First progress report on Cooperative Agreement NA08OAR4320751
1 July 2008 through 31 March 2009

Cooperative Institute For Alaska Research

Cooperative Institute for Alaska Research
University of Alaska Fairbanks
April 2009

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

(and incorporating shadow award NA08OAR4320870)

1 July 2008–31 March 2009

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Cooperative Institute for Alaska Research
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Table of Contents

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 will be 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
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, Alaska Fisheries Science Center (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 first 9 months of the new competitively awarded cooperative agreement, NOAA provided funding for CIFAR administration and 11 research or outreach projects totaling $1.9 M. All 10 research projects were Task III (projects that generally require only minimal direct collaboration with NOAA scientists); four were competitively awarded projects (funded under the "shadow" cooperative agreement NA08OAR4320870) and the remaining 6 projects were part of the CIFAR institutional cooperative agreement (NA08OAR4320751). Research projects address 2 of the 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 July 2008–31 March 2009: By Task and Theme

Theme	Number of Projects	Total Amount	Subtotals by Task	Percent of Total (rounded)
Administration (Task I)	**2**		**$120,000**	**6.2%**
Core Support	1	$110,000		5.7
State of the Arctic Land Report	1	$10,000		0.5
Research Themes (Task II)	**0**		**$0**	**0.0%**
Research Themes (Task III)	**10**		**$1,806,176**	**93.8%**
Climate Change & Variability	0	0		
Coastal Hazards	1	$953,733		49.5
Ecosystem Studies & Forecasting	9	$852,443		44.3
Total	**12**		**$1,926,176**	**100.0%**

Table 2: Summary of Projects Funded 1 July 2008–31 March 2009: By Funding Source
Includes administration + State of Arctic Land Report

Funding Source	Number of Projects	Total Amount	Percent of Total
OAR	7	$782,544	40.6%
NOS	0	0	
NWS	1	$953,733	49.5%
NMFS	4	$189,899	9.9%
Total		**$1,926,176**	

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 first 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 postponed offering our Summer Sessions 2009 Global Change Course for K-12 teachers until 2010.

Core Administration

In September 2008, John Walsh submitted a CIFAR proposal, "Downscaling of Climate Model Output for Alaska and Northern Canada" to the NOAA Climate Program office, for which funding from the Arctic Research Office has been provisionally approved. Also in September, Susan Sugai submitted a CIFAR proposal, "Integrating NOAA Science & Products into Regional Education (INSPiRE): Developing Community-based Research & Responses to Changes in Climate, Marine Ecosystems, and Coastal Hazards in Alaska" to the NOAA Educational Partnership Program, but no decision has been received to date.

A joint teleconference meeting of the CIFAR Executive Board and Fellows was held 25 November 2008 with Philip Hoffman representing the NOAA CI program. On the recommendation of Carven Scott and concurrence of all, Frank Kelly was invited to join the CIFAR Executive Board and he later accepted. The group also suggested inviting Richard Feely from PMEL to join the CIFAR Fellows, but he declined because of new responsibilities developing NOAA's new ocean acidification program. Other topics of discussion included the draft Memorandum of Agreement (MOA) between UA and NOAA, the 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, how CIFAR's competitive stock assessment traineeships can continue to successfully address the shortage of students with post-graduate degrees in fishery stock assessment & population dynamics.

John Walsh, CIFAR director, represented CIFAR and NOAA in a number of regional, national and international activities during the first 9-month reporting period for the new CIFAR. These activities include the following:

- Walsh contributed a section of the NOAA's ARCTic Alaska Regional Team's Integration Plan and provided review of the entire plan.
- He co-authored (with Dave McGuire) the Alaska chapter of the NOAA-coordinated Unified Synthesis Report (U.S. National Climate Assessment) that was the subject of a CIFAR "hot item":
- http://www.nrc.noaa.gov/ci/hotitems/2008/05_climate_change.html
- In November 2008, Walsh represented NOAA at the AMAP SWIPA (Snow, Water, Ice, and Permafrost in the Arctic) Integration meeting in Oslo, Norway.
- Walsh contributed a section to the NOAA coordinated Arctic Report Card:
- http://www.arctic.noaa.gov/reportcard/atmosphere.html
- Walsh attended a NESDIS workshop and made presentation on CIFAR activities in September 2008. He travelled to the Gilmore Creek Receiving Station, toured the facility and met with NESDIS personnel in February 2009.
- Walsh reviewed two proposals for the NOAA CI competition in early 2009 and two proposals for the NOAA climate program in winter 2009.

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

- She submitted a draft version of the UA-NOAA MOA to NOAA. After initial review by NOAA, CIFAR revised and resubmitted the MOA answering questions raised by NOAA reviewers. This version was submitted for NOAA legal review in November 2008.
- Sugai participated in NOAA's Alaska Regional Implementation Team meeting via teleconference in December and gave a brief presentation on how CIFAR could assist the NOAA ARCTic group.
- Sugai attended the Climate Change Research Coordination Workshop at the Alaska Forum on the Environment on 5 February 2009. In the afternoon, the research needs work group divided into round table topics, where she served as moderator of the "cross cutting issues" group. In the evening, she participated in the "NOAA Stakeholder Forum: Setting the Course for the Next 25 Years" organized by Amy Holman of NOAA's Alaska Regional Collaboration Team and attended by Paul Doremus, NOAA Director of Strategic Planning and Chet Koblinsky, NOAA Climate Office.

None of the CIFAR staff (Walsh, Sugai, Lynch) was able to attend the annual NOAA CI directors and administrators annual meeting held March 24-26, 2009 because the eruption of Mt. Redoubt halted air travel out of Alaska.

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.

University of Alaska President Hamilton made a new 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 has made a $50,000 per year contribution for a two-year pilot period, beginning in FY10. Thus, during summer 2008, major revisions were made to the funding announcement with the assistance of a team of UAF and UAA faculty. After the announcement was released in December 2008, Sugai met with UAA and UAF students via several group workshops to field questions and encourage their involvement. A record 57 proposals (54 graduate, 3 undergraduate) were received by the submission deadline and submitted to peer review. A joint UAF-UAA proposal review panel was scheduled to meet on 24 April 2009 to make funding recommendations on projects for awards running from 1 July 2009 to 30 June 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 first 9 months of the new CIFAR cooperative agreement 11 research or outreach projects were begun and progress reports are provided. However, no highlights will be provided in this overview because most projects are in a preliminary stage. Because of NOAA problems with securing a Russian icebreaker for use during the 2008 field season for the competitively funded Russian-American Long-term Census of the Arctic (RUSALCA) projects, there will be no results to report until next year. Likewise, two non-competitive projects (Naidu, Jewett) that required a NOAA cruise to collect sediment and biological samples from the eastern Bering Sea, have no results to report because NOAA was unable to collect the samples as planned.

Publications and Presentations

At this early stage of the new cooperative agreement there are no publications to report. Six presentations were reported and are listed in the individual project reports. All other publication and presentation activity by these PIs during the period 1 July 2008 through 31 March 2009 were considered as stemming from funding from NA17RJ1224 and will be reported in the FY09 annual report for the 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 2008 and 2012 in the northern Bering and Chukchi Seas depending on resources.

During the current funding period, 4 competitively selected RUSALCA projects were funded through CIFAR. However, because of NOAA's inability to secure an appropriate Russian icebreaker for the fall 2008 planned field expedition, the interdisciplinary cruise has been postponed until 2009.

Project reports for each RUSALCA project follow this overview.

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

Alignment with NOAA program mission goals

- Advancing understanding of ecosystems to improve resource management (Ecosystem Mission 6.4.1)
- Exploring our oceans (Ecosystem Mission 6.4.2)
- Document and understand changes in climate forcings and feedbacks, thereby reducing uncertainty in climate projections (Climate Mission 7.4.2)
- Understand impacts of climate variability and change on marine ecosystems to improve management of marine ecosystems (Climate Mission 7.4.4)
- Improve NOAA's understanding and forecast capability in coasts, estuaries, and oceans (Weather and Water Mission 8.4.4)

RUSALCA: A long-term census of Arctic zooplankton communities

Russell R. Hopcroft, PI *University of Alaska Fairbanks*

CIFAR theme: Ecosystem Studies & Forecasting

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

CIFAR 09-009: This project is new.

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 developing efforts by the International Polar Year and Census of Marine Life for a pan-Arctic program.

Research accomplishments/highlights/findings

- Field work does not begin until September 2009. (See section on *Changes/problems/special reporting requirements* at the end of this project report.)

NOAA relevance/societal benefits

This project examines the potential impacts of climate change in the Pacific–Arctic gateway.

Education

Nothing to report.

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

Hopcroft, R.R., K.N. Kosobokova, I. Rutzen and J. Questel. Has the summer zooplankton community of the Chukchi Sea changed over the past 50 years? Oral Presentation, ASLO meeting, Nice, France, January 2009.

Other products and outcomes

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/

Partner organizations and collaborators

ArcOD

Changes/problems/special reporting requirements

In late June 2008, Kathy Crane, from the NOAA Arctic Research Office, informed the RUSALCA principal investigators funded through CIFAR that the RUSALCA expedition planned for fall 2008 was cancelled. NOAA had been unable to secure funding in time to obtain the intended Russian icebreaker. Thus, the interdisciplinary cruise is planned for some time in the summer or fall 2009. Investigators were asked retain funding from year 1 of their awards for the delayed expedition.

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

Katrin Iken, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
Bodil A. Bluhm, PI
University of Alaska Fairbanks

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

CIFAR 09-010: This project is new.

Primary objectives
We propose to contribute to RUSALCA goals by linking physical and chemical observations of water mass characteristics to food web structure and benthic faunal assemblages. First, we propose that food web analysis is a meaningful quantitative key variable for long-term climate observations, because it reflects water mass properties and the extent of pelagic-benthic coupling. 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
- Nothing to report. (See section on *Changes/problems/special reporting requirements* at the end of this project report.)

NOAA relevance/societal benefits
The proposed 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
Nothing to report.

Outreach
Nothing to report.

Publications, conference papers, and presentations
Nothing to report.

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.

Changes/problems/special reporting requirements
In late June 2008, Kathy Crane, from the NOAA Arctic Research Office, informed the RUSALCA principal investigators funded through CIFAR that RUSALCA expedition planned for fall 2008 was cancelled. NOAA had been unable to secure funding in time to obtain the intended Russian icebreaker. Thus, the interdisciplinary cruise is planned for some time in the summer or fall 2009. Investigators were asked retain funding from year 1 of their awards for the delayed expedition.

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, Seattle*

CIFAR 09-011: This project is new.

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:

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

Research accomplishments/highlights/findings

- Planning of cruise sites and activities began in summer 2008, and bottom trawl nets were purchased. Fieldwork was delayed from August 2008 until September 2009, and therefore no research has been accomplished. (See section on *Changes/problems/special reporting requirements* at the end of this project report.)

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.

Education

Luke Carrothers, a student seeking a M.S. degree in Fisheries Oceanography, was provided with a software license for ArcGIS for year 2009, to assist with RUSALCA cruise planning.

Outreach

Nothing to report.

Publications, conference papers, and presentations

Nothing to report.

Other products and outcomes

Nothing to report.

Changes/problems/special reporting requirements

In late June 2008, Kathy Crane, from the NOAA Arctic Research Office, informed the RUSALCA principal investigators funded through CIFAR that the RUSALCA expedition planned for fall 2008 was cancelled. NOAA had been unable to secure funding in time to obtain the intended Russian icebreaker. Thus, the interdisciplinary cruise is planned for some time in the summer or fall 2009. Investigators were asked retain funding from year 1 of their awards for the delayed expedition.

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 new.

Primary objectives
We will use 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
- Survey of R/V *Professor Khromov* was performed to assess modifications needed to reconfigure and outfit laboratory spaces and deck equipment.
- The 2008 RUSALCA cruise was postponed so no samples were collected for analysis. (See section on *Changes/problems/special reporting requirements* at the end of this project report.)

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, was recruited to participate in the RUSALCA cruise as a part of his graduate research program investigating primary production processes in ice-covered seas. He will receive support in the summer and fall semesters of 2009.

Outreach
No outreach was undertaken in 2008 but outreach will occur with local school children in Nome at the start of the cruise in August 2009 with help from the Marine Advisory Program agent in Nome.

Publications, conference papers and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

Partner organizations and collaborators
None.

Changes/problems/special reporting requirements
In late June 2008, Kathy Crane, from the NOAA Arctic Research Office, informed the RUSALCA principal investigators funded through CIFAR that the RUSALCA expedition planned for fall 2008 was cancelled. NOAA had been unable to secure funding in time to obtain the intended Russian icebreaker. Thus, the interdisciplinary cruise is planned for some time in the summer or fall 2009. Investigators were asked retain funding from year 1 of their awards for the delayed expedition.

Non-competitive projects

TWEAK: Tsunami Warning and Environmental Observatory for Alaska

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

CIFAR 09-008: This project is new.

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.

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;* ***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

1. Development of an energy flux module as a practical tool for application in the tsunami warning and prediction system at WC/ATWC. The numerical experiments defined in an explicit way the bathymetric features which scatter the tsunami signal towards ports. The identification of the distant bathymetric

features was achievable since the energy flux delineated the energy pathways that coupled bathymetric features to ports located thousands of kilometers apart.

2. The formulation, verification, and validation of a depth-integrated, non-hydrostatic model with a semi-implicit, finite difference scheme. The formulation builds on the nonlinear shallow-water equations and utilizes a non-hydrostatic pressure term to describe weakly dispersive waves.
3. Improvement of the Global Tsunami Model through the grid refinement at the selected nearshore regions. Since space resolution of GTM is 1.850 km the local sub domains with the finest resolution of 30 m in the shallow water were embedded into the global model. This procedure allowed investigating the local tsunami enhancement caused by the fine bathymetry and coastlines.

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.

Education

This project will educate and support three graduate students.

Outreach

Educational tsunami animations, figures and descriptions have been made available for tsunami researchers and general public through the Website: http://www.sfos.uaf.edu/tsunami/.

Publications, conference papers, and presentations

Nothing to report.

Other products and outcomes

- A Fortran code for tsunami computation by the nonlinear shallow water equations with the four levels of subdomains consecutively embedded into the main computational domain.
- A Fortran code for dispersive tsunami wave propagation, transformation, breaking, and run-up.
- The Website: http://www.sfos.uaf.edu/tsunami/ has been developed by Tsunami Research Group (TRG) at the Institute of Marine Science (IMS), School of Fisheries & Ocean Sciences (SFOS). The TRG has developed the Global Tsunami Model (GTM) based on the Non-Linear Shallow Water (NLSW) approach. Non-hydrostatic codes like Boussinesq and Full Navier-Stokes have been developed as well and used for investigation and validation. The Website describes major tsunami events: Indian Ocean Tsunami of Dec. 2004, Augustine Volcano Tsunami of 1883 in Cook Inlet and Kuril Islands Tsunami of Nov. 2006. The tools used in tsunami investigations are elucidated through the energy flux and dispersive processes.

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.

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; **Cherri Pancake, Dylan Keon, Ben Steinberg,** Northwest Alliance for Computational Science and Engineering; **Harry Yeh,** Oregon State University; **Randall LeVeque, David George,** University of Washington*

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 has been 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 and maintenance, enhanced functionality, and the addition of the third tsunami model.

Research accomplishments/highlights/findings

The major accomplishment for the TCP during this reporting period was the addition of a third model to the portal. This model, TsunamiCLAW, was developed by researchers at the University of Washington Applied Mathematics department, under Randall LeVeque. It adds a very different modeling capability to the TCP, as TsunamiCLAW uses adaptive mesh refinement and solves equations using finite volume methods in terms of momentum and depth (other models use finite difference and velocity or flux).

The portal functionality was enhanced by the addition of options to save velocity vectors and to specify watch point (tide gauge) locations for the collection of point time series datasets.

NOAA relevance/societal benefits

The TCP was used by Uri Ten Brink (USGS) and colleagues in preparing presentation results for the Fall 2009 AGU meeting. Support included adding additional datasets to the portal and some offline hand run jobs. Based upon this user's input, the watch point functionality was implemented and the addition of segmented faults is planned for the near future.

The TCP was used by Eric Geist (USGS) in Spring 2009. Support included generation and inclusion of a new dataset into the portal and some offline hand run jobs. Based upon this user's input, it was determined that the portal supported no trans-Pacific propagation capability. A fix for this problem is currently being implemented.

Education

Nothing to report.

Outreach

Animations from several TCP model runs are regularly used as part of the tour of the virtual reality Discovery Lab of ARSC. As such, a wide range of the public is regularly exposed to tsunami modeling activities related to the TCP.

Publications, conference papers, and presentations

Keon, D. The Tsunami Computational Portal: Distributed Infrastructure for Executing and Comparing Multiple Computational Models. Presentation at the 2009 Association of American Geographers Annual Meeting in the Cyber infrastructure Specialty Group. March 2009, Las Vegas, NV. *[First place winner in student paper competition]*.

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 and the underlying computational models. As previously mentioned, the portal was enhanced by the addition of a third tsunami model, a velocity vector output capability, and a tide gauge functionality for the collection of time series datasets. Each of these additions required modification of the portal front-end as well as the computational models themselves. In addition, several new bathymetric/topographic datasets were added to the geospatial database for general use in the portal.

Partner organizations and collaborators

NACSE: Cherri Pancake, Dylan Keon, and Ben Steinberg have continued to be invaluable to the success of the TCP. Most front-end modifications that have been implemented and tested were first in their development version of the portal prior to being provided to ARSC for integration into the production version. They have provided instruction and expertise in the inclusion of new or enhanced datasets on a regular basis throughout this reporting period. In addition, they provided invaluable input on all of the portal enhancements.

University of Washington: Randall LeVeque and David George provided support for the TsunamiCLAW model, which they developed. They provided a more robust version of their code and have been an integral part of the porting, integration, and debugging of their code for use in 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, was also invaluable in providing modeling expertise and consultation to the project. Her help in troubleshooting and debugging has been greatly appreciated.

Impact

The usefulness of the TCP has once again been demonstrated during this reporting period, as evidenced by the several hundred jobs that have been run, the interest of and support for Uri Ten Brink, and the interactions with Eric Geist.

The addition of an adaptive mesh refinement model will only enhance the ability of portal users to compare different models, not only those existing in the portal, but with other tsunami models under development.

During this reporting period, the portal has become more stable with fewer job errors due to continued error checking, trouble shooting, and debugging. Moreover, a few additional user requested functionalities have been implemented with several more under development.

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

- First and foremost, the ShakeMap (SM) system at AEIC became the primary source of SMs for Alaska. The real-time SM production is controlled by the Antelope seismic monitoring system. A SM generation sequence is triggered once a new SM-eligible event appears in the event database (M>=3.5 or MMI>=II at the epicenter). This database receives automatically generated hypocenters as well as analysts-reviewed solutions from the Alaska Earthquake Information Center (AEIC), National Earthquake Information Center (NEIC) and WC/ATWC. An association algorithm maintains the consistency of event identification numbers in the database.
- Upgrade and expansion of the broadband seismic network has continued. Four brand new sites equipped with 3-c broadband and 3-c strong motion sensors have been installed, including the remaining three Pipeline stations and a site on Chirikof Island. Short-period sensors at five sites in interior and southern Alaska have been replaced with 3-c broadband and 3-c strong motion sensors. In addition, six short-period analog stations have been upgraded to digital telemetry through Q330 dataloggers and cell modem technology. We also completed real-time telemetry links on two six-component stations in interior Alaska that were installed the summer before.
- For the period between July 1, 2008 and March 31, 2009 AEIC reported a total of 19886 events within the combined seismic network. The events range in depth from 0 to 270 km, with the deepest earthquakes located in the central Aleutian arc. The magnitude range of reported events is between -0.2 and 6.0.

NOAA relevance/societal benefits

Improved detection of tsunamigenic earthquakes by AEIC and NOAA tsunami warning centers.

Education

Nothing to report.

Outreach

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

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*

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 65 regional moment tensor solutions were calculated (moment magnitudes Mw between 3.9 and 6.0) between July 2008 and April 20, 2009 in Alaska and Aleutians.
- Continuing expansion of the AEIC broadband network allows for more reliable calculations of the earthquake source parameters through inclusion of more waveform data into inversion.
- Library of the three basic Green's functions (synthetic seismograms) was expanded over a larger distance range, up to 700 km instead of the former 500 km. This would allow inclusion of more distant stations into the moment tensor inversion, which becomes important in the areas outside of the network core area, such as the Aleutians and the western and northern Alaska. This also may be critical in the event that near-field records go off-scale from a large earthquake.
- Trial (not real time) runs have been performed with the extended earthquake source inversion code.
- A graphic user interface (mt_inversion_tool) for moment tensor reviews was expanded to allow use of user defined filters and to perform full moment tensor inversion with isotropic component. This interface allows user to subset data from the continuous waveform archive, examine these data in terms of the quality of the recordings, to select stations for the inversion, to choose velocity model, to examine quality of the solution and to update AEIC moment tensor web archive and database.

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.

Outreach

See *Other products and outcomes* below.

Publications, conference papers, and presentations

Nothing to report.

Other products and outcomes

- Regional moment tensor website: http://www.aeic.alaska.edu/html_docs/moment_tensors.html
- Database of regional moment tensor solutions.

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.

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 continued working on the benchmarking of the numerical model of tsunami propagation and runup. This model was developed at the Alaska Earthquake Information Center (AEIC) and is used for tsunami inundation mapping of Alaska communities. As one of the important field benchmarks, we modeled propagation and runup of the 1964 tsunami in Resurrection Bay, Alaska, and its effects on the community of Seward. The model was validated by comparing results of numerical modeling with historical observations.
- We have developed and tested a web-based interface for tsunami inundation modeling and mapping. It is based on the AEIC's recently developed and benchmarked nonlinear shallow water model of tsunami propagation and runup that runs on the Sun Opteron cluster ("Midnight") at the Arctic Region Supercomputing Center. The interface uses Google maps for visualizations, and provides data outputs in NetCDF and KML formats. This interface aims at increased efficiency of tsunami inundation mapping of coastal Alaska.
- We completed quality control of the new set of grids developed by the National Geophysical Data Center (NGDC) for Prince William Sound communities Valdez, Cordova and Whittier, and integrated the grids into the model.

Education and outreach
Elena Suleimani reviewed several class units and multimedia tools for the Tsunami Curriculum that is under development in the scope of the Alaska Tsunami Educational Program. This project is funded by the Department of Education and carried out by the Geophysical Institute Information Office.

Publications, conference papers, and presentations
Nothing to report.

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 July 1, 2008 through March 31, 2009, the AEIC provided laboratory tours to 258 adults and 113 K-12 students, through various summer tours, tour groups, visits from school classes and the ATEP program. The AEIC also operates a booth at the Tanana Valley State Fair and the "Science Potpourri" (held on the UAF campus) where we provide information and demonstrations to an estimated 440 adults and 300 K-12 students. The information provided consists of Alaska seismicity, tectonics, and tsunami overviews as well as earthquake and tsunami preparedness.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

Partner organizations and collaborators
None.

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 new.

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).

Research accomplishments/highlights/findings
None; NOAA was unable to collect the samples so project has been postponed one year.

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
Nothing to report.

Outreach
Nothing to report.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

Changes/problems/special reporting requirements
NOAA was unable to collect the samples so project has been postponed one year.

Infaunal/epifaunal forage base for juvenile flatfish near Kodiak Island

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 09-004: This project is new.

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 75 preserved 0.1 m^2 van Veen grab samples were received at UAF from Kodiak NMFS. Max Hoberg began taxonomic analyses in January 2009 and, as of March 31, 2009, 50 of 75 samples were completely processed. Because of the large amount of preserved material in many samples, nearly one half of the samples required splitting or subsampling. Invertebrate groups with the most identified taxa were polychaete annelids (78), followed by crustaceans (35) and bivalve mollusks (19).

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 student Chris Oliver has performed sample sorting for this project.

Outreach
Nothing to report.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

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 this 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.

Stephen Jewett reported to him that crabs had only been found in low densities, only three out of 50 processed samples. We will continue to monitor the quantity of Tanner crabs in the remaining samples.

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 *University of Alaska Fairbanks*

CIFAR theme: Ecosystem Studies & Forecasting

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

CIFAR 09-002: This project is new.

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 AFSC will collect marine sediment samples in August 2008; laboratory processing and analysis is required on these samples to establish the geochemical properties of the benthic habitat. Approximately 31 sediment samples will be collected for laboratory analyses of total organic carbon, total nitrogen, total phosphorus, chlorophyll a and the stable isotopes of carbon and nitrogen.

Research accomplishments/highlights/findings
None; NOAA was unable to collect the samples so project has been postponed one year.

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
Nothing to report.

Outreach
Nothing to report.

Publications, conference papers, and presentations
Nothing to report.

Other products and outcomes
Nothing to report.

Changes/problems/special reporting requirements
NOAA was unable to collect the samples so project has been postponed one year.

State of the Arctic Land Report (2008/2009)

Vladimir Romanovsky, PI
University of Alaska Fairbanks

CIFAR theme: Climate Change & Variability

CIFAR 09-006: This project is new.

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

Our observations indicate that many of the trends documented in the Arctic Climate Impact Assessment (ACIA) Report (2004, 2005) continued and suggest a sustained period of warming in the Arctic region. Convincing evidence includes widespread changes in Arctic vegetation, with the tundra experiencing an increase in greenness and the boreal forest regions showing a decrease in greenness. Permafrost temperatures continued to rise within most of the permafrost-affected areas but with a noticeably slower rate than in the 1990s. The detailed characteristic of the warming varies between locations, but is typically from 0.5 to 2°C for the last 20 to 30 years at the depth of zero seasonal temperature variations in permafrost. A significant amount of permafrost temperature data collected by Russian scientists show that permafrost temperature has increased by 1 to 2°C in northern Russia during the last 30 to 35 years. An especially noticeable permafrost temperature increase in the Russian Arctic was observed during the last two years. The mean annual permafrost temperature at 15-m depth increased by more than 0.3°C in the Tiksi area and by 0.25°C at 10-m depth in the European North of Russia. Changes in the active layer thickness (the relatively thin layer of ground between the surface and permafrost that undergoes seasonal freezing and thawing) are inconsistent. While some of the monitored sites show a slightly increasing trend in the thickness of the active layer, most of them do not. Permafrost is actively thawing from the top down in the southern regions of permafrost distribution in the European North of Russia, in West Siberia, in Kazakhstan and in Alaska. Most observed long-term thawing of permafrost has occurred in the Vorkuta and Nadym (Russia) research areas.

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, V. Romanovsky was interviewed by US and Russian TV, by Australian TV, and by many news reporters including a reporter from the local Fairbanks newspaper, and reporters from the national Dutch daily De Volkskrant, from Scientific American, from the Deutschlandfunk - German Public Radio, from the journal Environmental Science and Technology, and from Swedish Radio. V. Romanovsky interview was filmed by San Francisco Exploratorium in summer 2008. This interview was included in the serial "Exploratorium in Barrow." In September 2008, he also was invited and presented at the Senate Staff Briefing: Accelerating Atmospheric CO_2 Growth from Economic Activity, Carbon Intensity, and Efficiency of Natural Carbon Sinks, organized by the American Meteorological Society. In October 2008, V. Romanovsky participated in a high profile teleconference organized by NOAA in relation with the NOAA State of the Arctic Report release.

V. Romanovsky worked with high school students and teachers. He made a presentation on Permafrost and IPY Plans for teachers and students of the ACMP Program. His lecture was a part of the ACMP (Arctic Climate Modeling Program) Mentor Lectures Program.

Publications, conference papers, and presentations
See *Other products and outcomes*.

Other products and outcomes
- Web site: http://www.permafrostwatch.org/
- Richter-Menge, J., J. Overland, M. Svoboda, J. Box, M.J.J.E. Loonen, A. Proshutinsky, V. Romanovsky, D. Russell, C.D. Sawatzky, M. Simpkins, R. Armstrong, I. Ashik, L.-S. Bai, D. Bromwich, J. Cappelen, E. Carmack, J. Comiso, B. Ebbinge, I. Frolov, J.C. Gascard, M. Itoh, G.J. Jia, R. Krishfield, F. McLaughlin, W. Meier, N. Mikkelsen, J. Morison, T. Mote, S. Nghiem, D. Perovich, I. Polyakov, J.D. Reist, B. Rudels, U. Schauer, A. Shiklomanov, K. Shimada, V. Sokolov, M. Steele, M.-L. Timmermans, J. Toole, B. Veenhuis, D. Walker, J. Walsh, M. Wang, A. Weidick and C. Zöckler. 2008. Arctic Report Card 2008. http://www.arctic.noaa.gov/reportcard.

Partner organizations and collaborators
None.

Arctic small Unmanned Aircraft System experimentation in support of NOAA FY08 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 new.

Primary objectives

We propose to use the University of Alaska Fairbanks (UAF) owned Unmanned Aircraft System (UAS), the Insitu Insight A-20 (now marketed by Boeing as the ScanEagle) to achieve the following research objectives:

1. Conduct flights and evaluate operations of the Insitu Insight A-20 in the Arctic under two situations: cold (subzero) weather situations and in seasonal weather conditions which include condensing clouds with the potential of icing.
2. Integrate payloads of interest to Arctic scientists into the Insitu Insight A-20 UAS. New payload(s) may include, but are not limited to: high-resolution (12 MP) digital imagers, ice roughness LIDAR (LIght Detection And Ranging), spectrometers for cloud and ice albedo, pyrometers for measuring surface temperature, thermal imagers for mapping temperature of the ocean surface, dropsondes for remote meteorological measurements and aerosol samplers for atmospheric chemistry measurements. Priority will be given to payloads that may be used in FY09 during a sea ice/ice seal project.

Research accomplishments/highlights/findings

1. Cold Weather Analysis
   a. The UAF Insight aircraft demonstrated a design flaw in the propulsion module on its last flight in October 2008. This rendered the aircraft unsafe to fly. This problem was reported to Insitu and a request to replace the propulsion module was initiated early November 2008.
   b. The UAF Insight was proven functional in -25º F weather but was not flown.
   c. The Catapult launcher was tested at below -20º F and would not hold pressure. This was expected and a specialized heat blanket was designed, built and installed that keeps the pneumatic system at room temperature in weather below -20º F.
   d. The recovery bungee cords were tested at -25º F and surprised all those involved. They did not lose their change in force as a function of their change in length from room temperature although they did shrink approximately by $1/15^{th}$ of their length.
   e. Boeing ISR (intelligence, surveillance, and reconnaissance) conducted flight tests of production aircraft, identical to what will be deployed in the Canadian Forces Maple Guardian Exercise in October 2008 in the Northwest Territories. In that exercise they never operated below 10º F. Boeing ISR shared their lessons learned with Greg Walker and there was nothing of significance that needed corrected other than their launcher leaked air also until they insulated the cylinder and put heat into the system.
2. Payload Integration
   a. A digital single-lens reflex camera has been integrated into an Insight UAS payload bay along with a custom circuit designed to control the cameras shutter and record global positioning system (GPS) coordinates on the camera without carrying two bulky accessories that would interfere with the aircraft's GPS receiver. Three of these payloads have been integrated. Additional camera control boards were also fabricated.
   b. James Maslanik, University of Colorado, Boulder (CU-Boulder) ice roughness LIDAR has been integrated and successfully tested in a UAF Insight payload bay. With the completion of the final test (a launch test on April 8^{th}) this payload is ready for a maiden flight test.
   c. A dropsonde dispensing payload for the Insight UAS was prototyped at CU-Boulder as an Aerospace Engineering Senior Design Project. This payload capitalizes on the NOAA sponsored (via Sandy MacDonald) miniature dropsonde development. The intent was to demonstrate the potential of a small UAS collecting precise <10m-interval vertical profiling of the atmosphere. The guidance for this mission was provided by both MacDonald of NOAA and Betsy Weatherhead of CU. If time allows, this prototype payload will be launch tested prior to the end of the Spring 2009 Semester. If it completes that test it will

either be considered a "rapid prototype" and the lessons learned would go into building a more reliable payload for flight-testing or it will be used in a demonstration flight prior to redesigning the system into a more reliable payload ready for operational deployment.

d. The first stages of installing a Resonon hyperspectral imager into an Insight payload bay have begun. Hardware for the imager was purchased as well as the processing capability to control the instrument and store images from the imager onboard the aircraft. A new electrical engineer hire within the UAF unmanned aircraft program will assist in furthering this payload.

e. An X-Band Synthetic Aperture RADAR payload with 30 cm resolution was purchased. This instrument fits into the Insight aircraft and is undergoing operational testing in combat aboard the aircraft. Flying this instrument in support of NOAA offers valuable insight into sea ice dynamics.

NOAA relevance/societal benefits

Unmanned aircraft systems offer NOAA unique technology developments for collecting mapping and monitoring data in remote expansive regions and/or under weather-limited (below clouds) or dangerous situations (such as during wildfires). This aligns with NOAA program mission goals:

- Advancing understand of ecosystems to improve resource management. (Ecosystem Mission)
- Developing integrated ecosystem assessments and scenarios, and building capacity to support regional management.
- Improve NOAA's understanding and forecast capability in coasts, estuaries, and oceans (Weather and Water Mission)

Education

Nothing to report.

Outreach

- UAF unmanned aircraft program soars to new heights. Fairbanks Daily News-Miner. Published November 10, 2008.
  Available online at: http://newsminer.com/news/2008/nov/10/uaf-unmanned-aircraft-program-soars-new-heights/
- Science for Alaska Lecture Series presentation, Planes without Pilots: Using Unmanned Aircraft for Research. January 27, 2009.
  http://www.uaf.edu/scienceforalaska/fbx-lectures/mason/
- Arctic scientists test out unmanned aircraft. Juneau Empire. October 30, 2008.
  Available online at: http://www.juneauempire.com/stories/103008/sta_350013985.shtml

Publications, conference papers, and presentations

Presentation – FAA Annual Unmanned Aircraft Program Review, Boulder, CO, November 2008
Presentation – NOAA Sponsored Unmanned Aircraft Arctic Stakeholders Meeting, Anchorage, AK, August 2008
Presentation – Lessons from Continuity and Change in the Fourth IPY, Fairbanks, AK, March 2009

Other products and outcomes

1. Airspace permission necessary for Bering Sea ice seals experiment was granted.
   a. The Certificate of Authorization (COA) submission was not the complicated part of this project.
   b. The real effort to get an acceptable COA started in the Spring of 2008 with the idea of doing a through airspace use analysis as a way forward and originally outlined to us by Nick Sabbatini, the FAA Associate Administrator for Safety. After Kathe Rich and Greg Walker worked out the details of such a concept we recruited and paid for Science Applications International Corporation (SAIC) to help execute the vision and with Rich guiding the work collected the necessary data from various sources, including the USAF through a Memorandum of Understanding. Analysis of that data was quite involved and was not complete until February 2009. In parallel, under a Memorandum of Agreement between the USCG and the UAF select FAA's Unmanned Aircraft Program Office, officials were educated about what the process would involve and why it would be useful and how such an airspace study would give them justification to authorize flights beyond visual range in uncontrolled airspace if it was conducted thoroughly. From this process with the USCG partner we were able to gain further insight into what the FAA would like to see so as we prepared the Airspace Use Study we had an expectation that it would be accepted. That expectation was realized and "safety of flight" is no longer a factor on the table that must be satisfied for the Bering Sea ice

seal experiments we are undertaking. Between Kathe Rich's time and travel and SAIC's time and travel, UAF has invested well over $300,000 to gain this permission.

2. Preliminary discussions with NOAA Corps regarding ship-based UAS were successfully conducted.
    a. Two ship integration plans were created and shared with the Office of Marine and Aviation Operations (OMAO). One was for the *Oscar Dyson* and the other for the *MacArthur II*.
    b. Expert advice and support was given to NOAA officers in generating the necessary documentation to receive favorable approval from OMAO.
    c. Flight tests were conducted aboard the *Oscar Dyson* in October 2008 and documented in an after action report.

Partner organizations and collaborators

US Navy Naval Surface Warfare Center Crane Division – Financial Support

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

University of Colorado, Boulder Aerospace Engineering Department – Collaborative Research

- Sea Ice Roughness payload design was sponsored by the University of Alaska Fairbanks and integrated by James Maslanik and his graduate students at CU-Boulder.
- The University of Alaska Fairbanks as a CU-Boulder senior design project sponsored Dropsonde Payload design.

New Mexico State University Physical Sciences Laboratory – Collaborative Research

- Helped under funding from the University of Alaska Fairbanks with the airspace use studies.

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 new.

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 has completed processing the CTD data and are analyzing these now in conjunction with the fisheries components. We have constructed cross-sections and are in the midst of water mass analyses. We see several different water masses in the western Beaufort Sea including waters penetrating the area from the Chukchi Sea, water that is likely remnant from the previous winter on the Beaufort Shelf, and riverine influenced water masses.
Benthic Invertebrates (Bluhm): Voucher specimens collected during the cruise were sent from NMFS to UAF. These were then transferred from formalin (the fixative) to isopropanol (the long-term preservative). Bluhm also entered additional data details on the collected invertebrates including some taxa identifications and sorting.
Zooplankton (Coyle): Provided zooplankton collection and sample storage advice prior to the field program.

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

We made a presentation on the project to the North Slope Borough in fall 2008 and a separate presentation at the Alaska Marine Science Symposium in January 2009.

Publications, conference papers, and presentations
See above.

Other products and outcomes
Nothing to report.

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.

Appendices

1. Projects Awarded 1 July 2008–31 March 2009

2. Index of PIs

Appendix 1
CIFAR Projects Awarded in Cooperative Agreement NA08OAR4320751 and NA08OAR4320870
First Nine-Month Report: 1 July 2008–31 March 2009

Last	First	Proposal Title	Proposal Budget	Theme Description	Funding Source
Task 1 Activities: CI Administration and Education & Outreach					
Walsh	**John**	Regional Alaska Cooperative Institute (2008 - 2009)	$110,000	Administration	OAR
Romanovsky	**Vladimir**	State of the Arctic Land Report (2008/2009)	$10,000	Administration	OAR
NOAA Non-Competitive Projects (NA08OAR4320751)					
Hansen	**Roger**	TWEAK: Tsunami Warning & Environmental Observatory for Alaska	$953,733	Coastal Hazards	NWS
Jewett	**Stephen**	Characterization of Bering Sea Infauna	$26,443	Ecosystem Studies & Forecasting	NMFS
Jewett	**Stephen**	Infaunal/epifaunal Forage Base for Juvenile Flatfish Near Kodiak Island	$71,854	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	$9,381	Ecosystem Studies & Forecasting	NMFS
Walker	**Gregory**	Arctic Small Unmanned Aircraft System Experimentation in Support of NOAA FY08 Arctic Objectives	$57,000	Ecosystem Studies & Forecasting	OAR
Weingartner	**Thomas**	Marine Fish Survey in the Beaufort Sea Outer Continental Shelf Planning Area	$82,221	Ecosystem Studies & Forecasting	NMFS
Competitively Awarded RUSALCA Projects (NA08OAR4320870)					
Hopcroft	**Russell**	A Long Term Census of Arctic Zooplankton Communities	$149,950	Ecosystem Studies & Forecasting	OAR
Iken	**Katrin**	RUSALCA: Arctic Food Web Structure & Epibenthic Communities in a Climate Change Context	$157,734	Ecosystem Studies & Forecasting	OAR
Norcross	**Brenda**	Fish Ecology & Oceanography: RUSALCA 2008 and 2012	$161,033	Ecosystem Studies & Forecasting	OAR
Whitledge	**Terry**	Understanding Climate Variability in the Arctic and its Effects on the Interactions of Productivity and Nutrient Processes in the Northern Bering and Chukchi Seas	$136,827	Ecosystem Studies & Forecasting	OAR
		Total projects funded (including CI administration)	$1,926,176		
		Competitively awarded projects (including CI administration)	$715,544		
		Non-competitive projects	$1,210,632		

Appendix 2. Index of Principal Investigators
(key words are in parentheses in cases where one PI has multiple project reports)