Second progress report on Cooperative Agreement NA08OAR4320751

1 April 2009 – 31 March 2010

Cooperative Institute For Alaska Research

UAF UNIVERSITY OF ALASKA FAIRBANKS

Second report from CIFAR to NOAA on Cooperative Agreement *NA08OAR4320751*

(and incorporating shadow award NA08OAR4320870)

1 April 2009–31 March 2010

Cooperative Institute for Alaska Research
P.O. Box 757740
University of Alaska Fairbanks
Fairbanks, AK 99775-7740
www.cifar.uaf.edu

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CIFAR annual reports can be found on the Web at http://www.cifar.uaf.edu/research/reports.php

Overview

Founded in 2008, the Cooperative Institute for Alaska Research (CIFAR) conducts ecosystem and environmental research related to Alaska and its associated Arctic regions, including the Gulf of Alaska, Bering Sea, Chukchi/Beaufort Seas, and Arctic Ocean. CIFAR continues to facilitate the developed long-term collaboration between NOAA and the University of Alaska (UA) begun under the Cooperative Institute for Arctic Research in 1994, within which targeted research, technology, education and outreach can be developed and sustained. CIFAR plays a central role in communication and coordination between NOAA, researchers, management agencies, non-governmental organizations, Alaska communities, and the general public in collaborative research, education, and outreach efforts.

Research Themes for CIFAR

1. **Ecosystem studies and forecasting**—Gain sufficient knowledge of Alaskan ecosystems to forecast their response to both natural and anthropogenic change.
2. **Coastal hazards**—Improve understanding of coastal hazards, storms, and tsunamis that affect Alaska's population, ecosystems and coast to improve weather forecast and warning accuracy.
3. **Climate change and variability**—Foster climate research targeted at societal needs and advance Arctic climate research to improve predictive capacity of climate variations affecting coastal regions and ecosystems.

CIFAR's research activities assist NOAA in four of its Mission Goals: (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; and (4) Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

Membership of CIFAR's Advisory Groups

Listed below are the members of the CIFAR Executive Board and CIFAR Fellows who are responsible for advising CIFAR.

The ***CIFAR Executive Board*** members are:
Eddie Bernard, NOAA Pacific Marine Environmental Laboratory (PMEL) Director
John Calder, NOAA Arctic Research Office Program Manager
John Cortinas Jr., NOAA Cooperative Institutes (CI) Program Manager
Douglas DeMaster, NOAA National Marine Fisheries Service, Director, Alaska Fisheries Science Center (AFSC)
Frank Kelly, NOAA National Weather Service, Alaska Region Director
Buck Sharpton, University of Alaska Fairbanks Chancellor's Director for Research
John Walsh, CIFAR director, ex officio

The ***CIFAR Fellows*** are:

1. Mark Herrmann, Dean, School of Management, UAF, Fairbanks, AK
2. Larry Hinzman, Director, International Arctic Research Center, UAF, Fairbanks, AK
3. Kris Holderied, NOS, NOAA, Homer, AK
4. Anne Hollowed, AFSC, National Marine Fisheries Service, NOAA, Seattle, WA
5. Henry Huntington, Huntington Consulting, Eagle River, AK
6. Zygmunt Kowalik, Professor of Physical Oceanography, Institute of Marine Science, School of Fisheries and Ocean Sciences, UAF, Fairbanks, AK
7. Gordon Kruse, President's Professor of Fisheries, School of Fisheries and Ocean Sciences, UAF, Juneau, AK
8. Molly McCammon, Director, Alaska Ocean Observing System, Anchorage, AK
9. Phil Mundy, Auke Bay Laboratory, AFSC, NMFS, NOAA, Juneau, AK
10. James Overland, Oceanographer, PMEL, NOAA, Seattle, WA
11. Carven Scott, Chief, Environmental & Scientific Services Division, NWS, NOAA, Anchorage, AK
12. Clarence Pautzke, Executive Director, North Pacific Research Board, Anchorage, AK
13. Buck Sharpton, President's Professor of Remote Sensing, Geophysical Institute, UAF, Fairbanks, AK
14. Terry Whitledge, Director, Institute of Marine Science, School of Fisheries and Ocean Sciences, UAF, Fairbanks, AK

Summary of Projects Funded during Reporting Period

During the second reporting period of the new competitively awarded cooperative agreement, NOAA provided funding for CIFAR administration and 9 research or outreach projects totaling $2.07 M. All 8 research projects were Task III (projects that generally require only minimal direct collaboration with NOAA scientists); one was a competitively awarded RUSALCA project (funded under the "shadow" cooperative agreement NA08OAR4320870) and the remaining 7 projects were part of the CIFAR institutional cooperative agreement (NA08OAR4320751). Research projects address all three CIFAR research themes. A full list of these projects is presented in Appendix 1, and summaries by task/theme and funding source are presented in Tables 1 and 2, respectively.

Table 1: Summary of Projects Funded 1 April 2009–31 March 2010: By Task and Theme

Theme	Number of Projects	Total Amount	Subtotals by Task	Percent of Total (rounded)
Administration (Task I)	**2**		**$120,000**	**5.8%**
Core Support	1	$110,000		5.3
State of the Arctic Land Report	1	$10,000		0.5
Research Themes (Task II)	**0**		**$0**	**0.0%**
Research Themes (Task III)	**8**		**$1,948,741**	**94.2%**
Climate Change & Variability	1	$190,000		9.2
Coastal Hazards	3	$1,302,762		63.0
Ecosystem Studies & Forecasting	4	$455,979		22.0
Total	**10**		**$2,068,741**	**100.0%**

Table 2: Summary of Projects Funded 1 April 2009–31 March 2010: By Funding Source
Includes administration + State of Arctic Land Report

Funding Source	Number of Projects	Total Amount	Percent of Total
OAR	3	$480,367	23.2%
NOS	0	0	
NWS	4	$1,492,762	72.2%
NMFS	3	$95,612	4.6%
Total		**$2,068,741**	

Highlights of CIFAR Task I Activities

Because CIFAR's task I administration budget was awarded at $110 K rather than the requested $300 K, we were forced to eliminate most proposed education and outreach functions and seek alternative funding. Travel had to be greatly reduced so our annual meeting of CIFAR fellows and executive board was held by teleconference. We endeavored to meet with stakeholders through meetings and workshops for which travel assistance from non-NOAA sources could be utilized, and again postponed offering our Summer Sessions Global Change Course for K-12 teachers.

Core Administration

A joint teleconference meeting of the CIFAR Executive Board and Fellows was held 30 November 2009 with John Cortinas representing the NOAA CI program. Topics of discussion included the draft Memorandum of Agreement (MOA) between UA and NOAA, students funded through new UA contribution to CIFAR's involvement in the Global Change Student Grant Competition, problems associated with NOAA's underfunding of CIFAR's task 1, update on the Russian-American Long Term Census of the Arctic (RUSALCA) program, update on the 2008 report

to Congress on shortage of students with post-graduate degrees in fishery stock assessment & population dynamics, and changes in funding for the Alaska Tsunami Warning and Environmental Observatory for Alaska (TWEAK).

John Walsh, CIFAR director, represented CIFAR and NOAA in a number of regional, national and international activities during the 12-month period ending 31 March 2010. These activities include the following:

- Walsh co-authored (with Dave McGuire) the Alaska chapter of the NOAA-coordinated National Assessment Report (Global Climate Change Impacts in the United States), published in late 2009.
- Walsh gave a seminar to the NOAA Climate Board, Silver Spring, MD, 22 May 2009.
- Walsh gave presentations of the results of the National Assessment Report at the AGU Fall Meeting in December 2009 (presentation on results for all regions except Alaska), and at a meeting of the AMAP (Arctic Monitoring and Assessment Programme) Climate Expert Group in October 2009 (presentation on results for Alaska).
- In September 2009, Walsh coordinated the AMAP Climate Expert Group's review of the NOAA-supported Arctic Report Card.
- In January 2010, Walsh represented NOAA at the Snow, Water, Ice and Permafrost in the Arctic (SWIPA) cross-fertilization meeting in Potsdam, Germany.
- Walsh contributed a section to the NOAA-coordinated Arctic Report Card: Update for 2009, accessible at http://www.arctic.noaa.gov/reportcard/atmosphere.html
- Walsh represented NOAA at a meeting of the AMAP Heads of Delegations, San Francisco, 8–12 February 2010
- In March 2010, Walsh was a member of the external review panel for NOAA's Earth System Research Laboratory (ESRL) and its collaborative activities with the Cooperative Institutes for Research in Environmental Sciences (CIRES). The report of the review panel was prepared in the two weeks following on-site review.

Susan Sugai, CIFAR associate director, managed CIFAR activities in Fairbanks and participated in regional activities including the following:

- In May 2009, Sugai participated in the joint NSF-NOAA Bering Strait Observatory workshop held at University of Washington's Pack Forest conference center.
- Sugai participated in NOAA's Alaska Regional Implementation Team face-to-face meeting in Juneau during July 2009 and participates in the team's monthly teleconference calls.
- During a break in the face-to-face meeting in Juneau, Sugai met with Doug DeMaster and Terry Quinn (principal investigator on the population dynamics traineeship on the old CIFAR) about continued funding for the highly successful traineeship program through the new CIFAR cooperative agreement. Quinn submitted a proposal through CIFAR but no AFSC funds were provided during the current reporting year.
- From July to November 2009, Sugai was responsible for closing out and reporting on projects funded through the old CIFAR cooperative agreement because of the departure of CIFAR's long term administrator in early July, and external delays in hiring a full-time replacement until March 2010.

Education and Outreach

Because of the level of Task I funding provided by NOAA and the lack of funding success for our NOAA educational partnership proposal, our education efforts have been limited to those opportunities arising from UA and other investments in the Global Change Student Research Grant Competition, established by the UAF Center for Global Change in 1992. The competition provides support to 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.

During each year of our new cooperative agreement, University of Alaska President Hamilton makes a university contribution of $50,000 per year for the Global Change student grant competition that is a voluntary University contribution to CIFAR's cost share. In addition, University of Alaska Anchorage (UAA) Chancellor Fran Ulmer made a $50,000 per year contribution for a two-year pilot period, beginning in FY10. A joint UAF-UAA proposal review panel met on 24 April 2009 and recommended full or partial funding of 23 projects (from a field of 57) for

awards running from 1 July 2009 to 30 June 2010. Seven of these awards were funded with CIFAR match or task 1 education funds. These FY10 CIFAR projects are:

- Katrina Knott, Biology & 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.
- Jared Weems, Marine Sciences, UAF, Stable isotope turnover rates in select invertebrates: Significance to ice-pelagic-benthic coupling in the Bering Sea.
- Robert McNabb, Geology & Geophysics, UAF, Monitoring and analysis of calving events at Franklinbreen, Vestfonna, Svalbard and Columbia Glacier, Alaska.
- Marc Mueller-Stoffels, Physics, UAF, The ice-albedo feedback from a complex systems point of view.
- Robert Burgess, Biology & Wildlife, UAF, Climate change impacts on microbial lignocellulose decomposers in Alaskan boreal forest soil.
- Barbara Truessel, Geology & Geophysics, UAF, Seasonality of snow line retreat on a lake calving glacier.
- Christopher Barger, Biology & Wildlife, UAF, Mechanisms determining resilience of common murre (*Uria aalge*) populations to climate variability in the Bering Sea.

In response to the 2010 announcement of funding opportunity, 71 proposals were received, reviewed, and scheduled to be considered by our review panel on 23 April 2010.

The only funded CIFAR outreach effort is the State of the Arctic Land report that is described with other CIFAR non-competitive projects.

Highlights of CIFAR Research Activities

During the second reporting period of the new CIFAR cooperative agreement 10 research or outreach projects were begun and progress reports are provided. The successful completion of the two legs of the RUSALCA expedition that had been delayed from 2008 will provide many research highlights and findings in the next reporting period after researchers and students have had time to process their samples and data.

Publications and Presentations

Twenty-two conference presentations (both national and international) were reported for the period 1 April 2009–31 March 2010. Two peer-reviewed papers were published, with an additional paper in press and 3 more reported as being submitted. Many PIs have papers under preparation. In addition, several of the RUSALCA projects and two additional projects had papers published (8) or in press (1) during the reporting period that stemmed from funding to those projects under the previous cooperative agreement NA17RJ1224 (Cooperative Institute for Arctic Research).

Competitively awarded projects

(CIFAR "Shadow Award"
NA08OAR4320870)

RUSALCA

RUSALCA: Joint Russian–American Long-term Census of the Arctic research program in the Bering and Chukchi Seas

The Russian–American Long-term Census of the Arctic (RUSALCA), a joint U.S.–Russia research program in the Bering and Chukchi Seas, focuses on sampling and instrument deployment in both U.S. and Russian territorial waters and operates under the auspices of two Memoranda of Understanding between NOAA and, respectively, the Russian Academy of Sciences and Roshydromet. The RUSALCA objectives are to support NOAA's Climate Observation and Analysis Program and the Russian interagency Federal Target Program "World Ocean." It also provides some of the Arctic components of international and national climate observing systems including Global Earth Observation System of Systems (GEOSS), Global Climate Observing System (GCOS), and Integrated Ocean Observing System (IOOS). RUSALCA has also contributed to the U.S. interagency Study of Environmental Arctic Change (SEARCH) Program, NOAA's Office of Ocean Exploration and the Census of Marine Life (CoML).

The RUSALCA program is focused on gathering long-term observations towards understanding the causes and consequences of the reduction in sea ice cover in the northern Bering Sea and the Chukchi Sea in the Arctic Ocean. Models suggest that the expected changes in sea ice and albedo in this area will translate to significant alterations in water column structure and flow and in associated ecosystems. The program began in summer 2004 with a multi-disciplinary cruise on the R/V *Khromov*, a Russian ice-strengthened research ship, to investigate water column physics, nutrient chemistry, and pelagic and benthic biology. Oceanographic moorings were deployed in the western portion of the Bering Strait in 2004, and recovered and redeployed yearly. For 2007 and beyond, the RUSALCA program had planned an annual cruise focused on the physics in the Bering Strait region and more extensive multi-disciplinary cruises in 2009 and 2012 in the northern Bering and Chukchi Seas depending on resources.

During the current funding period, 5 competitively selected RUSALCA projects were funded through CIFAR, and contributed participants in the 2009 Russian–American expedition in the Bering Strait, East Siberian and Chukchi Sea from 23 August through 30 September 2009. A total of 50 scientists and specialists from 6 countries (Russia, USA, Germany, Great Britain, Canada, and Korea) took part in the expedition.

http://www.arctic.noaa.gov/aro/russian-american/2009/

A series of hydrographic transects were conducted with intent to sample all water masses during this summer period with high priority given to collect samples across the Bering Strait in support of the Russian and American mooring(s) in the western Bering Strait during leg 1, and to collect a series of transects across Herald Valley and to conduct a census of marine life and increase knowledge of faunal distributions during leg 2.

RUSALCA leg 1 was the Bering Strait mooring cruise that left Nome on 29 August and returned 2 September 2009. Rebecca Woodgate, University of Washington, was chief scientist, and CIFAR participants included Dan Naber, Kevin Taylor, Michael Kong, and David Leech, moorings; and Terry Whitledge, science coordinator.

Terry Whitledge, UAF, served as chief scientist on leg 2 from 3–30 September 2009. Other CIFAR participants included Brenda Holladay and Christine Gleason, fish fauna; Sarah Mincks and Jared Weems, epibenthos; Michael Kong, productivity; and Russell Hopcroft and Cornelia Jaspers, zooplankton.

Goals of the RUSALCA program

- Make physical, chemical, and ecological observations where Arctic sea ice is diminishing
- Monitor fresh water and nutrient fluxes via long-term moorings in Bering Strait
- Monitor ecosystem indicators of climate change
- Improve international Arctic science collaboration
- Explore the unknown Arctic

Project reports for each CIFAR-funded RUSALCA project follow this overview.

RUSALCA: A long-term census of Arctic zooplankton communities

Russell R. Hopcroft, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

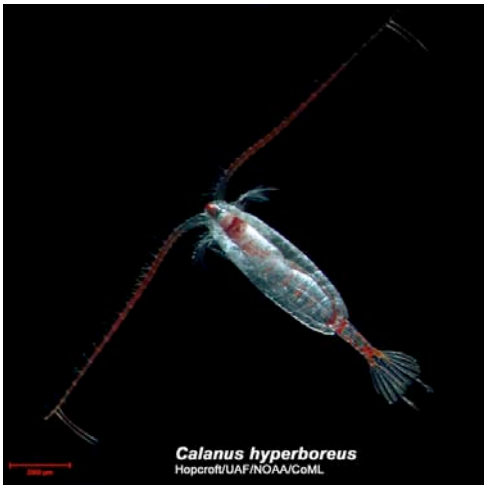
Other investigators/professionals associated this project:
Ksenia Kosobokova, *Russian partner, Russian Academy of Sciences, Moscow*

CIFAR 09-009: This project is ongoing.

Primary objectives

We propose repeated comprehensive surveys of zooplankton communities in the Bering Strait and Chukchi Sea to understand the transport patterns of Pacific zooplankton into the Arctic and build time-series to assess ecosystem change in this climatically sensitive region. The census will involve a combination of traditional taxonomic enumeration and identification, along with continued molecular sequencing and photographic documentation of the species collected by several types of plankton nets. This work will build on similar efforts from RUSALCA-2004, recent work in the Canada Basin under the Ocean Exploration program, and will temporally extend transects occupied by the Shelf-Basin-Interactions program, and tie into efforts by the International Polar Year and Census of Marine Life for a pan-Arctic program.

Research accomplishments/highlights/findings



The RUSALCA 2009 expedition was completed in September and represents an extensive survey and census of zooplankton species in the Bering Strait through the southern and western Chukchi Sea, plus the East Siberian Sea. The 2009 survey encompassed 63 stations, conducted using a package of vertically deployed 150 and 53 µm mesh nets, combined with a 505 µm oblique Bongo net at more than half of the stations. Post-cruise sample analysis will involve a combination of traditional taxonomic enumeration and identification. Entire 150 µm nets were also curated for molecular sequencing of the region's species, along with specimens identified during sorting of the live nets used for experimentation. To assess the 'health' of the zooplankton populations in the region, egg production experiments were conducted at 32 stations with several of the dominant copepod species in this region (i.e. primarily *Pseudocalanus* spp., with only several cases for by *Metridia pacifica*, *Metridia longa*, and *Calanus glacialis*). Compared to 2004, almost twice as many samples were collected and 50% more egg production experiments were executed, due largely to the expanded size of the zooplankton team (increased to 4 in 2009, compared to only 2 in 2004). Photographic documentation of the fauna of the region started in 2004 was continued, with ~2,000 images taken during the cruise, about half of which have been retained.
As observed in 2004, the differences in zooplankton communities encountered on the cruise have been striking. Strong across-shelf differences occurred in the northern sampling domain, and strong east-west gradients occurred in the southern Chukchi Sea. The copepod *Pseudocalanus* dominated all collections with the exception of the northern most stations on the Chukchi Plateau, followed by variable numbers of *Calanus* copepods and the chaetognath *Parasagitta elegans*. Small jellyfish were common or even abundant at the northwestern stations, while large jelly fish became common only in the southern Chukchi. Ctenophores, particularly *Mertensia* and *Bolinopsis* were present at most stations, and their abundance quantified. Alaska Coastal Current water had abundant populations of the pteropod *Limacina helicina*. Compared to 2004, meroplankton and the larvacean *Oikopleura vanhoeffeni*, were less abundant, although it is unclear if this reflects a between-year variation or differences in seasonal timing of the cruise. Like 2004, many of the stations had extremely thick communities of phytoplankton retained by our nets. Species composition of *Pseudocalanus* was variable across the sampling region, as were their rates of reproduction. A fuller characterization of the communities and their reproductive rates will require more detailed analysis of the samples scheduled to begin in the summer of 2010.

NOAA relevance/societal benefits
This project examines the potential impacts of climate change in the Pacific–Arctic gateway.

Education
Two graduate students participated on the cruise. Kosobokova's "Russian" student, Elizaveta Ershova, plans to begin a Ph.D. with Hopcroft at UAF in the fall of 2010 focusing on the RUSALCA project.

Outreach
Hopcroft, through ArcOD (Arctic Ocean Biodiversity Project), continues to develop a website that provides information on Arctic zooplankton and access to historical datasets. http://www.arcodiv.org/

Publications, conference papers, and presentations
Publications
Publications during the reporting period originated from work funded through the previous CIFAR cooperative agreement, NA17RJ1224. See below.
Oral Presentations
Hopcroft, R.R., K.N. Kosobokova, and 20 others. 2010. A pan-Arctic analysis of biodiversity patterns for zooplankton on Arctic shelves. Invited presentation, Arctic Frontiers Meeting, Tromso, Norway, January 2010.
Poster Presentations
Rutzen, I., F. Huettmann and R.R. Hopcroft. 2010. Predicting zooplankton abundance and distribution throughout the Arctic Ocean. Poster, Arctic Frontiers Meeting, Tromso, Norway, January 2010.
Rutzen, I., F. Huettmann and R.R. Hopcroft. 2010. Predicting zooplankton abundance and distribution throughout the Arctic Ocean. Poster, Alaska Marine Science Symposium, Anchorage, Alaska, January 2010.

Other products and outcomes
Hopcroft is working in conjunction with NOAA toward the development of a Circumpolar Biodiversity Monitoring Program (CBMP) under the International Arctic Council within which the RUSALCA program will represent a significant component from the USA.

Partner organizations and collaborators
Arctic Ocean Biodiversity Project (ArcOD)

Changes/problems/special reporting requirements
Other than a 1-year delay in the original plan because of the delay of the interdisciplinary cruise there are no changes to this project.

Publications related to this project as funded under NA17RJ1224 (previous cooperative agreement)
Bucklin, A., R.R. Hopcroft, K.N. Kosobokova, L.M. Nigro, B.D. Ortman, R.M. Jennings and C.J. Sweetman. 2010. DNA barcoding of Arctic Ocean holozooplankton for species identification and recognition. *Deep-Sea Research II*, 57:40–48.
Hopcroft, R.R. and K.N. Kosobokova. 2010. Distribution and egg production of Pseudocalanus species in the Chukchi Sea. *Deep-Sea Research II*, 57:49–56.
Hopcroft, R.R., K.N. Kosobokova and A.I. Pinchuk. 2010. Zooplankton community patterns in the Chukchi Sea during summer 2004. *Deep-Sea Research II*, 57:27–39.

RUSALCA: Arctic food web structure and epibenthic communities in a climate change context

Katrin Iken, PI
Bodil A. Bluhm, PI
University of Alaska Fairbanks

Other investigators/professionals associated this project:
Ken Dunton, *University of Texas at Austin*

CIFAR theme: Ecosystem Studies & Forecasting

CIFAR 09-010: This project is ongoing.

Primary objectives

Our primary objectives are to contribute to RUSALCA goals by linking physical and chemical observations of water mass characteristics to food web structure and epibenthic faunal assemblages. First, we propose that food web analysis is a meaningful quantitative key variable for long-term climate observations. Benthic ecosystems act as indicators of long-term of change in marine systems because they tend to integrate both seasonal and inter-annual variability in overlying water column processes. Secondly, we propose to analyze epibenthic community structure as an indicator for ocean current regime and sediment patterns. In collaboration with working groups investigating infauna, we propose to monitor epifaunal community trends in the RUSALCA region.

Research accomplishments/highlights/findings

We participated in the interdisciplinary RUSALCA cruise in 2009 to collect samples for stable isotope analysis and to collect benthic epifauna for community composition analysis. A total of 26 stations were sampled, with 18 stations sampled for food web structure analysis and 15 stations being quantitatively sampled for epibenthic community structure. Water samples from the chlorophyll a maximum (where present) were taken from the CTD (conductivity, temperature, depth) casts and filtered on GF/F glass fiber filters to obtain particulate organic material (POM). Surface sediments and infaunal invertebrates were taken from non-quantitative grab samples; infauna were sorted live on board ship and frozen for future analysis. Selected species of live zooplankton were provided by the zooplankton group from vertical plankton tows. Tissue samples from fishes and epifaunal invertebrates were taken from specimens collected in both beam and otter trawls. Samples were dried on board ship and are now ready for further treatment before carbon and nitrogen isotope analysis at the Alaska Stable Isotope Facility at UAF. These data will expand our previous results on Chukchi Sea food web structure (Iken et al., 2010) both spatially (e.g., including Siberian Sea), taxonomically (e.g., including zooplankton) and temporally (comparison between 2004 and 2009).

Sarah Mincks Hardy with live octocoral. Image courtesy of 2009 RUSALCA Expedition, RAS-NOAA.

Based on results of earlier RUSALCA sampling (Bluhm et al., 2009) and preliminary observations from the 2009 cruise, epibenthic community structure appears to be largely a function of substrate type rather than water mass distribution. Regional similarities between stations were found within the north-central Chukchi and in the southern Chukchi, with the "hot-spot" area of high productivity northwest of Bering Strait dominated by infaunal bivalves. Soft-bottom areas of the central Chukchi are inhabited by high densities of brittle stars, crabs, and "mud stars" (*Ctenodiscus crispatus*). Similar soft-bottom taxa were found at the Siberian Sea stations (SS3–5, WN3), with the addition of large isopods and a variety of large amphipod species, and a few species of holothurians. Crabs were largely absent from these sites. Sites adjacent to Wrangell Island on the south side were rocky and thus not sampled, but north of the island (WN1) high densities of large isopods and a wide variety of amphipods were recovered. High-flow areas like Bering Strait and the axis of Herald Canyon were dominated by sea urchins, tube-dwelling polychaetes, bryozoa, and other hard-bottom fauna.

NOAA relevance/societal benefits

This work will contribute to NOAA's strategic plan objective "to describe and understand the state of the climate system through integrated observations" of the biological components and the associated water mass characteristics.

Increased knowledge of food web connections and epibenthic communities will be essential information to "understand the consequences of climate variability and changes" in the Chukchi Sea marine ecosystem. This work will provide NOAA with a product that can assist to "improve society's ability to plan and respond to climate variability."

Education

One of our Masters graduate students, Jared Weems, participated in the cruise. This provided valuable field experience in the high-Arctic environment for the student, as well as the opportunity to work with an international and interdisciplinary team of renowned scientists.

Outreach

During the cruise, we contributed to the NOAA Ocean Exploration website (http://oceanexplorer.noaa.gov/explorations/09arctic/logs/sept24/sept24.html). In addition, our team member Sarah Mincks Hardy contributed to a web blog of a participating PolarTREC teacher on board (http://arctic.cbl.umces.edu/RUSALCA/).

Publications, conference papers, and presentations

Publications during the reporting period originated from work funded through the previous CIFAR cooperative agreement, NA17RJ1224. See below.

Other products and outcomes

Nothing to report.

Partner organizations and collaborators

Bluhm is one of the PIs of Arctic Ocean Diversity (ArcOD), the Arctic Ocean field project of the Census of Marine Life. Iken and Bluhm are also co-PIs of a NSF-sponsored Bering Sea Ecosystem Studies (BEST) project, which investigates pelagic-benthic coupling in the Bering Sea in relation to sea ice cover. Iken also is a member of the Marine Expert Monitoring Group of the Circumpolar Biodiversity Monitoring Program (CBMP), one of the programs under the directive of CAFF (Arctic Council Conservation of Arctic Flora and Fauna), where the RUSALCA program features strongly in monitoring the Chukchi Sea region.

Changes/problems/special reporting requirements

Other than a 1-year delay in the original plan because of the delay of the interdisciplinary cruise there are no changes to this project.

Publications related to this project as funded under NA17RJ1224 (previous cooperative agreement)

Bluhm, B.A., K. Iken, S. Mincks Hardy, B.I. Sirenko and B.A. Holladay. 2009. Community structure of epibenthic megafauna in the Chukchi Sea. *Aquatic Biology,* 7: 269–293.

Iken, K., B. Bluhm and K. Dunton. 2010. Benthic food-web structure under differing water mass properties in the southern Chukchi Sea. *Deep-Sea Research II*, 57:71–85.

RUSALCA: Fish ecology and oceanography

Brenda L. Norcross, PI *University of Alaska Fairbanks*

CIFAR theme: Ecosystem Studies & Forecasting

Other investigators/professionals associated this project:
Brenda A. Holladay, Co-PI, *University of Alaska Fairbanks*
Morgan S. Busby, *Senior Investigator, Alaska Fisheries Science Center (AFSC), Seattle*

CIFAR 09-011: This project is ongoing.

Primary objectives

We hypothesize that climate change, specifically a reduction of sea ice cover in the northern Bering and Chukchi Seas, will alter the species composition, abundance and distribution of fishes. Our objectives are to:

- Collect larval and juvenile fishes in specific water masses to estimate relative fish abundance and distribution.
- Determine ichthyoplankton and juvenile demersal fish assemblages (species composition).
- Determine physical and oceanographic features (water masses) characteristics that define ichthyoplankton and juvenile demersal fish habitat.
- Determine temporal distribution of ichthyoplankton and juvenile demersal fish from trace elements in otoliths.
- Determine the physical characteristics that define juvenile and adult fish communities and compare among collection periods.
- Determine mixed phyla benthic community assemblages, i.e., fish and invertebrates, and compare them among oceanographic feature and collection periods.

Research accomplishments/highlights/findings

During the September 2009 cruise aboard the Professor Khromov, the Fish Ecology Project Team was composed of Brenda Holladay and Christy Gleason (UAF), and Morgan Busby (AFSC). We used a 60-cm diameter net with 0.505-mm mesh bongo net to collect ichthyoplankton (planktonic fish eggs and larvae) at 31 stations and a small (7-mm) mesh bottom trawl (3-m plumb-staff beam trawl) to collect juvenile and small adult demersal fishes at 22 stations. The beam trawl collected 10,323 fish, with at least 41 species represented.

NOAA relevance/societal benefits

This project adds to the coordinated RUSALCA effort of identifying factors that underlie ecosystem change in the Arctic. Our research develops a broad-scale baseline of abundance and distribution of larval and juvenile fishes in the Chukchi Sea and identifies the physical mechanisms affecting fish distribution, thereby directly supporting the RUSALCA objective of developing methods of identifying ecosystem change.

Fish Ecology Team onboard 2009 RUSALCA cruise: (L–R) Brenda Holladay, Morgan Busby, Christy Gleason. Image courtesy of 2009 RUSALCA Expedition, RAS-NOAA.

Education

Christine Gleason is an MS student in Fisheries Oceanography who participated in the September cruise. During the cruise she collected fish from which she is processing the otoliths for stable isotopes. In addition to her own research, Christy's project is providing on the job training for undergraduate technicians. The undergraduates are learning to weigh and measure fish, remove otoliths and record data.

Outreach

Our Fisheries Oceanography Lab made preparations to participate in UAF's first Campus Research Day, an open house event planned for 9 April 2010.

Publications, conference papers, and presentations

Publications during the reporting period originated from work funded through the previous CIFAR cooperative agreement, NA17RJ1224. See below.

Other products and outcomes

Busby, M.S. 2009. RUSALCA Chukchi Sea Cruise. In: AFSC Quarterly Research Reports, Oct-Nov-Dec 2009. http://www.afsc.noaa.gov/Quarterly/ond2009/divrptsRACE7.htm

Changes/problems/special reporting requirements

Other than a 1-year delay in the original plan because of the delay of the interdisciplinary cruise there are no changes to this project.

Publications related to this project as funded under NA17RJ1224 (previous cooperative agreement)

Norcross, B.L., B.A. Holladay, M.S. Busby and K.L. Mier. 2010. Demersal and larval fish assemblages in the Chukchi Sea. *Deep-Sea Research II*, 57:57–70.

The Pacific Gateway to the Arctic—Quantifying and Understanding Bering Strait Oceanic Fluxes

Thomas Weingartner, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
Terry Whitledge, PI
University of Alaska Fairbanks

CIFAR 10-013: This project is new. Although this project was reviewed and competitively awarded with the other RUSALCA projects, this project was funded jointly by NSF and NOAA, with NSF covering year 1.

Primary objectives

- Provide mooring instrumentation and flotation for 4 complete moorings and recover the same;
- Provide CTD (conductivity, temperature, depth) data collection and analyses for stations occupied during the mooring deployment and recovery cruises;
- Collect and analyze nutrient data collected for stations occupied during the mooring deployment and recovery cruises;
- Assist in mooring data quality control, archiving and analysis.

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 four moorings deployed across the western channel of Bering Strait. Each mooring contains an RDI 300 kHz upward looking ADCP (Acoustic Doppler Current Profiler) 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 includes a fluorometer and a nitrate sensor. We are also engaged in analyzing the data from these moorings and the CTD section in conjunction with a 4 mooring array deployed in the eastern (US EEZ) channel of Bering Strait with Rebecca Woodgate of the University of Washington.

Research accomplishments/highlights/findings

We found that annual mean near-bottom temperatures increased by 1ºC step between 2001 and 2002, and a record-length high in 2007. Heat fluxes increase almost monotonically since 2001 to a record-length maximum in 2007. We estimated that the heat flux through Bering Strait in 2007 was ~5-6x1020J/yr. This is about twice the 2001 heat flux (~ 2-3x1020J/yr), comparable to the annual shortwave radiative flux into the Chukchi Sea (~ 4x1020J/yr), and enough to melt 1.8x106km^2 of 1-m-thick ice. (The 2007 seasonal Arctic sea-ice loss was 6x106km^2 of unknown thickness.) Especially when combined with timing issues, these sizeable estimates suggest the Bering Strait throughflow can significantly influence Arctic sea-ice – by providing a trigger for the onset of solar-driven melt, a conduit for oceanic heat into the Arctic, and (due to long transit times) a subsurface heat source to and within the Arctic pack in winter.

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.

Education

Michael Kong, a Ph.D. student in chemical oceanography, assisted with CTD data collection, nutrient sampling and analyses. Seth Danielson, a Ph.D. student in physical oceanography, analyzed CTD data. Undergraduate student Kevin Taylor assisted with mooring design, fabrication, deployment, recovery, and instrument handling.

Outreach

None this year.

Publications, conference papers, and presentations

Publications during the reporting period originated from work funded through the previous CIFAR cooperative agreement, NA17RJ1224. See below.

Other products and outcomes

We contribute to a project website hosted at the University of Washington: http://psc.apl.washington.edu/HLD/

Partner organizations and collaborators

State Research Navigational Hydrographic Institute of the Russian Federation: Expedition logistics and coordination (In-kind support, facilities)

Group Alliance (Russia): logistics and translation services (In-kind support, facilities)

Arctic and Antarctic Research Institute (Russian Federation): moorings and CTD (Collaborative Research)

Polar Science Center, Applied Physics Lab, University of Washington (Rebecca Woodgate), Co-PI, Co-Chief Scientist, moorings, CTD, physical oceanography (Collaborative Research)

Impact

The narrow, shallow Bering Strait is the only ocean gateway between the Pacific and the Arctic Ocean. Given the significant role of Pacific waters in the Arctic, quantifying the Bering Strait through flow and its properties is essential to understanding the present functioning of the Arctic system, and the causes and prediction of present and future Arctic change.

Changes/problems/special reporting requirements

Other than a 1-year delay in the original plan because of the delay of the interdisciplinary cruise there are no changes to this project.

Publications related to this project as funded under NA17RJ1224 (previous cooperative agreement)

Woodgate, R. A., T. Weingartner and R. Lindsay. 2010. The 2007 Bering Strait oceanic heat flux and possible relationships to anomalous Arctic Sea Ice Retreat. *Geophysical Research Letters* 37, L01602, doi:10.1029/2009GL041621.

RUSALCA: Global change in the Arctic: Interactions of productivity and nutrient processes in the northern Bering and Chukchi Seas

Terry E. Whitledge, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
Dean A. Stockwell, co-PI
University of Alaska Fairbanks

Other investigators/professionals associated this project:
Daniel Naber, *University of Alaska Fairbanks*

CIFAR 09-012: This project is ongoing.

Primary objectives
We are using measurements of nutrient and plant pigment distributions, phytoplankton taxonomy, and rates of primary productivity to assess changes in the carbon cycle related to nutrient utilization and primary production that may be driven by variations in the Arctic climate.

Research accomplishments/highlights/findings
- Two legs of the RUSALCA cruise aboard the R/V *Professor Khromov* in late summer 2009 were used to obtain samples for the second time series cruise to provide data to investigate climate change in the Chukchi Sea.
- Nutrient and chlorophyll samples were collected on 177 stations during legs 1 and 2 for a total of 476 samples. The nutrient samples were analyzed for nitrate, nitrite, ammonium, phosphate and silicate onboard within a few hours of collection. Size fractionated chlorophyll were also filtered at primary production sampling stations.
- Primary production rate measurements using carbon and nitrogen isotopes were determined at six light depths on 23 stations during leg 2 in collaboration with colleagues from the Korean Polar Research Institute.

NOAA relevance/societal benefits
This project will determine the amount of nutrients that are available to support primary production in the seasonally ice-covered waters of the Chukchi Sea and compare to prior data collected over the prior two decades to assess changes that are related to climate change.

Education
Michael Kong, a student enrolled in the Ph.D. program in Oceanography, participated in both legs of the RUSALCA cruise as a part of his graduate research program investigating primary production processes in ice-covered seas and has been receiving support from this project for his field and laboratory studies.

Outreach
Outreach was planned with local school children in Nome at the start of the cruise in August 2009 with help from Heidi Herter, the Alaska Sea Grant Marine Advisory Program agent in Nome, but weather conditions and new Transportation Security Administration rules prevented visitation to the vessel. Outreach material was coordinated with the NOAA personnel during the cruise but the connectivity to email and internet placed severe limits on the amount that could be sent out.

Publications, conference papers and presentations
Nothing to report but preparations are underway for both presentations and papers to be presented at the upcoming Principal Investigators meeting.

Partner organizations and collaborators
A collaborative proposal with Russian colleagues was submitted to the U.S. Civilian Research & Development Foundation to fund additional data analysis and synthesis based on the new cruise data.

Changes/problems/special reporting requirements
Other than a 1-year delay in the original plan because of the delay of the interdisciplinary cruise there are no changes to this project.

Non-competitive projects, by CIFAR theme:

Ecosystem Studies and Forecasting

Climate Change and Variability

Coastal Hazards

ECOSYSTEM STUDIES AND FORECASTING

Characterization of Bering Sea Infauna

Stephen Jewett, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

Other investigators/professionals associated this project:
Max Hoberg, *University of Alaska Fairbanks*

CIFAR 09-003: This project is ongoing.

Primary objectives
We propose to characterize the benthic infaunal community for modeling essential fish habitat in the Eastern Bering Sea in support of the Magnuson-Stevens Sustainable Fisheries Act. Sampling in August 2008 will use a van Veen grab and samples will be collected, sieved in the field on 1.0 mm mesh, fixed in buffered formalin, stained, and transferred to 50% isopropyl alcohol prior to sending them to UAF. We will process each sample, including identification to at least family level of taxonomy, counting, and wet weighting (blotted dry). *Due to unforeseen circumstances 2008 sampling was postponed until 2009.*

Research accomplishments/highlights/findings
NOAA was able to collect the benthic samples 26 July–8 August, 2009, after a one-year delay. Thirty-two (32) samples were processed by invertebrate taxonomist Max Hoberg and student assistant Kyle Schumann in Jewett's lab at SFOS, UAF. Analyses were completed 17 November 2009. After 100% QA/QC on the data a draft report was sent on 20 April 2010 to NOAA project coordinator Cynthia Yeung at the Alaska Fisheries Science Center. This report included the History file, Metadata file, Data file, and Benthic taxon list file.

NOAA relevance/societal benefits
This research is an effort to determine essential fish habitat as mandated by the Magnuson-Stevens Sustainable Fisheries Act. Characterization of the benthic infaunal community is necessary for successful modeling of essential fish habitat in the eastern Bering Sea.

Education
Student Assistant Kyle Schumann will receive a BS in Fisheries at UAF May 2010.

Outreach
Nothing to report.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

Changes/problems/special reporting requirements
The Draft Report sent to Yeung will become the Final Report if no changes are recommended by Yeung. Jewett and Sathy Naidu (Marine Geologist) will visit with Yeung in Seattle in late May 2010 to discuss future publication plans for this project.

Partner organizations and collaborators
Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115-0070 (PI: Cynthia Yeung, Ph.D.).

Impact
None to report.

Infaunal/epifaunal forage base for juvenile flatfish near Kodiak Island

Stephen Jewett, PI *University of Alaska Fairbanks*

CIFAR theme: Ecosystem Studies & Forecasting

Other investigators/professionals associated this project:
Max Hoberg, *University of Alaska Fairbanks*

CIFAR 09-004: This project is ongoing.

Primary objectives

We propose to characterize the benthic habitat available to juvenile flatfish in nursery embayments around Kodiak Island in support of the Magnuson-Stevens Sustainable Fisheries Act. Sampling in summer 2008 will use a van Veen grab and samples will be collected at stratified depths at the Holiday and Pillar Cove sites, sieved in the field on 1.0 mm mesh, fixed in buffered formalin, stained, and transferred to 50% isopropyl alcohol prior to sending them to UAF. We will process each sample, including sorting, taxonomy, counting, and wet weighting (blotted dry). All molluskan and crustacean fauna will be taken to family taxonomic levels; annelid fauna will be taken to the finest practical taxonomic level.

Research accomplishments/highlights/findings

In mid December 2008 74 preserved 0.1 m2 van Veen grab samples were received at UAF from Kodiak NMFS. Seventy-four (74) samples were processed by invertebrate taxonomist Max Hoberg and student assistants Chris Oliver and Jeannette Cochran in Jewett's lab at SFOS, UAF. Analyses were completed 30 June 2009. After 100% QA/QC on the data a draft report was sent on 7 July 2009 to NOAA project coordinator Clifford Ryer at the Alaska Fisheries Science Center, Hatfield Marine Science Center, Newport, OR. This report included the History file, Metadata file, Data file, and Benthic taxon list file.

NOAA relevance/societal benefits

This research is an effort to determine essential fish habitat as mandated by the Magnuson-Stevens Sustainable Fisheries Act and NOAA. Information on quality and quantity of potential benthic invertebrate prey of juvenile flatfishes is critical to understanding essential juvenile flatfish habitat. Thus, this taxonomic study should highlight not only prey availability, but habitat constituents, such as worm tube mats and sediment structure. In the long term, this information may form the basis for determining exclusive no-trawl zones to protect essential fish habitat. Protecting such habitat would be beneficial to the public that utilizes flatfishes in sport, commercial, and subsistence fisheries.

Education

Undergraduate students Chris Oliver and Jeannette Cochran performed sample sorting for this project. Cochran received a BS in Biology from UAF in May 2009. Oliver transferred to University of Washington in the Fall of 2009.

Outreach

Nothing to report.

Publications, conference papers, and presentations

Nothing to report.

Other products and outcomes

A joint (Ryer and Jewett) publication on this data is planned after Ryer analyzes the data and after the conclusion of this contract.

Changes/problems/special reporting requirements

The Draft Report sent to Ryer will become the Final Report if no changes are recommended by Ryer.

Partner organizations and collaborators
Fisheries Behavioral Ecology Program, Alaska Fisheries Science Center, Hatfield Marine Science Center, Newport, OR (PI: Clifford H. Ryer, Ph.D.)

Impact
During the previous reporting period Ryer asked about the quantity of juvenile Tanner crabs, a commercial species, found in the samples processed to date. This question arose because of the occasional juvenile crabs noted when samples were sieved in the field. He was curious if the embayments sampled might be considered as crab nursery habitat. Jewett reported to him that crabs had only been found in low densities, only three out of 50 processed samples. During this reporting period Tanner crabs were counted in the remaining samples. Overall, we found only 22 Tanner crabs in 74 samples or a density of 29.7 crabs/m2. The crabs' size ranged from 3.8–9.2 mm carapace width, all young-of-the-year.

Analyses of sediment samples for organic carbon, nitrogen, and their isotopes ($\partial^{13}C$ and $\partial^{15}N$), phosphorus and chlorophyll a in Bering Sea sediments

Sathy A. Naidu, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

Other investigators/professionals associated this project:
Dean Stockwell, *University of Alaska Fairbanks*

CIFAR 09-002 / 10-002: This project is ongoing.

Primary objectives
In collaboration with the NOAA Alaska Fisheries Center (AFSC), Seattle project on "Characterization of the Benthic Infauna Community for Modeling Essential Fish Habitat in the Eastern Bering Sea" in support of the Magnuson-Stevens Sustainable Fisheries Act. The specific objective of the project is to establish a sedimentary granulometric and geochemical database to characterize the benthic habitat.

Research accomplishments/highlights/findings
Thirty-two marine sediment samples were collected by the AFSC in August 2009 from the southeast Bering Sea. These samples were delivered in September 2009 to PI Naidu for laboratory processing and analysis to establish the substrate and geochemical properties of the benthic habitat. As stipulated in the contract the sediment samples were analyzed for grain size distribution, total organic carbon, total nitrogen, total phosphorus, chlorophyll a and the stable isotopes of carbon and nitrogen. These analyses have been completed, the sediment grain size statistical parameters have been calculated, and the data have been tabulated in a Excel format. Preliminary examination of the sediment granulometry data suggests presence of a broad geographic distribution pattern. Generally, the sediments at the mid- and outer shelf regions are sandy mud and have poorly to very poorly sorted and very positive skewed size distributions. In contrast, the inner shelf sediments are generally medium to well sorted muddy sand, with very negative to near symmetrical skewed size distributions. Throughout the study area no gravel size particles were detected in the samples analyzed, and no significant difference was noticed in the kurtosis values in the size distribution, which are almost invariably very leptokurtic.

The geochemical data are under examination to see if there is any regional cluster pattern. Apparently, the inner shelf sediments have relatively lower concentrations of organic carbon and nitrogen compared to rest of the shelf sediments. The middle shelf sediments would seem to have by a factor of two higher concentrations of chlorophyll a compared to the outer and inner shelf sediments. No regional cluster pattern is obvious in the sediment OC/N, $\delta^{13}C$ and $\delta^{15}N$. The above qualitative assessments must be clarified statistically, but such an effort is out of scope of the current contract.

NOAA relevance/societal benefits
This research is an effort to determine essential fish habitat as mandated by the Magnuson-Stevens Sustainable Fisheries Act. Characterization of the geochemical properties of the benthic habitat is necessary for successful modeling of essential fish habitat in the eastern Bering Sea.

Education
Out of scope of the contract.

Outreach
Out of scope of the contract.

Publications, conference papers, and presentations
Plans have been made to meet with Cynthia Yeung, AFSC project coordinator in Seattle, on May 25-26, 2010 to present the data collected and discuss further course of action to be taken to process the data statistically and collaborating on a joint journal publication. This task will have to be scoped out under a separate contract.

Other products and outcomes
Nothing to report.

Changes/problems/special reporting requirements
None.

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

Stephen Okkonen, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

CIFAR 10-014: This project is new.

General objectives
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.

Research accomplishments/highlights/findings
Analytical arguments (continuity and Ekman dynamics) indicate that changes in coastal sea level reflect wind-driven changes in current divergence/convergence and are, therefore, a proxy for changes in the potential aggregation of zooplankton and the relative size of whale groups on the western Beaufort shelf.

The acquisition of five years of field data has allowed us to **begin** to address how interannual changes in the meteorology and oceanography might be expressed in the feeding environment for Bowheads on the western Beaufort shelf.

NOAA relevance/societal benefits
We have proposed a predictive conceptual model relating changes in potential zooplankton abundance (and the likelihood of observing whale groups, as opposed to observing individual whales) on the western Beaufort shelf to changes in the local wind field. The predictive nature of the conceptual model makes it a potential management decision support tool.

Education
Nothing to report.

Outreach
Nothing to report.

Publications, conference papers, and presentations

Publication activity during the reporting period originated from work funded through the previous CIFAR cooperative agreement, NA17RJ1224. See below.

Poster presentations

Okkonen, S.R., C.A. Ashjian and R.G. Campbell. 2010. Circulation features associated with the Barrow area bowhead whale feeding hotspot. Alaska Marine Science Symposium, 18–22 January 2010, Anchorage, Alaska.

Okkonen, S.R., C.A. Ashjian and R.G. Campbell. 2010. Year-to-year variability of late summer hydrography across Barrow Canyon and the western Beaufort shelf: 2005–2009. Ocean Sciences 2010, 22–26 February 2010, Portland, Oregon.

Other products and outcomes

Nothing to report.

Partner organizations and collaborators

Woods Hole Oceanographic Institution – collaborative research
Univ. of Rhode Island – collaborative research
NOAA National Marine Mammal Laboratory – collaborative research
North Slope Borough (Alaska) Dept. of Wildlife Management – collaborative research

Impact

Data from CIFAR-funded current meter moorings have helped refine the conceptual model that relates changes in local winds to changes in potential zooplankton abundance and likelihood of whale group observations.

Changes/problems/special reporting requirements

None.

Publications related to this project as funded under NA17RJ1224 (previous cooperative agreement)

In press

Ashjian, C.A., S.R. Braund, R.G. Campbell, J.C. George, J. Kruse, W. Maslowski, S.E. Moore, C.R. Nicolson, S.R. Okkonen, B.F. Sherr, E.B. Sherr and Y. Spitz. Climate variability, oceanography, bowhead whale distribution, and Iñupiat subsistence whaling near Barrow, AK. *Arctic*.

Arctic small Unmanned Aircraft System experimentation in support of NOAA Arctic objectives

Gregory Walker, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

Other investigators/professionals associated this project:
Donald Hampton, Kathe Rich, *University of Alaska Fairbanks*

CIFAR 09-005: This project is ongoing.

Primary objectives

We propose to use the University of Alaska Fairbanks (UAF) owned Unmanned Aircraft System (UAS), the Insitu ScanEagle A-20 to further test the UAS for use in support of NOAA missions in the Bering, Beaufort, and Chukchi seas to monitor marine mammals in ice-covered waters.

The primary concerns for using UASs in the arctic are: 1) the ability of the sensors to record the presence of seals on the ice, 2) the combined ability of sensors and aircraft to provide sufficient areal coverage within time constraints imposed by seal life history events and seasonal melting of ice, 3) the ability of the aircraft to operate in the extreme weather conditions of the north, and 4) the ability to carry out frequent, long-range missions over pack ice in hard-to-access portions of the Arctic and North Pacific Oceans

We intend to evaluate the aircraft (a UAS designed for launching and recovering from a ship) for surveying off of the NOAA vessel *McArthur II* in the Bering Sea pack ice. Digital and infrared cameras mounted on the UAS will record geo-referenced images of the sea ice and seals below. These images will be analyzed for seals and relevant measures of sea ice. Concurrently, the flight characteristics (e.g., stability, speed, duration, payload, effects of icing, communications, telemetry, tasking) of the UAS will be evaluated for use in the Arctic and sub-arctic environments.

2009 goals towards ultimate science objective:
Scientifically rigorous surveys of the pack ice will ultimately require long duration flights far away from the ship or other base of operations. Recent conversations with the FAA have indicated that in 2009 we are unlikely to receive permissions to fly outside radio line-of-sight. As such, our goals for 2009 are to:

1. Acquire a Certificate of Authorization (COA) from the FAA that will allow us to conduct our UAS operations within an area that can be monitored with a ship-based radar system for sensing and avoiding other aircraft,
2. safely launch and retrieve a UAS from a NOAA ship multiple times,
3. conduct limited aerial surveys of the Bering Sea pack ice for ice seals, and
4. identify the number, species and perhaps sex and age of seals hauled out on the ice from geo-rectified images collected by the UAS during surveys.

Research accomplishments/highlights/findings

Ten flights were conducted in the Bering Sea south of St. Lawrence Island between 24 May and 8 June 2009
Overall statistics for the operation include:

- Total flying time in Bering Sea (41.66 hours). 8.4 hours was the longest (filled the image storage system)
- Highest linear transect flown in a day (single sortie) was 364 nm. Compares favorably with 200 nm with helicopters.
- Operationally
    - Did not scare the seals back into the water as with a helicopter. (more accurate survey potential)
    - Demonstrated longer flights are possible (more area surveyed possible)
    - The weather limitation did not affect the UAS any more than it would manned aviation
    - Collected over 30,000 high resolution images for post mission analysis
- Financially
    - A NOAA research vessel is a less expensive transport than a ship with a flight deck (U.S. Coast Guard ice breaker)

NOAA relevance/societal benefits

Bearded, ringed, spotted, and ribbon seals are important subsistence resources for northern coastal Alaska Native communities and are key components of arctic marine ecosystems, yet very little is known of their abundances and distributions. They are dependent on sea ice during their annual breeding and molting periods, and are often referred to collectively as "ice seals." Although there have been sporadic aerial surveys to estimate ice seal densities along the coastline of the Bering, Beaufort and Chukchi Seas, and a few surveys using helicopters based from icebreakers, the costs of surveying more frequently and the risks of surveying farther off shore have precluded reliable assessment of the status and trends for these populations. We intend to determine if recent advances in unmanned aerial systems (UAS) technology can reliably allow for large-scale, systematic ship-based surveys for ice seals in the Bering, Beaufort and Chukchi Seas.


Anchorage Daily
UNMANNED DRONE PATROLS THE BERING SEA
Eye in the sky
UAF aircraft being developed to help monitor seal populations

Education

Nothing to report.

Outreach

"Eye in the sky: UAF aircraft developed to help monitor seal populations." James Halpin, Anchorage Daily News, front page article on Wednesday, June 3, 2009 with two color photographs on page A-1 and two color photographs on back page (A-14).

Publications, conference papers, and presentations

Oral presentation
Walker, G. 2009. Recent ScanEagle operations in the Arctic. Technical Analysis and Applications Center (TAAC) Conference, Albuquerque, New Mexico, December 2009.

Poster presentation

Walker, G. 2009. UAF small unmanned aircraft activity. Small UAS Symposium, Johns Hopkins University, Baltimore, Maryland, June 2009.

Partner organizations and collaborators

U.S. Navy Naval Surface Warfare Center Crane Division – Financial Support

- University of Alaska Fairbanks is supporting NSWC Crane's interests in unmanned aircraft payload development, airspace integration, and small unit deployments.

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

Thomas Weingartner, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

Other investigators/professionals funded by this project:
Bodil Bluhm, *co-PI,* ***Ken Coyle,*** *co-PI,* ***Seth Danielson, Heloise Chenelot,*** *University of Alaska Fairbanks*

CIFAR 09-007: This project is in its final year.

Primary objectives

- Field measurements of four target fish species representative of Beaufort Sea species, habitats and offshore development issues.
- Deploy active in-situ trawl gear of a variety of types as a primary sampling method.
- Collect concurrent physical, biological, and other environmental data.
- Conduct multivariate analyses to determine the relationships between fish species and between fish and environmental characteristics (such as water column properties, phytoplankton biomass or zooplankton distribution).

Research accomplishments/highlights/findings

The fish survey cruise was conducted in August of 2008.

Physical Oceanography (Weingartner): Weingartner's group completed processing and analyzing the CTD (conductivity, temperature, depth) data in conjunction with the fisheries components. We have also contributed to the draft final and final report (lead author is L. Logerwell of NOAA-NMFS) and submitted both to Minerals Management Service (MMS).

NOAA relevance/societal benefits

1. 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 and so that it can be well-managed in the face of anticipated marine development activities.

2. 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-sensitive sector of the US Arctic.

3. 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.*

Education

This is a joint project with researchers at NOAA-NMFS-Alaska Fisheries Science Center and the University of Washington. The physical oceanographic data collected on this project are also being merged with another Beaufort Sea physical oceanography program headed by Weingartner in this region.

Outreach
Nothing to report.

Publications, conference papers, and presentations
Peer-reviewed papers are now being prepared.

Oral Presentation

Parker-Stetter, S., J. Horne, L. Logerwell, K. Rand and T. Weingartner. 2010. Assessment of Arctic cod and young-of-the-year fish distribution in the Beaufort Sea. Alaska Marine Science Symposium, 18–22 January 2010, Anchorage, Alaska.

Other products and outcomes
A PI meeting was held in Seattle during April 2009 to guide the data synthesis part of the project.

Partner organizations and collaborators
Under separate funding from the National Ocean Partnership Program (NOPP), Weingartner (UAF), A. Plueddemann and R. Pickart (Woods Hole), K. Stafford (U. Washington), S. Moore (NOAA-NMFS), and B. Holt and R. Kwok (Jet Propulsion Lab), are conducting an extensive field and satellite-based observational program on the eastern boundary of the fish survey region. This work includes oceanographic and passive acoustic recorder (for marine mammal calls) moorings, remote sensing, and CTD surveys. These data will be blended with the physical oceanographic data collected from the fish survey and also be used to help assess potential fish habitats in the Beaufort Sea. This is an in-kind and ad hoc collaboration, wherein we will share relevant data sets across both programs.

CLIMATE CHANGE AND VARIABILITY

Cooperative Alaska Research and Satellite Data Services

Thomas Heinrichs, PI ***CIFAR theme: Climate Change & Variability***
University of Alaska Fairbanks

Other investigators/professionals funded by this project:
Jessica Cherry, co-PI, *University of Alaska Fairbanks*

CIFAR 10-015: This project is new.

Primary objectives

- Enhance existing Alaska research and satellite data services and develop new services and applications in cooperation with NOAA personnel.
- Develop next generation scientific products from satellite data.
- Improve near-real-time and forecast snow products as a pilot application using Alaska's North Slope as the test area.

Research accomplishments/highlights/findings

A satellite proving ground activity, "The Winter Testbed Experiment" was designed in collaboration with the National Weather Service (NWS), National Environmental Satellite, Data, and Information Service (NESDIS), and other cooperative research institutes (especially CIMSS, Cooperative Institute for Meteorological Satellite Studies). The experiment has been designed via multiple teleconferences with NESDIS, in-person meetings with the project team, and visits to the NWS forecast offices in Fairbanks, Anchorage, and Juneau, as well as the Alaska Aviation Weather Unit and the River Forecast Center. Outcomes of the planning include:

- Target products for the Alaska domain were prioritized.
- Data capture and delivery processes have been identified and the project team is now working with the GOES-R (Geostationary Operational Environmental Satellite–R series) Algorithm Working Group members to get the appropriate algorithms to publish proxy data products in near-real time.
- Forecast offices have been briefed on the experiment and are willing to provide necessary evaluations of the product.
- The spring 2010 breakup and flood period was identified as the first iteration of the High Latitude experiment, so data production and evaluation will begin immediately.
- A search is underway for a project data manager and an Operations Plan has been drafted.

NOAA relevance/societal benefits

This project has the potential for huge impacts on Alaskan communities because it specifically focuses on developing satellite products to overcome data gaps for applications like flood forecasting and aviation safety. Because of Alaska's large size and sparse ground-based observations, satellites have the potential to provide information that may never be available from in situ networks. Another component of this project is to train forecasters to become more familiar with qualitative and quantitative use of remote sensing in Alaska.

Education

Katrina Bennett, a Ph.D. student, has been hired, to begin in July 2010. Funding for partial support for her work will be requested in the upcoming budget.

Outreach

Cherry visited the NWS forecast offices in Fairbanks, Anchorage, and Juneau, as well as the Alaska Aviation Weather Unit and the River Forecast Center. Here she discussed the development of the satellite products with the forecasters, who are not typically involved in remote sensing research.

Publications, Conference Papers, and Presentations

Oral presentations

Cherry, J. (presented by J. Walsh). 2009. Development of improved snow products for Alaska. High Latitude and Arctic Proving Ground Meeting, Fairbanks, Alaska, August 2009.

Heinrichs, T. and K. Engle. 2009. UAF Geographic Information Network of Alaska joint proving ground program with NWS and NESDIS. High Latitude and Arctic Proving Ground Meeting, Fairbanks, Alaska, August 2009.

Other Products and Outcomes

- Hosted workshop in Fairbanks and Anchorage, *High Latitude and Arctic Proving Ground Meeting,* 18–20 August 2009 with 27 participants: http://www.gina.alaska.edu/ground-station/2009-noaa-presentation/
- The new remote sensing snow and cloud products will include
    - Snow cover
    - Snow/cloud differentiation
    - Low cloud/fog and
    - Cloud phase.

  These will be made available in near-real time and archived.
- Work is also underway to implement NESDIS-developed volcanic ash detection and tracking algorithms in Alaska using real-time satellite data captured at the NESDIS receiving station in Fairbanks.
- Hundreds of Alaska- and Arctic-specific data products derived from NOAA, NASA, and Air Force satellites have been inserted into a Unidata Local Disk Manager (LDM) data feed in Fairbanks. They are available for incorporation into AWIPS (Advanced Weather Interactive Processing System) for Alaska Region forecasters. UAF and NWS staff are working together to introduce these products to forecasters in the Alaska Regional and Field offices.

Partner organizations and collaborators

NOAA National Weather Service: Collaborative research, Facilities

NOAA NESDIS, Fairbanks Command and Data Acquisition Station: In-kind support, Facilities, Collaborative Research

NASA-Cryosphere Group: Collaborative research

UW-Madison CIMSS: In-kind support, Collaborative research, Personnel exchanges

UW-Madison Space Science and Engineering Center (SSEC): In-kind support, Collaborative research, Personnel exchanges

Impact

The significant impact of this project for Alaska will be realized during the upcoming reporting period. The current, initial period has been characterized by organizing, requirements gathering, planning, and initial implementations of product lines.

Changes/problems/special reporting requirements

This project has been in startup mode in year one. It will also be one of the first "Proving Grounds" and pioneering the protocols for the activity has been challenging. The outcomes of the planning effort are being received well and will provide a good template for future Proving Ground activities.

A particular challenge has been the getting the data liaison position for the project established. The position is currently being advertised. Once the position is filled, we anticipate additional rapid progress on implementation of operational, satellite-derived products. The data liaison will also play a key role supporting Cherry and other researchers performing the science and algorithm development aspects of the project.

State of the Arctic Land Report (2008/2009)

Vladimir Romanovsky, PI ***CIFAR theme: Climate Change & Variability***
University of Alaska Fairbanks

CIFAR 09-006: This project is ongoing.

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.

Research accomplishments/highlights/findings

During the last 9 years, permafrost temperature has been relatively stable on the North Slope of Alaska. There was even a slight decrease in the Alaskan Interior during the last 3 years. Only coastal sites in Alaska still show continuous warming, especially during the last three to four years. Permafrost temperature has increased by 1 to 2°C in northern Russia during the last 30 to 35 years. A common feature for Alaskan and Russian sites is more significant warming in relatively cold permafrost than in warm permafrost in the same geographical area. An especially noticeable permafrost temperature increase in the Russian Arctic was observed during the last three years – the mean annual permafrost temperature at 15-m depth increased by more than 0.35°C in the Tiksi area and by 0.3°C at 10-m depth in the European North of Russia. The last 30-years of increasing permafrost temperatures have resulted in the thawing of permafrost in areas of discontinuous permafrost in Russia. This is evidenced by changes in the depth and number of taliks, a layer of year-round unfrozen ground that lies in permafrost, especially in sandy and sandy loam sediments compared to clay. A massive development of new closed taliks in some areas of the continuous permafrost zone, as a result of increased snow cover and warming permafrost, was responsible for the observed northward movement of the boundary between continuous and discontinuous permafrost by several tens of kilometers.

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. This will also contribute to International Polar Year (IPY) activities involving NOAA, NASA, and NSF.

Education

Nothing to report.

Outreach

During the last year, Romanovsky was interviewed by Italian TV; by *Scientific American*; by *The Guardian*, London in July 2009; by Greenlandic radio; and by Norwegian TV in August 2009. In September and October, he was interviewed by Russian and South Korean TV scientific programs. On 22 October 2009, he participated in a teleconference organized by NOAA in relation with the NOAA State of the Arctic Report release. In November, he presented at the Alaska Center for Climate Assessment and Policy webinar, "Changes to Permafrost in Alaska: Observations and Modeling." On 10 December 2009, he gave a real-time telephone interview with the Leonard Lopate Show on WNYC, NY Public Radio, about the societal impacts of changes in permafrost in Alaska. Romanovsky was involved as a key participant in the work of the Public Infrastructure Technical Working Group of the Alaska Climate Change Adaptation Advisory Group that prepared and delivered its report to the Alaskan Government Climate Change Sub-Committee in August 2009.

Publications, conference papers, and presentations

Peer-reviewed

Groisman, P.Y., E.A. Clark, D.P. Lettenmaier, V.M. Kattsov, I.N. Sokolik, V.B. Aizen, O. Cartus, J. Chen, C.C. Schmullius, S. Conard, J. Katzenberger, O. Krankina, J. Kukkonen, M.A. Sofiev, T. Machida, S. Maksyutov, D. Ojima, J. Qi, V.E. Romanovsky, D. Walker, M. Santoro, A.I. Shiklomanov, C. Vörösmarty, K. Shimoyama,

H.H. Shugart, J.K. Shuman, A.I. Sukhinin and E.F. Wood. 2009. The Northern Eurasia Earth Science Partnership: An example of science applied to societal needs. *Bulletin of the American Meteorological Society*, 90:671–688. DOI :10.1175/2008BAMS2556.1.

Romanovsky, V., N. Oberman, D. Drozdov, G. Malkova, A. Kholodov and S. Marchenko. 2009. Permafrost. In: State of the Climate in 2008. Special Supplement to the *Bulletin of the American Meteorological Society*, 90(8):S91–S92.

Other products and outcomes

- Web site: http://www.permafrostwatch.org/
- Richter-Menge, J. and J.E. Overland, Eds. 2009. Arctic Report Card 2009. http://www.arctic.noaa.gov/reportcard.

Partner organizations and collaborators

None.

COASTAL HAZARDS

Northern Bering Sea Improved Hazard Monitoring in the Marine and Coastal Environments

David Atkinson, PI ***CIFAR theme: Coastal Hazards***
University of Alaska Fairbanks

CIFAR 010-018: This project is new.

Primary objectives

- Deploy autonomous wind and wave buoys into the central/northern Bering Sea;
- Establish near-real time delivery of wind and wave data to the internet;
- Establish working community partnerships;
- Develop reporting metrics to determine the ways in which the data ultimately come to be utilized by the community;
- Assessment of data utility for National Weather Service forecasting activities;
- Use data to verify NOAA wave models, and other modeled/remotely sensed data, in the areas of buoy deployment in a research mode.

Research accomplishments/highlights/findings

- There are no accomplishments to report. The project has not been started yet; no funds have been drawn to date. The reason for this is a delay in getting appropriate assistance in the form of new graduate students for Atkinson.

Changes/problems/special reporting requirements

- The delay in commencement has arisen due to lack of student assistance. This will hopefully be resolved in the coming year when a new student is brought on.

TWEAK: Tsunami Warning and Environmental Observatory for Alaska

Roger Hansen, PI ***CIFAR theme: Coastal Hazards***
University of Alaska Fairbanks

CIFAR 09-008/10-008: This project is ongoing.

The University of Alaska Fairbanks (UAF) tsunami studies center called the Alaska Tsunami Center and Observatory (ATCO) combines the strengths of the UAF Institute of Marine Science (IMS), the Geophysical Institute (GI) and the Arctic Region Supercomputing Center (ARSC). By forming one organized group, ATCO allows a single point of contact to our partners and collaborators.

The proposed tasks for TWEAK are:

1. Tsunami code development and specification of non-seismic sources
2. Super computer support for tsunami codes
3. Seismic source function specification
4. Earthquake detection and warning with seismology
5. Assessment of tsunami hazard and wave run-up
6. Education and outreach in Alaska
7. Project management

Because this project continues on-going TWEAK efforts under the previous CIFAR cooperative agreement, this report will be limited to efforts begun or continued with this new award. Beginning in this reporting period, "TWEAK Task 3: Seismic network component" was funded as a separate CRESTnet (Consolidated Reporting of Earthquakes and Tsunamis) award entitled "Alaska Earthquake Information Center (AEIC) Seismic Station Operations and Maintenance." For continuity with our previous awards, we have included this report within the TWEAK umbrella, but with reference to the new award.

Partner organizations and collaborators

The University of Alaska has State and Federal partners in the tsunami program. These include the NOAA/NWS West Coast and Alaska Tsunami Warning Center (WC/ATWC), the Department of Homeland Security and Emergency Management (DHS&EM), and the Alaska Division of Geological and Geophysical Surveys (ADGGS). ATCO will continue to support the National Tsunami Hazard Mitigation Program (NTHMP) through improvements and enhancements in monitoring, modeling, and education and outreach.

TWEAK Task 1: Development of new tsunami hazard mitigation tools

Roger Hansen, PI
Zygmunt Kowalik, co-PI and Project Lead
University of Alaska Fairbanks

Other investigators/professionals associated this project:
J. Beget, J. Horrillo, W. Knight, T. Logan, *University of Alaska Fairbanks;* ***A. Proshutinsky****, Woods Hole Oceanographic Institution;* ***Y. Yamazaki,*** *University of Hawaii*

Primary objectives

The main task of the UAF IMS research is to assist with tsunami warnings and prediction services by developing numerical-hydrodynamical models. An important result of this work has been the construction of a global tsunami model (GTM). Our primary objectives during this reporting period were associated with further developing and testing of different components of the GTM. Three levels of models with progressively improved physics were used. These are: the Nonlinear Shallow Water models, dispersive Boussinesq type models, and 3D Navier-Stokes.

Research accomplishments/highlights/findings

- A 4-year cooperative effort by Z. Kowalik of the UAF School of Fisheries and Ocean Sciences (SFOS), W. Knight (Tsunami Warning Center, Palmer, AK), J. Horrillo (Texas A&M) and Y. Yamazaki (Univ. of Hawaii, Manoa) resulted in the formulation, verification, and validation of a depth-integrated, non-hydrostatic model with a semi-implicit, finite difference scheme. This model was presented at NEES Training Workshop: Simulation & Large Scale Testing of Near-Shore Wave Dynamics, July 8–10, 2009, Corvallis, Oregon. When compared against eight models, the organizers judged that our dispersive model provided the best comparison against the measured data.
- Improvement of the Global Tsunami Model by considering landslide generated tsunami. The landslide generated tsunami waves related to the St. Augustine volcano eruption in 1883 were solved by the full Navier-Stokes equation and by the 2D set of equations. Comparison of the two solutions allowed construction of a simple Fortran code for the landslide tsunami generation.
- Tide-tsunami interaction study. Important conclusions from these studies are that computed elevations 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.

NOAA relevance/societal benefits

Collaboration with the West Coast/Alaska Tsunami Warning Center in Palmer assures that the results of investigations will be implemented into every-day tsunami warning practice and find the way to the wide community of potential users. The advanced numerical models help to solve issues related to saving lives in the event of catastrophic tsunamis.

Outreach

Nothing additional since last reporting period.

Publications, conference papers, and presentations

Publication activity during the reporting period originated from work funded through the previous CIFAR cooperative agreement, NA17RJ1224. See below.

Oral presentations

Kowalik, Z., J. Horrillo and Y. Yamazaki. 2009. Dispersive model formulation, testing and intercomparison. NEES Training Workshop: Simulation & Large Scale Testing of Near-Shore Wave Dynamics, Oregon State University, Corvallis, Oregon, 8–10 July 2009.

Other products and outcomes

- A Fortran code for landslide generated tsunami.
- Logan worked with Kowalik to run the single grid GTM on ARSC's CRAY XT5 supercomputer to simulate the Samoa Tsunami that occurred in September 2009. This required porting the parallel single grid GTM to the Cray system, configuring the code for the Samoa Tsunami run, and additional modifications to the code to collect flux data at areas of interest.
- Logan worked with Kowalik and staff at the WCATWC to create a statement of work (SOW) regarding Logan's parallelization of the WCATWC's Tsunami propagation and inundation model. This SOW includes not only porting and parallelization of this model, but generation of a new database via nearly 500 simulation runs. Interactions have included not only e-mail, but also a face-to-face meeting at the WCATWC facility. Work on this project will commence in the very near future.
- Logan is currently working with Kowalik to port and parallelize the new multi-gridded GTM for use on the CRAY XT5 supercomputer at ARSC. This work has been ongoing part time since mid February 2010.

Partner organizations and collaborators

West Coast/Alaska Tsunami Warning Center; Arctic Research Supercomputing Center; Texas A&M University at Galveston; Department of Ocean & Resources Engineering, University of Hawaii at Manoa, Woods Hole Oceanographic Institute

Publications related to this project as funded under NA17RJ1224 (previous cooperative agreement)

Peer-reviewed

Kowalik, Z. and A. Proshutinsky. 2010. Tsunami–tide interactions: A Cook Inlet case study. *Continental Shelf Research*, 30:633–642.

TWEAK Task 2: Tsunami computational portal

Roger Hansen, PI
University of Alaska Fairbanks

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

Primary objectives

The Tsunami Computational Portal (TCP) 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 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.

- The Tsunami Portal development back-end has been revamped to allow multiple jobs to run simultaneously and asynchronously. For example, three jobs can run at the same time, and a new job can start whenever one of the existing jobs finishes without waiting for the other two to finish.
- Error reporting is more robust and error emails have been consolidated into a one-email-per-job summary in the Tsunami Portal development back-end. The current production back-end sends the administrators an email for each thing that goes wrong with a job. Once this change is integrated into the production back-end, the same level of detail will be available without being overwhelmed by emails when things do go wrong.
- The internal documentation of the Tsunami Portal received an overhaul. A comprehensive back-end technical implementation document was created. Much of the back-end source code has been broken down into functions and commented better. And, a written procedure for integrating new data sets into the Tsunami Portal front-end exists.
- The Tsunami Portal's front-end database is in the process of being moved to a dedicated database server. Once moved, this database will receive better maintenance support (e.g., software upgrades, database table optimization).
- A bug in the Tsunami Portal front-end was fixed. (The "Portal Registration" form had caused database errors when a person's name had an apostrophe in it.)

As before, each portal job is monitored for correctness and runs with errors have been analyzed. In the last year, 48 jobs have been run through the portal. Continued interest in use of the portal was evidenced by the approval of 19 new accounts during the last 12 months.

NOAA relevance/societal benefits

Nothing to report.

Education
Nothing to report.

Outreach
In past years, a navigable, animated 3D visualization of the '64 quake was built using OpenSceneGraph. This visualization was regularly displayed in the Discovery Lab for visitors until the lab's recent closure. 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. These animations will continue to live on in the ARSC informational kiosk.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
The main goal of this project is the development and support of the Tsunami Computational Portal wherein the public interface is the web site, https://tsunamiportal.arsc.edu. Therefore, the majority of the work during this period was focused on the enhancement of this site.

Partner organizations and collaborators
NACSE: Cherri Pancake, Dylan Keon, and Ben Steinberg have continued to be invaluable to the success of the TCP. During this reporting period, they provided the documentation describing the process of adding new datasets to the portal.

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, has been helpful in providing modeling expertise and consultation to the project

Impact
The usefulness of the TCP has once again been demonstrated during this reporting period, as evidenced by continued interest in user accounts and an average of 1 job per week over the last year.

[Please note that this report only covers the period from 1 July 2009 to 31 March 2010. Activities on this project from 1 April 2009 to 30 June 2009 were submitted in the final report for Cooperative Agreement NA17RJ1224.]

TWEAK Task 3: Seismic network component

Roger Hansen, PI
University of Alaska Fairbanks

Other investigators/professionals associated this project:
S. Estes, J. Sandru, J. Stachnik, T. Viggato, *University of Alaska Fairbanks*

Primary objectives
- Maintain seismic stations in the Alaska Seismic Network.
- Upgrade analog stations to Advanced National Seismic System (ANSS) standards of Modern broadband equipment.
- 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.
- Maintain data flow of selected stations to ATWC.

Research accomplishments/highlights/findings
- We continued to upgrade and expand our seismic network including the following work:
    - Installed two new strong motion sites with real-time telemetry.

- Replaced short-period sensors with digital broadband sensors at ten sites.
- Replaced analog short-period sensors with digital short-period sensors at five sites.
- Upgraded older digital broadband equipment to state-of-the-art broadband at two sites.
- Upgraded equipment at ten of our receiving sites.
- Swapped in new equipment at nine sites.
- Performed other maintenance at eight sites.

- Between April 1, 2009 and March 31, 2010, we have located 21,936 events, with magnitudes ranging between -0.3 and 6.5, and depths down to 280 km (Figure 1). The largest earthquake, magnitude 6.5, occurred on October 13, 2009, in the Fox Islands region.

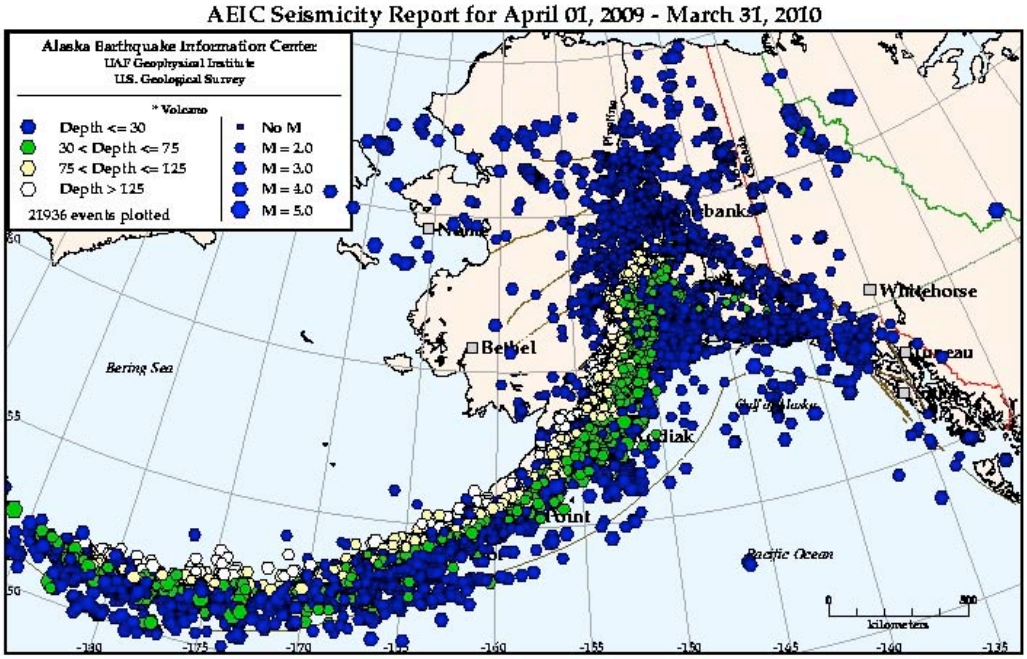


Figure 1. AEIC Seismicity Report for April 01, 2009 – March 31, 2010

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

Education
Nothing to report.

Outreach
AEIC continues to provide real-time and reviewed earthquake information to local Emergency Services offices through monitoring systems 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.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

Partner organizations and collaborators
None.

TWEAK Task 4: Earthquake detection and warning with seismology

Roger Hansen, PI
University of Alaska Fairbanks

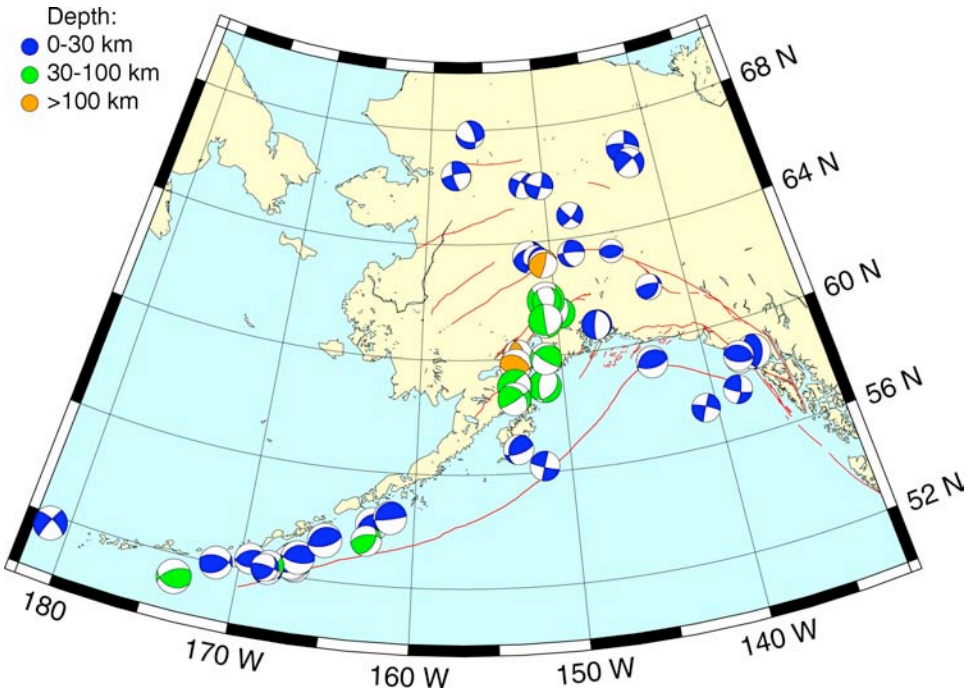
Other investigators/professionals associated this project:
Natalia Ruppert, Anna Bulanova, *University of Alaska Fairbanks;* ***Aurélie Guilhem, Douglas S. Dreger****, Berkeley Seismological Laboratory*

Primary objectives

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

Research accomplishments/highlights/findings

- A total of 53 regional moment tensor solutions were calculated (moment magnitudes MW between 3.7 and 6.3) between 1 April 2009 and 31 March 2010 in Alaska and Aleutians:



- Continued expansion of the AEIC broadband network has allowed for more reliable calculations of the earthquake source parameters through inclusion of more waveform data into inversion.
- Worked on inclusion of calculated moment magnitude MW values into the real-time earthquake database at AEIC. This is important for larger events when ML values get saturated.
- Worked on development of the following two tsunami early warning systems:

Part One: Development and Implementation of Continuous Moment Tensor Scanning for Offshore Seismicity and Tsunami Early Warning (Aurélie Guilhem and Douglas S. Dreger, Berkeley Seismological Laboratory)

Research Objectives

To more effectively monitor the offshore regions of northern California and Alaska, particularly for slow/low-stress-drop and large possibly tsunamigenic earthquakes, we are implementing a method for the automatic continuous scanning of long-period (> 20 sec) broadband seismic records (including on-scale strong motion and

real-time GPS) following the method proposed by Kawakatsu (1998) and implemented by Tsuruoka et al. (2009). For great earthquakes regional network stations are in the near-field and the point-source approach of Tsuruoka et al. (2009) requires modification to account for finite-rupture. We aim to accomplish this by developing composite Green's functions for finite-rupture scenarios in which point-source Green's functions distributed along the subduction zone are summed thereby accounting for the near-field source-receiver geometry as well as rupture delay times.

Approach

The continuous seismic scanning algorithm proposed by Kawakatsu (1998) and implemented by Tsuruoka et al. (2009) at the University of Tokyo Earthquake Research Institute (ERI) allows for the analysis of events ranging in size from 3.5 to 8+. Briefly, this method recognizes that the linear moment tensor inversion is composed of the autocorrelation of Green's functions and cross correlations of Green's functions with observed waveforms. This cross correlation may be obtained continuously on a streaming data set given adequate computational resources. The autocorrelation only needs to be done once, in advance saving computation time. Equation 1 gives the linear relationship between Green's functions (G), the moment tensor (M), and observed seismic waveforms (d):

$$GM = d \qquad (1)$$

The solution to (1) is,

$$M = \left[(G^T G)^{-1} G^T\right] d \qquad (2)$$

The $\left[(G^T G)^{-1} G^T\right]$ matrix is constructed for a predefined grid of virtual sources and seismic stations that are used in the analysis. The matrix may then be stored in computer memory thereby reducing processing time. The right hand side of equation 2 is essentially the convolution of the Green's functions with the data, and in GridMT (Tsuruoka et al., 2009) this convolution is performed every 2 seconds on the streaming data field. The fit for all source locations is monitored at each time step, and when the fit rises to a defined level the algorithm has automatically detected, located, and determined the scalar seismic moment and focal mechanism. In our implementation we use the velocity records of four broadband seismic stations of the Berkeley Digital Seismic Network (BDSN). We are implementing two parallel running algorithms: one focusing on Mw <= 8 earthquakes by scanning data filtered between 20 and 50 sec period and another on large, potentially tsunamigenic events (Mw >= 8) with data filtered between 100 and 200 sec period.

Accomplishments

To examine the feasibility of the Grid MT method in the offshore region of Mendocino we tested the concept on several events from Mw 4.2 to Mw 7.1. The grid in Figure 1 is sampled every 0.2 degree with 416 virtual sources for each depth. Depth in the proposed processing system is sampled at 3 km.

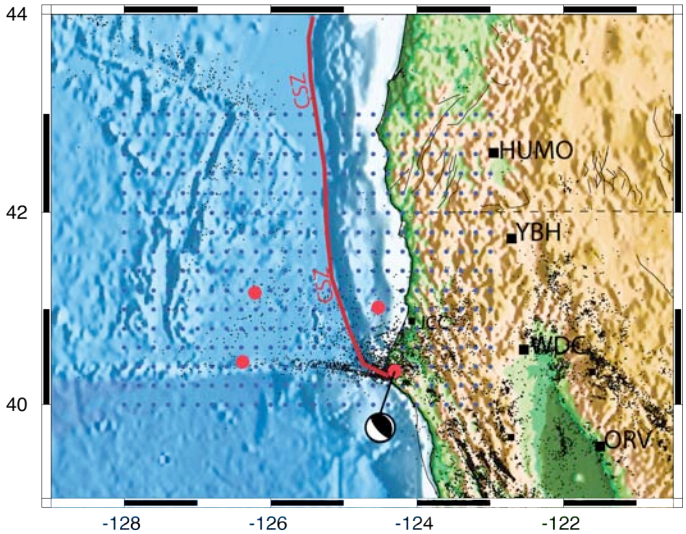


Figure 1. Map showing the location of Mendocino and Northern California seismicity (small black dots), magnitude 7 earthquakes (red circles), focal mechanism of the 23 April 1992 Cape Mendocino earthquake (Oppenheimer et al., 1993), broadband BDSN station (squares), and the Cascadia Subduction Zone (CSZ). The regular grid of points show virtual source locations for the proposed continuous scanning Grid MT (Tsuruoka et al. (2009) method).

Since in the Grid MT processing the source location is not known in advance we modified our moment tensor method to invert EW, NS and Z components rather than the usual R, T and Z components. Green's functions were computed using the GIL7 velocity model, which we use in our routine monitoring (e.g. Pasyanos et al., 1996). Preliminary tests show very good results in terms of timing, location, mechanism and moment magnitude for M4 to 7 earthquakes. The sequence of panels (left to right) in Figure 2 shows the progression of GridMT processing for an offshore M6.7 event. The synthetics for each source point in Figure 1 are aligned in absolute time. In the method as the data streams in it is convolved with the Green's functions for each source location to obtain the moment tensor. For the cases when the data is positioned 60 seconds before or after the actual time of the event (panels 1 and 4) the fits to data, location and moment tensor solutions are poor. The best fit to the data is found for the case when the data has shifted 2 seconds later than the reported origin time (panel 3). In this case the event is properly located and the correct moment and focal mechanism are obtained.

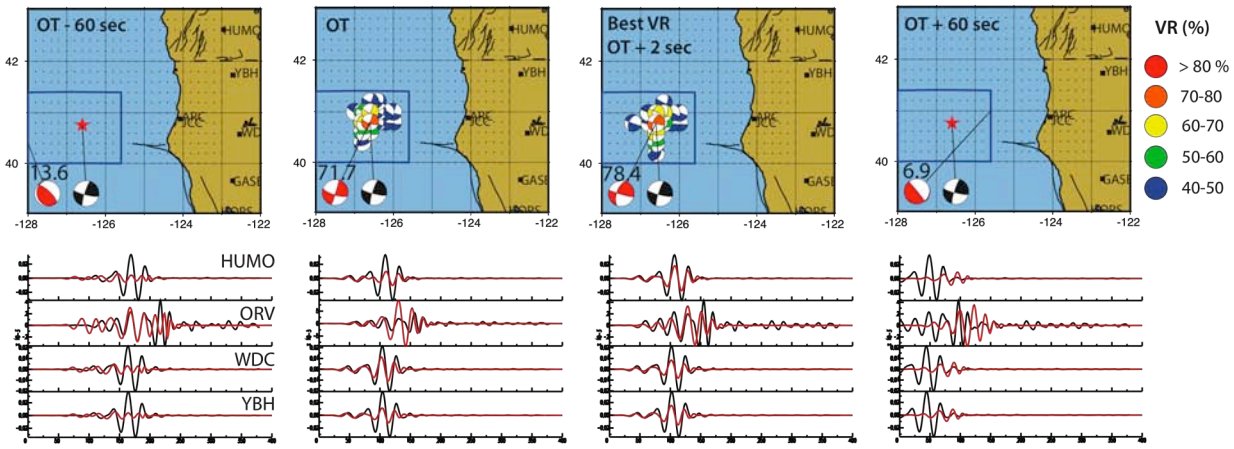


Figure 2. Tests for a 2005 M6.7 earthquake for cases origin time (OT) minus 60 sec, OT, OT + 2 sec (the best fit case), and OT + 60 sec. The black P-wave focal mechanism diagram shows the Berkeley moment tensor catalog reference solution. The red focal mechanism diagram corresponds to the best solution over the grid at the time considered, and the red star shows the correct location of the event. The variance reduction (VR) in % is indicated above the red mechanism. The EW component data (black) and synthetics (red) are also shown.

In addition we considered synthetic tests for large earthquakes (M>8) defined with uniform and variable slip models. We found that the inversions using the 20-50 second passband failed to recover the seismic moment tensor, scalar seismic moment and location for such large earthquakes. The moment magnitude is significantly underestimated yielding only a Mw 6.7, and our best solution shows that the event is located onshore more than 100 km from the centroid of the finite-source model. This occurs because the Grid MT point-source synthetic is only fitting a small portion of the record, and because the source corner frequency of the event (1/87sec=0.011 Hz) is less than the high pass filter corner of 0.02 Hz (50 seconds). However the 100 to 200 second passband works well and the inversion yields a point-source location near the fault centroid, Mw 8.1 and a dip-slip focal mechanism similar to the input mechanism (Figure 3).

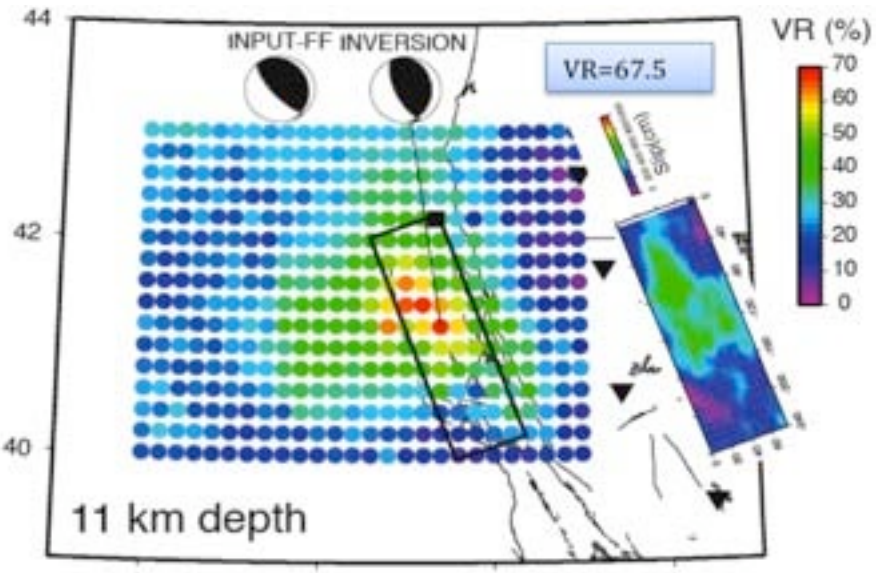


Figure 3. Result of the grid search for a Mw8.1 earthquake at 11 km depth. The virtual sources (dots) are color-coded by their best variance reductions (VR) over the grid search. The black rectangle represents the rupture segment. The input slip model (right) and mechanism (top left) as well as our inversion mechanism (top right) are also shown. The four seismic stations are shown by the black triangles.

The testing for the M8.1 event indicates that in using the 100 to 200 second passband it should be possible to detect, locate, and determine the seismic moment tensor of M8+ events using near-field stations in approximately 8 minutes after the origin time. Depending on the location of the slip centroid of the earthquake this can potentially provide between several to as much as 15 minutes of warning before tsunami waves arrive at the coast.

We have written the software utilizing equation (2) to test the algorithm, and are in the process of developing the tools for the generation of the Green's function database for other regions, as well as the software for the monitoring of goodness of fit, and solution reporting. We expect to have an operational prototype running for the Mendocino region sometime in summer 2010.

Conference presentations

Oral presentations

Guilhem, A., D.S. Dreger and R. Uhrhammer. 2009. Towards a continuous seismic scanning in the region of the Mendocino Triple Junction, California. American Geophysical Union Fall Meeting, San Francisco, California, December 2009.

Guilhem, A. and D.S. Dreger. 2010. Development and implementation of continuous moment tensor scanning for offshore seismicity and tsunami early warning. 7th annual National Earthquake Hazards Reduction Program (NEHRP) meeting, Menlo Park, California, January 2010.

Guilhem, A., D.S. Dreger and R. Uhrhammer. 2010. A continuous moment tensor analysis in the region of the Mendocino Triple Junction, California. Institut de Physique du Globe de Paris (IPGP) Annual Graduate Student Meeting, Paris, March 2010.

Poster presentations

Guilhem, A. and D.S. Dreger. 2009. Continuous seismic scanning in the region of the Mendocino Triple Junction, California. Seismological Society of America Annual Meeting, Monterey, California, April 2009.

Guilhem, A. and D.S. Dreger. 2009. Continuous seismic scanning in the region of the Mendocino Triple Junction, California. 2009 International Scientific Studies Conference, Vienna, Austria, June 2009.

References

Kawakatsu, H. 1998. On the realtime monitoring of the long-period seismic wavefield. *Bulletin of the Earthquake Research Institute*, 73:267–274.

Oppenheimer, D., G. Beroza, G. Carver, L. Dengler, L. Eaton, L. Gee, F. González, A. Jayko, W.H. Li, M. Lisowski, M. Magee, G. Marshall, M. Murray, R. McPherson, B. Romanowicz, K. Satake, R. Simpson, P.

Somerville, R. Stein and D. Valentine. 1993. The Cape Mendocino, California, earthquakes of April 1992: Subduction at the Triple Junction. *Science*, 261:433–438.
Pasyanos, M.E., D.S. Dreger and B. Romanowicz. 1996. Towards real-time determination of regional moment tensors. *Bulletin of the Seismological Society of America*, 86:1255–1269.
Tsuruoka, H., H. Kawakatsu and T. Urabe. 2009. GRiD MT (Grid-based Realtime Determination of Moment Tensors) monitoring the long-period seismic wavefield. *Physics of the Earth and Planetary Interiors*, 175:8–16.

Part 2: Development of GPS Shield Technique for Tsunami Early Warning (Natalia Ruppert and Anna Bulanova, University of Alaska Fairbanks)

Research Objectives

We have also been working towards implementing Sobolev and Babeyko's (2007, 2008) "GPS Shield" approach for using near-real-time GPS static displacement data to rapidly estimate the tsunamigenic potential of large earthquakes near Alaska.

In the event of a significant undersea earthquake, evaluating the potential for destructive tsunami waves requires quickly estimating moment magnitude along with faulting parameters such as length, width and slip. Accurate estimation of moment magnitude using seismic data might take more than a day, which is unacceptable for early warning. Our project is concerned with using near-real-time GPS static displacement data to determine an earthquake's tsunamigenic potential within minutes.

Approach

Our approach estimates moment magnitude and faulting parameters by comparing an event's GPS displacement data to earthquake scenarios stored in a large database. For each scenario, the database includes its epicenter, moment magnitude, and GPS displacement data. The parameters of a new earthquake can be estimated quickly by matching it to the database scenario that best fits its GPS displacement data. The database approach is much faster than optimization techniques, which are preferable for scientific analysis but take too long for tsunami forecasting. In the case of a database containing about 14,000 earthquakes, the inversion time is under 3 seconds on a Sparc SunBlade 1500 workstation.

Accomplishments

Our first goal was to determine the sensitivity of our existing array of GPS sites in the Prince William Sound region and coastal areas of southern Alaska and Kodiak Island. This required dividing the subduction interface in the test area into subfaults, generating a repository of surface displacement data (Green's functions) for the test area, and creating a database of 13,899 synthetic earthquake scenarios with magnitude values ranging from 6 to 9 with a step of 0.1.

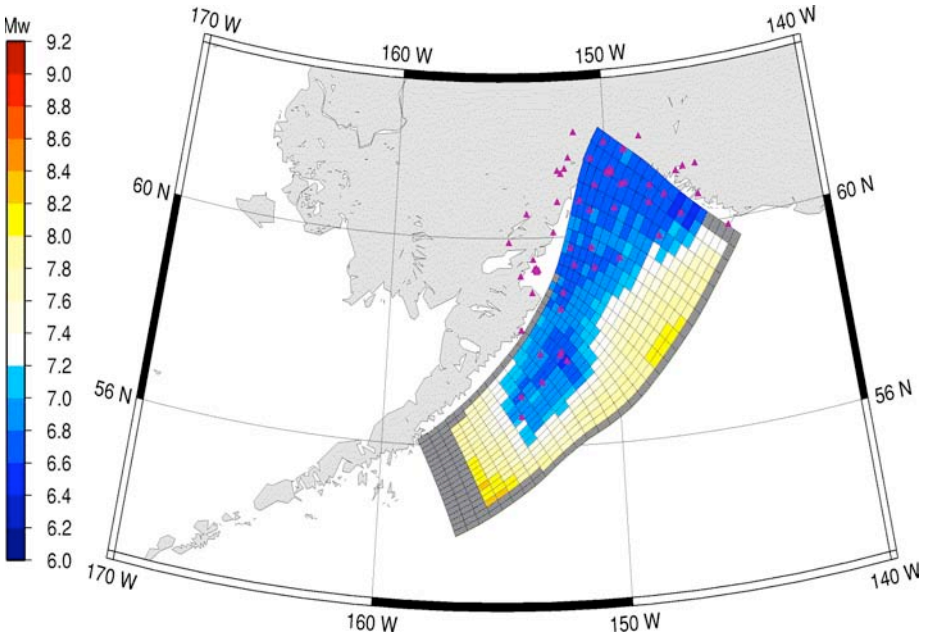
Our 600-tile discretization of the plate interface in southern Alaska is based on geometry of the Aleutians subduction zone published in Gudmundsson and Sambridge's RUM project (1998). The repository of Green's functions was created using a 1-D layered Earth dislocation model by Wang et al. (2003). The synthetic earthquake scenarios were created using Babeyko's "Rupture Generator." For a given epicenter and magnitude, rupture dimensions were calculated using scaling laws from Wells and Coppersmith (1994). Special C++ code and shell scripts were created for generating earthquake scenarios and for sensitivity testing.

We tested each scenario 100 times (with different GPS displacement errors) to see if the earthquake parameters were successfully recovered at least 90% of the time. Recovery was judged successful when magnitude errors were no greater than 0.2 and location errors were no greater than 0.5 degrees. In our tests, we found that we could successfully recover earthquakes of magnitude 7 or greater when they occurred close to GPS sites. For more distant earthquakes, the minimum magnitude for successful recovery was 8. See the table on page 36 and figure on page 37.

The next step in the project will be creating a database of real as well as synthetic earthquakes while extending our test area further into the Aleutian arc. We also need to expand and improve our array of GPS stations in order to increase recovery rates over a wider area. Finally, if we are to use this method for tsunami forecasting, we will need to upgrade as many of our GPS stations as possible to provide near-real-time data. Right now, we have very few near-real-time GPS stations.

Table 1. Sensitivity test results for the earthquake scenario database.

Magnitude	Number of scenarios	Max magnitude error	Max epicenter error (degree)	Average magnitude error	Average epicenter error (degree)
6	600	1.8	0	0.755333	0
6.1	600	1.8	0	0.638	0
6.2	600	1.7	0	0.513667	0
6.3	600	1.6	0	0.437833	0
6.4	600	1.5	0	0.338	0
6.5	600	1.4	0	0.2535	0
6.6	600	1.3	0	0.197167	0
6.7	588	1.2	0	0.169218	0
6.8	548	1.1	0	0.175182	0
6.9	524	1	0	0.202672	0
7	516	0.9	0	0.219767	0
7.1	505	0.9	0	0.208911	0
7.2	504	1	0	0.219048	0
7.3	504	1	0	0.215278	0
7.4	504	1.2	0	0.20873	0
7.5	503	1.3	0	0.197813	0
7.6	479	1.3	0	0.134864	0
7.7	472	1.5	0	0.109322	0
7.8	468	1.6	0	0.078846	0
7.9	450	1.2	0	0.033111	0
8	419	1	0	0.012649	0
8.1	400	0.4	0	0.00475	0
8.2	379	0.2	0	0.001583	0
8.3	351	0	0	0	0
8.4	327	0	0	0	0
8.5	301	0	0	0	0
8.6	268	0	0	0	0
8.7	231	0	0	0	0
8.8	192	0	0	0	0
8.9	153	0	0	0	0
9	113	0	0	0	0



Results of the tests for 90% parameter recovery for the scenario database (Table 1), i.e. out of 100 test runs, earthquake parameters are recovered with magnitude errors less than 0.2 and location errors less than 0.5 degrees for 90% of the cases. Grey rectangles indicate that earthquakes with epicenters at these locations are not successfully recovered in more than 10% of the tests.

References

Gudmundsson, O. and M. Sambridge. 1998. A regionalized upper mantle (RUM) seismic model. *Journal of Geophysical Research*, 103(B4), 7121–7136.

Hoechner, A., A. Babeyko, and S. Sobolev. 2008. Enchanced GPS inversion technique applied to the 2004 Sumatra earthquake and tsunami. *Geophysical Research Letters*, 35, L08310.

Sambridge M. and O. Gudmundsson. 1998. Tomography with irregular cells. *Journal of Geophysical Research*, 103(B1), 773–781.

Sobolev S., A. Babeyko, R. Wang, A. Hoechner, R. Galas, M. Rothacher, D. Sein, J. Schroter, J. Lauterjung and C. Subarya. 2007. Tsunami early warning using GPS-Shield arrays. *Journal of Geophysical Research*, 112, B08415.

Wang R., F. Martin and F. Roth. 2003. Computation of deformation induced by earthquakes in a multi-layered elastic crust - FORTRAN programs EDGRN/EDCMP. *Computers & Geosciences*, 29(2): 195–207.

Wells, D. and K. Coppersmith. 1994. New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacements. *Bulletin of the Seismological Society of America*, 84(4), 974–1002.

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.

Education

Nothing to report.

Publications, conference papers, and presentations

Publications in press

Ruppert, N.A. and R.A. Hansen. Temporal and spatial variations of local magnitudes in Alaska and Aleutians and comparison with body-wave and moment magnitudes. *Bulletin of the Seismological Society of America*, 100, doi:10.1785/0120090172.

Submitted papers

Ruppert, N.A., S. Prejean and R.A. Hansen. Seismic swarm associated with the 2008 eruption of Kasatochi Volcano, Alaska: earthquake locations and source parameters. Submitted to *Journal of Geophysical Research - Solid Earth*.

Oral presentations

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.

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.

Other products and outcomes

Nothing to report.

Partner organizations and collaborators

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.

The GPS source inversion project involved collaboration with A. Babeyko and A. Hoechner from Helmholtz Centre Potsdam, German Research Centre for Geosciences.

TWEAK Task 5: Assessment of tsunami hazard and wave run-up

Roger Hansen, PI
University of Alaska Fairbanks

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

Primary objectives

This task is a continuation of the original TWEAK initiative to complete hazard and risk assessment through inundation modeling in more than 70 Alaskan communities. 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.

Research accomplishments/highlights/findings

- We have completed the first stage of analytical and laboratory benchmarking of the numerical model for tsunami propagation and runup. The results were presented at the 24th International Tsunami Symposium (July 2009, Novosibirsk, Russia). The paper by Nicolsky *et al* is currently in review process.
- We have continued working on the ATOM (Alaska Tsunami Online Mapping) web-based interface. This interface aims at increased efficiency of tsunami inundation mapping of coastal Alaska. Dmitry Nicolsky submitted a proposal to the UAF Computer Science Department called "Improving an access to high performance tsunami modeling resources at the Arctic Region Supercomputing Center using a web interface." This proposal was selected to be a class project for a group of students finishing their degrees in computer science. The following tasks were outlined in the proposal:
  - Standardize an access to high performance tsunami modeling resources at ARSC using a recently developed User Interface Toolkit (https://www.uit.hpc.mil/),
  - Make the current version of the ATOM interface platform independent in order to help migration to other computational resources,
  - Optimize task managing and communication between the web browser, web server and ARSC computers,

- Reduce workload on a front node of the supercomputer by distributing post-processing tasks among other resources,
- Implement secure authentication at the web site.

- The proposed modifications to internet-based interface will provide secure and convenient access to explore numerical results and share mapping results with the state and local emergency officials. The proposed improvement to our modeling workflow will be instrumental in accelerating the production of inundation maps. Figures 1 and 2 demonstrate the current and the proposed configurations of the Alaska Tsunami Online Mapping interface, respectively.

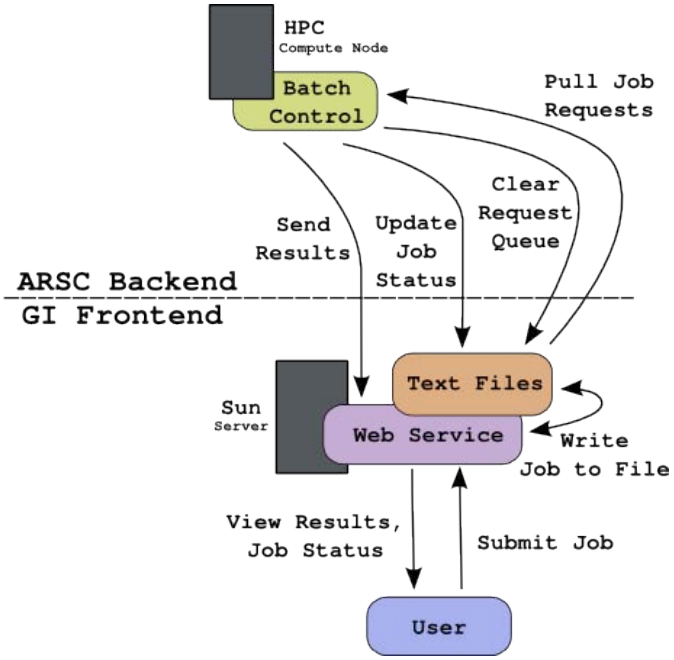


Figure 1. The current configuration of the Alaska Tsunami Online Mapping interface.

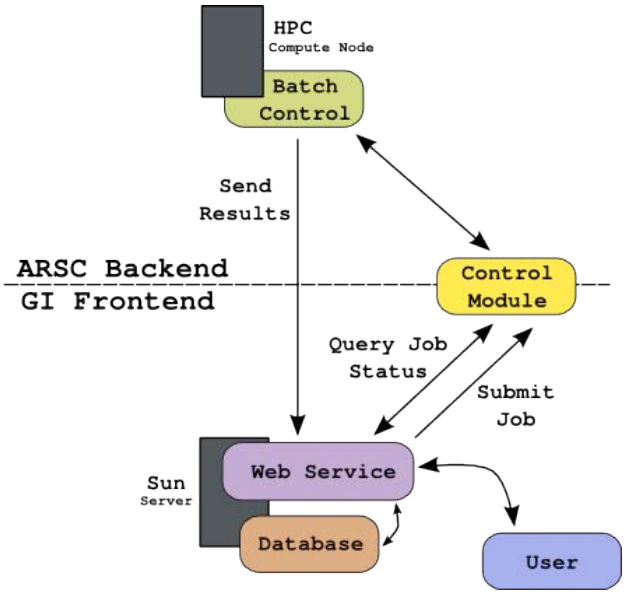


Figure 2. The proposed configuration of the Alaska Tsunami Online Mapping interface.

- We have continued working on the quality control of numerical grids made for tsunami inundation mapping of Whittier. During our visit to the city of Whittier in October of 2009, we conducted a high-resolution differential

Global Positioning System (GPS) survey (real time kinematic) within the harbor area and along near-shore roads. The locations of our GPS measurements are shown as red dots in Figure 3. Taking into account that GPS measurements are taken with respect to the WGS84 ellipsoid, elevation heights were adjusted to the Mean Higher High Water (MHHW) datum. Since the real time kinematic correction was used during the survey, the accuracy of collected points with respect to each other is within several centimeters (Leica Geosystem AG, 2002); the accuracy of converting the observations to the MHHW datum does not exceed one meter. We interpolate between the collected measurements in certain areas of flat topography such as the railroad tracks, harbor parking area, and ferry terminal, taking into account relatively sparse distribution of the GPS measurements. In Figure 4, we show the original and adjusted digital elevation model (DEM) within the Whittier downtown area.

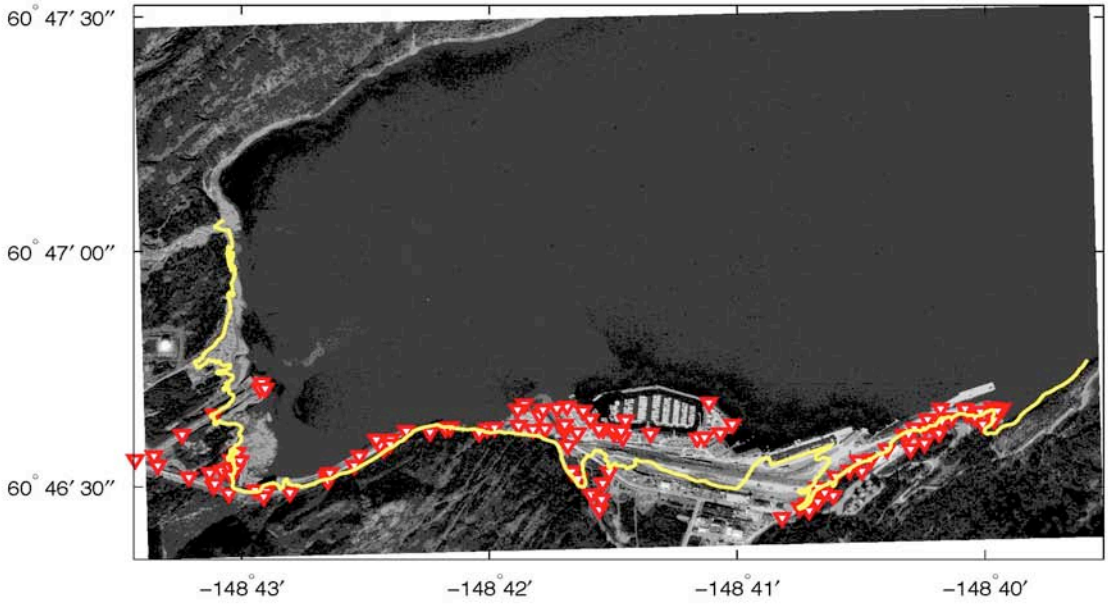


Figure 3. Location of GPS measurements taken during high-resolution differential GPS survey of Whittier harbor area and near-shore roads.

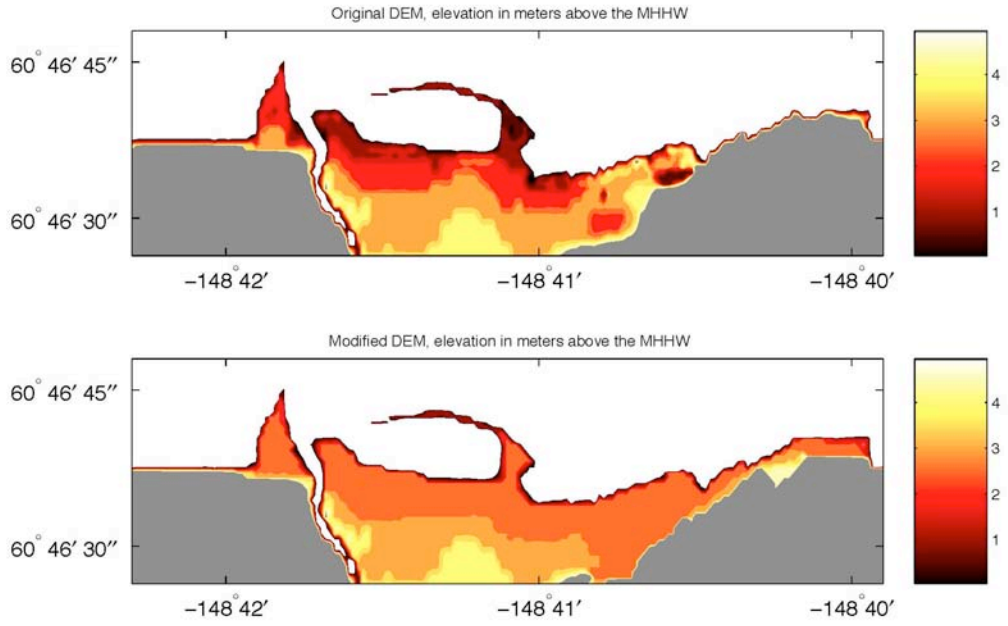


Figure 4. Original and adjusted DEM within the Whittier downtown area.

- We have completed inundation modeling and mapping for the city of Whittier, Alaska, and compiled the draft report and inundation maps. We used numerical modeling to estimate the extent of inundation due to tsunami waves generated from earthquake and landslide sources. Our tsunami scenarios included a repeat of the tsunami triggered by the 1964 Great Alaska Earthquake, as well as tsunami waves generated by a hypothetically extended 1964 rupture, a hypothetical Yakataga Gap earthquake in northeast Gulf of Alaska, hypothetical earthquakes in Prince William Sound and Kodiak asperities of the 1964 rupture, as well as local underwater landslides in Passage Canal. Results of numerical modeling combined with historical observations in the region are intended to help local emergency officials with evacuation planning and public education for reducing future tsunami hazard. Figure 5 shows the maximum composite calculated extend of inundation for all scenarios, and the maximum composite flow depths over dry land.

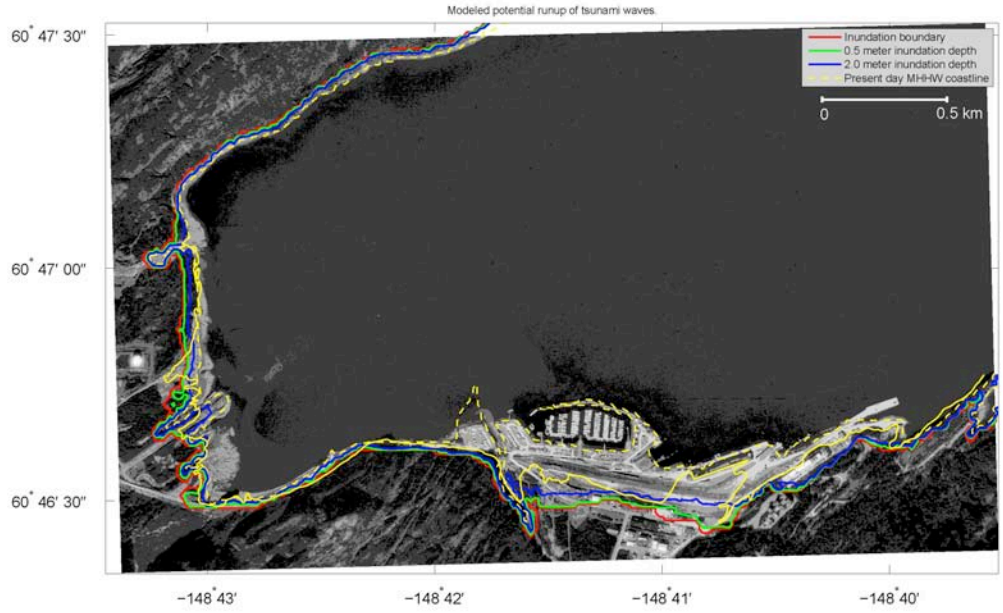


Figure 5. Maximum composite calculated extend of inundation for all scenarios, and the maximum composite flow depths over dry land.

Education and outreach

Nothing to report.

Publications, conference papers, and presentations

Submitted papers

Suleimani, E., D.J. Nicolsky, P. Haeussler and R. Hansen. Combined effects of tectonic and landslide-generated tsunami runup at Seward, Alaska, during the M9.2 1964 earthquake. *Pure and Applied Geophysics* topical volume on tsunamis, in review.

Nicolsky, D.J., E. Suleimani and R. Hansen. Validation and verification of a numerical model for tsunami propagation and runup. *Pure and Applied Geophysics* topical volume on tsunamis, in review.

Oral presentations

Suleimani, E., N. Ruppert, D. Nicolsky and R. Hansen. 2009. Near-field modeling of the 1964 Alaska tsunami: a source function study. 24th International Tsunami Symposium, Novosibirsk, Russia, July 2009.

Hansen, R., E. Suleimani, D. Nicolsky and D. West. 2009. Tsunami modeling and inundation mapping in Alaska: current status of the project. 24th International Tsunami Symposium, Novosibirsk, Russia, July 2009.

Nicolsky, D., E. Suleimani, D. West and R. Hansen. 2009. Tsunami modeling and inundation mapping in Alaska: validation and verification of a numerical model. 24th International Tsunami Symposium, Novosibirsk, Russia, July 2009.

Poster presentations

Nicolsky, D., E. Suleimani and R. Hansen. 2009. Numerical modeling of tectonic and submarine landslide-generated tsunamis in Whittier. Fall Meeting of the American Geophysical Union, San Francisco, California, 14–18 December 2009. (*abstract OS43A-1374*)

Other products and outcomes

Nothing to report.

Partner organizations and collaborators

None.

TWEAK Task 6: Education and outreach

Roger Hansen, PI
University of Alaska Fairbanks

Other investigators/professionals associated this project:
S. Hansen, L. Burris, T. Viggato, J. Sandru, *University of Alaska Fairbanks*

Primary objectives

To provide tsunami and earthquake mitigation and education and outreach activities for the communities and public in Alaska.

Education and outreach

From 1 April 2009 through 31 March 2010, the AEIC provided laboratory tours to365 adults and 429 K-12 students, through various summer tours, tour groups, visits from school classes and a talk to the Nome community in Nome. 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 450 adults and 500 K-12 students. The information provided consists of Alaska seismicity, tectonics, and tsunami overviews as well as earthquake and tsunami preparedness.

Publications, conference papers, and presentations

Nothing to report.

Other products and outcomes

Nothing to report.

Partner organizations and collaborators

None.

Appendices

Appendix 1
CIFAR Projects Awarded in Cooperative Agreement NA08OAR4320751 and NA08OAR4320870
Year 2 Report: 1 April 2009–31 March 2010

Last	First	Proposal Title	Proposal Budget	Theme Description	Funding Source
Task 1 Activities: CI Administration and Education & Outreach					
Walsh	**John**	Regional Alaska Cooperative Institute (2009 - 2010)	$110,000	Administration	OAR
Romanovsky	**Vladimir**	State of the Arctic Land Report (2009/2010)	$10,000	Administration	OAR
NOAA Non-Competitive Projects (NA08OAR4320751)					
Atkinson	**David**	Northern Bering Sea Improved Hazard Monitoring in the Marine and Coastal Environments	$122,999	Coastal Hazards	NWS
Hansen	**Roger**	TWEAK: Tsunami Warning & Environmental Observatory for Alaska	$891,255	Coastal Hazards	NWS
Hansen	**Roger**	AEIC CRESTnet Seismic Station Operations & Maintenance	$288,508	Coastal Hazards	NWS
Heinrichs	**Thomas**	NOAA Cooperative Alaska Research and Satellite Data Services	$190,000	Climate Change & Variability	NWS
Jewett	**Stephen**	Characterization of Bering Sea Infauna	$8,188	Ecosystem Studies & Forecasting	NMFS
Naidu	**Sathy**	Analyses of Sediment Samples for Organic Carbon, Nitrogen, and their Isotopes, Phosphorus and Chlorophyll A in Bering Sea Sediments	$3,125	Ecosystem Studies & Forecasting	NMFS
Okkonen	**Stephen**	Conditions, Whale Prey Distributions, and Whale Feeding and Foraging Behavior	$84,299	Ecosystem Studies & Forecasting	NMFS
Competitively Awarded RUSALCA Projects (NA08OAR4320870)					
Weingartner	**Thomas**	The Pacific Gateway to the Arctic- Quantifying and Understanding Bering Strait Oceanic Fluxes	$360,367	Ecosystem Studies & Forecasting	OAR
		Total projects funded (including CI administration)	$2,068,741		
		Competitively awarded projects (including CI administration)	$470,367		
		Non-competitive projects	$1,598,374		

Appendix 2. 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	13		2	11
Visiting Scientist	0			
Postdoctoral Fellow	0			
Research Support Staff	22	11	7	4
Administrative	3	3		
Total (≥ 50% NOAA Support)	**2**		**1**	**1**
Undergraduate Students	4	4		
Graduate Students	5		1	4
Total Students	**9**	4	1	4
Employees (< 50% NOAA Support)	36	14	8	14
Located in NOAA Lab	0			
Obtained NOAA employment within last year	0		0	

Appendix 3. Publication Activity

Work from projects funded through the Cooperative Institute for Alaska Research that was published, accepted, or in press during the reporting period.

Groisman, P.Y., E.A. Clark, D.P. Lettenmaier, V.M. Kattsov, I.N. Sokolik, V.B. Aizen, O. Cartus, J. Chen, C.C. Schmullius, S. Conard, J. Katzenberger, O. Krankina, J. Kukkonen, M.A. Sofiev, T. Machida, S. Maksyutov, D. Ojima, J. Qi, V.E. Romanovsky, D. Walker, M. Santoro, A.I. Shiklomanov, C. Vörösmarty, K. Shimoyama, H.H. Shugart, J.K. Shuman, A.I. Sukhinin and E.F. Wood. 2009. The Northern Eurasia Earth Science Partnership: An example of science applied to societal needs. *Bulletin of the American Meteorological Society*, 90:671–688. DOI :10.1175/2008BAMS2556.1.

Romanovsky, V., N. Oberman, D. Drozdov, G. Malkova, A. Kholodov and S. Marchenko. 2009. Permafrost. In: State of the Climate in 2008. Special Supplement to the *Bulletin of the American Meteorological Society*, 90(8):S91–S92.

Ruppert, N.A. and R.A. Hansen. Temporal and spatial variations of local magnitudes in Alaska and Aleutians and comparison with body-wave and moment magnitudes. *Bulletin of the Seismological Society of America*, 100, doi:10.1785/0120090172. (in press)

Summary table of publications during the current cooperative agreement

	JI Lead Author		NOAA Lead Author		Other Lead Author	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Peer-reviewed	0	1	0	0	0	1
Non Peer-reviewed	0	0	0	0	0	0

Year 1 = 1 July 2008–31 March 2009
Year 2 = 1 April 2009–31 March 2010

***NOTE**: In addition, several of the RUSALCA projects and two additional projects had papers published (8) or in press (1) during the reporting period that stemmed from funding to those projects under the previous cooperative agreement NA17RJ1224 (Cooperative Institute for Arctic Research).*

Appendix 4. Index of Principal Investigators
(key words are in parentheses in cases where one PI has multiple project reports)