanks

NOAA Goals: Understand Climate Variability and Change; Serve Society's Needs for Weather and Water Information

CIPY-34: This project is complete.

Primary objectives

This project is funding Druckenmiller's contribution to a component of an IPY project led by Eicken, entitled "The State of the Arctic Sea Ice Cover: An Integrated Seasonal Ice Zone Observing Network (SIZONET)." In addition to sampling sea-ice state variables, this work is guided by the concept of sea-ice system services (SISS). By assessing the nature and extent of SISS, an integrated observation network can be built that leads to prediction of key trends in a changing Arctic in a way that provides maximum benefit to stakeholders. Druckenmiller's role is to explore the two-way connection between local and traditional knowledge (LTK) and observations of Iñupiat sea-ice experts and western scientific studies of the sea ice.

Approach/methodology

1. Document the Barrow spring whaling trail networks using differential GPS and local interviews and perform analysis in the context of satellite imagery, coastal radar data, thickness surveys, and photography.
2. Compile information about past ice, weather, and whaling conditions from previous studies, historical text, and local interviews.
3. Compile Iñupiaq words for sea-ice and conduct a comparative sea-ice photography project in Wales using present day photos and historical photos from the Alfred Bailey Collection taken in the 1920s.

Research accomplishments/highlights/findings

- Performed sea-ice thickness surveys of the landfast ice off both Barrow and Wales in 2008 and 2009 using an electromagnetic induction sounding device. These datasets, along with coastal radar, satellite imagery, and local observations, are critical for this research which is characterizing the stability of landfast sea ice throughout winter and spring.
- From 2007 through 2009, collected GPS and ice thickness data along the ice trails used by Barrow whalers in springtime during their traditional bowhead whale hunt from the ice edge. Performed interviews with hunters about ice conditions and how these relate to on-ice travel, safety, and hunting success. Maps of the ice trails were produced and distributed to the Barrow community for assistance with navigation and search and rescue.
- Coordinated with and interviewed local sea-ice observers in both Barrow and Wales.
- Performed the interview component for the comparative sea-ice photography project in Wales and assisted with the editing of the Wales Iñupiaq Sea Ice Dictionary.

NOAA relevance/societal benefits

This project addresses the following NOAA mission goals: (1) understand climate variability and change to enhance society's ability to plan and respond, and (2) serve society's needs for weather and water information. The particular value of Druckenmiller's approach to these goals lies in his comprehensive examination of both LTK and western science to provide information relevant to stakeholders.

IPY linkages/partnerships/collaborators and networking

The majority of the research conducted thus far in regards to LTK and whaling trail documentation has been done in close collaboration with Igor Krupnik (cultural anthropologist, Smithsonian Institution) and his IPY project "Sea-Ice Knowledge and Use (SIKU)" and Craig George (wildlife biologist, North Slope Borough Department of Wildlife Management), respectively.

Education/outreach

Student participation

- Druckenmiller is pursuing a Ph.D. in Geophysics at the University of Alaska Fairbanks.
- Marie Kapsch, a diploma student in meteorology at Karlsruhe University in Germany, was an exchange student at UAF last year working with Hajo Eicken. She provided field assistance to Druckenmiller on this project and conducted a sea ice project on how ice conditions in the Bering Sea impact the subsistence harvest of walrus.

Presentations

Druckenmiller, M.L. 2008. RADAR satellite imagery and NSIDC sea-ice products. Alaska Center for Climate Assessment and Policy (ACCAP) Sea Ice Information Workshop, Barrow, Alaska, 18 November 2008.

Druckenmiller, M.L. 2008. Developing sea-ice information products for use by communities. Resilience and Adaptation Program Seminar Series, University of Alaska Fairbanks, Fairbanks, Alaska, 11 December 2008.

Druckenmiller, M.L. 2009. Geophysical and Iñupiaq perspectives and observations of shorefast sea ice. Inland Northwest Research Alliance (INRA) Symposium: Lessons from Continuity and Change in the Fourth International Polar Year, Fairbanks, Alaska, 4–6 March 2009.

Druckenmiller, M.L. 2009. Working with the community of Barrow to monitor and understand landfast sea ice. Barrow Young Researchers' Seminar Series, University of Alaska Fairbanks, Fairbanks, Alaska, 19 March 2009.

Workshops

In November 2008, a tutorial-style workshop was held in Barrow, Alaska to introduce a subset of online sea-ice information resources to local residents and community leaders. Druckenmiller, with the help of the Alaska Center for Climate Assessment and Policy (ACCAP), organized the workshop. The workshop aimed to improve the availability of information about sea ice and related ocean and weather phenomena from operational and academic observation programs to key stakeholder groups. The overarching goal was to work with a well-defined group of stakeholders with information needs representative of broader, more diverse groups to develop a template for an approach to better acquire, process and convey such environmental information to end users.

Publications and Products

Peer-reviewed

Eicken, H., A.L. Lovecraft and **M.L. Druckenmiller**. 2009. Sea-Ice System Services: A framework to help identify and meet information needs relevant for Arctic observing networks. *Arctic*, 62(2):119–136.

Druckenmiller, M.L., H. Eicken, M.A. Johnson, D.J. Pringle and C.C. Williams. 2009. Toward an integrated coastal sea-ice observatory: System components and a case study at Barrow, Alaska. *Cold Regions Science and Technology*, 56:61–72.

In press

Weyapuk, W. Jr. and I. Krupnik (compilers); Anungazuk, H., I. Krupnik and **M. Druckenmiller** (editors). Kinikmi Sigum Qanuq Ilitaavut – Wales Inupaiq Sea Ice Dictionary. Arctic Studies Center, Smithsonian Institution, Washington, D.C., in press.

Druckenmiller, M.L. and C. Haas. Integrated sea-ice observation programs. Chapter in: E. Eicken, R. Gradinger, M. Salganek, K. Shirasawa, D. Perovich and M. Leppäranta, Eds., *Field Techniques for Sea Ice Research*, University of Alaska Press, Fairbanks, Alaska, in press.

Haas, C. and **M.L. Druckenmiller**. Ice thickness and roughness measurements. Chapter in: E. Eicken, R. Gradinger, M. Salganek, K. Shirasawa, D. Perovich and M. Leppäranta, Eds., *Field Techniques for Sea Ice Research*, University of Alaska Press, Fairbanks, Alaska, in press.

Huntington, H.P., S. Gearheard, **M.L. Druckenmiller** and A. Mahoney. Community-based observation programs and indigenous and local sea-ice knowledge. Chapter in: E. Eicken, R. Gradinger, M. Salganek, K. Shirasawa, D. Perovich and M. Leppäranta, Eds., *Field Techniques for Sea Ice Research*, University of Alaska Press, Fairbanks, Alaska, in press.

In preparation

Druckenmiller, M.L. Whaling from shorefast sea ice at Barrow, Alaska. Book Contribution to an edited volume by Igor Krupnik, PI of the IPY Sea Ice Knowledge and Use Project.

Role that this award played in student's degree program

This award has largely supported Druckenmiller's fieldwork travel and opportunities throughout the past couple years as he has traveled to Barrow, Alaska and to the remote village of Wales on the Seward Peninsula. Given that his dissertation will be heavily dependent on field data, this support has played a significant role in his progress. Furthermore, many of these fieldwork opportunities have given him the chance to expand his work beyond just the

collection of data—he has delivered outreach presentations to schools and learned about sea ice from the members of these Native communities. In the spring of 2009, when Druckenmiller was in need of fieldwork assistance, this funding allowed him to cover the travel expenses for undergraduate student Marie Kapsch to assist in the field for a period of ten days. This was extremely helpful from the standpoint of having a successful field season, and also gave him the opportunity to mentor. The component of Druckenmiller's research that has been sponsored by this award has significantly contributed to his interdisciplinary training. He has conducted a number of interviews and sought advice from a range of anthropologists, including Igor Krupnik with the Smithsonian Institution and Herbert Anungazuk with the National Park Service.

Task III

Research Themes

Atmospheric and Climate Research
Climate Modeling
Fisheries Oceanography
Hydrographic and Sea Ice Studies
Marine Ecosystem Studies
Tsunami Research

Pacific Region Integrated Data Enterprise (PRIDE) projects: *Collaborative Research: Alaska PRIDE FY07* *Integrated Pacific Coastal Climatology Data and Information Products* (Pacific Region Integrated Climatology Products; PRICIP)

David Atkinson, PI
University of Alaska Fairbanks

NOAA Goals: Understand Climate Variability and Change; Serve Society's Need for Weather and Water Information

CIFAR 62-090a and CIFAR 40-091: These projects are complete.

Primary objectives

Funding received under the NOAA Pacific Region Integrated Data Enterprise (PRIDE) project has been directed towards two main efforts. The first, which involves working closely with NOAA/NWS Alaska Region Headquarters, has been focusing on improving NOAA's forecasting capacity in the coastal regions of Alaska. Work to date has involved improving wave models, building contacts throughout Alaska, and beginning to work directly with coastal erosion in a reconnaissance mode. The second effort concerns developing and improving end-user products for extreme winds in the Pacific region (the "Pacific Region Integrated Climatology Products – PRICIP"). This effort, led by John Marra and Eileen Shea of the NOAA Integrated Data and Environmental Applications (IDEA) Center in Honolulu, translates observational data into summary plots that are tailored to non-technical (in a meteorological sense) end-user groups, such as planning or insurance, and develops cross-sections of specific events of particular note (e.g., Hurricane Iniki).

Approach/methodology

For the Alaska PRIDE FY06 project the initial approach gathered together experts from a wide array of disciplines and research/operational groups in a workshop that was run as part of Atkinson's PRIDE FY05 activities. Based on results from this workshop a series of project steps were identified:

1. Identify a wave model.
2. Identify an expert group; determine end-user requirements.
3. Identify project sites.
4. Begin implementation of a wave model.
5. Secure observational and model data (storm, wind).
6. Develop climatologies.
7. Determine extreme event return frequencies.
8. Operationally implement wave model (Weather Forecast Office (WFO)-level access via NOAAPORT data stream).

Via this approach the current situation of both short-term prediction and long-term management in the Alaska coastal zone will be at least partially improved.

For the PRICIP project, the approaches were similar to those needed for the long-term elements of the PRIDE project, and included:

1. Identify end user needs.
2. Acquire necessary data.
3. Identify historical severe events for a database.
4. Build tailored climatology layers.
5. Incorporate into display system.

The tasks for both PRIDE projects are complementary, however in practice the return frequency algorithm development work was discharged exclusively with the PRICIP funding. The results will go to satisfy requirements in both projects, however (the PRICIP mandate is primarily Hawaii and the U.S. Pacific Flag Territories).

Research accomplishments/highlights/findings (student contributions mentioned by name)

- Three student-led papers (student: dos Santos Mesquita) regarding storm activity in the North Pacific have been published or are in press. The first paper was published in *Tellus A* during the previous reporting period. An important finding here concerns the long life-spans of summer storms relative to storms in any other season. Although winter storms are more intense, the longevity of summer storms means that they can potentially deposit greater amounts of precipitation. Summer flooding problems in Europe in recent years attest to this.
- The second paper, in press at *Journal of Climate*, focuses on seasonal climatological aspects of various storm parameters (track speed, genesis, lysis, lifetime) in the North Pacific. Important aspects of this work include consideration of the autumn season, which almost never appears in other storm analyses but which is a very important time of year for Alaska and its erosion problems, and consideration of storm activity before/after the climatic shift associated with the Pacific Decadal Oscillation.
- The third paper, recently published in *Geophysical Research Letters*, considers the dynamics of one severe storm in particular which affected Nome and the west coast of Alaska in 1992. The analysis includes an intercomparison of two storm track algorithms, including the one used operationally by NOAA's Climate Prediction Center. Consideration of the nature of a "storm" and of various ways to portray storms is an important issue because a storm's potential is not always felt in the immediate vicinity of the storm center. This also means that there is no one "best" storm track algorithm but that the storm tracking methodology must be selected with the broader analytical context in mind.
- Preliminary Recording Doppler Current Profiler (RDCP) results were obtained and the first RDCP was recovered. A second unit was procured and will be deployed in early fall 2009 (student: Francis).

Left: Ph.D. student Oceana Francis readies an Aanderaa RDCP-600 wave and current gauge for deployment into the Chukchi Sea, October 2008. Tech Cominco and Foss Maritime are major industry partners in this effort. Right: Fully assembled RDCP being lowered over the side of the Foss Maritime tug Jeffrey Foss *into the Chukchi Sea.*

- New results providing a detailed look at the time evolution of surface-based air temperature inversions have been obtained using data from weather balloons (student: Malingowski)
- More recent work for PRICIP has focused on collaborative development of the PRICIP *Distributed Data Products Guide*, which as of July 2009 is almost completed.

NOAA relevance/societal benefits

Over 80 percent of Alaska's population lives and works in the land/ocean coastal zone. The vulnerability of high latitude coastal communities in the face of decreasing sea ice was a key finding of the Arctic Climate Impact Assessment (2005). Storm surges and heavy wave activity along much of Alaska's coastline have resulted in almost yearly disaster declarations by Alaska governors. Coastal disasters in Alaska are compounded by a lack of infrastructure that hampers immediate relief, and by lack of economic diversity, which slows regional recovery. Thus, an improved applied operational capability to assess the risk of future coastal inundation and erosion events and their associated effects in Alaska is critical to NOAA's goal to understand climate variability and change to enhance society's ability to plan and respond.

Research linkages/partnerships/collaborators and networking

In many cases, linkages within the U.S. translate into direct project collaboration. The following are directly involved in NOAA-based or NOAA-related research as listed project collaborators under PRIDE or projects submitted to NSF or elsewhere in NOAA.

- John Jensen, NOAA National Climatic Data Center
- Carven Scott, NOAA NWS Alaska Region Headquarters
- Amy Holman, NOAA NWS Alaska Region Headquarters
- Aimee Fish, NOAA NOS Alaska Region Headquarters
- Sarah Trainor, Alaska Center for Climate Adaptation and Policy (administrator of ACCAP – NOAA RISA – Alaska)
- John Marra, NOAA IDEA Center, Honolulu
- Rosanne Lorenzana, Environmental Protection Agency Region 10
- John Lyon, Environmental Protection Agency, Environmental Sciences Division Director
- Reid Brewer, Marine Advisory Program, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
- David Levinson, NOAA National Climatic Data Center (NCDC), Asheville
- Mark Merrifield, University of Hawaii
- Christy Miller (ret.), Keith Jost, Ruth St. Amour – Alaska Department of Commerce, Community and Economic Development
- Orson Smith, School of Engineering, University of Alaska Anchorage
- Stephanie Fauver, NOAA Coastal Services Center
- Tom Weingartner, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
- Torre Jorgensen, ABR Alaska Inc.

Other research linkages with international groups are maintained. This serves as a broader knowledge base of coastal impacts from which to draw.

Arctic Coastal Dynamics Project

- Nicole Couture, McGill University, Montreal, Canada
- Paul Overduin, Alfred Wegener Institute, Potsdam, Germany
- Stanislav Ogorodov, Moscow State University, Russia
- Volker Rachold, Executive Secretary, International Arctic Science Committee (IASC) Secretariat, Stockholm, Sweden
- Dmitry Drozdov, Earth Cryosphere Institute, Russia
- Steve Solomon and Will Perrie, Bedford Institute of Oceanography, Halifax, Canada
- Nils Kvamsto and Asgeir Sorteberg, Bjerknes Climate Center, Bergen, Norway.

Education/outreach

Student participation

This funding has provided partial salary and tuition support for the following students:

- Oceana Francis (Ph.D. student)
- Michel Mesquita (Ph.D. student in progress—successfully went on to a job as a research scientist at the Bjerknes Climate Research Institute in Bergen, Norway)
- Austin Cross (M.S. student attached to WFO Fairbanks as a NOAA Student Career Experience Program [SCEP] student)
- Julie Malingowski (M.S. student attached to WFO Fairbanks as a NOAA SCEP student)
- Jennifer March (M.S. student)

K–12 Outreach

- An eighth-grade student (Karen Jorgensen) worked for Atkinson as an intern for one week to digitize storm tracks that could be compared to computer-generated tracks.

Public Outreach

Atkinson, D.E. Climate Change and the Alaskan Coastal Zone; part of the "Climate Impacts Panel," a UAF Panel Presentation to the Alaska State Cabinet. Other panel members included: Matthew Sturm (convener), Yuri Shur, Scott Rupp, and Terry Chapin. University of Alaska Fairbanks. Reported in the Fairbanks Daily News-Miner as "Alaska researchers, policymakers seek cooperation on climate issues" on 29 October 2008.

Publications

Peer-reviewed

Mesquita, M.d.S., D.E. Atkinson, I. Simmonds, K. Keay and J. Gottschalck. 2009. New perspectives on the synoptic development of the severe October 1992 Nome storm. *Geophysical Research Letters*, 36, L13808, doi:10.1029/2009GL038824.

In press

Mesquita, M.d.S., D.E. Atkinson and K. Hodges. Characteristics and variability of storm tracks in the North Pacific, Bering Sea, and Alaska. *Journal of Climate,* In press.

In preparation

Mesquita, M.d.S., K. Hodges, D.E. Atkinson and J. Bader. Sea-ice changes in the Sea of Okhotsk and the relationship with storm tracks in the Northern Hemisphere. In preparation.

Francis, O. and D.E. Atkinson. Strong wind return intervals for coastal Alaska, Hawaii and the U.S. Pacific Flag Territories. In preparation.

March, J. and D.E. Atkinson. Synoptic events on the Alaska North Slope during the International Geophysical Year. In preparation.

Reference

ACIA. 2005. Arctic Climate Impact Assessment. Cambridge University Press, 1042 pp.

Correction of Systematic Errors in TOVS Radiances

Jennifer Francis, PI
Rutgers University

NOAA Goals: Understand Climate Variability and Change; Serving Society's Need for Weather and Water Information

CIFAR 31-056a: This project is complete.

Primary objectives

In this collaborative project, we attempted to identify, quantify, and mitigate errors in radiances measured by the Television Infrared Observation Satellite (TIROS) Operational Vertical Sounder (TOVS). These errors result from changes to satellite orbits, instruments, and/or the calibration method. We expected to produce a 26-year (or more) record of TOVS radiances and retrieved products that are as error-free as is practicable, given available resources. Many of the known errors were expected to be regionally and seasonally independent, but we suspected that some may be peculiar to or exacerbated by Arctic conditions. Thus while our efforts were global, our focus was primarily Arctic. The expected product of this investigation was a data set of value both for geophysical retrievals, with sufficient accuracy to identify climatic changes since 1979, as well as for direct assimilation by numerical atmospheric models.

Summary of effort

Our approach to removing systematic errors from the TOVS radiances took several parallel avenues and was a collaborative effort by personnel at the National Environmental Satellite, Data, and Information Service (NOAA/NESDIS) (T. Reale), University of Washington (A. Schweiger), and Rutgers University (J. Francis). We focused on taking our new database of rawinsondes from high northern-latitude locations, including winter soundings from the Department of Energy's Atmospheric Radiation Measurement Program (ARM) Southern Great Plains site in Oklahoma, and developing software to catalog and quality-check them. We identified High-Resolution Infrared Sounder (HIRS) and Microwave Sound Unit (MSU) data collocated in space (within 11 HIRS pixels on either side of raob location) and time (within 6 hours) to create a new database of satellite radiances paired with rawinsondes. More detail on the technical aspects of this task follows below. Progress was significantly slower than expected owing to two unforeseen problems (described in last year's report). On a positive note, the project's increased visibility at the NOAA Center for SaTellite Applications and Research (STAR) and the positive feedback for this work has resulted in ongoing STAR funding to complete, expand, and apply these data in research activities complementary to this project.

Research accomplishments/highlights/findings

- A system was developed by A. Schweiger to calculate radiances from radiosondes and determine differences from observations.

- Forward radiative transfer calculations to match observed radiances with expected values based on radiosondes revealed that further errors existed in the collocation files. A. Schweiger alerted the personnel at NOAA of these ongoing problems, but they caused Schweiger and Francis significant delays while searching for physical reasons for differences between the radiances, when in fact (again) the collocation files were the source of the inconsistencies. Finally, a few weeks prior to the end of the project, A. Schweiger received an updated and expanded collocation data set from Reale's team. Collaborators at NOAA implemented quality assurance (QA) procedures including those developed at UW to assure that the data set is error-free, and are currently processing this data set under separate funding.
- Working with preliminary data sets, we have found a strong sensitivity of Radiative Transfer (RT)-bias corrections to the method by which radiosondes are extended to the top of the atmosphere. Channels peaking as low as 400 mb (Channel 4) exhibit a strong seasonal cycle in brightness temperature bias when extended with a "closest match" profile from the TOVS Initial Guess Retrieval (TIGR) library that is part of the Improved Initialization Inversion (3I) TOVS processing algorithm. We therefore revised our procedure to extend temperature and humidity profiles and use profiles from the ERA-40 reanalysis data set. This procedure eliminated the annual cycle in differences between RT results and observations.
- The Arctic displays a strong annual cycle in atmospheric CO_2 concentrations. To account for this we now include seasonally and annually varying CO_2 concentrations in our RT modeling framework.
- Using the preliminary data set, we have computed radiance bias corrections for each channel/satellite. After recomputation of those biases using the final collocation data set, we will compare those with differences calculated with re-calibration values from the Simultaneous Nadir Overlap (SNO) method. This method compares radiances at locations and times of simultaneous overpasses by two satellites.

In summary, while some of the deliverables planned for this project were not achievable, this project helped initiate a larger, global, and potentially more broadly beneficial endeavor that is ongoing. Ultimately it will lead to improved information about the Arctic as well as most other data-sparse regions of the globe. Our efforts have also provided NESDIS with software tools and expertise that will enable their global efforts to proceed more effectively. We thank NOAA and CIFAR for supporting this project.

NOAA relevance/societal benefits

TOVS data can be used both for weather forecasting and climate applications, both of high priority to NOAA.

Research linkages/partnerships/collaborators and networking

Co-PIs on the overall SEARCH project are Tony Reale, NOAA/NESDIS; Axel Schweiger, University of Washington (funded through JISAO).

Education/outreach

Presentations

Schweiger, A., J. Francis and T. Reale. 2008. Towards the intercalibration of HIRS NOAA-6 through NOAA-14 for the TOVS Polar Pathfinder (Path-P) project. Workshop on AVHRR plus HIRS Climate Data Records, Camp Springs, Maryland, 17–19 November 2008.

Reale, T., A. Schweiger and J. Francis. 2008. TOVS Historical Collocation Database and Plans. Workshop on AVHRR plus HIRS Climate Data Records, Camp Springs, Maryland, 17–19 November 2008.

State of the Arctic (Land) Report

Vladimir Romanovsky, PI ***NOAA Goals: Understand Climate Variability and Change***
University of Alaska Fairbanks

CIFAR 54-087a: This project is complete as funded under NA17RJ1224. See previous annual reports for details.

Primary objectives

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

1. Preparing a baseline report on the state of the Arctic.

2. Developing a methodology for an annual reassessment.
3. Widely disseminating the report.

NOAA relevance/societal benefits

This work is part of NOAA's contribution to the ongoing Study of Environmental Arctic Change (SEARCH) initiative involving close, two-way collaboration with other agencies and research teams studying the changing Arctic. It also contributes to International Polar Year (IPY) activities involving NOAA, NASA, and NSF.

Research linkages/partnerships/collaborators and networking

The State of the Arctic report is produced by a team led by Jacqueline Richter-Menge (CRREL), James Overland (NOAA-PMEL), Andrey Proshutinsky (WHOI), and Vladimir Romanovsky (UAF). We developed a network of researchers from Northern Eurasia to monitor changes in permafrost in a framework of the IPY Project #50, the Thermal State of Permafrost (TSP). Eleven institutions from Russia, one from Kazakhstan and one from Mongolia are participating in this project.

Publication

Peer-reviewed

Richter-Menge, J., Ed. 2008. The Poles: Arctic. In: D.H. Levinson and J.H. Lawrimore, Eds., State of the Climate in 2007. Special Supplement to the *Bulletin of the American Meteorological Society*, 89(7):S85–S97.

Climate Modeling

Initiation of an Arctic Reanalysis Activity in SEARCH

John E. Walsh, PI
University of Alaska Fairbanks

NOAA Goals: Understand Climate Variability and Change; Serve Society's Need for Weather and Water Information

Other investigators/professionals funded by this project:
Xingang Fan, *University of Alaska Fairbanks*
Jeff Tilley *(University of North Dakota) [funded prior to FY06]*

Collaborators funded by NOAA:
David Bromwich*, Ohio State University*
Mark Serreze, *CIRES/University of Colorado at Boulder*

CIFAR 09-063: This project is complete.

Primary objectives

The project's main objectives were (1) an assessment of the performance of the atmospheric reanalyses in the Arctic, (2) tests of data assimilation strategies for Arctic regional models, and (3) the adaptation of the Weather Research and Forecasting (WRF) model for use in the Arctic. Work toward these objectivities contributes to the design of an Arctic System Reanalysis (ASR), a NOAA initiative for SEARCH (Study of Environmental Arctic Change). The ASR is intended to integrate all available observations into a consistent framework, providing a vehicle for monitoring and diagnosing changes in the Arctic atmosphere, sea ice, upper ocean and terrestrial components.

Approach/methodology

The Arctic output of global reanalyses (ERA-40, National Center for Atmospheric Research (NCAR)/National Centers for Environmental Prediction (NCEP) and the Japanese 25-year Re-Analysis (JRA-25)) was validated against observational data by the UAF, Colorado and Ohio State groups. Emphasis was placed on precipitation, clouds and radiative fluxes, and upper-air winds. The effects of assimilation of TOVS (TIROS Operational Vertical Sounder) data over sea ice received particular emphasis because the assimilated profiles impact the upper-air winds, thermal structure and cloud distribution. The radiative fluxes and cloud-radiative interactions in ERA-40 were compared with in situ measurements, including those from the Department of Energy's (DoE) intensive observing sites on the North Slope of Alaska. During the past year, the NCEP's North American Regional Reanalysis (NARR)

was included with the three global models in a UAF-coordinated diagnosis of cloud-radiative interactions in the reanalyses.

Three-dimensional variational (3DVAR) data assimilation methodologies were explored with the MM5 (Mesoscale Model Version 5) model in conjunction with experiments addressing sensitivity to resolution. The experiments included assimilation of various combinations of observation types, and were performed on domains of different sizes. The experiments with different nudging and blending strategies were performed for typical synoptic regimes and for extreme events affecting the Arctic in different seasons the past several years. This task involved the North Dakota and UAF groups.

The choice of the land surface module for an Arctic System Reanalysis was addressed through an intercomparison of land surface model performance in cold regions. Particular attention was given to an assessment of the community NOAH (NCEP, Oregon State University, Air Force, Hydrologic Research Lab) land surface model. This task was performed by the Colorado group.

Toward the objectives listed above, the Ohio State group tested Polar-MM5 over a Greenland domain and experimented with parameterizations of Arctic processes. Emphases included topographically affected flows in the Arctic, ice–ocean surface fluxes, Arctic stratus, etc. Variables receiving particular attention were precipitation and winds over Greenland. (See reports for previous years by collaborator D. Bromwich, funded through a separate award.).

A recent enhancement of the Arctic System Reanalysis has been a change of the resolution from 30 km to 10 km. This improved resolution was made possible through support from the Ohio State University Supercomputer Center.

Research accomplishments/highlights/findings

During the past year, proof-of-concept simulations have been carried out for two full months, August 2007 and December 2007, enabling an assessment of the capabilities and limitations of the reanalysis system in summer and winter months. The test simulations showed that the sea level pressure field is well captured by the reanalysis, but that there are biases in the surface temperatures that are tied to the surface boundary specifications. Because these biases were most apparent in coastal areas, we have implemented a new set of sea ice concentrations and thicknesses, based on year-month fields of sea ice age and areal coverage from passive microwave satellite imagery. The new boundary conditions represent a significant advance over the single-thickness specifications used in previous global reanalyses.

- A summary of the Arctic System Reanalysis has been prepared and submitted to *EOS, Transactions of the American Geophysical Union*. This overview serves to alert the broader research community to the opportunities for participation in the Arctic System Reanalysis through analysis of output and provision of Arctic datasets for either assimilation into or validation of the reanalysis. The article lays out the history of the Arctic System Reanalysis, including the evolution from NOAA start-up funds through the ongoing support from the National Science Foundation.
- The performance of a set of 15 global climate models used in the Coupled Model Intercomparison Project is evaluated for Alaska and Greenland, and compared with the performance over broader pan-Arctic and Northern Hemisphere extratropical domains. Root-mean-square errors relative to the 1958–2000 climatology of the 40-yr ECMWF Re-Analysis (ERA-40) are summed over the seasonal cycles of three variables: surface air temperature, precipitation, and sea level pressure. The specific models that perform best over the larger domains tend to be the ones that perform best over Alaska and Greenland. The rankings of the models are largely unchanged when the bias of each model's climatological annual mean is removed prior to the error calculation for the individual models. The annual mean biases typically account for about half of the models' root-mean-square errors. However, the root-mean-square errors of the models are generally much larger than the biases of the composite output, indicating that the systematic errors differ considerably among the models. There is a tendency for the models with smaller errors to simulate a larger greenhouse warming over the Arctic, as well as larger increases of Arctic precipitation and decreases of Arctic sea level pressure, when greenhouse gas concentrations are increased. Because several models have substantially smaller systematic errors than the other models, the differences in greenhouse projections imply that the choice of a subset of models may offer a viable approach to narrowing the uncertainty and obtaining more robust estimates of future climate change in regions such as Alaska, Greenland, and the broader Arctic.

NOAA relevance/societal benefits

The ASR, for which this project provides input to the design, will permit the integration of all available observations into a consistent framework, providing a vehicle for monitoring and diagnosing environmental change in the Arctic.

As such, it will contribute directly to the NOAA mission goals of (1) documenting and understanding climate variability and change in the Arctic, and (2) serving society's need for weather and water information. More specifically, ASR will be a high-resolution regional prototype that complements the global reanalyses carried out by NCEP. The findings concerning the Arctic output of existing NCEP reanalyses, including the global NCEP reanalysis and the North American Regional Reanalysis, will guide future reanalyses at NCEP or elsewhere within NOAA.

Research linkages/partnerships/collaborators and networking

In addition to the UAF investigators supported by this award, NOAA funding of the Arctic System Reanalysis also supported David Bromwich, Ohio State University (see project reports from previous years) and Mark Serreze, University of Colorado/CIRES. More recently, the group has been joined by W. H. Kuo, D. Barker and several other NCAR scientists as the project has transitioned to an Arctic System Reanalysis (see following).

Three workshops in Boulder, Colorado, were held (November 2008, February 2009 and July 2009) as project team meetings for the Arctic System Reanalysis activity, which was seeded by the present project. Co-investigators Walsh, Bromwich and Serreze, together with a group of NCAR scientists, obtained funding from NSF's Office of Polar Programs for a continuation of the Arctic System Reanalysis activity through 2011. The February and November meetings included participation by staff of the NOAA Earth System Research Laboratory (see below).

The work to evaluate the NOAH land surface model was coordinated with Ken Mitchell, NOAA/NCEP.

Interaction with the NOAA Boulder Labs (including the NOAA Climate Diagnostics Center) has been ongoing through our participation in workshops and conferences in other venues.

Education/outreach

The Arctic System Reanalysis has entrained the NOAA Earth System Research Laboratory (ESRL) as a new partner. The ESRL Climate Diagnostics Branch (R. Dole, R. Webb) has agreed to provide the software that will enable visualization and downloading of ASR output from a publicly accessible website. This activity will build on the software developed by ESRL for visualization of the NCEP global reanalysis and the North American Regional Reanalysis. All products of the Arctic System Reanalysis will be publicly available. We are using vehicles such as the EOS publication (see below) to enhance usage by the broader research community.

Oral presentation

Walsh, J.E. 2008. Present and future Arctic and Antarctic climate change: A comparison. Keynote presentation, SCAR/IASC Open Science Conference, St. Petersburg, Russia, 8 July 2008.

Poster presentation

Bromwich, D.H., Y.-H. Kuo, M. Serreze, J. Walsh, F. Chen, K. Hines, L. Bai, S.-H. Wang, L. Liu, M. Barlage, Y. K. Wee and H. Lin. 2009. The Arctic System Reanalysis: Data assimilation challenges for high-resolution reanalysis in the polar regions. Tenth WRF Users Workshop, Boulder, Colorado, 23–26 June 2009.

Publications

Peer-reviewed

Fan X., J.E. Walsh and J.R. Krieger. 2008. A one-year experimental Arctic reanalysis and comparisons with ERA-40 and NCEP/NCAR reanalyses. *Geophysical Research Letters,* 35, L19811, doi:10.1029/2008GL035110.

Walsh, J.E., W.L. Chapman and D.H. Portis. 2009. Arctic cloud fraction and radiative fluxes in atmospheric reanalyses. *Journal of Climate,* 22:2316–2334.

Walsh, J.E. 2009. A comparison of Arctic and Antarctic climate change, present and future. *Antarctic Science*, 21(3):179–188.

Submitted

Bromwich, D.H., M.C. Serreze, J.E. Walsh, W. Kuo, K. Hines, D. Slater and M. Barlage. Arctic System Reanalysis. Submitted to *EOS, Transactions of the American Geophysical Union*.

Fisheries Oceanography

Relationship between Growth and Survival of Coho Salmon Utilizing the Coastal Gulf of Alaska

Milo Adkison, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

CIFAR 30-027d: This project is complete. Last year's report serves as the final annual report. Manuscript preparation is ongoing.

Primary objectives

This study will use archived scales from both adult and juvenile coho salmon to examine the relationships between growth during specific marine phases and subsequent survival to adult and size at maturity, and to evaluate how these parameters vary in relation to biophysical data sets. As a bonus, we contemplate making comparisons among growth and survival rates of female, male jack, and male hooknose fish to examine the costs and benefits of alternative life history choices.

Early Marine Growth and Survival of Bristol Bay Sockeye Salmon Smolt

Milo Adkison, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

CIFAR 50-040d: This project is complete. Last year's report serves as the final annual report. Manuscript preparation is ongoing.

Primary objectives

- To determine if Bristol Bay sockeye salmon production is influenced by early marine growth rates.
- To identify the relationship between environmental conditions and early marine growth of juvenile sockeye salmon in the eastern Bering Sea.

Inter-decadal Change in Sablefish Growth and Maturity in the Northeast Pacific Ocean

Milo Adkison, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

CIFAR 52-084a: This project is complete. Last year's report serves as the final annual report. Manuscript preparation is ongoing. K. Howard was awarded her M.S. degree in summer 2008. Her thesis is listed in Appendix 2, *Publications*.

Primary objectives

- Assemble data on size-at-age and maturity-at-age.
- Determine how to account for confounding factors such as location, season, and method of capture.
- Determine if sablefish size-at-age and maturity-at-age have shifted over the period 1981 to 2003.

Genetic Studies of Rockfishes (Phase I)

A.J. Gharrett, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

CIFAR 22-085: This project is complete.

Primary objectives

The *Sebastes* rockfishes are an important component of the marine food web and are also economically important. There are more than 100 species worldwide and more than 60 along the Pacific Coast of North America. In addition, they are morphologically similar; and during their embryological development, they pass through several morphological transformations. Consequently, many adults of some species are difficult and many larvae impossible to identify from their morphologies. Genetics provides tools that can be used to learn about population structure and the underlying demographic structures and markers that can be used to delineate species. This project addresses three questions:

1. Is there detectable population structure in Alaskan northern rockfish (*S. polyspinis*)?
2. Are there morphological differences between the sibling species of rougheye rockfish (*S. aleutianus* types I and II) (Gharrett et al. 2005)?
3. Are there additional mtDNA markers that will allow us to resolve (thus far) genetically indistinguishable species of rockfish (Li et al. 2006)?

Approach/methodology

The methodologies below correspond to the points under *Primary objectives*.

1. The genetic structure of five spatially distinct collections that represent the Bering Sea/Aleutian Island species range were analyzed by using data from microsatellite loci. We anticipated using 10 loci in this analysis of about 500 fish. Standard population genetics analyses include tests of (a) Hardy-Weinberg proportions, (b) homogeneity, and (c) correlation between geographic and genetic distances (Mantel tests).
2. J. Orr (NOAA/NMFS Alaska Fisheries Science Center, personal communication) suggests differences in spotting patterns between the two rougheye rockfish sibling species. We compared identifications of specimens collected in 2005 based on spotting pattern with identifications based on both mitochondrial and microsatellite markers, which are diagnostic for the two types. In 2006, additional fish were sampled, identified from spotting patterns, and digitally photographed; tissue samples were analyzed blindly for the genetic markers to determine species.
3. We developed single nucleotide polymorphism (SNP) markers to identify the two rougheye rockfish types. Restriction digests of mtDNA regions that we had not previously analyzed were examined for variation in two groups of rockfishes: (a) *Sebastes polyspinis*, *S. cilatus*, *S. variabilis*, and *S. crameri*; and (b) *S. variegatus*, *S. emphaeus*, *S. zacentrus*, and *S. wilsoni*.

Research accomplishments/highlights/findings

- We used 11 microsatellite loci to analyze four collections of 100 northern rockfish (*S. polyspinis*) from the Aleutian Islands and one from the Bering Sea. Available life history and environmental information as well as our genetic analysis are consistent with a population model for northern rockfish that is based on relatively continuous distribution with life-time dispersals that are much smaller than the species range. Homogeneity tests and assignment tests indicated that populations were somewhat discrete, and a test of isolation-by-distance indicated a correlation between genetic divergence and geographic distance along the shelf break. By applying assumptions about the distribution of dispersal, we estimated that the effective sizes of local populations (that is, neighborhoods) are about 40,000 and that limits on the span of dispersal are about 55 km. These estimates should be regarded as very crude. After taking the biases in the analysis into consideration, we must still conclude that the dispersal for northern rockfish is limited and much smaller than we might presume from the oceanographic conditions that they encounter and their longevity and mobility. The scales of structure that we estimated were on the order of 100 km. The relatively small range of the estimates that we obtained from a broad set of ratios of effective to census population sizes suggests that the order of magnitude of the dispersal scale is reliable. The average dispersal range includes larval, juvenile, and adult movements; but the overall dispersal includes individuals that may move substantially farther and many that do not move far. Our estimate

of dispersal is rough, but it seems reasonable that geographic scale of management plans would be no more than a few times that size (Riley et al., in prep).

- Until recently, rougheye (*S. aleutianus*) and blackspotted (*S. melanostictus*) were considered the same species. For conservation and management, it is important to be able to delineate them; and it would be most convenient to be able to do so visually. Unfortunately, they are often not easy to distinguish (Gharrett et al. 2006). From DNA sequencing, we identified one of the restriction site differences that delineates the two species (Gharrett et al. 2005). We designed a Single Nucleotide Polymorphism (SNP) assay and used it to identify a diagnostic restriction site that can delineate the two rockfish species. To test the ability of scientists aboard survey vessels to identify the species visually, we used both the SNP that we developed and a diagnostic microsatellite locus to delineate the species in a blind comparison of about 150 specimens. There were substantial differences between the visual and genetic determinations of species. But since the NOAA scientist who conducted the visual analysis obtained and used the genetic identifications to "fine tune the results of the visual identification," the scientific integrity of the comparison was compromised. The project will be repeated, more rigorously, at a later date.
- From DNA sequencing, we identified a diagnostic restriction site difference that will enable us to distinguish *S. alutus* from *S. aleutianus*, *S. ciliatus*, *S. crameri*, *S. reedi*, and *S. polyspinus*, the species that are difficult to distinguish visually as young-of-the-year juveniles. That SNP was used to confirm the visual identify of adult fish that were used in a study of the population genetic structure of Pacific ocean perch (*S. alutus*: POP) (Palof 2008). All of nearly 1000 individuals were confirmed as POP. In addition, it was used to identify fish that were not POP in collections of young-of-the-year Pacific ocean perch in a sample of more than 2000 fish, which was a part of a North Pacific Research Board project, as well as in a sample of about 300 that was provided by the Auke Bay laboratory.

NOAA relevance/societal benefits

As part of their stewardship of Alaska's living marine resources, the NOAA/NMFS Alaska Fisheries Science Center (AFSC) is responsible for conducting research that will lead to effective conservation and management. Genetics provides tools that can be used to learn about population structure and the underlying demographic structures and markers that can be used to delineate species, knowledge critical for effective management and conservation of a species. More research into rockfish population structure and basic biological development will aid in understanding population distributions, the locations of critical habitats throughout this distribution, and the times of the year when these habitats are necessary for survival.

Research linkages/partnerships/collaborators and networking

Funding for this project comes through collaboration with the National Marine Fisheries Service Auke Bay Laboratory (ABL). The scientists from ABL collected all of the specimens used in this analysis during stock assessment surveys. Although it is not possible to estimate the effort expended, it has been substantial. In addition, considerable vessel time was involved. Principal ABL personnel were J. Heifetz, C. Lunsford, and D. Clausen. K. and T. Mecklenburg (on subcontract) conducted the visual inspection of the rougheye rockfish to identify species based on spotting patterns.

Education/Outreach

Lisa Kamin has been supported in part by this CIFAR project. She is working on an M.S. in Fisheries.
Robert Marcotte, who completed a B.S. in Biology at Whitman College (2008), was supported during summer 2007 by this CIFAR project.

Publications

In preparation

Riley, R.J., P. Spencer and A.J. Gharrett. Genetic structure of northern rockfish (*Sebastes polyspinus*). Manuscript in preparation.

References

Gharrett, A.J., A.P. Matala, E.L. Peterson, A.K. Gray and J. Heifetz. 2005. Two genetically distinct forms of rougheye rockfish (*Sebastes aleutianus*) are different species. *Transactions of the American Fisheries Society*, 134:242–250.

Gharrett, A.J., C.W. Mecklenburg, L.W. Seeb, Z. Li, A.P. Matala, A.K. Gray and J. Heifetz. 2006. Do genetically distinct rougheye rockfish sibling species differ phenotypically? *Transactions of the American Fisheries Society*, 135:792–890.

Li, Z., A.K. Gray, M.S. Love, A. Goto, T. Asahida and A.J. Gharrett. 2006. A key to selected rockfishes (*Sebastes* spp.) based on mitochondrial DNA restriction fragment analysis. *Fishery Bulletin*, 104(2):182–196.

Palof, K.J. 2008. Population genetic structure of Alaskan pacific ocean perch (*Sebastes alutus*). M.S. Thesis. University of Alaska Fairbanks. Fairbanks, AK. 65pp.

Characterizing Movement Patterns of Atka Mackerel Using Ultrasonic Telemetry: A Pilot Study

Nicola Hillgruber, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

CIFAR 59-096: This project is complete.

Primary objectives

Atka mackerel (*Pleurogrammus monopterygius*) is an important groundfish resource in the Aleutian Islands. This species supports a major commercial fishery in addition to serving as a key food source for many species of birds, fish, and marine mammals. Recent efforts to balance fishery removals with requirements for a healthy ecosystem were enacted in response to the listing of the western population of Steller sea lions (*Eumetopias jubatus*) as an Endangered Species in 1990.

Information on abundance and spatial distribution is typically obtained through trawl surveys and the distribution of the commercial fishery, and is confounded by high variance in catch as well as the inability to survey untrawlable areas. In addition, Atka mackerel can undergo daily vertical migrations that may exclude them from trawl surveys conducted during the day. Also, acoustical methods for estimating abundance are precluded because Atka mackerel do not possess a swim bladder. Thus, tagging studies may provide a viable alternative to trawl survey methods for determining distribution and abundance.

Ultrasonic tagging techniques offer an approach that can complement the knowledge gained by conventional tags. Ultrasonic telemetry can provide spatial information at much finer temporal scales and in all habitat types, which will make it possible to study small-scale movement of Atka mackerel across harvest boundaries, in areas not available to trawl gear, and on a temporal scale that reflects their daily behavioral patterns. Recent developments in ultrasonic telemetry technology now allow large numbers of sonic tags to be deployed and detected simultaneously. The objectives of this pilot study are:

1. Assess the feasibility of conducting a telemetry project in the Aleutian Islands.
2. Determine optimal techniques for tag attachment.
3. Ensure that the SYNAPS (Synthetic Aperture Positioning System) program will work for faster-moving fish.

Approach/methodology

As discussed in last year's report, the Atka mackerel tag recovery cruise in October 2007 provided valuable insights on the logistics necessary to conduct active tracking from a large vessel in the Aleutian Islands. For future tracking studies, an extremely robust hydrophone attachment method must be developed prior to active tracking with a large vessel in the open waters of the Aleutian Islands because the rolling motion of the vessel in the ocean swells affects the accuracy of GPS data. Corrections for the location of the GPS antenna relative to location of hydrophones in swells will need to be developed prior to the use of GPS data in the SYNAPS calculations. Thus, laboratory tag attachment studies were done during the current reporting period.

Research accomplishments/highlights/findings

Tag attachment studies were conducted at the Ted Stevens Marine Research Institute in Juneau. Kelp greenling (*Hexagrammos decagrammus*), a locally available species that is closely related to Atka mackerel and is of similar size and weight, was used as a surrogate species for these experiments. Due to unanticipated time needed to obtain permits for the fish surgery component and difficulties collecting a sufficient number of fish for the study, the laboratory study took place in two stages. In the first stage, three fish were tagged in May 2008 as part of surgical training. Additional fish were collected over the summer and fall of 2008, and five more fish were tagged in November 2008. Eight untagged fish served as controls.

Lotek MAP11_4 dummy tags (11 mm diameter, 55 mm length and weighing 10.0 g in air and 5.1 g in water) were inserted in the abdominal cavity of six male fish; smaller MAP dummy tags (8 mm diameter, 40 mm length) were inserted into two female fish (Table 1). Two of the three fish tagged in May were sacrificed prior to the second stage of tagging in order to assess the position of the tag and check for internal tag effects. The remaining fish were sacrificed in April of 2009 at the end of the experiment. Observation times following tagging ranged from 152 to 335 days.

No mortality was observed in any tagged or control fish. Tagged fish exhibited no signs of infection or necrosis associated with the tag or incision. However, irritation or redness was observed around the sutures in 5 out of 8 tagged fish. Incisions were fully healed in all fish at time of sacrifice. Adherence of internal organs in the vicinity of the tag, which could be the initial stages of tag encapsulation, was observed in 5 out of 8 fish.

Table 1. Sex, length, weight, and dates for surgery and sacrifice of tagged fish.

Fish ID	Gender	Fork length [cm]	Wet weight [kg]	Surgery date	Sacrifice date
1	male	37.8	0.774	5/29/2008	4/29/2009
2	male	35.8	0.68	5/29/2008	11/28/2008
3	male	40.0	0.88	5/29/2008	11/5/2008
4	male	43.5	1.41	11/28/2008	4/29/2009
5	male	39	0.962	11/28/2008	4/29/2009
6	male	40	1.042	11/28/2008	4/29/2009
7	female	36.5	0.794	11/28/2008	4/29/2009
8	female	40	0.906	11/28/2008	4/29/2009

The three fish that were tagged in May gained an average of 47% of their initial body weights between May and November. However, fish tagged in November exhibited a very slight reduction in body weight between November and April (an average decline of -1.2%). Control fish did not grow much during this time period either (an average of 1.8%), so this outcome could reflect a seasonal growth phenomenon rather than a tagging effect. There was no significant difference in weight change between tagged and control fish (T-test, 2 tail, alpha = 0.05).

In summary, kelp greenling responded well to surgical insertion of dummy tags and had 100% tag retention over the time period of the experiment. The observation of internal organs adhering in the vicinity of the tag suggests that tag encapsulation and eventual expulsion could occur over longer (multi-year) time scales. Use of absorbable suture material for future surgeries could reduce irritation that was observed around the sutures. Future laboratory studies should be conducted over the summer season in order to assess growth rates between tagged and control fish more efficiently.

NOAA relevance/societal benefits

New telemetry techniques hold great potential for answering important questions about Atka mackerel small-scale distribution and movement patterns by complementing the results obtained through a multi-year study using conventional tags. The Aleutian Islands present a challenge for all field work due to their remoteness and often inclement weather conditions. In addition, Atka mackerel inhabit areas of high currents which pose additional problems when working with high technology underwater acoustic equipment. Therefore this pilot study tested these telemetry techniques before they can be employed in a large-scale study in the Aleutian Islands.

Research linkages/partnerships/collaborators and networking

This pilot project represents a collaboration between NOAA, the University of Alaska Fairbanks, School of Fisheries and Ocean Sciences (UAF, SFOS), and commercial fishers (F/V *Seafisher*). Development of tracking methods for Atka mackerel in the waters of the Aleutian Islands could also facilitate movement studies of other commercially important fish, such as Pacific cod (*Gadus macrocephalus*) or walleye pollock (*Theragra chalcogramma*) in this area.

Education/outreach

Approximately 15 students were taught how to perform fish surgery and implant transmitters during an ichthyology laboratory class in October, 2008.

Presentations

Nielsen, J.K. and N. Hillgruber. 2009. First steps for fish movement studies: Tag attachment considerations for Atka mackerel and Pacific cod. Poster presentation at the Alaska Marine Science Symposium, Anchorage, Alaska, 19–23 January 2009.

Hydrographic and Sea Ice Studies

Bering Strait: The Pacific–Arctic Ocean Connection: RUSALCA 2006

Thomas Weingartner, PI ***NOAA Goal: Understand Climate Variability and Change***
Terry Whitledge, Co-PI
University of Alaska Fairbanks

CIFAR 42-082a: This project is complete as funded under NA17RJ1224 and is a continuation of the RUSALCA project, CIFAR 10-071.

Primary objectives

Our goals are to:

1) Recover and analyze data from 3 moorings deployed in the western channel of the Bering Sea (Russian Exclusive Economic Zone, EEZ) in August 2007
2) Replace these moorings with 1 new mooring containing an Acoustic Doppler Current Profiler (ADCP) and temperature-conductivity-fluorometer (T/C) recorder, and an In Situ Ultraviolet Spectrophotometer (ISUS) nitrate analyzer
3) Supplement the two Russian moorings (under the direction of I. Lavrenov of the Arctic and Antarctic Institute) with T/C recorders and ADCP current meters
4) Continue collaborating with Rebecca Woodgate (U. Washington), who is making similar measurements in the U.S. EEZ (eastern channel of Bering Strait) with support from the NSF.

Approach/methodology

Our approach involves making measurements of the salinity, temperature, velocity, fluorescence, and nitrate in the western channel of Bering Strait at hourly intervals for a period of one year. The measurements are and will continue to be made from three moorings deployed across the western channel of Bering Strait. Each mooring will contain an RDI 300 kHz upward looking ADCP current meter for measuring velocity and a SeaCat (SBE-16 T/C recorder) for the temperature and salinity measurements. The mooring in the center of the strait will include a fluorometer and a nitrate sensor. This mooring at about 65 53.8'N, 169 25.9'W is the approximate position of the A1 mooring previously deployed in the western channel under this program and is linked to historical deployments made in the strait in the early 1990s (Roach et al. 1995).

Research accomplishments/highlights/findings

- In late June 2008, Kathy Crane, from the NOAA Arctic Research Office, informed the RUSALCA principal investigators funded through CIFAR that the interdisciplinary RUSALCA expedition planned for fall 2008 was postponed until fall 2009. This necessitated securing a vessel and funding to conduct a mooring cruise in fall 2008. This was done through primarily NSF funding for the research and NOAA funding for the vessel.
- Despite the expected bad weather and darkness in October 2008, the three moorings were successfully recovered and redeployed during the cruise.
- Unfortunately, weather prevented the taking of related high resolution CTD (conductivity, temperature, depth) sections, although surface bucket samples were taken for salinity and nutrients at the mooring sites, and some benthic grab work was done opportunistically.
- We are continuing our processing of the moored and hydrographic (shipboard) data.

NOAA relevance/societal benefits

Bering Strait is the sole connection between the Pacific and Arctic oceans. As such it provides an efficient environmental monitoring location able to detect integrated changes in the Bering Sea ecosystem. The flux of nutrients, salinity, and heat from the Bering to the Arctic Ocean has important influences on this ecosystem and on climate.

Research linkages/partnerships/collaborators and networking

This project continues work originally funded under NOAA's RUSALCA program—a multi-investigator, interdisciplinary program to conduct marine research in Bering Strait and the Chukchi Sea. The RUSALCA program afforded the first opportunity since the early 1990s for U.S. scientists to work in Russian waters of the Chukchi Sea.

Our measurements complement those obtained from moorings in the eastern channel (U.S. EEZ) of Bering Strait, which, with the exception of one year, have been maintained since 1990 under NSF, NOAA, and/or ONR support by K. Aagaard and R. Woodgate from the University of Washington. Aagaard, Woodgate, Weingartner, and Whitledge have worked together for over a decade and so collaborative analyses and data sharing are easily facilitated among these PIs.

Education/outreach

Project website

Our data and findings are being combined with those of Rebecca Woodgate, who is maintaining a joint project website: http://psc.apl.washington.edu/HLD/Bstrait/bstrait.html

References

Roach, A.T., K. Aagaard, C.H. Pease, S.A. Salo, T. Weingartner, V. Pavlov and M. Kulakov. 1995. Direct measurements of transport and water properties through Bering Strait. *Journal of Geophysical Research,* 100:18,443–18,457.

Assessment of Arctic Snowcover Change and its Impact on Large River Runoff

Daqing Yang, PI *University of Alaska Fairbanks*

NOAA Goal: Understand Climate Variability and Change

CIFAR 56-081b: This project is complete.

Primary objectives

The primary objective of this research is to determine arctic snowcover change and assess its impact on large river runoff change and variation.

Approach/methodology

Three major aspects of research are designed to accomplish the objectives: a) Generation and analysis of weekly snowcover and runoff time-series for all major arctic watersheds; b) Examination of streamflow response to snowcover extent change; and, c) Cross-validation of results.

Research accomplishments/highlights/findings

A new climate data record (CDR) for Northern Hemisphere snow extent was completed in fall 2008. As discussed in earlier reports, reasons for this effort include the need to standardize land masks and address inconsistencies in the definition of what constitutes a snow covered cell. This includes eliminating cells considered snow covered during the first half of the satellite era when mapped as "patchy" and accounting for a major change in the late 1990s from the weekly NOAA visible map product to the daily Ice Mapping System (IMS) product. This effort has resulted in a definitive Northern Hemisphere snow cover extent climate data record (CDR) from late 1966 to present. Preliminary analyses of adjustments within the major study areas of this project suggest strongly that the new CDR will not result in any significant changes in study results. However, any future hydrological analyses using this extent record will benefit greatly from the CDR.

We have investigated the relationship between snowcover and river runoff changes over the large Siberian rivers and the Yukon watershed in North America (Yang et al. 2009). We used the daily Advanced Very High Resolution Radiometer (AVHRR) and Special Sensor Microwave/Imager (SSM/I) data to generate weekly basin-mean snow cover extent (SCE) and snow water equivalent (SWE) time-series during 1988–2001. Based on these weekly records, we define the snowcover seasonal cycle—the dates of snowcover formation/disappearance and duration of snowcover/snow-free days, and rates of snow extent and mass change during the accumulation and melt seasons. We also derive weekly discharge time-series from the daily streamflow data collected at the Yukon basin outlet, and use the weekly data to describe the seasonal streamflow changes, including discharge regime, rates of

streamflow rise and peak flow during the melt period. We calculate the weekly correlation between streamflow and basin SCE/SWE, and determine the consistency between snow cover and streamflow changes over the seasons. The results of our analyses indicate a general response of river discharge to seasonal snowcover changes over the Yukon River, i.e., an association of low streamflow with high basin SCE and SWE during the cold season, and an increase in discharge associated with a decrease of the basin SCE and SWE during the melt periods. They also show the inter-annual variations in both SWE and streamflow. Relative to the basin SWE, streamflow varies much more between years. There is a discrepancy between basin snowcover and streamflow variations, perhaps due to the limitations of SSMI SWE algorithm.

We have obtained and analyzed long-term hydrologic and climatic data from the period 1977 to 2006 over the Yukon River Basin (Ge et al. 2009). Results of our analyses at four gauging stations (Eagle, Stevens Village, Nenana, and Pilot) show that the runoff in low-flow season (November to April) is low with small variations. In the high-flow season (May to October), the runoff is high with big variations. Maximum discharge occurs in June due to snowmelt over the basin, except for the Nenana River, which occurs in July due to glacier-melt. The monthly discharge data for the Pilot station show a positive trend (177,000 ft^3/s) in May, with confidence at 97%. April flow has increased by 4,586 ft^3/s with confidence over 85%. The negative trends (7,502 ft^3/s–12,184 ft^3/s) in other months are not statistically significant. Daily discharge data at 2 gauging stations (Stevens Village and Pilot) indicate that the timing of peak flow shifts to an earlier time. We also found annual discharge increased during 1977–2006 by 18,213 ft^3/s (8.0%) for the Yukon basin. Over the same time period, basin-mean annual temperature warmed slightly by 0.3 ^oC, while annual precipitation increased by 28 mm (Ge et al. 2009).

NOAA relevance/societal benefits

By developing a comprehensive climatic and hydrologic database for the watersheds of the five largest rivers in the Arctic, this project specifically addresses a high priority research topic of the NOAA Climate Change Data and Detection (CCDD) program element, namely climate change detection and attribution. The methods and results of this research will improve our understanding of spatial and temporal variability of the high-latitude snowcover, and its contribution and impact on Arctic large river streamflow changes. This work will enhance our capability to predict future changes in the water cycle over the Arctic regions and at the global scale.

Research linkages/partnerships/collaborators and networking

Collaborators on this project are co-PI David Robinson of Rutgers University and co-PI Henchung Ye of California State University Los Angeles.

Education/outreach

Student participation

Ipshita Majhi, a Ph.D. student in environmental engineering, as well as Jakob Theurich and Shaoqing Ge, M.S. students in civil and environmental engineering, have been supported by this project.

Presentations

Ge, S., D. Yang and D. Kane. 2009. Hydrological analyses of the Yukon River: Preliminary results. American Water Resources Association, 2009 Spring Specialty Conference, Managing Water Resources Development in a Changing Climate, Anchorage, Alaska, 4–6 May 2009.

The Project PI will host a special session, Hydroclimatology of Large Northern Watersheds: From Surface Observation, Remote Sensing, to Modeling, at the AGU fall meeting in San Francisco in December 2009. The PI and Co-PI's of this project plan to present a summary talk and a poster at this session.

Publications

Peer-reviewed

Yang, D., Y. Zhao, R. Armstrong and D. Robinson. 2009. Yukon River streamflow response to seasonal snowcover Changes. *Hydrological Processes*, 23:109–121. doi:10.1002/hyp.7216.

Ye, H., D. Yang and D. Robinson. 2008. Winter rain on snow and its association with air temperature in northern Eurasia. *Hydrological Processes,* 2:2728–2736.

Ye, B., D. Yang, Z. Zhang and D.L. Kane. 2009. Variation of hydrological regime with permafrost coverage over Lena Basin in Siberia. *Journal of Geophysical Research*, 114, D07102. doi:10.1029/2008JD010537.

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

Stephen Okkonen, PI ***NOAA Goal: Ecosystem-based Management***
University of Alaska Fairbanks

Other Collaborators funded by NOAA:
Carin J. Ashjian *and* ***Mark F. Baumgartner****, Woods Hole Oceanographic Institution*
Robert G. Campbell*, University of Rhode Island*

CIFAR 58-095: This project is complete as funded under NA17RJ1224.

Primary objectives

This project is part of a larger study to understand "the relationships among bowhead whale prey, oceanographic conditions, and bowhead whale feeding behavior… and to identify predictable aspects in those relationships" (Bowhead Whale Feeding in the Western Beaufort Sea, Draft Study Plan). The goal of the study is to gain a better understanding of the shelf environment in order to develop effective mitigation plans for future oil and gas development. The present project addresses three specific objectives of the larger study: (1) Document bowhead whale prey distributions and abundance in the immediate vicinity of feeding bowhead whales as well as in neighboring areas without whales; (2) Document "fine scale" oceanographic and other relevant environmental conditions both near feeding bowhead whales and in neighboring areas without whales; (3) Characterize oceanographic features on a "coarse scale" relative to the study area.

Approach/methodology

Okkonen was the project leader for the physical oceanographic components, Ashjian and Campbell were project leaders for the prey sampling components, and Baumgartner was project leader for the tagging, tracking, and whale proximate physical and biological sampling components.

Photo by Phil Alatalo, Woods Hole Oceanographic Institution

General Project Methodology:
Sampling was conducted on the Beaufort Sea shelf from Barrow, AK east to ~152 °E during mid-August to mid-September field seasons. A 43' (13-m) boat was used to conduct high vertical-resolution biophysical oceanographic sampling along several shore–shelfbreak transects. Finer scale oceanographic and prey sampling adjacent to feeding bowhead whales was conducted using two boats (43' and 32') following a nested sampling design (whale tracking was conducted simultaneously using a third, smaller (20') boat). Oceanographic moorings instrumented with acoustic Doppler current profilers (ADCPs) and microcat conductivity-temperature sensors were deployed to monitor shelf–slope exchange events and, using acoustic backscatter data acquired by the ADCPs, identify the presence of zooplankton (krill) on the shelf.

Okkonen's principal tasks within this methodology were to:

1. Prepare, deploy and recover oceanographic moorings,
2. Participate in the acquisition of field data from vessel and mooring platforms,
3. Participate in the analyses of those data, and
4. Provide analyses of ancillary (meteorological and remote sensing) data sets.

Research accomplishments/highlights/findings

Synthesis of hydrographic, mooring, and ancillary (wind, sea surface temperature satellite imagery) data acquired during 2005–2008 field seasons allowed us to identify conditions which regulate the intrusion of Bering/Chukchi origin waters onto the western Beaufort shelf and publish these results (Okkonen et al. 2009). Generally speaking, when winds are weak or from the southwest, Bering/Chukchi waters from Barrow Canyon intrude onto the western Beaufort shelf. When winds are from the east/southeast, currents on the inner Beaufort shelf flow northwestward and oppose significant eastward intrusions of Bering/Chukchi waters onto the western Beaufort shelf.

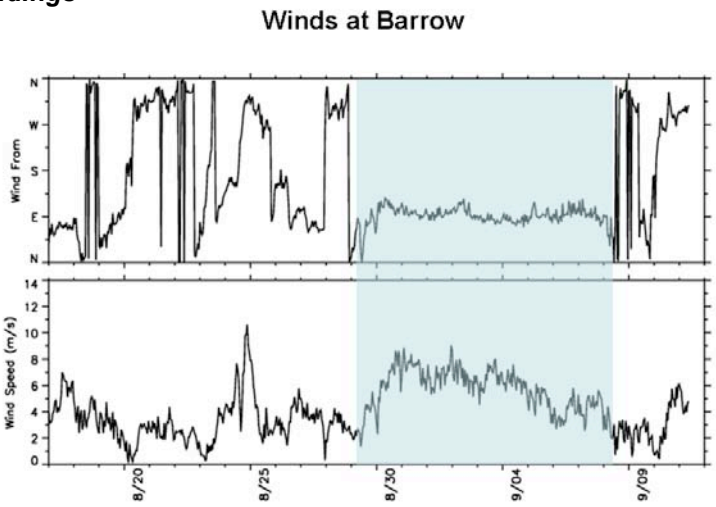

Figure 1. Winds begin to blow from the eastern quadrant on 29 August (blue shading). Winds from the east are upwelling-favorable for the Beaufort shelf.

These two wind-driven current regimes are also components of the mechanism that makes the Barrow area a bowhead whale feeding hotspot. Winds from the eastern quadrant promote upwelling of zooplankton (krill) onto the western Beaufort shelf where wind-driven shelf currents carry the krill westward toward Barrow (Figures 1 and 2). When the winds become weak, the krill become concentrated near the southern flank of Barrow Canyon by eastward-intruding Bering/Chukchi waters. These processes were illustrated schematically in the poster produced for North Slope Borough High Schools (see *Presentations*).

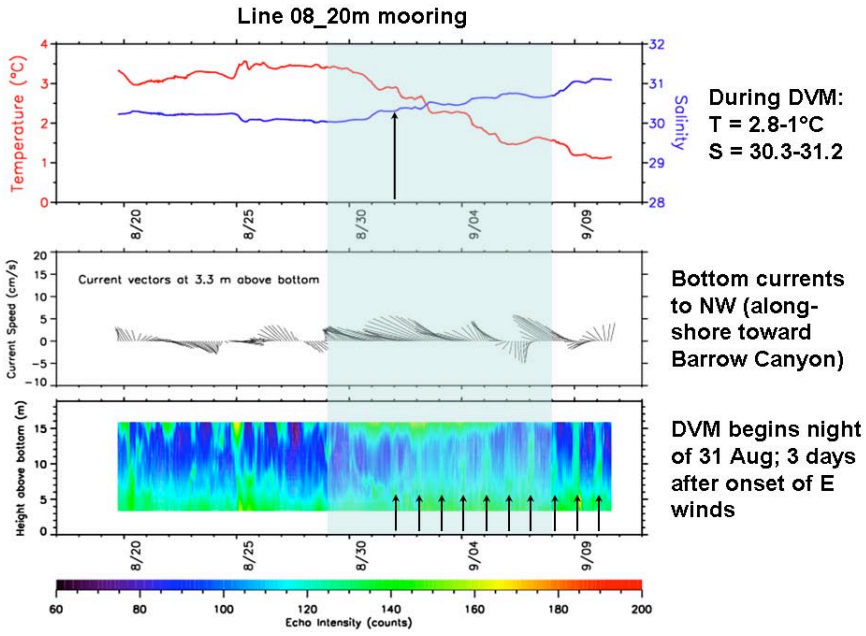

Figure 2. Oceanographic conditions leading to whale feeding behavior. ***(Top panel)*** *Bottom temperature begins to decrease and bottom salinity begins to increase with the onset of winds from the eastern quadrant.* ***(Middle panel)*** *Near-bottom currents flow to the northwest during the period of winds from the eastern quadrant.* ***(Bottom panel)*** *ADCP echo intensity reveals signatures of inferred zooplankton diel vertical migration (DVM, arrows) beginning the night of 31 August. Comparison with the top and middle panels suggests that winds from the east promote upwelling of zooplankton along with cooler (less than ~2.6C), saltier (>30.3) water onto the middle Beaufort shelf and concurrent northwest-ward advection by shelf currents.*

NOAA relevance/societal benefits

This research will lead to improved understanding of the natural environment and its relationship to fishery resources, and will assist NOAA/NMFS in its mission to manage and conserve the Nation's resources.

Research linkages/partnerships/collaborators and networking

This was a collaborative effort between marine scientists at the University of Alaska Fairbanks through CIFAR, Woods Hole Oceanographic Institution through CICOR, and the University of Rhode Island.

Education/outreach

Presentations

Okkonen, S., C. Ashjian, R. Campbell and D. Jones. 2009. Upwelling and aggregation of zooplankton on the western Beaufort shelf. Poster presented at the Alaska Marine Science Symposium, Anchorage, Alaska, January 2009.

Winds, Currents, and Krill: The Story of the Barrow Area Bowhead Whale Feeding Hotspot. Poster produced for North Slope Borough High Schools. 2009.

Publications

Peer-reviewed

Okkonen, S., C. Ashjian, R. Campbell, W. Maslowski, J. Clement-Kinney and R. Potter. 2009. Intrusion of warm Bering/Chukchi waters onto the shelf in the western Beaufort Sea. *Journal of Geophysical Research*, 114, C00A11, doi:10.1029/2008JC004870.

RUSALCA Preparation for FY08 Multidisciplinary Ocean Climate Observations

Susan Sugai, PI
University of Alaska Fairbanks

NOAA Goals: Understand Climate Variability and Change; Ecosystem-based Management

CIFAR 61-093: This project is ongoing, but this will be the final report.

Primary objectives

This project provides advance funding to investigators with competitively selected Russian–American Long-term Census of the Arctic (RUSALCA) projects. Specifically, this project funds research and logistical activities necessary in preparation for a joint U.S.–Russian multidisciplinary cruise in the northern Bering and Chukchi Seas aboard a Russian icebreaker in late summer 2008.

Approach/methodology

These funds are available to RUSALCA investigators by contacting the PI and describing their specific, time-sensitive need for advance funding. Examples of appropriate use of funds include:

- Support for investigators needing to order specific instrumentation or sampling gear needed for the RUSALCA cruise that require significant lead time for fabrication, testing, and shipping prior to use.
- Support for shipping costs of sampling gear, hazardous chemicals, and isotopes via barge to Nome or other port for field operations.

Research accomplishments/highlights/findings

- Planned joint U.S.–Russian multidisciplinary cruise for late summer 2008 was rescheduled for 2009. Leg 1, the Bering Strait mooring cruise was scheduled from August 21–31, 2009, and Leg 2, the multidisciplinary cruise was scheduled from September 1–30, 2009, with both legs embarking out of Nome, AK.
- This project allowed RUSALCA investigators to purchase supplies necessary for field collections or subsequent laboratory analyses as well as provided modest salary support to cover the additional time required to prepare for the rescheduled 2008 cruise.
- The project PI has requested an "extension to closeout" on this task 3 project which supports NOAA's RUSALCA program that is continued in the new CIFAR cooperative agreement. As such, this project's objectives of preparing for the multidisciplinary ocean climate observations will have been achieved through this project, but the results will reported through the individual RUSALCA projects in the new CIFAR cooperative agreement.

NOAA relevance/societal benefits

RUSALCA is supported by the Climate Observations and Analysis Program of NOAA. The primary goal of this program is to develop climate-quality observations, and associated data ingest, archiving, and dissemination systems.

Research linkages/partnerships/collaborators and networking

This project continues work originally funded under NOAA's RUSALCA program—a multi-investigator, interdisciplinary program to conduct marine research in Bering Strait and the Chukchi Sea. The RUSALCA program afforded the first opportunity since the early 1990s for U.S. scientists to work in Russian waters of the Chukchi Sea.

Marine Fish Survey in the Beaufort Sea Outer Continental Shelf Planning Area

Thomas Weingartner, PI
University of Alaska Fairbanks

Other investigators/professionals funded by this project:
Bodil Bluhm and Ken Coyle, *co-PIs*
University of Alaska Fairbanks

NOAA Goals: Ecosystem-based Management; Understand Climate Variability and Change; Safe, Efficient, and Environmentally Sound Transportation

CIFAR 53-092: This project is complete as funded under NA17RJ1224.

Primary objectives

The project's goals are to assess the distribution, abundance, prey resources and oceanographic habitats of marine fish in the Alaskan Beaufort Sea.

Approach/methodology

The field effort involves sampling adult and juvenile fish by trawl and hydroacoustic surveys, larval fish and zooplankton by vertical net tows, and CTD casts from a fishing vessel in the Alaskan Beaufort Sea.

Research accomplishments/highlights/findings

- Completed fieldwork in late summer 2008.
- Completed and submitted a draft final report to the Minerals Management Service (MMS). We are compiling the data for final submission and awaiting MMS comments on the draft final report.

NOAA relevance/societal benefits

Protect, Restore, and Manage the Use of Coastal and Ocean Resources through an Ecosystem Approach to Management. This will be achieved by measurements in the Alaskan Beaufort Sea that determine the health and productivity of this marine ecosystem so that it can be well-managed in the face of anticipated marine development activities.
Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond. This survey represents the first comprehensive fisheries survey of the Alaskan Beaufort Sea conducted in more than 20 years. As such it assesses the fish populations in this climate climate-sensitive sector of the U.S. Arctic.
Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation. If offshore oil development proceeds in this area, it is likely that produced oil will be transported onshore by underwater pipelines. The proposed measurements help define critical biological issues to be addressed in the event of offshore oil development.

Research linkages/partnerships/collaborators and networking

This is a joint project with researchers at NOAA-NMFS-Alaska Fisheries Science Center and the University of Washington.

Education/outreach:

We made a presentation of this project to the North Slope Borough in fall 2008.

Alaska Earthquake Information Center Seismic Station Upgrade and Installation and TWEAK (Tsunami Warning and Environmental Observatory for Alaska): Seismic Network Expansion and Upgrades

Roger Hansen, PI *University of Alaska Fairbanks*

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

Other investigators/professionals directly funded by this project:
Steve Estes, John Sandru, Joshua Stachnik, Tammy Viggato, Sharon Hansen, Morgan Fowler, and Mitch Robinson, *University of Alaska Fairbanks*

CIFAR 44-013e: This project is complete as funded under NA17RJ1224.

Primary objectives

1) Maintain seismic stations in the Alaska Seismic Network.
2) Upgrade analog stations to Advanced National Seismic System (ANSS) standards of modern broadband equipment.
3) Locate seismic events occurring in Alaska and produce alarms and warnings to the West Coast and Alaska Tsunami Warning Center (WC/ATWC) and Emergency Managers.
4) Maintain data flow of selected stations to ATWC.

Research accomplishments/highlights/findings

For the period between 1 July 2008 and 30 June 2009 AEIC reported a total of 25,675 events within the combined seismic network. The events range in depth from 0 to 270 km, with the deepest earthquakes located in the central Aleutian arc. The magnitude range of reported events is between -0.2 and 6.0.

Installations and maintenance

- Alaska Earthquake Information Center (AEIC) personnel continue to monitor and process data from the combined CREST (Consolidated Reporting of Earthquakes and Tsunamis) network funded by the National Tsunami Hazard Mitigation Program (NTHMP). In the past year, twelve CREST seismic or communication sites needed attention for either routine maintenance or hardening for harsh weather. Site visits are listed below:
  - COLD (near Coldfoot) – GPS timing antenna failed, replaced. Due to remodel of telemetry building, equipment has been relocated for better accessibility.
  - DCPH (Deception Hills seismic station south of Yakutat) – Telemetry problems, data intermittent. With trees removed at Yakutat, Internet protocol (IP) freewave radios re-installed. Hit by lightning again. Replaced solar panels, digitizer and sensor. Working now.
  - DIV (Divide – East of Valdez) – Replace bad GPS unit. Repaired interrupted telemetry. System functioning.
  - DOT (Dot Lake) – Uninterruptible power supply (UPS) and micro-serial server failure. All replaced, and seismometer re-orientation required. Sensor failed and was replaced with a loaner while repair is made. Power failed at telemetry receive site, should be repaired in September.
  - FALS (near False Pass) – Poor telemetry with lots of dropped packets. Station working well after telemetry and digitizer swap last fall.
  - GAMB (Gambell) – Station is out. Visited in July and swapped digitizer. Found trouble with the Static IP address. IP issues have been solved with data flowing. A return visit is required in September to finish cable swaps for new digitizer.
  - PIN (Pinnacle – north of Yakutat) – New Guralp Digitizer and reprogram VHF radios. Very poor telemetry will be fixed by USCG tower (see below).
  - SWD (Seward) – Need to replace bad modem again. Site visit indicates a potential for a cell phone modem upgrade.
  - TNA (Tin City) – All OK.
  - ATKA (Atka Island) – Phone line for communications is still voice grade. Trying again to upgrade to digital phone line through USGS. Digitizer appears to be failing.
  - NIKO (Nikolski) – Station removed and relocated to NIKH.

NIKH (Nikolski) – Relocated site currently operating as well as NIKO through donated internet access. Improved response and telemetry over NIKO.

Yakutat – NOAA weather service building site visit. Communications hub at NOAA weather service tower inspected and maintained. Upgraded antennas. Serviced radios and router. Trees to the south were cleared from telemetry paths. Have applied for and been granted permission to move to the USCG tower and facility in Yakutat. This should vastly improve telemetry for CREST stations PIN and DHCP.

- In the past year we have continued upgrading and expanding the broadband seismic network. We have finalized the installation of the station on Chirikof Island. The permitting process was completed, and a radio relay site was established to now transmit the data into the Plate Boundary Observatory in Akhiok for telemetry through their VSAT system. As part of the relay site on Sitkinak Island, a second seismic station was installed. In addition, we now have several new or upgraded sites throughout Alaska. Upgrades consist of a minimum of 24-bit digitizers and digital telemetry from the sites. Broadband seismometers have been acquired for many of the stations:

  Akhiok – Wireless telemetry service was established that was not reliable. Now we have established a cooperative very small aperture terminal (VSAT) link with the EarthScope Plate Boundary Observatory for telemetry of SII and Chirikof.

  BERG (Iceberg Lake) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 120.

  BGLC (Bering Glacier BLM Camp) – VSAT telemetry system was hardened with additional batteries and wind generator service. System had improved performance throughout winter 2008/2009 with no power drop out. The system telemeters between 12 and 16 broadband seismic stations in real-time. Swapped PASSCAL portable equipment for permanent Q330s and Trillium 120.

  BPAW (Bear Paw Mountain) – Telemetry of broadband digital station modified and improved.

  BRLK (Bradley Lake) – Complete re-install of the station to digital broadband and strong motion. Cell phone modem for data telemetry was intermittent, so was replaced with fiber comms through the Alaska Energy Authority hydroelectric facility.

  CAST (Castle Rocks) – Site visit for strong motion instrument installation, repair of power subsystem wiring, re-level of the broadband.

  CCB (Clear Creek Butte) – Upgrading analog short period station to on-site 24-bit digital acquisition and digital IP telemetry. Seismometer upgraded to a Trillium 240.

  CHUM (Lake Minchumina) – Site visit and trouble shooting of receive site for station KTH, PPLA and CAST. Improved IP radios. All works well at this time.

  CHX (Chaix Hills) – Upgraded short period station to local digitizing and digital telemetry. Receive site through DCPH. Still needs seismometer upgrade.

  CNP (China Poot) – Upgraded short period station to local 24-bit digitizing and digital telemetry. Cell phone modem for data telemetry unreliable, now uses Freewave radios to UA internet in Homer. Seismometer upgraded to Trillium 240.

  DDM (Donnelly Dome) – Upgraded short period station to local 24-bit digitizing and digital telemetry. Uses cell phone modem for data telemetry. Seismometer upgraded to Trillium 240.

  DHY (Denali Highway) – Complete upgrade of a short period analog station to 6-component digital broadband and strong motion. Uses cell phone modem for data telemetry.

  GRIN (Grindle Hills) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 240.

  HDA (Harding) – Upgrading analog short period station to on-site 24-bit digital acquisition and digital IP telemetry. Seismometer upgraded to a Trillium 240.

  KHIT (Khitrov Hills) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 240.

  KLU (Klutina) – Upgrading analog short period station to on-site 24-bit digital acquisition and digital IP telemetry. Seismometer upgraded to a Trillium 240.

  KTH (Kantishna Hills) – Site visit. Guralp digitizer failed. Upgraded to a Q330 digitizer with new Freewave radios to Lake Minchumina.

  KULT (Kultieth Hills) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 240.

  LOGN (Logan Glacier) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 240.

  MCAR (McCarthy) – Site visit. VSAT telemetry site and broadband seismic station. Functioned well through the winter. Power subsystem upgrade.

  MDM (Murphy Dome) – Complete upgrade of seismic station to digital broadband and strong motion. Uses IP Freewave radios for telemetry.

  NICH (Nichuak) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 240.

PNL (Peninsula) – Site visit to existing Broadband station. Firmware upgrade to digital radio system. Needs upgraded tower in Yakutat.
RAG (Ragged Mountain) – Site visit of existing Broadband and strong motion station. Firmware upgrade to digital IP radio system. Now has alternate telemetry path through BGLC. Working reliably.
RC01 (Rabbit Creek) – Site visit of existing Broadband station. Removed repeater site for new station at Skwentna (SKN).
RIDG (Independence Ridge) – New installation of a 24-bit digital broadband and strong motion site. Data telemetry with digital IP cell phone modem. Unreliable at this time.
RND (Reindeer) – Complete upgrade of a short period analog station to 6-component digital broadband and strong motion. Uses cell phone modem for data telemetry. Cell phone modem and antenna swapped out.
SCM (Sheep Mountain) – Upgraded short period station to local 24-bit digitizing and digital telemetry. Uses cell phone modem for data telemetry. Seismometer upgraded to a Trillium 240.
SCRK (Sand Creek) – New installation of a 24-bit digital broadband and strong motion site. Data telemetry with digital IP cell phone modem.
SII (Sitkinak Island) – Site visit. Hardened power subsystem and swapped out telemetry to a VSAT system located in Akhiok. Created a repeater capability for new station at Chirikof.
SKN (Skwentna) – Complete upgrade of seismic station to digital broadband and strong motion. Uses IP Freewave radios for telemetry through station SSN.
SSN (Susitna) – Complete upgrade of seismic station to digital broadband and strong motion. Uses IP Freewave radios for telemetry.
SUCK (Suckling Hills) – Swapped PASSCAL portable equipment for permanent Q330s and Trillium 120.
TRF (Thorofare Mountain) – Site visit. Broadband station functioning as new.
Ultima Thule – Site visit. VSAT telemetry site. Functioned well through the winter. Power subsystem upgrade.

NOAA relevance/societal benefits
Improved detection of tsunamigenic earthquakes by AEIC and NOAA tsunami warning centers.

Outreach
A new system has been designed to provide real-time and reviewed earthquake information to local Emergency Services offices. It is now installed in the following population centers in the state: Fairbanks, Anchorage, Valdez, Seward, Soldotna, and Kodiak. The system resides on a stand-alone MAC computer that displays real time earthquakes on a State map with audio announcements of earthquake locations and magnitudes.

Alaska Tsunami Inundation Mapping Project and TWEAK (Tsunami Warning and Environmental Observatory for Alaska) Element I: Accelerated Alaska Inundation Mapping Production

Roger Hansen, PI *University of Alaska Fairbanks*

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

Other investigators/professionals associated this project:
Elena Suleimani, *University of Alaska Fairbanks*
Dmitry Nicolsky, *University of Alaska Fairbanks*
Rod Combellick, *State of Alaska Division of Geological and Geophysical Surveys*

CIFAR 51-0143 and 06-028a. This project is complete as funded under NA17RJ1224.

Primary objectives
This task is a continuation of the original TWEAK initiative to complete hazard and risk assessment through inundation modeling for more than 70 Alaskan communities. Tsunami waves are a threat for many Alaska coastal locations, and community preparedness plays an important role in saving lives and property. Bathymetry and topography for these communities are needed as necessary input for creating community inundation maps that are utilized for defining evacuation routes for the at-risk communities. We develop hypothetical tsunami scenarios that

are based on parameters of potential underwater earthquakes and landslides for a specified coastal community. The modeling results are delivered to the community for local tsunami hazard planning and construction of evacuation maps.

Research accomplishments/highlights/findings

We have continued working on the benchmarking of the numerical model of tsunami propagation and runup. This model was developed at the Alaska Earthquake Information Center (AEIC) and is used for tsunami inundation mapping of Alaska communities. As one of NOAA's recommended field benchmarks, we modeled propagation and runup of tsunami waves generated by the 1993 Hokkaido-Nansei-Oki earthquake. Most of the tsunami damage was concentrated around Okushiri Island located west of Hokkaido Island. We have acquired detailed runup measurements and high-resolution bathymetry grids that allowed us to simulate runup of tsunami waves on Okushiri Island and compare results with available field data (Figure 1). The numerical results are in good agreement with observations, and have demonstrated that the numerical algorithm is stable and successfully models the overland flow.

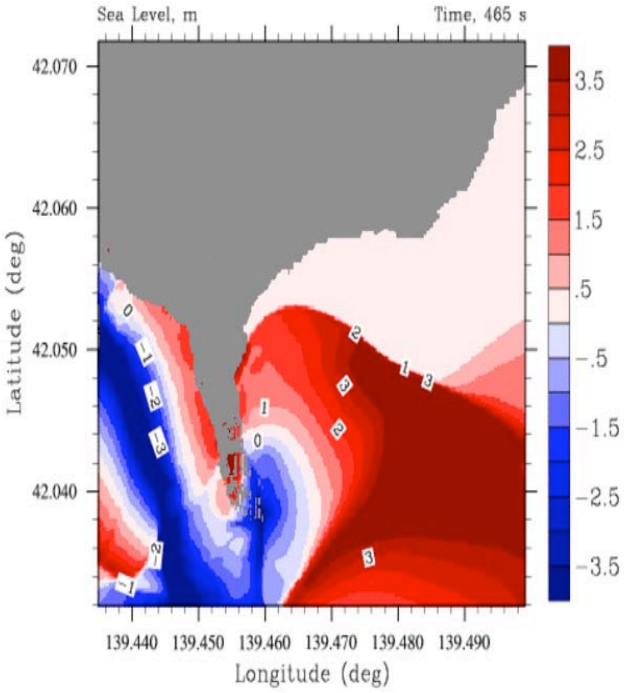

Figure 1. Snapshot from the numerical simulation of tsunami waves flooding the narrow peninsula at the southern end of Okushiri Island, 465 seconds after the earthquake (gray color represents dry land.)

We have continued working on the ATOM (Alaska Tsunami Online Mapping) web-based interface. It is built on the AEIC's recently developed and benchmarked nonlinear shallow water model of tsunami propagation and runup that runs on the Sun Opteron cluster ("Midnight") at the Arctic Region Supercomputing Center. The interface uses Google maps for visualizations, and provides data outputs in NetCDF and KML formats. This interface aims at increased efficiency of tsunami inundation mapping of coastal Alaska. We have added an important capability to this tool, which allows for the interactive online generation of earthquake parameters and subsequent calculation of the tsunami source function. If a user wants to create a simple one-fault scenario, he/she first selects a point on the Google Map that is the epicenter of the hypothetical earthquake. Then, a line can be dragged in the direction of the strike, with its length equal to the rupture length. Other required parameters (width of the fault, dip angle, rake angle, amount of slip on the fault) can be specified through the pop-out window. Also, the new feature allows the user to specify the multiple-fault scenario by uploading the parameter file. Then, the corresponding deformation of the ocean floor can be calculated by the built-in numerical procedure that uses the Okada algorithm for derivation of surface deformation due to a finite fault in a half-space. Results are shown in the same Google Map window as a filled contour plot of the seafloor deformation (Figure 2). This feature is extremely useful for hypothetical tsunami source scenario generation in communities that have not been affected by historical tsunamis.

We have worked on construction of numerical grids for Sitka (Figure 3). The grids are 75% complete. We compiled tectonic source functions for historic tsunami events that affected Sitka. Also, we completed quality control of the new set of grids developed by the National Geophysical Data Center (NGDC) for Prince William Sound communities Valdez, Cordova and Whittier, and integrated the grids into the model. All tectonic scenarios are compiled for the Prince William Sound communities. We have completed preliminary model runs for the communities of Whittier and Cordova (Figure 4).

We have worked on the source mechanism of the 1964 tsunami. For many locations in the Gulf of Alaska, the 1964 tsunami generated by the M_w9.2 Great Alaska earthquake may be the worst-case tsunami scenario. We use the 1964 tsunami observations to verify our numerical model of tsunami propagation and runup; therefore it is essential to use an adequate source function of the 1964 earthquake to reduce the level of uncertainty in the modeling results. The analysis of the eyewitness arrival times of the highest observed waves in Kodiak and Kenai Peninsula showed

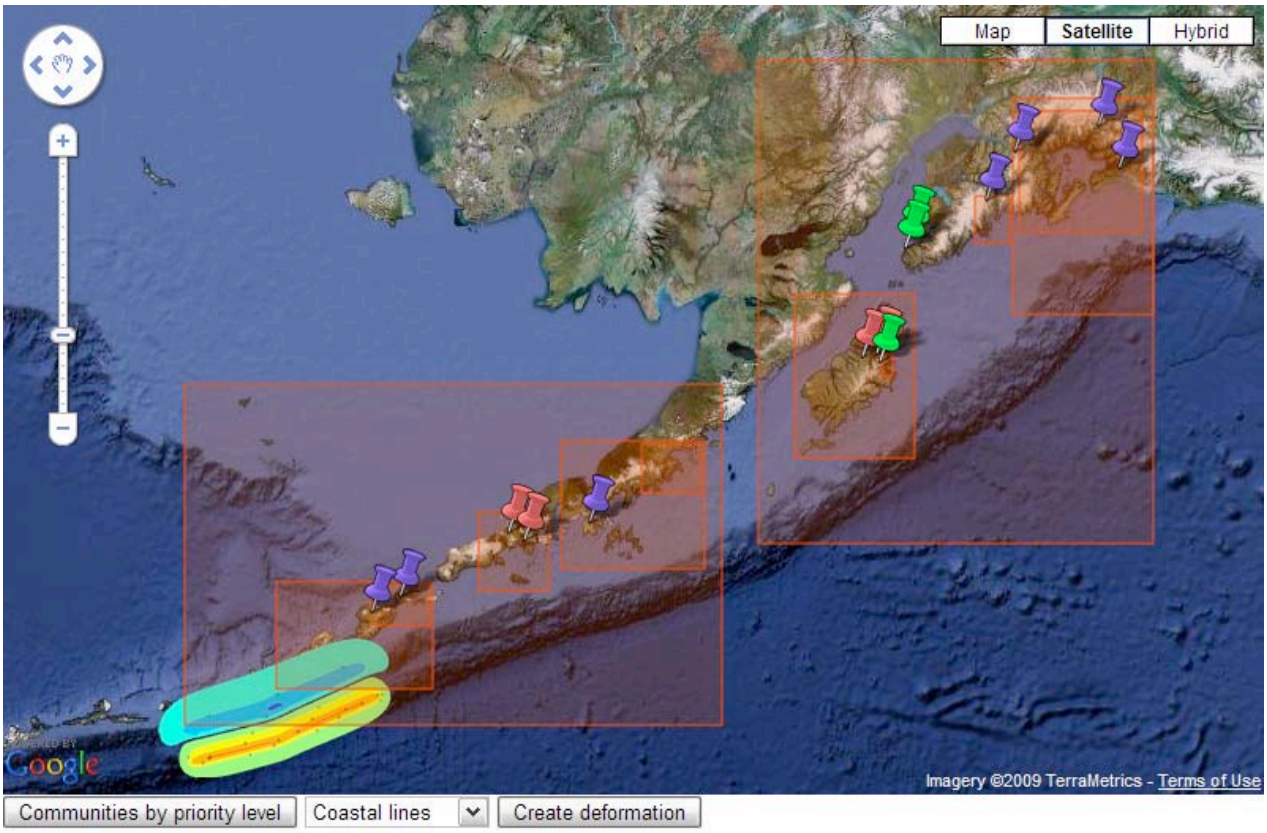

Figure 2. Snapshot of the front end of ATOM interface. Shown are embedded telescopic grids of different resolution that are built around the communities from the Alaska inundation mapping priority list. Pins indicate locations of communities and are color-coded according to the priority level of a community. The elliptic shape in the lower left corner is a hypothetical tectonic tsunami source function. It is a M_w8.9 earthquake that ruptures a section of the Alaska-Aleutian subduction zone and generates tsunami waves that are threat to the communities of Akutan, Unalaska and Nikolski.

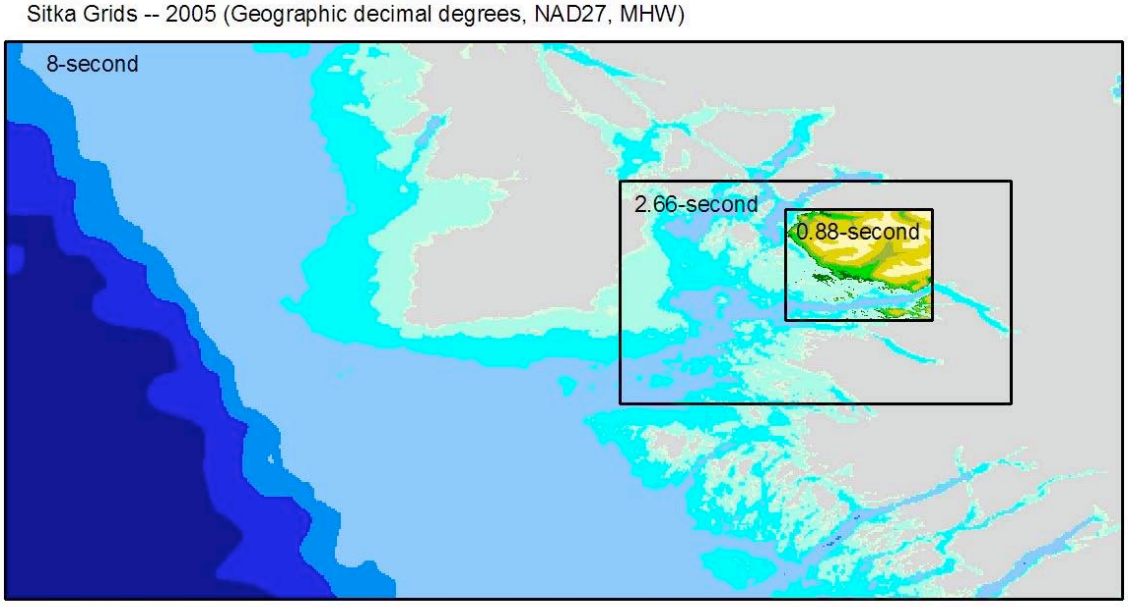

Figure 3. Embedded telescopic grids of 8-sec, 2.66-sec and 0.88-sec resolution around Sitka. The grid of 0.88-sec resolution combines bathymetry and topography data for tsunami inundation modeling.

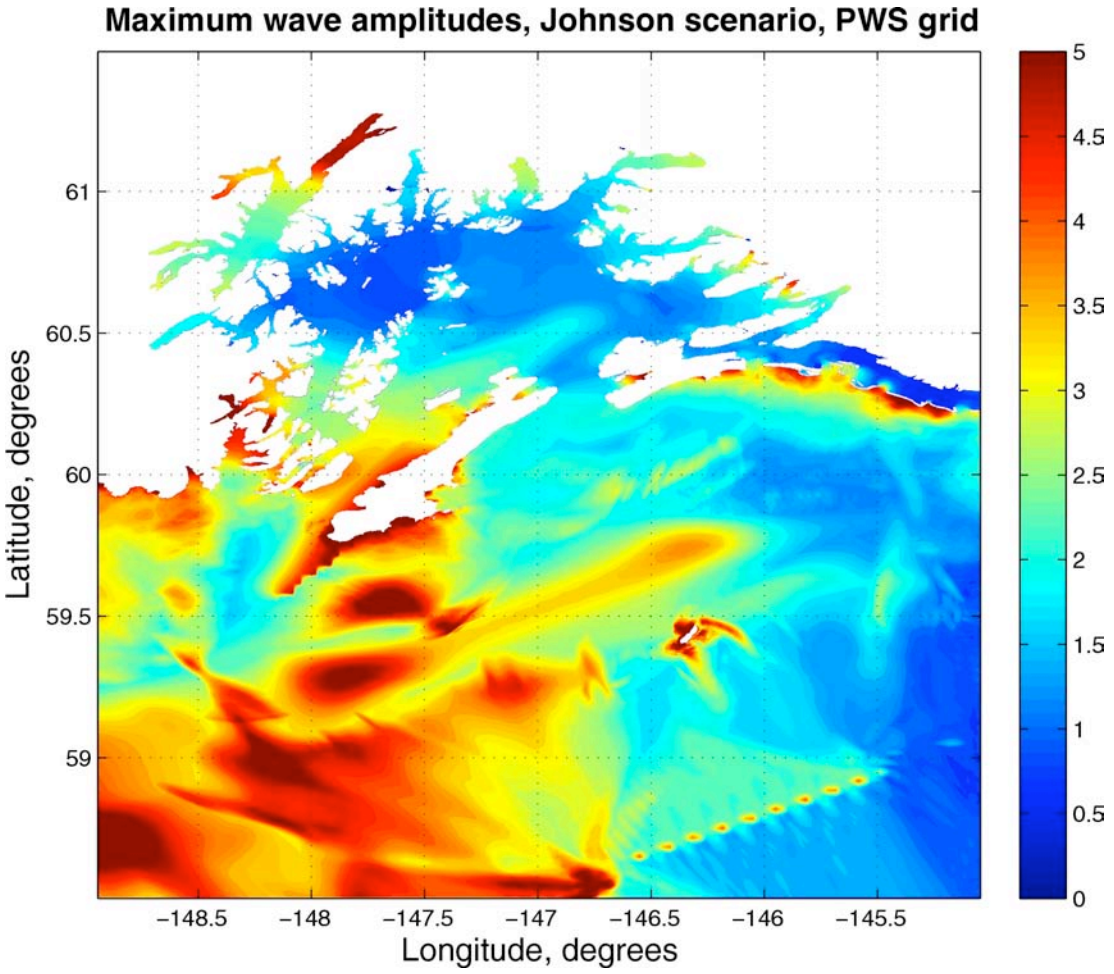

Figure 4. Distribution of maximum tsunami amplitudes (in meters) for the Johnson et al. (1996) scenario of the 1964 tsunami in the Prince William Sound (PWS) grid of 8-sec resolution.

that the initial tsunami wave was higher and closer to the shore than it would be if it was generated by slip on the megathrust. That resulted in a hypothesis that crustal splay faults were a major contributor to vertical displacements that generated local tsunami waves. We conducted a numerical study of different source functions of the 1964 tsunami to test whether the crustal splay faults had significant effects on local tsunami runup heights and arrival times. We considered the following source models of the 1964 earthquake: the slip model by Johnson et al. (1996) developed by joint inversion of the far-field tsunami waveforms and geodetic data (Figure 5), and the recent model by Suito and Freymueller (in review) (Figure 6). The last one extends the Montague Island fault farther along the Kenai Peninsula coast and thus reduces slip on the megathrust in that region. Although in the far field all source functions produce very similar waveforms, which are also in good agreement with the tide gage records, the near-field amplitudes and arrival times differ substantially. In order to study the near-field tsunami effects, we constructed embedded telescoping bathymetry grids around the tsunami generation area to calculate tsunami arrival times and sea surface heights for the source models of the 1964 earthquake and used available observation data to verify model results.

NOAA relevance/societal benefits

This work directly benefits NOAA's National Tsunami Hazard Mitigation Program, which is intended to provide emergency officials in at-risk coastal communities with tsunami hazard assessment. Inundation maps that are based on numerical modeling results are an essential part of community tsunami preparedness.

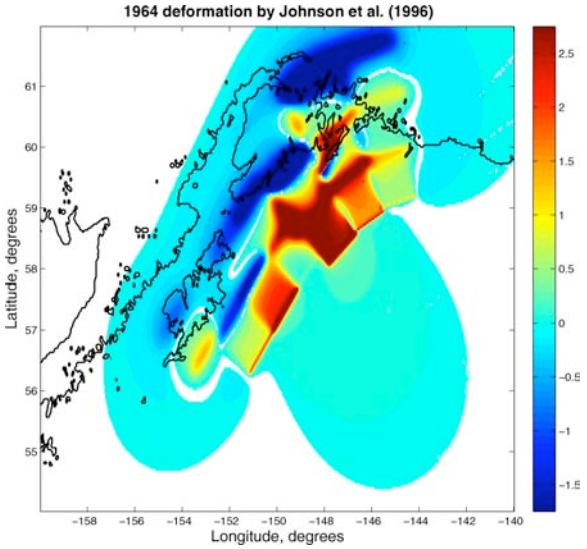

Figure 5. Vertical coseismic deformations of the 1964 earthquake based on the source function derived by Johnson et al. (1996) from joint inversion of the far-field tsunami waveforms and geodetic data.

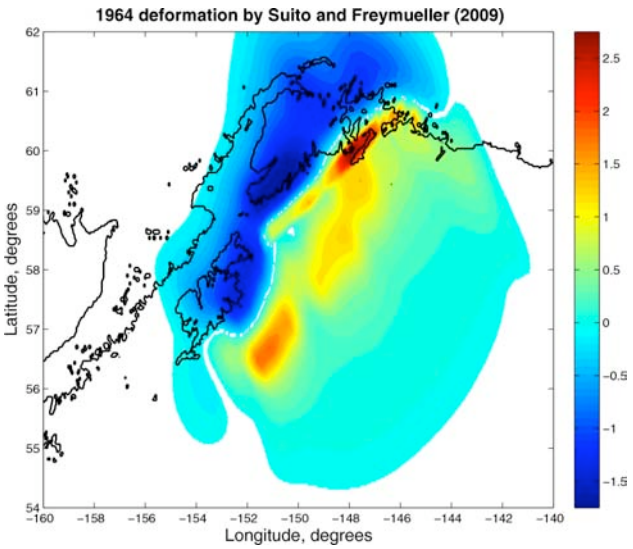

Figure 6. Vertical coseismic deformations of the 1964 earthquake based on the source function derived by Suito and Freymueller (in review) from a 3-D viscoelastic model developed together with the afterslip model.

Education/outreach

Presentations

Suleimani, E., N. Ruppert, M. Fisher, D. West and R. Hansen. 2008. The contribution of coseismic displacements due to splay faults into the local wavefield of the 1964 Alaska tsunami. Fall Meeting of the American Geophysical Union, San Francisco, California, 15–19 December 2008. (*abstract OS43D-1334*)

Nicolsky, D., E. Suleimani, D. West and R. Hansen. 2008. Benchmarking the UAF Tsunami Code. Fall Meeting of the American Geophysical Union, San Francisco, California, 15–19 December 2008. (*abstract OS43D-1326*)

West, D., E. Suleimani and R. Hansen. 2008. Tsunami inundation mapping with KML. Fall Meeting of the American Geophysical Union, San Francisco, California, 15–19 December 2008. (*abstract IN41A-1123*)

Suleimani, E., D. Nicolsky and R. Hansen. 2009. Near-field modeling of the 1964 Alaska tsunami: a source function study. 6th Biennial Workshop on Japan–Kamchatka–Alaska Subduction Processes (JKASP 6), Fairbanks, Alaska, 22–26 June 2009.

Nicolsky, D., R. Hansen, E. Suleimani and D. West. 2009. Tsunami modeling and inundation mapping in Alaska: current status of the project. 6th Biennial Workshop on Japan–Kamchatka–Alaska Subduction Processes (JKASP 6), Fairbanks, Alaska, 22–26 June 2009.

Suleimani, E., D. Nicolsky and R. Hansen. 2009. Inundation modeling for near-field tsunami sources with applications to the Aleutians. Aleutian Geohazards Workshop, Fairbanks, Alaska, 21 June 2009.

Publications

Peer-reviewed

Suleimani, E., R. Hansen and P. Haeussler. 2009. Numerical study of tsunami generated by multiple submarine slope failures in Resurrection Bay, Alaska, during the M_W9.2 1964 earthquake. *Pure and Applied Geophysics*, 166:131–152, doi: 10.1007/s00024-004-0430-3.

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Johnson, J.M., K. Satake, S.R. Holdahl and J. Sauber. 1996. The 1964 Prince William Sound earthquake: Joint inversion of tsunami waveforms and geodetic data. *Journal of Geophysical Research*, 101(B1):523–532.

Suito, H. and J. Freymueller. A viscoelastic and afterslip postseismic deformation model for the 1964 earthquake. In review for *Journal of Geophysical Research*.

TWEAK (Tsunami Warning and Environmental Observatory for Alaska) Education Outreach Activities by AEIC

Roger Hansen, PI *University of Alaska Fairbanks*

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

Other investigators/professionals funded by this project:
Sharon Hansen, Lea Burris, Tammy Viggato, John Sandru, *University of Alaska Fairbanks*

An element of CIFAR 57-047c: This project is complete as funded under NA17RJ1224.

Primary objectives

The Geophysical Institute/Alaska Earthquake Information Center (AEIC) participates in the National Tsunami Hazard Mitigation Program (NTHMP) by evaluating and mapping potential inundation of selected parts of Alaska coastlines and providing education and outreach to educate the inhabitants. These efforts are in collaboration with the Division of Homeland Security and Emergency Management (DHSEM) and Alaska Tsunami Warning Center (ATWC), with consideration to local community involvement. Emergency managers need training along with tsunami evacuation maps for these communities, showing the extent of inundation with respect to human and cultural features, and evacuation routes.

Education and outreach

From 1 July 2008 through 30 June 2009, the AEIC provided laboratory tours to 450 adults and 262 K–12 students, through various summer tours, tour groups, visits from school classes and the Alaska Tsunami Education Program (ATEP). The AEIC also operates a booth at the Tanana Valley State Fair and the "Science Potpourri" (held on the UAF campus) where we provide information and demonstrations to an estimated 440 adults and 300 K–12 students. The information provided consists of Alaska seismicity, tectonics, and tsunami overviews as well as earthquake and tsunami preparedness.

In addition, we participated in the Alaska Summer Research Academy, leading students age 13–18 on a seismology experiment in Denali National Park. Also, a group of kids with Upward Bound assisted in a couple of our seismic station upgrades.

Lastly, we continue to participate with DHSEM and ATWC on community visits for seismic and tsunami safety briefings.

NOAA relevance/societal benefits

These activities all pertain to the National Tsunami Hazard Mitigation Program with NOAA's Weather Service.

Research linkages/partnerships/collaborators and networking

Collaborations for this work include the Alaska Division of Geological and Geophysical Surveys, the Alaska Department of Emergency Services, the Alaska Tsunami Warning Center, and the Pacific Marine Environmental Laboratory of NOAA in Seattle.

TWEAK (Tsunami Warning and Environmental Observatory for Alaska): Tsunami Code Development

Roger Hansen, PI ***NOAA Goals: Serve Society's Needs for Weather and Water Information;***
Zygmunt Kowalik, Co-PI and task lead ***Safe, Efficient and Environmentally Sound Transportation***
University of Alaska Fairbanks

Other investigators/professionals funded by this project:
James Beget, Tatiana Proshutinsky, *University of Alaska Fairbanks*
Juan Horrillo, *University of Alaska Fairbanks and Texas A&M University at Galveston*

An element of CIFAR 57-074c: This project is complete as funded under NA17RJ1224.

Primary objectives

The objective of this project is to improve the present numerical models and afterwards develop a comprehensive numerical model for tsunami generation, propagation and transformation to be used at the West Coast/Alaska Tsunami Warning Center (WC/ATWC). Although the current models have been successfully used, there is a need of actualization using the state-of-the-art approaches. To carry out these activities we closely cooperated with the WC/ATWC in model development, testing and implementation and with internal and external institutions that are in the vanguard in specific fields of tsunami research, Arctic Region Supercomputing Center (ARSC), Woods Hole Oceanographic Institution (WHOI), University of Hawaii (UH), Texas A&M University at Galveston (TAMUG), amongst others.

Approach/methodology

We have approached objectives by developing particular tasks with the aim to improve the model components. These tasks are:

1. *Tsunami runup*
2. *2D/3D hybrid tsunami model*
3. *Interaction of tide and tsunami*
4. *Tsunami generation by subaerial and submarine landslides*
5. *Construction of the comprehensive tsunami model*

We especially concentrated on task 2 with the purpose of model improvement by including dispersive processes. The results obtained with hydrostatic model and dispersive models were compared against the full Navier-Stokes equations (FNS) model in order to assess differences caused by vertical acceleration and identify the importance of dispersion for the global propagation model. This investigation is a cooperative effort of J. Horrillo (TAMUG) and Z. Kowalik (UAF, SFOS), Yoshiki Yamazaki (UH) and Bill Knight (WC/ATWC and UAF).

For comparison of the constructed dispersive model we chose the data collected by Briggs et al. (1995) in a large-scale laboratory experiment to investigate solitary wave runup on a conical island. The details of comparison are given in the paper by Yamazaki et al. (2008). In Figure 1, the time sequence of the trapped wave around the conical island is given. The left panels of Figure 1 show that the trapped waves from the two sides superpose with the diffracted wave at the lee side of the island and generate the large amplitude wave. The right panels show the free surface when the trapped waves have passed each other and continue to wrap around to the front. At the same time the reflected wave from the lee side of the island is sending a new converging wave into the open domain. Thus the island becomes the secondary source of the high amplitude. These secondary sources may locally generate higher amplitude than the one generated by the initial tsunami (Kowalik 2008). Tsunami amplification has been observed as well along the chain islands. For example, the Emperor Island chain, during the Kurile tsunami of 2006, was the source of short transient coherent waves that eventually converged, concentrating tsunami energy along an extended portion of the ocean. Therefore, identification of the sources of the high amplitude secondary signals and the time delay between the initial tsunami wave and secondary signals is of crucial importance for tsunami warning and prediction.

The 3D Full Navier-Stokes (FNS) numerical model was implemented in collaboration with TAMUG and WC/ATWC. The 3D model has been optimized for tsunami waves by mean of a simplified donor-acceptor algorithm to track the free surface. Contrary to the former Volume of Fluid (VOF) algorithm, which comprises several sea level values to define the free surface (especially for broken waves), a single sea level value is kept for

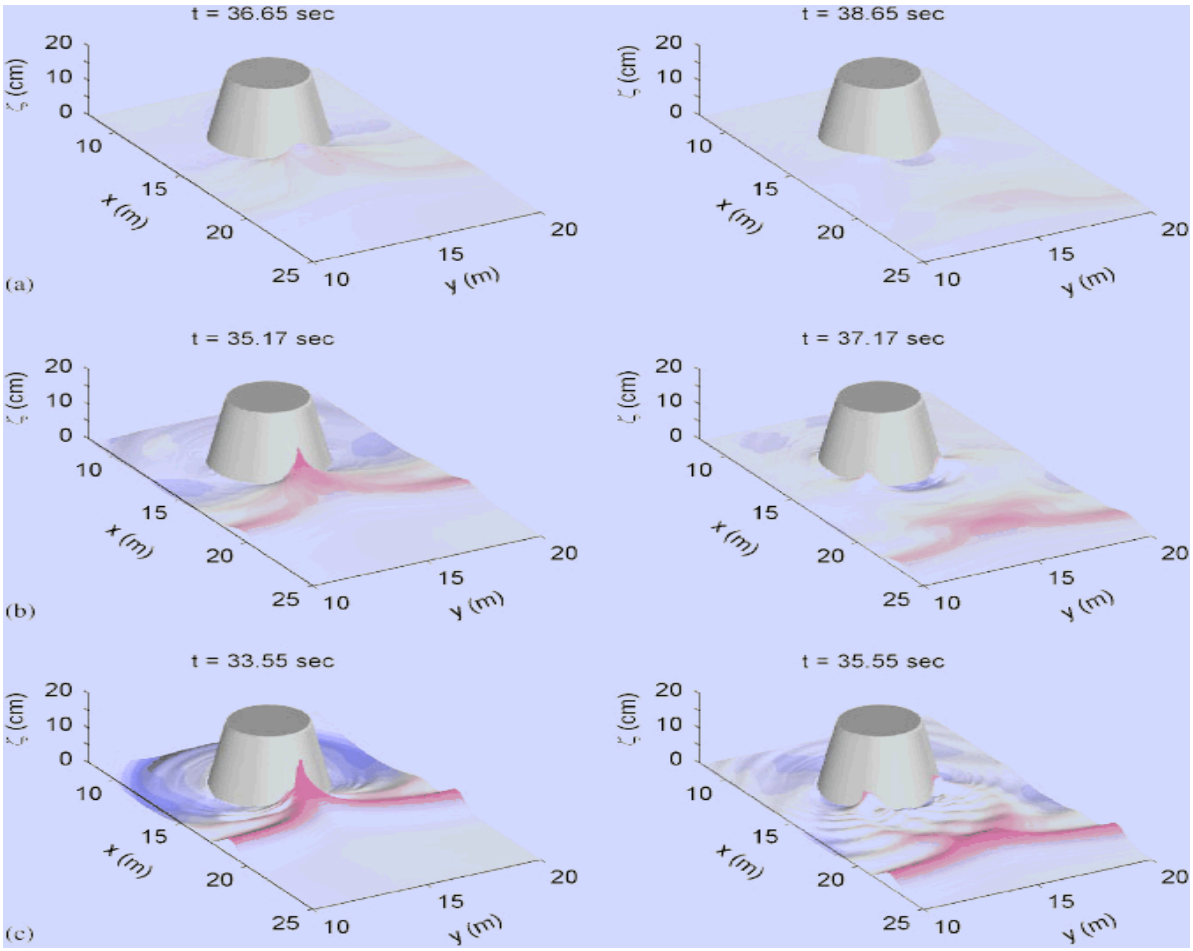

Figure 1. Wave transformation on the lee side of the conical island. Figure 1c (left panel) shows maximum amplitude of the trapped wave; Figure 1c (right panel) shows that the island generates a converging wave propagating away from the island.

each discrete point in the domain. The implemented surface treatment has the advantage of dealing with coarser grids that are proper in tsunami computation but still keeping most of the physical process involved in the breaking and post breaking regimes. The computational efficacy of the model was evaluated using measured data from recent lab experiments posted at the Network for Earthquake Engineering Simulation (NEES) Training Workshop: Simulation & Large Scale Testing of Near-Shore Wave Dynamics, 8–10 July 2009, Oregon State University (OSU), Corvallis, Oregon. As seen in Figure 2, the leading wave phase and height is reproduced fairly well even after the wave breaking takes place.

Task 3: *Interaction of tide and tsunami* was jointly investigated by Kowalik and Proshutinsky (accepted) through careful examination of the Cook Inlet response to tsunami and tide signals. Theoretically, by changing total ocean depth, tidal elevations influence the speed and magnitude of tsunami waves in shallow regions with dominating tidal signals. We tested this assumption by employing a simple 1-D (1-dimensional) model that describes propagation of tidal waves in a channel with gradually increasing depth and the Cook Inlet bathymetry. Results of this work show that tsunami–tide interactions can easily be detected in shallow regions. Important conclusions from our studies are that computed elevations obtained by simulating the tsunami and the tide together differ significantly from linear superposing of the sea surface heights obtained when simulating the tide and the tsunami separately, and that maximum tsunami–tide interaction depends on tidal amplitude and phase. The major cause of this tsunami–tide interaction is tidally induced ocean depth that changes the conditions of tsunami propagation, amplification, and dissipation.

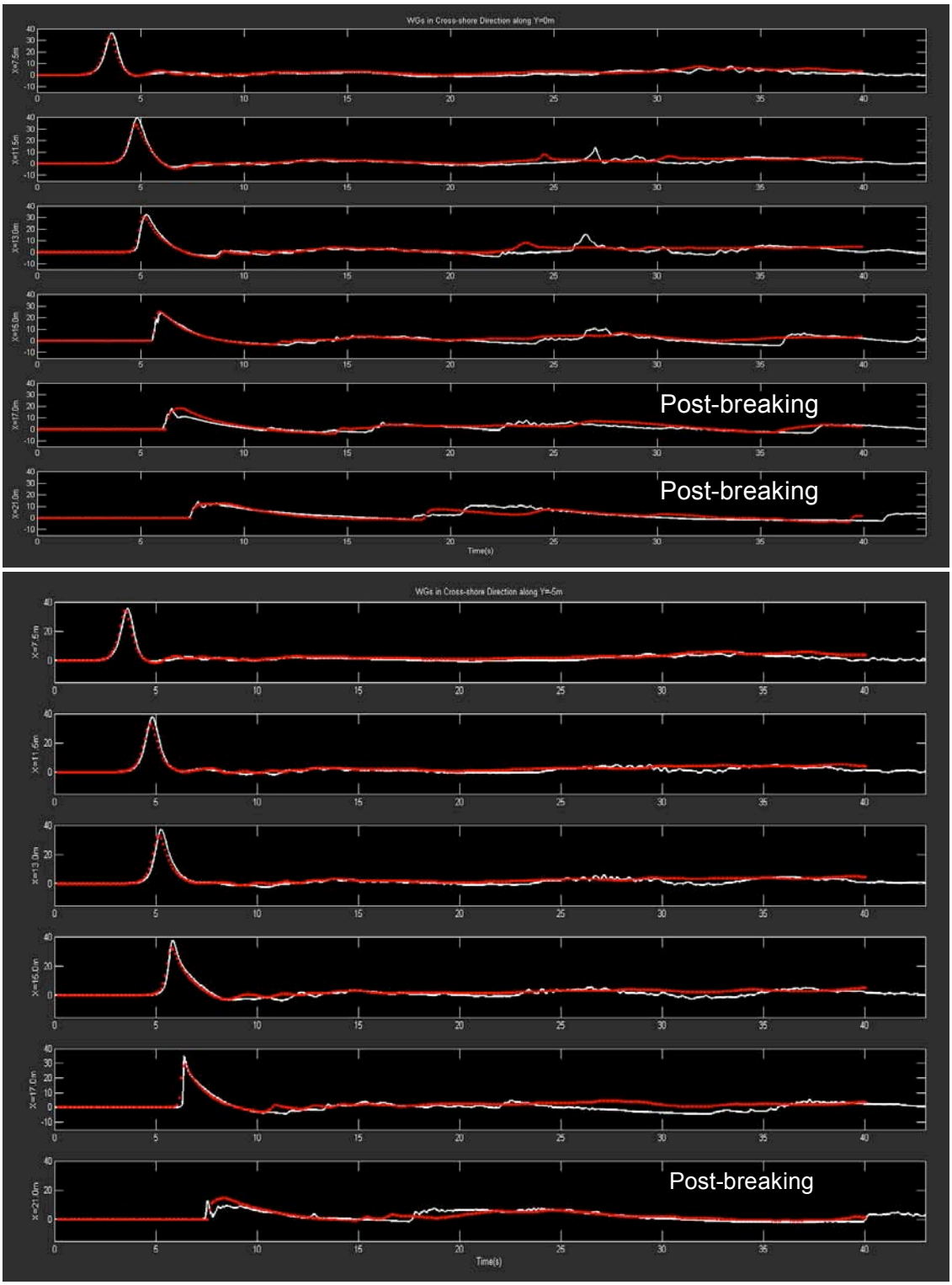

Figure 2. 3D-Navier–Stokes computational result (red) compared against measured sea level (white). Snapshot of the wave propagation at different locations in the large tsunami wave basin of OSU.

Task 4: *Tsunami generation by subaerial and submarine landslides.* A land/submarine slide model is in development by Z. Kowalik (IMS-UAF), J. Horrillo (TAMUG) and W. Knight (WC/ATWC), while potential scenarios of generation are constructed by J. Beget (GI-UAF) and S. Naidu (IMS-UAF). Numerical calculations for hazard mapping of tsunamis generated by subsea/subaerial landslides have not been addressed in full yet. Therefore, this study aims to gather current developments and identify the best and most practical framework for numerical modeling and source characterization so that tsunami hazards due to this natural phenomenon can be incorporated into planning efforts in a manner comparable to tsunami flooding caused by subsea earthquakes.

Subaerial and submarine mass failures are complex phenomena, which involve strong vertical flows, turbulence and slide/water interactions, and sometimes wave breaking. In this context, a 3D (3-dimensional) Navier-Stokes model will be further implemented and tested using the scenarios mentioned above. So far the 2D (2-dimensional) Navier-Stokes (2D NS) has been developed and it is currently in the validation stage. The distinctive parts of the 2D numerical model are: a) the slide is considered as viscoplastic fluids with various constitutive laws depending on whether it behaves as a solid, granular or debris flow; b) the model includes the coupling between slide and water and vice versa; c) a water–landslide interface is provided to minimize the slide material diffusion into the water; d) several slide rheologies are considered, i.e., Coulomb friction for sea bottom and plane of failure, angle of repose for granular material, and kinematic viscosity for mud flow. The Lituya Bay tsunami of 10 July 1958 has been selected to validate the 2D NS. Figure 3 depicts the subaerial landslide and extent of damage caused by the wave runup at the opposite side of the Gilbert Inlet. Figure 4 shows a sequence of the numerical model result. The 2D NS model results are consistent with the extent of inundation found by the field observations. The higher runup obtained by the model is probably because the 2D geometry does not allow for the horizontal divergence of the flow.

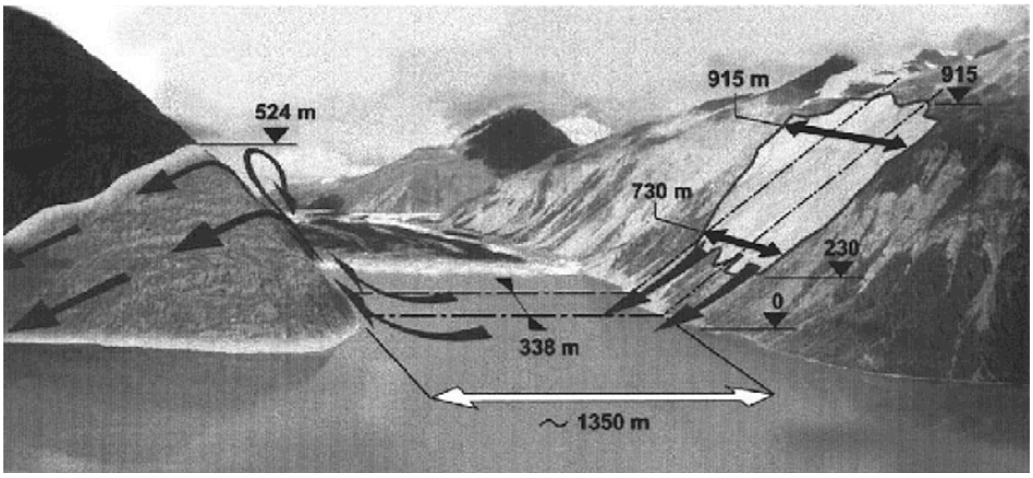

Figure 3. Illustration of the subaerial landslide tsunami in Lituya Bay, Alaska, 1958 (from Fritz et al. 2001)

Research accomplishments/highlights/findings

In 2008–2009, major accomplishments were associated with formulation and testing dispersive models. We continue this line of research aimed at constructing a simple dispersive set of equations which can be implemented into everyday prediction and warning at WC/ATWC. The formulation builds on the nonlinear shallow-water equations and utilizes a non-hydrostatic pressure term to describe weakly dispersive waves (Yamazaki et al. 2008). The computed results show very good agreement with laboratory data for wave propagation, transformation, breaking, and runup. This reporting period we have performed extensive model validation based on the nearshore wave benchmark problems. The problems were offered by NEES Training Workshop: Simulation & Large Scale Testing of Near-Shore Wave Dynamics, 8–10 July 2009, Corvallis, Oregon. In the hydraulic experiments a single solitary wave propagated up a triangular-shaped shelf (benchmark No. 1) and additionally an island was placed on the shelf (benchmark No. 2). Free surface and velocity were recorded and compared against seven models. Our model, which is a cooperative effort of the University of Alaska and the University of Hawaii, was presented at the workshop by Ph.D. student Yoshiki Yamazaki. The organizers judged that our dispersive model provided the best comparison against the measured data. In Figure 5 the sea level compared against measured data by the seven different models has been plotted.

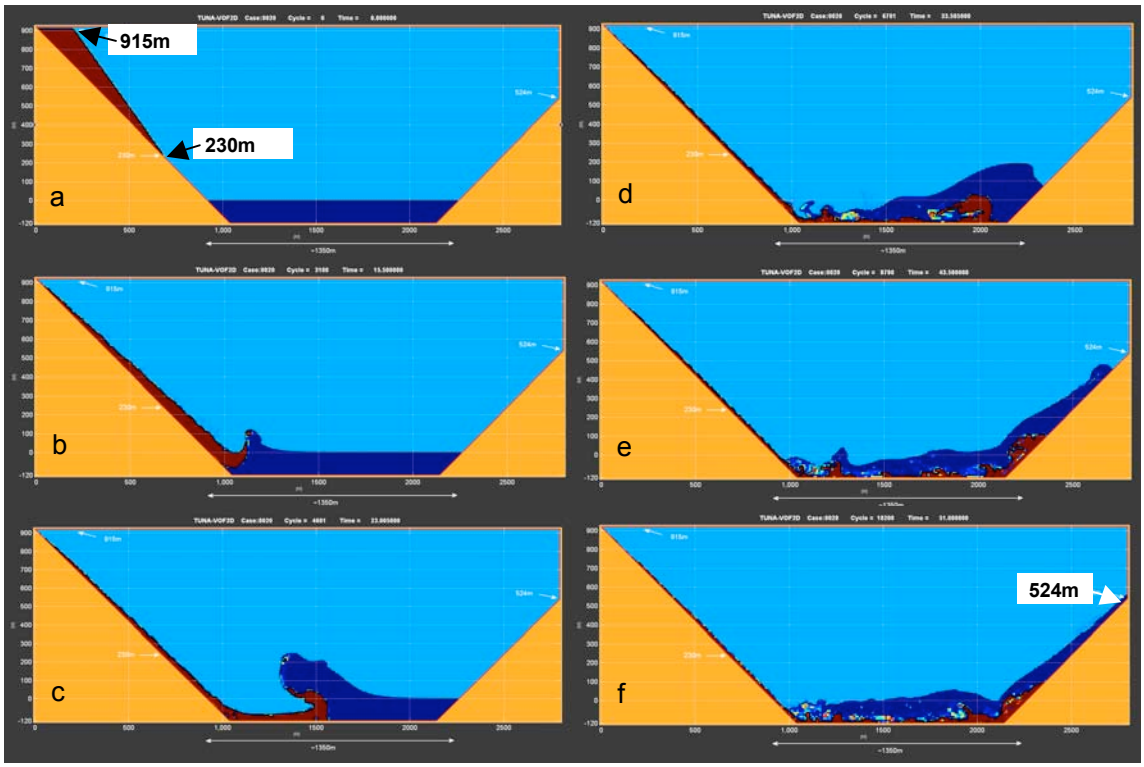

Figure 4. 2D NS numerical model result sequence. Landslide: brown color, water: dark blue and air: blue. The water, air and sliding material are entrained as a mixture which moves up the shore.

NOAA relevance/societal benefits

Numerical models are required to assess expected coastal tsunami impact, in amplitude, horizontal inundation distance and velocities, so that proper evacuation decisions can be made during tsunami warnings, as well as for long-term planning of coastal zone development. The new part of the comprehensive tsunami model under development in the past 2 years, the dispersive model, after further comprehensive testing will be transferred to WC/ATWC and through cooperation with University of Hawaii will be used in a Hawaiian tsunami mitigation program.

Research linkages/partnerships/collaborators and networking

The numerical modeling technique used by the West Coast/Alaska Tsunami Warning Center (WC/ATWC) which forms the present basis of the U.S. Tsunami Warning System's predictive technique was developed during the period 1984–1990 by the Institute of Marine Science, University of Alaska in cooperation with the Institute of Ocean Sciences, Sidney, BC, Canada through a National Science Foundation (NSF) grant.

Several teams from institutions of the U.S.A. and Japan are involved in the new model construction and testing. For the continuing model development, the responsibility lies with the University of Alaska (Kowalik and Horrillo, Institute of Marine Science and Texas A&M University at Galveston; Tom Logan and Ed Kornkven, Arctic Region Supercomputing Center (ARSC)), W. Knight and P. Whitmore (WC/ATWC), Y. Shigihara (National Defense Academy, Japan) and T. and A. Proshutinsky (WHOI/IMS). Input to the project was also made by G. Gisler (Los Alamos), J. Beget (UAF), S. Naidu (IMS) and Y. Yamazaki, University of Hawaii. William Knight coordinated research activities related to model implementation at the WC/ATWC.

We envision that many of the tsunami algorithms can be most effectively transported to and tested on the UAF supercomputers. The development of the efficient tsunami codes relies heavily on ARSC staff (T. Logan and E. Kornkven) and the inclusion of new parallel computational tools. For instance, new parallel codes for global tsunami algorithm developed at ARSC will enable the WC/ATWC to quickly generate new database entries as needed or to re-compute the old database entries.

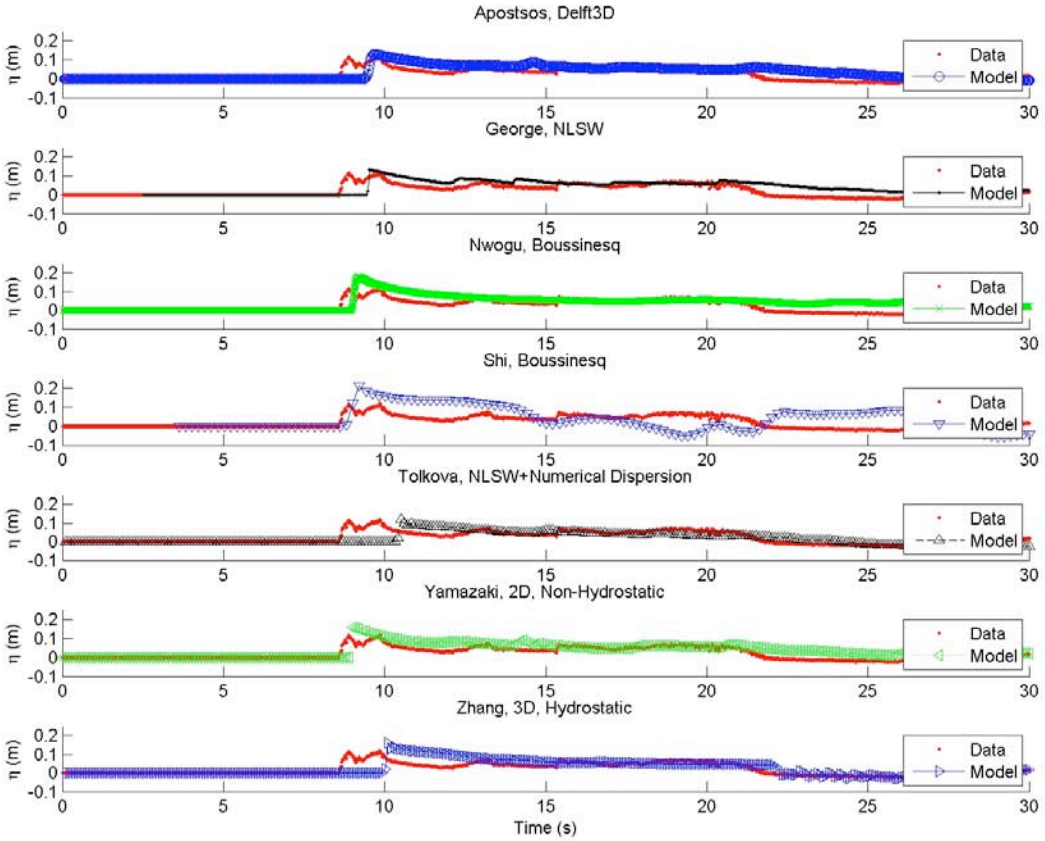

Figure 5. Comparison of water level numerical results of seven models with the experimental data for the benchmark No. 2 offered by the NEES Workshop: Simulation & Large Scale Testing of Near-Shore Wave Dynamics, 8–10 July 2009, Corvallis, Oregon.

Education/outreach

Student participation

- William Knight is a Ph.D. student at the Institute of Marine Science and he works at WC/ATWC. He continues research towards developing a dispersive tsunami model and fine grid resolution for coastal flooding. These models will be applied at the Alaska Tsunami Warning Center. Z. Kowalik chairs his advisory committee.
- Yoshiki Yamazaki is a Ph.D. student at the University of Hawaii at Manoa, Department of Ocean & Resources Engineering. He tests dispersive models against laboratory measurements and analytical solutions. He is implementing these new models to Hawaii coastal waters. Z. Kowalik is a member of his advisory committee.

Workshop attendance & participation

NEES Training Workshop: Simulation & Large Scale Testing of Near-Shore Wave Dynamics, 8–10 July 2009, Oregon State University, Corvallis Oregon.

Publications

Peer-reviewed

Yamazaki, Y., Z. Kowalik and K.F. Cheung. 2008. Depth-integrated, non-hydrostatic model for wave breaking and run-up. *International Journal for Numerical Methods in Fluids*, doi:10.1002/fld.1952

Kowalik, Z., J. Horrillo and E. Kornkven. 2008. Tsunami runup onto a plane beach. Chapter 7 in: P.L.-F. Liu, H. Yeh and C. Synolakis, Eds. Advances in Coastal and Ocean Engineering, Vol. 10: *Advanced Numerical Models for Simulating Tsunami Waves and Runup*, pp. 231–236. World Scientific.

Kowalik, Z., J. Horrillo and E. Kornkven. 2008. Tsunami generation and runup due to a 2D landslide. Chapter 13 in: P.L.-F. Liu, H. Yeh and C. Synolakis, Eds. Advances in Coastal and Ocean Engineering, Vol. 10: *Advanced Numerical Models for Simulating Tsunami Waves and Runup*, pp. 269–272. World Scientific.

Accepted
Kowalik, Z. and A. Proshutinsky. Tsunami–tide interactions: A Cook Inlet case study. Accepted for publication in *Journal of Continental Shelf Research*.

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Briggs, M.J., C.E. Synolakis, G.S. Harkins and D.R. Green. 1995. Laboratory experiments of tsunami runup on a circular island. *Pure and Applied Geophysics*, 144(3/4):569–593.
Fritz, H.M., W.H. Hager and H.-E. Minor. 2001. Lituya Bay case: rockslide impact and wave run-up. *Science of Tsunami Hazards,* 19(1):3–22.
Kowalik, Z. 2008. Energy flux as a tool in locating tsunami secondary sources. *Science of Tsunami Hazards*, 27(3):1–29.

TWEAK (Tsunami Warning and Environmental Observatory for Alaska): Tsunami Portal for Comparison of Tsunami Code

Roger Hansen, PI *University of Alaska Fairbanks*

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

Other investigators/professionals associated this project:
Barbara Horner-Miller (*Task lead****), Craig Stephenson, Thomas Logan, Elena Suleimani***
University of Alaska Fairbanks

An element of CIFAR 57-074c: This project is complete as funded under NA17RJ1224.

Primary objectives

The Tsunami Computational Portal (TCP) (https://tsunamiportal.arsc.edu) is a shared web portal for executing computational models of tsunami behavior. Researchers, operational staff and other interested parties are able to select bathymetric data for different scenarios to run on the available models. They specify parameters for explicit scenarios, specify which of the available models to use to create computer runs, submit those runs for execution, access or download the results from the computational systems to the portal, and share comments on their results, issues and recommendations. The web portal was built by an outsourced team from the Northwest Alliance for Computational Science and Engineering (NACSE) and Oregon State University (OrSU), and includes the necessary user interface/infrastructure to provide access to three prominent tsunami codes and professionally developed case studies. This web portal is fully functional, with the entire portal hosted by Arctic Region Supercomputing Center (ARSC). Objectives for the portal during this period included continued support, maintenance and enhanced functionality.

Research accomplishments/highlights/findings

During this reporting period, several enhancements were made to the infrastructure of the portal:

- Real-time backups of jobs and user databases were implemented. In addition, backups of other, less dynamic, databases were streamlined for efficiency.
- Several typographical errors were found and corrected in the portal front-end.
- A test and development version of the portal was established at ARSC, including both a development front-end and development back-end that use the same infrastructure as the production portal.
- Work is underway to improve error communications to end users, including incidents of failed transfers, corrupt files, incomplete runs, and bad values found in output files.

The problem with trans-Pacific propagation was resolved by the addition of a "rotated" ETOPO dataset to the portal database. This dataset ranges in latitude from 0 to 360, rather than -180 to 180, thus encapsulating the entire Pacific Ocean within a single continuous grid.

In addition, during testing of the latest model added to the portal (TsunamiCLAW), a few minor problems were uncovered and resolved.

As before, each portal job is monitored for correctness and runs with errors have been analyzed. Since its inception, over 400 jobs have been run through the portal. During this reporting period, no unresolved errors were encountered. Continued interest in use of the portal was evidenced by the approval of 5 new accounts during the last 3 months.

NOAA relevance/societal benefits

The TCP was used by Eric Geist (USGS) and colleagues during this reporting period. A fix for Mr. Geist's reported problem with trans-Pacific propagation has been implemented.

Research linkages/partnerships/collaborators and networking

NACSE: Cherri Pancake, Dylan Keon, and Ben Steinberg have continued to be invaluable to the success of the TCP. They have provided instruction and expertise in the inclusion of new or enhanced datasets on a regular basis throughout this reporting period. In addition, they provided invaluable input on all of the portal enhancements.

Oregon State University: Harry Yeh has provided modeling expertise and consultation on many aspects of the portal, including debugging, usability, and enhancements. In addition, he is responsible for screening all new portal account applications.

University of Alaska Fairbanks: Barbara Horner-Miller provides project oversight and coordination between all of the collaborators in this project. Elena Suleimani, the developer of the UAF tsunami model, was also invaluable in providing modeling expertise and consultation to the project. Her help in troubleshooting and debugging has been greatly appreciated.

Education/outreach

Recent visualization work at ARSC has included the 3D representation of the '64 earthquake in south-central Alaska. A navigable, animated 3D visualization of the '64 quake was built using OpenSceneGraph, and is displayed in the ARSC Discovery Lab for visitors. The visualization includes a detailed model of the ocean floor along with an exaggerated sea-surface animation portraying the first few hours of the event. In addition a variety of 2D tsunami animations have been created. Users such as Dave Nobel of the NWS (Valdez, AK) have requested the use of these ARSC tsunami visualizations.

Presentations

Logan, T. 2008. Community portal for collaborative research on tsunamis. 2008 Department of Defense High Performance Computing Modernization Program (HPCMP) Users Group Conference, Seattle, Washington, 14–17 July 2008.

Logan, T. 2008. Tsunami modeling on a global scale: Kuril Island tsunami of November 2006. 2008 Department of Defense HPCMP Users Group Conference, Seattle, Washington, 14–17 July 2008.

Other outcomes

Presentations by TCP users

Barkan, R., U.S. ten Brink and J. Lin. 2008. Trans-Atlantic tsunamis: simulations of the 1755 Lisbon and of hypothetical Puerto Rico trench earthquake tsunamis. American Geophysical Union Fall Meeting, San Francisco, California, 15–19 December 2008. (*Abstract OS53B-06*).

ten Brink, U.S. 2009. Presentation to the National Academy committee on Tsunami warning and preparedness, National Academies, Washington, D.C., January.

Publications by TCP users

Barkan, R., U.S. ten Brink and J. Lin. 2009. Far field tsunami simulations of the 1755 Lisbon earthquake: Implications for tsunami hazard to the U.S. East Coast and the Caribbean. *Marine Geology*, 264:109–122. doi:10.1016/j.margeo.2008.10.010.

ten Brink, U., D. Twichell, E. Geist, J. Chaytor, J. Locat, H. Lee, B. Buczkowski, R. Barkan, A. Solow, B. Andrews, T. Parsons, P. Lynett, J. Lin and M. Sansoucy. 2008. Evaluation of tsunami sources with the potential to impact the U.S. Atlantic and Gulf coasts. USGS Administrative report to the U.S. Nuclear Regulatory Commission, 300 pp., 22 August 2008.

TWEAK (Tsunami Warning and Environmental Observatory for Alaska): Earthquake Characteristics and Finite Fault Processes

Roger Hansen, PI *University of Alaska Fairbanks*

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

Other investigators/professionals funded by this project:
Natalia Ruppert, *University of Alaska Fairbanks*

An element of CIFAR 57-074c: This project is complete as funded under NA17RJ1224.

Primary objectives

Implementation of the near-real-time moment tensor inversion and extended earthquake source inversion procedures at the Alaska Earthquake Information Center (AEIC).

Approach/methodology

The real-time earthquake detection system at AEIC is based on the Antelope software package from BRTT, Inc. Automatic earthquake locations are searched over a pre-calculated three-dimensional grid. Once an event is located, its magnitude is calculated. Location and magnitude along with the set of associated arrivals and other information are written into the real-time earthquake database. The moment tensor inversion program is triggered by a module that continuously watches the real-time earthquake database. When a new event above a certain magnitude level has been recorded, it triggers the execution of the moment tensor inversion module.

The procedure consists of several steps. First, the waveforms are extracted from the continuous waveform archive for the broadband stations. If waveforms within a certain epicentral distance are available, then the moment tensor inversion is performed. The inversion uses a library of precalculated Green's functions to compute synthetic seismograms for a range of source depths (from 5 to 200 km with 5 km interval). Currently, we use 3 regionalized velocity models: (1) Aleutian Islands region east of 157º W longitude; (2) central Alaska region north of 62.5º N latitude; (3) southern Alaska region south of 62.5 º N latitude and east of 157 º W longitude. Three different frequency ranges are used depending on the magnitude of the earthquake: 0.02–0.1 Hz for magnitude less than 4.0, 0.02–0.05 Hz for magnitudes between 4.0 and 5.4, 0.01–0.05 Hz for magnitudes 5.5 and greater. The program generates a series of output files including a postscript graphics file with the actual and synthetic wave forms and the best fit moment tensor parameters, a map with the earthquake location and the focal mechanism obtained, and an ascii file with the moment tensor parametric data.

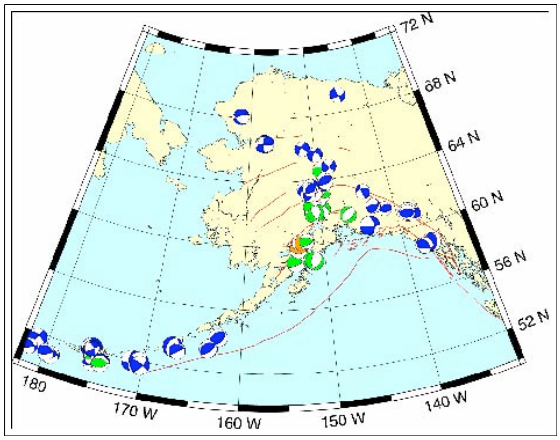

Figure 1. Map of regional moment tensors computed for events that occurred in Alaska and Aleutians between 1 July 2008 and 30 June 2009. Beach-balls are color-coded according to the earthquake depth: blue 0–30 km, green 30–100 km, orange 100–150 km, red >150 km.

The automatic moment tensor information in three forms is available through the AEIC webpage: http://www.aeic.alaska.edu/html_docs/moment_tensors.html. Automatic moment tensors are reviewed on the following business day.

Research accomplishments/highlights/findings:

- A total of 76 regional moment tensor solutions were calculated (moment magnitudes Mw between 3.8 and 6.0) between 1 July 2008 and 30 June 2009 in Alaska and Aleutians (Figure 1).
- Continuing expansion of the AEIC broadband network allows for more reliable calculations of the earthquake source parameters through inclusion of more waveform data into inversion.
- We have begun a project concerned with the use of near-real-time GPS static displacement data to determine seismic moment (Mo) and magnitude (Mw) within minutes. Our appoach is to iteratively refine the estimates of Mo and Mw through time as more information becomes available. With seismological input of aftershock

zones, and regional moment tensors, we can improve our models to include estimates of fault length, width, and slip as well.

- There are several real-time GPS stations in the Aleutian arc that we intend to use for data.

NOAA relevance/societal benefits

Rapid calculation of earthquake source parameters through the moment tensor inversion allows scientists to determine sense of motion along the ruptured fault. While many other conditions determine whether an earthquake is capable of generating potentially destructive tsunamis, the foremost condition is the type of earthquake source (underthrusting vs. normal or strike-slip) and size.

Research linkages/partnerships/collaborators and networking

This project is one of several research tasks identified under TWEAK (Tsunami Warning and Environmental observatory for Alaska) and share the linkages and partnerships outlined under the other tasks.

The moment tensor inversion package at AEIC was installed in close cooperation with D. Dreger from Berkeley Seismic Laboratory. This cooperation is continuing as part of installation and tuning of the program package for extended source inversion at AEIC. All AEIC earthquake source data is available on-line through open-access web pages. This information is available to scientists at the West Coast/Alaska Tsunami Warning Center (WC/ATWC) as well as many other institutions.

Education/Outreach

Presentations

Ruppert, N.A., R.A. Hansen, M. West and S. Prejean. 2008. Seismic swarm associated with the 2008 eruption of Kasatochi Volcano, Alaska. American Geophysical Union Fall Meeting, San Francisco, California, December 2008. *(Abstract A53B-0261)*

Haeussler, P.J., R.W. Saltus, N. Ruppert and S.M. Karl. 2008. Evidence for Pliocene to present thrust faulting on the south side of the Alaska Range in the vicinity of the Peters Hills piggyback basin. American Geophysical Union Fall Meeting, San Francisco, California, December 2008. *(Abstract T44A-08)*

Kozyreva, N.P., N.A. Ruppert and R.A. Hansen. Strong crustal Earthquakes in Central Aleutian Islands in 2006–2008: Implications for the Block Rotation Model. American Geophysical Union Fall Meeting, San Francisco, California, December 2008. *(Abstract S23B-1893)*

Ruppert, N.A., N.P. Kozyreva and R.A. Hansen. 2009. Strong crustal earthquakes in Central Aleutian Islands in 2006–2008: Implications for the Block Rotation Model. 6th Biennial Workshop on Japan–Kamchatka–Alaska Subduction Processes (JKASP 6), Fairbanks, Alaska, 22–26 June 2009.

Ruppert, N.A., R.A. Hansen and S. Prejean. 2009. Seismic swarm associated with the 2008 eruption of Kasatochi Volcano, Alaska. 6th Biennial Workshop on Japan–Kamchatka–Alaska Subduction Processes (JKASP 6), Fairbanks, Alaska, 22–26 June 2009.

Publications

Peer-reviewed

Ruppert, N.A., K.D. Ridgway, J.T. Freymueller, R.S. Cross and R.A. Hansen. 2008. Active tectonics of interior Alaska: Seismicity, GPS geodesy, and local geomorphology. In: J.T. Freymueller, P.J. Haeussler, R.L. Wesson and G. Ekström, Eds. Active Tectonics and Seismic Potential in Alaska (Geophysical Monograph 179), pp. 109–133. American Geophysical Union, Washington, D.C.

Ruppert, N.A. 2008. Stress map for Alaska from earthquake focal mechanisms. In: J.T. Freymueller et al., Eds. Active Tectonics and Seismic Potential in Alaska (Geophysical Monograph 179), pp. 351–367. American Geophysical Union, Washington, D.C.

TWEAK (Tsunami Warning and Environmental Observatory for Alaska) National Academy of Sciences Review of the NOAA Tsunami Program

Roger Hansen, PI *University of Alaska Fairbanks*

NOAA Goals: Serve Society's Needs for Weather and Water Information; Safe, Efficient and Environmentally Sound Transportation

Other investigators/professionals funded by this project:
Elena Suleimani, Jamie Roush, Natasha Ruppert, Kate Pyatek, *University of Alaska Fairbanks*

An element of CIFAR 57-047c. This project is complete.

Primary objectives and approach

The Geophysical Institute/Alaska Earthquake Information Center (AEIC) participates in the National Tsunami Hazard Mitigation Program (NTHMP) by evaluating and mapping potential inundation of selected parts of Alaska coastlines and providing education and outreach to educate the inhabitants. These efforts are in collaboration with the Division of Homeland Security and Emergency Management (DHSEM) and Alaska Tsunami Warning Center (ATWC), with consideration to local community involvement. Emergency managers need training along with tsunami evacuation maps for these communities, showing the extent of inundation with respect to human and cultural features, and evacuation routes.

The Tsunami Warning and Education Act of 2006 states that the National Academy of Sciences (NAS) will "review the tsunami detection, forecast, and warning program established under this Act to assess further modernization and coverage needs, as well as long-term operational reliability issues, taking into account measures implemented under this Act."

Under NOAA direction we are funding the above-described study as a subcontract given through the University of Alaska Fairbanks. The review assesses education and outreach efforts to improve tsunami preparedness of the at-risk population and how well these efforts complement and enhance state and local tsunami hazard mitigation programs. The review also includes an assessment of how well the detection equipment has been integrated into other United States and global ocean and coastal observation systems and the global earth observing system of systems. The goal of the review is to assess NOAA's efforts to strengthen the Tsunami Program and to identify areas for improvement. The review also focuses on integration with other earth observing systems and will identify promising areas of research that may improve tsunami warning and preparedness both nationally and worldwide.

Research accomplishments/highlights/findings

The Academy of Sciences review of the NOAA tsunami program continues. The Academy has invoiced the University of Alaska, and the invoice was paid in full in June of 2009. The final report is due to be delivered by December 2009.

NOAA relevance/societal benefits

These activities all pertain to the National Tsunami Hazard Mitigation Program with NOAA's Weather Service.

Research linkages/partnerships/collaborators and networking

Collaborations for this work include the Alaska Division of Geological and Geophysical Surveys, the Alaska Department of Emergency Services, the Alaska Tsunami Warning Center, and the Pacific Marine Environmental Laboratory of NOAA in Seattle.

Appendices 1–3

1. Personnel

2. Publication Activity

3. Index of PIs

Appendix 1. Summary of CIFAR-funded Personnel and their Terminal Degree

Category	Number	B.A./B.S. or unknown	M.A./ M.S.	Ph.D.
Research Scientist	1			1
Visiting Scientist	0			
Postdoctoral Fellow	0			
Research Support Staff	2			2
Administrative				
Total (≥ 50% NOAA Support)	**3**			**3**
Undergraduate Students	2	2		
Graduate Students	12		4	8
Total Students	**14**			
Employees (< 50% NOAA Support)	32	10	6	13
Located in NOAA Lab	0			
Obtained NOAA employment within last year	0		0	

Appendix 2. Publication Activity

Work from projects funded under cooperative agreement NA17RJ1224 that was published, accepted, or in press during the reporting period.

Addison, J.A. 2009. Tales from the abyss—results from high-resolution studies of past environments in the Gulf of Alaska. *Global Glimpses*, 15(1):8–10. (http://www.cgc.uaf.edu/Newsletter/index.html)

Alix, C. Ethnoarchéologie de la production des object en bois dans l'Arctique.nord-américain (Ethnoarchaeology of the production of wooden objects in the North American Arctic). Les Civilisations du Renne d'Hier et d'Aujourd'hui - Approches Ethnohistoriques, Archéologiques et Anthropologiques. XXVIIe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes. Ed. S. Beyries and V. Vaté. Editions APDCA, Antibes, in press.

Amundson, J., M. Truffer, M.P. Lüthi, M. Fahnestock, M. West and R. Motyka. 2008. Glacier, fjord, and seismic response to recent large calving events, Jakobshavn Isbræ, Greenland. *Geophysical Research Letters*, 35, L22501, doi:10.1029/2008GL035281.

Barron, J.A., D. Bukry, W.E. Dean, J.A. Addison and B.P. Finney. 2009. Paleoceanography of the Gulf of Alaska during the past 15,000 years: results from diatoms, silicoflagellates, and geochemistry. *Marine Micropaleontology*, 72:176–195.

Bechtol, W.R. 2009. Abundance, Recruitment, and Environmental Forcing of Kodiak Red King Crab. Ph.D. Dissertation, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Bechtol, W.R. and G.H. Kruse. 2009. Analysis of a stock–recruit relationship for red king crab off Kodiak Island, Alaska. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, 1:29–44.

Berman, M. 2008. Endangered species, threatened fisheries: Science to the rescue!: Evaluating the Congressionally designated Steller Sea Lion Research Program. *Marine Policy*, 32:580–591.

Bluhm, B.A., K. Iken and R.R. Hopcroft. Observations and explorations of the Arctic's Canada Basin and the Chukchi Sea: the Hidden Ocean and RUSALCA expeditions. *Deep-Sea Research II*, in press.

Boughan, M. 2008. Paleoceanographic Shifts in the Gulf of Alaska over the Past 2000 Years: A Multi-Proxy Perspective. M.S. Thesis, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Bromwich, D.H., K.M. Hines and L.-S. Bai. 2009. Development and testing of Polar Weather Research and Forecasting Model. 2. Arctic Ocean. *Journal of Geophysical Research–Atmospheres*, 114:D08122. doi:10.1029/2008JD010300

Brown, M.E. 2008. Impact of Local External Forcing of the 2006 Augustine Volcano Eruption on Regional Weather Conditions. M.S. Thesis, University of Alaska Fairbanks. 123 pp.

Bucklin, A., R.R. Hopcroft, K.N. Kosobokova, L.M. Nigro, B.D. Ortman, C.J. Sweetman and R.M. Jennings. DNA barcoding of Arctic Ocean halozooplankton for species identification and recognition. *Deep-Sea Research II*, in press.

Budge, S.M., M.J. Wooller, A.M. Springer, S.J. Iverson, C.P. McRoy and G.J. Divoky. 2008. Tracing carbon flow in an arctic marine food web using fatty acid–stable isotope analysis. *Oecologia*, 157(1):117–129. doi:10.1007/s00442-008-1053-7.

Carmack, E.C., F.A. McLaughlin, S. Vagle and H. Melling. 2008. Canada's three oceans (C30): A Canadian contribution to the International Polar Year. *PICES Press*, 16(2):22–25.

Cooper, M.H., S.M. Budge, A.M. Springer and G. Sheffield. 2009. Resource partitioning by sympatric pagophilic seals in Alaska: monitoring effects of climate variation with fatty acids. *Polar Biology*, doi: 10.1007/s00300-0090614-5

Cooper, L.W., C. Lalande, R. Pirtle-Levy, I.L. Larsen and J.M. Grebmeier. 2009. Seasonal and decadal shifts in particulate organic matter processing and sedimentation in the Bering Strait Shelf region. The Western Arctic Shelf-Basin Interactions (SBI) Project, Vol. 2, *Deep-Sea Research II*, 56(17):1137-1143.

Druckenmiller, M.L., H. Eicken, M.A. Johnson, D.J. Pringle and C.C. Williams. 2009. Toward an integrated coastal sea-ice observatory: System components and a case study at Barrow, Alaska. *Cold Regions Science and Technology*, 56:61–72.

Druckenmiller, M.L. and C. Haas. Integrated sea-ice observation programs. Chapter in: E. Eicken, R. Gradinger, M. Salganek, K. Shirasawa, D. Perovich and M. Leppäranta, Eds., Field Techniques for Sea Ice Research, University of Alaska Press, Fairbanks, Alaska, in press.

Eicken, H., A.L. Lovecraft and M.L. Druckenmiller. 2009. Sea-Ice System Services: A framework to help identify and meet information needs relevant for Arctic observing networks. *Arctic*, 62:119–136.

Emeis, K.-C., B. Finney, R. Ganeshram, D. Gutierrez, B. Poulsem and U. Struck. Impacts of past climate variability on marine ecosystems: Lessons from sediment records. *Journal of Marine Systems*, in press.

Fan, X., J.E. Walsh and J.R. Krieger. 2008. A one-year experimental Arctic reanalysis and comparisons with ERA-40 and NCEP/NCAR reanalyses. *Geophysical Research Letters*, 35:L19811, doi:10.1029/2008GL035110

Fissel, D.B., J.R. Marko and H. Melling. 2008. Advances in marine ice profiling for oil and gas applications. In: Proceedings of the International IceTech Conference 2008.

Fissel, D.B., J.R. Marko and H. Melling. 2008. Advances in upward looking sonar technology for studying the processes of change in Arctic Ocean climate. *Journal of Operational Oceanography*, 1(1);9–18.

Haas, C. and M.L. Druckenmiller. Ice thickness and roughness measurements. Chapter in: E. Eicken, R. Gradinger, M. Salganek, K. Shirasawa, D. Perovich and M. Leppäranta, Eds., Field Techniques for Sea Ice Research, University of Alaska Press, Fairbanks, Alaska, in press.

Hopcroft, R.R. and K.N. Kosobokova. Distribution and egg production of Pseudocalanus species in the Chukchi Sea. *Deep-Sea Research II*, in press.

Hopcroft, R.R., K.N. Kosobokova and A. Pinchuk. Zooplankton community patterns in the Chukchi Sea during summer 2004. *Deep-Sea Research II*, in press.

Howard, K. 2008. Inter-decadal Changes in Sablefish (Anoplopoma fimbria) Growth and Size at Maturity in the Northeast Pacific Ocean. M.S. Thesis, University of Alaska Fairbanks.

Huntington, H.P., S. Gearheard, M.L. Druckenmiller and A. Mahoney. Community-based observation programs and indigenous and local sea-ice knowledge. Chapter in: E. Eicken, R. Gradinger, M. Salganek, K. Shirasawa, D. Perovich and M. Leppäranta, Eds., Field Techniques for Sea Ice Research, University of Alaska Press, Fairbanks, Alaska, in press.

Iken, K., B. Bluhm and K. Dunton. Benthic food web structure under differing water mass properties in the southern Chukchi Sea. Accepted for publication in *Deep Sea Research II*.

Janout, M.A., T.J. Weingartner, S.R. Okkonen, T.E. Whitledge and D.L. Musgrave. Some characteristics of Yakutat Eddies propagating along the continental slope of the northern Gulf of Alaska. *Deep-Sea Research*, in press.

Kelly, B.K., M.E. Ponce, D.A. Tallmon, B.J. Swanson and S.K. Sell. 2009. Genetic diversity of ringed seals at breeding sites: implications for population structure and sensitivity to sea ice loss. North Pacific Research Board Final Report, Project 631.

Kowalik, Z., J. Horrillo and E. Kornkven. 2008. Tsunami propagation and runup due to a 2D landslide. Chapter 13 in: P.L.-F. Liu, H. Yeh and C. Synolakis, Eds., Advances in Coastal and Ocean Engineering, Vol. 10: Advanced Numerical Models for Simulating Tsunami Waves and Runup, pp. 85–89. World Scientific.

Kowalik, Z., J. Horrillo and E. Kornkven. 2008. Tsunami runup onto a plane beach. Chapter 7 in: P.L.-F. Liu, H. Yeh and C. Synolakis, Eds., Advances in Coastal and Ocean Engineering, Vol. 10: Advanced Numerical Models for Simulating Tsunami Waves and Runup, pp. 231–236. World Scientific.

Kowalik, Z. and A. Proshutinsky. Tide–tsunami interactions: A Cook Inlet case study. Accepted for publication in *Journal of Continental Shelf Research*.

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Summary of publications from projects funded under NA17RJ1224.

	JI (subgrantee) lead							
Fiscal year:	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Peer-reviewed	0	10	11	12	17	18	28	28
Non-peer-reviewed	0	1	13	12	13	9	9	10

	NOAA lead							
Fiscal year:	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Peer-reviewed	0	0	0	0	0	3	2	0
Non-peer-reviewed	1	0	1	1	2	1	0	0

	Other lead							
Fiscal year:	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Peer-reviewed	0	4	5	4	13	11	9	11
Non-peer-reviewed	0	1	0	0	3	2	1	2

Appendix 3. Index of Principal Investigators
(key words are in parentheses in cases where one PI has multiple project reports)