Seventh (final) progress report on Cooperative Agreement NA08OAR4320751

1 April 2014 – 31 December 2014

CIFAR
Cooperative Institute For Alaska Research

UAF
UNIVERSITY OF ALASKA FAIRBANKS

Seventh (final) report from CIFAR to NOAA on Cooperative Agreement *NA08OAR4320751*

1 April 2014–31 December 2014

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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) *Healthy oceans:* Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management; (2) *Climate adaptation & mitigation*: Understand climate variability and change to enhance society's ability to plan and respond; (3) *Weather ready nation:* Serve society's needs for weather and water information; and (4) *Resilient coastal communities & economies:* 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:
Christopher Sabine, NOAA Office of Oceanic & Atmospheric Research (OAR) Pacific Marine Environmental Laboratory (PMEL) Director
Kathy Crane, NOAA OAR Arctic Research Office Program Manager
Douglas DeMaster, NOAA National Marine Fisheries Service (NMFS), Director, Alaska Fisheries Science Center (AFSC)
Aimee Devaris, National Weather Service (NWS) Alaska Division Director
Philip Hoffman, NOAA OAR Cooperative Institutes (CI) Program Office Director
Mark Myers, University of Alaska Fairbanks (UAF), Vice Chancellor for Research
James Partain, NOAA, NWS Regional Climate Director for Alaska
Susan Sugai, CIFAR director, ex officio

The ***CIFAR Fellows*** are:

1. Larry Hinzman, Director, International Arctic Research Center (IARC), UAF, Fairbanks, AK
2. Kris Holderied, National Ocean Service (NOS), NOAA, Homer, AK
3. Anne Hollowed, AFSC, NMFS, NOAA, Seattle, WA
4. Henry Huntington, Huntington Consulting, Eagle River, AK
5. Katrin Iken, Professor of Marine Biology, Institute of Marine Science (IMS), School of Fisheries and Ocean Sciences (SFOS), UAF, Fairbanks, AK
6. Zygmunt Kowalik, Professor Emeritus of Physical Oceanography, IMS, SFOS, UAF, Fairbanks, AK
7. Gordon Kruse, President's Professor of Fisheries, SFOS, UAF, Juneau, AK
8. Molly McCammon, Director, Alaska Ocean Observing System, Anchorage, AK
9. Jeremy Mathis, Supervisory Oceanographer, PMEL, NOAA, Seattle, WA, and Affiliate Professor of Chemical Oceanography, IMS, SFOS, UAF, Fairbanks, AK (*effective 12/10/14*)
10. Phil Mundy, Division director, Auke Bay Laboratory, AFSC, NMFS, NOAA, Juneau, AK
11. James Overland, Oceanographer, PMEL, NOAA, Seattle, WA
12. Carven Scott, Chief, Environmental & Scientific Services Division, NWS, NOAA, Anchorage, AK

13. Denby Lloyd, Executive Director, North Pacific Research Board, Anchorage, AK
14. Terry Whitledge, Professor of Biological Oceanography, IMS, SFOS, UAF, Fairbanks, AK

Summary of Projects Funded during Reporting Period

During the seventh and final reporting period of NA08OAR4320751, we finished our no-cost extension year. During this same time period, NOAA provided funding on our renewal cooperative agreement NA13OAR4320056 for three increments of CIFAR Task I administration and 15 research projects that will be reported in the April 2015 progress report. Projects on NA08OAR4320751 that continue in the renewal agreement are reported here only if labor was charged during the reporting period to the expiring agreement.

Highlights of CIFAR Task I Activities

Core Administrative Task IA Activities

The primary role of CIFAR administration is to support research, education, and outreach carried out under the auspices of the Cooperative Institute. CIFAR is currently staffed by three UAF employees who also staff the UAF Center for Global Change & Arctic System Research: Susan Sugai, director; Sarah Garcia, CIFAR administrator working remotely on a 62% FTE basis, and Barb Hameister, publications and meetings manager. For this reporting period CIFAR Task I funds (NA08OAR4320751) supported 843 hours of the CIFAR director who also received 370 hours of CIFAR match funds from UAF (for CIFAR renewal NA13OAR4320056) while serving as acting CIFAR administrator for approximately 25% of this reporting period prior to Sarah's hire in mid-May and during Sarah's training period. During this nine-month reporting period, the CIFAR staff work load was:

- Susan Sugai, CIFAR director, 82% FTE (Task I and match)
- Sarah Garcia, CIFAR administrator, 61% FTE (Task I and match)
- Barb Hameister, publications and meetings manager, 33% FTE (Task I and match)

Susan Sugai provides overall CIFAR programmatic guidance, oversees daily operations and serves on the 25-member NOAA Alaska regional collaboration team. She is responsible for submitting all CIFAR proposals and overseeing reporting obligations.

As discussed in previous annual reports, CIFAR's low level of Task I support, combined with unavoidable staff reduction in year 5 extending into year 1 of our renewal, provided us with unused salary funds that we redirected toward student support. Working in close collaboration with the OAR CI office and Gayle Elkins, our NOAA administrator at PMEL, we formally submitted in early June 2014 our request to deobligate unexpended Task I funds (consisting of OAR funding for core administration and continued support for the Global Change Student Research Competition and graduate student gap funding, and NMFS funding for Stock Assessment Improvement Traineeships) from NA08OAR4320751 for immediate transfer to our renewal cooperative agreement. In response to a recommendation made by our 2011 NOAA Science Advisory Board (SAB) review team, the core administrative funds that we proposed to deobligate and transfer were designed to provide administrative transition funding when Susan Sugai, CIFAR director and Barb Hameister, CIFAR's meeting and publications manager both retire, projected for mid-2017. Deobligation and transfer of Task I support of students both through the Global Change Student Research Grant Competition and the Stock Assessment Improvement Traineeships were approved by the relevant NOAA program managers who strongly supported these student support activities but had no new funding available. These education efforts had been highlighted in our NOAA SAB review as outstanding investments, with the review board noting that "CIFAR produces high-quality students that work in areas of high relevance to NOAA and have the potential to directly feed the NOAA workforce having done so in the past. CIFAR has demonstrated success in regional capacity building especially in the areas of stock assessment and climate research, with an impressive number of alumni working in research-related positions in Alaska."

Unfortunately, when Susan Sugai and Sarah Garcia attended the NOAA Grants Management Division (GMD) Financial Assistance Workshop in Seattle on June 11–13, 2014, we learned that we could not deobligate funds from our expiring cooperative agreement for transfer to our renewal. In subsequent conversations with the OAR CI office, we were told that any funds not expended by 31 December 2014 would be returned to the U.S. Treasury, in effect dissolving our administrative transition plan and abruptly ending student support on the highly successful Stock Assessment Improvement Traineeships. Thus, expiring Task I funds were used during the remaining months to fund additional students, student travel, and community outreach described in "Education and Outreach Task IB activities" on page iii.

Other CIFAR Administrative Activities

In July and August 2014, CIFAR worked with CIFAR PI and Fellow Katrin Iken, a professor of marine biology in the School of Fisheries and Ocean Sciences (SFOS) at the University of Alaska Fairbanks to revise and resubmit a successful proposal to lead a five-year, $6 million project to establish the **Arctic Marine Biodiversity Observing Network (AMBON)**, a multi-institutional data collection and integration effort focused on the U.S. Chukchi Sea.

- AMBON was one of three proposals competitively selected under a NOAA initiative to develop a demonstration project through the National Ocean Partnership Program (NOPP) as a first step toward developing an operational Marine Biodiversity Observation Network (BON) in the U.S. In addition to NOAA, funders include the Bureau of Ocean Energy Management (BOEM) and the Shell Exploration and Production Company.
- The AMBON award is associated with CIFAR's renewal cooperative agreement and involves 6 investigators at UAF, 2 collaborators from the University of Maryland, and one each from the University of Washington, U.S. Fish & Wildlife Service, and NOAA. AXIOM (affiliated with the Alaska Ocean Observing Network) will be involved with the project data management as they have for the Russian-American Long-Term Census of the Arctic Program (RUSALCA).

A joint teleconference meeting of the CIFAR Executive Board and Fellows was held 30 October 2014, where new funding opportunities and challenges for CIFAR were discussed.

In November 2014, CIFAR worked with six groups of SFOS investigators to submit full proposals to the NOAA Climate Program Office for continued long-term observations and monitoring in the Pacific Arctic including some of the **RUSALCA** field locations. These competitive awards, if funded as requested, would total $3.36M for the five-year duration and would be linked to CIFAR's renewal cooperative agreement NA13OAR4320056.

Education and Outreach Task IB Activities

All four of the NOAA mission goals require highly trained scientists and managers, and many retirements from the U.S. labor force are impending over the next decade. Also, the NOAA human resource needs include research scientists with an interdisciplinary training in the physical, environmental, and social sciences. Thus, CIFAR has placed specific emphasis upon competitively supporting graduate and undergraduate students (in addition to those supported on CIFAR research projects) whose research addresses issues critical to both NOAA and the Alaska region. Because CIFAR is positioned within the University of Alaska system, we bring together faculty and students from various departments and campuses to collaborate with NOAA scientists on research and educational efforts. Names of students involved in CIFAR research and education projects are given in **bold face** in the summary below.

Stock Assessment Traineeships

Building upon the success of the Stock Assessment Traineeships initiated in 2002 as part of the prior cooperative agreement, the Ted Stevens Marine Research Institute (TSMRI), AFSC, provided funding in 2011 to continue supporting young scientists in quantitative fisheries sciences, including population dynamics, management, and stock assessment (CIFAR 12-024). Four students received stipend support and seven received travel support during the three years that this award was active. Unfortunately, because of the time required to recruit appropriate students to take on the research associated with these traineeships, funding for the remaining year of Ph.D. student stipend and tuition was unobligated when NA08OAR4320751 expired. With the knowledge that her Stock Assessment funded stipend would be ending, **Kari Fenske**, a Ph.D. student who began her Ph.D. program in Fall 2012, focusing on the apportionment and population dynamics of sablefish, accepted a job with the Washington Department of Fisheries and Wildlife beginning June 2015.

Global Change Student Research Program (Graduate and Undergraduate Support)

Because of the low level of Task I funding provided by NOAA, CIFAR education efforts have focused on 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 related to global change with a focus on arctic or boreal regions presented in an interdisciplinary context. 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.

In her CIFAR-funded project, 2013 CGC awardee **Lauren Bell** employed a novel approach to marine food web analysis by using a combination of different isotope tracers, including deuterium (δD), to provide new insight into the trophic dynamics of an Arctic region highly vulnerable to global change. The use of hydrogen stable isotopes to

track terrestrial origins of organic matter into benthic consumers revealed that relative incorporation of terrestrially-derived organic matter (OM_{terr}) is depth related but independent of Mackenzie River influence, deriving instead from widespread coastal erosion along the Beaufort coast. Carbon and nitrogen stable isotopes confirmed trophic structure variation across the study region, suggesting that trophic organization may shift to accommodate increased microbial processing in the future. Given that OM_{terr} inputs to the Arctic Ocean are expected to increase dramatically with climate change, these methods represents a powerful tool for assessing the impact of changing food sources in the marine environment. By understanding the drivers shaping the structure of the eastern Beaufort marine ecosystem now, we are better poised to anticipate and mitigate the effects that global change will have on the biology and health of this region in the future.

Anna Szymanski, a 2013 CGC awardee funded by CIFAR, found that ice algae are released into the water even before the ice begins to melt, which results in both their seeding of the early spring phytoplankton and the export of ice algae to the benthos. Ice algal seeding extends the importance of the ice algal community beyond the period of ice cover, influencing the timing, magnitude and composition of the spring phytoplankton bloom; while exported ice algae becomes an important early spring source of high quality food for benthic organisms. Her research found that Bering Sea ice algae were important not only for the sympagic ecosystem, but also to the pelagic and benthic systems as well.

A proposal review panel met on 4 April 2014 and recommended full or partial funding of 14 projects (from a field of 26) for awards running from 1 July 2014 to 30 June 2015. Eight of these awards were funded with a combination of CIFAR Task 1 and match education funds. Because the student award period timing bridges the two CIFAR cooperative agreements, activities prior to 31 December 2014 were covered with Task I funds relevant to this final report, and activities in 2015 will be covered by UAF match funds associated with NA13OAR4320056, the CIFAR renewal agreement.

The students, the degree that they are seeking, and their FY15 CIFAR projects are listed below:

- **Kimberly (Tweet) DeGrandpre,** Department of Geology & Geophysics, UAF. *"Relative sea level change in western Alaska as constructed from repeat tide gauge and GPS measurements."*
- **Kyle Dilliplaine**, School of Fisheries & Ocean Sciences (SFOS), UAF. *"Sea ice meiofauna in an ice free Arctic summer; who is present and where will they go?"*
- **Amanda Meyer**, School of Natural Resources and Extension, UAF. *"Exploring community climate change discourses in Nome, Alaska using Q-methodology."*
- **Kelly Overduijn**, Department of Biology & Wildlife, UAF. *"Reproductive success of arctic-breeding shorebirds in a changing climate."*
- **Charlotte Regula-Whitefield**, SFOS, UAF. *"Nutrition and reproduction in the California sea cucumber (Parastichopus californicus)."*
- **Alexander Sacco**, Department of Geology & Geophysics, UAF. *"Sea ice conditions and walrus migration near St. Lawrence Island: Integrating local knowledge for assessing change and interpreting satellite data."*
- **Tanja Schollmeier**, SFOS, UAF. *"Effects of sea ice algal loss on benthic communities using biomarker analysis."*
- **Chris Waigl**, Department of Geology & Geophysics, UAF. *"Boreal forest fire severity and area assessment using mid- and thermal infrared remote sensing and field observations."*

Student Support through Individual Awards

As shown in Appendix 2, 11 graduate students (6 M.S., 5 Ph.D.) were funded through individual CIFAR projects. Four graduate students were supported by Stock Assessment Training Stipends, one M.S. Physical Oceanography student was funded through our Task I education and outreach effort, one Ph.D. student was funded through the Bowhead whale feeding project, and one Ph.D. student through the IARC GOES-R project. Four students were funded on Center for Global Change Student Research Awards.

Other Task IB Education and Outreach Efforts

M.S. student **James Kelly** was provided gap funding for the final semester of his degree program. He successfully defended his thesis "An examination of hydrography and sea level in the Gulf of Alaska: tidal to decadal time scales" while also providing important hydrographic data to the NOAA NOS Kasitsna Bay Laboratory.

CIFAR Task I education and outreach funds were used for Hannah Foss, University of Alaska Museum of the North (UAMN) animator, to travel to Gambell and Savoonga on St. Lawrence Island in December to conduct a special

showing of "**Arctic Currents: A Year in the Life of the Bowhead Whale**" and get feedback from whaling captains and others in these highly bowhead whale dependent communities that was then incorporated into the film's final version. The new 24-minute animated film based in part on CIFAR-funded research and spearheaded by a CIFAR PI, had its public debut in January 2015 and has been released in English, St. Lawrence Yupik, and Inupiat on the UAMN website (http://www.uaf.edu/museum/exhibits/digital-media/arctic-currents/) in addition to being shown daily at the museum in Fairbanks and at the Alaska SeaLife Center in Seward.

- CIFAR PI Steve Okkonen of SFOS wanted to incorporate traditional knowledge, earlier published research, his own ongoing CIFAR-funded research and that of many colleagues from different agencies and institutions (funded by NOAA and the Bureau of Ocean Energy Management/BOEM) to illustrate aspects of bowhead whales' life history related to their annual migration through the Bering, Chukchi, and Beaufort Seas. The annual nature of the migration itself suggested a calendar as an organizing and presentation format.
- The highly successful 2013 calendar, produced and distributed with CIFAR outreach funds, then became the basis for the animated film project, which was funded through the University of Alaska Coastal Marine Institute with support from BOEM, SFOS and the UAF Center for Global Change. The film was produced in-house by the UAMN in close collaboration with Okkonen and colleagues.

Highlights of CIFAR Research Activities

Because this final report is focused on the last 9 months of the no-cost extension period of our cooperative agreement, highlights primarily involve publications and presentations of research results.

Publications and Presentations

Eleven conference presentations (both national and international) and 12 community presentations were reported for the period 1 April 2014–31 December 2014. From research projects directly funded by NOAA through CIFAR, we report twelve peer-reviewed papers were published in year 7 along with one from year 6 that was not reported previously, with 1 additional paper in press; several more have been submitted or are in review. Two of the publications and one submitted are major synthesis papers resulting from the Synthesis of Arctic Research (SOAR) efforts. Many PIs also have papers under preparation.

In addition to these outcomes, 5 peer-reviewed papers were published and an additional paper has been accepted for publication by students who have received CIFAR Task I or match funding through the Global Change Student Research Grant Competition during the current cooperative agreement, and many students have papers that have been submitted or are now in review. Many of these students also made presentations at national and international meetings. Of note, the publication by **Mike Garvin**, a 2010 awardee, in *Journal of Zoological Systematics and Evolutionary Research* was the "Editor's Choice" for the issue in which it appeared. A news story on this publication and the CIFAR-funded research from which it grew can be found on the CIFAR website at: http://www.cifar.uaf.edu/#story-new-paper-garvin

Task I: Stock Assessment Training Stipends

Stock assessment training stipends

Terrance Quinn II, PI ***CIFAR theme: Ecosystem studies and forecasting***
University of Alaska Fairbanks

NOAA Goals: Healthy Oceans

CIFAR 12-024: This project is complete. NOAA Office: NMFS-AFSC; Dana Hanselman, Sponsor

Primary objectives

This project has been highly successful in preparing young scientists for careers in quantitative fisheries sciences, including population dynamics, management, and stock assessment. Training students in quantitative fisheries science is critical to NOAA and the state of Alaska. This CIFAR program has been in place since 2002 as a collaboration between the University of Alaska and Alaska Fisheries Science Center (ASFC), NOAA Fisheries. This support was provided through CIFAR to Terrance Quinn II at the University of Alaska Fairbanks, School of Fisheries and Ocean Sciences (SFOS). A committee of AFSC (Dana Hanselman) and SFOS scientists (Terrance Quinn, Franz Mueter) evaluated graduate student applications and made funding decisions. In year 4 of the CIFAR cooperative agreement, AFSC and its Auke Bay Lab unit (Ted Stevens Marine Research Institute, TSMRI) contributed $293,984 to graduate student research about sablefish stock assessment.

Research accomplishments/highlights/findings

This project provided student training stipends and travel to quantitative students in conjunction with the research project "Cooperative research on sablefish between Ted Stevens Marine Research Institute (TSMRI) and UAF fisheries" project (see the Ecosystem Studies and Forecasting section of this report) with professors Anne Beaudreau and Terrance Quinn as co-PI's. During this reporting period, one M.S. student has graduated and one Ph.D. student is making good progress in her research. In addition, start-up funding for two new students was provided.

Karson Coutre (M.S. student) finished her research on: (1) Temporal and ontogenetic patterns in the diet of juvenile sablefish; and (2) Movement patterns and habitat use of juvenile sablefish in Southeast Alaska. She successfully defended her thesis in August 2014 and graduated in December 2014. She currently has a manuscript detailing the results of her research in review at *Transactions of the American Fisheries Society*.

The research of **Kari Fenske** (Ph.D. student) has 3 objectives that will ultimately be dissertation chapters and published manuscripts.

(1) **Development of a spatially explicit assessment model for sablefish that includes estimated movement between the management regions (Aleutian Islands, Bering Sea, and four Gulf of Alaska sub-regions).** A major part of this work is to disaggregate data into appropriate regions. Through a careful review of sample sizes and data quality, it was decided that three regions will be used (Bering Sea/ Aleutians Islands/ Western Gulf of Alaska [GOA], Central GOA, and Eastern GOA). The disaggregation is near completion.

This work is in conjunction with James Murphy, who developed an age-structured movement model before leaving TSMRI for the private sector. This collaborative work continues with Quinn taking the lead in converting this earlier work into a scientific manuscript for publication in a leading journal.

Fenske has completed model development and coding of the model. Several scenarios involving different movement rates have been determined and are being implemented. Initial results are encouraging in that good agreement with the original stock assessment has been obtained and reasonable parameter estimates for the three areas are being obtained.

(2) **Use the spatially-explicit model as a basis for data simulations to explore management strategy evaluations**. The goal is to develop a strategy or suite of harvest strategies that will optimize the harvest of sablefish in Alaska in a sustainable manner, while also examining the social and economic effects of potential harvest strategies. Various scenarios have been developed and are being finalized.

(3) **Examine environmental and climate change effects on the management strategy evaluation** in objective 2.

With knowledge that her Stock Assessment funded stipend was ending, Fenske has taken a job with the Washington Department of Fisheries and Wildlife beginning 1 June 2015. Because of her expertise acquired through the Stock Assessment Traineeship and education with the SFOS Juneau fisheries program, she will likely also serve as a Washington State member on the Scientific and Statistical Committee of the North Pacific Fishery Management Council. Fenske's goal is to complete a draft of her dissertation by May 2016 and have her defense in summer 2016.

Two new students. When CIFAR found out in June 2014 that stock assessment funds would not be transferable to the renewal cooperative agreement to continue support for already-identified students, we used part of the remaining funds to provide support to two entering students. **Phil Ganz** (M.S. Fisheries) will be studying time-varying natural mortality in age-structured assessment models with Terrance Quinn. He will be funded after December 31, 2014 from a new grant from NMFS under the Stock Assessment Training Program (SAIP). **Courtney Pegus** (Ph.D. Fisheries) will be studying interactions between humpback whales and harbor seals and their prey in Glacier Bay with co-advisors Terrance Quinn and Shannon Atkinson. He received 1.5 months of funding from this award, will have a teaching assistantship in Spring 2015, obtained the Carlson research fellowship, and is applying for future research grants.

NOAA relevance/societal benefits

This joint program between UAF and NOAA/NMFS/AFSC is designed to prepare young scientists for careers in fish stock assessment, a field that requires strong quantitative skills. The NMFS Stock Assessment Improvement Plan requires such scientists for its implementation, and the available pool of qualified applicants is shrinking. Under the previous cooperative agreement, thirteen students were supported on these competitive training stipends and five of these students are current NOAA fisheries research biologists at the Ted Stevens Marine Research Institute. Of those five students, two Ph.D. and one M.S. quantitative fisheries professionals were hired by NOAA after graduation and two Ph.D. students were hired before completing their dissertations. Two former Ph.D. students funded by these traineeships have already become members of Plan Teams of the North Pacific Fishery Management Council.

Education

Coutre successfully defended her thesis in August 2014, and graduated in December 2014.

Fenske presented a clear and concise Powerpoint presentation on her research progress at her annual graduate committee meeting in March 2014. She took the comprehensive exam in summer 2014 and passed.

In November 2014, Quinn took 7 quantitative students (Fenske, Coutre, Ganz, Jane Sullivan, Bryce Mecum, Ben Williams, Jen Marsh) to the Workshop on Growth organized by the Center for the Advancement of Population Assessment Methodology (CAPAM) in La Jolla, California. The students were able to meet some of the top researchers in the field of fisheries stock assessment and share their thesis work, as well as learn about contemporary methods for fisheries stock assessment. The large presence of these students and some of UAF's former students highlighted the strengths of the UAF fisheries graduate program.

Presentation (made by the student first author)

Oral presentation

Fenske, K.H., D.H. Hanselman and T.J. Quinn II. 2014. Incorporating movement in a spatial stock assessment model. Alaska Chapter, American Fisheries Society, Annual Meeting, Juneau, Alaska, October 2014.

Partner organizations and collaborators

Ted Stevens Marine Research Institute, Alaska Fisheries Science Center, Juneau, Alaska (Dana Hanselman, Chris Lunsford, Pat Malecha).

Impact

This project accomplished two major impacts: (1) training for four graduate students, some of whom may be recruited by TSMRI when done, (2) innovative thesis research that will improve the stock assessment for sablefish in the North Pacific.

Changes/problems/special reporting requirements

This project was fully in operation and funded through December 2014. CIFAR in consultation with the OAR Cooperative Institutes Office had planned to deobligate the remaining funds in this expiring award and transfer them to the CIFAR renewal. In June 2014, CIFAR learned at a NOAA Grants Management workshop in Seattle that this would not be possible. At that point, the CI office suggested that CIFAR have the PI spend out the funds by 31 December 2014, hence, stipend for two additional students and student travel was spent during the final 6 months of this award.

The Stock Assessment Training Stipends program through CIFAR had been in place since 2002. It was the most successful CIFAR program during that time for education. Over 20 quantitative students received stipends or travel support over this time period, and most have had, or are on track to have, successful careers in quantitative fisheries research, assessment, and/or management.

There will be negative impacts from the cancellation of this program: lack of training for quantitative graduate students, lack of novel research through the University, and unavailability of quantitatively-trained Master's and Ph.D. students to fill needed positions in government for both assessment and management of marine fisheries resources. NMFS would benefit greatly from continuation of this training program. In CIFAR's year 4 program review, the NOAA Science Advisory Board appointed review panel reported, "Especially noteworthy is the high leverage achieved by minimal CIFAR support that helps close funding gaps and recruit students in the area of stock assessment, an area recognized as an important national need." A mechanism needs to be found within NOAA to allow CI funds for graduate student support from being lost between two linked 5-year cooperative agreements when the program has been found to be making "outstanding" progress.

Non-competitive projects, by CIFAR theme:

Ecosystem Studies and Forecasting
Including SOAR (Synthesis of Arctic Research) projects

Climate Change and Variability

Coastal Hazards

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

NOAA Goal: Healthy Oceans

CIFAR 10-014/12-014/13-014: This project is complete. NOAA Office: NMFS-AFSC, Kim Shelden, Sponsor

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

CIFAR-funded research has refined our understanding of the conditions that create a late summer–early autumn foraging hotspot for bowhead whales on the western Beaufort shelf near Barrow. A draft manuscript summarizing observations from CIFAR-funded current meter moorings as they relate to wind-driven circulation and the Barrow area bowhead whale feeding hotspot is being expanded to accommodate additional statistical analyses. This manuscript will be submitted to a peer-review journal. Another manuscript on relationships between krill and characteristic water masses in the Chukchi Sea is being prepared by Heather McEachen, a Ph.D. student supported, in part, by this CIFAR project.

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

CIFAR support for Heather McEachen, a Ph.D. student at UAF, concluded as of 31 December 2014. Ms. McEachen is continuing as a part time student and will acknowledge CIFAR support in future publications.

Publications and presentations

Peer-reviewed book chapter

Maslowski, W., J. Clement Kinney, S.R. Okkonen, R. Osinski, A.F. Roberts and W.J. Williams. 2014. The large scale ocean circulation and physical processes controlling Pacific–Arctic interactions. In: The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment, J.M. Grebmeier and W. Maslowski (eds.), DOI 10.1007/978-94-017-8863-2_5, Springer Science+Business Media Dordrecht.

Poster presentation

Ashjian, C., R. Campbell, S. Okkonen, P. Alatalo and F. Bahr. 2014. Inter-annual and shorter-term variability in physical and biological characteristics across Barrow Canyon in August–September 2005–2014. American Geophysical Union Fall Meeting 15–19 December 2014, San Francisco, California.

Other products and outcomes

A beta-version of the animated film "Arctic Currents: A year in the life of the bowhead whale," based in large part on the CIFAR-funded 2013 calendar (see 2013 report), was screened 23 October 2014 at the Alaska Federation of Natives meeting in Anchorage. English and St. Lawrence Island Yupik language versions were also shown in Gambell and Savoonga during December. All three language versions (Inupiat, St. Lawrence Island Yupik, and

English) of the film were released in late January 2015 and are available to the public on the Museum of the North website:
http://www.uaf.edu/museum/exhibits/digital-media/arctic-currents/

The film debut in Fairbanks on Friday, 16 January 2015 had an overflow crowd at the University of Alaska Museum of the North (UANM) Auditorium. Arctic Currents was shown in St. Lawrence Island Yupik during lunch on Thursday, the Arctic research day of the Alaska Marine Science Symposium on 22 January 2015. The film is currently being shown daily at UAMN and plans are underway to show the film at the small movie theater on the exhibit floor of the Alaska SeaLife Center in Seward that has almost 150,000 visitors per year. As of early March, Arctic Currents has been viewed over 1,400 times in English, 250 times in Inupiat, and 350 times in St. Lawrence Island Yupik. DVDs were made and distributed to rural schools where Internet download speeds are inadequate to view the film online.

Left: Audience members of all ages arrive for the Fairbanks debut screening of "Arctic Currents: A year in the life of the bowhead whale," 16 January 2015. Right: Roger Topp, Head of Production at UAMN and writer/director of the film, welcomes the audience.

Partner organizations and collaborators

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

Impact

Programs that were written to analyze oceanographic, meteorological, and aerial observational data related to bowhead whale distribution and behavior have been adapted for similar analyses of beluga whale distribution and behavior in the Barrow area.

Cooperative research on sablefish between Ted Stevens Marine Research Institute (TSMRI) and UAF Fisheries

Terrance Quinn II, PI ***CIFAR theme: Ecosystem studies and forecasting***
Anne Beaudreau, PI
University of Alaska Fairbanks

NOAA Goal: Healthy Oceans

CIFAR 12-025: This project is complete. NOAA Office: NMFS-AFSC, Dana Hanselman, Sponsor

Primary objectives

This project provides support for UAF fisheries faculty supervising graduate student research on sablefish stock assessment in collaboration with the Alaska Fisheries Science Center (AFSC)/TSMRI. Areas of interest to TSMRI are:

Apportionment and population dynamics (Quinn): This graduate research project will focus on analyzing harvest strategies for sablefish. This will include examining different strategies of regional apportionment with the primary goal of optimizing the harvest with respect to maintaining adequate female spawning biomass. Consideration of the socioeconomic aspects of regional apportionment will also be included. This will involve working directly with TSMRI staff on the development of a spatially explicit model to simulate test apportionment strategies including recent updates to movement parameters.

Juvenile sablefish ecology (Beaudreau): This project will collect 2 years of oceanographic, benthic, food habits, and growth data and make use of the available movement data available for St. John the Baptist Bay. The study will occur in the vicinity of St. John the Baptist Bay, where juvenile sablefish are found consistently. The goal is to examine what makes this good habitat for sablefish juveniles. The study will be done in conjunction with TSMRI scientists and the student will be supervised by Anne Beaudreau, a marine fish ecologist. Quantitative analysis and potentially some habitat modeling will be undertaken in this study, similar to a study by Beaudreau that used field-based and quantitative analytical tools to address ecological questions relevant to rocky reef ecosystems in relation to lingcod.

Research accomplishments/highlights/findings

Juvenile sablefish ecology (Beaudreau)

Karson Coutre (M.S. student) finished her research on: (1) Temporal and ontogenetic patterns in the diet of juvenile sablefish; and (2) Movement patterns and habitat use of juvenile sablefish in Southeast Alaska. She successfully defended her thesis in August 2014 and graduated in December 2014. She currently has a manuscript detailing the results of her research in review at *Transactions of the American Fisheries Society*.

Apportionment and population dynamics (Quinn)

The research of Kari Fenske (Ph.D. student) has 3 objectives that will ultimately be dissertation chapters and published manuscripts.

(1) **Development of a spatially explicit assessment model for sablefish that includes estimated movement between the management regions (Aleutian Islands, Bering Sea, and four Gulf of Alaska sub-regions).** A major part of this work is to disaggregate data into appropriate regions. Through a careful review of sample sizes and data quality, it was decided that three regions would be used (Bering Sea/ Aleutians Islands/ Western Gulf of Alaska [GOA], Central GOA, and Eastern GOA). The disaggregation is near completion.

This work is in conjunction with James Murphy, who developed an age-structured movement model before leaving TSMRI for the private sector. This collaborative work continues with Quinn taking the lead in converting this earlier work into a scientific manuscript for publication in a leading journal.

Fenske has completed model development and coding of the model. Several scenarios involving different movement rates have been determined and are being implemented. Initial results are encouraging in that good agreement with the original stock assessment has been obtained and reasonable parameter estimates for the three areas are being obtained.

(2) **Use the spatially-explicit model as a basis for data simulations to explore management strategy evaluations**. The goal is to develop a strategy or suite of harvest strategies that will optimize the harvest of sablefish in Alaska in a sustainable manner, while also examining the social and economic effects of potential harvest strategies. Various scenarios have been developed and are being finalized.

(3) **Examine environmental and climate change effects on the management strategy evaluation** in objective 2.

With her committee's encouragement, Fenske's goal is to complete a draft of her dissertation by May 2016 and have her defense in Summer 2016.

NOAA relevance/societal benefits

This joint program between UAF and AFSC/TSMRI is to provide research support to UAF SFOS faculty for mentoring graduate students receiving stock assessment training stipends under the companion CIFAR project "Stock assessment training stipends" related to sablefish in the North Pacific.

Education

Kari Fenske, Ph.D. Fisheries (in progress), Advisor: Terrance Quinn II
Karson Coutre, M.S. Fisheries (awarded December 2014), Advisor: Anne Beaudreau

Presentations

One presentations was made during the reporting period, see companion project "Stock assessment training stipends" in the Task I section of this report.

Partner organizations and collaborators

Ted Stevens Marine Research Institute (Dana Hanselman, Chris Lunsford, Pat Malecha), Alaska Fisheries Science Center, Juneau, Alaska.

Impact

This project accomplished two major impacts: (1) training for two graduate students who may be recruited by TSMRI when done, (2) innovative thesis research that will improve the stock assessment for sablefish in the North Pacific.

Synthesis of Arctic Research (SOAR): Overview

The Synthesis of Arctic Research (SOAR) aims to bring together a multidisciplinary group of Arctic scientists and Alaskan coastal community representatives to explore and integrate information from completed and ongoing marine research in the Pacific Arctic Region. The goal of SOAR is to increase scientific understanding of the relationships among oceanographic conditions, benthic organisms, lower trophic pelagic species (forage fish and zooplankton), and higher trophic species (seabirds and marine mammals) in the Pacific Arctic, with particular emphasis on the Chukchi Sea Lease Sale Areas. SOAR is supported by the Bureau of Ocean Energy Management (BOEM) and NOAA, and led by Sue Moore (NOAA/NMFS Marine Ecosystem Division, Office of Science & Technology (S&T)), Phyllis Stabeno (NOAA/PMEL), and an 11-member Science Steering Committee.

As proposed, the major product from SOAR will be a collection of peer-reviewed scientific publications in a special issue of *Progress in Oceanography*. The SOAR projects from CIFAR are:

- *Factors maintaining sea bird and mammal benthic hotspots: a latitudinal analysis*, PI Bodil Bluhm
- *Influence of sea ice and oceanographic conditions and prey availability on the timing of the fall bowhead whale migration*, PI Stephen Okkonen
- *Oceanographic factors associated with bowhead whale hotspots and variation in the migration path*, PI Stephen Okkonen
- *An ocean acidification sensitivity index for the Pacific Arctic region*, PI Tom Weingartner.

From these four projects (one of which was completed in the previous reporting period), three major synthesis papers have been produced:

Mathis, J.T., S.R. Cooley, N. Lucey, S. Colt, J. Ekstrom, T. Hurst, C. Hauri, W. Evans, J.N. Cross and R.A. Feely. 2014. Ocean acidification risk assessment for Alaska's fishery sector. *Progress in Oceanography*, available online 18 July 2014. http://dx.doi.org/10.1016/j.pocean.2014.07.001

Citta, J.J., L.T. Quakenbush, S.R. Okkonen, M.L. Druckenmiller, W. Maslowski, J. Clement-Kinney, J.C. George, H. Brower, R.J. Small, C.J. Ashjian, L.A. Harwood, and M.P. Heide-Jørgensen. 2014. Ecological characteristics of core-use areas used by Bering–Chukchi–Beaufort (BCB) bowhead whales, 2006–2012. *Progress in Oceanography*, available online 10 September 2014. http://dx.doi.org/10.1016/j.pocean.2014.08.012

Grebmeier, J., B.A. Bluhm, L.W. Cooper, S. Danielson, K. Arrigo, A.L. Blanchard, J.T. Clarke, R.H. Day, K.E. Frey, R.R. Gradinger, M. Kedra, B. Konar, K.J. Kuletz, S.H. Lee, J.R. Lovvorn, B.L. Norcross and S.R. Okkonen. Ecosystem characteristics and processes facilitating persistent macrobenthic biomass hotspots and associated benthivory in the Pacific Arctic. Submitted to *Progress in Oceanography* 2-3-15.

Synthesis of Arctic Research (SOAR): Factors maintaining sea bird and mammal benthic hotspots: a latitudinal analysis

Bodil Bluhm, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
Arny Blanchard, co-PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Jacqueline Grebmeier, PI, *University of Maryland*

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

CIFAR 13-036: This project is complete. NOAA Offices: NMFS-S&T, OAR/PMEL: Sue Moore & Phyllis Stabeno, Sponsors

Primary objectives

The proposed synthesis activity and resulting manuscript will evaluate the biological and environmental factors that support a productive benthic prey base with a focus on four infaunal biomass "hotspots" that help maintain seabird and marine mammal populations in the northern Bering and Chukchi Seas in the Pacific Arctic.

Approach

1. Define benthic "hotspots" as regions of persistent, high macrobenthic biomass and intense higher trophic level use.
2. Synthesize data from identified hotspots (with characteristic benthivores).
3. Determine environmental and biological factors driving and maintaining marine mammal and seabird benthic hotspots.
4. Make spatial comparisons of hotspots over latitudinal gradients.
5. Build conceptual analysis of spatial, hydrographic, and biogeochemical controls on benthic hotspots.

Synthesis accomplishments/highlights

We received three peer-reviews for the manuscript that is to be included in a special SOAR issue in Progress in Oceanography. All suggested publication of the manuscript after moderate to substantial revisions and restructuring. The reviews along with a thorough revision were circulated to all co-authors. Subsequently, comments by all co-authors were included in the next version that was critically streamlined by the lead team of this effort, J. Grebmeier and B. Bluhm. The lead team discussed the progress face-to-face near Seattle in late November 2014 and in Tromsø mid-January 2015. The thoroughly revised manuscript along with a detailed response to the reviews were submitted to the guest editors 4 February 2015 and now awaits comments and a decision.

The paper characterizes four areas in the northern Bering and Chukchi seas in the Pacific Arctic. This region is characterized by high northward advection of Pacific Ocean water, with seasonal variability in sea ice cover, water mass characteristics, and benthic processes. In this review, we evaluate the biological and environmental factors that support persistent regions of benthic prey on the continental shelves, with a focus on four "hotspots", defined here as areas of particularly high macrobenthic biomass and supporting a corresponding ecological guild of benthivorous seabird and marine mammal populations. These four benthic hotspots are regions within the influence of the St. Lawrence Island Polynya (SLIP), the Chirikov Basin between St. Lawrence Island and Bering Strait (Chirikov), north of Bering Strait in the southeast Chukchi Sea (SECS), and in the northeast Chukchi Sea (NECS). Detailed benthic macrofaunal collections indicate these "hotspot" regions have been persistent in benthic biomass for up to four decades of sampling due to annual reoccurrence of seasonally consistent moderate-to-high water column production with significant export of carbon from overlying waters to the underlying sediments. We also evaluate the usage of the four benthic hotspot regions by benthic prey consumers to investigate predator-prey connectivity, with different upper trophic consumers utilizing the benthic hotspots seasonally. In the SLIP hotspot, spectacled eiders and walruses are important winter consumers of infaunal bivalves and polychaetes, along with epibenthic gastropods and crabs. In the Chirikov hotspot, gray whales have historically been the largest summer consumers of benthic macrofauna, primarily of ampeliscid amphipods in the summer, but they have been increasingly sighted foraging further northward in the SECS and NECS hotspots recently during years with reduced sea ice. Areas of concentrated walrus foraging occur in the SLIP hotspot in winter and early spring, the NECS hotspot in summer, and the SECS hotspot in fall. Bottom up forcing by hydrography and food supply to the benthos influences

persistence and composition of benthic prey that then influences the benthivore upper trophic level populations. We conclude the paper with suggestions for future research directions.

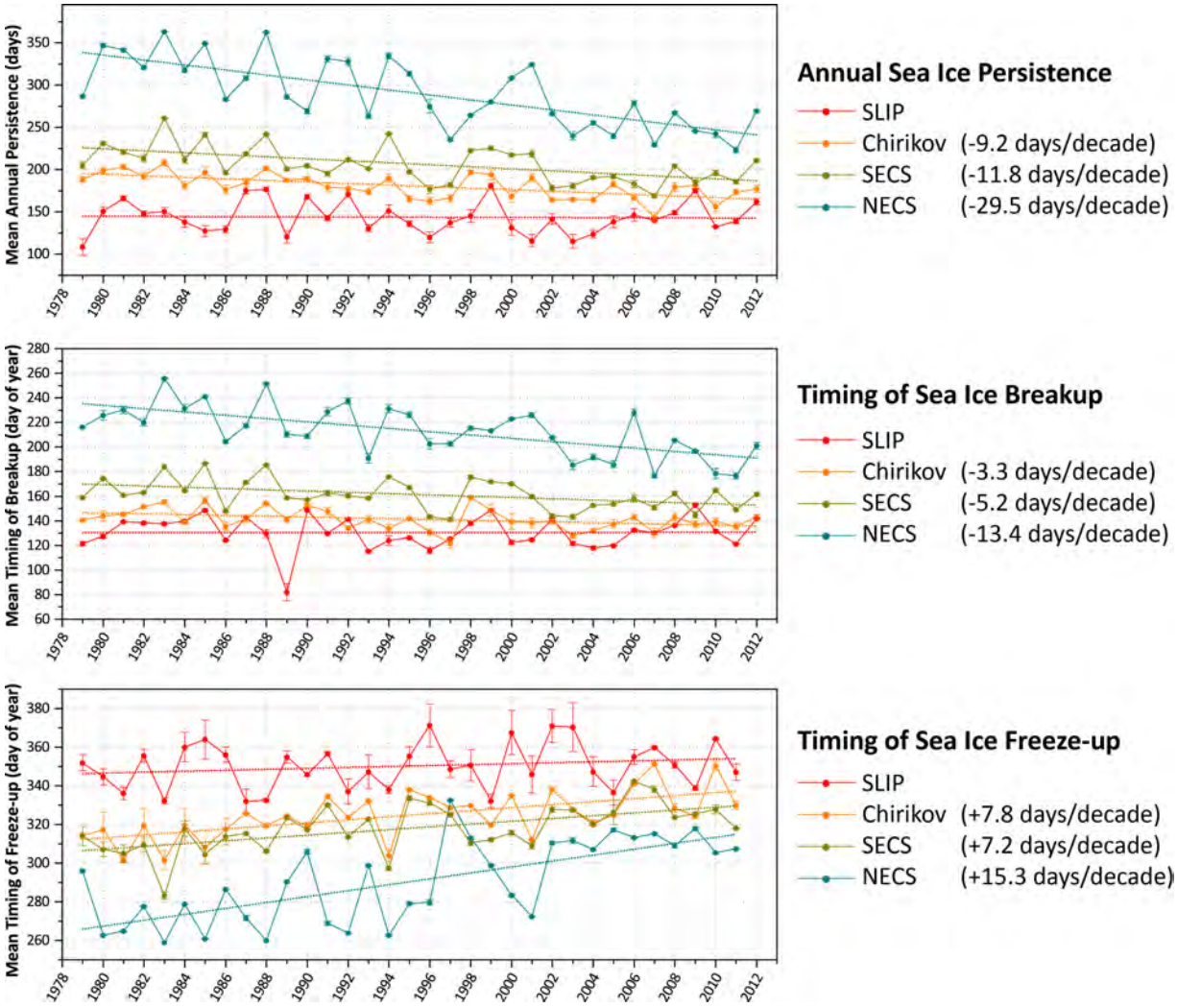

Figure 1. Time series of annual sea ice persistence (top panel), break-up (middle panel), and sea ice-freeze up (bottom panel) for the study region from south to north: SLIP (St. Lawrence Island Polynya region) hotspot, Chirikov (Chirikov Basin) hotspot, SECS (Southeast Chukchi Sea) hotspot, and NECS (Northeast Chukchi Sea) hotspot. Values in parentheses are the significant ($p < 0.1$) days per decade obtained through trend analysis for each of the following parameters: top panel: negative value=reduced number of days for sea ice persistence, middle panel: negative value=earlier breakup of sea ice by days, and bottom panel: positive value is number of days of later sea ice freeze-up. The vertical bars for each year value are standard deviation values for the annual point. Data source: Sea ice concentration for data spanning the years 1979–2012 are derived from the Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I) passive microwave instruments (Cavalieri et al., 1996, 2008).

NOAA relevance/societal benefits

The goal of the entire SOAR project is to increase scientific understanding of the relationships among oceanographic conditions, benthic organisms, lower trophic pelagic species (forage fish and zooplankton) and higher trophic species (seabirds and marine mammals) in the Pacific Arctic, with particular emphasis on the Chukchi Sea Lease Sale Areas.

Partners and collaborators

The list of authors of the paper submitted to a special issue in Progress in Oceanography includes:

Grebmeier, Jacqueline M.[1], Bodil A. Bluhm[2*], Lee W. Cooper[1], Seth Danielson[2], Kevin R. Arrigo[3], Arny L. Blanchard[2], Janet T. Clarke[4], Robert H. Day[5], Karen E. Frey[6], Rolf R. Gradinger[2^], Monika Kedra[7], Brenda Konar[2], Kathy J. Kuletz[8], Sang H. Lee[9], James R. Lovvorn[10], Brenda L. Norcross[2], Stephen R. Okkonen[2]

[1]Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD 20688, USA
[2]School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775, USA; *University of Tromsø, Norway; ^Institute of Marine Research, Tromsø, Norway
[3]School of Earth Sciences, Stanford University, CA
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[5]ABR, Inc.-Environmental Research & Services, Fairbanks, AK 99708, USA
[6]Graduate School of Geography, Clark University, Worcester, MA 01610, USA
[7]Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland
[8]US Fish and Wildlife Service, Alaska Region, Anchorage, AK 99503, USA
[9]Department of Oceanography, Pusan National University, Pusan, Republic of Korea
[10]Department of Zoology and Center for Ecology, Southern Illinois University, Carbondale, IL 62901, USA

Grebmeier and Bluhm were co-leading the effort, and conducted the majority of the writing and all of the organizing with Grebmeier serving as the lead author. All co-authors contribute data, paragraphs describing their data, and comments on the complete manuscript.

Presentations/Outreach

Co-author K. Kuletz presented the paper at the Pacific Seabird Meeting in 2014 (Kuletz, K.J., A.E. Gall, B. Hurley, E.A. Labunski, T.C. Morgan and R.E. Day. Seasonal and spatial patterns of marine bird distributions in the Pacific Arctic.)
Lead author and PI J. Grebmeier reported on the progress of the effort to the SOAR steering group at their meeting in January 2015.

References

Cavalieri, D., C. Parkinson, P. Gloersen and H. J. Zwally. 1996. Sea ice concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS passive microwave data. Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

Cavalieri, D., C. Parkinson, P. Gloersen and H.J. Zwally. 2008. Sea ice concentrations from Nimbus-7 SMMR and DMSP SSM/I passive microwave data. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

Changes/problems/special reporting requirements

The original author list of the manuscript has changed some in the course of the discussions of the paper focus and content relative to the originally submitted author list. Most of the originally listed co-authors, however, have contributed sections to the revised and resubmitted manuscript.

Synthesis of Arctic Research (SOAR): Influence of sea ice and oceanographic conditions and prey availability on the timing of fall bowhead whale migration

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

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

CIFAR 13-034: This project is complete. NOAA Offices: NMFS-S&T, OAR/PMEL: Sue Moore & Phyllis Stabeno, Sponsors

Primary objectives

The timing of bowhead whale migrations from the Canadian Arctic along the Beaufort Shelf to Barrow AK in the fall varies interannually. Our hypothesis is that bowhead whales "linger" in the Canadian Arctic when prey is

plentiful, ice is minimal, and/or ocean temperature is warm. Our objective is to identify how environmental conditions (sea ice, hydrography, prey availability) in the Canadian Arctic (Amundsen Gulf and to the west) and on the Beaufort Shelf are associated with bowhead whale distributions on the shelf and the timing of their fall migration.

Synthesis accomplishments/highlights

We have developed a straw man hypothesis suggesting that the cue for the onset of the fall westward migration of bowhead whales from the eastern Beaufort Sea is some threshold availability of zooplankton prey. In the eastern Arctic, these zooplankton prey are believed to be primarily copepods. Greater residence depths associated with diapause, imply stronger and more persistent easterly winds as being necessary to upwell the copepods onto the shallow shelf in the eastern Beaufort Sea whereupon they can be efficiently grazed by bowhead whales. Of the ten seasons (mid-August to mid-September 2005-2014) in which we have been conducting oceanographic field work in the Barrow area, there were two years (2007 and 2011) in which we did not see bowhead whales near Barrow. Both of these years were characterized by unusually strong and persistent easterly winds in the southern Beaufort Sea and late arrivals (October) of whales at Barrow. At present, we are awaiting analyses of passive acoustic recordings of marine mammal vocalizations acquired by hydrophone arrays deployed on the Alaskan Beaufort shelf east of Prudhoe Bay in support of this hypothesis.

We also revisited the ASAMM (Aerial Surveys of Arctic Marine Mammals) (formerly BWASP; Bowhead Whale Aerial Survey Project) aerial survey record to investigate migration timing across the Alaskan Beaufort Sea. Although the raw survey data suggest that migration is becoming less coherent (becoming more distributed in time), these data have not been scaled by survey effort and, as such, cannot definitively characterize migration timing. Nonetheless, we continue to investigate the migration timing issue.

NOAA relevance/societal benefits

The goal of the SOAR project is to increase scientific understanding of the relationships among oceanographic conditions, benthic organisms, lower trophic pelagic species (forage fish and zooplankton) and higher trophic species (seabirds and marine mammals) in the Pacific Arctic, with particular emphasis on the Chukchi Sea Lease Sale Areas.

Partners and collaborators

Carin Ashjian, Woods Hole Oceanographic Institute (WHOI)
Bob Campbell, University of Rhode Island
Susanna Blackwell, Greeneridge Sciences
George Divoky, Friends of Cooper Island
Craig George, North Slope Borough Department of Wildlife Management
Lois Harwood, Department of Fisheries and Ocean Sciences, Canada
Kate Stafford, University of Washington
Matt Druckenmiller, National Snow and Ice Data Center
Wieslaw Maslowski, Naval Postgraduate School
Robert Pickart, WHOI
Tom Weingartner, UAF

Synthesis of Arctic Research (SOAR): Oceanographic factors associated with bowhead whale hotspots and variations in the migration path

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

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

CIFAR 13-035: This project is complete. NOAA Offices: NMFS-S&T, OAR/PMEL: Sue Moore & Phyllis Stabeno, Sponsors

Primary objectives

1) Describe areas that bowhead whales consistently use (i.e., "hotspots") and summarize what is known about those areas regarding oceanography, sea ice, and zooplankton. The primary question to be addressed is: Can bowhead

whale seasonal presence and behavior at these locations be explained by oceanographic processes (i.e. currents, winds, fronts) that concentrate zooplankton?
2) Develop a mechanistic model that, based on relevant meteorological, oceanographic, cryospheric, and/or acoustic conditions, identifies likely trajectories for bowhead whales crossing the Chukchi Sea, and then relate model predictions to the actual paths of bowhead whales with satellite tags.

Synthesis accomplishments/highlights

A manuscript incorporating numerical model output showing oceanographic features associated with bowhead core use areas was accepted by *Progress in Oceanography* and is in press (see below).

A second manuscript comparing migratory paths of tagged bowheads with modeled oceanographic features is being developed and a poster of preliminary results will be presented at the Alaska Marine Science Symposium in January 2015 (see below).

NOAA relevance/societal benefits

The goal of the SOAR project is to increase scientific understanding of the relationships among oceanographic conditions, benthic organisms, lower trophic pelagic species (forage fish and zooplankton) and higher trophic species (seabirds and marine mammals) in the Pacific Arctic, with particular emphasis on the Chukchi Sea Lease Sale Areas.

Publications and presentations

Peer-reviewed

Citta, J.J., L.T. Quakenbush, S.R. Okkonen, M.L. Druckenmiller, W. Maslowski, J. Clement-Kinney, J.C. George, H. Brower, R.J. Small, C.J. Ashjian, L.A. Harwood, and M-P. Heide-Jørgensen. 2014. Ecological characteristics of core-use areas used by Bering–Chukchi–Beaufort (BCB) bowhead whales, 2006–2012. *Progress in Oceanography*, available online 10 September 2014. doi: 10.1016/j.pocean.2014.08.012.

Poster

Citta, J.J., L.T. Quakenbush, S.R. Okkonen, J.C. George, R.J. Small, M-P. Heide-Jørgensen, L.A. Harwood, and H. Brower. 2015. Inter-annual variability in the fall movements of bowhead whales in the Chukchi Sea. Alaska Marine Science Symposium, Anchorage, January 2015.

Partners and collaborators

Lori Quakenbush, Alaska Department of Fish and Game
John Citta, Alaska Department of Fish and Game
Matt Druckenmiller, National Snow and Ice Data Center
Wieslaw Maslowski, Naval Postgraduate School

Cooperative Alaska research and satellite data services

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

Other investigators/professionals funded by this project:
Eric Stevens, Amy Jacobs, Katrina Bennett, Molly Tedesche, Vladimir Alexeev, Sergei Maurits, Jiang Zhu, *University of Alaska Fairbanks*

NOAA Goal: Climate Adaptation & Mitigation

CIFAR 10-015/12-015/13-015: This project is complete. NOAA Office NESDIS/GOES-R, Steve J. Goodman, Sponsor

This project is implemented through the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) Alaska Proving Ground program in cooperation with the NOAA National Weather Service (NWS). Goals include enhancing the operational interactions between the Geographic Information Network of Alaska (GINA) at the University of Alaska Fairbanks and the National Weather Service and NOAA-NESDIS, deploying risk reduction products in preparation for the NOAA-NESDIS GOES-R mission, and demonstrating new near-real-time and forecast snow products derived from satellite data. The Geostationary Operational Environmental Satellite (GOES) Program is a joint effort of the National Aeronautics & Space Administration (NASA) and NOAA.

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.

Project accomplishments in current reporting period

Enhanced and stabilized flow of operational data *from NESDIS Fairbanks Command and Data Acquisition Station and GINA to NWS and other users.*

The University of Alaska continued work with NASA's Short-term Prediction Research and Transition Center (SPoRT) to deliver products to the NWS in Alaska for use in forecasting and issuing warnings. GINA built virtual machines to run SPoRT software and produce satellite imagery locally in Alaska, with the motivation of maximizing the speed of delivering the imagery to the NWS in Alaska. GINA and SPoRT collaborated to deliver multi-spectral composite imagery built from Moderate Resolution Imaging Spectroradiometer (MODIS) and *Visible Infrared Imaging Radiometer Suite* (VIIRS) data received in Alaska via direct broadcast. Building on previous work, the Red, Green, Blue (RGB) 24-hr Microphysics imagery was also delivered to the NWS in near real-time beginning during the second half of 2014. This imagery is intended to help the NWS identify areas of low clouds and fog that can impact aviation and the general public, especially in areas of complex terrain.

GINA continues to deliver imagery to the NWS for use by the "Ice Desk" in analyzing and forecasting the extent of sea ice over the ocean surrounding Alaska. In addition to accessing Proving Ground imagery via Advanced Weather Interactive Processing System (AWIPS), the NWS Ice Desk makes consistent use of GINA's "Puffin Feeder" website to access imagery.

GINA staff continued to meet with NWS forecasters and managers from Anchorage, Juneau, and Fairbanks to gather feedback concerning the utility of Proving Ground imagery in the forecast process. GINA staff also recorded two additional editions of "Alaska Weather Facts" on the topic of satellite imagery for use on the NWS television show "Alaska Weather" during this reporting period.

Previously, through leveraged funds, Cherry co-located *in-situ* instrumentation with NOAA Climate Reference Network sites and continues to make these data available through near-real time data feeds on a public webpage

(http://ine.uaf.edu/werc/projects/atpn/index.html). These sites include the NESDIS Fairbanks Command and Data Acquisitions Station (FCDAS) facility near Fox, Alaska, and the NOAA Earth System Monitoring Laboratory in Barrow, Alaska.

*Strategic planning and **implementation white paper** and a proof of concept **demonstration project** in Alaska's Interior for improved near-real-time snow and hydrology forecast products for high latitudes.*

Cherry and Katrina Bennett (Ph.D. student, now graduated) have developed several key features of the Community Hydrologic Prediction System (CHPS)/Flood Early Warning System (FEWS) forecasting system in offline-mode to support the integration of MODIS (MOD10A1 version 5 from the Terra satellite) 500m pixel daily satellite imagery of snow cover fraction (SCF) in the Snow-17 snow model as an observed variable for the time period 2000–2010.

Two peer publications have been written and submitted on this project and are under review (see Publications section).

Ph.D. student Molly Tedesche was involved in the project with a focus on south central and southeast Alaska. Cherry and Tedesche are working with NOAA's National Marine Fisheries Service on determining snow cover and corresponding water resources for existing and proposed hydroelectric facilities. The Juneau NWS forecast office and the RFC are also partners in this effort.

Amy Jacobs, Vladimir Alexeev, and Sergei Maurits all worked with Cherry on organizing validation data and generating model-derived value-added products used to compare satellite snow cover with precipitation data. Two more manuscripts are under preparation on these topics.

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 (degree awarded December 2014), began working on this project in August 2010 and was supported in part through this project through to summer 2014.
Molly Tedesche, a Ph.D. student, began working on this project in April 2012 and was supported in part through this project during the summer of 2014.

Outreach

Heinrichs, Dayne Broderson (GINA Technical Services Manager), Eric Stevens (GINA-NWS liaison), and Jiang Zhu discussed development of the satellite products with forecasters from the NWS forecast offices in Fairbanks, Anchorage, and Juneau, the Alaska Aviation Weather Unit, the River Forecast Center, and the Center Weather Service Unit and gathered product evaluations. Bennett and Cherry are working with the RFC in Anchorage primarily in support of spring breakup, and Tedesche, Stevens, and Cherry are working with the NWS forecast office in Juneau with an emphasis on hydropower.

Publications, conference papers, and presentations

Submitted for publication

Bennett, K.E., J.E. Cherry, C.A. Hiemstra, L.D. Hinzman and K. Semmens. MODIS-derived snow melt timing in boreal warm-permafrost watersheds of Interior Alaska: validation, modeling and comparison. *In review.*

Bennett, K.E., J.E. Cherry, B. Balk and S. Lindsay. Using MODIS estimates of fractional snow cover extent to improve river forecasting models. *In review.*

Oral presentations

Stevens, E. 2014. The High Latitude Satellite Proving Ground and wildfires in Alaska, Alaska CFFDRS Summit, October 28–30, 2014.

Bennett, K.E., J.E. Cherry, J. Walsh and L.D. Hinzman. 2014. Understanding future projected changes and historical trends in extreme climate and streamflow events in warm boreal permafrost basins of Interior Alaska. American Geophysical Union meeting, San Francisco, California, December 2014.

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
NOAA National Marine Fisheries Service
NOAA National Operational Hydrology Remote Sensing Center
NOAA Climate Reference Network
NOAA Environmental System Research Laboratory (Barrow)
NASA-Cryosphere Group: Collaborative research
NASA-Short-term Prediction Research and Transition Center (SPoRT)
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

COASTAL HAZARDS

TWEAK: Tsunami Warning and Environmental Observatory for Alaska

Natalia Ruppert, PI ***CIFAR theme: Coastal Hazards***
University of Alaska Fairbanks

NOAA Goal: Weather Ready Nation

CIFAR 09-008/10-008/11-008/12-008: This project is complete NOAA Office: NWS Tsunami Program, Michael Angove, Sponsor

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 FY10, "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 separate 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

Natalia Ruppert, PI
Zygmunt Kowalik, co-PI and Project Lead
University of Alaska Fairbanks (UAF)

Other investigators/professionals associated with this project:
***J. Horrillo**, Texas A&M University at Galveston (TAMUG); **W. Knight**, West Coast and Alaska Tsunami Warning Center (WC/ATWC)*

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, Kowalik et al, 2005, 2008, Horrillo et al., 2012). 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

The main results achieved during the TWEAK project and the models developed for the tsunami warning and prediction have been described in the book: Introduction to Numerical Modeling of Tsunami Waves by Z. Kowalik. http://www.sfos.uaf.edu/directory/faculty/kowalik/Tsunami_Book/book_sum.pdf. The book contains four major chapters: Ch. I. General Equations, Ch. II. One-Dimensional Motion, Ch. III. Investigation into Tsunami Generation Processes, Ch. IV. Investigation into Tsunami Propagation by Vertically Integrated Equations. The book contains analytical and numerical solutions (including Fortran programs) to the various topics related to tsunami generation, propagation and runup/rundown.
(https://www.sfos.uaf.edu/directory/faculty/kowalik/Tsunami_Book/Fortran_programs/). Therefore, it is possible to continue research achieved in TWEAK by simply starting from the available Fortran programs. During the past 9 month period we have again made considerable effort to check and re-check these Fortran programs. In this reporting period the tsunami code development proceeded along two directions: modeling of the large scale tsunami dynamics and development and application of models for the land-slide generated tsunami.

As previously reported, the main contribution to this project contains Task 1 of the plan: *Tsunami program optimization and physics enhancement by dispersive processes*. The task was accomplished by cooperation of Z. Kowalik and D. Brazhnikov (UAF), J. Horrillo (TAMUG), W. Knight (WC/ATWC). We have based our research on the previously developed and tested Global Tsunami Model (GTM). The model domain covered the entire World Ocean extending from 80S to 69N. The model spatial resolution was 1 minute and its domain included approximately 200 million grid points. The model was applied to test its skill in the simulation of the Indian Ocean tsunami (IOT) case of 26 December 2004 and Kuril Islands of November 15, 2006. To elucidate the physics of the dispersive processes for the trans-oceanic propagation we compared the energy fluxes for both the dispersive and non-dispersive waves. In numerical experiments the results of the dispersive and non-dispersive computation for the same source function were compared for the Japan Tsunami (JT) of March 2011 (Horrillo et al., 2012) and for the laboratory experiments by Yamazaki et al. (2010). Numerical experiments defined bathymetric features which scatter the tsunami energy towards the West Coast via the Mendocino Escarpment. This escarpment seems to be efficient in delivering enhanced tsunami energy if the approaching tsunami signal travels from the west along the escarpment. To pinpoint the sources of the strong tsunami signal occurring often at Crescent City the energy flux was examined. The results are quite surprising; showing the key role in refocusing tsunami signal towards Crescent City played by the two bathymetric features Koko Guyot and the Hess Rise located thousands of kilometers from Crescent City.

Our main effort in this reporting period was directed again towards understanding directional/focusing properties of the Koko Guyot. This time we have used the simple idea of wave refraction or bending of wave paths caused by changes in phase speed (Figure 1).

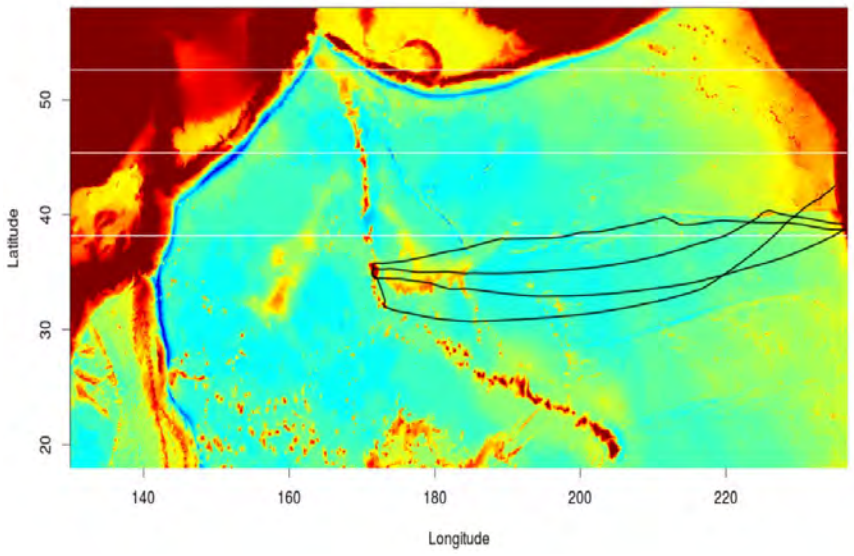

Figure 1. Ray paths of tsunami scattering from the Koko Guyot during 2011 Japan Tsunami.

This result when correlated with a full picture of the high-energy flux scattering from the Koko Guyot (Figure 2) allows for the quick estimate of directions for the main energy fluxes.

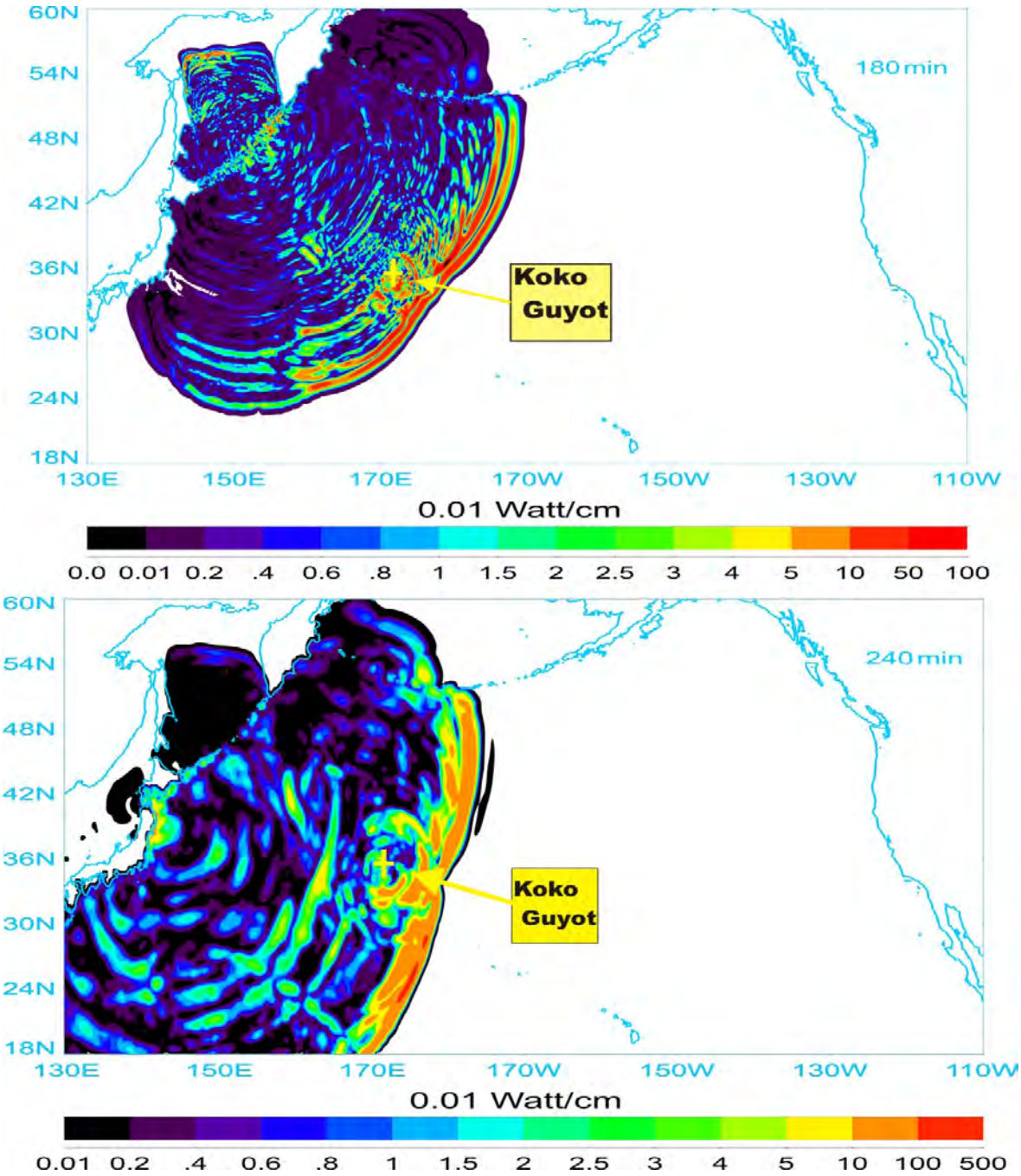

Figure 2. Energy flux contours for the non-dispersive waves, Kuril Island Tsunami 2006 (upper panel) and Japan Tsunami 2011 (lower panel). The signals of higher energy have been identified as scattered from the Koko Guyot, the Emperor Seamounts and Hess Rise. Yellow plus marker points to location of the Koko Guyot seamount. Time from the tsunami onset.

The tsunami wave propagating over ocean releases its energy during runup. To this important topic the effort was directed by J. Horrillo and a group of researchers concerned with inundation mapping along the US coasts. The various models used to calculate runup by dispersive and non-dispersive processes as well as by 2-D and 3-D approaches were tested and compared (Horrillo et al., 2014).

In Task 2 of the plan (*development of realistic models and landslide source functions*) the three-dimensional tsunami numerical simulations have been carried out with collaboration of Texas A&M University at Galveston tsunami team led by Juan Horrillo.

J. Horrillo and D. Brazhnikov (UAF, graduate student) have continued the numerical work required to improve the landslide capability of our 3-D Navier-Stokes model (VOF3D). The existing model efficiently solves three dimensional Navier-Stokes equations with explicit time integration method and finite difference representation of spatial derivatives. The physics of the coupled system of water and landslide can be considered as a motion of highly viscous Newtonian fluid. Such an approach introduces variable and often extremely large kinematic viscosity into momentum equations. Therefore, new numerical schemes were developed and tested by D. Brazhnikov and subsequently used by J. Horrillo.

J. Horrillo and his team (Lopez-Venegas et al., 2014) applied VOF3D model to submarine landslide as a source of the tsunami off Puerto Rico. The most recent tsunami observed along the coast of the island of Puerto Rico occurred on October 11, 1918, after a magnitude 7.2 earthquake in the Mona Passage. The earthquake was responsible for initiating a tsunami that mostly affected the northwestern coast of the island. Runup values from a post-tsunami survey indicated the waves reached up to 6 m. A controversy regarding the source of the tsunami has resulted in several numerical simulations involving either fault rupture or a submarine landslide as the most probable cause of the tsunami. To resolve the processes of generation and propagation a 3D–2D coupled numerical model specifically developed for the tsunami is used. The three-dimensional Navier–Stokes model tsunami solution using the Navier–Stokes algorithm with multiple interfaces for two fluids (water and landslide) was used to determine the initial wave characteristic generated by the submarine landslide (Horrillo, 2006). At the propagation and runup phase the non- hydrostatic numerical model NEOWAVE (non-hydrostatic evolution of ocean WAVE) featuring two-way nesting capabilities has been applied. Use of NEOWAVE enabled us to solve for coastal inundation, wave propagation, and detailed runup (see Yamazaki et al., 2010). Our results were in agreement with previous work in which a submarine landslide is favored as the most probable source of the tsunami, and improvement in the resolution of the bathymetry yielded inundation of the coastal areas that compare well with values from a post tsunami survey. Our unique energy analysis indicates that most of the wave energy is isolated in the wave generation region, particularly at depths near the landslide, and once the initial wave propagates from the generation region its energy begins to stabilize.

NOAA relevance/societal benefits

Numerical models are required to assess expected coastal tsunami impact, in amplitude, horizontal inundation distance and velocities, so that proper evacuation decisions can be made during tsunami warnings, as well as for long-term planning of coastal zone development. The new part of the comprehensive tsunami model under development, the dispersive model, was comprehensively tested against the Kuril Island Tsunami of November 2006 and the Japan Tsunami of March 2011. Numerical experiments defined bathymetric features which scatter the tsunami energy towards the West Coast via the Mendocino Escarpment. Obtained results suggest that due to interference with the Koko Guyot the short period waves experience large changes in their propagation. This has important consequences for accurate tsunami prediction and warnings. Basic results achieved during the multiyear TWEAK project have been documented in the Kowalik (2012/2014) book which also contains Fortran programs necessary for continuing the present research.

Education/outreach

Student participation: Dmitry Brazhnikov is a Ph.D. graduate student under guidance of Zygmunt Kowalik. He has been continuing his research towards incorporating of submarine landslide into the existing three dimensional models of tsunami waves. This included developing and comparison of the numerical solution with known analytical viscous flows and with results of verified numerical solutions. He was also researching the role of directional properties of the major seamounts (Koko Guyot) on tsunami propagation in the Northern Pacific. Mr. Brazhnikov was sponsored by this award and successfully finished two and a half years of graduate study. Gyeong-Bo is a graduate student at Texas A&M University at Galveston (TAMUG). He has contributed to several submarine landslide numerical simulations for model validation; J. Horrillo chairs his advisory committee.

Publications

Peer-reviewed

Horrillo, J., S. Grilli, D. Nicolsky, V. Roeber and J. Zhang. 2014. Performance benchmarking tsunami models for NTHMP's inundation mapping activities. *Pure and Applied Geophysics*, DOI 10.1007/s00024-014-0891-y.

Lopez-Venegas, A., J. Horrillo, A. Pampell-Manis, V. Huerfano and. A. Mercado. 2014. Advanced tsunami numerical simulations and energy considerations by use of 3D–2D coupled models: The October 11, 1918, Mona Passage tsunami. *Pure and Applied Geophysics*, DOI 10.1007/s00024-014-0988-3.

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Horrillo, J., W. Knight and Z. Kowalik. 2012. Tsunami propagation over the North Pacific: dispersive and nondispersive models. *Journal of Tsunami Society International*, 31(3), 154–177.

Kowalik Z., W. Knight, T. Logan and P. Whitmore. 2005. Numerical modeling of the global tsunami: Indonesian Tsunami of 26 December 2004. *Science of Tsunami Hazards*, 23(1):40–56.

Kowalik, Z., J. Horrillo, W. Knight and T. Logan. 2008. Kuril Islands tsunami of November 2006: 1. Impact at Crescent City by distant scattering. *Journal of Geophysical Research*, 113, C01020, doi:10.1029/2007JC004402.

Yamazaki, Y., K.F. Cheung and Z. Kowalik. 2010. Depth-integrated, non-hydrostatic model with grid nesting for tsunami generation, propagation, and runup. *International Journal for Numerical Methods in Fluids*. doi: 10.1002/fld.2485

Other products and outcomes

Kowalik, Z. 2012/2013/2014. Introduction to Numerical Modeling of Tsunami Waves, 196 pp. http://www.sfos.uaf.edu/directory/faculty/kowalik/Tsunami_Book/book_sum.pdf [Updated since last report]

TWEAK Task 2: ARSC Computational Support for Tsunami Simulations

Natalia Ruppert, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
***Sergei Maurits**, University of Alaska Fairbanks*

Primary objectives

Arctic Region Supercomputing Center (ARSC) will support tsunami research at UAF by providing parallel programming and visualization expertise, consulting expertise and support, and compute cycles as required by the UAF tsunami researchers and TWEAK participants.

Research accomplishments/highlights/findings

ARSC's efforts from April 1, 2014 – December 31, 2014 have supported tsunami projects with computational and programming expertise as well as with support of computer visualization and scientific web applications. As in previous years, the main efforts were dedicated to the following sub-projects

(1) Alaska Tsunami Inundation and Mapping Project (ATOM) web portal (Dmitry Nicolsky)
(2) Estimates of potential landslide sources and computing the scope of local tsunamis they can generate in the vicinity of Juneau, Alaska

The ATOM sub-project was a continuation of previous years' efforts. The available Keyhole Markup Language (KML) information was added to the portal site (http://atom.giseis.alaska.edu/index_test.html), including a list of historical locations of tsunami-generating earthquakes with on-line links to the NOAA and USGS catalogs of the events, KML-representation of the Alaska geological rupture zones and seismic faults, and a list of Alaska communities with computed maps of inundation lines and flow depth, superimposed with the Google Map v.3 with explanatory disclaimers. A suite of on-screen tools allows the user to find a feature on the map and then apply inundation lines and flow depth maps of controllable transparency to estimate a potential tsunami danger. Thus, this display became a convenient tool for decision-makers as well as for the general public.

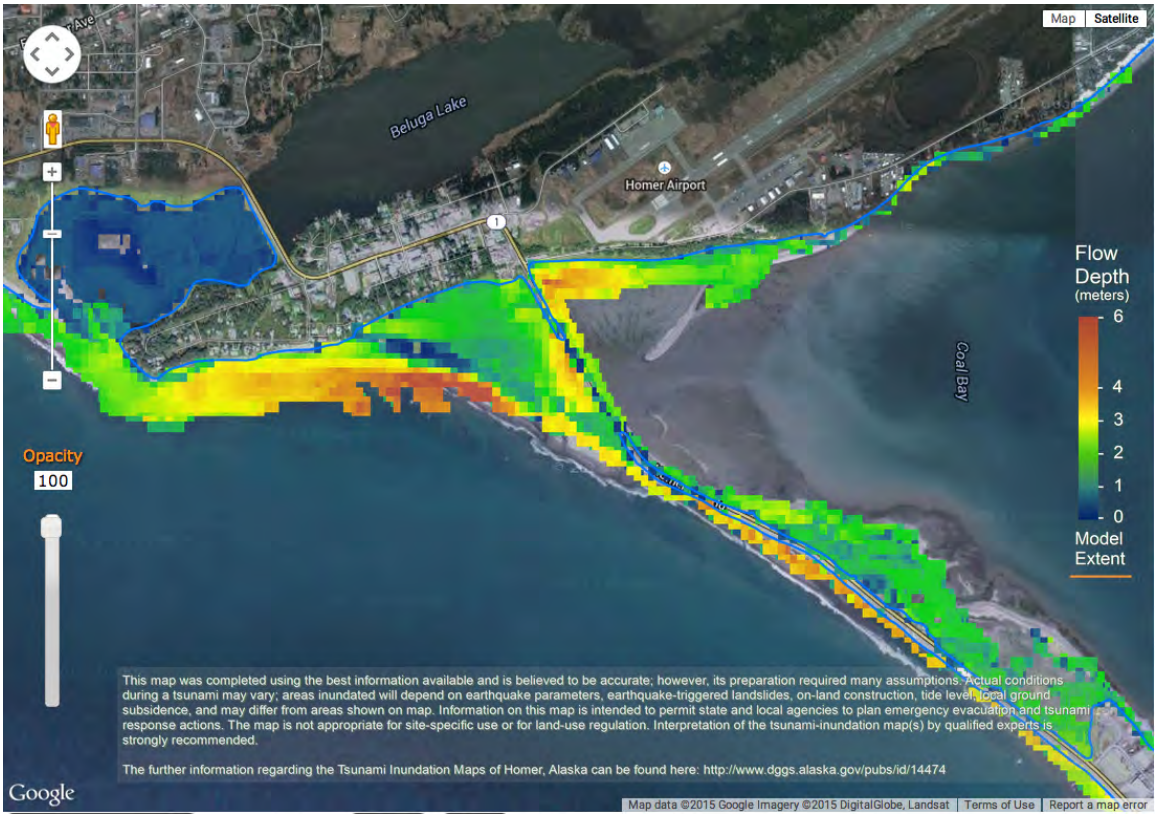

Figure 1. Screen shot of the ATOM portal page showing the Homer area satellite Google Map superimposed with inundation line and flow depth data. Transparency control of the data allows for easy feature tracking.

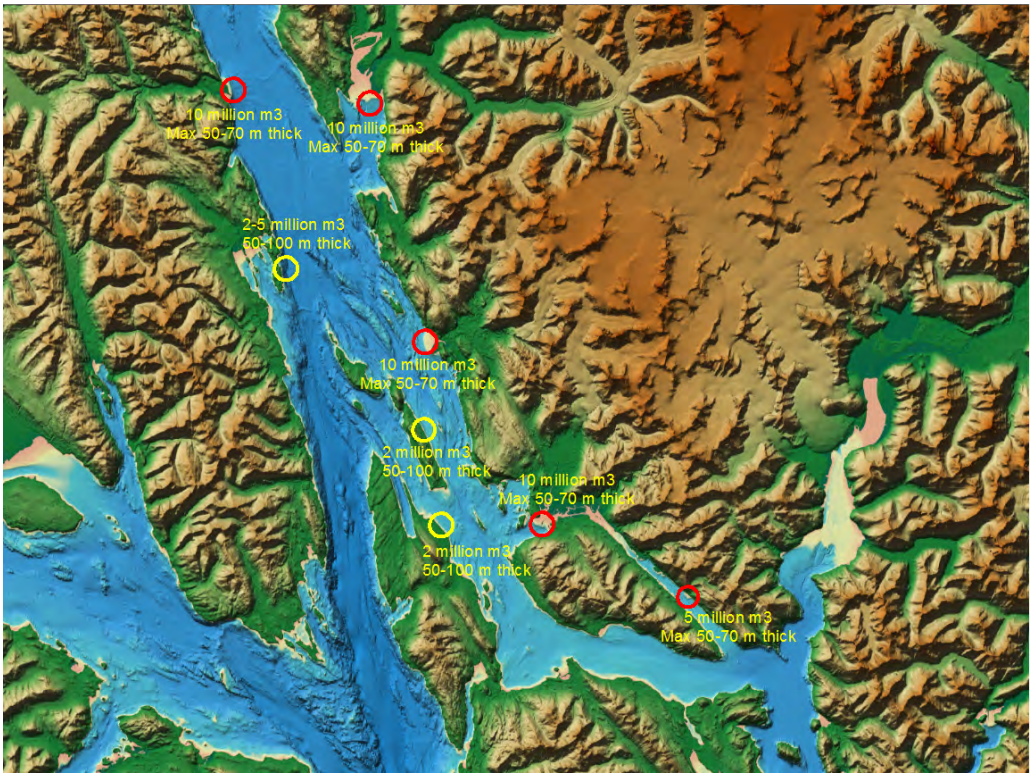

Figure 2. Juneau, Alaska area with markings of potential landslides, their volume, and thickness. Red circles represent accumulation of sediments in the mouth of the local streams, the subject of the current study.

Juneau, Alaska area computations. The second area of the ARSC activity in the project is providing computational capabilities for high-performance computing of the tsunami-generating effects of landslides and earthquakes, propagating the resulting tsunami waves in realistic water basins near communities of interest using high-resolution bathymetry data, and, finally, processes of run-ups to the shores. ARSC provides to the project participants long (up to 240 hours) computational queues for these goals with massive CPU allocations (up to 512 CPUs), massive short-term and long-term storage, and fast networking capabilities. Maurits also contributes through computational study of the Juneau, AK area for potential tsunami sources. Figure 2 below shows the locations of interest in the Juneau vicinity.

Locations marked by red circles were investigated for potential landslide volume and thickness using a suite of Matlab scripts. Based on the findings, the intensity of the tsunami waves that can be generated by these slides was modeled applying the Fortran code NHWAVE. This code simultaneously simulates temporal development of both landslide and tsunami wave formation from the time that the landslide begins. Therefore, this code is computationally very intensive. Long runs (50-60 wall clock hours) of the code at 15x15 grids (typical problem size at that resolution is ~1500x~1500 or 2M nodes) required about 200 CPUs to cover the first ten minutes (600 sec) of the wave's propagation and the landside development. The fully generated tsunami wave (computed by NHWAVE) can be used as inputs to another code, FUNWAVE for a faster run (despite the higher resolution of FUNWAVE). This later code assumes that the energy and momentum transfer from the landslide is over, a reasonable assumption after two to three minutes of landslide development; the major event is over or continues at reduced intensity too deep (> 100 m) to affect the surface. Because FUNWAVE focuses on the wave propagation and run up, this approach accelerates computations quite noticeably and allows for extension of the temporal coverage up to 30 minutes after the landslide (and the tsunami wave) beginning, which improves spatial resolution needed for run-up simulations. This time interval and resolution are sufficient for all practical purposes for completing run-up computations and for preparation maps of inundation lines and flow depth at the entire shoreline. As the final step, the inundation lines and flow depth data from gridded FUNWAVE outputs were transferred to ArcGIS shape-files format using Matlab utility.

Sensitivity studies were performed to establish quantitative differences of the simulations, depending on the instant of switching to FUNWAVE from the NHWAVE-generated input. Such transitions were performed at 90 seconds, 120 seconds and 180 seconds after the landslide beginning, and the obtained solutions were compared. Comparisons revealed that certain differences are present but not dramatically significant. It was established that postponing the instant of transition to 120 seconds after the beginning of the landslide is a good computational practice. This delay time is quite sufficient for the wave to be fully formed and to start the propagation on its own without major additions of energy and momentum from the landslide as it reaches its dampening phase.

TWEAK Task 3: Seismic network component (Alaska CRESTnet)

Michael West, PI
Natalia Ruppert, Co-PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Miriam Braun, Christopher Bruton, Scott Dalton, Ian Dickson, Dara Merz, Sara Meyer, Natalia Kozyreva *University of Alaska Fairbanks*

CIFAR 10-017/11-017/12-017/13-017: This project is complete. It continues under NA13OAR4320056.

NOAA Office: NOAA Tsunami Program, Michael Angove, Sponsor

Alaska CRESTnet (Consolidated Reporting of Earthquakes and Tsunamis): Alaska Earthquake Center (formerly referred to as "Alaska Earthquake Information Center") seismic station operations & maintenance.

Primary objectives

- Maintain Alaska Tsunami Center and Observatory (ATCO)- and CREST-funded seismic stations in the integrated 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 integrated seismic network, including the following work on ATCO- and CREST-funded stations. Please note that half of these stations were de-scoped from the project in 2013:

- At ATKA, we installed a radio shot to allow telemetry via community health center internet, allowing us to cancel the expensive, USGS-leased circuit.
- At BESE (Bessie Mountain near Juneau), we addressed intermittent power outages by replacing the power supply.
- At COLD (Coldfoot), we worked with IRIS personnel to convert the station to a Transportable Array site with a new borehole cored into bedrock.
- At DCPH (Deception Hills, south of Yakutat), we took the site offline to accommodate construction of a USCG Rescue 21 communications tower.
- At DIV (Divide Microwave, on Richardson Highway, 15–20 miles north of Valdez), we upgraded the power system, installed lightning protection, and completed the connection to state internet.
- At DOT (Dot Lake), we installed lightning protection and converted the site from radio telemetry to a direct connection to state internet.
- At FALS (False Pass), we upgraded the power controller and installed a new router.
- At PIN (Pinnacle), we replaced batteries and upgraded the power controller.
- At TNA (Tin City), we installed a VSAT system and replaced the broadband sensor with a Trillium T120PH. We are receiving data from TNA for the first time since 2012.

Between April 1 and December 31, 2014, the Alaska Earthquake Center reported 31,786 events, with magnitudes ranging between -0.5 and 7.9 and depths between 0 and 296 km (Figure 1). Five earthquakes had magnitudes of 6 or greater. The largest earthquake, of magnitude 7.9, occurred on 23 June 2014 in the Rat Islands region of Alaska. Over 2,000 aftershocks have been recorded following this earthquake.

NOAA relevance/societal benefits

Improved detection of tsunamigenic earthquakes by Alaska Earthquake Center (AEC) and NOAA tsunami warning centers.

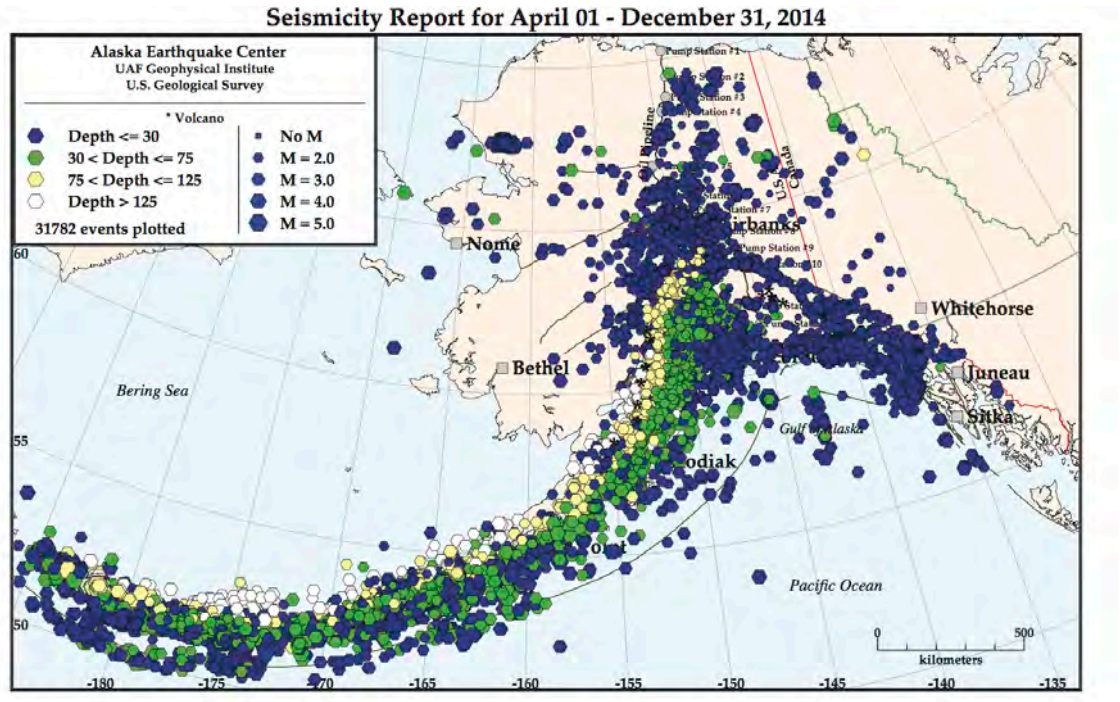

Figure 1. AEC Seismicity Report for 1 April 2014 – 31 December 2014.

Outreach

AEC 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 systems reside on stand-alone MAC computers that display real time earthquakes on a state map with audio announcements of earthquake locations and magnitudes.

TWEAK Task 4: Earthquake detection and warning with seismology

Natalia Ruppert, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Kenneth Macpherson, *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 Center (AEC).

Research accomplishments/highlights/findings

Activities during the period April 1, 2014 until December 2014 focused on the development of computer code for the implementation of a continuous moment tensor scanning algorithm. This algorithm monitors a grid of potential sources by continuously cross-correlating, pre-computed synthetic seismograms with a data stream, allowing for the rapid determination of an earthquake's location, moment, and mechanism (Kawakatsu, 1998; Tsuruoka et al., 2009; Guilhem et al., 2013). Real-time data at AEC is handled using the Antelope Real Time system, and the technical crux of implementing the algorithm is developing an Antelope-native version of the code. We have achieved this by developing the 'orbgridmt' code base. This software package performs continuous moment tensor scanning as a task within the existing Antelope real-time framework. This will allow the algorithm to be incorporated seamlessly into AEC's real-time operational regime. We have also developed 'dbgridmt,' which is an off-line version of the code that has utility for research and algorithm testing. Output from the code for a moderate south-central Alaska earthquake is shown in Figure 1. Our primary accomplishment for this time period is that we now have a continuous moment tensor scanning computer program suitable for use in AEC's real-time processing environment.

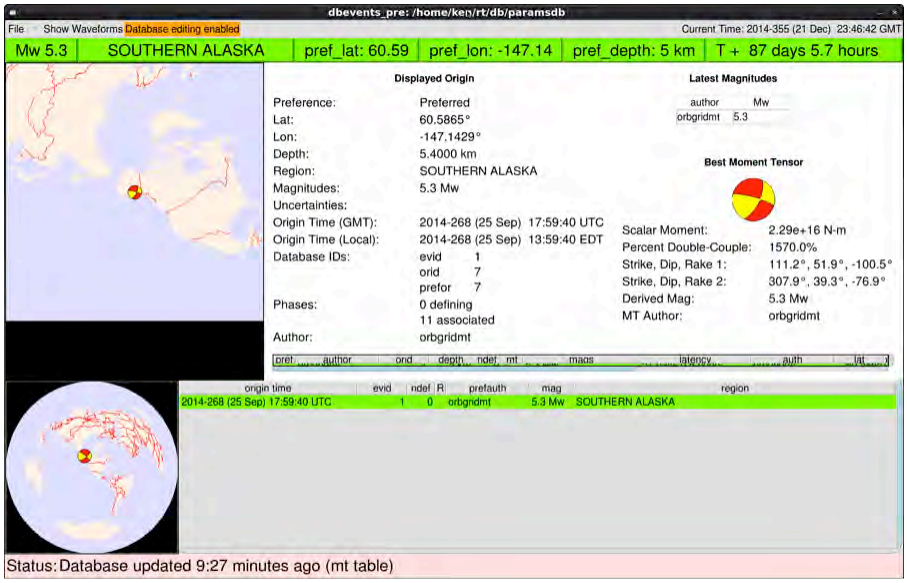

Figure 1. Example of output from the 'dbgridmt' program. The algorithm has detected a moderate earthquake (Mw = 5.3) in south-central Alaska. Note that this calculation was made in the off-line testing mode.

We have concentrated on the development of the continuous moment tensor scanning code so that we can test the algorithm in an operational setting. However, the grid set-up and calculation of synthetic seismograms necessary for the set-up of 'orbgridmt' is currently time and computer intensive, and consists of a complicated amalgamation of scripts and binaries. In order to enhance the usability and operational life of 'orbgridmt', we are developing a unified Antelope-native code called 'gridgli', that will construct the monitoring grid, compute synthetics, and find the generalized linear inverses (g.l.i.) required by 'orbgridmt'. Progress on this code thus far includes grid construction and synthetics calculation and storage in Antelope format. We are now working to expand the capability of the code to include g.l.i. calculation.

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Guilhem, A., D. Dreger, H. Tsuruoka and H. Kawakatsu. 2013. Moment tensors for rapid characterization of megathrust earthquakes: the example of the 2011 M9 Tohoku-oki, Japan earthquake. *Geophysical Journal International*, 192(2):759–772, 2013. Doi:10.1093/gji/gg5045

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

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*, doi:10.1016/j.pepi.2008.02.014.

Presentations

Poster

Macpherson, K.A., N. Ruppert, D. Dreger, P. Lombard, J. Freymueller, D. Nicolsky and A. Guilhem. 2014. Mainshock and aftershock mechanisms of the Mw=7.5 Craig, Alaska earthquake of January 5, 2013 from continuous moment tensor scanning. Annual meeting of the Seismological Society of America, May 2014.

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

Natalia Ruppert, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Elena Suleimani, Dmitry Nicolsky, *University of Alaska Fairbanks*

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, which are utilized for defining evacuation routes for the at-risk communities.

Research accomplishments/highlights/findings

Tsunami inundation modeling and mapping in selected communities:

- **Elfin Cove, Gustavus and Hoonah:** We completed the tsunami inundation mapping project for the three communities of Southeast Alaska: Elfin Cove, Gustavus and Hoonah. The tsunami inundation modeling and mapping report is being published by the Alaska Division of Geological & Geophysical Surveys (ADGGS).
- **Yakutat, and Sand Point:** We completed the tsunami inundation modeling and mapping. The inundation mapping reports are submitted to ADGGS for peer review.
- **Chignik Bay, King Cove, Cold Bay and Nikolski:** We started the tsunami inundation modeling and mapping project for the communities of King Cove and Cold Bay. We identified potential tectonic tsunami sources and performed the preliminary model runs.

Publications and presentations

Peer-reviewed

Nicolsky D.J., E.N. Suleimani and R.D. Koehler 2014. Tsunami Inundation Maps of Chenega Bay and northern Sawmill Bay, Alaska. Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2014-3, 50p.

Nicolsky D.J., E.N. Suleimani and R.D. Koehler. 2014. Tsunami Inundation Maps of Cordova and Tatitlek, Alaska. Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2014-1, 49 p. doi:10.14509/27241.

Harris, M.W., D.J. Nicolsky, E.N. Pelinovsky and A.V. Rybkin. 2014. Runup of nonlinear long waves in trapezoidal bays: 1-D analytical theory and 2-D numerical computations. *Pure and Applied Geophysics*, DOI 10.1007/s00024-014-1016-3. *[available online]*

In press

Suleimani, E.N., D.J. Nicolsky and R.D. Koehler. Tsunami inundation maps of Elfin Cove, Gustavus and Hoonah, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation, *in press.*

In review

Nicolsky, D.J., E.N. Suleimani, and R.D. Koehler, Tsunami Inundation Maps of the city of Sand Point, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation, *in review.*

Suleimani, E.N., Nicolsky, D.J., and Koehler, R.D., Tsunami inundation maps of Yakutat, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation, *in review.*

Nicolsky D.J., E.N. Suleimani, R.D. Koehler and J.T. Freymueller. Tsunami Inundation Maps of Unalaska and Akutan, Alaska. Alaska Division of Geological & Geophysical Surveys, Report of Investigation, *in review*.

Poster presentations

Nicolsky, D.J., E. Tolkova, E.N. Suleimani. 2014. No-source tsunami forecasting for Alaska communities: Abstract NH13A-3722 presented at 2014 Fall Meeting, American Geophysical Union, San Francisco, Calif., 15–19 December, 2014.

Suleimani, E.N., D.J. Nicolsky, and R.D. Koehler. 2014. Inundation mapping and hazard assessment of tectonic and landslide tsunamis in Southeast Alaska, Abstract NH13A-3718 presented at 2014 Fall Meeting, American Geophysical Union, San Francisco, Calif., 15–19 December, 2014.

Education/Outreach

Nicolsky, D.J., Presentation of the tsunami inundation maps and reports to the city of Unalaska and Dutch Harbor, November 14, 2014.

Suleimani, E.N., Presentation of the tsunami inundation maps and reports to the communities of Gustavus and Hoonah, December 1–2, 2014.

TWEAK Task 6: Education and outreach

Natalia Ruppert, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Helena Buurman, Ian Dickson, Lea Gardine, Amy Macpherson, Ken Macpherson, Carl Tape, Mike West *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

Throughout the reporting period we distributed information releases after notable events, spoke with news organizations on request, and answered telephone and email queries from the public. Additionally, the Alaska Earthquake Center (AEC) presented earthquake and tsunami education through the following activities:

- At the University of Alaska Science Potpourri in April, AEC staff presented information on earthquakes and tsunamis to students of all ages. Around 1500 people, mostly children, attended the event.

- Lea Gardine and Helena Buurman spoke to 24 middle school and high school students in Minto on May 14 about earthquake science, the Minto Flats Seismic Zone, and the benefits of hosting a seismic station in their community.
- Lea Gardine spoke to 70 people at the University of Alaska Anchorage Development Day on May 15.
- Carl Tape and Lea Gardine spoke and gave a lab tour to North Slope high school students participating in the GeoForce project.
- Carl Tape and Lea Gardine gave a lecture to high school students attending the Alaska Summer Research Academy in July.
- AEC staff manned an information booth at the Tanana Valley Fair in August.
- Mike West appeared on the popular Talk of Alaska public radio call-in show to talk about earthquakes and tsunamis in Alaska.
- Natasha Ruppert traveled to the village of Noatak to speak to villagers during the April-June earthquake swarm near their community.
- Ian Dickson continued building social media outreach via twitter and Facebook. During the reporting period the combined followers for both accounts grew from 264 to 1,840. The Facebook group hosts discussion on various earthquake-related topics, while the twitter account is used primarily for rapid communication after felt events.
- Lea Gardine is now tracking media coverage of the Alaska Earthquake Center. She found 273 Earthquake Center-related media items for the reporting period. 49% were newspaper articles, while the rest were divided among radio, TV, and web-only outlets. Surprisingly, only 34% of these items appeared in Alaska media. 50% were in national media or local U.S. media outside Alaska, while 7% were international.

Outreach activities focused on Alaska seismicity, tectonics, and tsunami overviews as well as advice on earthquake and tsunami preparedness.

Supporting NOAA's mission goals using unmanned aircraft systems (UAS) technology

Marty Rogers, PI *(as of 3/1/14)*
Greg Walker, PI *(as awarded)*
University of Alaska Fairbanks

CIFAR themes: Coastal Hazards; Ecosystem Studies & Forecasting

NOAA Goal: Healthy Oceans; Weather Ready Nation

CIFAR 13-031: This project is complete. It continues under NA13OAR4320056.

NOAA Office: OAR, Robbie Hood, Sponsor

Primary objectives

The main science objective of this project is to use two different UAS to meet NOAA's mission goals in three areas.

1. **Survey of marine debris generated by the 2011 Japanese tsunami**. We plan to search and map the location, type, distribution and movement of marine debris originating from the tsunami that struck Japan on March 11, 2011.
2. **Arctic Ocean and sea ice engineering system development tests**. In coordination with the NASA funded UAS project "Marginal Ice Zone Observations and Processes Experiment (MIZOPEX)" we plan to conduct UAS field trials from Oliktok Point, Alaska.
3. **Augment existing Steller sea lion research project with field time**. This project will supplement and continue the technology evaluation underway to evaluate augmenting current Steller sea lion surveys with UAS.

Research accomplishments/highlights/findings

Survey of marine debris generated by the 2011 Japanese tsunami - Under this effort, managed a subcontractor, Airborne Technologies, Inc. (ATI) of Wasilla, Alaska in their preparation of the Resolution sUAS that they have designed and built under a NOAA Small Business Innovation Research (SBIR) contract.

Field Program - Avon Park, FL June, 2014

On June 6th, a demonstration flight for NOAA was performed by ATI personnel in Avon Park, FL. The one day demonstration was to highlight the Resolution Unmanned Aircraft System (UAS). ATI provided a single airframe,

two launch systems, a Ground Control Station (GCS) and a UAS field kit. Two flights were performed, showing autonomous flight & control, lost link procedures and sensor package capabilities.

ATI completed the following tasks:
• Sensor Package for demo flight -
    ◦ Samsung NX210 installed for demo flight
    ◦ Trigger hardware/software set for 10% ground coverage overlap on images
    ◦ Automatic "rubber-sheeting" display of image ground coverage location displayed in near-real time on GCS display
    ◦ Post-process integration of flight data and images to geo-reference images and allow for post-process mosaic
• Prepare one airframe for FL demo flight, over land, at Avon Park
• Prepare presentation for NOAA personnel at Avon Park
• Continued testing of autonomous take-off and landing
• Pass private pilot written test for Curt Olson
• Obtain 2nd class FAA medical for Tim Veenstra and Curt Olson

The Samsung NX210 replaced the Mightex SCE-CG04-U camera which had been used on the previous missions.

Demonstration Flight Results
Below are representative images that were taken during the demonstration flights on June 6, 2014. The camera was set in manual mode with 1/1000 sec shutter speed, aperture of 6.3 and ISO at 400. While the images were acceptable with good exposure, results would have been improved with a slight increase in the aperture. The image histograms were skewed slightly to the right which results in washed out highlights. Generally, the settings are adjusted for the ground cover (e.g., water color, vegetation) and objects that you intend to capture. In Figure 1 and 2, the white sun tent and car are slightly washed out.

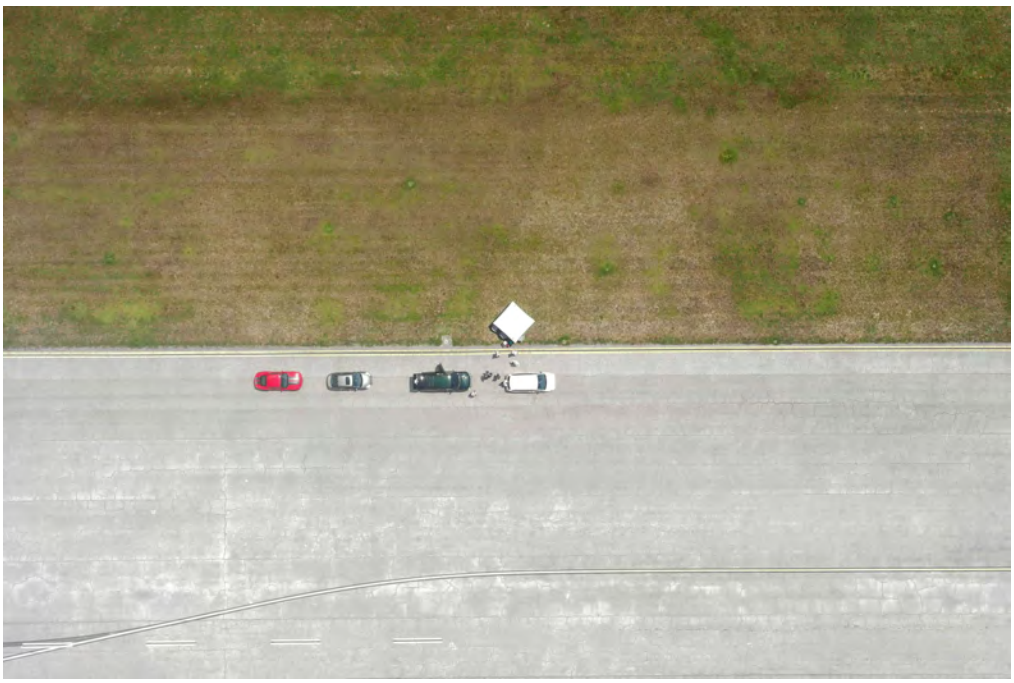

Figure 1. Image #0083 of runway with vehicles and sun shelter

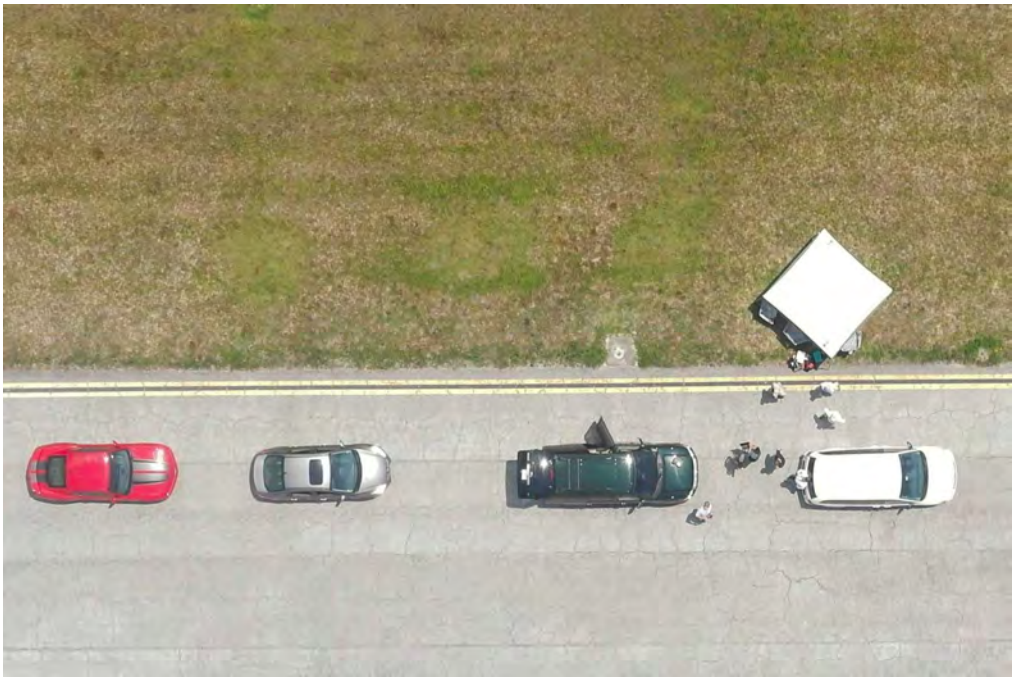

Figure 2. Cropped view of image #0083 with 1.5 cm per pixel ground resolution

Figure 3. In this enhanced crop of image #233, the red bungee cord used for launching the UAS is visible stretching across the grass and coiled up on the runway. The bungee cord is ½ inch in diameter.

Final Field Program - Avon Park, FL December, 2014

Dec 8, 2014: The ATI Resolution launched after a fairly lengthy series of troubleshooting steps--battery change due to not holding power, issue with a position updating process in the software, etc. The launch was normal. During the first few minutes of flight the normal approach is to maintain manual control through a typical RC aircraft controller, and then transition to autopilot operations, and then return to manual control to land. 43 seconds after launch the system was still in manual control when it stopped responding to controller inputs, rolled sharply right,

nosed down and flew into the water. The captain motored the Shearwater over to the Resolution and it was retrieved. It incurred significant damage and is not considered to be restorable. There was no risk to crew or the vessel as the planned and actual flights were well clear of the boat. The immediate review of the flight logs indicated the last commands transmitted from the controller were received and acknowledged by the UAS. Post event assessment, to include a review of the telemetry data and testing of the airframe components, indicated the cause of the incident appeared to be the control failure of the left wing elevon caused by a damaged/bad servo, potentially as a result of damage incurred during shipment of the system.

Arctic Ocean and sea ice engineering system development tests – The UAF portion of 2013 MIZOPEX (Marginal Ice Zone Oceans and Ice Observations and Process Experiment) mission has been completed successfully.

Augment existing Steller sea lion research project with field time – The Steller sea lion (SSL) project has been completed successfully. (See last year's report.)

NOAA relevance/societal benefits

We believe all three projects have extended the NOAA UAS capabilities and understanding of the sUAS potential for NOAA missions.

Partner organizations and collaborators

Columbia University
University of Colorado
Ball Aerospace
US Air Force Special Operations Command
AeroVironment Inc.
Airborne Technologies Inc.

Impact

The value of low-cost aerial imagery in remote locations in Alaska is profound. From managing endangered species, such as the Steller sea lions in the Western Aleutians to understanding the Marginal Ice Zone in the Arctic, this technology affords NOAA many new methods of understanding the environment that they must manage. Alaska is a challenging environment for these platforms and applications, and our research increases the understanding of this technology and identifying the existing limitations to realize fully their potential mission set.

Towards a 90-day monthly storm outlook for Alaska, North Pacific, and Hawaii

John Walsh, PI ***CIFAR theme: Coastal Hazards***
University of Alaska Fairbanks

Other investigators/professionals funded by this project:
David Atkinson, *sub-contractor,* ***University of Victoria***

NOAA Goal: Weather Ready Nation

CIFAR 13-032: This project is complete. NOAA Office: NWS, James Partain, Sponsor

Background

In all seasons of the year, storms represent high-impact weather events over Alaska and its adjacent seas. Alaska's extensive coastline and, in many cases, shallow offshore shelves makes the region especially vulnerable to coastal flooding and erosion, particularly where a protective sea ice buffer is absent. Even in the Alaskan Interior, cyclonic systems can produce major floods, ranging from the Fairbanks inundation of 1967 to the recent Eagle/Tok floods in summer 2010. Extensive commercial fishing, oil and gas field development, tourism, and increasing military and Coast Guard interest add to the potential parties impacted by storms in coastal waters. Hawaii can experience considerable coastal impact, including inundation and damage to harbors, during low-press system transits.

Forecasts containing information about storm events are currently issued by the National Weather Service (NWS) out to 7 days; model guidance through Week 2 is also available at a NOAA Climate Prediction Center (CPC)

"Storm Tracks" website: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/stormtracks/strack_alaska.shtml. This website currently includes summaries of storm tracks and accumulated precipitation for the past 10-, 30-, and 90-day periods, together with Week-1 and Week-2 forecast storm tracks from the Global Forecast System (GFS) Operational Run and the GFS Ensemble. Given the limits of deterministic predictability, we will extend the window of the storm outlook to 90 days using probabilistic methods, which draw upon the present and CPC-predicted states of El Niño–Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and the Arctic Oscillation—three large-scale modes of variability known to affect Alaska.

The envisioned product is a map depicting the likelihood of enhanced (or reduced) storminess relative to the climatological normal.

The project objectives are:

- Objective 1: Literature review summarizing: identification of nature and strength of all modes of variability that affect Alaska, North Pacific, and Hawaii; representation of storms in aggregate and rationales for using different types of storm classification; methodologies for empirically relating climatic indices to storminess or other parameters such as precipitation.
- Objective 2: Development of experimental forecast product in "hindcast" mode.

Research accomplishments/highlights/findings

Experimental forecast products have been developed using statistical modeling techniques such as Generalized Linear Models (GLMs) and "Random Forest" ensemble regression techniques to reproduce storm activity patterns in sub-regions of the study area. These reproductions are driven by teleconnection indices that have been established to be well correlated with storm activity patterns in the region. Breaking the large study area into smaller subdivisions was made necessary by the differences in distribution of storm events with relation to main storminess regions seen in the Empirical Orthogonal Function analysis.

GLM hindcasts for the wintertime months (January, February, March, JFM) generated from teleconnection indices with a 1-month lag (i.e. beginning in November) provided reasonably good fit to the storm activity distribution in the Bering Sea with a correlation coefficient of 0.73 (Figure 1). Using this technique, the most influential teleconnections in the Bering Sea region are the Pacific Decadal Oscillation (PDO), the North Atlantic Oscillation (NAO), the North Pacific Index (NPI), and the Pacific/North American Pattern (PNA). Using GLMs, it has been shown that a change of one standard deviation (1σ) of the PDO leads to a 3.28% reduction in wind events in the region, making it the most influential teleconnection in the region. Other teleconnections also provide influences wind events in the Bering Sea region, including the NAO (1σ increase representing 1.74% decrease) and the PNA (1σ increase representing 1.74% increase).

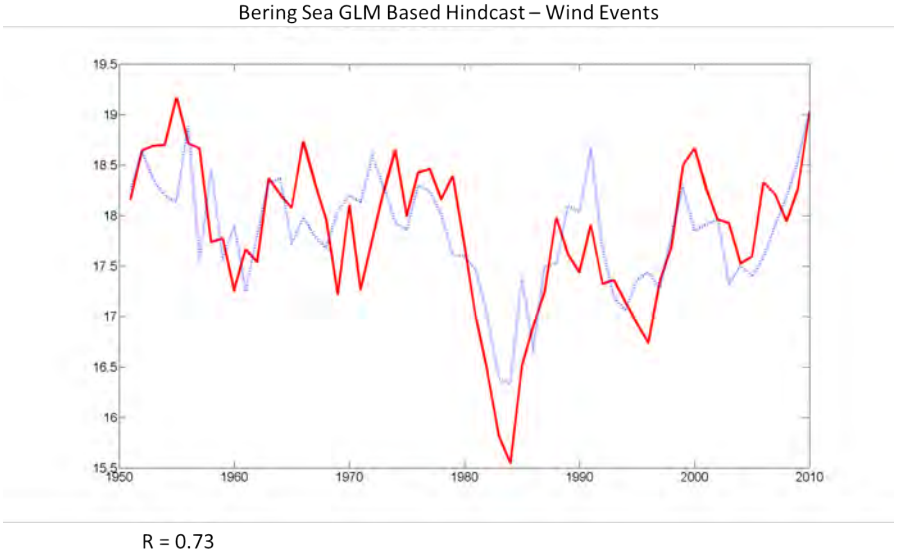

Figure 1. Seasonally predicted wintertime (JFM) wind event activity (blue-dashed) verified against actual wind event activity (red) for the Bering Sea region, for the period 1951–2010. This hindcast was created using a Generalized Linear Modeling (GLM) technique.

*Table 1. Trends and significance of storm frequency by method and subregion. Trends that are significant at 95% are indicated by **bold and italic** numbers. Trends that are significant at 99% are indicated by **bold, italic, and underlined** numbers.*

	1950 - 2010 Serreze				1950 - 2010 Hodges				1950 - 2010 Atkinson			
Region	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND
North Pacific	***0.83***	0.08	0.84	***0.91***	***2.58***	***1.99***	***2.55***	***2.20***	***1.88***	0.99	***1.24***	***2.34***
Gulf of Alaska	-0.89	-1.90	1.19	2.61	2.26	1.22	2.53	***4.29***	***4.21***	-0.22	0.90	0.46
Bering Sea	1.49	-1.62	0.21	1.93	***3.01***	-1.59	2.16	1.52	-0.16	-0.72	***1.25***	-2.05
Chukchi/Beaufort	1.60	-0.53	-0.66	0.74	1.85	1.54	1.72	0.36	-1.24	0.30	***2.47***	0.08
Alaska Interior	-0.41	0.10	-0.30	0.92	0.07	1.22	1.08	0.95	***4.04***	***0.90***	***2.40***	***4.44***

	1950 - 1978 Serreze				1950 - 1978 Hodges				1950 -1978 Atkinson			
Region	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND
North Pacific	***1.93***	0.39	***5.11***	1.02	1.83	1.03	***5.63***	***2.61***	0.81	0.35	***4.03***	***2.03***
Gulf of Alaska	0.74	4.22	2.08	4.67	-2.82	9.14	-0.49	7.02	1.26	2.19	-0.97	3.49
Bering Sea	5.02	-0.42	4.89	3.14	4.47	4.69	4.54	3.10	-0.75	3.07	-0.10	-0.45
Chukchi/Beaufort	-1.12	-1.97	-5.32	0.76	4.66	1.78	-3.55	7.02	5.79	1.11	***5.61***	8.00
Alaska Interior	-0.88	-1.22	-4.78	5.13	-1.10	-2.41	-2.77	1.76	4.07	2.03	0.65	***7.44***

	1979 - 2010 Serreze				1979 - 2010 Hodges				1979 - 2010 Atkinson			
Region	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND
North Pacific	0.16	-0.61	0.55	***2.27***	-0.24	2.24	0.56	2.19	***10.10***	5.05	***6.26***	***7.07***
Gulf of Alaska	6.13	-5.75	7.09	15.96	-2.04	0.61	3.19	9.14	***9.58***	2.76	***7.30***	8.39
Bering Sea	-5.65	-5.22	-1.04	-0.18	-2.50	-6.08	-3.72	4.41	6.04	0.12	5.45	1.49
Chukchi/Beaufort	0.30	0.80	-3.93	-0.65	-4.13	-4.29	0.15	0.73	-5.96	-6.85	1.56	-0.33
Alaska Interior	1.25	-0.26	1.55	2.07	-6.08	-2.59	0.08	-3.36	6.67	2.65	4.56	***8.79***

Storminess trends were computed for each subregion for all available time series for the entire duration (1948 to 2012), the pre-PDO shift period (1950–1978), and the post-PDO shift period (1979–2012). Trend analysis is separated by subregions and time periods. These trends were investigated to determine the best representative storm tracking algorithm for the basis of the seasonal storminess outlook. In each individual subregion, a linear trend is applied to the mean time series of event counts, with significance tested by a non-parametric Mann Kendall trend test. Trends, expressed as percent change, are summarized in Table 1. In the North Pacific, the Serreze method (Serreze et al. 1993; Serreze 1995) shows statistically significant trends only in January–March (JFM) and October–December (OND) across the duration of the dataset. Both trends in these seasons are visible at only a 1% increase in storm events. By comparison, the Hodges method shows similar trends with slightly higher percentages (2–2.5%) increases in the seasons of JFM and OND. The Hodges method also shows statistically significant trends in April–June (AMJ) and July–September (JAS). The Atkinson wind event identification method (Atkinson 2005) appears to agree with the Hodges method (Hodges 1994; Hodges 1995; Hodges 1999) across the length of the dataset, with statistically significant trends in nearly all seasons of between 1–2.3 %.

For the Gulf of Alaska, significant trends are only detected in this region in the fall (OND) for the Hodges methods and winter (JFM) by the Atkinson method. Additionally, the trends detected by Hodges and Serreze methods are, in some cases, opposite in direction and not statistically significant. It is possible that differing trend signs and magnitudes may be due to sensitivity to tracking algorithm thresholds or due to the fewer overall number of events in the spring and summer seasons. In the other subregions, few significant trends are found overall. The Bering Sea shows significant trends in the Hodges algorithm during the winter (JFM) at a 3% increase and by the Atkinson method during the summer (JAS) at a 1.25% increase. The Chukchi/Beaufort Sea region shows only a significant trend during the summer (JAS) in the Eulerian Atkinson wind event method and not in the two Lagrangian tracking methods. Interestingly, statistically significant trends in the Alaska Interior are only seen with the Atkinson method, with increases between 1–4% across all seasons. As these trends are not highlighted in the Lagrangian methods, it suggests that the increases in wind events is not necessarily associated with storm centers but more complex dynamical setups in this region.

When broken into shorter temporal ranges, there are far fewer statistically significant trends detected across all regions. In the 1950–1978 period, the North Pacific region once again shows the most significant trends across all methods. For example, the summer season (JAS) shows a 4–5% increase across all three storm algorithms. In the 1979–2010 period, the significant trends are mainly noticed in the Atkinson method, seen across most seasons. In the North Pacific, winter (JFM), summer (JAS), and fall (OND) seasons show a between 6–10% increase in wind

events. The only Lagrangian method with a statistically significant trend is the Serreze method in the fall (OND) season, with an approximately 2% increase.

NOAA relevance/societal benefits

The project impacts to NOAA and to the region are manifold. There exists a major need for an expanded temporal range of storm outlooks to enable proactive responses by coastal communities and the various industries noted above.

Outreach

Multiple teleconferences, hosted by Rick Thoman at the Fairbanks WFO, were conducted throughout the year (January 2014, October 2014, November 2014, and January 2015) to share results and gather feedback on the seasonal outlook products and the needs of the WFO. This included work determining potential storminess trends in the Bering and Chukchi Seas.

Publications and conference presentations

Publications under preparation

Shippee, N. and D.E. Atkinson. The development of a statistically-based seasonal extratropical cyclone activity outlook for the North Pacific, Bering Sea, and Alaskan regions. *In Preparation.*

Shippee, N. and D.E. Atkinson. An intercomparison of semi-eulerian and lagrangian based cyclone tracking methods in the North Pacific and Alaskan regions. *In Preparation.*

Poster presentations

Shippee, N. and D.E. Atkinson. 2014. Developing weather indicators for Arctic Shipping seasonal outlooks. *Arctic Change Conference*, Ottawa, Canada. 9–10 December 2014.

Shippee, N. and D.E. Atkinson. 2014. An intercomparison of semi-eulerian and lagrangian based cyclone tracking methods for the North Pacific and Alaskan regions. A33D-3216. American Geophysical Union Fall Meeting, San Francisco, California, 17 December, 2014.

Partner organizations and collaborators

- Arctic Region Supercomputing Center
- Kevin Hodges at the National Center for Earth Observation in Britain. Hodges has been providing extensive support for Shippee as he further implements Hodges' TRACK storm track algorithm on NOAA's 20th Century Reanalysis.

References

Atkinson, D.E. 2005. Observed storminess patterns and trends in the circum-Arctic coastal regime. *Geo-Marine Letter*s, 25:98–109.

Hodges, K.I. 1994. A general method for tracking analysis and its application to meteorological data. *Monthly Weather Review*, 122:2573–2586.

Hodges, K.I. 1995. Feature tracking on the unit sphere. *Monthly Weather Review*, 123:3458–3465.

Hodges, K.I. 1999. Adaptive constraints for feature tracking. *Monthly Weather Review*, 127:1362–1373.

Serreze, M.C. 1995. Climatological aspects of cyclone development and decay in the Arctic. *Atmosphere–Ocean*, 33:1–23.

Serreze, M.C., J.E. Box, R.G. Barry and J.E. Walsh. 1993. Characteristics of Arctic synoptic activity, 1952–1989. *Meteorology and Atmospheric Physics*, 164:147–164.

Validation of GOES-R volcanic ash products: near real-time operational decision support/hazard analysis

Peter Webley, PI ***CIFAR theme: Coastal Hazards***
Martin Stuefer, PI
University of Alaska Fairbanks

Other investigators/professionals funded by this project:
Jonathan Dehn, Stephen McNutt, co-PIs, *University of Alaska Fairbanks*

NOAA Goal: Weather Ready Nation

CIFAR 12-028/13-028: This project is complete. NOAA Office: NESDIS, Ingrid Guch, Sponsor
It continues under NA13OAR4320056.

Primary objectives

- Produce a Weather Research & Forecasting (WRF)-Chem/Puff model-satellite comparison product for operations.
- Provide a confirmation and an assessment of Geostationary Operational Environmental Satellite – R Series (GOES-R) derived ash cloud detections and heights.
- Determine the full particle size distribution and total mass and relate to retrieved GOES-R products.
- Support development of an improved operational volcanic ash tracking product to NWS for use in Alaska and farther afield.

Research accomplishments/highlights/findings

For the past year, we continued our comparisons between satellite-derived volcanic ash retrievals and the WRF-Chem volcanic ash transport model. We continued building the capability to perform analysis with sulfur dioxide (SO_2) for volcanic eruptions. The aim of our work was to provide a systematic assessment of the merit of the volcanic WRF-Chem simulations using GOES-R like products. These methodologies will be applicable operationally where WRF-Chem model simulations for active volcanoes can be evaluated against the GOES-R AWG (Algorithm Working Group) ash retrievals from Day 1 of the GOES-R products. We can now include SO_2 products from WRF-Chem. We: (1) furthered the satellite to model comparisons for Kasatochi 2008 and Sarychev Peak 2009 eruptions; (2) continued the development of WRF-Chem for sulfur dioxide/sulfate (SO_2/ SO_4^{2-}) comparison to satellite data; and (3) improved the WRF-Chem programming code to accept volcanic activity reports without the necessity to recompile the modeling framework. This step is essential for our next step to create an automated scheme for near real-time WRF-Chem model runs. Additionally, we worked on accessing the remote sensing data that is collected locally at UAF for comparison to any WRF-Chem model simulations for the North Pacific volcanoes. This aim is to assess the modeling workflow to be able to compare to any satellite data available from NOAA and NASA satellite sensors and be ready for GOES-R Day 1.

For the SO_2 analysis, we continued WRF-Chem simulations as well as OMI (Ozone Monitoring Instrument) UV satellite retrievals. Our aim was to assess the model's capability to perform SO_2 simulations as well as the sulfur dioxide (SO_2) into sulfate (SO_4^{2-}) conversion. There is an option 2 GOES-R SO_2 product and although there is no operational required advisory for SO_2, there are cases such as Hawaii where knowledge of the erupting SO_2 and its forecasted location is important for the local NWS office to provide advice upon. WRF-Chem with the inline Numerical Weather Prediction Model (NWP) and chemistry provides a unique tool over other SO_2 forecasting tools. A publication by Egan et al. (2015) was submitted to Annals of Geophysics (title: WRF-Chem modeling of sulfur dioxide emissions originating from the 2008 eruption of Kasatochi Volcano). This was from the EGU (European Geophysical Union) session where the work was presented in April 2014. It has been reviewed and is now back with the lead author and will be sent to press in early 2015.

Figures 1 and 2, from Egan et al. (2015) show examples of the WRF-Chem results versus the satellite data in terms of spatial extent at defined timings, Figure 1, and temporally by examining a cross section through the cloud as the WRF-Chem simulates its movement and the satellite detects the SO_2, Figure 2. Examining the cross section, we see that the model has a close match to the timing of the highest satellite SO_2 column densities and the model

provides a good approximation to spatial extent of the cloud. These show how the WRF-Chem model could then be applied for modeling volcanic SO_2 for future eruptions and use the results as a potential proxy to volcanic ash.

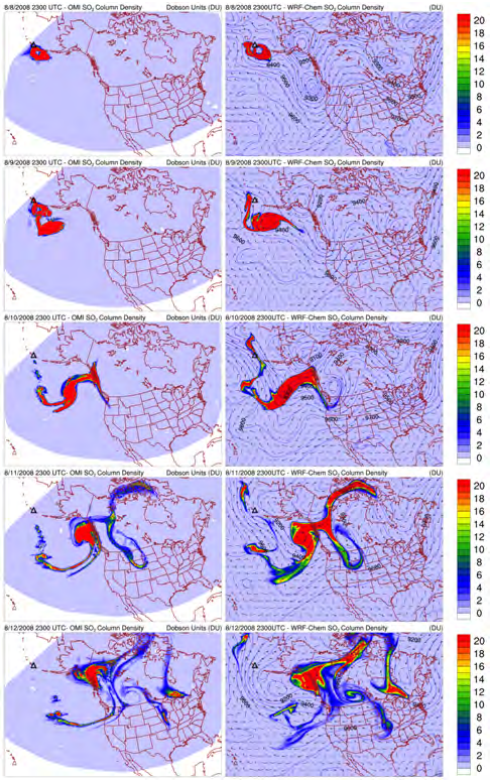

Figure 1. August 8th, 9th, 10th, 11th and 12th 2008 analysis for the Kasatochi eruption showing both from OMI (on left) and WRF (on right) SO_2 column densities. The August 10th image shows a transect, used in Figure 2, along the plume located at 145°W, adapted from Egan et al. (2015).

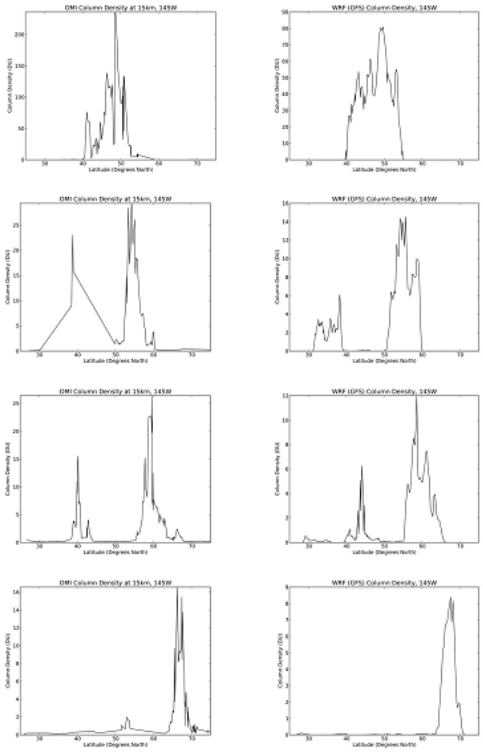

Figure 2. Cross sections on August 10, 11, 12 and 13, 2008 from transect in Figure 1. OMI (left) and WRF-Chem (right) column densities of SO_2 at 145°W from 20 to 30 °N, adapted from Egan et al. (2015).

NOAA relevance/societal benefits

GOES-R is a key element in NOAA's ongoing satellite series. We will provide a confirmation, validation and assessment of one of the GOES-R baseline products. We will provide tools to better understand the outputs of effective particle size, volcanic ash mass and height from the volcanic ash cloud detection and height algorithm.

Volcanic ash clouds are a severe event and can cause serious damage to aircraft, cause airport closures and affect human health. This project aims to provide improved hazard assessment and reduce the potential risk from volcanic eruptions.

Education

Sean Egan, Ph.D. candidate student in Environmental Chemistry. Role on Project: Comparison of WRF-Chem SO_2 simulations to satellite based retrievals using UV and thermal infrared (TIR) data, including ASTER (Advanced Spaceborne Thermal Emission & Reflection), MODIS (Moderate Resolution Imaging Spectroradiometer), OMI and AIRS (Atmospheric Infrared Sounder) data.

Publications and presentations

In review

Egan, S., M. Stuefer, P. Webley, C. Cahill and J. Dehn. 2015. WRF-Chem modeling of sulfur dioxide emissions originating from the 2008 eruption of Kasatochi Volcano. Special Issue of *Annals of Geophysics*. *In Review.*

Poster presentations

Stuefer, M., S. Egan, P. Webley, G. Grell, S. Freitas, M. Pavolonis and J. Dehn. 2014. Online-coupled modeling of volcanic ash and SO_2 dispersion with WRF-Chem. European Geophysical Union (EGU) General Assembly. Id: EGU2014-16167, 27 April–2 May 2014.

Egan, S., M. Stuefer, P. Webley, G. Grell and S. Freitas. 2014. Modeling and remote sensing of the 2008 Kasatochi eruption. European Geophysical Union (EGU) General Assembly. Id: EGU2014-16308, 27 April–2 May 2014.

Partner organizations and collaborators

Jeff Osiensky (NWS Volcanic Ash Program Manager), NWS Alaska Region, Anchorage, Alaska.

Michael Pavolonis (GOES-R Volcanic Ash Algorithm Developer), NOAA Center for Satellite Applications and Research, Advanced Satellite Products Branch, Madison, Wisconsin.

Kristine Nelson (Meteorologist in Charge), Center Weather Service Unit, NWS, Anchorage, Alaska.

Georg A. Grell (Leads development for inline WRF-chemistry model and WRF-Chem working group), NOAA Earth Systems Research Laboratory, Boulder, Colorado.

Saulo Freitas (Development of the plume emission module in WRF-Chem and collaborator on forest fire and volcanic cloud modeling with WRF-Chem), Centro de Previsão de Tempo e Estudos Climáticos (CPTEC – INPE), Brazil

Impact

Knowledge of the location and amount of volcanic ash is critical for NOAA and the NWS in their role to maintain the Anchorage and Washington Volcanic Ash Advisory Centers (VAAC). Satellite data from any volcanic ash algorithm, including the GOES-R products, can only determine the ash cloud location and mass loadings at one instant in time. Our work in this project analyzes the ash products from satellite data with products from volcanic ash transport and dispersion models.

We have shown the significance of the input parameters to the downwind concentrations and how this affects the mass loadings that are compared to the volcanic ash products. Additionally, we have shown how the cloud and plume top measurements from satellite data require both knowledge of the timing of the measurement as well as optical depth if they are to be used for the true cloud top height.

Improved tools to compare the volcanic ash products from the satellite data to the Volcanic Ash Transport and Dispersion (VATD) models will benefit the NWS in Alaska as they will be able to use them in their duties in the VAAC and in the production of their volcanic ash advisories. The tools and analysis in this project can be applied directly to the VAAC office and Alaska Meteorological Watch Office and Alaska Aviation Weather Unit.

Appendices

Appendix 1.
CIFAR Projects Awarded in Cooperative Agreement NA08OAR4320751
1 July 2008 to 30 June 2013

Last	First	Proposal Title	Project Budget	Theme Description	Funding Source	Amd #
Task 1 Activities: CI Administration and Education & Outreach						
Walsh	**John**	Regional Alaska Cooperative Institute (2008–2009)	$110,000	Administration	OAR	
Walsh	**John**	Regional Alaska Cooperative Institute (2009–2010)	$110,000	Administration	OAR	15
Walsh	**John**	Regional Alaska Cooperative Institute (2010–2011)	$110,000	Administration	OAR	20
Walsh	**John**	Regional Alaska Cooperative Institute (2011–2012)	$110,000	Administration	OAR	29
Walsh	**John**	Regional Alaska Cooperative Institute (2012–2013)	$110,000	Administration	OAR	49
Romanovsky	**Vladimir**	State of the Arctic Land Report (2008/2009)	$10,000	Climate Change & Variability	OAR	6
Romanovsky	**Vladimir**	State of the Arctic Land Report (2009/2010)	$10,000	Climate Change & Variability	OAR	17
Romanovsky	**Vladimir**	State of the Arctic Land Report (2011/2012)	$20,000	Climate Change & Variability	OAR	28
Quinn	**Terrance**	Stock assessment training stipends	$293,984	Ecosystem Studies & Forecasting	NMFS	30
Smoker	**William**	Influence on the early growth of walleye pollock (Theragra chalcogramma) in the eastern Bering Sea (Student stipend support)	$15,498	Ecosystem Studies & Forecasting	NMFS	36
NOAA Non-Competitive Projects (NA08OAR4320751)						
Atkinson	**David**	Northern Bering Sea improved hazard monitoring in the marine and coastal environments	$122,999	Coastal Hazards	NWS	16
Bluhm	**Bodil**	SOAR: Factors maintaining seabird and mammal benthic hotspots: A latitudinal analysis	$31,495	Ecosystem Studies & Forecasting	OAR	54
Hansen	**Roger**	TWEAK: Tsunami Warning & Environmental Observatory for Alaska	$953,733	Coastal Hazards	NWS	8
Hansen	**Roger**	TWEAK: Tsunami Warning & Environmental Observatory for Alaska	$891,255	Coastal Hazards	NWS	19
Hansen	**Roger**	TWEAK: Tsunami Warning & Environmental Observatory for Alaska	$554,600	Coastal Hazards	NWS	26
Hansen	**Roger**	TWEAK: Tsunami Warning & Environmental Observatory for Alaska	$628,781	Coastal Hazards	NWS	39
Hansen	**Roger**	Alaska Earthquake Information Center seismic station operations and maintenance (Alaska CRESTnet, year 1)	$288,508	Coastal Hazards	NWS	18
Hansen	**Roger**	Alaska Earthquake Information Center seismic station operations and maintenance (Alaska CRESTnet, year 2)	$290,000	Coastal Hazards	NWS	24
Hansen	**Roger**	Alaska Earthquake Information Center seismic station operations and maintenance (Alaska CRESTnet, year 3)	$350,000	Coastal Hazards	NWS	38
Hansen	**Roger**	Alaska Earthquake Information Center seismic station operations and maintenance (Alaska CRESTnet, year 4)	$276,763	Coastal Hazards	NWS	48
Heinrichs	**Thomas**	NOAA cooperative Alaska research and satellite data services	$190,000	Climate Change & Variability	NWS	14
Heinrichs	**Thomas**	High Latitude Proving Ground--GOES-R	$136,000	Climate Change & Variability	NESDIS	37
Heinrichs	**Thomas**	High Latitude Proving Ground--GOES-R	$139,769	Climate Change & Variability	NESDIS	55
Heinrichs	**Thomas**	NOAA cooperative Alaska research and satellite data services (GOES)	$354,252	Climate Change & Variability	NESDIS	35
Heinrichs	**Thomas**	NOAA cooperative Alaska research and satellite data services (GOES) Year 2A	$260,000	Climate Change & Variability	NESDIS	45
Heinrichs	**Thomas**	NOAA cooperative Alaska research and satellite data services (GOES) mod 57	$27,613	Climate Change & Variability	NESDIS	57
Heinrichs	**Thomas**	NOAA cooperative Alaska research and satellite data services (GOES) mod 58	$104,956	Climate Change & Variability	NESDIS	58
Hopcroft	**Russell**	Oceanography and lower trophic level productivity: the Seward Line 2010	$100,000	Ecosystem Studies & Forecasting	NMFS	22
Hopcroft	**Russell**	RUSALCA data management: A proposal for full featured functionality FY11–12	$199,077	Ecosystem Studies & Forecasting	OAR	32
Jewett	**Stephen**	Characterization of Bering Sea infauna	$26,443	Ecosystem Studies & Forecasting	NMFS	3
Jewett	**Stephen**	Characterization of Bering Sea infauna	$8,188	Ecosystem Studies & Forecasting	NMFS	13
Jewett	**Stephen**	Infaunal/epifaunal forage base for juvenile flatfish near Kodiak Island	$71,854	Ecosystem Studies & Forecasting	NMFS	4
Jewett	**Stephen**	Bering Sea benthic habitat and ecosystem infauna	$22,485	Ecosystem Studies & Forecasting	NMFS	44
Logan	**Tom**	Parallelization and porting of the Alaska tsunami forecast model to ARSC	$70,238	Coastal Hazards	NWS	21
Mathis	**Jeremy**	Moored observations of ocean acidification in high latitude seas	$315,000	Ecosystem Studies & Forecasting	NMFS	25
Mathis	**Jeremy**	Moored observations of ocean acidification in high latitude seas (supplemental funds)	$15,000	Ecosystem Studies & Forecasting	NMFS	40
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	2
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	12
Okkonen	**Stephen**	Bowhead whale feeding behavior in the western Beaufort Sea: Oceanographic conditions, whale prey distributions, and whale feeding and foraging behavior	$84,299	Ecosystem Studies & Forecasting	NMFS	11
Okkonen	**Stephen**	Bowhead whale feeding behavior in the western Beaufort Sea: Oceanographic conditions, whale prey distributions, and whale feeding and foraging behavior	$79,684	Ecosystem Studies & Forecasting	NMFS	23

Last	First	Proposal Title	Project Budget	Theme Description	Funding Source	Amd #
Okkonen	**Stephen**	Bowhead whale feeding behavior in the western Beaufort Sea: Oceanographic conditions, whale prey distributions, and whale feeding and foraging behavior	$96,237	Ecosystem Studies & Forecasting	NMFS	27
Okkonen	**Stephen**	Bowhead whale feeding behavior in the western Beaufort Sea: Oceanographic conditions, whale prey distributions, and whale feeding and foraging behavior	$53,102	Ecosystem Studies & Forecasting	NMFS	46
Okkonen	**Stephen**	SOAR: Influence of sea ice and oceanographic conditions and prey availability on the timing of the fall bowhead whale migration from the Canadian Arctic along the Beaufort Shelf to Barrow	$14,518	Ecosystem Studies & Forecasting	OAR	53
Okkonen	**Stephen**	SOAR: Oceanographic factors associated with bowhead whale hotspots and variation in the migration path of bowhead whales across the Chukchi Sea during the fall migration	$17,006	Ecosystem Studies & Forecasting	OAR	50
Polyakov	**Igor**	Improving predictive capabilities for the Arctic ice: International cooperative network	$183,093	Climate Change & Variability	OAR	31
Quinn	**Terrance**	Cooperative research on sablefish between TSMRI and UAF fisheries	$94,956	Ecosystem Studies & Forecasting	NMFS	34
Trainor	**Sarah**	Quarterly Alaska climate seasonal overview	$22,499	Climate Change & Variability	NWS	51
Walker	**Gregory**	Arctic small Unmanned Aircraft System (UAS) experimentation in support of NOAA FY08 Arctic objectives	$57,000	Ecosystem Studies & Forecasting	OAR	5
Walker	**Gregory**	Arctic small Unmanned Aircraft System (UAS) experimentation in support of NOAA FY09 Arctic objectives	$154,526	Ecosystem Studies & Forecasting	NMFS	10
Walker	**Greg**	UAS survey of marine debris generated by 2011 Japanese tsunami (Year 1)	$152,190	Coastal Hazards	OAR	56
Walsh	**John**	Towards a 90-day monthly storm outlook for Alaska, North Pacific and Hawaii	$15,000	Coastal Hazards	NWS	47
Webley	**Peter**	Validation of GOES-R volcanic ash products: Near real-time operational decision support/ hazard analysis	$240,000	Coastal Hazards	NESDIS	33
Webley	**Peter**	Validation of GOES-R volcanic ash products: Near real-time operational decision support/ hazard analysis (Year 2A)	$180,000	Coastal Hazards	NESDIS	43
Weingartner	**Thomas**	Marine fish survey in the Beaufort Sea Outer Continental Shelf (OCS) planning area	$82,221	Ecosystem Studies & Forecasting	NMFS	9
Weingartner	**Thomas**	Marine fish survey in the Beaufort Sea Outer Continental Shelf (OCS) planning area	$58,664	Ecosystem Studies & Forecasting	NMFS	7
Weingartner	**Tom**	SOAR: An ocean acidfication sensitivity index for the Pacific Arctic region	$51,113	Ecosystem Studies & Forecasting	OAR	52
		Total projects funded (including CI administration)	**$8,977,105**			

Appendix 2. Summary of CIFAR-funded Personnel and their Terminal Degree (or degree seeking for students)

Category	Number	unknown or none	B.A./B.S.	M.A./M.S. or M.B.A.	Ph.D
Research Scientist	13			2	11
Visiting Scientist	0				
Postdoctoral Fellow	0				
Research Support Staff	16		6	5	5
Administrative	4		1	2	1
Total (≥ 50% NOAA Support)	1				**1**
Total	33		7	9	17
Employees (< 50% NOAA Support)	32		7	9	16
Located in NOAA Lab	0				
Obtained NOAA employment within last year	0				
Undergraduate Students	0				
Graduate Students	11			6	5
Total Students	**11**	**0**	**0**	**6**	**5**

Appendix 3. Publication Activity

Summary table of publications during the current cooperative agreement

	Institute Lead Author							NOAA Lead Author							Other Lead Author						
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7
Peer-reviewed	0	1	4	6	4	12	**6**	0	0	1	1	1	1*	0	0	1	0	1	6	1	**6**
Non Peer-reviewed	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
In press							1							0							0
In review							7														

*All "in press" and "in review" publications are peer-reviewed. *Not previously reported.*

Year 1 = 1 July 2008–31 March 2009
Year 2 = 1 April 2009–31 March 2010
Year 3 = 1 April 2010–31 March 2011
Year 4 = 1 April 2011–31 March 2012
Year 5 = 1 April 2012–31 March 2013
Year 6 = 1 April 2013–31 March 2014
Year 7 = 1 April 2014–31 December 2014

***NOTE**: Besides this activity for projects funded directly by NOAA through CIFAR, **5** peer-reviewed papers were published during this reporting period by students who received CIFAR funding through the UAF Global Change Student Research Grant Competition during cooperative agreement NA08OAR4320751; 1 additional student paper has been accepted for peer-reviewed publication, 1 paper has been submitted, and a dozen more are currently in preparation.*

List of peer-reviewed papers published or in press during the reporting period
(^first author is a UAF Global Change Student Research Grant Competition awardee funded by CIFAR)

^Bender, A.M., R.C. Witter and M. Rogers. 2014. Testing the use of bulk organic ^{13}C, ^{15}N, and C_{org}:N_{tot} ratios to estimate subsidence during the 1964 great Alaska earthquake. *Quaternary Science Reviews*, available online November 2014. doi: 10.1016/j.quascirev.2014.09.031

Bieniek, P., J.E. Walsh, R.L. Thoman and U.S. Bhatt. 2014. Using climate divisions to analyze variations and trends in Alaska temperature and precipitation. *Journal of Climate*, 27(8):2800–2818. doi: 10.1175/JCLI-D-13-00342.1

Bennett, K.E. and J.E. Walsh. 2014. Spatial and temporal changes in indices on extreme temperature and precipitation for Alaska. *International Journal of Climatology*. Published online 15 July 2014. doi: 10.1002/joc.4067

Citta, J.J., L.T. Quakenbush, S.R. Okkonen, M.L. Druckenmiller, W. Maslowski, J. Clement-Kinney, J.C. George, H. Brower, R.J. Small, C.J. Ashjian, L.A. Harwood, and M.P. Heide-Jorgensen. 2014. Ecological characteristics of core-use areas used by Bering–Chukchi–Beaufort (BCB) bowhead whales, 2006–2012. *Progress in Oceanography*, available online 10 September 2014. doi: 10.1016/j.pocean.2014.08.012

^Garvin, M.R., J.P. Bielawski, L.A. Sazanov and A.J. Gharrett. 2015. Review and meta-analysis of natural selection in mitochondrial complex I in metazoans. *Journal of Zoological Systematics and Evolutionary Research*, 53(1):1–17. doi: 10.1111/jzs.12079. *Editor's Choice for this issue.*

Harris, M.W., D.J. Nicolsky, E.N. Pelinovsky and A.V. Rybkin. 2014. Runup of nonlinear long waves in trapezoidal bays: 1-D analytical theory and 2-D numerical comparisons. *Pure and Applied Geophysics*, available online December 2014. doi: 10.1007/s00024-014-1016-3.

Horrillo, J., S.T. Grilli, D. Nicolsky, V. Roeber and J. Zhang. 2014. Performance benchmarking tsunami models for NTHMP's inundation mapping activities. *Pure and Applied Geophysics,* available online July 25, 2014. doi: 10.1007/s00024-014-0891-y.

Lopez-Venegas, A., J. Horrillo, A. Pampell-Manis, V. Huerfano and A. Mercado. 2014. Advanced tsunami numerical simulations and energy considerations by use of 3D–2D coupled models: The October 11, 1918, Mona Passage tsunami. *Pure and Applied Geophysics*, available online 29 November 2014. doi: 10.1007/s00024-014-0988-3.

Maslowski, W., J. Clement Kinney, S.R. Okkonen, R. Osinski, A.F. Roberts and W.J. Williams. 2014. The large scale ocean circulation and physical processes controlling Pacific–Arctic interactions. Chapter 5 (pp. 101–132) in: J.M. Grebmeier and W. Maslowski, Eds., *The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment*. doi 10.1007/978-94-017-8863-2_5, Springer Science+Business Media Dordrecht.

Mathis, J.T., J.N. Cross, N. Monacci, R.A. Feely and P. Stabeno. 2014. Evidence of prolonged aragonite undersaturations in the bottom waters of the southern Bering Sea shelf from autonomous sensors. *Deep Sea Research II*, 109:125–133. doi: 10.1016/j.dsr2.2013.07.019

Mathis, J.T., S.R. Cooley, N. Lucey, S. Colt, J. Ekstrom, T. Hurst, C. Hauri, W. Evans, J.N. Cross and R.A. Feely. 2014. Ocean acidification risk assessment for Alaska's fishery sector. *Progress in Oceanography*, available online 18 July 2014. doi: 10.1016/j.pocean.2014.07.001

Nelson, R.J., C.J. Ashjian, B.A. Bluhm, K.E. Conlan, R.R. Gradinger, J.M. Grebmeier, V.J. Hill, R.R. Hopcroft, B.P. Hunt, H.M. Joo, D.L. Kirchman, K.N. Kosobokova, S.H. Lee, W.K.W. Li, C. Lovejoy, M. Poulin, E. Sherr and K.V. Young. 2014. Biodiversity and biogeography of the lower trophic taxa of the Pacific Arctic Region: Sensitivities to climate change. Chapter 10 (pp. 269–336) in: J.M. Grebmeier and W. Maslowski, Eds. *The Pacific Arctic Region: Ecosystem Status and Trends in a Rapidly Changing Environment*. doi: 10.1007/978-94-017-8863-2_10. Springer Science+Business Media Dordrecht.

Nicolsky D.J., E.N. Suleimani and R.D. Koehler. 2014. Tsunami Inundation Maps of Cordova and Tatitlek, Alaska. Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2014-1, 49 p. doi: 10.14509/27241.

Nicolsky D.J., E.N. Suleimani and R.D. Koehler. 2014. Tsunami Inundation Maps of Chenega Bay and northern Sawmill Bay, Alaska. Alaska Division of Geological & Geophysical Surveys, Report of Investigation 2014-3, 50p. doi:10.14509/29126

^Richar, J.I., G.H. Kruse, E. Curchitser and A.J. Hermann. 2014. Patterns in connectivity and retention of simulated Tanner crab (*Chionoecetes bairdi*) larvae in the eastern Bering Sea. *Progress in Oceanography*, available online 20 August 2014. doi: 10.1016/j.pocean.2014.08.001

^Seymour, J., L. Horstmann-Dehn and M.J. Wooller. 2014. Proportion of higher trophic-level prey in the diet of Pacific walruses (*Odobenus rosmarus divergens*). *Polar Biology*, 37:941–952. doi: 10.1007/s00300-014-1492-z

*Stewart, B.C., K.E. Kunkel, L.E. Stevens, L. Sun and J.E. Walsh. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 7. Climate of Alaska. NOAA Technical Report NESDIS 142-7. 60 pp. *[Not previously reported.]*

Suleimani, E.N., D.J. Nicolsky and R.A. Combellick. Tsunami Inundation Maps of Elfin Cove, Gustavus and Hoonah, Alaska. Alaska Division of Geological & Geophysical Surveys, Report of Investigation, in press.

^Wang, S.W., S.M. Budge, K. Iken, R.R. Gradinger, A.M. Springer and M.J. Wooller. 2015. Importance of sympagic production to Bering Sea zooplankton as revealed from fatty acid–carbon stable isotope analyses. *Marine Ecology Progress Series*, 518:31–50. doi: 10.3354/meps11076.

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