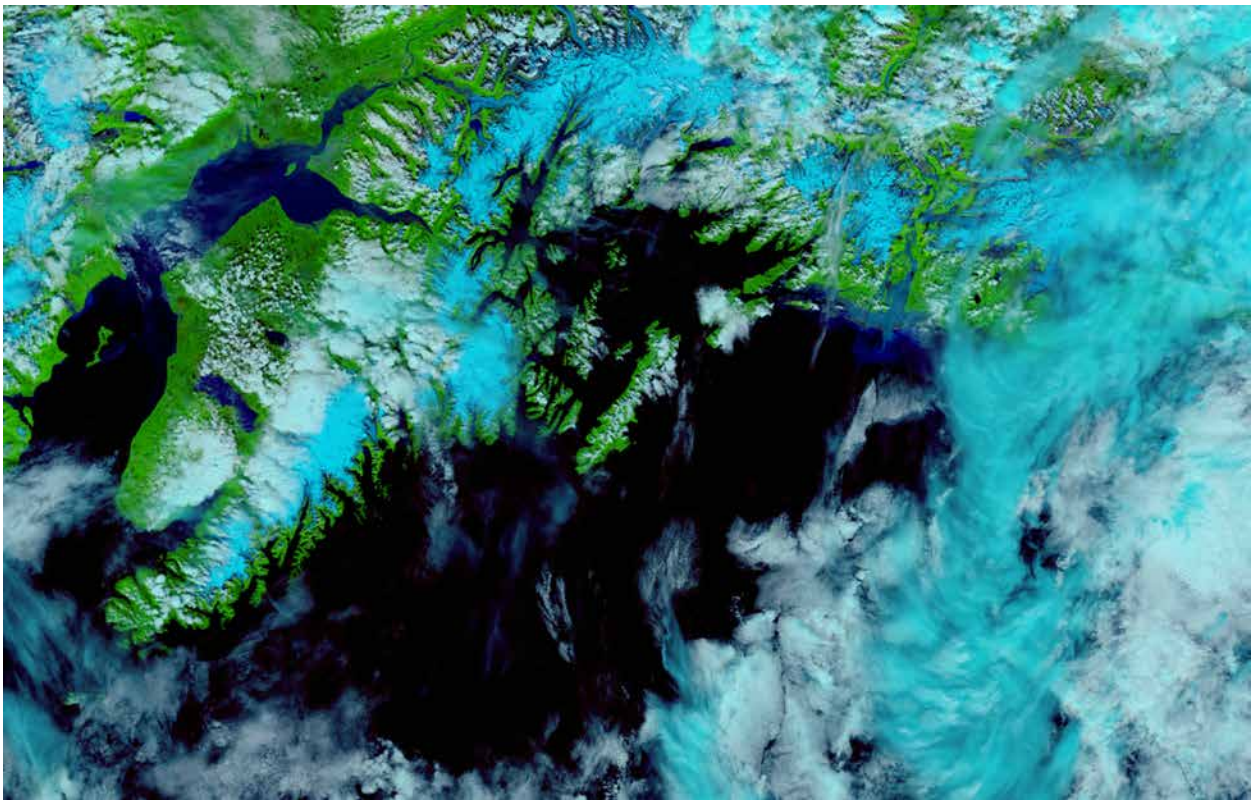
Cooperative Institute For Alaska Research

Third Report to NOAA on Cooperative Agreement NA13OAR4320056

1 April 2015 - 31 March 2016



UNIVERSITY OF ALASKA FAIRBANKS

Third report from the Cooperative Institute for Alaska Research (CIFAR) to NOAA, regarding Cooperative Agreement *NA13OAR4320056*

1 April 2015-31 March 2016

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

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

Overview

Founded in 2008, the Cooperative Institute for Alaska Research (CIFAR) conducts ecosystem and environmental research related to Alaska and its associated Arctic regions, including the Gulf of Alaska, Bering Sea, Chukchi/Beaufort Seas, and Arctic Ocean. CIFAR continues to facilitate the well-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 (retired December 2015)
Douglas DeMaster, NOAA National Marine Fisheries Service (NMFS), Director, Alaska Fisheries Science Center (AFSC)
Aimee Devaris, Regional Director, Alaska, USGS (effective November 2015)
Philip Hoffman, NOAA OAR, Office of Policy, Planning, and Evaluation
Mark Myers, Natural Resources Commissioner State of Alaska (retired March 2016)
James Partain, NOAA, NWS Regional Climate Director for Alaska

The ***CIFAR Fellows*** are:

1. Larry Hinzman, University of Alaska Fairbanks (UAF), Vice Chancellor for Research
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. Denby Lloyd, Executive Director, North Pacific Research Board, Anchorage, AK
9. Molly McCammon, Director, Alaska Ocean Observing System, Anchorage, AK

10. Jeremy Mathis, Director for the Arctic Research Program within the Climate Observation Division NOAA (effective July 2015)
11. Phil Mundy, Division director, Auke Bay Laboratory, AFSC, NMFS, NOAA, Juneau, AK
12. James Overland, Oceanographer, PMEL, NOAA, Seattle, WA
13. Carven Scott, Acting Regional Director, NWS, NOAA, Anchorage, AK (effective November 2015)
14. Terry Whitledge, Professor of Biological Oceanography, IMS, SFOS, UAF, Fairbanks, AK

Summary of Awards Made during Reporting Period

During the third reporting year of our renewal cooperative agreement NA13OAR4320056, NOAA provided two amendments to the CIFAR renewal agreement for CIFAR core administration, one Task I education and outreach amendment, one Task II and eleven Task III research awards totaling over $1.2M. A full list of CIFAR awards made during the reporting period is presented in Appendix 1.

Summaries of CIFAR awards funded this reporting period by task/theme are shown in Table 1. Table 2 shows the distribution of CIFAR Task II & III projects (percentage of total) by NOAA line office.

Table 1: Summary of CIFAR Awards Funded 1 April 2015-31 March 2016: by Task and Theme

Theme	Number of Awards	Total Amount	Subtotals by Task	Percent of Total (rounded)
Administration (Task I)	**3**		**$220,861**	**15.5%**
Core Support	2	$121,427		
Education & Outreach	1	$99,434		
Research Themes (Task II & III)	**11**		**$1,207,690**	**84.5%**
Climate Change & Variability	2	$302,473		21.2%
Coastal Hazards	3	$538,224		37.7%
Ecosystem Studies & Forecasting	6	$366,993		25.7%
Total	**14**		**$1,428,551**	**100.0%**

Table 2: Summary of CIFAR Task II & III Awards Made 1 April 2015-31 March 2016: by Funding Source

Funding Source	Number of Awards	Total Amount	Percent of Total	% of Task I "tax" paid
OAR	4.6	$310,312	25.7%	22.7%
NESDIS	3.2	$520,672	43.1%	32.2%
NWS	1	$240,025	19.9%	12.5%
NMFS	2	$116,681	9.7%	15.3%
NOS	0.2	$20,000	1.7%	1.5%
CPO	0	$-	0.0%	15.8%
Total	**11**	**$1,207,690**	**100.0%**	

During the current reporting year, the funding of Task I core administration support for CIFAR was billed to line offices based upon funding in Year 2 (amendment 40), as well as the application of the Task 1 recovery policy (amendment 45). CIFAR's Task 1 recovery is 8.9%.

Highlights from CIFAR Task I Activities

Core Administration

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 four UAF employees, three of whom also have appointments in various other departments: Uma Bhatt, director; Nancy Fresco, associate director; Sarah Garcia, CIFAR administrator; and Nate Bauer, publications manager. The previous director and publications manager left CIFAR in June 2015. During this reporting period, the CIFAR staff work load was:

- Uma Bhatt, CIFAR director, 15.9% FTE (match)
- Nancy Fresco, CIFAR associate director, 0.0% FTE (match)
- Sarah Garcia, CIFAR administrator, 62.5% FTE (Task I and match)
- Nate Bauer, publications manager, less than 1% FTE (match)

Uma Bhatt provides overall CIFAR programmatic guidance and oversees daily operations. She is responsible for approving all CIFAR proposals and overseeing reporting obligations.

Education and Outreach

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 continues to emphasize 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 link 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 shown in bold face in the summary below.

Global Change Student Research Program (Graduate and Undergraduate Support)

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.

A proposal review panel met on 3 April 2015 and recommended full or partial funding of 13 projects for awards running from 1 July 2015 to 30 June 2016. Six of these awards were funded with CIFAR match education funds.

The students and their FY16 CIFAR projects are listed here:

- **Doug Brinkerhoff**, Department of Geosciences, UAF
  "Towards developing a sliding law for the tidewater glacier cycle."
- **Patrick Charapata**, School of Fisheries & Ocean Sciences, UAF
  "Using the past to give insight into the future: Pacific walrus diet and stress response in a changing environment using bone and teeth."
- **Brandon Hassett**, School of Fisheries and Ocean Sciences, UAF
  "Sea ice microbial eukaryotes: baseline studies to compare and predict future change."
- **Ilona Kemp-Noordeloos**, Department of Anthropology, UAF
  "Economic globalization and its effects on the local economy, social structure and identity of the coastal Yup'ik village of Togiak, Alaska."
- **Deanna Leonard**, School of Fisheries and Ocean Sciences, UAF
  "Late summer distribution of bowhead whales in the Canadian Beaufort Sea: Environmental correlates and predicting future habitat use."

- **Jenna Zechmann**, Department of Geosciences, UAF
  "A seismic reflection study to characterize yearly and seasonal changes in sediments beneath Taku Glacier, Southeast Alaska."

Student Support through Individual Awards

Two graduate students, funded through CIFAR RUSALCA projects, completed their graduate degrees (Ph.D. in Marine Biology for Elizaveta Ershova; M.S. in Marine Biology for Carlos Serratos) during the reporting period and both received more than 50% of their support from NOAA. In addition, three undergraduate students and five other graduate students received salary support through CIFAR.

Other CIFAR Administrative Activities

In July 2015, Uma Bhatt was appointed director of CIFAR as Susan Sugai retired. At this time, the Center for Global Change (CGC) was moved under the University of Alaska Provost's office to administer the Global Change Student Research Grant Competition. CIFAR director Bhatt has worked closely with the CGC staff, Barbara Hameister and Mike Castellini (Associate Dean UAF Graduate School) to hold the 2016 CGC student grant competition.

With the administrative changes in CIFAR, there were no meetings during the reporting period with the CIFAR Executive Board and CIFAR fellows. Numerous board members and fellows have retired and changed positions so it is a priority to update this list and replace retired members to align with the scientific needs of NOAA and CIFAR as well as new funding opportunities.

Highlights of CIFAR Research Activities

CIFAR's modest research portfolio has a high impact through its focus on observational monitoring of key environmental parameters and through the development of operational products that serve NOAAs mission in Alaska. Training students is a key focus of CIFAR as part of workforce development and students are highlighted in boldface. Not only have CIFAR-funded students authored peer-reviewed publications in highly regarded journals; their research has also contributed to NOAA operations on a near real-time basis.

Ecosystem Studies and Forecasting

CIFAR PI Jessica Cross is working with the Innovative Technology for Arctic Exploration program at NOAA-PMEL to develop new mission capabilities for Arctic Regions. In 2015, the program tested the Saildrone, a novel autonomous surface vehicle, a new platform with many advantages. It has a high payload capacity that can house many sensors necessary for investigating a complex environment. The Saildrone can move at a faster speed than other current commercial platforms, meaning that it can cover an extremely large territory (this year, we transited through the entire Bering Sea shelf and back). This specially designed vehicle capably handled harsh conditions in the Bering Sea, including cold temperatures, high winds (up to 46 kts last year), and potential biofouling (e.g., jellyfish). Dockside deployment and recovery also reduces the cost of Saildrone missions. The inaugural 2015 field mission confirmed that the Saildrone collects data quality similar to ships and moored platforms. The team is currently working to add carbon sensors and active and passive acoustic devices to further the Saildrone's capacity to collect integrated environmental intelligence in future missions.

PIs Katrin Iken and Bodil Bluhm now have three years of data documenting the epibenthic community structure from the RUSALCA project in the Chukchi Sea. The data suggest that the epibenthic community structure is relatively stable despite differences in abundance and biomass in some species. This indicates that the benthic system is not responding to short-term changes in environmental conditions. For example, a single warm year, or one with low primary production, the benthic community does not respond quickly because responses are buffered by the very long life spans on the order of decades. However, should environmental changes happen on a more permanent basis, then the benthic community will show this as it is clearly structured by the prevalent environmental conditions. This makes benthic communities especially good indicators for long-term changes, such as from climate changes, because they factor out the short-term environmental variability that happens naturally from year to year.

Climate Change and Variability

Geology and Geophysics M.S. student **Jenna Zechmann** used the CGC support to perform an active seismic survey at Taku Glacier during the summer of 2015. They used small explosions to generate waves in the ice, and used seismographs to record reflections returning from the glacier bed. The amplitudes and polarity of these reflected waves suggest that the glacier overlies a soft, saturated sediment layer that allows the glacier to slide quickly. They plan to repeat this survey in March, to see if the sediment water content might decrease in the wintertime. In a related project Geology and Geophysics M.S. student **Doug Brinkerhoff** used CGC support to assemble 5 arrays of instruments known as inclinometers. The inclinometers work by measuring the strength of gravity in three directions and as the orientation of the inclinometers changes over time it measures the glacier's stress field. Combining the stress measurement with contemporaneous measurements of water pressure using the seismographs discussed above will advance our knowledge of how the Taku Glacier will change over time in response to changes in climate.

PI Thomas Heinrichs leads a collaborative team at Geographic Information Network of Alaska (GINA) to deliver additional polar orbiting satellite imagery for use by NOAA/NWS in Alaska. This was facilitated by the installation of a second direct broadcast antenna outside of Fairbanks, which makes accessible additional data from more satellites readily available for preparing products. Through upgrades in the processing hardware the data is now converted into imagery faster, further reducing the already-low latency in delivering products to the NWS in Alaska for use in making weather forecasts and warnings.

Coastal Hazards

Sean Egan, a Ph.D. candidate in environmental chemistry, has contributed to two CIFAR projects (PI Peter Webley and PI Martin Stueffer) by comparing WRF-Chem volcanic ash transport modeling to GOES-R volcanic ash retrievals. This research provides a critical evaluation of GOES-R baseline products and contributes to improved hazard assessment to reduce the potential risk from volcanic eruptions. The suite of tools has begun to incorporate the Rapid Refresh (RAP) model to improve volcanic ash hazard awareness and the communication of volcanic alerts.

The Alaska Earthquake Center (AEC) reported 36,128 events with magnitudes ranging between -1.2 and 7.1 and depths between 0 and 271 km over the reporting period. PI Michael West has CIFAR support to maintain and upgrade seismic stations in Alaska and to ensure data flow from select stations to the NTWC. In July 2015 they completed the last remaining digital upgrade by replacing the original sensors and digitizer at UNV with new, AEC-purchased instruments and by upgrading the analog phone line to a DSL circuit. Through partnering with EarthScope, AEC has provided new instruments at several sites, as well as critical instrument replacements for ensuring uninterrupted monitoring of earthquake hazards.

Publications and Presentations

In this last reporting period, there are 11 peer-reviewed completed publications, one publication at the stage of revision and three publications in preparation where three publications are first authored by students. A total of 47 conference presentations (both national and international) were reported for the period 1 April 2015–31 March 2016**.**

Task I: AMBON Traineeships

Arctic Marine Biodiversity Observing Network (AMBON) student traineeships

Katrin Iken, PI
University of Alaska Fairbanks

CIFAR theme: Ecosystem studies and forecasting

NOAA Goal: Healthy Oceans

Amendments 30, 35

NOAA Office NOS; Gabrielle Canonico, Sponsor

Primary objectives

This proposal is for funding two Ph.D. graduate students whose research will be aligned with the Arctic Marine Biodiversity Observing Network (AMBON) for a period of 4 years. One student will be working on benthic communities and also will provide program management for AMBON. The other PhD student will work on the genetic analysis of microbes, small plankton and meiofauna.

Both of these students will be receiving education, research, and outreach experience in this 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. These students will be mentored by the multi-national, multi-institutional, multi-agency collaborators who form the AMBON principal investigators.

This effort, led by Katrin Iken at UAF, will provide these students with a unique opportunity to acquire research training as part of a 5-year research program covering two field seasons in an understudied marine environment that is subject to rapid climatic and resource management challenges. As a part of the AMBON/CIFAR graduate student traineeships, these students will gain education and training that will be valuable to NOAA's strategic needs in both climate services and ocean resource management, and continues CIFAR's priority on graduate student education and outreach.

Research accomplishments/highlights/findings

The PhD student for the benthic community and food web portion of the project, **Ann-Christine Zinkann**, started in April 2015 in the Marine Biology degree program at the School of Fisheries and Ocean Sciences. Ann previously completed her M.S. degree at the University of Hamburg, Germany. She has since worked on her PhD student proposal that is part of the degree requirement, has completed required coursework, and participated in the AMBON research cruise in August 2015. She collaborated and interacted with the multidisciplinary groups during the cruise and learned new sampling techniques and conceptual framework ideas in oceanographic and Arctic science. During the cruise, she also collected samples that will be available for the specific and innovative research questions to be answered through her PhD work. This work revolves around the contribution of microbial carbon processing as part of benthic food webs in the Chukchi Sea. This topic builds on the AMBON food web objective but presents a significant extension in scope of that objective, including new, innovative analysis techniques (amino acid-specific stable isotope analysis and fingerprinting) that she will apply and refine for her project. Ann is making good progress.

A student for the microbial portion, **Esty Willcox,** started in fall 2014. She was involved and learned new techniques in DNA extraction and PCR amplification of samples from AMBON. She collaborated with student **Brian Ulaski**, who also helped process AMBON samples and is currently working with additional samples and the resulting data as part of his M.S. thesis. Some of these samples have recently been analyzed by small subunit ribosomal RNA gene sequencing for Bacteria and Eukarya. After the fall semester, however, Esty Willcox decided that this was not the type of work she wanted to do and she changed her project and is no longer supported by the AMBON traineeship. We are currently actively seeking a new student to take into this traineeship program in the fall 2016.

NOAA relevance/societal benefits

AMBON will provide information on ecosystem components that are currently not part of long-term observation programs in the Chukchi Sea, namely the microbial and other small size fractions, the epifauna and fish components, and functional diversity through food webs. Through integration with other programs such as the Distributed Biological Observatory (DBO;), this benefits our larger Arctic ecosystem understanding and will improve our detection of biodiversity trends and changes. The AMBON will increase our ability to forecast possible changes, which will be useful to inform the various audiences, from managers to scientists. Through this educational effort, two students will develop their dissertation research with direct involvement of multi-national, multi-institutional, multi-agency researchers.

Partner organizations and collaborators

In addition to NOAA, funders include the Bureau of Ocean Energy Management (BOEM) and the Shell Exploration and Production Company. Besides UAF, AMBON collaborators are from the University of Maryland Center for Environmental Science, the University of Washington Applied Physics Lab, the U.S. Fish and Wildlife Service, NOAA, and the Alaska Ocean Observing System.

Impact

This project will accomplish two major goals: (1) training for two graduate students, (2) innovative thesis research that will improve our knowledge of the biodiversity of the U.S. Chukchi Sea continental shelf.

Non-competitive projects, by CIFAR theme:

Ecosystem Studies and Forecasting
Including RUSALCA (Russian-American Long-term Census of the Arctic) projects

Climate Change and Variability

Coastal Hazards

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

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

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

During the reporting period, RUSALCA efforts were focused primarily on data analysis and synthesis with limited analyses of additional samples collected from mooring cruises.

Goals of the overall RUSALCA program

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

Project reports for CIFAR awards associated with the RUSALCA program follow this overview, and reflect current synthesis efforts.

A synthesis of long-term observations of Pacific-Arctic zooplankton communities

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

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

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Amendments 14, 36 NOAA Office: OAR-CPO, Kathleen Crane, Sponsor

Primary objectives

Conduct a synthesis of recent zooplankton observations in the Chukchi Sea and over the past 30–50 years, specifically tackling the question: Can a climate change signal be detected for zooplankton in terms of major species or community structure? A key component of this analysis will be observations collected by the Russian-American Long-term Census of the Arctic (RUSALCA) program, and its precursor, the Bering Pacific (BERPAC) program. Additional information will be drawn from agencies, industry, and international scientists working in the Chukchi region.

Research accomplishments/highlights

The paper summarizing the zooplankton communities of the 3 primary RUSALCA cruises (plus a mooring cruise) has been published. The paper lead by Pisareva exploring the connections between physics and biology has also been published. Within the same special issue, we have published on long-term changes in the distribution of zooplankton species/communities in the Chukchi Sea over the last 60 years. It reveals there has been an overall increase in zooplankton biomass over this period. Ershova has just completed the draft of her third manuscript on Pseudocalanus copepods in the Chukchi Sea to be submitted to Journal of Plankton Research.

Work continues on consolidating and unifying existing planktonic data sets throughout the arctic. Hopcroft continues to participate in the Plankton Experts group for CBMP. He presented a preliminary analysis of patterns on arctic shelves at Arctic Science Summit week in Toyama Japan in April 2015.

NOAA relevance/societal benefits

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

Education

Elizaveta Ershova recently defended her Ph.D. under this project – she will be returning to Shirshov Institute, Moscow during May to translate her dissertation into Russian, and defend it there during fall 2016.

Outreach

Hopcroft, through ArcOD (Arctic Ocean Biodiversity Project) website, continues to develop webpages providing information on Arctic zooplankton and access to historical datasets: see http://www.arcodiv.org/. The species page concept has been expanded upon through a related fellowship by the Encyclopedia of Life to Ershova, that will be merged with ArcOD content over time. The ArcOD website has received over 1.1 million page loads since its development in 2008.

Publications, conference papers, and presentations

Ershova EA, Hopcroft RR, Kosobokova KN, Matsuno K, Nelson RJ, Yamaguchi A, Eisner LB (2015) Long-term changes in summer zooplankton communities of the western Chukchi Sea, 1945-2012. Oceanography 28:100-115

Ershova EH, Hopcroft RR, Kosobokova KN (2015) Inter-annual variability of summer mesozooplankton communities of the western Chukchi Sea: 2004-2012. Polar Biol 38:1461-1481

Pisareva MN, Pickart RS, Iken K, Ershova EA, Grebmeier JM, Cooper LW, Bluhm BA, Nobre C, Hopcroft RR, Hu H, Wang J, Ashjian CJ, Kosobokova XN, Whitledge TE (2015) Patterns of Benthic Fauna and Zooplankton in the Chukchi Sea in Relation to the Physical Forcing. Prog Oceanogr 28:68-83

Wassmann P, Kosobokova KN, Slagstad D, Drinkwater K, Hopcroft RR, Moore SE, Ellingsen I, Nelson RJ, Popova E, Berge J, Carmack E (2015) The contiguous domains of Arctic Ocean advection: trails of life and death Prog Oceanogr 139:42-65

Conference presentation

Hopcroft RR, Kosobokova N K, Ershova EA, Questel JM, Smoot CS (2015) Zooplankton communities on arctic shelves: a panarctic analysis of faunal regions. Fourth International Symposium on Arctic Research, Toyama, Japan

Ershova EA, Hopcroft RR, Kosobokova NK (2016) Long-term changes in the summer zooplankton communities of the western Chukchi Sea. Alaska Marine Science Symposium, Anchorage, AK

Other products and outcomes

Hopcroft continues to work with NOAA and the Circumpolar Biodiversity Monitoring Program (CBMP) under the International Arctic Council within which the RUSALCA program will represent a significant component from the USA. Hopcroft also provides oversight on the RUSALCA data management project that is aggregating data at pan-arctic scales.

Partner organizations and collaborators

Arctic Ocean Biodiversity Project (ArcOD)

Circumpolar Biodiversity Monitoring Program (CBMP)

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

Katrin Iken, PI ***CIFAR theme(s): Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

Bodil Bluhm, PI
University of Alaska Fairbanks, University of Tromso, Norway

Other investigators/professionals associated with this project (w/affiliation):
Ken Dunton, University of Texas at Austin

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Amendments 3, 27 NOAA Office: OAR-CPO, K. Crane, Sponsor
NCE until 31 December 2016

Primary objectives

Synthesize information on food web structure and epibenthic faunal assemblages in the Chukchi Sea including their links to the physical and chemical properties of water mass characteristics. This synthesis will build on data collected during RUSALCA cruises in 2004, 2009, and 2012.

Provide an assessment of the temporal variability in the benthic food web and epibenthic community structure in relation to climatic variability.

Research Accomplishments/highlights

We have completed the work on epibenthic community structure and this work is part of the MS thesis of student Carlos Serratos. A manuscript has been submitted to the journal Arctic. We have received reviews on the manuscript and are in the process to address the comments for the submission of a revised version. Specific results of the thesis were presented already during the last report.

We have also completed the analysis of the stable isotope data for food web structure comparisons and this work is part of the completed MS thesis of student Carlos Serratos. Specific results were presented during the last report.

We included data from our epibenthic work in two recent synthesis publications, in the special issue of Oceanography:

Grebmeier JM, Bluhm BA, Cooper LW, Denisenko SG, Iken K, Kedra M, Serratos C (2015) Time-series benthic community composition and biomass and associated environmental characteristics in the Chukchi Sea during the RUSALCA 2004–2012 Program. Oceanography 28: 116-133. http://dx.doi.org/10.5670/oceanog.2015.61

Pisareva MN, Pickart RS, Iken K, Ershova EA, Grebmeier JM, Cooper LW, Bluhm BA, Nobre C, Hopcroft RR, Hu H, Wang J, Ashjian CJ, Kosobokova KN, Whitledge TE (2015) The relationship between patterns of benthic fauna and zooplankton in the Chukchi Sea and physical forcing. Oceanography 28: 68-83. http://dx.doi.org/10.5670/oceanog.2015.58

Snow crab samples from the RUSALCA cruises contributed to an additional manuscript:

Divine LM, Bluhm BA, Mueter FJ, Iken K (2015) Diet analysis of Alaska Arctic snow crabs (Chionoecetes opilio) using stomach contents and δ13C and δ15N stable isotopes. Deep-Sea Res II. http://dx.doi.org/10.1016/j.dsr2.2015.11.009

We have requested and were granted a no-cost extension for the remaining funds to pay partial stipend and tuition for a new student to use the RUSALCA epifauna community data and re-analyze these data in the context of

functional groups and functional diversity. The student has been recruited (**Lauren Sutton**) and will start this work in the fall semester 2016 (September 2016). This work will expand on our previous work on epibenthic community structure and diversity based on taxonomic affiliations. Here, we will assign taxa a functional group based on feeding mode, mobility, reproductive mode, size, etc and assess whether diversity and community structure patterns differ from classical taxonomic analyses. Such an approach is informative to better assess the ecosystem functions being supplied by the epibenthic community rather than simply using taxonomic associations. This work will include the temporal comparison of the project objectives.

NOAA relevance/societal benefits

This work contributes to NOAA's strategic plan objective "to describe and understand the state of the climate system through integrated observations" of the biological components and the associated water mass characteristics. Increased knowledge of food web connections and epibenthic communities over the RUSALCA project study time is essential information to "understand the consequences of climate variability and changes" in the Chukchi Sea marine ecosystem. This work provides NOAA with a product that can assist to "improve society's ability to plan and respond to climate variability." Knowledge gained during the RUSALCA work has contributed to the development of the Circumpolar Biodiversity Monitoring Program (CBMP) Implementation Plan and is part of the currently developed State of the Arctic Marine Biodiversity Report (SAMBR).

Education

Graduate student **Carlos Serratos** has completed his M.S. degree in Marine Biology in fall 2015. His thesis work compared epifaunal community and food web structures for the southern and central Chukchi Sea from 2004, 2009 and 2012. A publication on part of his work is in revision.

A new student starting in the fall 2016 in the M.S. Marine Biology degree program will make use of the epibenthic community data and perform a functional trait analysis to assess diversity patterns based on ecosystem functions rather than taxonomy. Remaining funds of this project will be used for this purpose.

Outreach

Photographs from the RUSALCA expeditions have been used in a variety of educational and scientific materials. PI Iken performs regular touch tank exhibits for K-12 students with Alaskan marine invertebrates to educate them about marine life, threats to marine life and ecosystem functioning, and the need for long-term scientific monitoring.

Publications and presentations

Publications

Grebmeier JM, Bluhm BA, Cooper LW, Denisenko SG, Iken K, Kedra M, Serratos C (2015) Time-series benthic community composition and biomass and associated environmental characteristics in the Chukchi Sea during the RUSALCA 2004–2012 Program. Oceanography 28: 116-133. http://dx.doi.org/10.5670/oceanog.2015.61

Pisareva MN, Pickart RS, Iken K, Ershova EA, Grebmeier JM, Cooper LW, Bluhm BA, Nobre C, Hopcroft RR, Hu H, Wang J, Ashjian CJ, Kosobokova KN, Whitledge TE (2015) The relationship between patterns of benthic fauna and zooplankton in the Chukchi Sea and physical forcing. Oceanography 28: 68-83. http://dx.doi.org/10.5670/oceanog.2015.58

Divine LM, Bluhm BA, Mueter FJ, Iken K (2015) Diet analysis of Alaska Arctic snow crabs (Chionoecetes opilio) using stomach contents and δ13C and δ15N stable isotopes. Deep-Sea Res II. http://dx.doi.org/10.1016/j.dsr2.2015.11.009 (This paper includes RUSALCA crab data)

Serratos C, Bluhm BA, Iken K. Epibenthic community structure on the southern and eastern Chukchi Sea shelf. In revision with Arctic

Presentations at conferences

Divine LM, Mueter FJ, Kruse GH, Bluhm BA, Iken K. New estimates of growth, size-at-maturity, mortality and biomass of snow crab, Chionoecetes opilio, in the Arctic Ocean off Alaska. Alaska Marine Science Symposium, Anchorage AK, 25-28 January 2016, Poster (This poster included RUSALCA crab data)

Schollmeier T, Iken K, Wooller MJ. Characterizing the carbon isotopic composition of dissolved inorganic carbon in sea ice pore water as a carbon source for sea ice algae in the Arctic. Alaska Marine Science Symposium, Anchorage AK, 25-28 January 2016, Poster (This poster included RUSALCA crab data)

Schollmeier T, Iken K, Wooller MJ. Characterizing the carbon isotopic composition of dissolved inorganic carbon in sea ice pore water as a carbon source for sea ice algae in the Arctic. Ocean Sciences Meeting, New Orleans 21-26 February 2016, Poster (This poster included RUSALCA crab data)

Partner organizations and collaborators

Iken (lead PI) and Bluhm are part of the newly funded AMBON (Arctic Marine Biodiversity Observing Network) project, which builds heavily on RUSALCA and aims to maintain the time series stations in the southern Chukchi Sea (US side only) and adds to the RUSALCA coverage by adding investigations on the northeastern Chukchi shelf. Both PIs have recently been working on snow crab population and reproductive dynamics in the Chukchi and Beaufort Seas (CMI-funded, BOEM-funded as part of Arctic EIS project), which ties together with RUSALCA epifaunal community and food web structure objectives and sampling. The connection of these projects with RUSALCA has led so several presentations and publications. Both PIs also are part of the US-Canada Transboundary project funded through BOEM that investigates epifaunal community and benthic food web structure in the Beaufort Sea in an effort paralleling our RUSALCA objectives. Bluhm was also a co-PI on the recent NPRB-funded Pacific Arctic Marine Regional Synthesis (PacMARS) project that aggregated and synthesized research across multiple disciplines in the northern Bering, Chukchi and Beaufort Seas including RUSALCA efforts.

Iken and Bluhm are members of the Marine Expert Monitoring Group of the Circumpolar Biodiversity Monitoring Program, one of the programs under the directive of CAFF (Arctic Council Conservation of Arctic Flora and Fauna), where the RUSALCA program features strongly in monitoring efforts in the Chukchi Sea region.

Under North Pacific Research Board (NPRB) and Norwegian funding, Bluhm is working with Russian collaborators (several of which are involved in RUSALCA) on editing English versions of Russian-authored taxonomic identification keys for Arctic fauna in an effort to both provide better access to identification material and uniform identifications between Russian and western Arctic researchers. An online photo ID catalogue also is part of the AMBON project objectives and pictures and identifications done during RUUSALCA are part of this effort.

Publications related to this project, funded under previous cooperative agreements:

See above – since all recent publications include time series data, these publications include data from pervious RUSALCA awards

Continuation of RUSALCA fish ecology research

Brenda L. Norcross, PI ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

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

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Amendments 1, 24 NOAA Office: OAR-CPO, Kathleen Crane, Sponsor
Continues research from NA08OAR4320870

Primary objectives

To synthesize and publish results of the fish ecology investigations of larval and demersal fishes during the 2004, 2009, and 2012 cruises of the Russian-American Long-term Census of the Arctic (RUSALCA) to provide for better understanding of fish distribution, abundance, and demersal species associations in the present-day Chukchi Sea.

Planned publications will also incorporate data from the extensive fish surveys we have conducted in the eastern Chukchi Sea from 2007 to 2010 under non-RUSALCA funding.

Research accomplishments/highlights/findings

During the past year efforts were concentrated on publishing a manuscript that underwent four extensive reviews. The result is a well-crafted piece of literature that is available online and will be part of a special publication on various aspects of fish otoliths. Being in that volume will ensure that the article read by the focus community of scientists. Christine Gleason, who received her M.S. Fisheries Oceanography degree under Norcross in 2012, developed her thesis research based on specimens she collected during the 2009 RUSALCA cruise, thus is a lead author on this publication.

Gleason, C.M., B.L. Norcross, K.J. Spaleta. In press 2016. Otolith chemistry discriminates water mass occupancy of Arctic fishes in the Chukchi Sea. Marine and Freshwater Research. Published online 24 Nov 2015, http://dx.doi.org/10.1071/MF15084

The microchemistry of otoliths has the potential to reconstruct fish movement patterns and habitat use between environmentally different habitats for individual age classes of Arctic marine fish. Herein, we tested the relationship between the bottom water mass from which a fish was collected and the microchemistry of the most recent growth edge of the fish's otolith using Mg, Sr, Ba and Ca, and then determined the physical and biological factors that affected the chemical signatures. A discriminant function post hoc analysis of fish occupying bottom water masses resulted in 76% correct classification of Arctic or Polar cod (Boreogadus saida) and 82% correct classification of Arctic staghorn sculpin (Gymnocanthus tricuspis) into bottom water masses of capture when ages were pooled. By separating age classes, correct classifications into water masses of capture were as high as 87% for Arctic cod (three water masses) and 90% for Arctic staghorn sculpin (two water masses). Otolith Ba:Ca, Mg:Ca and Sr:Ca ratios were most consistently affected by bottom water temperature; the latter two were also affected by fish age and fish length. The use of otolith microchemistry to determine occupancy of water masses over time is most promising for Arctic cod, which is widespread and occupies the most thermally diverse habitats in Arctic waters.

Although we have other manuscripts drafted, none of them are yet ready to be submitted to journal.

We corresponded, spoke with, and met with Co-Investigator Morgan Busby over the past year regarding reanalysis and revisions of the following manuscript. Busby, Holladay, Norcross, Mier. Ichthyoplankton of the Chukchi Sea 2004–2012: Russian-American Long-Term Census of the Arctic. This includes 2004, 2009, and 2012 RUSALCA cruises. Several iterations of this paper have been shared among the investigators, and we plan to submit this to a journal such as Polar Biology during the next year.

The significant findings are as follows: Larval fish species, number, size and location are strongly related to timing of cruise as well as cruise track. The timing of the cruises ranged from early August in 2004 to late September in 2009, with the 2012 occurring between those times. More larval/juvenile fish were captured in bongo plankton nets when sampling was early in the ice-free season. For example, abundance of Arctic Cod was greatest in 2004 and lowest in 2009; mean standard length was greater in September 2009 than in August 2004 or 30 August 2012. Diversity of ichthyoplankton was significantly greater in 2004 than 2009. We conclude that most larval fish grew beyond the size normally captured in bongo nets or may have settled out of the water column. Because we now know what to expect, more than one gear type may be needed in future to be appropriate to size of ichthyoplankton anticipated.

We discussed iterations of this epibenthos–fish ecosystem paper with the lead author, but substantial progress was not made. Bluhm, Holladay, Huettmann, Iken, Norcross, Sirenko. Interactions of epibenthic invertebrates and fish community structure in the Chukchi Sea. This includes field collections from 2004, 2009 and 2012 RUSALCA cruises, 2007 and 2008 Japanese R/V Oshoro-Maru cruises and a 2007 NOAA Bering-Aleutian Salmon International Survey (BASIS) cruise. A preliminary draft of this manuscript has been written and several iterations have been passed among the authors. We expect to submit to a journal during the coming year.

The significant findings include: fish to epifauna biomass ratios may be a useful indicator of carbon flow patterns and ecosystem conditions that is worth monitoring over time.

Two drafts of this manuscript have been circulated, but substantial progress was not made this year. Holladay, Chernova, Mecklenburg, Norcross, Voronina. Working title: Spatial and temporal variability in fish communities of the Chukchi Sea, 2004–2012. This includes 2004, 2009, and 2012 RUSALCA cruises. We expect to submit this to a journal such as Polar Biology during the next year.

Significant findings include: The basic content of dominant species in communities was stable. The list of five most common and numerous fishes was the same over years. No dramatic changes in fish fauna of the Chukchi Sea were detected during the years 2004–2012.

NOAA relevance/societal benefits

This project adds to the coordinated RUSALCA effort of identifying factors that underlie ecosystem change in the Arctic. Our research develops a broad-scale baseline of abundance and distribution of larval and demersal fishes throughout the Chukchi Sea and identifies the physical mechanisms affecting fish distribution, thereby directly supporting the RUSALCA objective of developing methods of identifying ecosystem change. Also through this research we tested methods to use trace elements to determine association of fish and their environment, with the potential for determining movement of fish in the Chukchi Sea.

Publications, conference papers, and presentations

Publication

Gleason, C.M., B.L. Norcross, K.J. Spaleta. In press 2016. Otolith chemistry discriminates water mass occupancy of Arctic fishes in the Chukchi Sea. Marine and Freshwater Research. Published online 24 Nov 2015, http://dx.doi.org/10.1071/MF15084

RUSALCA: Global change in the Arctic: Interactions of productivity and nutrient processes in the northern Bering and Chukchi Seas (year 2)

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

Other investigators/professionals associated with this project:
Dean A. Stockwell, co-PI
University of Alaska Fairbanks

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Amendment 22 NOAA Office: OAR-CPO, Kathleen Crane, Sponsor

Primary objectives

Investigate whether measurable changes have occurred in nutrient properties, biomass of phytoplankton and photosynthetic production of organic matter in the Bering Strait/Chukchi Sea using the nine years of RUSALCA data.

- Analysis of nutrient, chlorophyll and primary production samples
- Data for nutrients, chlorophyll and primary production will be sent to designated archive for inclusion in RUSALCA database.
- Data products will be prepared for presentation at one or two planned RUSLCA workshops.
- Collaborative manuscripts will be prepared with physical, chemical, biological and microbiological groups either as lead author or contributing author. It is expected that at least three additional manuscripts will be prepared that emphasize physical-nutrient processes, nutrient primary productivity processes and nutrient-primary production-microbial processes.

Research Accomplishments/highlights

Primary production rate measurements using carbon and nitrogen isotopes were analyzed and combined with nutrient data for inclusion in a joint publication of the journal Oceanography. (See “In preparation” publication below.)

Collaborated with RUSALCA investigators in preparation of a RUSALCA joint publication. (See “Published” –two publications- in publications below.)

NOAA relevance/societal benefits

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

Education

Two Ph.D. students have been employed to process, collate, aid in the analysis of nutrient data obtained during RUSALCA cruises and place nutrient data with accessible data bases.

Publications and presentations

Pisareva, M.N., R... Pickart, M.A. Spall, C. Nobre, D.J. Torres, G.W.K. Moore and T.E. Whitledge. 2015. Flow of Pacific water in the western Chukchi Sea: Results from the 2009 RUSALCA expedition. Deep-Sea Research I 105: 53-73.

Pisareva, M.N., R.S. Pickart, K. Iken, E.A. Ershova, J.M. Grebmeier, L.W. Cooper, B.A. Bluhm, C. Nobre, R.R. Hopcroft, H. Hu, J. Wang, C.J. Ashjian, K.N. Kosobokova, and T.E. Whitledge. 2015. The relationship between patterns of benthic fauna and zooplankton in the Chukchi Sea and physical forcing. Oceanography 28(3):68–83, http://dx.doi.org/10.5670/oceanog.2015.58.

Yun, M.S., T.E. Whitledge, D. Stockwell, S.H. Son, J.H. Lee, J.W. Park, D.B. Lee, J. Park and S.H. Lee. 2016. Primary production in the Chukchi Sea with potential effects of freshwater content. Biogeosciences 13:737-749

Lee, S.H., J.H. Lee, H. Lee, J. H. Lee, D. Lee, S. An, H.T. Joo, D.A. Stockwell and T.E. Whitledge. In Prep. Light-limited uptake rates of carbon and nitrogen of phytoplankton in the Laptev and the East Siberian seas. Geophysical Research Letters

Partner organizations and collaborators

Dr. Sang Heon Lee and four Ph.D. students, Department of Oceanography, Pusan National University, Busan 609-735, South Korea

Publications related to this project, funded under previous cooperative agreements

Pisareva, M.N., R... Pickart, M.A. Spall, C. Nobre, D.J. Torres, G.W.K. Moore and T.E. Whitledge. 2015. Flow of Pacific water in the western Chukchi Sea: Results from the 2009 RUSALCA expedition. Deep-Sea Research I 105: 53-73.

Pisareva, M.N., R.S. Pickart, K. Iken, E.A. Ershova, J.M. Grebmeier, L.W. Cooper, B.A. Bluhm, C. Nobre, R.R. Hopcroft, H. Hu, J. Wang, C.J. Ashjian, K.N. Kosobokova, and T.E. Whitledge. 2015. The relationship between patterns of benthic fauna and zooplankton in the Chukchi Sea and physical forcing. Oceanography 28(3):68–83, http://dx.doi.org/10.5670/oceanog.2015.58.

Yun, M.S., T.E. Whitledge, M. Kong, S.H. Lee, 2014. Low primary production in the Chukchi Sea shelf, 2009. Continental Shelf Research 76: 1-11

Lee, S.H., D.A. Stockwell, H.M. Joo, Y.B. Son, C.K. Kang, T.E. Whitledge. 2013. Phytoplankton production from melting ponds on Arctic sea ice. Journal of Geophysical Research.117, C04030, doi:10.1029/2011JC007717.

C Lee, S.H., M.S. Yun, J.H. Lim, B.K. Kim, E.J. Choy, C.K. Kang, T.E. Whitledge. 2013. Contribution of small phytoplankton to total primary production in the Chukchi Sea. Continental Shelf Research 68:43-50.

Lee, S.H., M.S. Yun, B.K. Kim, S. Saitoh, C.K. Kang, S.H. Kang, T.E. Whitledge. 2013. Latitudinal carbon productivity in the Bering and Chukchi Seas during the summer in 2007. Continental Shelf Research 59:28-36.

Alaska Ocean Acidification (OA) Research: Autonomous observations of OA in the Alaska coastal ocean

Jessica Cross, PI
Ocean Acidification Research Center
University of Alaska Fairbanks
NOAA Pacific Marine Environmental Laboratory

CIFAR theme: Ecosystem studies and forecasting

NOAA Goals: Healthy Oceans; Climate adaptation and mitigation

Amendment 34
This project is new.

NOAA Office: OAR, Libby Jewett, Sponsor

Primary objectives

The main deliverable for this project was to conduct a regional Ocean Acidification Monitoring Cruise in the Gulf of Alaska in 2015 to quantify the extent and intensity of summertime ocean acidification events brought on by coastal upwelling, respiration processes and freshwater runoff from rivers and the region's extensive glacier fields. Stations will be occupied from the western end of Kodiak Island to the U.S.-Canadian maritime boarder (Figure 1) along 15 CTD transects, with biological net-tows at every other CTD station. We anticipate approximately 117 CTD stations and 58 net tows. At each CTD station we will collect samples for DIC and TA, inorganic nutrients, and dissolved oxygen for CTD-sensor calibration. Additionally, the Brown is equipped with an underway pCO2 system and these data will be integrated into the cruise dataset.

Research Accomplishments/highlights

In FY2015, this project successfully carried out a 19 day OA survey cruise along the continental shelf of the Gulf of Alaska, designed to fill observing gaps that have made it difficult to quantify the extent of OA events. The cruise covered 18 transects, including the first carbon measurements collected in Cook Inlet, to the best of our knowledge. Extremely good weather throughout the cruise period permitted the sampling at three additional transects, including Shelikof Strait, which otherwise may not have been accessible during this time. During this cruise, water samples and underway surface data were collected to assess basic ocean chemistry and physics. Additionally, we also collected phytoplankton and zooplankton samples using bongo net tows and hand tows. In collaboration with NOAA, two Argo floats were released during this expedition.

NOAA relevance/societal benefits

Since the industrial revolution, the global oceans have taken up approximately one-half to one-third of the total anthropogenic emissions of carbon dioxide (CO2), resulting in a significant decrease in ocean pH through a process known as Ocean Acidification, OA (Doney et al., 2009). This increase in acidity could have dramatic consequences for some ocean fauna (Orr et al., 2005). The central mandate of the NOAA OA program is to understand, monitor and predict these changes to ocean chemistry, and to conserve and manage ecologically, economically, and culturally important species vulnerable to OA-related stresses.

The goal of this project is to quantify the extent and intensity of summertime OA events in the Gulf of Alaska, a critically under-studied region of the Alaskan coast. Some species important to commercial and subsistence fishing industries in this area are known to be particularly susceptible to OA processes (Mathis et al., 2014). This project will also collect pteropod specimens, an important food source for juvenile Alaskan pink salmon (Doubleday and Hopcroft, 2015, Aydin et al., 2005). Pteropods are highly sensitive to OA processes (Bednaršek et al., 2012a; Fabry et al., 2008) and OA effects on these organisms are already apparent in other areas (Bednaršek et al., 2012b).

Education

This project helped to support data collection and summer funding for four graduate students (**Jennifer Questel**, **Caitlin Smoot**, **Max Shoenfeld**, and **Jessica Pretty** (UAF); one undergraduate student, **Katie Beaumont** (UAF); and one intern, Rachel Kaplan. All students were encouraged to contribute to the cruise blog, at http://rb1504goacruise.blogspot.com/, which was run by Katie Beaumont.

Outreach

Dan Naber, another of the cruise participants, collaborated directly with Eamon O'Regan's fourth grade class at University Park Elementary School in Fairbanks, AK on an oceanographic art project. Naber and Eamon spoke with the class about oceanographic fieldwork and scientific expeditions, and the students were encouraged to decorate sytrofoam cups. These cups were then attached to the CTD, a deep-diving ocean instrumentation package, and shrunk using the water pressure at great depths.

Publications and presentations

Publications in preparation

Mathis, J. T., W. Evans, J. N. Cross and N. Monacci. The Physical and Biogeochemical Influences on Ocean Acidification in the Northern Gulf of Alaska, Journal of Geophysical Research, in preparation.

Other products and outcomes

During the Gulf of Alaska cruise, we were able to collect some samples opportunistically to help assess the current state of harmful algae in the Gulf of Alaska, which have recently been linked to marine mammal illness and significantly increased mortality. During the summer of 2015, the annual HAB was record-breaking in its size, stretching all the way from California to the Gulf of Alaska, and in its persistence throughout the entire summer. Samples from our cruise helped to assess this unusual spatiotemporal extent.

Partner organizations and collaborators

This project was conducted in partnership with the NOAA Ocean Acidification Program and the carbon group at the NOAA Pacific Marine Environmental Laboratory. To collect underway measurements of CO2 on the Gulf of Alaska cruise and to analyze and publish this data, we continue to work with Wiley Evans, now of Hakai Research Institute in British Columbia, Canada.

Geological substrate and potential habitat map for deep sea corals and sponges in the Gulf of Alaska margin and the Aleutian shelf and slope regions

Jennifer R. Reynolds ***CIFAR theme: Ecosystem Studies & Forecasting***
University of Alaska Fairbanks

NOAA Goal: Healthy Oceans

Other investigators/professionals associated with this project (w/affiliation):
Agno Rubim de Assis, *UAF summer intern;* ***H. Gary Greene,*** *Moss Landing Marine Laboratories and SeaDoc Society****; Chris Rooper,*** *NOAA/NMFS AFSC****; Bob Stone,*** *NOAA/NMFS AFSC****; Peter Etnoyer,*** *NOAA/NOS NCCOS Center for Coastal Environmental Health and Biomolecular Research****; Robert McGuinn,*** *NOAA/NOS NCCOS Center for Coastal Environmental Health and Biomolecular Research****; Enrique Salgado,*** *NOAA/NOS NCCOS Center for Coastal Environmental Health and Biomolecular Research****; Cheryl Morrison,*** *USGS Leetown Science Center****; Rhian Waller,*** *University of Maine, Darling Marine Center****; Keri Feehan,*** *University of Maine at Orono (student)****; Branwen Williams,*** *Claremont McKenna College*

Amendment(s): 6, 25 NOAA Office: NMFS-AFSC, Chris Rooper, Sponsor

Primary objectives

The Alaska Deep Sea Coral and Sponge Initiative (AKCSI) is funded by NOAA's Deep Sea Coral Research and Technology Program to better understand the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats. This CIFAR project addresses the need to characterize and map seafloor habitats, and particularly seafloor substrates, in order to predict distribution of deep sea corals and sponges.

Geologists Jennifer Reynolds and Gary Greene, funded separately, will collaborate with AKCSI researchers from NOAA and US Geological Survey (USGS) to construct interpreted (from geology) substrate and potential habitat maps for deep-sea corals and sponges in Gulf of Alaska and Aleutian Islands waters. The potential habitat maps will be based on the compiled and georeferenced bathymetry, sonar and sediment data layers from AKCSI collaborators; groundtruth from any available seafloor video and still photo imagery; and geological interpretation that takes into account the bedrock and tectonic patterns, sediment type and depth, oceanography, and seafloor morphology at the highest resolution available. Geologic interpretation is used to understand a suite of seabed characteristics in terms of the processes that create them, and to use this understanding to extrapolate seabed characteristics in poorly sampled areas. These maps can then be combined with other types of information, e.g., bycatch in bottom trawls, for predictive modeling of species distribution.

Research Accomplishments/highlights

Jennifer Reynolds and collaborators conducted a research cruise in June 2015 to study sites in the eastern Gulf of Alaska. These sites had been selected and mapped in 2012 as potential hotspots for occurrence of Primnoa deep-sea corals in the Gulf of Alaska. The ROV dives in 2015 contributed to several components of the Alaska Coral and Sponge Initiative (AKCSI); for Reynolds' research this included high-resolution study of Primnoa habitat associations and groundtruthing the interpretations in the benthic substrate maps of the sites. These high resolution sites are an important building block for the regional-scale substrate maps under development by Reynolds and Greene.

The 2015 cruise (PRS-15-RTC) sailed on the R/V Dorado Discovery with the ROV Zeuss II, both operated by Odyssey Marine and contracted by NOAA via Pelagic Research Services. Cruise dates were June 2-11, 2015 from Sitka to Ketchikan. Reynolds participated in the cruise as the team geologist, providing expertise in seafloor geology, interpretation of seafloor maps in terms of potential habitat for Primnoa deep sea coral, dive planning, and ROV dive navigation. An undergraduate intern working with Reynolds for the summer, Agno Rubim de Assis, joined the science party in his first research cruise.

The AKCSI cruise was highly successful. Thirteen ROV dives were conducted at four sites: Mid Shelf Cone near the Edgecumbe Pinnacles (1 dive), Fairweather Ground (8 dives), Shutter Ridge near Cape Ommaney (2 dives), and

Dixon Entrance (2 dives). One day was lost to rough weather. Results from the Fairweather dives will be presented by Agno Assis at the international GeoHab conference in Winchester, England (May 2-6, 2016). Results from all dives are being used by Reynolds and Greene to groundtruth and refine benthic substrate maps of the sites, and to guide interpretation of lower-resolution data sets for the regional substrate maps.

NOAA relevance/societal benefits

The goal of NOAA's exploration and research on deep-sea coral and sponge ecosystems is to provide decision-makers with sound scientific information that will enable effective ecosystem-based management decisions. Research activities in Alaska will provide a better understanding on the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats.

Deep sea coral and sponge ecosystems are widespread throughout most of Alaska's marine waters. In some places, such as the western Aleutian Islands, these may be the most abundant cold-water coral and sponge communities in the world. Deep sea coral and sponge communities are associated with many different species of fishes and invertebrates in Alaska. For example, the consistent association of sponges and corals with juvenile Pacific Ocean perch (Sebastes alutus) may imply better growth or survival in these habitats. The challenges facing management of deep coral and sponge ecosystems in Alaska begin with the lack of knowledge of where these organisms occur in high abundance and diversity.

Two critical information needs developed by stakeholder participants at the NOAA Deep-Sea Coral and Sponge Ecosystems Exploration and Research Priorities Workshop for Alaska (September 2010):

- • Mine existing knowledge to expand our understanding of deep-sea coral and sponge distribution.
- • Implement a regional rather than "postage stamp" approach to deep-sea coral studies.

This project uses existing, archived data as well as new data collected through the Alaska Coral and Sponge Initiative, to determine which areas may contain valuable and potentially vulnerable deep-sea corals and sponges. The product, a regional-scale benthic habitat map, will be the first such map covering large areas of Alaskan waters and will be specifically developed to identify potential locations of deep-sea corals and sponges.

Education

A summer intern, Agno Rubim de Assis, assisted Reynolds with cruise operations and with data analysis after the cruise. Mr. Assis is a talented undergraduate student who spent 18 months in the U.S. on a scholarship from the Brazilian Scientific Mobility Program of the Brazilian government. He is specifically interested in benthic habitat mapping, and spent academic semesters at Cal State Monterey Bay which offers a relevant program of undergraduate courses. Through his 2015 summer internship with Jennifer Reynolds at UAF he gained experience in hands-on research in the application of marine geology to seafloor habitat mapping. He will represent the project's scientific team at the upcoming 2016 international GeoHab conference in Winchester, England. His travel will be sponsored by the conference.

Outreach

NOAA project web page: http://www.afsc.noaa.gov/quarterly/jfm2012/divrptsrace7.htm

Publications and presentations

Assis, A.R., Reynolds, J.R, Greene, H.G., Stone, R.P. and Rooper, C.N. (2016): Benthic habitat for Primnoa deep-sea coral in the Fairweather Ground, Gulf of Alaska. GeoHab 2016 (Winchester, England), May 2-6, 2016.

Partner organizations and collaborators

NOAA Deep Sea Coral Research & Technology Program (funding)

NOAA/NMFS Alaska Fisheries Science Center: Chris Rooper, Bob Stone

NOAA/NOS/NCCOS Center for Coastal Environmental Health and Biomolecular Research: Peter Etnoyer, Robert McGuinn, Enrique Salgado

USGS Leetown Science Center: Cheryl Morrison

Moss Landing Marine Laboratories and SeaDoc Society: H. Gary Greene

University of Maine at Orono and Darling Marine Center: Rhian Waller, Keri Feehan

Claremont McKenna College, Keck Science Center: Branwen Williams

Publications related to this project, funded under previous cooperative agreements:

Literature review of cetacean ship strikes & suggested mitigation measures for use in Glacier Bay National Park

Terrance J. Quinn II, PI ***CIFAR theme(s): Ecosystem studies and forecasting***
University of Alaska Fairbanks

Other investigators/professionals associated with this project (w/affiliation)
Kelly Cates *(M.S. Fisheries graduate student)*

NOAA Goal: Healthy Oceans

Amendment 39 NOAA Office: NMFS, Douglas DeMaster, Sponsor
This project is new.

Primary objectives

The recovery of large whale populations is threatened by lethal interactions with large marine vessels. The International Whaling Commission (IWC) has identified a need to produce a Strategic Plan outlining the direction of ship strike work for the period 2017-2020. The purpose of such a document is to outline areas in which ships and large whales frequently meet ("hot spots"), to identify vulnerable whale populations, to identify worthwhile avoidance technologies in ship/whale encounters, to encourage collaboration in key sectors, and to streamline data collection and communication.

In order to address the issue of ship strikes with large whales, research will be done to provide the scientific basis for this Strategic Plan. Three research objectives are: (1) to review the literature on ship strikes of large whales around the world, (2) to identify areas where ship strikes are more likely (hot spots), and (3) to synthesize this research into a draft of a Strategic Plan that can be used by the IWC Ship Strike Working Group.

Research Accomplishments/highlights

An annotated bibliography on ship strike literature has been compiled and distributed to the IWC Ship Strike Working Group, meeting Objective 1. Research has commenced on identifying hot spots for Objective 2. For Objective 3, an annotated outline for the Strategic Plan has been drafted and sent to the Working Group for comment. A full draft of the Strategic Plan is anticipated by August.

NOAA relevance/societal benefits

The project will provide support for NOAA's participation in a Working Group of the International Whaling Commission concerning the impacts of ship strikes on large whale populations. Support will include, but is not limited to, production of a Strategic Plan on the subject, to assist in avoidance technologies in Glacier Bay National Park, and to develop tactics to increase reporting of ship strike events throughout the world. This information will be

used to support various positions of the US Government over the next two years. This Plan will be used cooperatively by governments and international organizations to mitigate lethal ship strikes and will be presented at the upcoming meeting of the International Whaling Commission.

Education

Kelly Cates was hired to work on this project as her thesis research in a M.S Fisheries degree program at the University of Alaska Fairbanks. As a result of her research on ship strikes, Kelly has networked with many of the experts in the field. Kelly will meet with her graduate research committee in May and take her comprehensive exam.

Outreach

This project accomplishes two major outreach impacts: (1) training of a master's level fisheries graduate student in drafting of strategic reports (2) translating existing knowledge of ship strikes with large whales into research about mitigation efforts to reduce these occurrences.

Publications and presentations

2015 Society of Marine Mammalogy Conference - Poster

2016 Alaska Marine Science Symposium - Poster

2016 AFS Student Symposium - 15 minute Talk

Other products and outcomes

Ship Strike Strategic Report Annotated Outline for the IWC – April 2016

Partner organizations and collaborators

IWC, NOAA

Doug DeMaster (AKFSC), Robert Brownell (SWFSC), Greg Silber (NMFS), Shannon Atkinson (UAF), Aleria Jensen (NMFS), Scott Gende (NPS)

Program for Innovative Technology for Arctic Exploration (ITAE)

Jessica Cross, PI
Ocean Acidification Research Center
University of Alaska, Fairbanks
NOAA Pacific Marine Environmental Laboratory

CIFAR theme(s): Ecosystem Studies and Forecasting

Healthy Oceans; Climate Adaptation and Mitigation

Amendment 13 NOAA Office: OAR-PMEL, Chris Sabine, Sponsor

Primary objectives

A primary NOAA OAR mission requirement is to understand and predict changes in climate, weather, ocean, and coasts. However, NOAA has few programs that address this goal in the Arctic environment, and the Arctic presents unique technical challenges that limit the agency's capacity to conduct regional science and stewardship operations. The Program for Innovative Technology for Arctic Exploration (PITAE) will utilize and develop new and innovative sensors and platforms to address this gap in NOAA's present scientific capabilities.

In order to leverage diverse engineering expertise, infrastructure, and technological assets necessary to advance this technological development, implementation of this program was directed primarily by NOAA Cooperative Institutes. By funding salary support and some travel through CIFAR, Cross will apply her expertise in the Arctic environment and the marine carbon system in order to integrate new and innovative carbon sensors with appropriate platforms and to extend the utility of the data collected through the development of some basic proxies.

The main deliverables of this project are as follows:

(1) To purchase and integrate MAPCO2 and pH systems with a Saildrone hull, and to conduct preliminary design tests. Currently, the unique capabilities of the new Saildrone autonomous platform to move quickly (2-3x as fast as gliders) and to cover a large spatial area, in addition to its easily adaptable design, make it ideal for short-term development.
(2) To examine the effects of lower temperatures and high-energy environments on carbon Prawler operations. The carbon Prawler is a new moored device that uses wave energy to winch itself along a mooring line in order to make carbon measurements throughout the water column, rather than at single depths.
(3) To begin development of skills, expertise, and software necessary for the operation of new sensors on new platforms. Presently, the capabilities of the MAPCO2 system, even when coupled with a cutting-edge pH sensor, cannot fully resolve the carbon system. Existing data can be used to develop proxies that may enable the estimation of other carbon system factors when applied to the datasets from these new moorings.

Research Accomplishments/highlights

Last year, we leased two vehicles from Saildrone, Inc. These two platforms were deployed on April 21, 2015 from Dutch Harbor and successfully completed a 97-day proof-of-concept mission in the Bering Sea. This mission was designed to test the baseline operating capacity of the Saildrone vehicles in the challenging light-limited, high-traffic, strong current area. Joint operations conducted with the research vessel Oscar Dyson showed good agreement between the sensors on the Saildrone and underway instrumentation deployed on the ship. Given the success of this test, in the current year we have purchased two MAPCO2 systems for integration into the Saildrone and one Saildrone hull. This summer, the MAPCO2 systems will be integrated into the Saildrone hull with extensive testing conducted in Puget Sound. Field tests for the Saildrone-MAPCO2 system in the Bering Sea and Pacific Arctic Region are expected in summer 2017.

Last year, we also continued development of the carbon PRAWLER. Tests were conducted from the PRAWLER in Puget Sound, where the primary goal was to resolve lag in the PRAWLER's oxygen sensor. An initial deployment of the basic PRAWLER (without carbon sensors) took place in the Chukchi Sea. Based on this deployment, we performed some basic modifications to ease the movement of the PRAWLER through the water column, and another deployment will take place in the Chukchi Sea again this year (summer 2016).

NOAA relevance/societal benefits

- Addresses the NOAA OAR mission goal to understand oceanographic changes
- In line with the NOAA Arctic Action Plan, to develop better capabilities to observe and monitor changes in the Arctic Ocean
- Full delivery of these ecosystem-capable research vehicles will provide new capabilities in all NOAA mission environments, not just the Arctic, and will help to monitor and sustain important ecosystems and fisheries.

Education

Last year, ITAE participated in the Junior Leadership Program (JLP) at the NOAA Science Camp held at PMEL. The JLP Program aims to provide hands-on learning experiences in youth leadership, communication, team-building, and scientific research for high school aged students. After a tour of our professional facilities, the students were given some brief information about NOAA's mission and some of our current technological challenges that can complicate operations in the Arctic. Then, the students were split into teams and invited to develop a new technology and incorporate it into a full-fledged program to investigate climate change in the Arctic. Students' presentations were judged on four areas: content, communication, engagement, and originality. A bonus was given for utilizing visual components in their presentation. The best presentation, titled "Prediction for Preparation," clearly identified a current and relatable issue, defined their research objective based on that problem, and thought

out the entirety of their investigation from timeline to social media. Their project not only was executable but also met several of NOAA's current Goals including addressing Climate Adaption and Mitigation and a Weather Ready Nation.

Outreach

In order to plan the test deployments for the Saildrones, we generated a number of types of public outreach. Firstly, we developed a document that lists some of the primary information about the PITAE project and the Saildrones as a platform, otherwise known as a NOAA fact sheet. This document is used when we are discussing this project both with the public and with other scientists. Based on this document, we were also asked to develop and submit variations of this report both for the NOAA OAR outreach program, as well as Cabinet Affairs (a White House document). Secondly, we also developed a document that we shared with a variety of marine research and maritime institutions in Alaska, including the Aleutian Pribiloff Islands Association and the large company fishing fleet in Alaska. This document describes the purpose of the Saildrones and the operating area. The goal is to educate local mariners and residences about research being conducted along the coast.

Publications and presentations

The initial findings of these missions were presented in a special session at the Marine Technology Society Oceans Conference in Washington, DC., including four extended white paper publications in the conference proceedings:

Cross, J.N., Mordy, C.W., Tabisola, H.M., Meinig, C., Cokelet, E.D., and Stabeno, P.J., 2016. Innovative Technology Development for Arctic Exploration. Oceans 2015 – MTS/IEEE Washington, IEEE, 8 pp. Available at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7404632&refinements%3D4225891946%2C4224617075%26filter%3DAND%28p_IS_Number%3A7401802%29

Cokelet, E.D., Meinig, C., Lawrence-Slavas, N., Stabeno, P.J., Mordy, C.W., Tabisola, H.M., Jenkins, R., and Cross, J.N., 2016. The use of Saildrones to examine spring conditions in the Bering Sea. Oceans 2015 – MTS/IEEE Washington, IEEE, 7 pp. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7404357&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7404357

Meinig, C., Lawrence-Slavas, N., Jenkins, R., and Tabisola, H., 2016. The use of Saildrones to examine spring conditions in the Bering Sea: Vehicle specification and mission performance. Oceans 2015 – MTS/IEEE Washington, IEEE, 6 pp. Available at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7404348&refinements%3D4225791370%2C4224619983%26filter%3DAND%28p_IS_Number%3A7401802%29

Osse, T.J., Meinig, C., Stalin, S., and Milburn, H., 2016. The PRAWLER, a verticle profiler powered by wave energy. Oceans 2015 – MTS/IEEE Washington, IEEE, 8 pp. Available at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7404354&refinements%3D4225791370%2C4224619983%26filter%3DAND%28p_IS_Number%3A7401802%29

Presentations of this initial data were also made at several other national conferences, including:

Cross, J.N., Evans, W., Mordy, C.W., Stabeno, P.J., Mathis, J.T., Bell, S., Salo, S., and Tabisola, H., Integrated Analysis of high-resolution autonomous observations in the Pacific Arctic Region, Arctic Research Consortium of the United States Open Science Conference, Seattle, WA., November 2015.

Cross, J.N., Mordy, C.W., Meinig, C., Cokelet, E.D., Stabeno, P.J., Tabisola, H., and Evans, W., Surface mapping of the Bering Sea during seasonal ice retreat, Alaska Marine Science Symposium, Anchorage, AK, January 2016.

Tabisola, H., Cross, J.N., Meinig, C., and Mordy, C.W., Developing Oceanographic Infrastructure Specifically for the US Arctic, Alaska Marine Science Symposium, Anchorage, AK, 2016. Poster.

Cokelet, E.D., Meinig, C., Jenkins, R., Lawrence-Slavas, N., Mordy, C.W., Tabisola, H.M., Stabeno, P.J., and Cross, J.N., The first Saildrone scientific mission: The Bering Sea, AGU Ocean Sciences Meeting, New Orleans, LA, February 2016. Poster.

Other products and outcomes

Demonstration of the technological readiness of the Saildrone as developed by Saildrone, Inc. to launch from the dockside and conduct autonomous and adaptive oceanographic research in a harsh, high-latitude environment. The Saildrones successfully navigated below-freezing temperatures and winds in excess of 20 kn several times with gusts of over 46 kn, typical conditions for the Arctic and sub-Arctic. This mission also demonstrated successful operation of baseline sensors for physical oceanographic research in these conditions, including: vehicle attitude, atmospheric pressure, wind speed and direction, PAR, air temperature, relative humidity, magnetic field strength, ocean skin temperature, water temperature, salinity, dissolved oxygen concentration, chlorophyll and CDOM fluorescence. Measurements were validated against shipboard and mooring observations. Saildrone sampling strategies were modified on the fly, first to measure the effects of sea-ice melt on surface cooling and freshening, and then to study the Yukon River plume.

Partner organizations and collaborators

The PITAE grant is conducted with the assistance of several NOAA cooperative institutes and labs, including the Pacific Marine Environmental Laboratory (PMEL) Engineering Group, the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) at the University of Washington, and the Cooperative Institute for Marine Resources Studies (CIMRS) at Oregon State University. This project is made possible through a Cooperative Research Agreement (CRADA) between Saildrone, Inc. and the Pacific Marine Environmental Laboratory. This year, collaborations with the National Marine Fisheries Service (NMFS) and the National Weather Service (NWS) are also ongoing.

Regional, seasonal and species differences in trophic feeding ecology of western and central Aleutian Steller sea lions (Eumetopias jubatus) prey

Lorrie Rea, PI ***Ecosystem Study and Forecasting***
Todd O'Hara, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project (w/affiliation)
NMFS collaborators: Libby Logerwell *(AFSC),* ***Susanne McDermott*** *(AFSC);* ***Industry partner: Todd Loomis*** *(Ocean Peace Inc.)*

NOAA Goal: Healthy Oceans

Amendment 20 NOAA Office: NMFS-AFSC, Elizabeth Logerwell, Sponsor

Primary objectives

Stable isotope ratios of carbon (δ13C) and nitrogen (δ15N) were determined in 11 marine finfish and 2 cephalopod species known to, or thought to, contribute to Steller sea lion (SSL, Eumetopias jubatus) diet in the Aleutian Islands to better understand the trophic (food web) position of these potential prey species. These δ13C and δ15N stable isotope data contribute to other ongoing δ13C- and δ15N-based diet modeling efforts for SSL to build a better understanding of what prey species are important in the western (WAI) and central Aleutian Islands (CAI). We have validated mixing models to predict the percent composition of SSL diet using δ13C and δ15N measured in the whisker tissues of young Steller sea lion pups and δ13C and δ15N values from the published literature for marine fish which are potential prey species for SSL in the Gulf of Alaska and eastern Aleutian Islands (Stricker et al. 2015, Rea et al. 2015, Scherer et al. 2015). While these models are promising, they are currently limited in regional scope by the lack of published δ13C and δ15N data for marine fishes in the WAI and CAI. Samples of known and potential SSL finfish prey species and some non-finfish bycatch species, were collected and donated by fishermen on Ocean Peace Inc. vessels during customary commercial fishing practices in the Aleutian Islands and additional WAI fish collections have been facilitated through Alaska Fisheries Science Center (AFSC) researchers on scheduled research cruises in 2014 and 2015 to target collection of potential prey from regions in the proximity of SSL breeding rookeries.

Feeding ecology of marine fishes has the potential to change spatially and seasonally due to changes in prey availability and in primary productivity that could alter δ13C and δ15N values throughout the food web. Ocean Peace Inc. summer trawls (May – July) allowed us to collect samples of potential prey relevant to animals foraging in both the WAI and CAI. In addition to summer trawls in fisheries management areas 542 (July 2014) and 543 (July 2013), Ocean Peace Inc. have provided fish collected in fisheries management area 542 in the winter (March 2013) allowing us to test for seasonal differences in δ13C and δ15N within sampled prey species in the CAI. Our AFSC partners have also provided predominantly Atka mackerel, Pacific cod and squid samples collected near SSL haulouts in the WAI in May 2014, October 2014 and April 2015. δ13C and δ15N data will also be made available to AFSC researchers studying the diet of killer whales (Orca orca) in the Aleutian Islands. These isotope data will also help us interpret differences in total mercury concentrations in Aleutian groundfish (analyses currently funded in part through Alaska Department of Environmental Conservation [ADEC]) based on the trophic level of feeding of each fish species.

Research Accomplishments/highlights

A total of 1071 individual fish, representing 11 species of finfish and 2 species of cephalopod were collected from the CAI and WAI. Sampling was extremely successful and included approximately 20 individuals for each species (in some case genera or family) from each region/season grouping which will allow for robust seasonal comparisons within each region, and comparison between WAI and CAI during both the summer and winter.

Sample processing in the Wildlife Toxicology Laboratory included collection of morphometric data from whole fish (length, mass) followed by subsampling of muscle for stable isotopes. We also subsampled and archived muscle, liver, eggs (when available) and bone for contaminants and stable isotope analyses funded through other sources. Otoliths were also archived for aging (not included in this grant). Concurrent funding from ADEC to analyze total mercury concentration in groundfish muscle tissues significantly increased the number of samples that could be processed for both studies, since the most costly aspect of these studies (time for subsampling of whole fish and freeze drying of samples) was shared between the two studies. Student tuition support provided by ADEC allowed us to use tuition funds provided in this cooperative agreement to expand our stable isotope analysis to include lipid extracted muscle tissue for a set of fish that had very high lipid contents.

Muscle samples were weighed (to calculate % water content for contaminants analyses), freeze dried and homogenized using a stainless steel mill. Dried and homogenized muscle samples were weighed into tin capsules for stable isotope analysis and submitted to the Alaska Stable Isotope Facility for analysis. For 244 fish that were found to have high lipid content (molar C:N ratios in the initial bulk isotope analysis above 3.1), a subsample of dried, homogenized muscle tissue was rinsed with chloroform methanol solution (3 times) to remove lipids. The resulting lipid extracted tissue was freeze dried and weighted into tin capsules for stable isotope analysis at the Alaska Stable Isotope Facility.

A total of 1071 muscle samples were analyzed for stable isotope data (δ13C and δ15N) and a subset of 244 muscle samples were reanalyzed for bulk δ13C and δ15N after lipid extraction. Stable isotope data were entered into an Access database with associated collection and morphometric data. Stable isotope data and total mercury concentration data (funded separately) for a subset of these fish sampled in the CAI and WAI were presented at the Alaska Marine Science Symposium (AMSS) in Anchorage, AK in January 2016 (see Cyr et al., 2016 under Publications and Presentations). Initial findings indicate that there are differences in δ13C and δ15N among key SSL prey species, but that temporal and regional effects must be considered when modelling SSL diet or any other trophic relationships in the Aleutian Islands. Lipid rich muscle tissue showed depleted δ13C values. Lipid extraction of muscle tissues prior to isotope analysis resulted in an increase in the δ13C values between 0.5 ‰ to 6 ‰, depending upon the initial lipid levels in the tissues, with a mean change of 1.9 ± 1.2 ‰ in this sample of 244 fish.

NOAA relevance/societal benefits

The δ13C and δ15N data generated by this study are currently being used to model seasonal changes in the diet of adult and subadult SSL in the Aleutian Islands, and will be available for future modeling of diet composition of adult female SSL during late gestation using stable isotope data from the whiskers of their young pups (funding for this project to begin July 2016 through a new competitive NOAA cooperative agreement to L. Rea). Understanding diet of this endangered species will help NOAA develop sound fisheries management policy for the Aleutian Islands. These data will also help us to interpret total mercury concentrations in groundfish (funded separately by

ADEC), and consequently understand which prey species may be contributing to high total mercury concentrations measured in some SSL in the western and central Aleutian Islands.

Education

A large part of initial sample processing was carried out as a group effort in the Wildlife Toxicology Laboratory, involving several graduate and undergraduate students, providing an excellent opportunity to teach/learn comparative anatomy of fish and cephalopods. Processing and data management has continued under the mentorship of a graduate student who has been working directly with 3 undergraduate students, including an intern completing a University of Alaska Southeast (UAS) Fisheries Technology Associates degree (internship is a degree requirement). One undergraduate student summarized preliminary data, competed for a UAF undergraduate research travel grant and presented a poster at the AMSS (see Opp et al. in Publications and Presentations)

Outreach

Preliminary data were presented to the Alaska scientific community at the 2015 and 2016 Alaska Marine Science Symposiums.

Publications and presentations

Opp, K.R., O'Hara, T.M., Castellini, J.M., Cyr, A.P., Mcdermott, S., Loomis, T.M., Rea, L.D. 2015. Variations in carbon and nitrogen stable isotope ratios of Atka mackerel, Pacific cod and walleye pollock in the central and western Aleutian Islands. Poster presentation at the Alaska Marine Science Symposium, Anchorage, AK, 19-23 January, 2015.

Cyr, A., L.D. Rea, J.M. Castellini, T.M. Loomis, and T.M. O'Hara. 2016. Chemical feeding ecology of mercury in Aleutian Island groundfish: Special consideration for yellow Irish Lord (Hemilepidotus jordani). Poster presentation at the Alaska Marine Science Symposium, Anchorage, AK. 25-28 January, 2016.

Other products and outcomes

Steller sea lion prey stable isotope dataset for modeling diet of adult female Steller sea lions. These data will also be contributed to the ADEC fish contaminants monitoring dataset after publication by the PIs. These data will also be included in a Ph.D. dissertation by A. Cyr. A subset of these data were also included in Scherer et al. 2015.

Partner organizations and collaborators

Industry partner: Ocean Peace Inc. (contact: Todd Loomis)

NMFS collaborators: Libby Logerwell (AFSC), Susanne Mcdermott (AFSC)

State of Alaska Department of Environmental Conservation partners: Bob Gerlach

Publications related to this project, funded under previous cooperative agreements:

Rea, L.D., A.M. Christ, A.B. Hayden, V.K. Stegall, S.D. Farley, C.A. Stricker, J.E. Mellish, J.M. Maniscalco, J.N. Waite, V. Burkanov, K.W. Pitcher. 2015. Age-specific vibrissae growth rates: A tool for determining the timing of ecologically important events in Steller sea lions. Marine Mammal Science 31(3):1213-1233 DOI: 10.1111/mms.12221

Stricker, C.A., A.M. Christ, M.B. Wunder, A.C. Doll, S.D. Farley, L.D. Rea, D.A.S. Rosen, R.D. Scherer, and D.J. Tollit. 2015. Carbon and nitrogen isotope discrimination for Steller sea lion (Eumetopias jubatus) vibrissae relative to milk and fish/invertebrate diets. Marine Ecology Progress Series 523:255-266.

Scherer, R.D., Doll, A.C., Rea, L.D., Christ, A.M., Stricker, C.A., Witteveen, B., Kline, T. C., Kurle, C.M., and Wunder, M.B. 2015. Isotope values in pup whiskers reveal geographic variation in diets of gestating Steller sea lions (Eumetopias jubatus). Marine Ecology Progress Series 527:261-274.

RUSALCA data management

Russell Hopcroft, PI ***CIFAR theme: Ecosystem studies and forecasting***
University of Alaska Fairbanks

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Amendments 10, 23, 44 NOAA Office: OAR-CPO, Kathleen Crane, Sponsor

Primary objectives

In support of the Russian-American Long-term Census of the Arctic (RUSALCA) research projects, NOAA has provided support for digitally archiving data from all disciplines to be made available to the public and principal investigators via a web based interface. Data will come from biological, physical oceanography, geological, meteorological, and possibly sea ice researchers. Subsets of these data will need to be restricted to access only by principal investigators for certain periods of time.

The project objectives are:

Data Consolidation - Collection of raw data from principal investigators and the ingestion of this data and associated metadata into a University-National Oceanographic Laboratory System (UNOLS) Rolling Deck to Repository (R2R) compatible data format.

Web Interface - An advanced web interface that allows users to browse existing data sets, search for data based on a fully cross referenced set of metadata selection criteria including graphical geo-location bases search will be created. The ability to restrict access of specific data sets to principal investigators via a web based users logging on a per user basis will be pursued.

Data Distribution - Users browsing datasets need the ability to download "folders" or multiple selected datasets of data with a single download action that does not require installation of software beyond the web browser on the client side. Automated dataset distribution by remote computers with authentication will be a product of this project.

Research accomplishments/highlights/findings

The protected workspace is now operational and in use by US project investigators. Data has been deposited for most funded disciplines, although a few projects have yet to post results from 2012. Work by Axiom has focused primarily on web-based data visualizations for a subset of the datasets fully QCed (Figure1). The intuitive public interface allows pan and zoom, refinement of date range, and superposition of various physical and environmental layers available on the AOOS portal (Figure 2). For larger datasets, data can be binned and summarized on the fly into a tessellation that scales with the map domain. Graphical details of samples points appear by simply mousing over a location. A second generation interface is now close to release with even greater range of visualizations.

NOAA relevance/societal benefits

This project provides the data infrastructure to for PI to share and explore their data, thus examining the potential impacts of climate change in the Pacific–Arctic gateway.

It places RUSALCA data into public domain, as well as distributes it to major data repositories.

Partner organizations and collaborators

Alaska Ocean Observing System (AOOS)

Axiom Consultants

Impact

This project will place this data into the same cyber-infrastructure as the AOOS, part of the national observing network. AOOS is becoming the major repository for many other datasets for the Pacific-Arctic region from agencies, industry and academia.

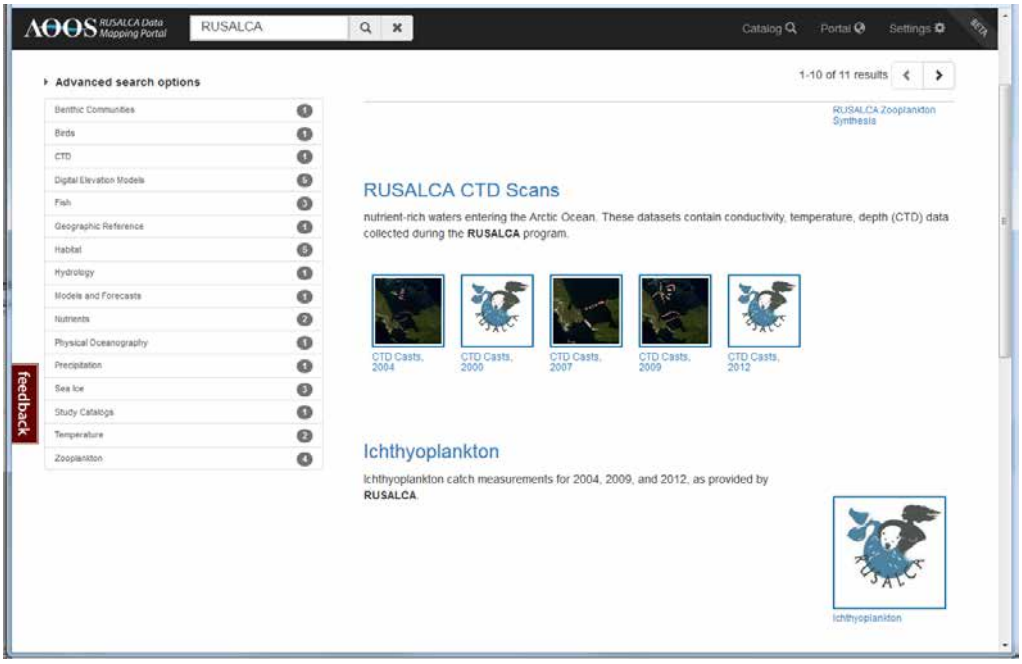


Figure 1. Example of the RUSALCA catalogue on AOOS website

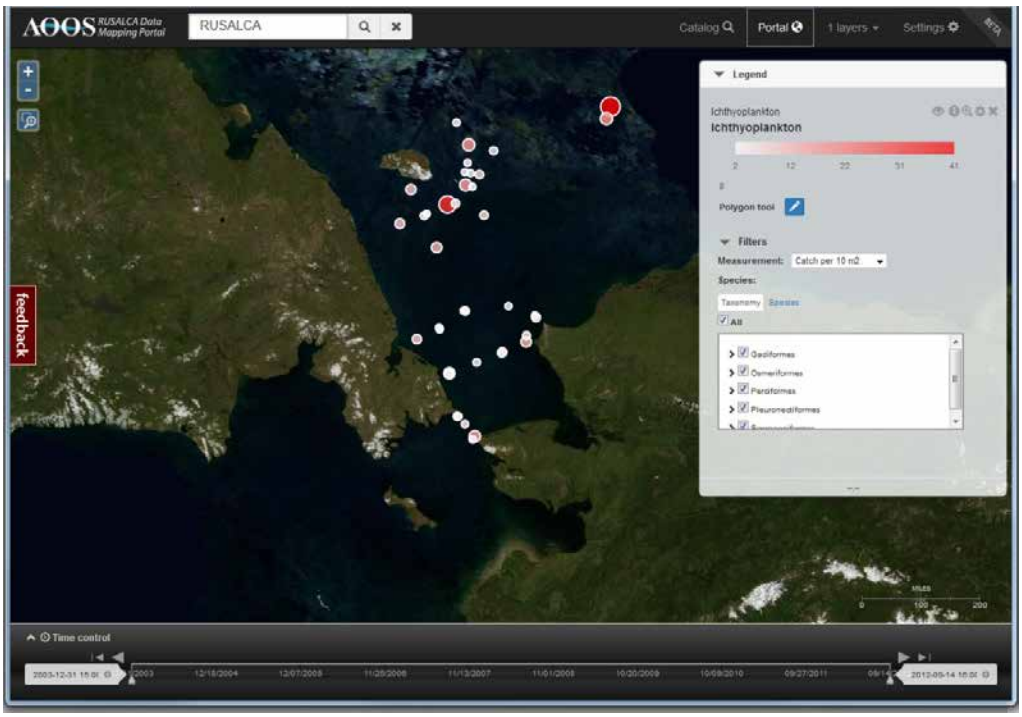


Figure 2. Example of a RUSALCA larval fish dataset on the AOOS website. Details of each sample appear when selected. The species displayed can be interactively selected or deselected though the taxonomic hierarchy list.

Outreach

The Alaska Ocean Observing System (AOOS) has developed several outreach and visualization products based upon data collected during the RUSALCA sampling program. These can be accessed from the AOOS website: http://data.aoos.org/maps/search/rusalca.php

Changes/problems/special reporting requirements

The persistent problem has been getting PIs to put datasets into the workspace, along with appropriate metadata. Deposited data frequently requires substantial reformatting to produce a useable georeferenced data product.

The Stock Varying Assessment Program (SAIP): Time-varying natural mortality: random versus covariate effects

Terrance Quinn II, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem studies and forecasting

NOAA Goal: Healthy Oceans

Amendments 28, 38

NOAA Office: NMFS-AFSC, Peter-John F. Hulson, Sponsor

Primary objectives

As part of the Stock Assessment Improvement Program, our first objective is to determine the circumstances under which time-varying natural mortality, M is estimable in an age-structured assessment model. We hypothesize that the precision of datasets is most important, especially survey data. The second objective is to compare the performance of estimating M with random effects versus using covariates. We hypothesize that using covariates increases precision unless M is misspecified. Thus, this proposal is responsive to two objectives of the Assessment Methods Working Group to conduct "investigations to develop best practices for addressing specific topics in stock assessments" and "investigations of the performance of assessment methods across a range of data availability and quality". Furthermore, this proposal is "oriented to the broadly applicable theme" of the feasibility of estimating natural mortality, a topic that comes up in discussion of almost all stock assessments.

This is a simulation-estimation study in which a true population is created, simulated datasets are generated, and parameters are estimated with an age-structured assessment model. Estimated parameter values are then compared to the values used to simulate the population, which come from existing stock assessments for the respective species. In this way, the precision and accuracy of estimates can be evaluated. This study will model populations after Alaska sablefish (Anoplopoma fimbria) and Eastern Bering Sea pollock (Gadus chalcogrammus), both of which are of commercial importance.

The primary comparison being made in this study is between the performance of covariate and random approaches of estimating time-varying M. Covariate approaches incorporate data on an index that trends with natural mortality (i.e. predation, disease, or environmental conditions) while random approaches make additional assumptions about the error structure of the model so that the assumption of constant natural mortality can be relaxed without necessarily including additional data. Within each of these broad categories of approaches, several sub-scenarios will be investigated. Within the covariate approach, we will investigate the effect that different levels of observation error in the covariate have on the accuracy and precision of estimates. Within the random approach, we will test the performance of models that estimate time-varying M using individual random effects and random walks. Estimation model configurations will be tested on three scenarios of time-varying M: (1) linearincrease, (2) linear decrease, and (3) sinusoidal fluctuation. The performance of a model that attempts to estimate time-varying M in the case where true M is constant will also be evaluated. In addition, we will evaluate model performance under low and high

survey biomass variability and both a 1-to-1 and 2-to-1 ratio of fishing mortality to natural mortality. In testing the performance of different model structures under these various data qualities and states of nature, we hope to broadly characterize the performance of models that attempt to estimate time-variable M, while keeping the size of the study appropriate for a master's thesis.

Research Accomplishments/highlights:

- We have conducted a literature review of the body of existing knowledge relevant to fisheries stock assessment in the treatment of natural mortality.
- Ganz has gained proficiency in R and ADMB software, to be used in project analysis.
- We have chosen Gulf of Alaska sablefish and Eastern Bering Sea pollock stock assessments that will be used to construct the operating models for this project; these two represent a relatively slow-growing and a fast-growing population, respectively.
- We have attained code for Gulf of Alaska sablefish stock assessment that will be used as a starting point for incorporating time-varying natural mortality.
- We have decided on three operating models to be used for the deterministic component of natural mortality M: constant M, a linear increase in M over time, and sinusoidal variation in M over time. These models will contain two different levels of stochastic variation. A covariate will constructed following these trends, also with two levels of variation to represent measurement error.
- Four estimation models will be used: stock assessment with (1) M constant and fixed, (2) M constant and estimated, (3) M estimated with random effects, and (4) M estimated with the covariate.

NOAA relevance/societal benefits

The primary benefit for the Stock Assessment Improvement Program (SAIP) will be better information about what circumstances allow M to be estimated, particularly across time and age. This study will determine if random and correlated effects are sufficient to estimate M. If only limited circumstances exist, covariates may make estimating time-varying M possible; efforts should then be increased in the real world to find covariates, such as predator biomass, predator consumption, and disease incidence that are related to M. There is currently a trend to use more and more random effects to improve the realism of assessment models. But if this use compromises estimability through parameter confounding, this use may be misguided.

Education

Quinn hired graduate student **Philip Ganz** to work on this project for his M.S Fisheries degree.

In November 2014, Quinn and Ganz attended a conference held by the Center for the Advancement of Population Assessment Methodology on growth modeling, which also provided state-of-the-art information on stock assessment modeling and the treatment of natural mortality.

In January 2016, Quinn and Ganz gave presentations each at two workshops in Chile.

Outreach

Ganz P.D. Quantifying Death: A Love Story. 2015. Presentation for the general public as part of FISH 692: Communicating Science. Juneau, AK. 25 April 2015.

Publications and presentations

Presentations

Ganz, P.D. and T.J. Quinn II. 2015. Estimability of time-varying natural mortality in exploited groundfishes. Alaska Chapter of the American Fisheries Society Student Symposium. Juneau, AK. 3 April 2015.

Ganz, P.D., T.J. Quinn II, P.J.F Hulson and D.H. Hanselman. 2015. Estimability of Time-Varying Natural Mortality in Gulf of Alaska Sablefish with a Simulated Covariate. American Fisheries Society National Meeting. Portland, OR. 16-20 August 2015.

Ganz, P.D., T.J. Quinn II and P.J.F Hulson. 2016. The Mathematics of Mortality: How Do We Model Death in Fish Populations? Valparaiso's Math and its Applications Days. Valparaiso, Chile. 7-8 January 2016.

Ganz, P.D., T.J. Quinn II and P.J.F Hulson. 2016. Time of Death: Modeling Time-varying Natural Mortality in Fish Populations. Jornadas de Modelamiento Matemático para la Toma de Decisiones en Evaluación y Gestión Pesquera. Valparaiso, Chile. 18-20 January 2016.

Quinn, T.J., II. 2016. Contemporary Models in Fish Population Dynamics. Valparaiso's Math and its Applications Days. Valparaiso, Chile. 7-8 January 2016.

Quinn, T.J., II. 2016. Contemporary Models in Fish Population Dynamics and Their Application to Fisheries Management. Jornadas de Modelamiento Matemático para la Toma de Decisiones en Evaluación y Gestión Pesquera. Valparaiso, Chile. 18-20 January 2016.

Support for Arctic Science Summit Week and Arctic Observing Summit

Hajo Eicken, PI
International Arctic Research Center
University of Alaska Fairbanks

CIFAR themes: Ecosystem Study and Forecasting, Climate Change and Variability

NOAA Goals: Climate Adaptation and Mitigation, Healthy Oceans

Amendment 45
This project is new.

NOAA Offices: NOS, NESDIS, OAR; Jeremy Mathis, Sponsor

Primary objectives

Support key elements of the 2016 Arctic Science Summit Week (ASSW) and Arctic Observing Summit (AOS), hosted at University of Alaska Fairbanks (UAF) 12-18 March 2016. Specific objectives include:

- Foster international coordination, collaboration and cooperation in all fields of Arctic science in the context of the ASSW.
- Provide a forum for government agencies and stakeholder groups to exchange information on science needs and opportunities, with a particular focus on opportunities presented through co-convening conferences with the Arctic Council Senior Arctic Officials and the Arctic Observing Summit.
- Through organization of AOS provide community-driven, science-based guidance for the design, implementation, coordination and sustained long-term operation of an international network of Arctic observing systems that serves a wide spectrum of needs.
- Serve as a forum for coordination and exchange between academia, government agencies, Indigenous organizations, local communities, industry, non-governmental organizations and other Arctic stakeholders involved in or in need of long-term observing activities.
- Leverage the presence of a diverse range of Arctic experts and stakeholders for education and outreach opportunities.

Research Accomplishments/highlights

The ASSW meetings generated a number of key outcomes and highlights associated with each of the component meetings. A major accomplishment for the ASSW as a whole was the update and discussion of key Arctic issues at

the science/policy interface during the International Arctic Assembly that brought all major groups of constituents of the different meetings (incl. Arctic Council Senior Arctic Officials and Working Group meetings) together.

- The AOS key accomplishments include the solicitation, review, synthesis and sharing of over 80 white papers and short statements that helped inform working group activities at the summit. This work culminated in a conference statement that highlights key points that will be explored in depth in the forthcoming detailed reports from the working groups. In brief, key points highlighted by the conference participants include recommendations and plans for action on:
- Developing international guidelines for research in the Arctic, including the involvement of Indigenous Peoples and private sector entities.
- Building the business case for a comprehensive Arctic observing system by identifying economic benefits and costs avoided and taking that case to the highest levels of government.
- Creating opportunities for stakeholder engagement to take advantage of natural capital and to resolves jurisdictional, regulation and policy hindrances to active participation.
- Coordinating the implementation of an Arctic observing system that draws on existing Arctic and global initiatives and secures resources for sustained operation.
- Creating a strategy for international, sustained funding to overcome current hurdles for globally coordinated Arctic research.
- Ensuring that the observations can be maintained consistently over the long term.
- Developing a globally connected open data and information system that provides value to Arctic and global communities.

NOAA relevance/societal benefits

Workshop, panels and plenaries at ASSW and AOS addressed several of the goals of NOAA's Arctic Vision and Strategy (AVS), with plenary presentations by David Kennedy and Stephen Volz from NOAA helping frame the discussion. The AOS Global Linkages Thematic Working Group (TWG) focuses on how to improve linkages between Arctic activities and global observing programs, such as Argo, and how to enhance international partnerships in support of improved foundational science and operational prediction (AVS Goals 1, 2, 3 and 4). The Private Sector Partnerships TWG addresses AVS Goals 3 and 4 and focuses specifically on developing frameworks, protocols and best practices for (industry) platforms of opportunity in the Arctic, extending well-established low/mid-latitude efforts into the Arctic. The Stakeholder Engagement and Needs TWG addresses AVS Goals 5 and 6, with a focus on Arctic-wide community emergency response and action plans. All six TWGs, but in particular the Strategies for sustained, international support of long-term Arctic observing TWG are seeking to enhance international and national partnerships (AVS Goal 4).

NOAA scientists have been engaged in these working groups, such as Jeremy Mathis co-chairing the Theme 1 Working Group. In addition, both ASSW and AOS facilitated leveraging of international resources and programs and planning of research activities in the U.S. Arctic, e.g., through the Pacific Arctic Group. The summit working groups have identified observing priorities and approaches towards common standards (e.g., observed variables common to all programs), common data management approaches, and other best practices that minimize duplication, enhance the value of observations and datasets generated and increase the reach of data products. Some of this work will continue well beyond the summit itself and involved members of the UAF team supported through this grant. This includes production of a special issue of the journal Arctic that highlights key white papers and synthesis documents compiled through the summit, that help define common core goals, priorities and shared elements of Arctic observing systems, with a number of specific links to NOAA priorities.

Education

ASSW included a number of education events, with the following three representing the range of education activities (mostly directed at graduate students and early career researchers):

- APECS Early Career Arctic Policy Workshop
- Make an Impact: The Arctic in the Classroom (TAC) Workshop 2016 (includes teachers)
- Workshop on “Why DOES the Arctic Matter? Tips and Tools for Effective Communication”

Outreach

There was a broad range of activities for outreach at ASSW/AOS, including 33 Public events ranging from a public symposium: “Do we speak the same language of science?”, through an Arctic Family Games Night to an evening panel on “Healing and Wellness: Addressing Historical Trauma through Indigenous Knowledge and Practices”.

The ASSW/AOS Media Fellows program served as an outreach multiplier with a number of papers published through different media outlets (see also below).

A key outreach product from the AOS was a press release by the co-organizers of the Summit to disseminate information on the AOS conference statement.

Publications and presentations

This NOAA grant directly supported two early career researchers (Dr Olivia Lee, Dr Jane Wolken) who worked with the AOS thematic working groups in soliciting, compiling and reviewing, and then synthesizing over 80 white papers and short statements submitted to the summit. These papers and the six synthesis papers have been published through the AOS website: http://www.arcticobservingsummit.org/aos-2016-white-papers-and-short-statements-public.

A key outcome of the AOS is the conference statement, published through the AOS website (http://www.arcticobservingsummit.org/aos-2016-conference-statement-0).

Other products and outcomes

44 newspaper or magazine articles, radio or television broadcasts, blog or other internet outlet pieces have been published (as of 3 April 2016).

ASSW and AOS plenary sessions and media briefings were live-streamed during the meeting, drawing between 522 and 962 unique views, with average views ranging between 12 minutes for the press briefings and 30 minutes for the AOS plenaries. These videos are archived and accessible at https://assw2016.org/streaming.

Partner organizations and collaborators

The ASSW/AOS meeting is the outcome of a number of key partnerships, in particular the International Arctic Science Committee, the International Study of Arctic Change, the Arctic Council’s Sustaining Arctic Observing Networks initiative and a number of other partners.

Support for US participation in the CBMP Expert Network

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

Other investigators/professionals associated with this project:
Katrin Iken, *University of Alaska Fairbanks*
Eric Collins, *University of Alaska Fairbanks*

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Amendment 32 NOAA Office: OAR, Kathleen Crane, Sponsor
This project is new.

Primary objectives

The Arctic Council's Conservation of Arctic Flora and Fauna (CAFF, www.caff.is) working group has developed the multi-national Circumpolar Biodiversity Monitoring Program (CBMP, www.cbmp.is). The CBMP seeks to coordinate pan-Arctic biodiversity monitoring through an international network of scientists working in conjunction with national agency representatives. The overall purpose of the CBMP is to determine the status of, and any changes within, six major components of Arctic biodiversity. These Expert Networks, each with equal representation by all primary participant countries, are tasked with coordination, data integration and data synthesis. Hopcroft and Iken have participated in the development of the implementation plan (Gill et al. 2011), with Hopcroft currently serving as the co-lead of the Pelagic Marine Expert Network, and both Iken and Collins serve as the US members of the Benthic and Sea Ice Biota Marine Expert Network, respectively.

Research accomplishments/highlights/findings

During 2015/16, the primary task has been preparation of the State of the Arctic Marine Biodiversity Report (SAMBR), as a follow up to the Arctic Biodiversity Assessment (ABA) Report. The report consists of contributions by each of CBMP's Marine Expert Networks. Writing workshops were held in Akureyi, Iceland during April 2015 and in Pasvik, Norway during November 2015. The report is currently undergoing internal review.

NOAA relevance/societal benefits

This project documents the state and examines the potential impacts of climate change in circumpolar Arctic domain. It provides interaction between the member countries of the Arctic Council.

Publications, conference papers, and presentations

In preparation

Partner organizations and collaborators

Circumpolar Biodiversity Monitoring Program (CBMP)

Conservation of Arctic Flora and Fauna (CAFF)

Partner organizations and collaborators

Ted Stevens Marine Research Institute, Alaska Fisheries Science Center, Juneau, Alaska (Peter-John Hulson).

High latitude proving ground—improving forecasts and warnings by leveraging GOES-R investment to deliver and test NPP/JPSS data in support of operational forecasters

Thomas Heinrichs ***Climate Change and Variability***
University of Alaska Fairbanks

Other investigators/professionals associated with this project (w/affiliation)
Eric Stevens, Carl Dierking Jiang Zhu, Jay Cable, Scott Macfarlane, Will Fisher, Dayne Broderson
University of Alaska Fairbanks

NOAA Goal: Climate Adaptation & Mitigation

Amendments 8, 19, 42 NOAA Office: NESDIS, Christopher W. Brown, Sponsor
Continues research from NA08OAR4320751

Primary objectives

The objective of this activity is to build upon the already established collaborative team of National Weather Service(NWS) Alaska Region, University of Alaska Fairbanks-Geographic Information Network of Alaska (UAF-GINA), National Environmental Satellite, Data, and Information Service(NESDIS), and Cooperative Institute for Meteorological Satellite Studies(CIMMS), Cooperative Institute for Research in the Atmosphere(CIRA), and Short-term Prediction Research and Transition Center(SPoRT) to improve the near real-time distribution of the Suomi National Polar-orbiting Partnership(SNPP)/Joint Polar Satellite System(JPSS) data to algorithm developers, science users, and the operational NWS forecast offices.

In cooperation with University of Wisconsin, Colorado State, and National Oceanic and Atmospheric Administration(NOAA) Center for Satellite Applications and Research(STAR) algorithm developers and direct broadcast application developers, UAF-GINA will provide an operational environment to run the Community Satellite Processing Project (CSPP) SNPP sensor processor. Both the stable and pre-release development processors for the SNPP sensors will be generating products in near real-time for distribution to the Alaska NWS and algorithm developers at other university and NOAA research sites. These products delivered to the Alaska NWS will initially include natural color and infrared imagery in near-real-time. GINA staff will work closely with NOAA and Cooperative Institutes to train, deploy, and evaluate products in Alaska Region forecast offices and river, aviation, and sea ice units.

Research Accomplishments/highlights

(1) GINA's additional X, L, and S-band direct broadcast antenna named "Sandy Dog" was installed at NOAA/NESDIS's Fairbanks Command and Data Acquisition Station in April, 2015. The Sandy Dog antenna compliments GINA's legacy Big Dog antenna on the University of Alaska Fairbanks and allows for the tracking of more polar orbiting satellites and enhances the robustness and reliability of the High Latitude Proving Ground's support for the National Weather Service. The figure below shows the installation of the Sandy Dog antenna.

Figure 1. Installation of GINA's new X, L, and S-band direct broadcast antenna on the roof of a facilities building at NOAA/NESDIS Gilmore Creek, Alaska in early April.

(2) The generation of "client-side" or "on the fly" multispectral (or "RGB") products became possible at NWS forecast offices in Alaska in April 2015. GINA's Carl Dierking has participated in NASA/SPoRT's Experimental Products Development Team (EPDT) and, as part of this effort, has implemented the capability to generate RGB products on AWIPS2 workstations. This is known as "client-side" RGB production, or RGB production "on the fly." The vision is that GINA will deliver the base direct broadcast VIIRS channels to the NWS field offices, and then a variety of RGB combinations can be made at the WFO level. The advantages of this approach include greater flexibility in customized product generation at the WFOs, more meaningful mouse roll-over information in the RGBs on AWIPS, and greater bit-depth of the resulting RGBs. An example is included below.

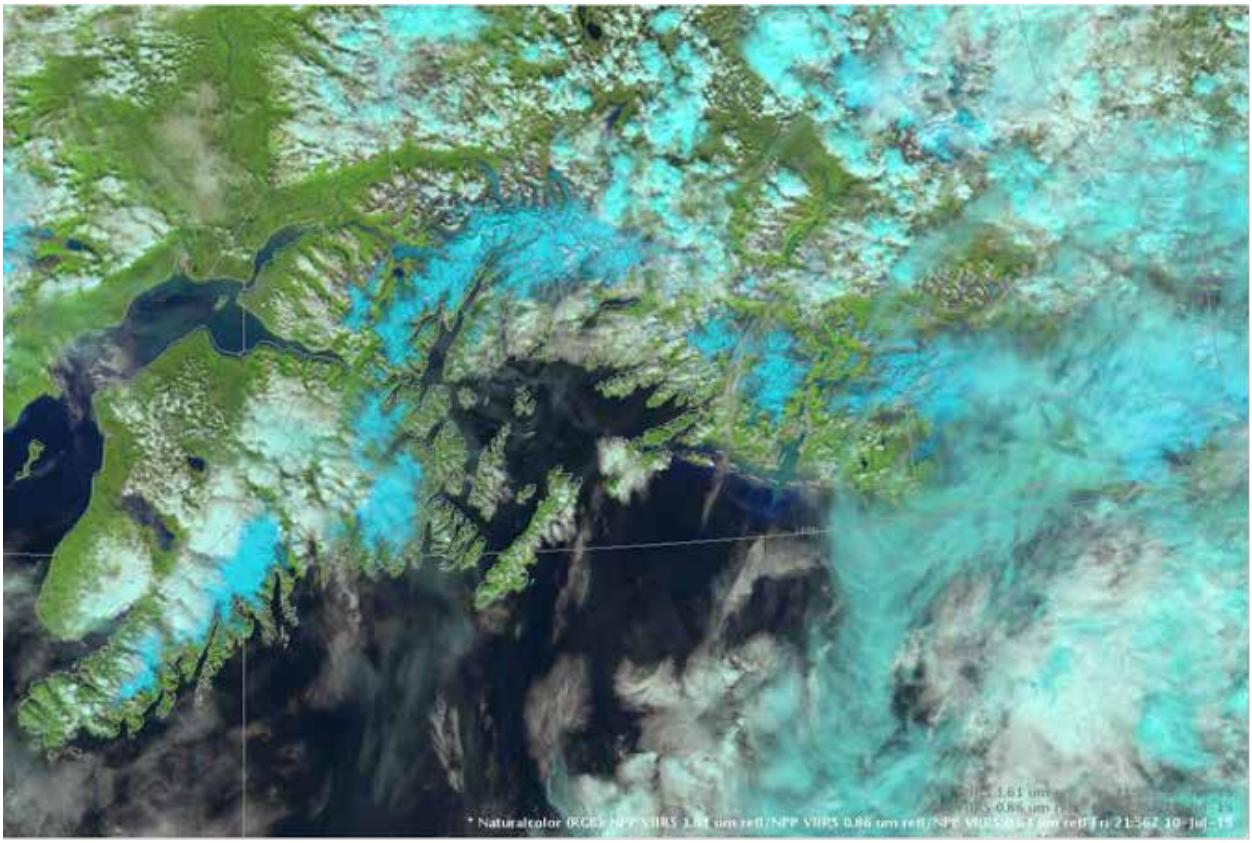


Figure 2. A sample VIIRS multi-spectral RGB from July made "on the fly" on AWIPS2 from single-channel direct broadcast VIIRS imagery generated and delivered by GINA. In this specific case over Alaska's Kenai Peninsula and Prince William Sound, the VIIRS I1, I2, and I3 bands are combined to highlight the contrast between snow-covered ground (blue), bare ground (green), open ocean (dark blue), water-based clouds (white), and glaciated clouds (cyan).

(3) In support of the National Weather Service's efforts to observe and forecast ice jam flooding during Alaska's spring "breakup" period, airborne images were collected by J. Cherry and processed into orthomosaics for delivery to the Alaska Pacific River Forecast Center before 7 am the following day. Flights were coordinated with NWS field team and conditions communicated over the radio in flight as well. Images were also sent to the George Mason University and City College of New York where developers of the JPSS river ice and flooding products could use them in assessing the quality of their products.

(4) Direct broadcast VIIRS-based active fires delivered to USDA's RSAC website. In May and June, 2015 GINA staff worked with Dr. Ivan Csiszar of NESDIS/STAR and Dr. Even Ellicott of the University of Maryland to finalize the connection between GINA and the USDA's Remote Sensing Applications Center (RSAC) to ensure that GINA's direct broadcast VIIRS data are available to Alaska Fire Service via the RSAC website http://www.fs.fed.us/eng/rsac/ .

(5) Two different enhancements of the Day Night Band are now being delivered to NWS Alaska.

(6) Working with developers at CIRA, GINA began delivering two different versions of the VIIRS Day Night Band to National Weather Service field offices by the fall of 2015. The challenge being addressed here is that a stripe of bright aurora can overwhelm a DNB image. A "dynamic" enhancement is used to dampen the effect of the aurora and make the underlying cloud and terrain features easier to identify. However, while this dampening improves the utility of the DNB near the aurora, regions far away from the aurora are rendered less sharp in the dynamic enhancement. Thus, until a perfect "one size fits all" enhancement is developed, Alaskan WFOs will need both of these versions to deal with the aurora.

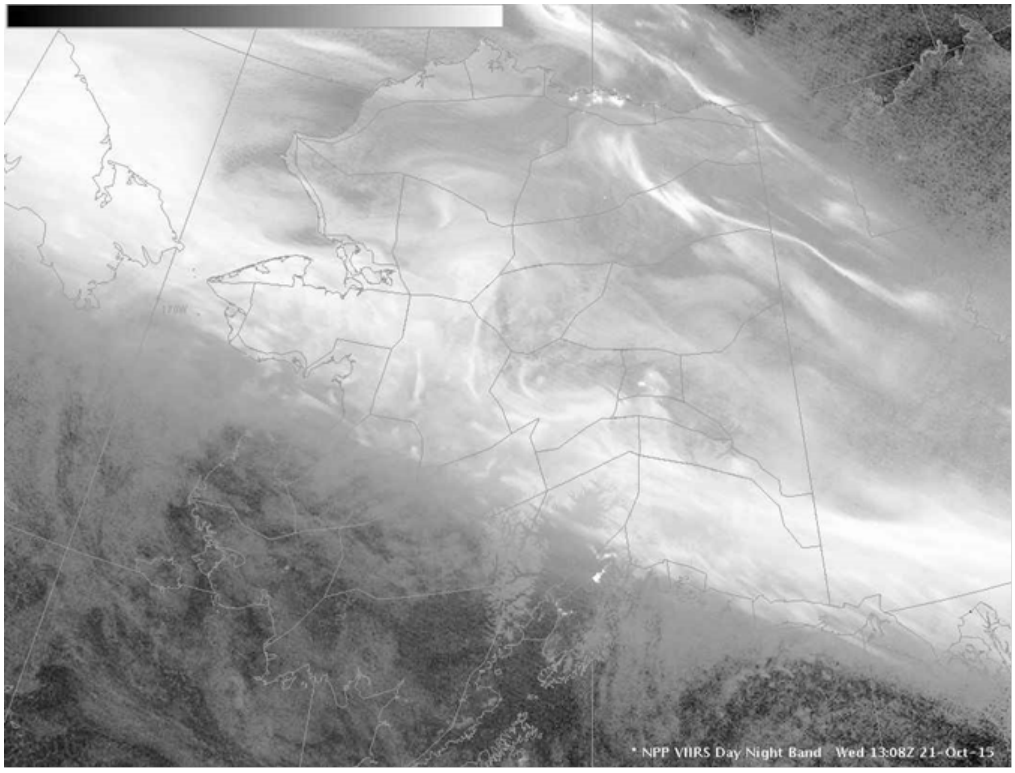


Figure 3 VIIRS Day Night Band during a prominent display of the northern lights. Meteorological and terrain features under and near the aurora are obscured.

Figure 4 The same Day Night Band image as shown in figure 3, but this time using the "dynamic" scaling approach developed at CIRA. Clouds and terrain are now easier to identify near the aurora, but this improvement comes at the cost of making features far away from the aurora harder to identify.

(7) GINA completed initial development of an AWIPS script for creating individual channel Mosaic composites from all available polar sensors. The purpose of this Mosaic script is to provide NWS field offices with a composite of all available polar sensor data received over a set time. For example, several different satellites carry imagers that sense longwave radiation at approximately 11 μm, but until now there was no way in AWIPS to easily create a single running overlay using 11 μm imagery from the VIIRS instrument as well as the MODIS and AVHRR imagers flying on other polar satellites. This technique provides a sequence of high resolution views of the entire region with minimal parallax.

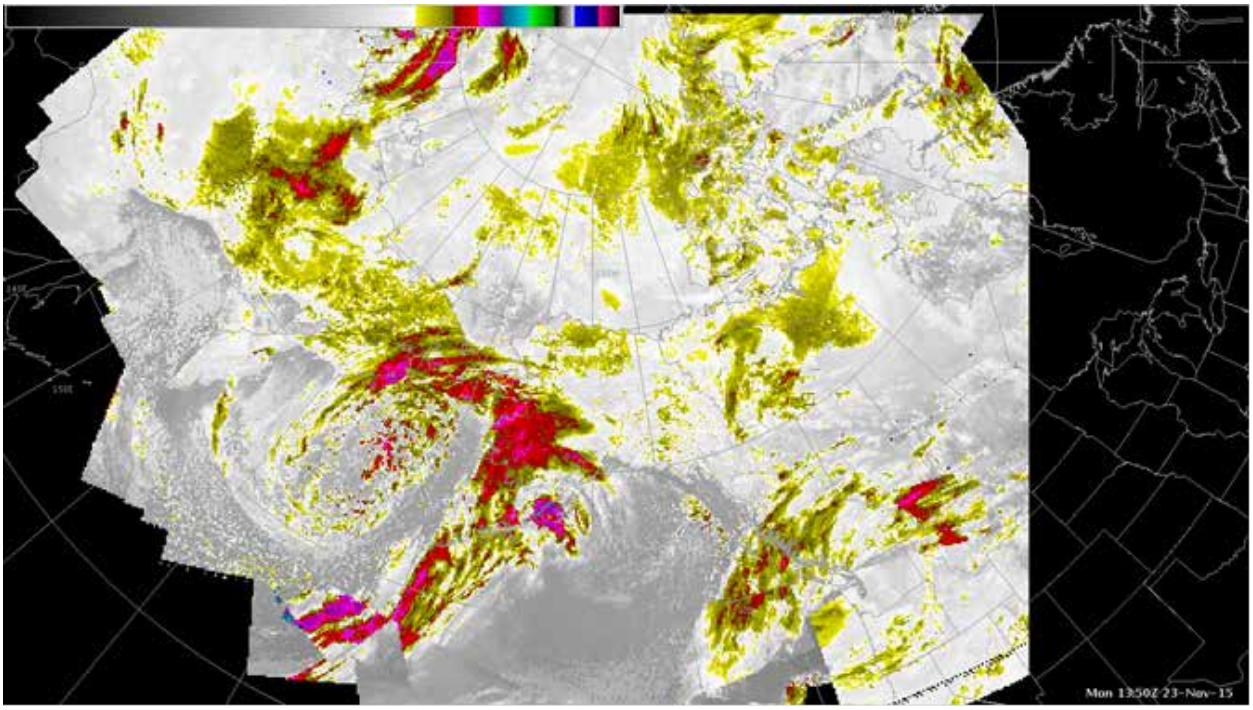


Figure 5 AWIPS screen capture of 11 μm imagery from the VIIRS instrument combined into a mosaic with imagery from MODIS and AVHRR.

(8) GINA continues working on satellite data assimilation in the regional WRF model project. Jiang Zhu used the level1 CrIS/ATMS data received by GINA in near real-time and applied NUCAPS algorithm to produce level2 sounding profile, then assimilated the data into WRF model. Observation data were used to evaluate the performance for case study and one month statistics analysis. Root-mean-square-error(RMSE) were calculated. As an example, Figure 6 shows RMSEs of analysis of three variables at 850 mbar pressure level. RMSE is composed of mean bias and centered pattern variation. The distance between a point to origin indicates the RMSE value. RMSE projection to X axis represents mean bias, and RMSE projection to Y axis represents centered pattern variation. Comparing to WRF control run, WRF runs with AIRS and CrIS/ATMS profile data assimilation improve significantly dew point and wind speed. The major contribution of the improvement attributes to the decreasing of variation between analysis and observation. Temperature from data WRF runs with data assimilation have the similar performance as WRF control run.

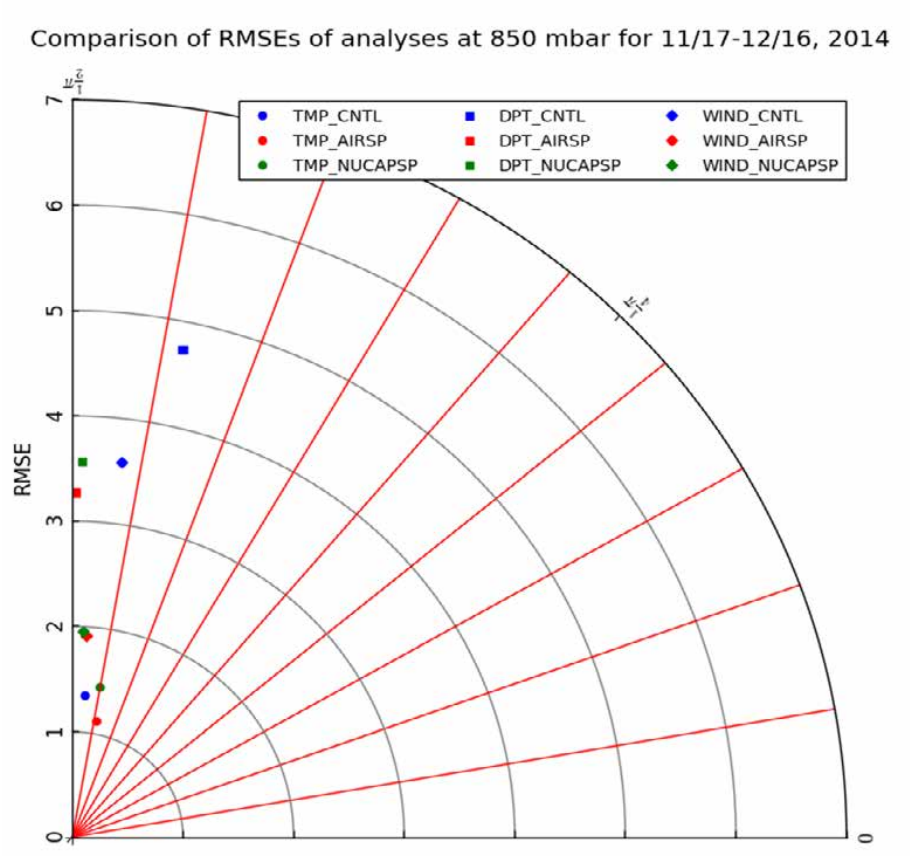


Figure 6. Comparison of RMSEs of analyses produced by WRF run in three modes: control, with AIRS profile assimilation, and with CrIS/ATMS profile assimilation.

NOAA relevance/societal benefits

The National Weather Service, Alaska Region, is the largest operational forecasting user of polar orbiting satellite data in NOAA because of its unique high latitude location and forecasting and warning domains. In addition to polar orbiting data, geostationary satellite data is used effectively in southeast Alaska and the Aleutians and as a synoptic tool for the rest of the state. Effective use of polar orbiting data is essential for accurate forecasting and warning at high latitudes.

Outreach

In April of 2015 GINA's Eric Stevens recorded an outreach segment for the statewide public television broadcast, 'Alaska Weather' addressing how satellite imagery from the High Latitude Proving Ground can be used to find wildfires and even to determine which portions of a wildfire are burning hottest and are the most active. Video can be watched at: https://www.youtube.com/watch?v=BNqPUv9aeVI

Publications and presentations

Publications

Abshire, W. and the COMET Program, 2015. JPSS River Ice and Flooding Products. https://www.meted.ucar.edu/satmet/river_ice_flooding/

Hillger, D., T. Kopp, C. Seaman, S. Miller, D. Lindsey, E. Stevens, J. Solbrig, W. Straka, M. Kreller, A. Kuciauska, and A. Terborg, 2016. User Validation of VIIRS Satellite Imagery. Remote Sensing, 8(1); doi:10.3390/rs8010011 http://www.mdpi.com/2072-4292/8/1/11/pdf

Oral presentations [All presentations were co-reported by a related project under lead PI Cherry]

Stevens, E. 2015. High Latitude Proving Ground update. CSPP/IMAPP Users' Group Meeting hosted by EUMETSAT in Darmstadt, Germany, April 13-17, 2015.

Cherry, J. 2015. Pan-Arctic Snowfall Reconstruction: Product Description and Analysis. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Zhu, J. 2015. Improving Alaska Region Short-term Weather Forecasts with Data Assimilation. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Heinrichs, T. 2015. Sensors You May Not Be Aware Of: Real-time Satellite Data and Services Available at UAF-GINA. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Cherry, J. 2015. Tracing Arctic Hydrology with Observations of Water Vapor Isotopes from In Situ, Airborne, and Satellite Platforms. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Heinrichs, T. 2015. Direct Readout Enhancements in Alaska. OCONUS Technical Interchange Meeting, Anchorage, Alaska, May 12-15, 2015.

Dierking, C. 2015. Sandy Supplemental Project: New AWIPS Data for NWS Alaska. OCONUS Technical Interchange Meeting, Anchorage, Alaska, May 12-15, 2015.

Cherry, J. and K. Bennett, 2015. Demonstration of Airborne Hydrology. OCONUS Technical Interchange Meeting, Anchorage, Alaska, May 12-15, 2015.

Stevens, E. 2015. Operational Use of the Day-Night Band in Alaska. Proving Ground User Readiness meeting, Kansas City, Missouri, June 15-19, 2015.

Stevens, E. 2015. Operational Use of RGBs in Alaska. Proving Ground User Readiness meeting, Kansas City, Missouri, June 15-19, 2015.

Zhu, Jiang, E. Stevens, T. Heinrichs, J. Cherry, and C. Dierking, 2016: AIRS/CrIS Sounding Profile Data Improves Short-term Weather Forecast in Alaska, poster, 96th American Meteorology Society annual meeting, Jan 10-14, 2016, New Orleans, USA.

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 NESDIS Center for Satellite Applications and Research (STAR), In-kind support, Collaborative Research

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

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

Colorado State University CIRA: In-kind support, Collaborative research, Personnel exchanges

NASA Direct Readout Laboratory: In-kind support, Collaborative research, Personnel exchanges

High Latitude proving ground for GOES-R: Advanced data products and applications for Alaska

Jessica Cherry, PI ***CIFAR themes: Climate Change and Variability, Coastal Hazards***
Thomas Heinrichs, Co-PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project (w/affiliation):
Eric Stevens, Carl Dierking, Jiang Zhu, University of Alaska Fairbanks

NOAA Goal: Climate Adaptation & Mitigation

Amendments 18, 33 NOAA Office: NESDIS, Steven Goodman, Sponsor
Continues research from NA08OAR4320751

Primary objectives:

Based on needs of the National Weather Service, the Geographic Information Network of Alaska (GINA) at the

University of Alaska Fairbanks proposes the following research efforts centered on the themes of 1. Cryospheric products; 2. Assimilation of products into models; and 3. Hazardous weather. The primary objectives of the proposed work are to enhance existing satellite data services and research in Alaska and develop next generation scientific products from satellite data. Collaboration will include the Weather Forecast Offices (WFOs), the Alaska Pacific River Forecast Center (APRFC), the Alaska Aviation Weather Unit (AAWU), and the Alaska Sea Ice Program (SIP), the NOAA research partners (Cooperative Institute for Meteorological Satellite Studies--CIMSS, Center for Satellite Applications and Research--STAR, Short-term Prediction Research and Transition and Center--SPoRT, Cooperative Institute for Research in the Atmosphere--CIRA), and the National Operational Hydrologic Remote Sensing Center (NOHRSC).The primary objectives of the proposed work are to:

• Enhance existing satellite data services and research in Alaska and

• Develop next generation scientific products from satellite data.

Research Accomplishments/highlights:

(1) GINA staff Carl Dierking and Eric Stevens developed ten “Quick Guides” highlighting the scientific principles and best practices concerning VIIRS and other geostationary and polar imagery, with the intended audience being National Weather Service forecasters in Alaska. The long-term vision is for GINA to develop a Quick Guide for every type of imagery and product than GINA generates and delivers to the NWS. For the time being, each Quick Guide is available on line at https://github.com/gina-alaska/satellite-quick-guides, and hard copies of each Quick Guide have been distributed to the National Weather Service offices in Alaska. Below is the Quick Guide for GINA’s 1.61 μm band.

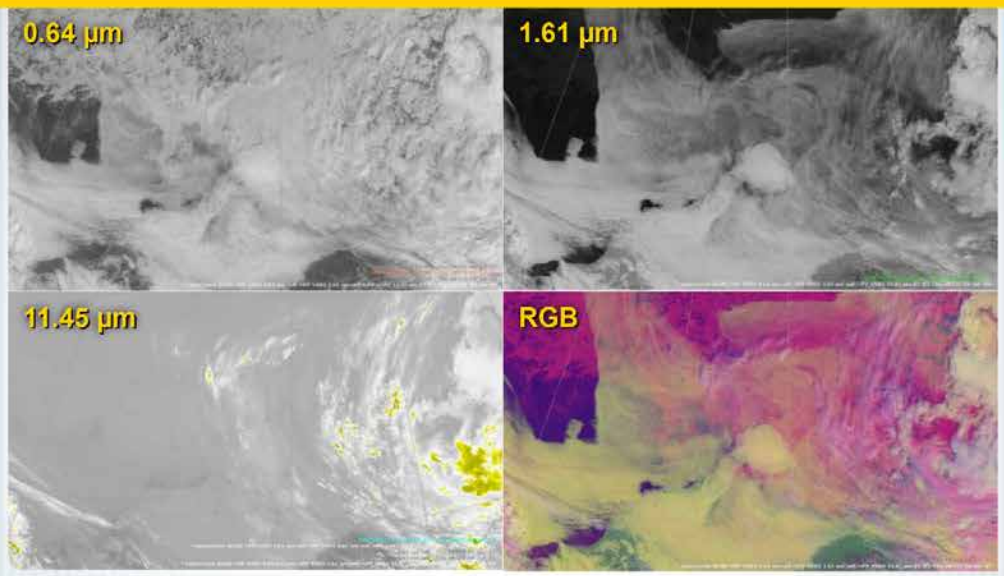
GINA

ALASKA DIRECT BROADCAST QUICK GUIDES

The 1.61 µm Near-IR "Snow/Ice" Band

OVERVIEW

1.61 µm channel earned the nickname "snow/ice band" because surfaces covered by snow and ice strongly absorb the 1.61 µm wavelength of incoming sunshine, while non-glaciated clouds strongly reflect the 1.61 µm wavelength. These properties of the 1.61 µm band make it a useful component of RGB images in Alaska, as the following examples demonstrate.



1.61 µm BAND AS COMPONENT OF RGBS

The four images above are from the Suomi NPP pass over the North Slope and Arctic Ocean at 1857Z July 9, 2015, with the Snow/Cloud RGB in the lower right being a combination of the other three single-channel images. The upper left image is the VIIRS 0.64 µm visible band (red component of the RGB), the upper right is the 1.61 µm snow/ice band (green in the RGB), and the lower left is the VIIRS 11.45 µm longwave infrared (IR) band (blue in the RGB).

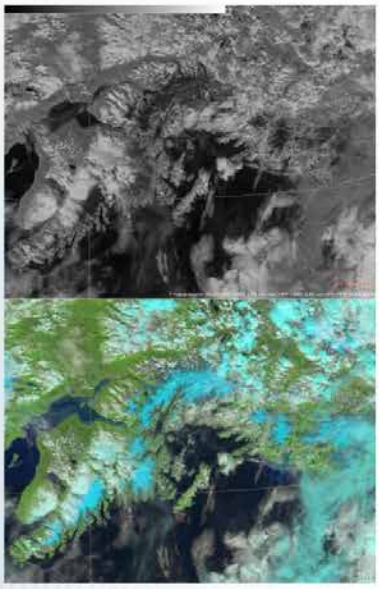
In each image, the upper left corner of the swath is free of clouds, so a mix of sea and open water may be observed. The sea ice appears reddish magenta in the RGB because the 1.61 µm channel is well absorbed by sea ice, meaning there is no green signal over sea ice. As shown in the 11.45 µm image, the sea ice and open water have similar longwave brightness temperatures, but since sea ice is much more reflective in the visible than open ocean, the sea ice appears reddish magenta, while the open ocean appears as a darker purple.

ADDITIONAL REFERENCES

Quick guides to channels on the GOES-R Advanced Baseline Imager (ABI). ABI Band 5 is centered at 1.61 µm
http://www.goes-r.gov/education/ABI-bands-quick-info.html

Eric Stevens: eric@gina.alaska.edu | Carl Dierking: cfdierking@alaska.edu | GINA Staff: www.gina.alaska.edu/people

Figure 1. Front of 1.61 µm band Quick Guide.



SURE, GLACIERS LOOK BLUE, BUT REALLY...

The imagery at left centered over Prince William Sound is from the Suomi NPP VIIRS instrument at 2156Z on July 10, 2015. The top image is the 1.61 µm snow/ice channel alone. The bottom image is the Natural Color RGB which assigns the 1.61 µm snow/ice channel to the red component, the 0.84 µm channel to the green component, and the 0.64 µm channel to the blue component.

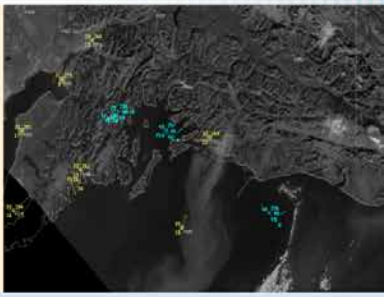
The glaciers and snow in the mountains surrounding Prince William Sound appears dark in the 1.61 µm image, due to this wavelength's strong absorption over snow and ice. Snow and ice are also not very reflective at 0.86 µm (the "veggie band"), so this RGB gets most of its signal over snow and ice from the 0.64 µm visible channel in the blue component, and hence the glaciers and snow appear blue. Liquid phase clouds are highly reflective at all three wavelengths used in this RGB, so they appear white. Glaciated cirrus clouds (in the lower right) are bluish-green because they don't reflect at 1.61 µm but do reflect at 0.64 µm and 0.86 µm.

Suomi NPP VIIRS image from 2156Z July 12, 2015.

HERE'S SILT IN YOUR EYE

1.61 µm imagery can also highlight areas of blowing glacial dust. At right, dust is blowing southward out of the Copper River Delta and over the Gulf of Alaska during an outbreak of strong northerly winds. Thus the VIIRS 1.61 µm channel can, thanks to the absence of obscuring clouds and the presence of daylight, allow forecasters to qualitatively "see the wind." This information can be useful in identifying stronger wind gusts out of bays and passes for marine forecasts.

Image courtesy Jim Nelson, WFO Anchorage



Satellite(s)	Instrument	Band Name	Wavelength	Resolution at NADIR
Suomi NPP	VIIRS	I3	1.61 µm	375 m
Terra and Aqua	MODIS	6	1.64 µm	500 m
POES and METOP	AVHRR	3a (available only during daytime)	1.61 µm	1100 m

The various satellites that carry instruments generating imagery at roughly 1.61 µm.

CONTACT

909 Koyukuk Drive
Suite 111 WRRB
P.O. Box 757275

University of Alaska Fairbanks
Fairbanks, Alaska 99775-7275

www.gina.alaska.edu | support@gina.alaska.edu

Figure 2. Back of 1.61 µm band Quick Guide.

(2) Building on the volcanic ash detection and characterization algorithms and software developed under the GOES-R program, JPSS imagery generated by GINA and delivered to the NWS captured the eruption of Pavlov Volcano in late March. Pavlov Volcano near the western tip of the Alaska Peninsula erupted in late March and sent a plume of volcanic ash to the north-northeast. Alaska Airlines cancelled dozens of flights on March 28 and

March 29 due to the presence of ash in the flight routes. Performing a channel differencing between 12 μm and 11 μm is particularly useful in highlighting the exact location of a plume of ash.

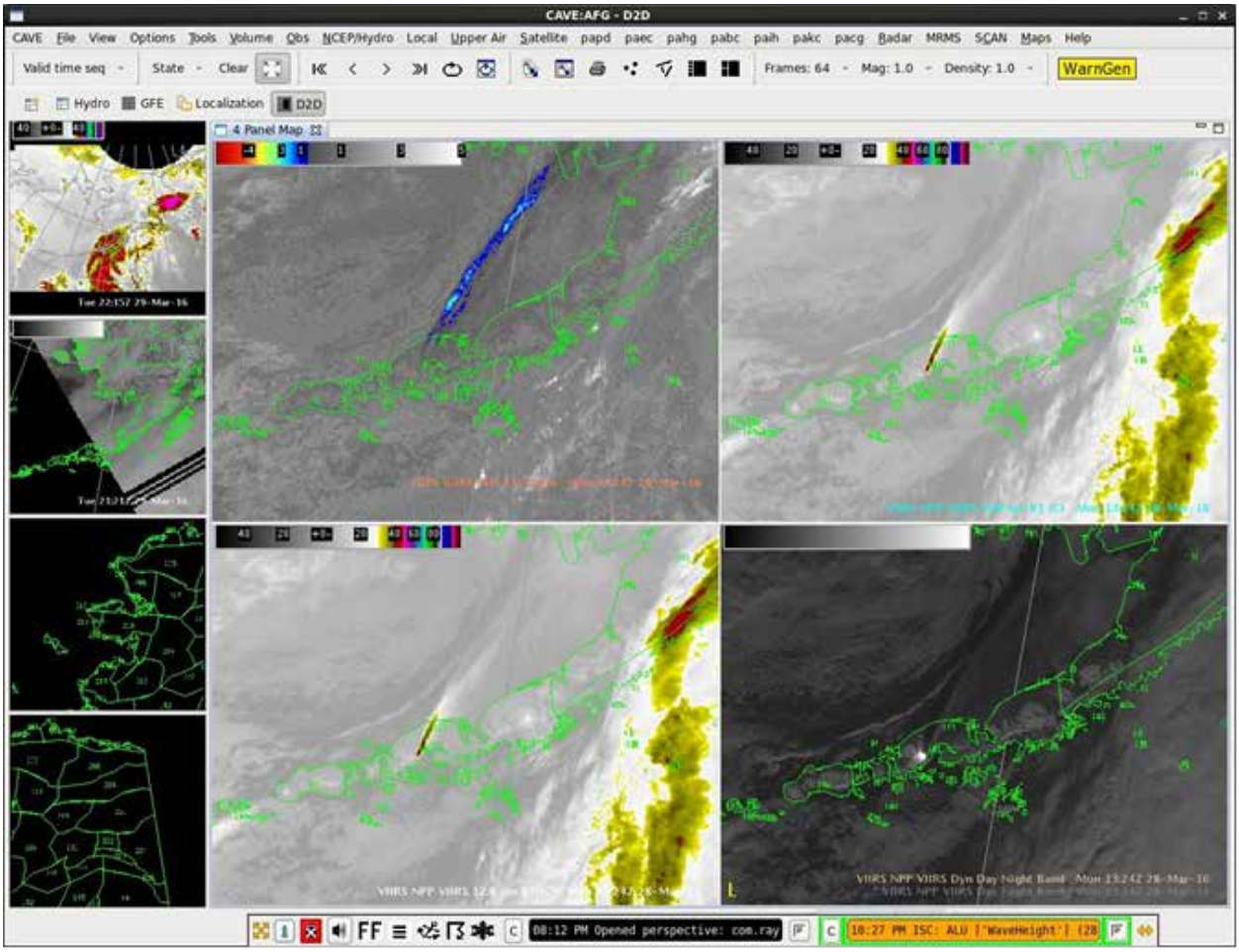


Figure. 3. Screen capture from the NWS AWIPS in Fairbanks, Alaska during the eruption of Pavlov Volcano. This 4-panel highlights the VIIRS imagery from the S-NPP satellite's pass at 1324 UTC (5:24am local Alaska time) on March 28. The upper left panel shows the difference between the VIIRS M15 and M16 bands, with the result that the presence of a volcanic ash plume is enhanced in shades of blue. The corresponding M15 (11μm) channel alone is in the upper right, and the M16 (12μm) channel is in the lower left. The lower right panel shows the Day Night Band. The Day Night Band plays no role in the channel differencing scheme used to enhance the signature of an ash plume as per the upper left panel, but since this S-NPP pass occurred during the hours of darkness the erupting volcano itself appears prominently as a small but very bright spot in the Day Night Band.

(3) Data assimilation to improve the Alaska regional weather forecast is another one of the key foci of this project. The experiments assimilate the atmospheric profile data from Advanced Infrared Sounder (AIRS) and combined Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS) into the initial condition of the WRF model. The level1 CrIS/ATMS data received by GINA in near real-time are converted into level2 sounding profile by NUCAPS algorithm. then the sounding profile data are assimilated the into WRF model. Observation data were used to evaluate the performance for case study and one month statistics analysis in terms of Root-mean-square-error(RMSE) methods. As an example, Figure n shows RMSEs of analysis of three variables at 850 mbar pressure level. RMSE is composed of mean bias and centered pattern variation. The distance between a point to origin indicates the RMSE value. RMSE projection to X axis represents mean bias, and RMSE projection to Y axis represents centered pattern variation. Comparing to WRF control run, WRF runs with AIRS and CrIS/ATMS profile data assimilation improve significantly dew point and wind speed. The major contribution of the improvement attributes to the decreasing of variation between analysis and observation. Temperature from data WRF runs with data assimilation have the similar performance

as WRF control run. The overall conclusion is that both AIRS and CrIS/ATMS profile data significantly improve the initial condition. They also have positive impact on short-term forecast.

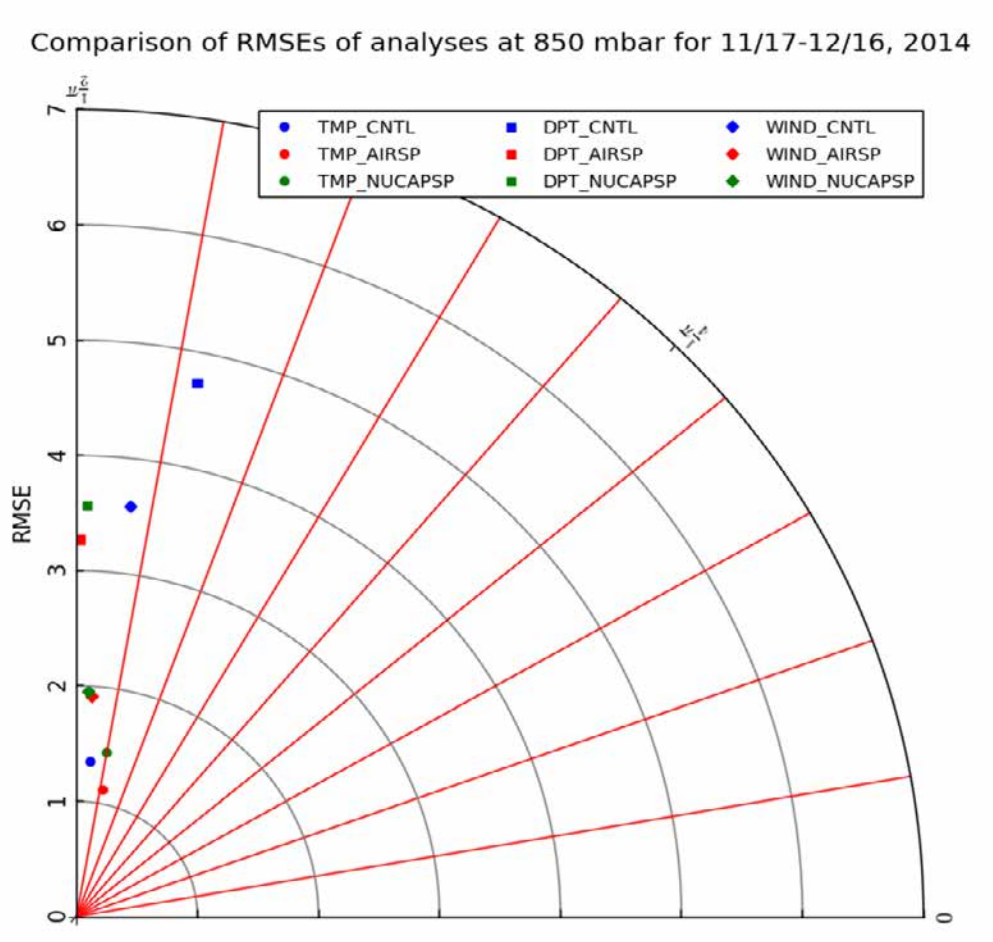


Figure 4. Comparison of RMSEs of analyses produced by WRF run in three modes: control, with AIRS profile assimilation, and with CrIS/ATMS profile assimilation.

(4) Hazardous weather is another area of emphasis for this proving ground project and plans are in place for monitoring of spring river breakup in Alaska, including airborne validation of Alaska-Pacific River Forecast Center (APRFC) models and the Joint Polar Satellite System (JPSS) river ice and flood product. Other hazards include fire weather and aviation flight hazards for low cloud and fog. Eric Stevens spent a week-long shift at the Joint Fire Service supporting fire weather prediction in 2015. In the spring of 2016, the group met with the Alaska Aviation Weather Unit (AAWU) to discuss support for case study analysis and forecast verification for flight category and other AAWU products and are planning additional activities in year two of the project, including additional simulations of cold air aloft.

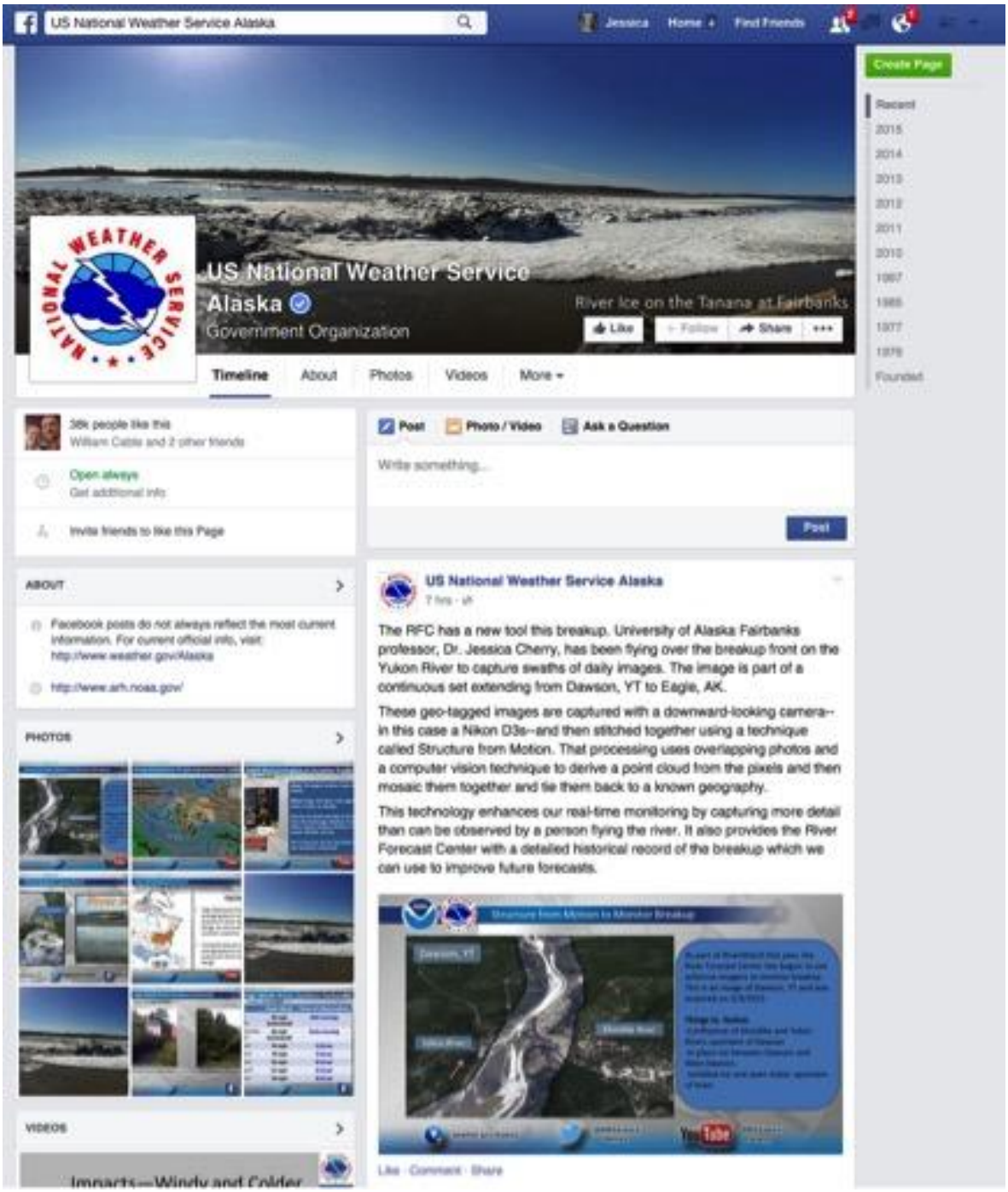
NOAA relevance/societal benefits

The National Weather Service, Alaska Region, is the largest operational forecasting user of polar orbiting satellite data in NOAA because of its unique high latitude location and forecasting and warning domains. In addition to polar orbiting data, geostationary satellite data is used effectively in southeast Alaska and the Aleutians and as a synoptic tool for the rest of the state. Effective use of polar orbiting data is essential for accurate forecasting and warning at high latitudes.

Outreach

In April of 2015 GINA's Eric Stevens recorded an outreach segment for the statewide public television broadcast, 'Alaska Weather' addressing how satellite imagery from the High Latitude Proving Ground can be used to find wildfires and even to determine which portions of a wildfire are burning hottest and are the most active. Video can be watched at: https://www.youtube.com/watch?v=BNqPUv9aeVI

Cherry's airborne river breakup flights were a valuable tool for the Alaska Pacific River Forecast Center and also a powerful outreach exercise. She was interviewed by a local news station in Circle, AK and NWS posted samples of the imagery she provided them. This is illustrated on the Alaska NWS Facebook page:



Publications and presentations

Publications

Stevens, E. 2015. High Latitude Proving Ground update. CSPP/IMAPP Users' Group Meeting hosted by EUMETSAT in Darmstadt, Germany, April 13-17, 2015.

Cherry, J. 2015. Pan-Arctic Snowfall Reconstruction: Product Description and Analysis. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Zhu, J. 2015. Improving Alaska Region Short-term Weather Forecasts with Data Assimilation. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Heinrichs, T. 2015. Sensors You May Not Be Aware Of: Real-time Satellite Data and Services Available at UAF-GINA. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Cherry, J. 2015. Tracing Arctic Hydrology with Observations of Water Vapor Isotopes from In Situ, Airborne, and Satellite Platforms. Alaska Weather Symposium, Anchorage, Alaska, May 11-12, 2015.

Heinrichs, T. 2015. Direct Readout Enhancements in Alaska. OCONUS Technical Interchange Meeting, Anchorage, Alaska, May 12-15, 2015.

Dierking, C. 2015. Sandy Supplemental Project: New AWIPS Data for NWS Alaska. OCONUS Technical Interchange Meeting, Anchorage, Alaska, May 12-15, 2015.

Cherry, J. and K. Bennett, 2015. Demonstration of Airborne Hydrology. OCONUS Technical Interchange Meeting, Anchorage, Alaska, May 12-15, 2015.

Stevens, E. 2015. Operational Use of the Day-Night Band in Alaska. Proving Ground User Readiness meeting, Kansas City, Missouri, June 15-19, 2015.

Stevens, E. 2015. Operational Use of RGBs in Alaska. Proving Ground User Readiness meeting, Kansas City, Missouri, June 15-19, 2015.

Zhu, Jiang, E. Stevens, T. Heinrichs, J. Cherry, and C. Dierking, 2016: AIRS/CrIS Sounding Profile Data Improves Short-term Weather Forecast in Alaska, poster, 96th American Meteorology Society annual meeting, Jan 10-14, 2016, New Orleans, USA.

Partner organizations and collaborators

Weather Forecast Offices (WFOs), the Alaska Pacific River Forecast Center (APRFC), the Alaska Aviation Weather Unit (AAWU), and the Alaska Sea Ice Program (SIP), the NOAA research partners (Cooperative Institute for Meteorological Satellite Studies--CIMSS, Center for Satellite Applications and Research--STAR, Short-term Prediction Research and Transition and Center--SPoRT, Cooperative Institute for Research in the Atmosphere--CIRA), and the National Operational Hydrologic Remote Sensing Center (NOHRSC).

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

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

CIFAR themes: Coastal Hazards; Ecosystem Studies & Forecasting

NOAA Goals: Healthy Oceans; Weather Ready Nation

Amendment 11 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.

Phase 5 (Final Mission) – Channel Islands Field Program (July 2014 – December 2014)

Description - Upon successful completion of the Avon Park Demonstration in June 2014, preparations were made for the final field program of the project, a two-day cruise on the Channel Islands National Marine Sanctuary R/V Shearwater out of Santa Barbara, California harbor. Only flights of the Resolution were scheduled since the Puma already had a number of marine debris flights both within this project and within other projects. Required documents were prepared and sent to Matthew Nardi of AOC. AOC sought and received an FAA COA, frequency approval, and approval of the Commanding Officer AOC for the mission. A Flight Readiness Review was held on November 17 and final approvals were received just prior to the flights on December 5. Artificial targets were collected and stored on the Shearwater to be ready for the cruise on December 8 and 9. High-resolution multispectral visible satellite data were scheduled for just before and during the cruise. Matthew Nardi contacted the FAA to issue a NOTAM, and local helicopter and flightseeing companies were advised of the UAS operations as was the Santa Barbara Airport, Point Mugu, and the Coast Guard. Participants in the cruise were:

(1) William Pichel, NOAA/NESDIS/STAR/SOCD – Project Principal Investigator
(2) Tim Veenstra, Airborne Technologies Inc. (ATI) – Developer of the Resolution-3 and Pilot in Charge
(3) Rosanne Bailey - University of Alaska Fairbanks – Mission Coordinator
(4) Curtis Olson – ATI – Resolution Supplemental Pilot and Operator
(5) Todd Jacobs – NOAA Channel Islands National Marine Sanctuary (NMS) - Observer and Representative of NOAA UAS Program Office and Channel Islands NMS
(6) Terrence Shinn – Captain of the R/V Shearwater
(7) Charles Lara – First Mate of the R/V Shearwater
(8) Elizabeth Mackie – NOAA Commissioned Corps – NOAA Shearwater Representative

On December 8, after loading aboard two Resolution aircraft, fire and abandon ship training were given by the Shearwater crew, and Rosanne Bailey led a briefing on the Resolution aircraft and safe operation. Weather and visibility were excellent and there were numerous natural surface targets (birds, kelp, porpoises and a whale). The Resolution was successfully launched from its catapult launcher and flew for 43 seconds. Then a random failure occurred in the servo controlling the left elevon. The aircraft rolled and dived into the water, damaging the wing on impact and the electronics after water entered the aircraft through the broken wing. It was determined that no more flights should be attempted with the backup aircraft until the problem was diagnosed. On December 9, an incident report was prepared for AOC and Matthew Nardi submitted it to the FAA. It was decided that the cause of the failure was not known sufficiently to consider another flight and probably would not have been approved by AOC in any case. The ATI crew briefed everyone on the ATI aircraft, launcher, and the image mosaicking and analysis software system. Artificial debris targets were returned to their source and the field program was concluded.

Results and Deliverables – Documents submitted to AOC and received from the FAA for the COA and from AOC for mission approval included:

(1) CINMS Operation Risk Management Assessment ("2014 ATI Resolution 3 Marine Debris CINMS ORM Final-1.pdf")
(2) CINMS Operations Plan ("Channel_Islands_Reslution_Field_Program_Ops_Pland_V5.docx")
(3) CINMS Aircraft Support Form ("NOAA Form 57-11-51 Aircraft Support Request Form_UAS_survey _of_Japanese_Marine_Debris_Pichel_final_field_program-1_signed.pdf')
(4) Resolution Technical Document ("Resolution Tech document.pdf")
(5) UAS Flight Request Form ("UAS Flight Request – Resolution_Channel_Islands_NMS_4.pdf'")
(6) COA ("121203_FAA Form 7711-1 2014-WSA-182 COA NOAA (Resolution) Channel Islands CA.pdf")
(7) AOC Commanding Officer approval: (ATI_Resoltuion_COFltAuthorization_DEC_2014.pdf")

The ATI Resolution Pre-flight checklist was used during the Resolution launch preparations

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 (water color, vegetation...) and objects that you intend to capture. In image #1 and #2, you will notice that the white sun tent and car are slightly washed out.

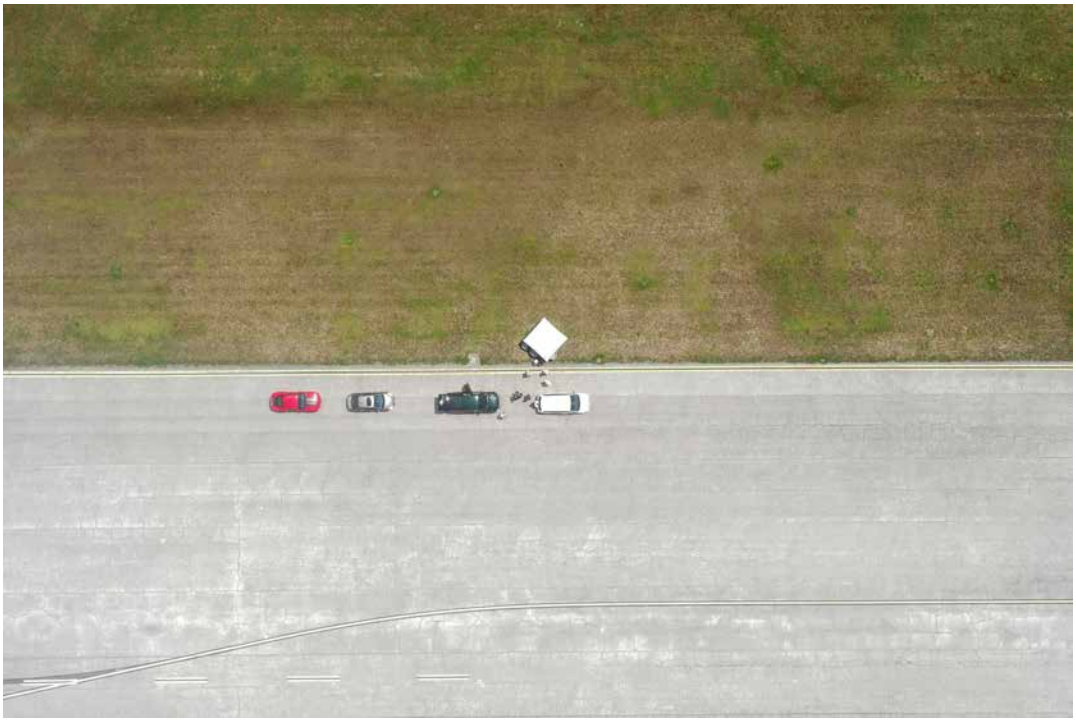


Illustration 1: Image #0083 of runway with vehicles and sun shelter

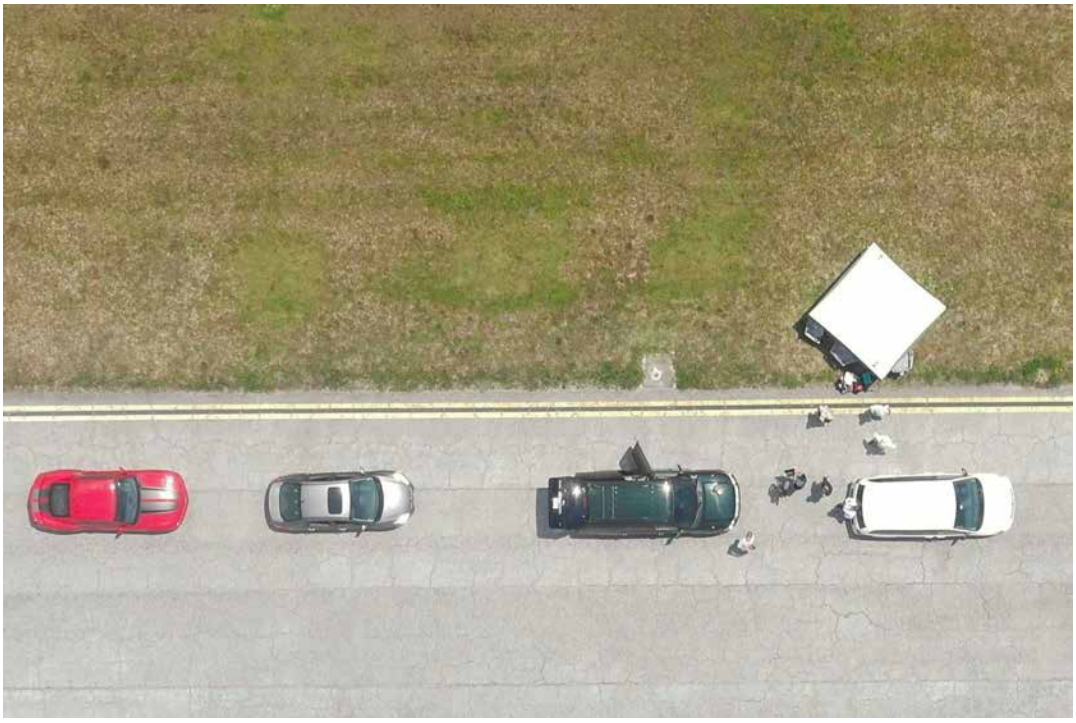


Illustration 2: Cropped view of image #0083 with 1.5 cm per pixel ground resolution

Illustration 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.

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 previous reports)

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

(1) Columbia University
(2) University of Colorado
(3) Ball Aerospace
(4) US Air Force Special Operations Command
(5) AeroVironment Inc.
(6) 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.

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 associated with this project:
Jonathan Dehn, Stephen McNutt, co-PIs, University of Alaska Fairbanks

NOAA Goal: Weather Ready Nation

Amendments 9, 17 NOAA Office: NESDIS, Andrew Heidinger, Sponsor

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

For the past year we have been continued our comparisons between satellite-derived volcanic ash retrievals and the WRF-Chem volcanic ash transport model. Our aim here was to transition between this research project and the follow on project that will continue to use the WRF-Chem model and build more real-time products. Our work in this final year has focused on how to perform model simulations quickly using both Lagrangian models, such as HYSPLIT or Puff, and Eulerian models, WRF-Chem. As the project is coming to an end then we have been winding down the research being performed.

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 SO2 and ash 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. Sean's work has transitioned into the follow-on project [PI Martin Stuefer, GOES-R RAP, amendment 21 to this cooperative agreement].

Martin C. Harrild, MSc. Student in Geology and Geophysics. Role on the Project: Early detection of volcanic events in real-time ground observations to instigate WRF-Chem real-time simulations for active volcanoes. Martin has been to continue to work with ground-based webcams and comparing the data to satellite imagery for the every detection of events.

This work leads into the follow-on project [PI Martin Stuefer, GOES-R RAP, amendment 21 to this cooperative agreement] of integrating the WRF-Chem model into the Rapid Refresh (RAP), the continental-scale NOAA hourly updated assimilation/modeling system operational at the National Center for Environmental Prediction (NCEP).

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.

Publications related to this project, funded under previous cooperative agreements:

The work published from this project is being continued as part of the follow-on project [PI Martin Stuefer, GOES-R RAP, amendment 21 to this cooperative agreement] of integrating the WRF-Chem model into the Rapid Refresh (RAP), the continental-scale NOAA hourly updated assimilation/modeling system operational at the National Center for Environmental Prediction (NCEP).

GOES-R Volcanic Ash Risk Reduction: Operational decision support within NOAA's Rapid Refresh (RAP)

Martin Stuefer, PI
Peter Webley, PI
Geophysical Institute, University of Alaska Fairbanks

Other investigators/professionals associated with this project (w/affiliation):
Georg Grell *(NOAA Earth Systems Research Laboratory****), Michael J Pavolonis*** *(NOAA/NESDIS Center for Satellite Applications and Research (STAR))*

NOAA Goal: Weather Ready Nation

Amendments 21, 37 NOAA Office: NESDIS, Andrew Heidinger, Sponsor

Primary objectives

Evaluate the GOES-R Advanced Baseline Imager (ABI) Volcanic Ash Algorithm (VAA) baseline product with case studies using the Weather Research Forecasting model with inline Chemistry (WRF-Chem), and to provide pathways to implement the ABI VAA in NOAA's operational Rapid Refresh modeling system. The work aims to improve NWS operational numerical weather prediction capabilities for aviation hazard support.

Research Accomplishments/highlights:

- WRF-Chem case studies have been completed with historic eruption source parameters. The data are available for comparison with the GOES-R equivalent ash retrievals from MODIS data.

- Volcanic ash alerts are implemented in scripts triggering a routine to create a modelling domain, all pre-processing files; the routine consequently initiates the WRF-Chem model run. The scripts are transferable and will be used for RAP.
- An ash aggregation scheme is in development. The WRF-Chem source code has been modified to test the aggregation parameterization. A description follows below.
- Observational data were compiled.

Model Development: A main goal of our case studies is to refine the volcanic eruption source parameters and to improve our assumptions on ash particle size distributions. The inclusion of ash particle aggregation in operational runs of WRF-Chem and RAP depends on computational costs, and benchmark tests still need to be performed. In general ash aggregation occurs when two or more ash particles collide and stick together forming ash aggregates. The rate or probability of collisions of ash particles and the efficiency with which they stick together upon impact must be considered. A simplified version of the Smoluchowski coagulation scheme captures the rate of change in ash particle number density. The change in particle distribution (ΔN) due to aggregation is derived by

$$\Delta N = \alpha(A_B n_{tot}^2 + A_S \phi^{\frac{3}{D_f}} n_{tot}^{2-\frac{3}{D_f}} + A_{DS} \phi^{\frac{4}{D_f}} n_{tot}^{2-\frac{4}{D_f}})\Delta t$$

where α is a unitless sticking efficiency, n_tot is the total number of primary particles available for aggregation and ϕ is the volume fraction of primary particles in the size distribution. The collision kernels A_B, A_S and A_DS represent the rate at which ash particles collide based on Brownian motion, fluid shear and differential sedimentation, respectively. Table 1, below, shows the equations for each of these kernels.

The solid volume fraction, ϕ, is calculated as the sum of all particle concentrations in each WRF grid cell, divided by the density of these particles. For our study, we assume that each WRF-Chem ash-bin corresponds to particles with a density of 2,500 kg/m3. The variable ϕ is calculated according to

$$\phi = \sum_{i}^{10} \frac{C_i \left(\frac{kg}{m^3}\right)}{2{,}500 \left(\frac{kg}{m^3}\right)}$$

The total number of primary particles available for aggregation is calculated by assuming spherical shape and converting to a number density based on density. This can be expressed mathematically as

$$n_i = \frac{C_i}{2{,}500\ \pi\ d_i^3}$$

The fractal exponent D_f requires the assumption that volcanic ash aggregates assume fractal geometry. The above equation for ΔN exploits the power law relationship between the diameter and number density of initially identical primary particles to the diameter of the aggregates formed. The value of the fractal dimension is related to the amount of space the aggregate fills and ranges from $0 < D_f < 3$. A fractal dimension of 3, for example, would fill all available space whereas a fractal dimension of 0.5 would leave a great amount of unfilled space. This geometry, therefore, depends on the type of particle being considered; values between 2.8 and 3.0 are good approximations for volcanic ash.

Table 1 – Collection Kernel Equations

Kernel	Equation	Variables and Units
Brownian Motion	4) $K_B = -\frac{4}{3}\frac{k_b T}{\mu}$	k_b– Boltzmann Constant - m^2 kg s^{-1} K^{-1} T – Temperature – K μ – Dynamic Viscocity - kg m^{-1} s^{-1} d – Diameter - m
Fluid Shear	5) $K_S = -\frac{2}{3}\xi^3 \Gamma_s$	Γ_s - Fluid Shear – s^{-1} d – Diameter - m
Differential Sedimentation	6) $K_{DS} = \frac{\pi(\rho_p - \rho)g}{48\mu}\xi^4$	d – Diameter – m V_d - Fall Velocity – m s^{-2}

The kernels representing fluid shear and differential sedimentation rely on a fractal size to volume relationship. We assume ξ=1.

While the collection kernels give an empirical measurement of the total collisional cross section of two particles forming an aggregate, the terms do not allow conclusions about their probability to stick together. For this reason, the total collection kernel, K, which is a sum of the individual kernels, K = KB + KS + KDS, must be multiplied by a sticking efficiency factor.

The probability of whether or not two particles stick together upon collision depends greatly on water vapor content. By using an exponential fit to various observational studies, a lookup table has been implemented in WRF-Chem based on ambient water vapor.

Near Real-Time WRF-Chem runs: A scheme to run the WRF-Chem volcanic ash cloud dispersion model in an operational-like setting has been developed. Volcanic activity alerts from the U.S. Geological Survey (USGS) Volcano Notification Service (VNS) (http://volcanoes.usgs.gov/vns) occur daily, and we are now able to run WRF-Chem volcanic ash predictions for the 'color coded' volcanoes daily. The WRF-Chem runs are initialized with default volcanic eruption source parameters, which could be replaced by GOES-R volcanic baseline products in the future potentially providing very accurate forecast alerts. We tested options to initialize WRF-Chem with RAP, and plan to run RAP-WRF-Chem in near-real time daily or whenever activity alerts are present.

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. The GOES-R high temporal resolution in combination with the Rapid Refresh (RAP) model will allow for a timely volcanic ash hazard awareness and dissemination of volcanic warnings.

Education

Sean Egan is a Ph.D. candidate student in Environmental Chemistry working within this project.

Publications and presentations:

S. Egan, M. Stuefer, P. Webley, and C. Cahill, "WRF-Chem modeling of sulfur dioxide emissions from the 2008 Kasatochi Volcano," Ann. Geophys., vol. 57, no. 0, 2015.

Stuefer, M., Freitas, S. R., Grell, G., Webley, P., Peckham, S., McKeen, S. A., & Egan, S. D. (2013). Inclusion of ash and SO2 emissions from volcanic eruptions in WRF-Chem: development and some applications. Geoscientific. Model Development, 6(2), 457–468.

Stuefer, M., G., Egan, S. D., Webley, P., Freitas, S. R., Grell G.: Volcanic WRF-Chem Model Application Updates. Invited Poster presentation at the 7th International Workshop on Volcanic Ash; October 2015, Anchorage.

Impact, Other products and outcomes:

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.

Partner organizations and collaborators:

Georg Grell, NOAA Earth Systems Research Laboratory

Michael J Pavolonis, NOAA/NESDIS Center for Satellite Applications and Research (STAR)

Alaska Earthquake Center seismic station operations and maintenance

Michael West, PI ***CIFAR theme: Coastal Hazards***
Natalia Ruppert, Co-PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project (w/affiliation):
Miriam Braun, Christopher Braun, Scott Dalton, Ian Dickson, Dara Merz, Sara Meyer, Natalia Kozyreva, Mitch Robinson
University of Alaska Fairbanks

NOAA Goal: Weather Ready Nation

Amendments 7, 26, 41 NOAA Office: NWS, Michael Angove, Sponsor

Primary objectives

- Maintain NOAA-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 National Tsunami Warning Center (NTWC) and emergency managers.
- Maintain data flow of selected stations to NTWC

Research Accomplishments/highlights:

Between April 1, 2015 and March 31, 2016, the Alaska Earthquake Center (AEC) reported 36,128 events with magnitudes ranging between -1.2 and 7.1 and depths between 0 and 271 km (figure 1). Six earthquakes had magnitudes of 6 or greater. The largest earthquake, of magnitude 7.1, occurred on 24 January 2016 in the Cook Inlet region of Alaska. The earthquake caused four homes to be lost on the Kenai Peninsula due to a gas leak and related fires. Power outages affected about 100,000 meters across Southcentral Alaska.

In July 2015 we completed the last remaining digital upgrade by replacing the original sensors and digitizer at UNV with new, AEC-purchased instruments and by upgrading the analog phone line to a DSL circuit.

The average data return rate for the 17 NOAA-funded seismic stations was 97%. Excluding DCPH, which remains out of service due to USCG tower construction, only UNV had a data return rate below 90% (UNV's post-upgrade data return rate was 97%). By devoting AEC funds and leveraging EarthScope priorities, we raised the average data return rate at the nine previously de-scoped stations to 99%. These metrics are much better than in previous funding cycles.

However, the instruments at several NOAA-funded sites are approaching fifteen years in the field, and we are not budgeted for replacements. While several sites have benefitted from EarthScope- or AEC-provided instruments, other NOAA-funded sites will require additional funding to replace aging instruments.

- During the reporting period, we performed the following work on NOAA-funded sites:
- At ATKA, fixed timing problem and improved radio link.
- At DCPH, inspected USCG-installed seismic vault.
- At DOT, installed new Ethernet cable and removed old radio equipment from tower and school.
- At EYAK, upgraded radio and installed radome antenna.
- At GAMB, upgraded both sensors with EarthScope-provided instruments.
- At PAX, extracted 1964 sensor from borehole and installed a new, EarthScope-provided sensor in the borehole. This will improve data quality, as the old pier installation suffered from tilt.

- At SPIA, upgraded both sensors with EarthScope-provided instruments.
- At TNA, repaired animal damage to cabling. The sensors were upgraded in 2014 with new instruments provided by EarthScope.
- At UNV, replaced original broadband and strong motion sensors with Alaska Earthquake Center-purchased sensors and upgraded telemetry from analog phone line to DSL.

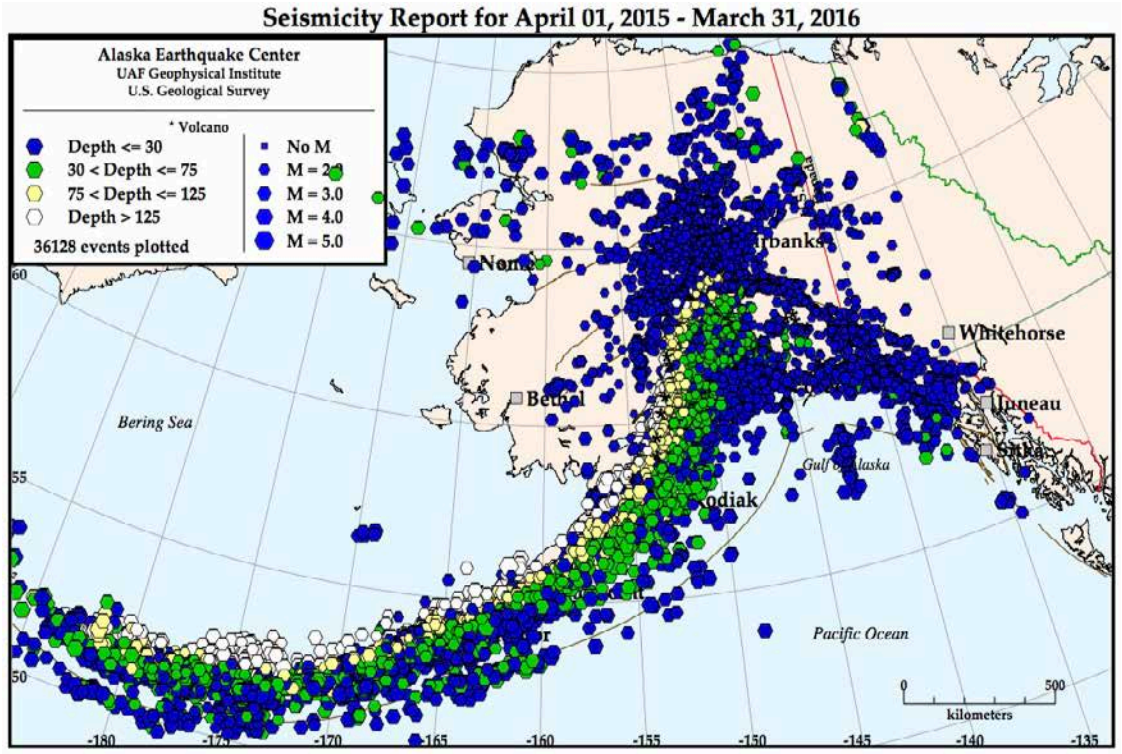


Figure 1. Events located from April 1, 2015 through March 31, 2016.

NOAA relevance/societal benefits

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

Outreach

AEC continues to provide real-time and reviewed earthquake information to local emergency services offices through monitoring systems installed in the following Alaska population centers: 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.

Awards through CIFAR 1 April 2015-31 March 2016

Appendix 1

CIFAR Projects Awarded in Cooperative Agreement NA13OAR4320056

1 April 2015 to 31 March 2016

Last	First	Proposal Title	Ame	Project Budge	Theme Description	Funding Sourc	NOAA PM
Task 1 Activities: CI Administration and Education & Outreach							
Sugai	Susan	Cooperative Institute for Alaska Reseach (CIFAR) renewal (2013-2018)	40	$37,309	Administration	NESDIS	Decker
Sugai	Susan	Cooperative Institute for Alaska Reseach (CIFAR) renewal (2013-2018)	40	$19,233	Administration	CPO	Decker
Sugai	Susan	Cooperative Institute for Alaska Reseach (CIFAR) renewal (2013-2018)	40	$15,145	Administration	NWS/ STI	Decker
Sugai	Susan	Cooperative Institute for Alaska Reseach (CIFAR) renewal (2013-2018)	40	$18,612	Administration	NMFS/ AKC	Decker
Sugai	Susan	Cooperative Institute for Alaska Reseach (CIFAR) renewal (2013-2018)	40	$12,229	Administration	OAR/ HQ	Decker
Sugai	Susan	Cooperative Institute for Alaska Reseach (CIFAR) renewal (2013-2018)	40	$10,000	Administration	OAR/ PMEL	Decker
Bhatt	Uma	Task I Request for S22127 - Eicken	45	$1,780	Administration	NOS	Mathis
Bhatt	Uma	Task I Request for S22127 - Eicken	45	$1,780	Administration	NESDIS	Mathis
Bhatt	Uma	Task I Request for S22127 - Eicken	45	$5,340	Administration	OAR	Mathis
Iken	Katrin	Arctic Marine Biodiversity Observing Network (AMBON) Graduate Student Traineeships (year 2 of 4)	35	$99,434	Education & Outreach	NOS/IOOS	Canonico

NOAA Non-Competitive Projects (NA13OAR4320056)							
Cherry	**Jessica**	High latitude proving ground for GOES-R: Advanced data products and applications for Alaska (year 2 of 3)	33	$202,473	Climate Change & Variability; Coastal Hazards	NESDIS	Goodman
Cross	**Jessica**	Alaska Ocean Acidification (OA) Research: Autonomous observations of OA in the Alaska coastal ocean	34	$100,000	Ecosystem Studies & Forecasting	OAR	Jewett
Heinrichs	**Thomas**	FY14 High latitude proving ground--Improving forecasts and warnings by leveraging GOES-R investment to deliver and test NPP/JPSS data in support of operational forecasters (year 3)	42	$203,425	Coastal Hazards	NESDIS	Brown
Hopcroft	**Russell**	Support for U.S. Participation in Circumpolar Biodiversity Monitoring Program (CBMP) expert networks	32	$29,927	Ecosystem Studies & Forecasting	OAR	Crane
Hopcroft	**Russell**	Long-term observations of Pacific-Arctic zooplankton communities 2015	36	$10,000	Ecosystem Studies & Forecasting	OAR	Crane
Quinn	**Terrance**	SAIP: Time-varying natural mortality: random versus covariate effects (year 2 of 2)	38	$91,681	Ecosystem Studies & Forecasting	NMFS	Hulson
Quinn	**Terrance**	Literature review of cetacean ship strikes & suggested mitigation meaures for use in Glacier Bay National Park	39	$25,000	Ecosystem Studies & Forecasting	NMFS	DeMaster
Stuefer	**Martin**	GOES-R Volcanic ash risk reduction: Operational decision support within NOAA's Rapid Refresh (RAP) year 2 of 2	37	$94,774	Coastal Hazards	NESDIS	Heidinger
West	**Michael**	Alaska Earthquake Information Center (AEIC) seismic station operations and maintenance (CRESTnet) year 3	41	$240,025	Coastal Hazards	NWS	Angove
Hopcroft	**Russell**	RUSALCA Datamanagement 15-20	44	$110,385	Ecosystem Studies & Forecasting	OAR	Crane
Eicken	**Hajo**	Support to Convene ASSW 2016	45	$20,000	Climate Change & Variability	NOS	Mathis
Eicken	**Hajo**	Support to Convene ASSW 2016	45	$20,000	Climate Change & Variability	NESDIS	Mathis
Eicken	**Hajo**	Support to Convene ASSW 2016	45	$60,000	Climate Change & Variability	OAR	Mathis
		Total projects funded (including CI administration)		**$1,428,551**			
		Task II & III awards for Task I formula		$1,207,690			

Personnel

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	18			2	16
Visiting Scientist					
Postdoctoral Fellow					
Research Support Staff	24		13	7	4
Administrative	2			2	
Total (≥50 % NOAA Support)	0				
Total	**44**		**13**	**11**	**20**
Employees (≥50 % NOAA Support	44				
Located in NOAA Lab	1				
Obtained NOAA employment within last year	0				

Undergraduate students	3		3		
Graduate students	11			7	4
Total students	**14**				

Publications

Appendix 3. Publication Activity

Summary table of publications during the current cooperative agreement NA13OAR4320056

	Institute Lead Author			**NOAA Lead Author**			**Other Lead Author**		
	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3
Peer-reviewed	0	1	1	0	0	2	0	1	12
Non Peer-reviewed	0	0	2	0	0		0	0	7
Accepted for publication		1	1		0			1	1

"Accepted" publications are peer-reviewed.

Year 1 = 1 July 2013-31 March 2014; Year 2 = 1 April 2014-31 March 2015; Year 3 = 1 April 2015-31 March 2016

Peer-reviewed papers published, in press, or accepted for publication during the reporting period

Assis, A.R., Reynolds, J.R, Greene, H.G., Stone, R.P. and Rooper, C.N. (2016): Benthic habitat for Primnoa deep-sea coral in the Fairweather Ground, Gulf of Alaska. GeoHab 2016 (Winchester, England), May 2-6, 2016.

Cokelet, E.D., Meinig, C., Lawrence-Slavas, N., Stabeno, P.J., Mordy, C.W., Tabisola, H.M., Jenkins, R., and Cross, J.N., 2016. The use of Saildrones to examine spring conditions in the Bering Sea. Oceans 2015 – MTS/IEEE Washington, IEEE, 7 pp. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7404357&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7404357

Cross, J.N., Mathis, J.T., Pickart, R.S., and Bates, N.R., 2016. Formation and transport of corrosive water in the Pacific Arctic Region. Deep Sea Research II, in preparation.

Cross, J.N., Mordy, C.W., Tabisola, H.M., Meinig, C., Cokelet, E.D., and Stabeno, P.J., 2016. Innovative Technology Development for Arctic Exploration. Oceans 2015 – MTS/IEEE Washington, IEEE, 8 pp. Available at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7404632&refinements%3D4225891946%2C4224617075%26filter%3DAND%28p_IS_Number%3A7401802%29

Divine LM, Bluhm BA, Mueter FJ, Iken K (2015) Diet analysis of Alaska Arctic snow crabs (Chionoecetes opilio) using stomach contents and δ13C and δ15N stable isotopes. Deep-Sea Res II. http://dx.doi.org/10.1016/j.dsr2.2015.11.009

Egan, S., M. Stuefer, P. Webley, and C. Cahill, "WRF-Chem modeling of sulfur dioxide emissions from the 2008 Kasatochi Volcano," Ann. Geophys., vol. 57, no. 0, 2015.

Ershova EA, Hopcroft RR, Kosobokova KN, Matsuno K, Nelson RJ, Yamaguchi A, Eisner LB (2015) Long-term changes in summer zooplankton communities of the western Chukchi Sea, 1945-2012. Oceanography 28:100-115

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Gleason, C.M., B.L. Norcross, K.J. Spaleta. In press 2016. Otolith chemistry discriminates water mass occupancy of Arctic fishes in the Chukchi Sea. Marine and Freshwater Research. Published online 24 Nov 2015, http://dx.doi.org/10.1071/MF15084

Grebmeier JM, Bluhm BA, Cooper LW, Denisenko SG, Iken K, Kedra M, Serratos C (2015) Time-series benthic community composition and biomass and associated environmental characteristics in the Chukchi Sea during the RUSALCA 2004–2012 Program. Oceanography 28: 116-133. http://dx.doi.org/10.5670/oceanog.2015.61

Hillger, D., T. Kopp, C. Seaman, S. Miller, D. Lindsey, E. Stevens, J. Solbrig, W. Straka, M. Kreller, A. Kuciauska, and A. Terborg, 2016. User Validation of VIIRS Satellite Imagery. Remote Sensing, 8(1); doi:10.3390/rs8010011 http://www.mdpi.com/2072-4292/8/1/11/pdf

Lee, S.H., J.H. Lee, H. Lee, J. H. Lee, D. Lee, S. An, H.T. Joo, D.A. Stockwell and T.E. Whitledge. In Prep. Light-limited uptake rates of carbon and nitrogen of phytoplankton in the Laptev and the East Siberian seas. Geophysical Research Letters

Mathis, J. T., W. Evans, J. N. Cross and N. Monacci. The Physical and Biogeochemical Influences on Ocean Acidification in the Northern Gulf of Alaska, Journal of Geophysical Research, in preparation.

Mathis, J.T., Cross, J.N., Evans, W., Monacci, N., and Muscelwicz, S., Five years of time series measurements of ocean acidification along the Alaskan coast. Continental Shelf Research, in preparation.

Meinig, C., Lawrence-Slavas, N., Jenkins, R., and Tabisola, H., 2016. The use of Saildrones to examine spring conditions in the Bering Sea: Vehicle specification and mission performance. Oceans 2015 – MTS/IEEE Washington, IEEE, 6 pp. Available at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7404348 &refinements%3D4225791370%2C4224619983%26filter%3DAND%28p_IS_Number%3A7401802%29

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Pisareva MN, Pickart RS, Iken K, Ershova EA, Grebmeier JM, Cooper LW, Bluhm BA, Nobre C, Hopcroft RR, Hu H, Wang J, Ashjian CJ, Kosobokova XN, Whitledge TE (2015) Patterns of Benthic Fauna and Zooplankton in the Chukchi Sea in Relation to the Physical Forcing. Prog Oceanogr 28:68-83

Pisareva MN, Pickart RS, Iken K, Ershova EA, Grebmeier JM, Cooper LW, Bluhm BA, Nobre C, Hopcroft RR, Hu H, Wang J, Ashjian CJ, Kosobokova KN, Whitledge TE (2015) The relationship between patterns of benthic fauna and zooplankton in the Chukchi Sea and physical forcing. Oceanography 28: 68-83. http://dx.doi.org/10.5670/oceanog.2015.58

Pisareva, M.N., R... Pickart, M.A. Spall, C. Nobre, D.J. Torres, G.W.K. Moore and T.E. Whitledge. 2015. Flow of Pacific water in the western Chukchi Sea: Results from the 2009 RUSALCA expedition. Deep-Sea Research I 105: 53-73.

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Wassmann P, Kosobokova KN, Slagstad D, Drinkwater K, Hopcroft RR, Moore SE, Ellingsen I, Nelson RJ, Popova E, Berge J, Carmack E (2015) The contiguous domains of Arctic Ocean advection: trails of life and death Prog Oceanogr 139:42-65

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PI Index

Appendix 4. Index of Lead Principal Investigators