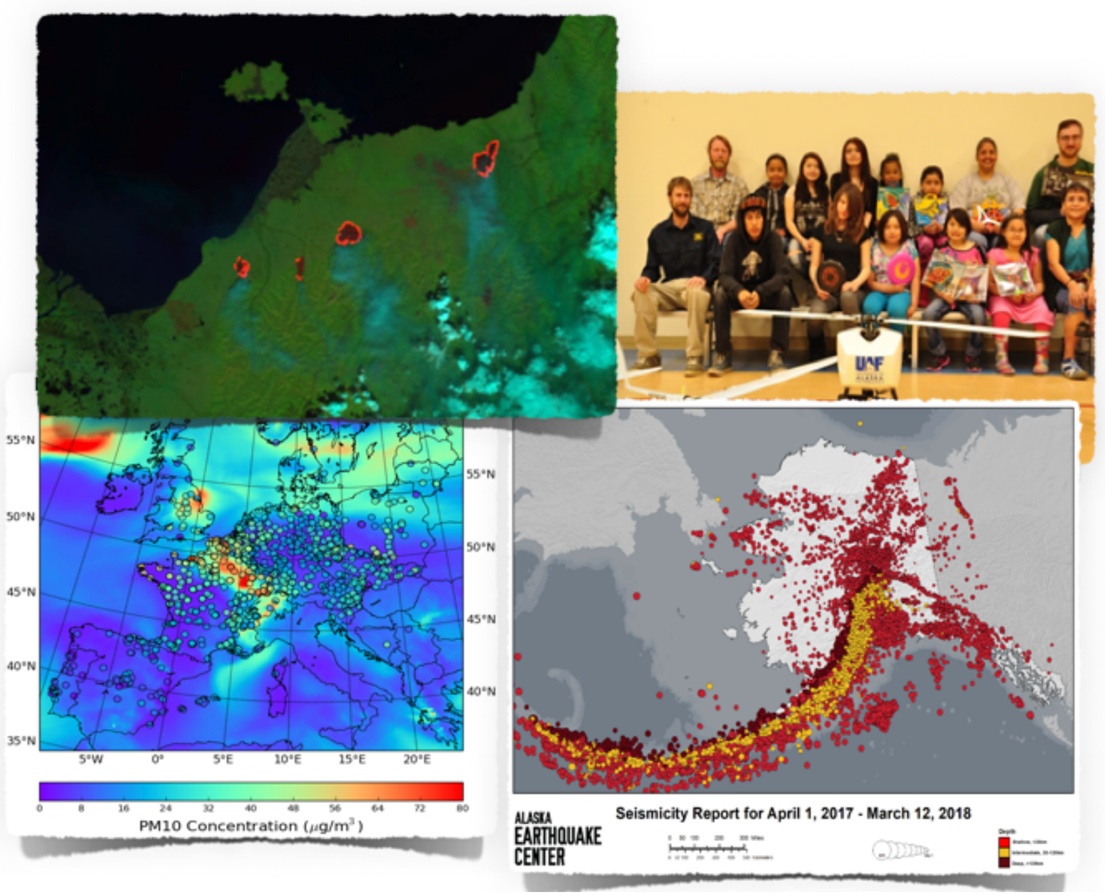
CIFAR
Cooperative Institute For Alaska Research

Fifth Report to NOAA on Cooperative Agreement NA13OAR4320056

1 April 2017 - 31 March 2018



UNIVERSITY OF
ALASKA
FAIRBANKS

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

1 April 2017-31 March 2018

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Cover graphic credits. *(Top Left)* The VIIRS-based Natural Fire Color RGB, highlighting fires near the southeastern coast of Alaska's Norton Sound from "High latitude proving ground – Improving forecasts and warnings by delivering and testing NPP/JPSS data in support of operational forecasters" project led by GINA. *(Top Right)* ACUASI's UAS crew with the local Circle school students and staff along with the ING Responder and additional UAS Aeromapper in the foreground from "Developing UAS CONOPS in support of NWS monitoring and forecasting of river ice breakup in Alaska" from project led by Dr. Cahill. *(Bottom Right)* Map of seismicity from April 1, 2017 through March 12, 2018 from "Alaska Earthquake Center seismic station operations and maintenance" project led by Drs. West and Ruppert. *(Bottom Left)* Daily average PM10 WRF-Chem simulated ground concentrations compared to measurements at air-quality stations in central Europe from "GOES-R Volcanic Ash Risk Reduction (R3): New operational GOES-R decision support within NOAA's High Resolution Rapid Refresh" project led by Drs. Stuefer and Webley.

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.

Vision, Mission, and Research Themes for CIFAR

The ***CIFAR Vision*** *is*:
Understand the Alaska environment for the protection of society.

The ***CIFAR Mission*** *is*:
Fostering collaboration between NOAA, the University of Alaska, and others doing research in Alaska and its associated Arctic regions.

The ***CIFAR Research Themes*** are:

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 Executive Board and Fellows did not meet in FY18 but new members were contacted and added when the Fellows were updated. Advice was sought and followed on the makeup of the Fellows from both the Board and continuing Fellows.

The ***CIFAR Executive Board*** members are:

1. Chidong Zhang, NOAA Office of Oceanic & Atmospheric Research (OAR) Pacific Marine Environmental Laboratory (PMEL) Director
2. Sandy Starkweather, NOAA OAR Arctic Research Office Program Manager
3. Douglas DeMaster, NOAA National Marine Fisheries Service (NMFS), Director, Alaska Fisheries Science Center (AFSC)
4. Carven Scott, Director NWS Alaska Region
5. Robert McCoy, Director of Geophysical Institute, University of Alaska Fairbanks
6. Bradley Moran, Dean of the College of Fisheries and Ocean Sciences (CFOS), University of Alaska Fairbanks
7. James Partain, NOAA Regional Climate Services Director, Alaska Region
8. Uma Bhatt, CIFAR director, ex officio

The ***CIFAR Fellows*** are:

1. Larry Hinzman, Vice Chancellor for Research, University of Alaska Fairbanks (UAF), Fairbanks, AK
2. Kris Holderied, Director NOAA/NOS Kasitsna Bay Laboratory, 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), CFOS, UAF, Fairbanks, AK
6. Seth Danielson, Research Associate Professor of Physical Oceanography, CFOS, UAF, Fairbanks, AK
7. Gordon Kruse, President's Professor of Fisheries, SFOS, UAF, Juneau, AK
8. Betsy Baker, Executive Director, North Pacific Research Board, Anchorage, AK
9. Molly McCammon, Director, Alaska Ocean Observing System, Anchorage, AK
10. Phil Mundy, Division director, Auke Bay Laboratory, AFSC, NMFS, NOAA, Juneau, AK
11. James Overland, Oceanographer, PMEL, NOAA, Seattle, WA

Summary of Awards Made during Reporting Period

During the fifth reporting year of our renewal cooperative agreement NA13OAR4320056, NOAA provided 19 amendments to the CIFAR renewal agreement for CIFAR core administration, one Task I education and outreach/ Task 1 recovery amendment and 18 Task III research awards/ Task 1 recovery totaling over $2.6M. 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 I & III projects (percentage of total) by NOAA line office. Each of the amendments provided funding for Task 1 Core Support, including the amendment received for the Education and Outreach project. CIFAR did not receive any Task II funds this reporting period.

Table 1: Summary of CIFAR Awards Funded 1 April 2017-31 March 2018: by Task and Theme

Theme	Number of Awards	Total Amount	Subtotals by Task	Percent of Total (rounded)
Administration (Task I)	**19**		**$220,830**	**8.39%**
Core Support	19	$206,045		7.82%
Education & Outreach	1	$14,785		0.56%
Research Themes (Task II & III)	**18**		**$2,412,475**	**91.61%**
Climate Change & Variability	8	$838,732		31.85%
Coastal Hazards	3	$469,879		17.84%
Ecosystem Studies & Forecasting	7	$1,103,864		41.92%
Total	**19**		**$2,633,305**	**100.00%**

Table 2: Summary of CIFAR Task I III Awards Made 1 April 2017-31 March 2018: by Funding Source

Funding Source	Number of Awards	Total Project Amount	Percent of Total	Total Task 1 Recovery Amount	% of Task I Recovery paid
NESDIS	4	$948,736	39.09%	$80,645	39.14%
OAR	7	$660,797	27.22%	$55,832	27.10%
NWS	2	$387,465	15.96%	$32,935	15.98%
NMFS	5	$415,477	17.12%	$35,317	17.14%
NOS	1	$14,785	0.61%	$1,316	0.64%
Total	**19**	**$2,427,260**	**100.00%**	**$206,045**	**100.00%**

During the current reporting year, the funding of Task I core administration support for CIFAR was billed to line offices based upon the NOAA's implementation of the Task 1 recovery 'pay as you go' policy. CIFAR's Task 1 recovery fee was 8.5% for part of this reporting period, and is now 7.3%.

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 three UAF employees, two of whom also staff various other departments: Uma Bhatt, director, working on a 1.0 FTE; Nancy Fresco, associate director, working on a 0.75 FTE; and Sarah Garcia, CIFAR administrator, working remotely on a 0.75 FTE. During this reporting period, the CIFAR staff dedicated work load was:

1) Uma Bhatt, CIFAR director, 24.6% FTE (match)
2) Nancy Fresco, CIFAR associate director, 21.4% FTE (match)
3) Sarah Garcia, CIFAR administrator, 65.9% FTE (Task I and match)

Uma Bhatt provides overall CIFAR programmatic guidance and oversees daily operations. She is responsible for approving all CIFAR proposals and overseeing reporting obligations. Nancy Fresco provides support for CIFAR activities and scientific content to the CIFAR web page.

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.

A proposal review panel met on 17 April 2017 and recommended full or partial funding of nine projects for awards running from 1 July 2017 to 30 June 2018. Eight of these awards were funded with CIFAR match or Task 1 education funds.

The students and their FY18 CIFAR projects are listed here:

1. **Rebecca Rolph**, Geophysical Institute, UAF
"Investigating the impact of Arctic storms on the timing of freeze-up and changes in storm intensity and frequency over a lengthening open water period."
2. **Duncan Green**, College of Fisheries and Ocean Sciences, UAF
"Bioenergetic assessment of juvenile broad whitefish responses to climate change in the Alaskan Arctic."
3. **Aaron Bland**, College of Fisheries and Ocean Sciences, UAF
"Delineating Aleutian Epibenthic Communities: The Role of the Changing Environment."
4. **Ryan McCoy**, Institute of Northern Engineering, UAF

"Analysis of catchment characteristics of frozen debris lobes - Brooks Range, Alaska."

5. **Cole Payne**, Geophysical Institute, UAF
"Changing Colville River Environment and its Impact on River Navigation and Subsistence Travel."
6. **Tessa Minicucci**, College of Fisheries and Ocean Sciences, UAF
"Effects of Asian pink and chum salmon on western Alaska chum salmon."
7. **Lei Cai**, International Arctic Research Center, UAF
"The Arctic Summer Dipole, its remote controls, and climatic implications for coastal Alaska."
8. **Matvey Debolskiy**, International Arctic Research Center, UAF
"Modeling impact of dynamic permafrost on long term response of terrestrial mesoscale watersheds in a warming environment."

This year, in addition to the competitively funded student projects listed above, CIFAR provided student support funds to six ongoing CIFAR Task III projects. CIFAR realized the need for this due to several research proposal budgets (while at the proposal stage) reducing or eliminating their student employee efforts simply because lack of funding. The student funds provide support only for the students' efforts and related costs while working directly on the CIFAR Task III project. Names of students supported through these additional Task 1 education funds are shown in bold face in the summary below, along with the name of the CIFAR Task III project.

The student support awards ran from 1 July 2017 to 30 June 2018, with a few being extended through 30 June 2019. All of these awards were funded with Task 1 education funds.

1. **Lauren Sutton**, College of Fisheries and Ocean Sciences, UAF
Dr. Katrin Iken's "Arctic Marine Biodiversity Observing Network (AMBON) Graduate Student Traineeships."
2. **Kyle Jones**, Geophysical Institute, UAF
Dr. Michael West's "Alaska Earthquake Information Center (AEIC) seismic station operations and maintenance (CRESTnet)."
3. **Christina Waigl**, Geophysical Institute, UAF
Dr. Martin Stuefer's "GOES-R Volcanic ash risk reduction: Operational decision support within NOAA's Rapid Refresh (RAP)."
4. **Jennifer March**, College of Fisheries and Ocean Sciences, UAF
Dr. Franz Mueter's "Fish and Fisheries research in the Central Arctic Ocean."
5. **Samuel George**, Geophysical Institute, UAF
Mrs. Lisa Wirth's (formerly Mr. Thomas Heinrich's) "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."
6. **TBD**, Geophysical Institute, UAF
Mrs. Lisa Wirth's (formerly Dr. Jessica Cherry's) "High Latitude Proving Ground for GOES-R Advanced Data Products and Applications for Alaska."

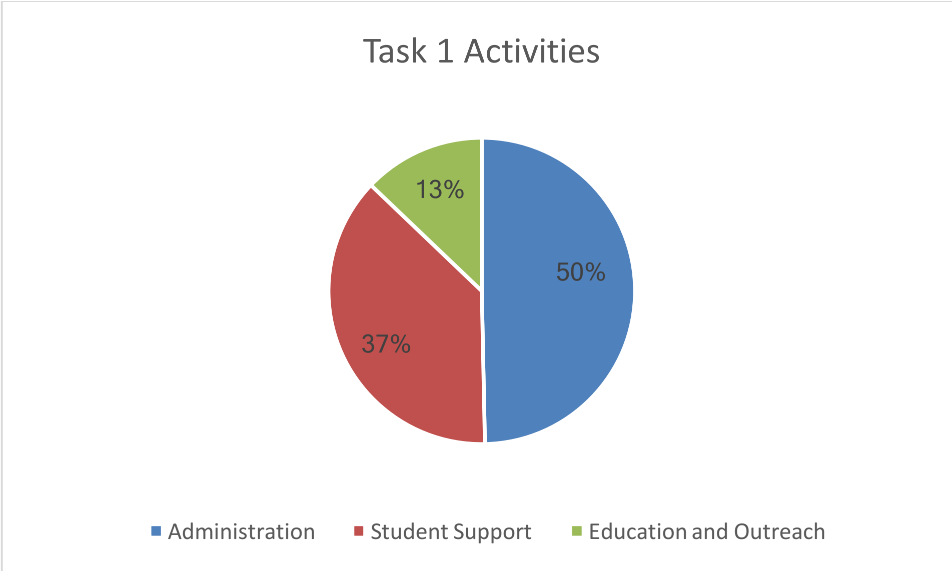


Figure 2: Pie chart displaying TASK 1 breakdown over period 1 April 2017-31 March 2018.

Other CIFAR Administrative Activities

Figure 1: Group photo taken in the meeting room of the International Arctic Research Center of the University of Alaska Fairbanks in August 2017 during the CI/JI administrators meeting hosted by CIFAR.

The annual CI/ JI administrators meeting (Figure 1) was hosted by CIFAR in August. 2017 in Fairbanks Alaska. Administrators traveled from almost all of the CI/ JIs. Those that were unable to attend were invited to view/ participate in the meeting via a live stream. The meeting covered challenges as well as solutions for managing the CIs effectively.

Highlights of CIFAR Research Activities

CIFAR's modest but diverse research portfolio covers a breadth of activities from observational monitoring of key environmental parameters to the development of operational products to serve NOAA. Training students continues to be a focus of CIFAR in order to serve NOAAs need for workforce development. Students are highlighted in boldface in the highlights section. CIFAR-funded students have been well-trained as young scientists and are ready to contribute to NOAAs mission.

Ecosystem Studies and Forecasting

PI Gibson collaborated with NOAA personnel Kelly Kearney to develop and merge code updates from multiple versions of a lower trophic level marine ecosystem model for the Bering Sea (BEST NPZ). This suite of coupled models is employed to test hypothesis to evaluate alternative management strategies for the Bering Sea pollock fishery. Notable updates brought by Gibson to the new model version include consumption of detritus by euphausiids, daily vertical migration of euphausiids in response to light levels, improved representation of benthic feeding and more realistic representation of feeding and respiratory behavior of zooplankton when in diapause. These models enable an improved understanding of pollock fisheries dynamics in the Bering Sea, which contributes to advancing fisheries management.

PI Pinchuk is investigating the feeding ecology of major planktivorous predators in Alaskan subarctic pelagic ecosystems of the Northern Bering Sea (NBS) and Eastern Gulf of Alaska (EGOA). This project analyzes and interprets data on fish and scyphozoan jellyfish diets in relation to zooplankton prey fields collected by NOAA. Samples come from the Northern Bering Sea (NBS) and Eastern Gulf of Alaska (EGOA) pelagic trawl surveys in the summer of 2017. Zooplankton samples from EGOA will be analyzed to determine their taxonomic composition. Commercially harvested salmon, as well as forage fish and jellyfish play a central role in the food web of the southeastern Bering Sea and Gulf of Alaska, where they potentially compete for available zooplankton prey. A better understanding of their feeding ecology and their interactions with different ecosystem components will enhance our ability to success fully model these populations via changing prey and prey quality as they are mediated by changing climatic conditions.

Climate Change and Variability

PI Cahill, director of the Alaska Center for UAS Integration (ACUASI) worked with NOAA partners to evaluate the use of unmanned aircraft systems (UAS) to augment monitoring river-ice conditions and breakup at significantly higher temporal and spatial resolution than presently available from satellite imagery. They examined near real-time operational forecaster Decision Support Services (DSS), provided rapid response surveillance of river ice and flooding, and validated and calibrated derived satellite river ice and flood products. ACUASI developed a river-ice breakup UAS monitoring Concept of Operations (CONOPS). At the end of each survey, four types of data products were produced; (1) geotagged imagery; (2) orthorectified data (mosaics and Digital Elevation Models); (3) processed classification products including open water, snow, ice, and open-water ice mix; (4) and a derived water-height levels product from imagery. The integration of UAS information into the NOAA DSS, supports the NWS and River Forecast Office with monitoring and decision-making.

PI Walsh and his team are developing a climatology of storm tracks (locations and intensity) in the model hindcasts over the period 1982-2010 for CFSv2 and several other NMME models. A surprising outcome was a correspondence between wintertime sea ice conditions in the Alaskan waters and the number of storms in the general vicinity of the ice anomalies. Storms tend to track farther westward, increasing their frequencies in the Bering Sea during years of minimum Bering Sea ice cover. By contrast, Bering Sea ice is heavier when storms track primarily through the Gulf of Alaska. The project is targeting storms and other extreme events that represent environmental hazards to people and property in Alaska. Storminess outlooks at time scales of weeks to months are frequently requested in Alaska because of the high impacts (flooding, erosion) of coastal storms, especially during the summer and autumn (and increasingly the winter) when sea ice is not present to buffer the coast.

Coastal Hazards

PI West and co-PI Ruppert with their team maintain NOAA-sponsored seismic stations in the integrated Alaska Seismic Network and data flow of selected stations to the National and Pacific Tsunami Warning Centers to support improved knowledge of tsunamigenic earthquake sources. Between April 1, 2017 and March 12, 2018, the Alaska Earthquake Center reported 42,246 events, with magnitudes ranging between -1.3 and 7.9 and depths between 0 and 300 km. This represents an increase of nearly 5,000 events over the previous reporting period. Seven earthquakes had magnitudes of 6 or greater. The largest earthquake, of magnitude 7.9, occurred on January 23, 2018 south of Kodiak Island. This earthquake caused minor damage on Kodiak Island, but no destructive tsunami was generated. The addition of EarthScope USArray stations throughout Alaska has vastly improved the accuracy and detection thresholds for earthquakes. The distribution and fidelity of USArray stations has significantly improved the ability to quickly determine the tsunamigenic potential of earthquakes occurring offshore Alaska. The updates support faster and more accurate detection of tsunamigenic earthquakes by the NOAA tsunami warning centers and the Alaska Earthquake Center.

PI Alexeev and his team conducted a project that supports NOAA efforts to improve relationships between the agency and the communities in which they work. This project fosters a better fit between decisions and the ecological and social processes occurring in communities integrating the necessary diverse expertise and developing and implementing societally relevant and sustainable solutions to complex socio-ecological problems. It also cultivated a pathway for professional development in Alaska youth and helps expand the knowledge base and working approaches of agency professionals. Key findings on the landscape of barriers and challenges to Alaska Native and rural Alaskan participation in NOAA's workforce. Key barriers were identified and are centered around 5 main themes: localized opportunities, messaging and outreach, engagement and Investment, social and cultural barriers, and internal NOAA barrier. Practical and implementable recommendations were developed for increasing Alaska Native and rural Alaskan participation in NOAA's workforce. They identified five categories of recommendations: create more opportunities for undergraduate and graduate students, address the federal hiring process, direct and targeted international with undergraduate and graduate students, increase engagement with middle and high school students, and create and strengthen support structures to build a more inclusive work environment. The model developed in this project aims to prepare students to be effective members and leaders in multidisciplinary teams that are able to design, evaluate, and implement responses to complex socio-environmental challenges.

Publications and Presentations

In this last reporting period, there are 8 peer-reviewed completed publications and four publications at submitted to make a total of 12 publications. A total of 18 conference presentations (both national and international) were reported for the period 1 April 2017–31 March 2018**.** See Appendix 3 for detailed information on the publications.

TASK I: AMBON TRAINEESHIPS

Arctic Marine Biodiversity Observing Network (AMBON) student traineeships

Katrin Iken, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

NOAA Goal(s): Healthy Oceans

Amendments 30, 35, 52, 70 NOAA Office: NOS, Gabrielle Canonico, Sponsor
Budget Amounts: Cumulative $296,013, This year $15,785 (Amendment 70)
This project is set to end 10/31/2018.

Primary objectives

This project provides funding to train graduate students whose research will be aligned with the Arctic Marine Biodiversity Observing Network (AMBON) for a period of 4 years. Students will be trained in the fields of benthic ecology, food web ecology, microbial ecology, molecular techniques, and metagenomics analyses.

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

One PhD student (Ann-Christine Zinkann) is working on the benthic community and food web portion of the project. She is using amino-acid specific stable isotope analyses to identify trophic linkages between different carbon sources (microbial, terrestrial, marine photosynthetic) and benthic invertebrates. She helped implementing these new techniques here at the University of Alaska Stable Isotope Facility and has since been involved in guiding other students in the technique. Her first results show that carbon sourcing is species-specific and grouping benthic invertebrates into functional groups (e.g., feeding types) can mask some of this individual variability and obvious feeding plasticity. She presented this work at the 2018 Alaska Marine Science Symposium (January 2018, Anchorage AK) and at the 2018 Ocean Sciences Meeting (February 2018, Portland OR) (Figure 1). This also gave her the opportunity to interact with other scientists in the field and make connections. Over the past year, Ann also participated in a collaboration cruise in June 2017 to the northern Bering and southern Chukchi seas (ASGARD cruise), where she was the discipline lead for the epibenthic community collections and collected sediments for experimental work. Being a discipline lead on a research cruise was a great experience for her and prepared her for better leadership ion a future research career. This experimental work on sediments investigated the response of sediment microbes to temperature variation in the context that warmer temperatures in the Arctic are likely to support higher microbial production at the base of the food web. Ann participated in a month-long intensive course in Ecopath modeling at the University of Vancouver, BC; this will be building the groundwork for one of her dissertation chapters and will synthesize multiple aspects of the AMBON project by including the various ecosystem elements into the model.

One student (Brian Ulaski) conducted DNA extractions and PCR amplifications of microbial communities from the Chukchi Sea from the AMBON 2015 cruise. Both prokaryotes (16S rRNA) and eukaryotes (18S rRNA) were targeted, to study the total community of microbial heterotrophs and autotrophs. The amplicon DNA was provided to the UAF DNA Core Lab for paired end sequencing on the Illumina MiSeq, resulting in about 20 million sequencing reads from 205 samples (~100,000 sequences per sample). Brian used multivariate statistics to examine the microbial community structure in the Chukchi Sea and found that water mass was the primary determinant of microbial community, with temperature, salinity, and nutrients as significant driving factors of the community composition. Brian presented preliminary results from this analysis at the 2017 Ocean Sciences Meeting ("Ulaski, B. P., Collins, R. E. (2017) A molecular assessment of marine bacterial and protist communities within two gateways to the Arctic Ocean. Abstract 30087. Ocean Sciences Meeting, Honolulu, HI") (Figure 2).

NOAA relevance/societal benefits

AMBON provides 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. All students in this traineeship program are deeply involved with these novel aspects of the AMBON project. 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, students are gaining invaluable research experience and complete their thesis 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, and the National Science Foundation (NSF). Shell has since withdrawn its support, but we were recently able to garner some support from the National Science Foundation for additional support for ship time in summer 2017, which will also benefit further the student education and training. 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 impacts: (1) training graduate students in novel research approaches and in working with a multi-discipline research team, and (2) innovative thesis research that will improve our knowledge of the biodiversity of the U.S. Chukchi Sea continental shelf.

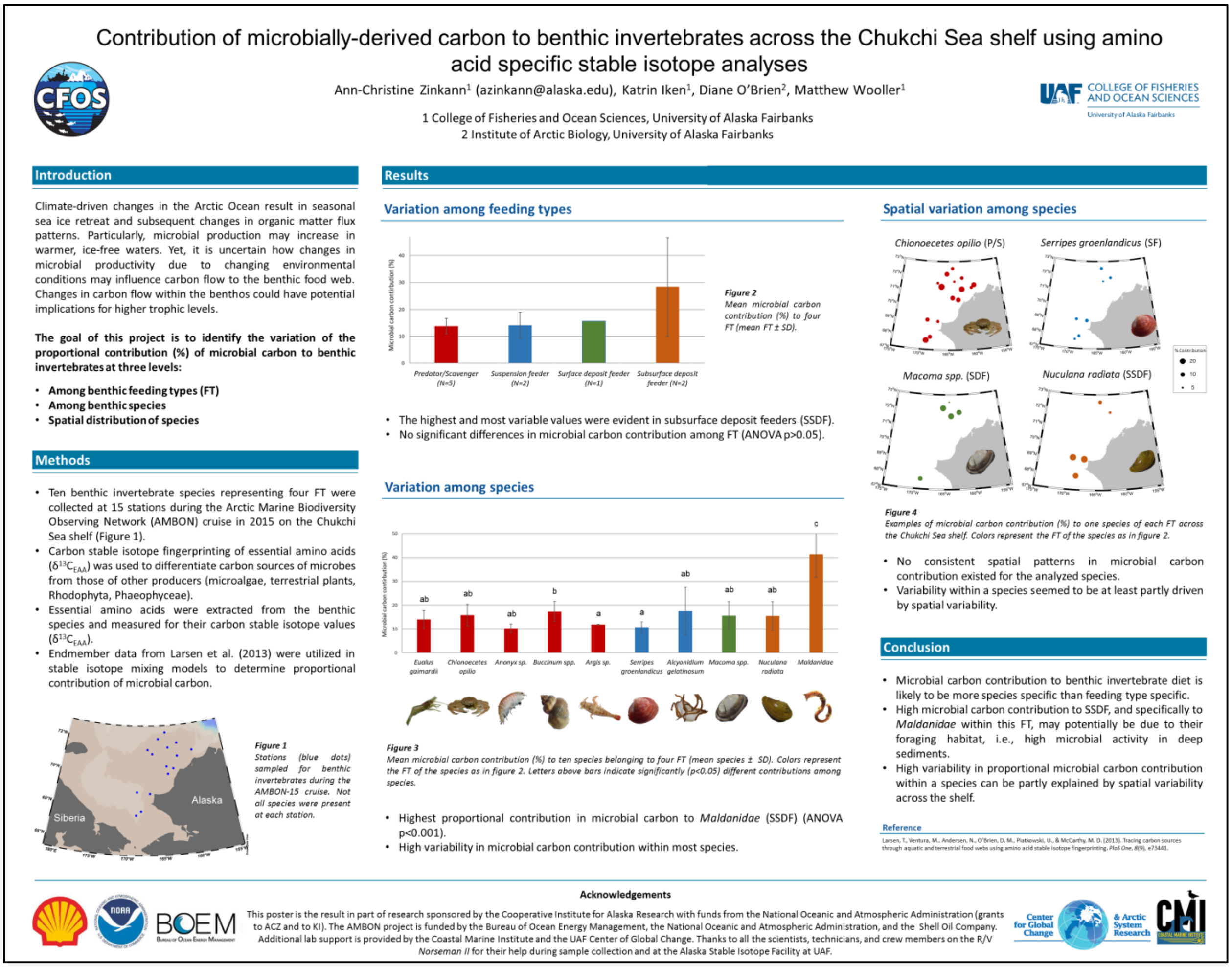


Figure 1: Poster presented by Ann-Christine Zinkann at AMSS 20018 and OSM 2018.

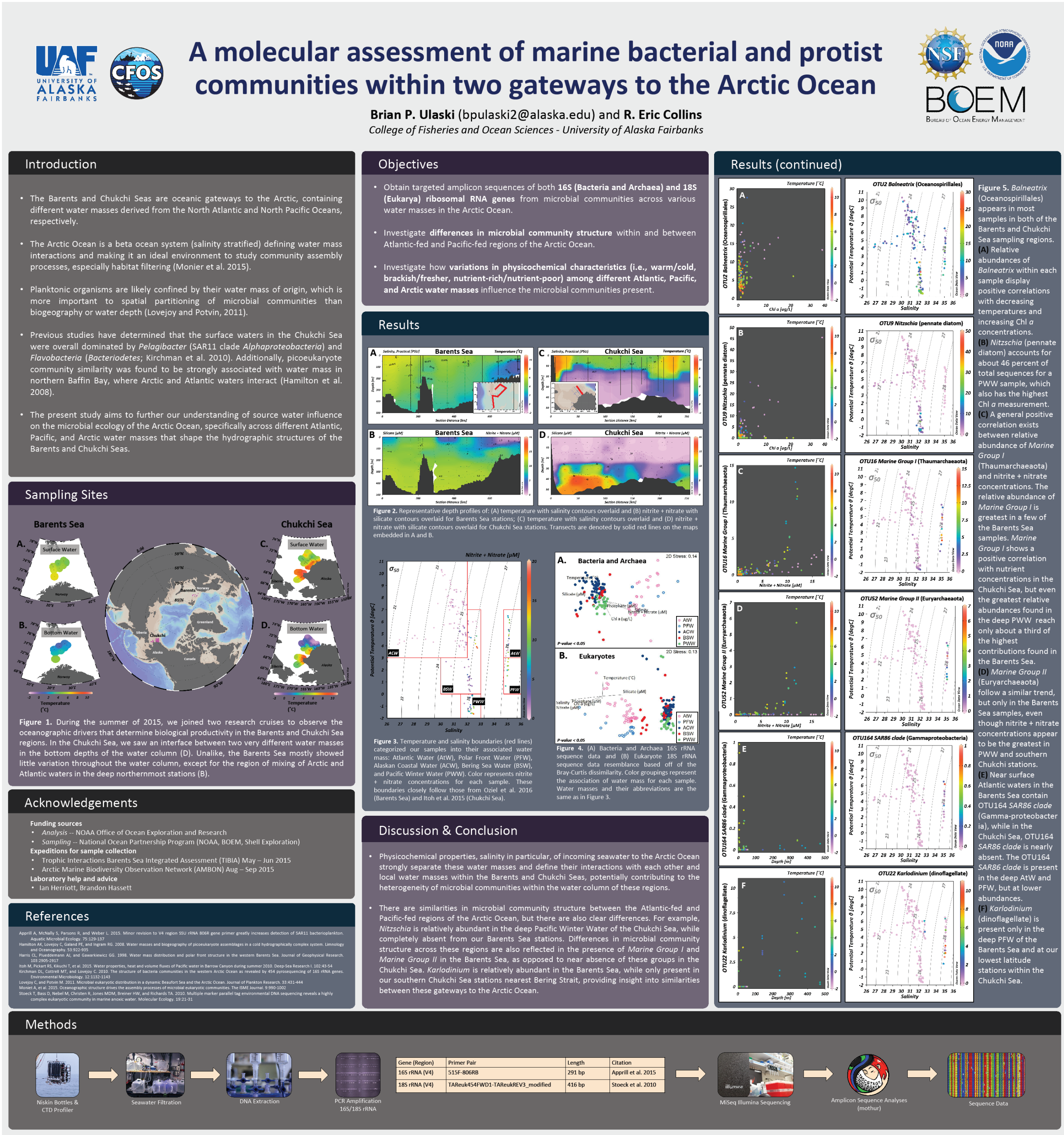


Figure 2: Poster presented by Brian Ulaski at OSM 2018.

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

ECOSYSTEM STUDIES AND FORECASTING

RUSALCA Overview: 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.

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

Katrin Iken, PI
Bodil Bluhm, Co-PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

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

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendments 3, 27
NOAA Office: OAR-CPO, Jeremy Mathis, Sponsor
Budget Amount: Cumulative $319,191, This year $0
This project is complete.

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 built 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

Work on community composition and food web structure was part of the MS thesis of Carlos Serratos (Spatial and temporal patterns of epibenthic community and food web structures in the Chukchi Sea between 2004 – 2012; completed in fall 2015). Results of this thesis have been incorporated into the following manuscript:

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

Other parts of the work completed and samples collected during the RUSALCA project were included in the following manuscripts:

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. 135: 124-136; http://dx.doi.org/10.1016/j.dsr2.2015.11.009

In the past year, we used the community data collected from eight stations in the southern Chukchi Sea repeatedly occupied during 2004, 2009, and 2012 (Figure 1) to assess differences and changes over time in functional diversity. Functional diversity is defined the range of organismal traits of species within a community that, combined, influence ecosystem functioning. In other words, functional diversity explores what communities do as opposed to their taxonomic composition. Biological traits are assigned to each species based on morphology (body form, fragility, sociability), behavior (mobility, adult movement, feeding habit, depth range, surface affinity), and life history (reproductive strategy, larval development) (Table 1). Combining these traits for all species within an entire community, community functioning in a specific environment can be determined.

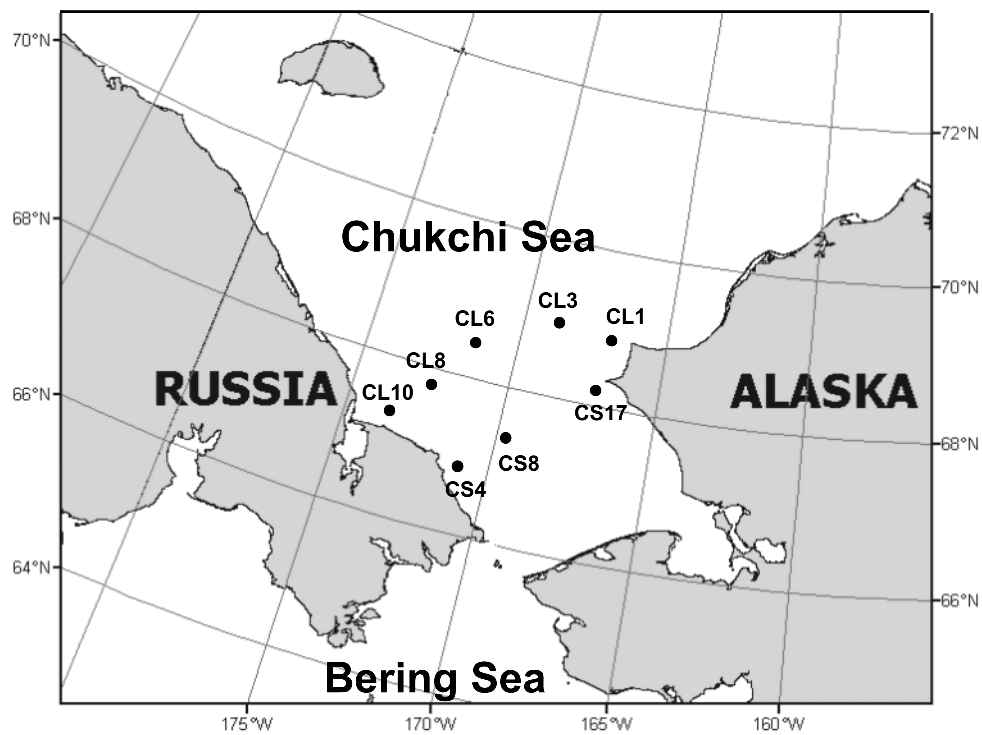


Figure 1: Repeat stations in the southern Chukchi Sea sampled for epibenthic community structure during RUSALCA cruises in 2004, 2009 and 2012 and coded for functional diversity.

Table 1: Biological traits, and modalities within each trait, for which epibenthic invertebrate species were coded.

Trait	Modality	Abbrev.	Trait	Modality	Abbrev.
Size	small	S1	Living habit	free living	LH1
	small-medium	S2		crevice dwelling	LH2
	medium	S3		tube dwelling	LH3
	medium-large	S4		burrow dwelling	LH4
	large	S5		epi/endo zoic/phytic	LH5
Weight (WM, g)	low	W1		attached	LH6
	low-medium	W2	Mobility	none	MO1
	medium	W3		low	MO2
	medium-high	W4		medium	MO3
	high	W5		high	MO4
Body form	globulose	BF1	Adult movement	sessile/none	MV1
	vermiform	BF2		burrower	MV2
	dorso-ventral compressed	BF3		crawler	MV3
	laterally compressed	BF4		swimmer (facultativ)	MV4
	upright	BF5	Feeding habit	surface deposit feeder	FH1
Fragility	fragile	F1		subsurface deposit feeder	FH2
	intermediate	F2		filter/suspension feeder	FH3
	robust	F3		oportunist/scavenger	FH4
Sociability	solitary	SO1		predator	FH5
	gregarious	SO2		parasite	FH6
	colonial	SO3	Trophic level	1	TL1
Reproduction	asexual	R1		2	TL2
	sexual - broadcast spawner	R2		3	TL3
	sexual - planktonic larvae	R3		4	TL4
	sexual - brooder	R4		5	TL5
Larval developement	planktotrophic	LD1	Bioturbation	diffusive mixing	B1
	lecithotrophic	LD2		surface deposition	B2
	direct development	LD3		conveyer belt transport	B3
Adult age/Life span	short	A1		downward (reverse) conveyor	B4
	medium	A2		none	B5
	medium-long	A3	Depth range	shallow	DR1
	long	A4		shelf	DR2
Environmental position	infauna	EP1		shelf-slope	DR3
	epibenthic	EP2		slope-basin	DR4
	hyper-benthic	EP3		depth generalists	DR5
			Substratum affinity	soft	SA1
				hard	SA2
				biological	SA3

Epibenthic communities were sampled with a plumb-staff beam trawl with a 2.26 m opening and a 7 mm mesh net with a 4 mm cod end liner. Trawls were brought on board, washed and sorted to the lowest possible taxonomic level. Large catches were quantitatively subsampled from a well-mixed haul. Organisms were counted and wet weight was acquired at the lowest taxon resolution using spring or digital hanging scales. Area trawled was used to estimate abundance and biomass as catch per unit effort (CPUE), which were then normalized to 1000 m^{-2}. Taxonomic identifications were conducted by the field teams and names were standardized to the World Register of Marine Species (www.marinespecies.org). We used primary literature to determine biological traits, and modalities within traits (Table 1) for all taxa within the phyla Mollusca, Arthropoda, and Echinodermata. These phyla make up the majority of the epibenthic fauna and 74 taxa within these phyla were coded for biological traits. Excluded were Cnidaria, Ascideacea, Bryozoa as taxonomic resolution for those groups was very low, limiting the ecological relevance of biological traits analysis. Modalities within a trait were "fuzzy coded" for each species, meaning that a species could be assigned values between 0 and 3 for more than one modality within a trait, adding to a total score of 3 per trait. Trait profiles for each species were then multiplied by the biomass of that species at a station to result in a quantitative score for each modality at a station (station profile).

When comparing overall functional diversity across years (using stations per year as replicates), we did not find any significant differences (ANOSIM R = 0.109, p = 0.24).

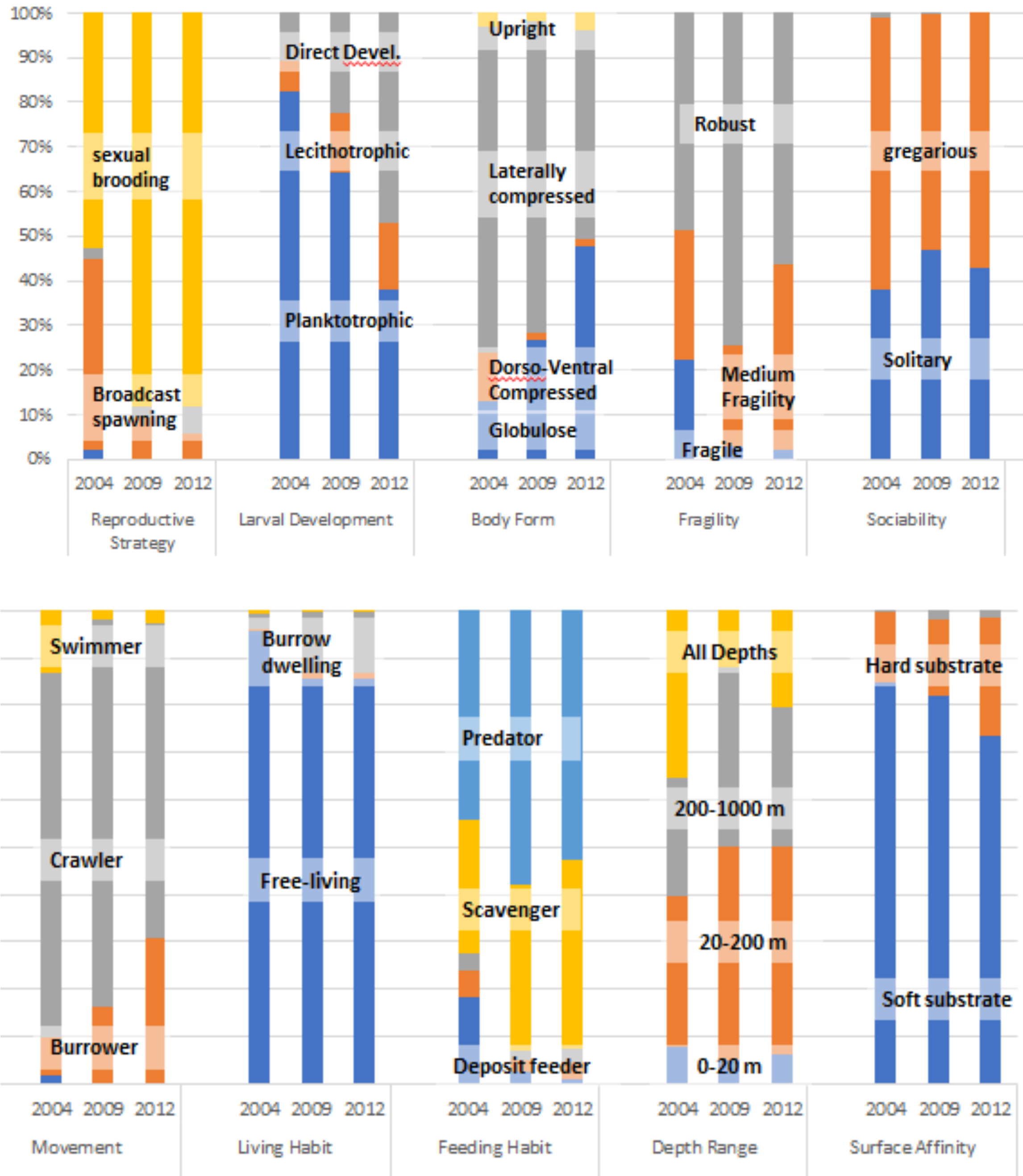


Figure 2: Biological traits in epibenthic communities of eight stations sampled during three years. Bars within traits give the proportion of modalities within each trait per year. Colors correspond to modalities within each trait for the three years but do not correspond among different traits.

The proportion of modalities within each biological trait for the entire system of the eight stations sampled remained similar from year to year, except for the proportion of reproductive strategies from 2004 to 2009/2012. Here, the community changed from similar proportions of broadcast spawning and sexual brooding to a community more dominated by sexual brooders (Figure 2).

Using Fuzzy Correspondence Analysis, we investigated relationships of stations among the three sampling years (Figure 3). Some stations grouped closely together for all three years (e.g., CL1, CL10) but others aligned with different dominant traits in different years (e.g., CL8, CS8). This indicates that functional diversity can change considerably at a single location (station) over time, while on the larger spatial scale (the larger region represented by all stations per year), the functional diversity was relatively consistent over time.

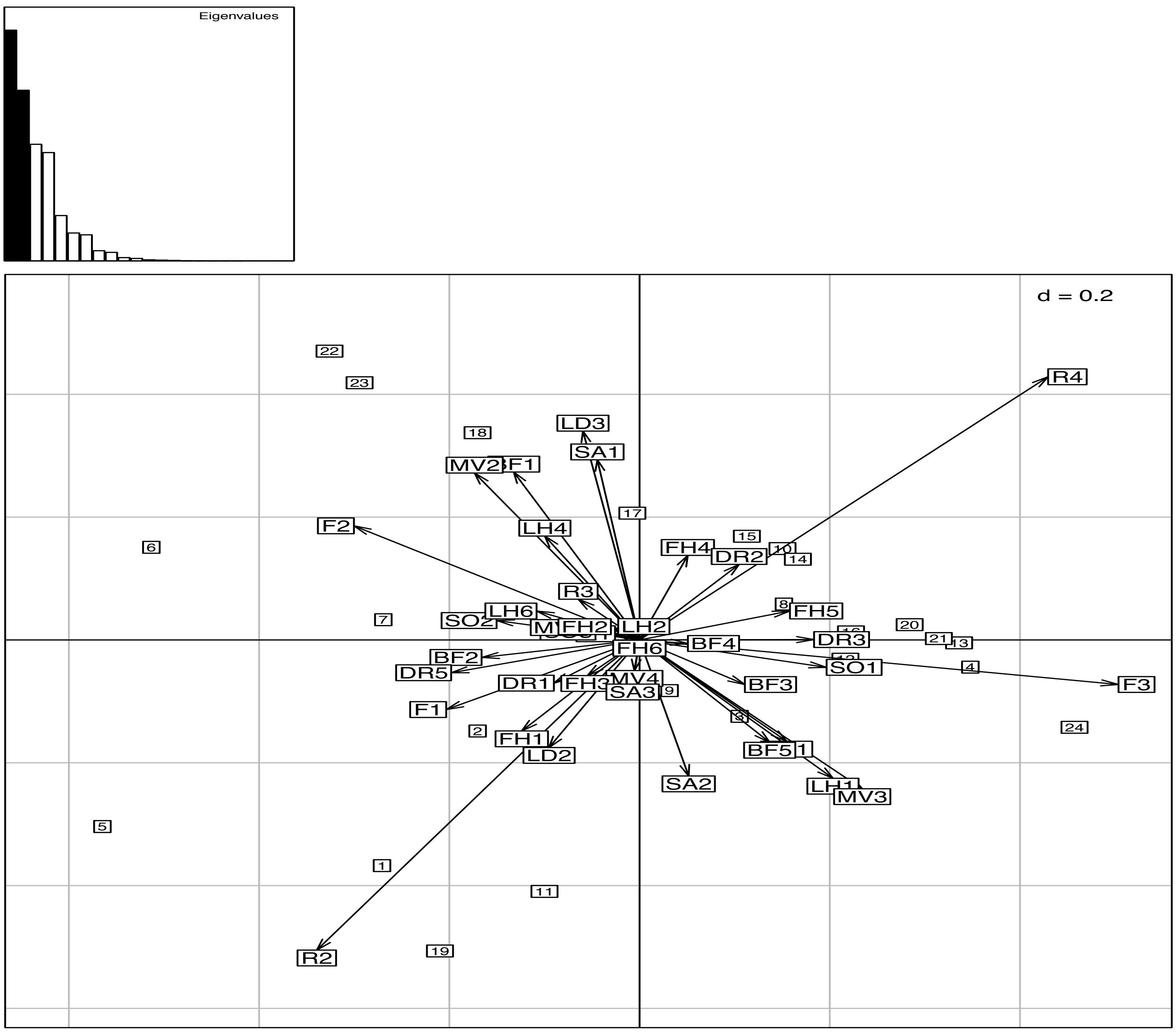


Figure 3: Fuzzy Correspondence Analysis of biological traits and their modalities (boxes, abbreviations as in Table 1) for eight stations (color dots) repeatedly sampled over three years. Modalities are included as vectors showing the directional and stength (length of vector) that modalities have on placement of community functional diversity.

When we analyzed community composition based on taxonomic diversity before (C. Serratos thesis, Grebmeier et al. 2015 publication), we found that biomass of some taxa could change considerably among years at any given station (Figure 4) but that overall taxonomic community composition was relatively stable over time per station (Figure 5a). It could be that the at times dramatic changes of taxon biomass causes the significant differences we see in functional diversity per station among years (Figure 5b). While species biomass proportions may change over time at a station, overall taxonomic community composition may be less affected by this, especially if relative proportions of some of the more abudnant taxa stay similar. However, a change in biomass of a species can chance the relative contribution of modalities within the different traits, dispersing this effect much more over the entire functional composition of the community than taxonomic identity will do. This work indicates that taxonomic and fuinctional analyses of the same community can provide different insights into the spatial and temporal dynamics of benthic communities in the Chukchi Sea.

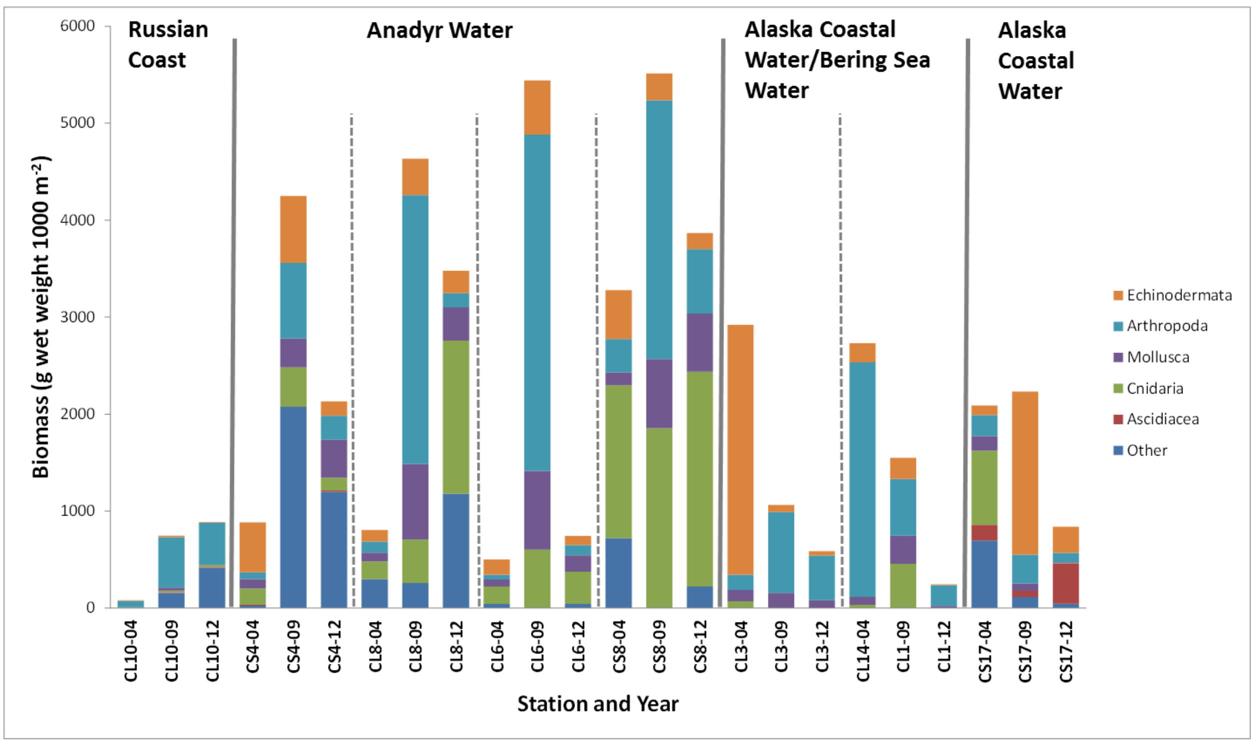
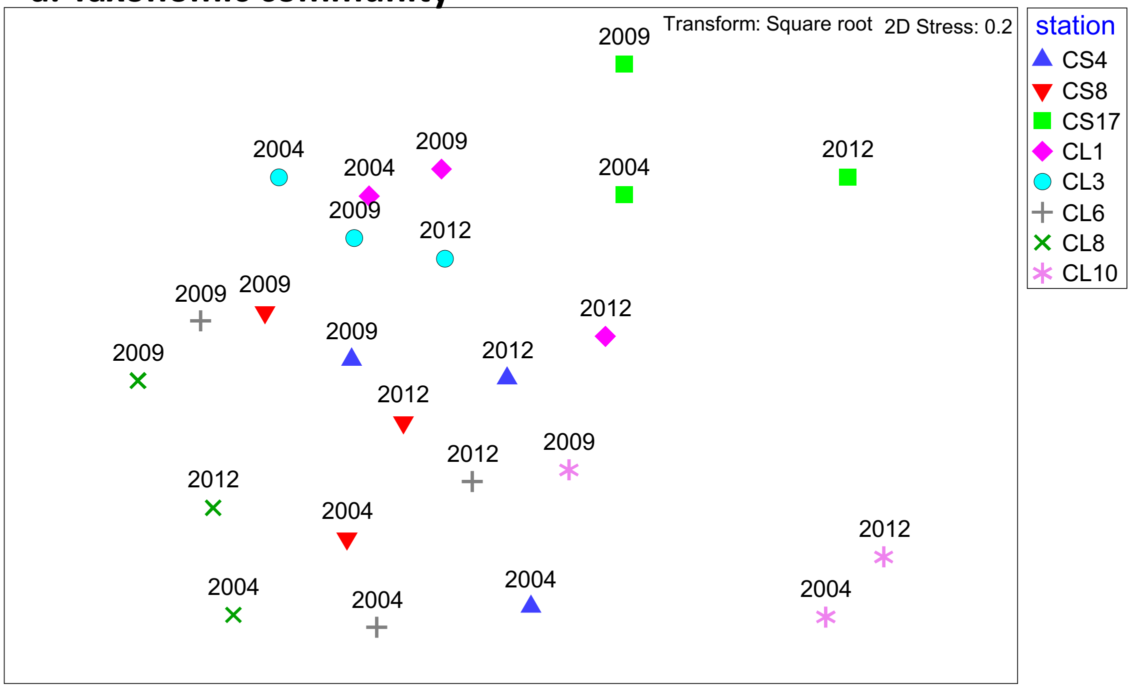


Figure 4: Epifaunal biomass at eight time series stations for RUSALCA 2004, 2009, and 2012 (g wet weight 1000 m^{-2}). Dotted lines separate station-year groups and solid lines group stations by the dominant water mass in which they occurred. Total biomass per station, as well as biomass proportion among phyla, varied considerably in several cases (Figure from C. Serratos thesis, also in Grebmeier et al. 2015).

a. Taxonomic community



b. Functional community

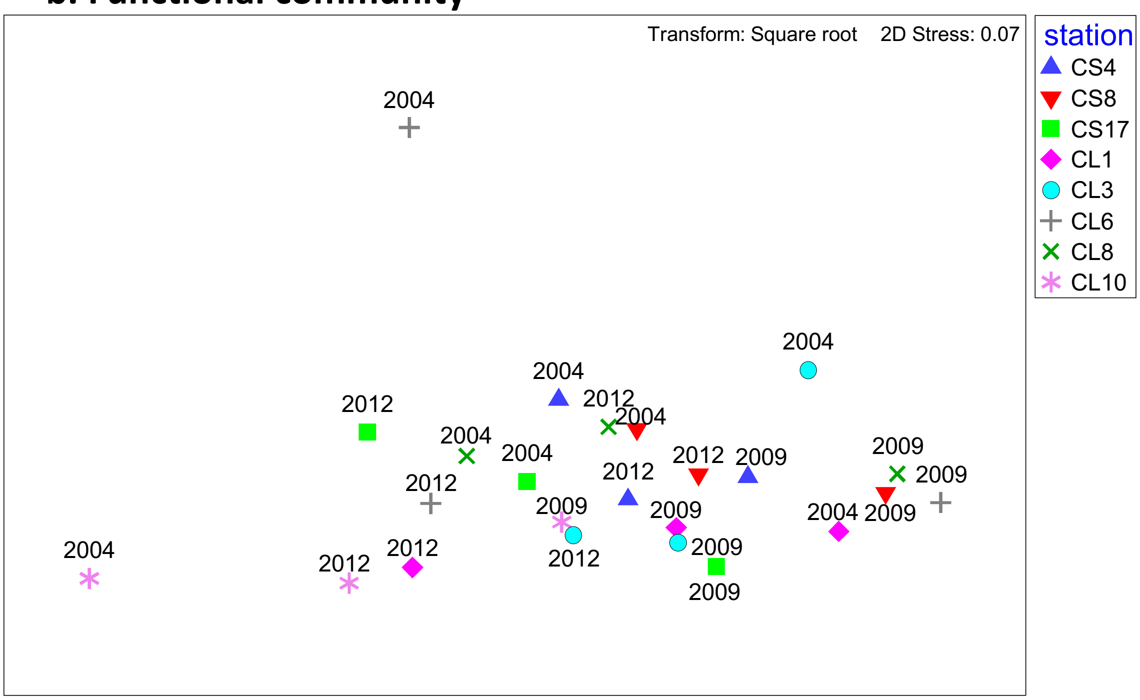


Figure 5: Multi-dimensional scaling plot for community structure based on taxonomy (a) and on functional traits (b). Stations are characterized by symbols and years are noted next to station symbols.

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 epibenthic communities and their function 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."

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. Part of his work is published.

Graduate student Lauren Sutton is continuing her MS degree in Marine Biology (start in fall 2016) and is anticipating completing her degree by fall 2018 or spring 2019. She is making use of the RUSALCA epibenthic community data and is performing functional trait analyses to assess diversity patterns based on ecosystem functions rather than taxonomy.

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 (cumulative)

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 is based heavily on RUSALCA snow crab samples and data from all years and contributes to the food web objective of the RUSALCA project.)

Schollmeier T, Oliveira ACM, Wooller MJ, **Iken K** (2018) Tracing sea ice algae into various benthic feeding types on the Chukchi Sea shelf. Polar Biol 41(2):207-224. (This publication is based on

invertebrate samples (snow crab and clams) collected during the 2012 RUSALCA cruise) and contributes to the food web objective of the RUSALCA project.)

Presentations at conferences (since April 2017)

Sutton L, **Iken K**, **Bluhm B**. 2017. A comparison of functional diversity of two Alaskan arctic shelf systems. Poster at Alaska Marine Science Symposium, 22-25 Jan 2018, Anchorage AK.

Other products and outcomes

Benthic invertebrate samples (crabs and clams) that were collected during the RUSALCA 2012 cruise are being used in an ongoing study by PhD student Tanja Schollmeier (Iken is advisor) to trace sea ice algal production into benthic invertebrates. These samples were used in a fist chapter of this student using fatty acid and fatty-acid specific isotopes as biomarkers (Schollmeier et al. 2018). In a second chapter, the student is using the same samples to trace sea ice algae by using a novel sea ice biomarker, the highl branched isoprenoid IP_{25}. This work is related to the original scope of the RUSALCA project in analyzing food web connections, but is mostly funded by a recent research grant from the North Pacific Research Board.

Schollmeier T, Oliveira ACM, Wooller MJ, **Iken K** (2018) Tracing sea ice algae into various benthic feeding types on the Chukchi Sea shelf. Polar Biol 41(2):207-224

Schollmeier T, **Iken K**, Wooller MJ, Belt S. 2017 Tracing the presence of sea ice algae in Arctic benthic consumers using the biomarker IP25. Poster at Alaska Marine Science Symposium, 22-25 Jan 2018, Anchorage AK.

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. As part of the AMBON project, we educate graduate students though a current CIFAR Student Traineeship, which includes advances methodology of studying food web connections in the Chukchi Sea benthos, as well as molecular techniques to better understand microbial community diversity and functioning. Some of the station coverage used by these students includes the continuation of the original RUSALCA CS and CL lines.

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.

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.

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 cooperative agreement awards.

A manuscript that is based on AMBON sampling, which includes the continuation of the original RUSALCA CS (also equivalent with DBO3) and CL lines, is under revision with Deep-Sea Research II:

Iken K, Mueter F, Grebmeier JM, Cooper LW, Danielson S, **Bluhm B**. 2018: Does one size fit all? Observational design for epibenthos and fish assemblages in the Chukchi Sea. Submitted to Deep-Sea Res II.

Continuation of RUSALCA fish ecology research

Brenda L. Norcross, PI
Brenda A. Holladay, Co-PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendments 1, 24
NOAA Office: OAR, Jeremy Mathis, Sponsor
Continues research from NA08OAR4320870
Budget Amount: Cumulative $144,833, This year $0
This project is set to end 06/30/2018.

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 species associations in the present-day Chukchi Sea.

Research accomplishments/highlights/findings

Efforts during the past year have been on continuing to develop a manuscript that describes ichthyoplankton abundance and distribution during the RUSALCA surveys and also presents new illustrations and photographs of fish larvae. The manuscript is undergoing in-house review at the Alaska Fisheries Science Center in Seattle, WA., and is planned for submission to a journal such as *Polar Biology* during the next year. We have been in contact with our NOAA counterparts multiple times, but their review and approval process has delayed publication. Busby, Holladay, Meir, Norcross. Ichthyoplankton of the Chukchi Sea 2004–2012: Russian-American Long-Term Census of the Arctic.

The most common fish eggs encountered in the Chukchi Sea were the flatfishes *Limanda* spp. and *Hippoglossoides robustus* (Bering flounder), whereas *Boreogadus saida* (Arctic cod) was the most abundant species of ichthyoplankton. *B. saida* accounted for 61% of the total planktonic catch of larval and juvenile fishes from the surveys in 2004, 2009 and 2012, and were distributed throughout the Chukchi Sea and in the East Siberian Sea. Overall, catch of this species was greatest in 2004 and lowest in 2012. Diversity of ichthyoplankton was greater in 2004 than 2009. Cluster analysis of ichthyoplankton abundance revealed three distinct assemblages: one dominated by *B. saida*, *Liparis* spp. (snailfishes), and the family Stichaeidae (pricklebacks); the second, by *Limanda aspera* (yellowfin sole) and *H. robustus;* and the third by *Gadus chalcogrammus* (walleye pollock).

This manuscript presents new illustrations and photographs that will assist in identification of early life stages of Arctic fishes. We present illustrations of five species from the cod family, including Arctic cod and walleye pollock, and photographs of cleared and stained *Limanda proboscidea* (longhead dab) and *Stichaeus punctatus* (Arctic shanny).

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.

Partner organizations and collaborators

None to report at this time.

Impact

Because early life history stages of marine fishes are vulnerable to both gradual environmental changes and episodic perturbations, the data obtained from this project are fundamental to understanding the dynamics of fish communities in the Pacific-Arctic ecosystem.

The new illustrations help to complete developmental series of Arctic fishes, which will assist in future identifications.

Education

None this reporting period.

Outreach

None this reporting period.

Publications

None this reporting period.

Conference presentations

None this reporting period.

Other products and outcomes

None this reporting period.

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

Terry E. Whitledge, PI
Dean A. Stockwell, co-PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendments 2, 22
NOAA Office: OAR, Jeremy Mathis, Sponsor
Continues research from NA08OAR4320870
Budget Amount: Cumulative $214,169, This year $0
This project is set to end 03/31/2019.

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
- Prior RUSALCA nutrient/chlorophyll data from mooring cruises were calculated edited and quality checked
- Data for nutrients, chlorophyll and primary production will be sent to designated archive for inclusion in RUSALCA database.
- Data products are planned for presentation at one or two national meetings.
- 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 two 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.

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

A Ph.D. student has 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

Shen, Y., R. Benner, K. Kaiser, C. Fichot and Terry E. Whitledge. 2018. Pan-Arctic distribution of bioavailable dissolved organic matter and linkages with productivity in ocean margins. Geophysical Research Letters, 45. https//doi.org/10.1002/2017GL076647.

Ahn, S.H., S.H. Lee, T.E. Whitledge, D.A. Stockwell, J.H. Lee and H.W. Lee. Submitted. Biochemical composition of phytoplankton in the Laptev and East Siberian seas during the summer, 2013. Journal of Geophysical Research Oceans.

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. Submitted. 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, previously reported

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

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.

ECOSYSTEM STUDIES AND FORECASTING — OTHER PROJECTS

AFSC FY 2015 – FY 2017 Alaska Ocean Acidification Research: Autonomous Observations of Ocean Acidification in Alaska Coastal Seas

***Amanda Kelley, PI** (formerly Jessica Cross)*
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting, Climate Change and Variability

Other investigators/professionals associated with this project:
***Natalie Monacci,** University of Alaska Fairbanks*

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendments 51, 68
NOAA Office: OAR, Libby Jewett, Sponsor
Budget Amount: Cumulative $137,060, This year $9,620 (Amendment 68)
This project is set to end 02/28/2019.

Primary objectives

This project provides support for ongoing monitoring through the GAKOA surface buoy, a time series site in the central Gulf of Alaska, and the M2 surface buoy (Peggy), a time series site in the southeastern Bering Sea. It also provides support for ongoing subsurface monitoring at the M2 and M8 time series sites in the southeastern Bering Sea. Opportunistically, we were also able to deploy an unsupported sub- surface Gulf of Alaska package in 2017 during the deployment of the Gulf of Alaska surface buoy.

Research accomplishments/highlights/findings

GAKOA 2017 deployment notes (Gulf of Alaska surface buoy): Upon turnover of the MAPCO_2 surface system at this site in late March 2017, seawater CO_2 concentrations showed a gradual drop during April, coincident with the start of the spring bloom. This process was slower than has been observed in previous years. As compared with older data collected by the Ocean Acidification Research Center at the University of Alaska, this bloom appears to have been starting earlier since the beginning of the data record, and that trend continued in 2017 despite the slow rate of drawdown. The 2016 spring bloom set a record for annual CO_2 minimum that was not surpassed in 2017. CO_2 concentrations remained low through May and June, and slowly began to recover to atmospheric levels starting in July. The overwintering period for 2015/2016 and 2016/2017 both showed weakly supersaturated conditions at the surface layer in winter, although these event-scale observations are relatively minor. A plot of this data is given in Figure 1.

GAK1 2017 deployment notes (Gulf of Alaska bottom package, 267 m): In March 2017, SAMI pH and pCO_2 sensors (Sunburst Sensors, LLC) were deployed at 265 m at the GAK1 mooring site. The pH sensor deployment was not successful (unfortunately the sensor flooded). The pCO_2 sensor deployment delivered reasonable data, but corresponding diagnostic data indicated that the sensor integrity may have been compromised. Evaluation of this dataset is ongoing. In March 2017, SAMI pH and pCO_2 sensors (Sunburst Sensors, LLC) were deployed at 265 m at the GAK1 mooring site. This mooring is serviced annually in March and data will become available again after recovery. A plot of all sub-surface GAK1 data is given in Figure 2.

Peggy 2017 deployment notes (Bering Sea surface buoy): Upon deployment of the $MAPCO_2$ surface system at this site, seawater CO_2 concentrations were already very low, showing the drawdown typical of the spring bloom. The $MAPCO_2$ system operated reasonably well for the first half of the season, although data integrity was compromised for some sampling periods during the summer. We suspect that this may have been the result of early interference with the system (e.g., seals) combined with equipment malfunction. Deterrent designs for the surface buoy were deployed in May 2017. SeaFET pH data was also collected during this deployment. The data quality from this instrument was much higher than in past deployments, indicating additional success at this location (Figure 3).

M2 2017 deployment notes (Bering Sea bottom package, 67 m): For the fall 2017/2018 deployment, a SAMI *p*CO2 sensor was deployed alongside a SeaFET pH sensor (Satlantic). The 67 m depth of the sensor package at this site knowingly exceeds the depth rating for the SeaFET, which was revised to 50m during a previous 67 m deployment by OARC. When exceeding the depth rating, OARC has found that the failure rate of SeaFET sensors is similar to the overall cold- weather failure rate of SAMI sensors. These sensors did collect data during the deployments. Data processing and QA/QC is ongoing. A plot of all M2 sub-surface data is given in Figure 4.

NOAA relevance/societal benefits

Coastal regions around Alaska are experiencing the most rapid onset of ocean acidification (OA) compared to anywhere else in the U.S. Recent research using OA forecast models as well as species and human impact assessments have shown that Alaska coastal communities and the vast fisheries that support them have a varying degree of vulnerability to OA, ranging from moderate to severe (Mathis et al., 2014). The most vulnerable communities rely heavily on the economic and nutritional value of fisheries and other ecosystem services. OA in Alaska also has the potential to have cascading economic impacts well beyond the state level. Because Alaska fisheries provide over $3 billion annually to the U.S. gross domestic product (GDP), even a relatively small decline in one or more of the fisheries in the Gulf of Alaska or Bering Sea could have a very large net economic impact—large enough to dwarf the combined impacts occurring in other U.S. areas.

Partner organizations and collaborators

This project represents a close collaborative relationship between the Pacific Marine Environmental Laboratory and the Ocean Acidification Research Center at the University of Alaska, Fairbanks. These mooring data also contribute to the International Ocean Observing System (IOOS) program and the Global Ocean Acidification Observing Network (GOA-ON) and pollock abundance forecasts.

Impact

The researchers involved with this project also work closely with the Alaska Ocean Acidification Observing Network, an impact-driven group designed to connect scientists to stakeholders. Through that group, these monitoring activities support a number of cross-cutting research efforts. Firstly, the time series provides new insights into the seasonal progression of OA events caused by the progressive accumulation of anthropogenic CO_2 into the region's coastal seas. The mooring data can also be used as an early warning system for stakeholders around the state, as well as to provide information for other types of OA research. Other projects within the OAP Alaska Enterprise focus on laboratory based evaluation of the impact of OA on commercially and ecologically important Alaskan species, especially during the vulnerable larval and juvenile life stages. This environmental monitoring informs those studies by describing the intensity, duration, and extent of OA events and providing a baseline for projecting future conditions. Finally, this observational data is used to validate new OA models that are currently being developed for the Gulf of Alaska and Bering Sea, and are applied in bio-economic models of crab and pollock abundance forecasts.

Publications

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

Cheng, W., Cross, J.N., and Mathis, J.T., Future projections of ocean acidification in the Gulf of Alaska from the CCSM4 model. Geophysical Research Letters, in preparation.

Conference presentations

Monacci, N.M., Musilewicz, S., Cross, J.N., Evans, W., and Mathis, J.T., 2018. Alaska Ocean Acidification Mooring Network: 2013 – 2015. American Geophysical Union Ocean Sciences Meeting, February 2018.

Cross, J.N., 2017. Ocean acidification in Alaska: Ecosystems and Economies. Southeast Alaska Fisheries Habitat Partnership, Southeast Alaska Watershed Coalition, and United Fishermen of Alaska, Juneau, AK, November 2017.

Veerhusen, B., Cross, J.N., Williams, C., and Grondin, A., 2017. Is Ocean Acidification taking a toll on salmon? Panel, Pacific Marine Expo, Seattle, WA, November 2017.

Cross, J.N., Mathis, J.T., Foy, R., Hurst, T., Sigler, M., Dalton, R., Stone, R., 2017. US Arctic and Alaska Ocean Acidification: Current monitoring efforts, trends, and areas of highest concern. NOAA Ocean Acidification Program PI Meeting, Seattle, WA, January 2017.

Cross, J.N., Mathis, J.T., Monacci, N.M., 2017. Ocean acidification in Alaska: Ecosystem and Economies. Alaska State Legislature House Resources Committee, Juneau, AK, February 2017.

Cross, J.N., Mathis, J.T., 2016. Ocean acidification in Alaska: OA basics, current monitoring efforts, trends, and areas of highest concern. Alaska Ocean Observing System Ocean Acidification PI Meeting, Anchorage, AK, November, 2016.

Cross, J.N., Mathis, J.T., 2016. Ocean acidification in Alaska: OA Ecosystems and Economies. NOAA Pacific Marine Environmental Laboratory, Seattle, WA, November 2016.

Cross, J.N., Mathis, J.T., Monacci, N.M., 2016. Ocean Acidification in Alaska: Introduction and Integrated Monitoring. Aleutian Life Forum, Dutch Harbor, AK, May 2016.

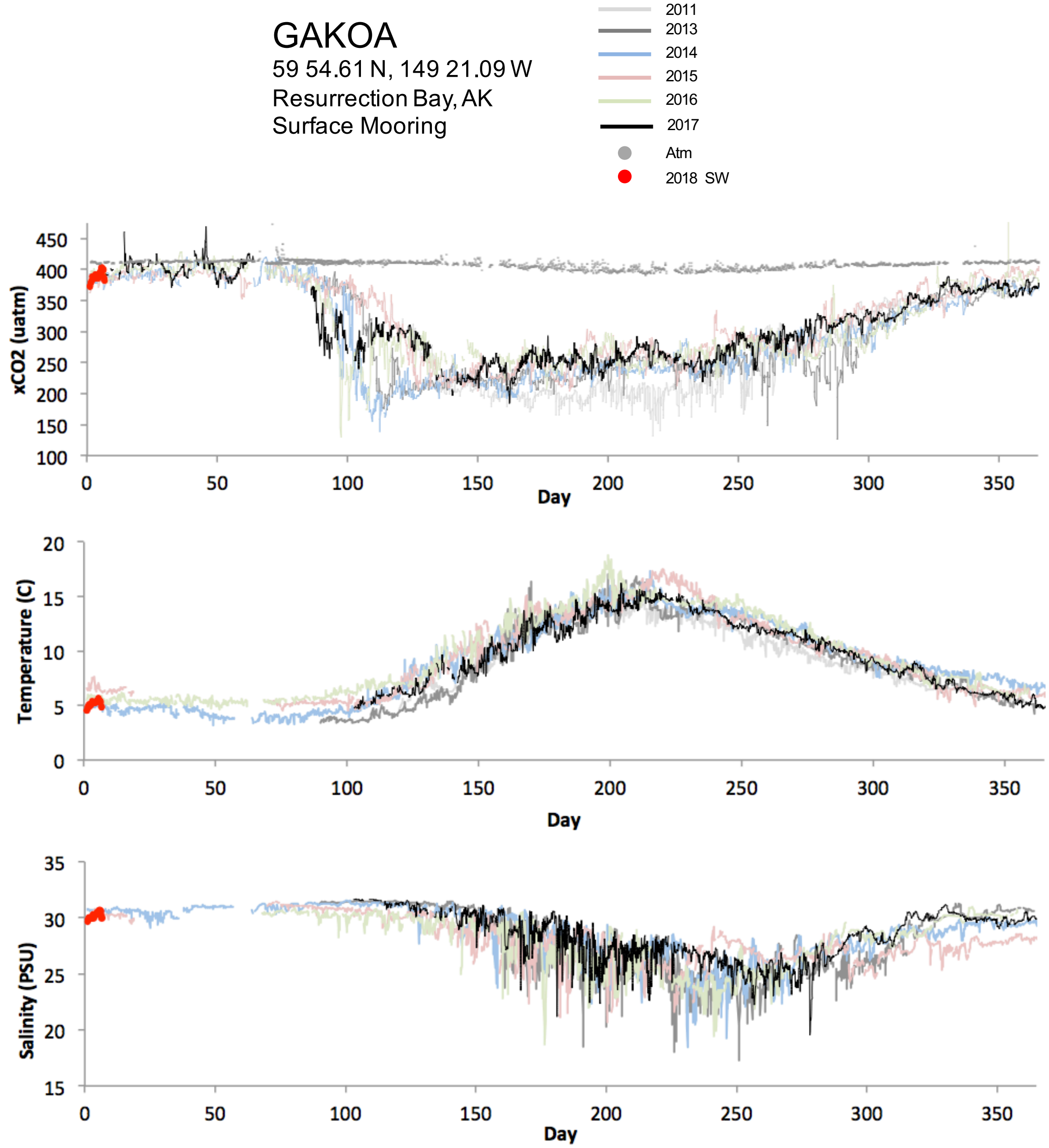


Figure 1. GAKOA surface mooring data from 2011 to 2018. Data shown are preliminary, xCO2 values. For final data: https://www.nodc.noaa.gov/ocads/oceans/Moorings/GAKOA.html.

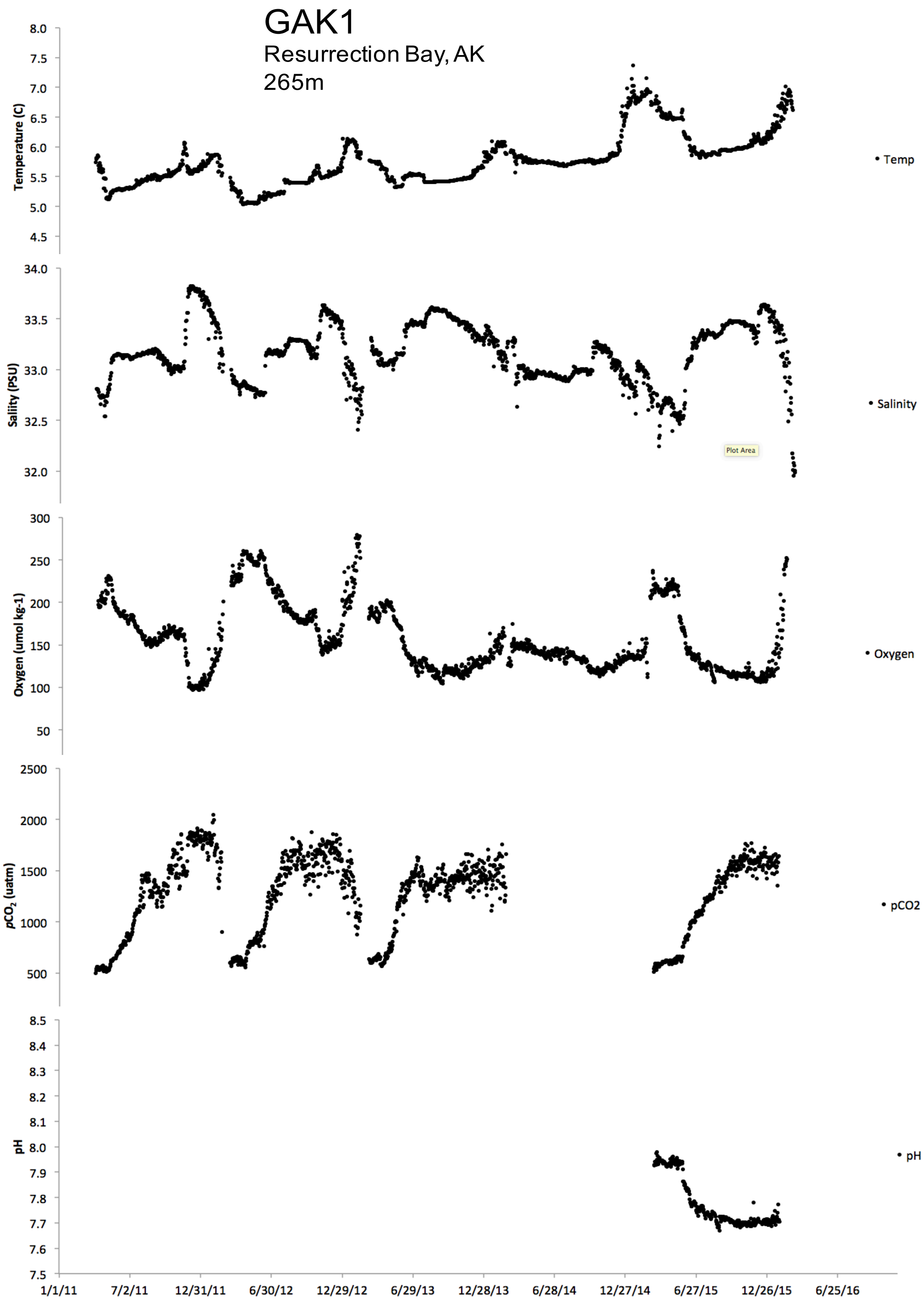


Figure 2. GAK1 subsurface mooring data.

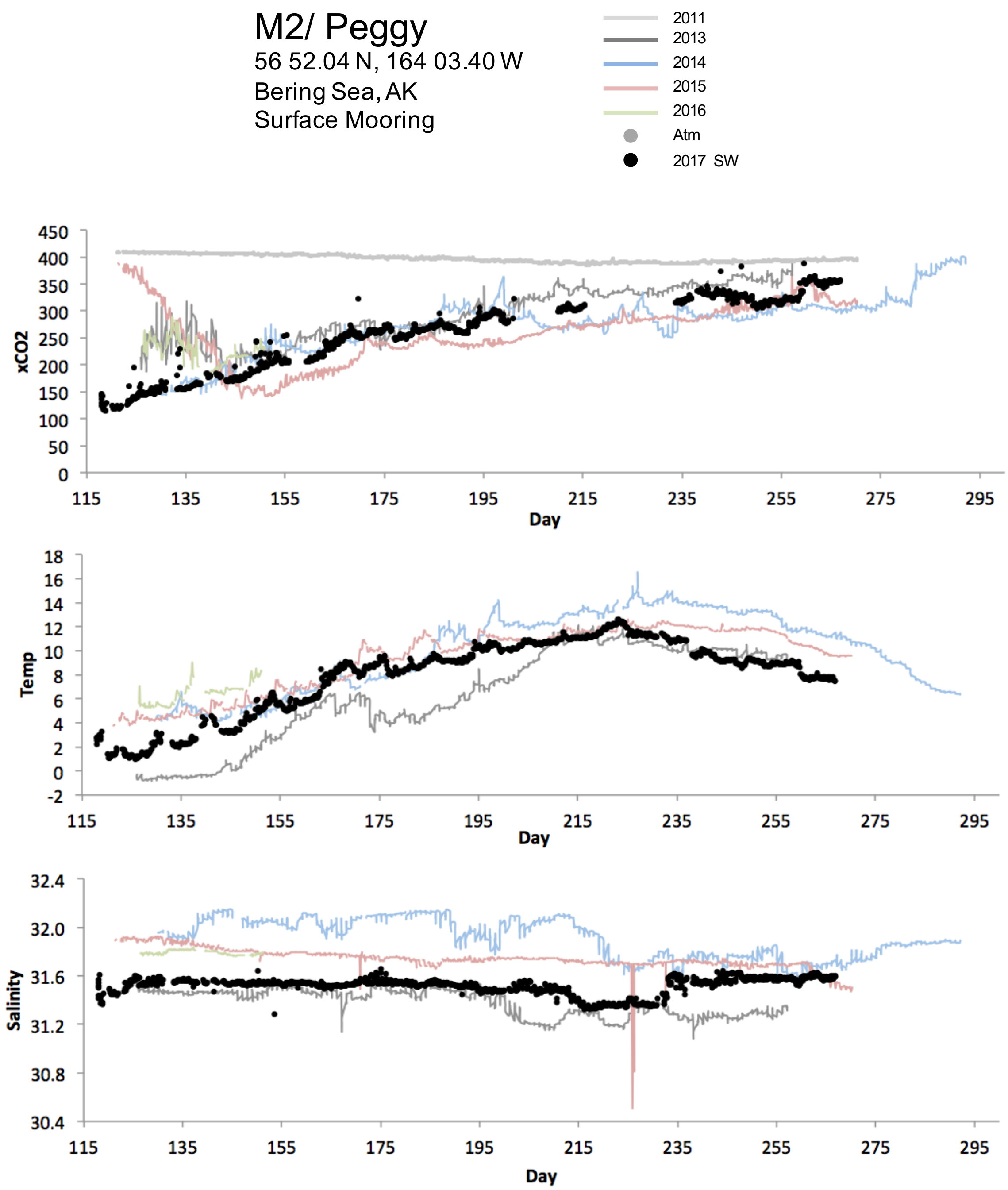


Figure 3. Figure 1. M2 surface mooring data from 2011 to 2017. Data shown are preliminary, xCO2 values. For final data: https://www.nodc.noaa.gov/ocads/oceans/Moorings/M2_164W_57N.html.

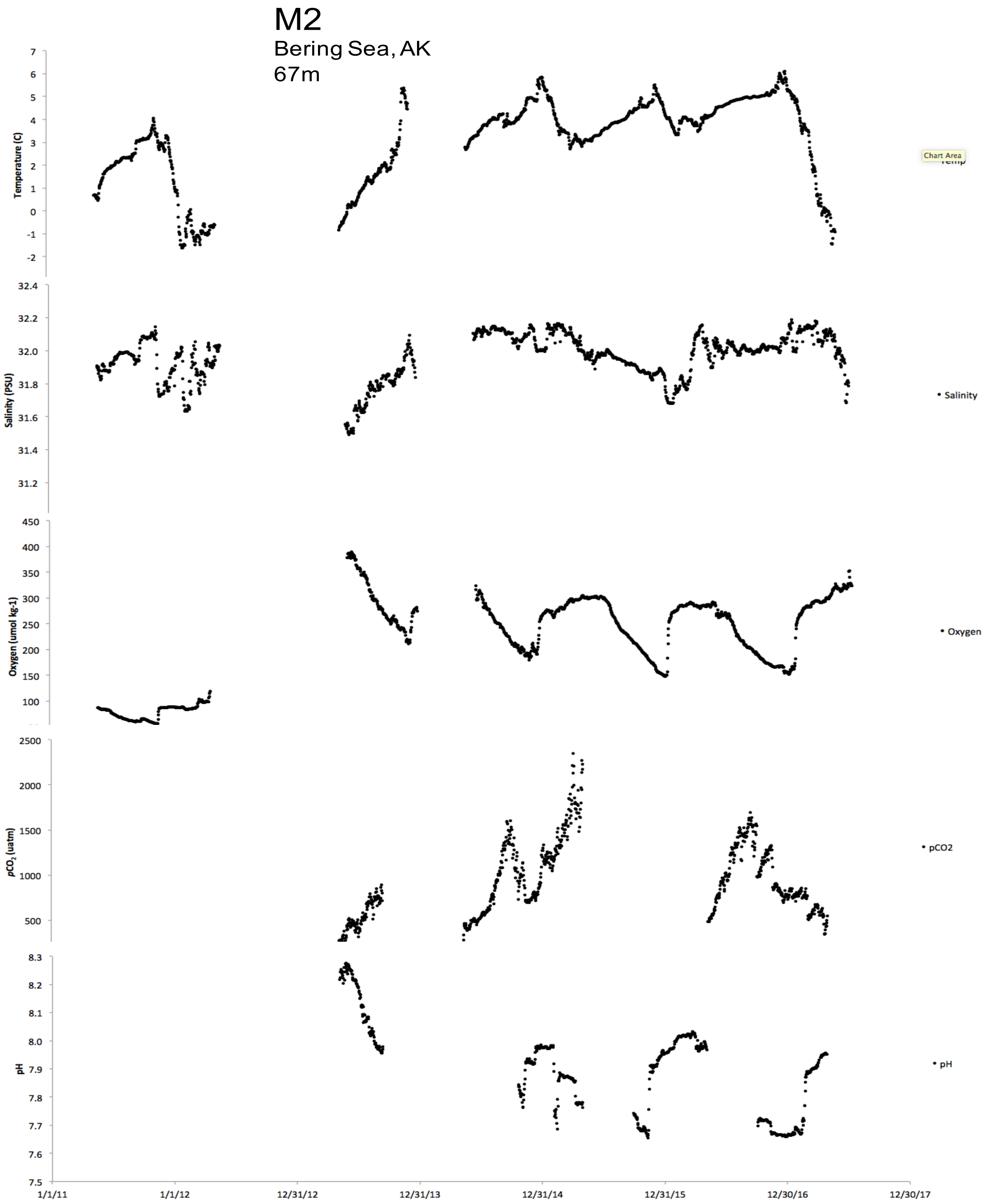


Figure 4. M2 subsurface mooring data.

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

Terrance J. Quinn II, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

NOAA Goal(s): Healthy Oceans

Amendments 39, 49
NOAA Office: NMFS, Douglas DeMaster, Sponsor
Budget Amount: Cumulative $47,957, This year $0
This project is complete.

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 been conducted on identifying hot spots, meeting Objective 2. The Strategic Plan has been finalized and was presented to the IWC in October of 2017, meeting Objective 3.

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 June for her annual review. She has previously completed her comprehensive exam and recently finished a NOAA Knauss Marine Policy Fellowship.

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-15min Talk

2016 Presentation of SP Outline to IWC working group on ship strikes

2017 Office of Naval Research Review

Other products and outcomes

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

Ship Strike Strategic Report- In Review April 2017

Partner organizations and collaborators

IWC, NOAA

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

Publications related to this project, funded under previous cooperative agreements

Cates, K., D.P. DeMaster, R.L. Brownell Jr, G. Silber, S. Gende, R. Leaper, F. Ritter, and S. Panigada. 2017. Strategic Plan to Mitigate the Impacts of Ship Strikes on Cetacean Populations: 2017-2020. IWC/66/CC20 CC Agenda Item 5.2.

Innovative Technology for Arctic Exploration[1]

Jessica Cross, PI ***CIFAR theme: Ecosystem Studies and Forecasting***
NOAA Ocean Acidification program

Other investigators/professionals associated with this project:
Natalie Monacci, University of Alaska Fairbanks

NOAA Goals: Healthy Oceans; Climate Adaptation and Mitigation

Amendments: 13, 54 NOAA Office: OAR-PMEL, Chris Sabine, Sponsor
Budget Amounts: Cumulative $155,964, This year $0
This project was set to end 03/31/2017. It was hoped that additional funds were to be received, but they were not. Last year was the last year any work was performed on this project.

Primary objectives

The goal of this proposal is to quantify the spatial and temporal variability of physical, chemical, and biological properties in the surface layers of the Bering and Chukchi Seas after ice retreat using advanced innovative glider technology.

The objective of this proposal is to conduct wave glider surveys to quantify the spatial and temporal variability of carbonate parameters (pCO_2 and pH) as well as associated biogeochemical measurements (i.e. dissolved oxygen, chlorophyll, etc.). The benefits of this proposal could be enormous and include new partnerships, interdisciplinary discovery and baseline characterization of evolving processes in a poorly understood ocean region.

Research accomplishments/highlights/findings

From FY 15-17, the central goal of this program has been to conduct autonomous vehicle surveys in coastal Alaska in order to assess surface water carbon parameters with high resolution sensors. During FY 15, a survey was conducted in the Chukchi Sea that helped to map the progression of sea-air CO_2 exchange during the summer season, as correlated with other biogeochemical mechanisms. That deployment worked to identify differences in sea-air exchange between various types of surface water, including ice melt. Analysis of the FY 15 deployment continued during this year. One key finding showed that ice melt, even late in the season, could prompt extremely rapid influx of atmospheric CO_2 into the shelf system, despite simultaneous buildup of CO_2 in bottom waters from respiration (Figure 1). This facilitated continued CO_2 influxes through September, later than expected.

[1] No funds were provided for this project in FY18 and the final report is provided from the FY17 annual report.

During FY16, we made a second deployment of the wave gliders in the Bering Sea during summer and fall. The location of this deployment was based on availability of a ship for the deployment and recovery of the vessels. However, this adjustment proved to be extremely fruitful. Previous ship-based surveys of the coastal Bering Sea have identified high CO_2 concentrations close to shore. While we have speculated on the causes, extent, and duration of these signals in previous work, the wave glider deployment allowed us to further investigate this phenomenon. Firstly, we did confirm the signal again during 2016, indicating that this is likely a persistent feature. pCO_2 values above atmospheric levels first appeared in July, peaked in early August, and moderated through September, somewhat earlier than had been previously hypothesized (Figure 2). These conditions were also well-correlated with lower oxygen concentrations, indicating that the excess CO_2 is likely produced through respiration of organic matter (Figure 3). One last goal of this deployment was to determine whether this organic matter was marine or terrestrial in origin. Unfortunately, the Ecosystem Wave Glider with the instrumentation for this research was not recovered.

NOAA relevance/societal benefits

Extensive physical changes are underway in the Arctic Ocean including a transition from multi-year to seasonal ice, an increase in open water, and changes in water chemistry, particularly ocean acidification (OA) that is largely due to rising atmospheric carbon dioxide (CO_2) levels. However, there are non-CO_2 drivers of OA in the Arctic Ocean that can play a dominant role in determining carbonate mineral saturation states. In conjunction with anthropogenic carbon, sea ice melt, river runoff, upwelling and the retention of respiration products can all drive carbonate mineral undersaturations so that the extent, duration and intensity of OA events can be highly variable both spatially and temporally. It remains unknown how these dramatic changes will impact the marine ecosystem (from microbes to whales) as well as the native communities that rely on marine services for a significant portion of their subsistence diet and cultural identity. Because of the rapid pace of change and the remote and harsh environment of the Arctic, it has proved difficult to obtain adequate information needed to assess ongoing changes in the ecosystem, especially in the technically challenging surface domain of the marginal ice zone. This project uses cutting edge tools to address these challenges.

Partner organizations and collaborators

This project relies closely on collaboration with the Ocean Acidification Research Center at the University of Alaska Fairbanks, the NOAA Arctic Research Program, the Fisheries-Oceanography Coordinated Investigations Program, the NOAA Fisheries Resource Assessment and Conservation Engineering Division, and the Innovative Technology for Arctic Exploration Program. This project leverages ship time from other projects in order to deploy and recover the wave gliders, and ship time availability in the Chukchi Sea was not available during 2016. Secondly, the third deployment will be conducted with a more advanced platform, the ASV-CO_2 Saildrone. The development of this platform is being leveraged through other projects, and will be completed in time for a 2017 deployment. The shift to the new platform was necessitated by the loss of one of the wave gliders used in the Bering Sea during 2016. Lastly, by leveraging other project funding the deployments for this mission have been expanded to 2-3 month missions across three years, rather than a single 30-day mission during one year. This represents a 300% increase in the data generation suggested in the original proposal.

Outreach

Rachel Pryor, NOAA Office of Response and Restoration profiled this project online: https://usresponserestoration.wordpress.com/2016/07/28/remotely-controlled-surfboards-oil-spill-technology-of-the-future/

Publications

Mathis, J.T., and Cross, J.N., 2016. 'Ocean Acidification.' In: Richter-Menge, J., Overland, J.E., and Mathis, J.T., Eds. Arctic Report Card 2016, http://www.arctic.noaa.gov/Report-Card

Conference presentations

Cross, J.N., Carbon Cycling and Ocean Acidification in the Pacific Arctic Region, Fall 2015 Update. Pacific Arctic Group Fall Meeting, Incheon, South Korea, October 2015.

Cross, J.N., Carbon biogeochemistry and ocean acidification in the Bering Sea and Pacific Arctic Region. University of Alaska, Fairbanks School of Fisheries and Ocean Sciences Fisheries Division, Juneau, AK, October 2015.

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 Observing Open Science Meeting, November 2015.

Mathis, J.T., Cross, J.N., Evans, W., and Doney, S.C. Ocean Acidification in the Pacific-Arctic Boundary Regions. Alaska Marine Science Symposium, Anchorage, AK, January 2016.

Cross, J.N., Ocean Acidification in Alaska: Ecosystems, Economies, and the DBO Advantage, IARPC DBO Collaboration Team, webinar, May, 2016.

Mathis, J.T., Cross, J.N., Evans, W., and Doney, S.C. Ocean Acidification in the Pacific-Arctic Boundary Regions: Ecosystems and Economies. Oceans in a High CO_2 World IV, Hobart, TAS, Australia, May 2016.

Cross, J.N., Integrated Ocean Acidification Monitoring in Coastal Alaska, Aleutian Life Forum, Dutch Harbor, AK, August, 2016.

Barbero, L., Cross, J.N., Salisbury, J. NOAA Monitoring Efforts and Needs. Joint NOAA OAP - DFO Workshop, St. Andrews-By-The-Sea, NB, Canada, September 2016.

Cross, J.N., 2016. Ocean acidification in Alaska: OA basics, current monitoring efforts, trends, and areas of highest concern. Alaska Ocean Observing System – Alaska Ocean Acidification Coastal Observing Network Open Science Workshop, November, 2016.

RUSALCA data management

Russell Hopcroft, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendments 10, 23, 44
NOAA Office: OAR, Jeremy Mathis, Sponsor
Budget Amounts: Cumulative $396,328, This year $0
This project is complete.

Primary objectives

In support of the Russian-American Long-term Census of the Arctic (RUSALCA) research projects, NOAA has provided support to digitally archive data from all disciplines that would then 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 allowing 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

During this period the PI has been primarily involved in hounding several RUSALCA PIs to deposit their data to the workspace. Nutrient datasets are finally secured, fisheries datasets remain delinquent. Work by Axiom has focused primarily on improving web-based data visualizations for the datasets (see last report). A second-generation interface was released 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.

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(s): Healthy Oceans

Amendments 28, 38
NOAA Office: NMFS-AFSC, Peter-John F. Hulson, Sponsor
Budget Amounts: Cumulative $183,116, This year $0
This project is set to end 06/30/2018.

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 models 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 are investigated. Within the covariate approach, we 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 test the performance of models that estimate time-varying M using individual random effects and random walks. Estimation model configurations are tested on three scenarios of time-varying M: (1) linear increase, (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 is also evaluated. In addition, we 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 attempt 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

1. We conducted a literature review of the body of existing knowledge relevant to fisheries stock assessment in the treatment of natural mortality.
2. Ganz gained proficiency in R and ADMB software, to be used in project analysis.
3. We chose Gulf of Alaska sablefish and Eastern Bering Sea pollock stock assessments that are used to construct the operating models for this project; these two represent a relatively slow- growing and a fast-growing population, respectively.
4. We obtained code for the Gulf of Alaska sablefish and eastern Bering Sea walleye pollock stock assessments that were used as a starting point for incorporating time-varying natural mortality.
5. We 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 contain two different levels of stochastic variation. A covariate is constructed following these trends, also with two levels of variation to represent measurement error.
6. Four estimation models are 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.
7. Ganz completed a draft of a thesis which contains the findings of this study.
8. Ganz successfully defended his thesis in May 2017, turned in his revised thesis, and graduated in Summer 2017.
9. Submitting a manuscript for publication is planned.

NOAA relevance/societal benefits

The primary benefit for the Stock Assessment Improvement Program (SAIP) is better information about what circumstances allow M to be estimated, particularly across time and age. This study determined that a random effects model was sufficient to estimate time-varying M, when a hierarchical model with penalized likelihood was implemented. A mixed effects model that used an integrated likelihood approach performed poorly in comparison. Covariates make estimating time-varying M possible with high precision and accuracy; 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. The Deviance Information Criterion was found to be a useful metric for comparing models.

Education

Quinn hired graduate student Philip Ganz to work on this project for his M.S Fisheries degree. Graduate student Alex Fejer entered the program in Fall 2016 to work on a thesis examining estimability of M for Prince William Sound herring, but funding was not found for him after one semester. Still, some work was accomplished in developing a covariate involving estimation of humpback whale abundance using mark- recapture methods.

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

Publications

Ganz, P.D. 2017. Estimability of time-varying natural mortality in groundfishes: covariates and hierarchical models. M.S. Thesis, University of Alaska Fairbanks, Fairbanks AK.

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 Matematico para la Toma de Decisiones en Evaluaci6n y Gesti6n Pesquera. Valparaiso, Chile. 18-20 January 2016.

Ganz, P.D. 2017. What the heck are random effects? American Fisheries Society Alaska Chapter, Annual Meeting, March 21, 2017.

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 Matematico para la Toma de Decisiones en Evaluaci6n y Gesti6n Pesquera. Valparaiso, Chile. 18-20 January 2016.

Quinn, T.J., II. 2016. Contemporary Models in Fish Population Dynamics and Their Application to Fisheries Management. lnstituto de lnvestigaci6n Pesquera (INPESCA), Concepcion, Chile. 18-20 January 2016.

Quinn, T.J., II. 2016. Contemporary Models in Fish Population Dynamics and Their Application to Fisheries Management. Seminario Departamento De Matematica, Universidad Tecnica Federico Santa Marfa, Sala de Seminarios, Edificio F, UTFSM, Valparaiso, Chile. 17 March 2016.

Quinn, T.J., II. 2016. Mathematical, statistical and computational modeling of fish population dynamics remains the core of fisheries stock assessment and management. World Fisheries Congress, Busan, Korea. 24 May 2016.

Bering Sea NPZ model development and collaboration

Georgina Gibson, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

Other investigators/professionals associated with this project:
Kelly Kearney, *NOAA, AFSC*

NOAA Goal(s): Healthy Oceans

Amendment 57
NOAA Office: AFSC, Kerim Aydin, Sponsor
Budget Amount: Cumulative $18,782, This year $0
This project is complete.

Primary objectives

By collaborating with Alaska Fisheries Science Center NOAA personnel on algorithm and computer coding improvements, PI Gibson will provide support for the continued improvement of the Nutrient-Phytoplankton- Zooplankton (NPZ) component of Bering-10K marine ecosystem model. Discussion and updates will occur via weekly phone conferences and supplemental e-mail correspondence as need. The project deliverable will be a finalized version (version 2) of the NPZ code, which will include a merger of the various code branches that presently exist at IARC/UAF and AFSC/NOAA.

Research accomplishments/highlights/findings

Through this project PI Gibson collaborated with NOAA personnel Kelly Kearney to develop and merge code updates from multiple versions of a lower trophic level marine ecosystem model for the Bering Sea (BEST NPZ). The collaboration was conducted by establishing a GIT, an open source distributed version control system. Notable updates that Gibson brought to the new version of the model include consumption of detritus by euphausiids, daily vertical migration of euphausiids in response to light levels, improved representation of benthic feeding and more realistic representation of feeding and respiratory behavior of zooplankton when in diapause. All of Gibson's code updates were transferred to https://github.com/kakearney/roms-bering-sea/tree/ggibson. Kearney worked to incorporate changes to the main branch of the updated code which can be found at https://github.com/kakearney/roms-bering-sea/tree/master.

NOAA relevance/societal benefits

The BEST NPZ model has previously been coupled to the NOAA developed Forage and Euphausiid Abundance in Space and Time (FEAST) model. FEAST is an upper trophic level fish model that was subsequently coupled to a management strategy evaluation model. The suite of coupled models is being used to perform hypothesis testing including evaluations of alternative management strategies for the Bering Sea pollock fishery. The work performed by Gibson under this CIFAR project provided integration of essential NPZ model updates into the suite of coupled models. Periodically assessing, updating, and revising the algorithms used in the models is integral to ensuring that predictions of ecosystem and fisheries dynamics are as realistic and informative as possible.

Partner organizations and collaborators

Gibson performed this model update effort in conjunction with NOAA personnel Kelly Kearney.

Impact

The work performed by Gibson provided updated model code and improved functionality to a lower trophic level ecosystem model for the Bering Sea. This model in used internally by NOAA personnel to provide prey fields (secondary production estimates) to a higher trophic level fish model (FEAST). Together these models have enabled an improved understanding of pollock fisheries dynamics in the Bering Sea.

Education

No outreach activities were planned or performed within Gibson's scope of work for this project.

Outreach

No outreach activities were planned or performed within Gibson's scope of work for this project.

Publications

The scope of work for Gibson's contribution to this model development effort did not include publications.

Conference presentations

Gibson did not perform any presentations related to this project.

Other products and outcomes

The work Gibson performed under this project has contributed to a newly updated lower trophic ecosystem model for the Bering Sea ecosystem. This model was originally developed primarily by Gibson and is now used in house at NOAA's AFSC coupled to a higher trophic level fish model.

Gulf of Alaska Integrated Ecosystem Assessment Postdoctoral Research

Gordon H. Kruse, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies & Forecasting

Other investigators/professionals associated with this project:
Kerim Aydin, *National Marine Fisheries Service*

NOAA Goal(s): Healthy Oceans

Amendments 58, 78, 81 NOAA Office: NMFS, Jamal Moss, Sponsor
Budget Amount: Cumulative $269,461, This year $133,039 (Amendments 78 and 81)
This project is set to end 06/30/2019.

Primary objectives

Primary duties of the post-doctoral researcher will involve: (1) developing a conceptual model, or series of models that emulate the major ecological functions of the GOA; (2) an overarching Gulf of Alaska-wide plan for the Alaska IEA Program; and (3) the drafting of a proposal for a regional IEA specific to Southeast Alaska. Additional analyses will focus on determining which data are the most useful for ecosystem indicators.

Research accomplishments/highlights/findings

After an extensive search, a postdoctoral researcher was hired on November 30, 2017, when Dr. Judith Rosellon Druker began her employment with UAF. Thus, this annual report covers research progress during just four months between December 2017 – March 2018. Progress is reported and discussed during weekly teleconferences with project personnel from UAF, NMFS, and the University of Washington. UAF PI Gordon Kruse distributes a meeting recap shortly after each weekly teleconference. For meetings when Gordon Kruse is unavailable, NMFS PI Jamal Moss takes meeting notes.

The top research priority during this period was the development of a conceptual model for the eastern Gulf of Alaska (GOA). The project is near the end of the first phase of development of an Integrated Ecosystem Assessment (IEA), namely project scoping. Based on oceanography and other considerations, it was agreed to divide the GOA into eastern, central and western gulf. When completed, the conceptual model would include a description of the regional climate and oceanography, key ecosystem components (lower to upper trophic levels), hypothesized mechanisms for changes, identification of key ecosystem indicators, and possibly simulations to explore the evidence for the various mechanisms/hypotheses. Qualitative network models were identified as a useful tool for this effort. The initial effort focused on the eastern GOA with a place-based focus on Sitka, Alaska. Based on considerations, such as numbers of fishing permits and economic values, the following focal species were identified for Sitka – salmon, halibut, and sablefish. After initial discussions with Sitka stakeholders, herring was added as a fourth focal species. Based on a literature review, draft conceptual models were developed including the focal species, biotic interactions (e.g., phytoplankton, zooplankton, forage fish), and interactions with environmental variables (e.g., temperature, alongshore winds, freshwater input). Two spreadsheets were developed, one for the biotic interactions and the other for the environmental interactions. The spreadsheets include the sign (positive or negative) of the interaction and a description of the mechanism. A 3-hour workshop with Sitka stakeholders was planned for April 5th to solicit stakeholder perceptions about key drivers of the four focal species for comparison to the literature-based conceptual model. The comparison will be discussed at the next community workshop, tentatively planned for fall 2018. Progress from this initial stakeholder meeting is currently being compiled and will be reported in the next progress report. A separate, but closely related, 3-hour workshop with Sitka stakeholders was held on April 4th to focus on the linkages between local fisheries and Sitka residents' social, economic, and ecological wellbeing. This human dimensions workshop was led by NMFS colleagues in the GOA IEA workgroup.

NOAA relevance/societal benefits

NOAA Fisheries has identified a need for ecosystem-based management to fully support 21st century stewardship of our oceans and coasts. Integrated Ecosystem Assessments (IEAs) are a next generation tool designed to incorporate ecological processes in decision making and transfer scientific knowledge to managers and stakeholders. When fully implemented, IEAs have the power to quantify ecosystem services and feed into Management Strategy Evaluations (MSEs).

Partner organizations and collaborators

This project involves collaborations with fisheries oceanographers, stock assessment scientists, ecosystem modelers, natural resource economists, commercial fishermen's organizations, tribal entities, and non-profit research organizations. In addition to UAF co-PI Gordon Kruse and postdoctoral researcher Judith Rosellon Druker, primary NMFS partners and collaborators include Jamal Moss (co-PI), Kerim Aydin (co-PI), Curry Cunningham, Ellen Yasumiishi, Marysia Szymkowiak, and Stephen Kasperski. Laura Nelson of the University of Washington is also a regular participant in the weekly meetings. Primary fishery stakeholders in Sitka represent users of the salmon, herring, halibut and sablefish resources, including members of the Native community, fishers, and researchers with the University of Alaska Southeast and non-profit organizations.

Impact

Results from this project will provide strategic guidance on management of federally managed fisheries in the Gulf of Alaska. Since the 1980s, fishery managers have been advised to move away from single-species management toward ecosystem-based fisheries management. Marine resources in the Gulf of Alaska support a wide variety of ecosystem services in addition to provisioning services in the form of fishery landings and seafood products. Integrated ecosystem assessments provide an efficient means to summarize the status of ecosystem components and provide a framework to screen and prioritize potential risks and evaluate alternative management strategies (i.e., management strategy evaluations), including evaluate tradeoffs in ecosystem services.

Education

N/A. The project is primarily conducted by a postdoctoral researcher.

Outreach

Although early in the process, this project has already involved substantial outreach with commercial fishermen's organizations, tribal entities, non-profit research organizations, other resource agencies, and academic researchers located in Sitka. NMFS PI Jamal Moss made most initial and follow-up contacts. Staff with the Sitka Sound Science Center served as an initial sounding board and provided invaluable feedback and connections to the community of Sitka. The first in-person stakeholder meeting was held on April 5, 2018.

Publications

None. As the project began four months ago, no publications have been developed yet. In the future, the main product is intended to be a peer-reviewed publication in the journal, *Deep-Sea Research*. A companion product may be a report (NOAA Technical Memorandum) containing details of the work.

Conference presentations

None.

Other products and outcomes

A workshop flyer was developed to announce the Sitka community workshops that were held on April 4th and 5th.

Support for US participation in the CBMP Expert Network

Russell R. Hopcroft, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

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

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendments 32, 59
NOAA Office: OAR, Jeremy Mathis, Sponsor
Budget Amount: Cumulative $57,471, This year $0
This project is set to end 06/30/2018.

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 2017/18, activities the primary task has been promoting the State of the Arctic Marine Biodiversity Report (SAMBR) report. Hopcroft and Iken attended the annual CBMP Marine Experts held in Anchorage Oct 11-13, 2017 and participated in discussions with the emerging CBMP Coastal Experts Group. Plans were made for broader promotion of the SAMBR report at the World Conference on Marine Biodiversity to be held May 2018 in Montreal, Canada, as well as other relevant meeting during summer and fall of 2018. Work plans were prepared for the next year for each expert group. Hopcroft contributed a subsection on Arctic plankton to a draft of an IPCC special report. Iken met with Norwegian CBMP benthic expert member Lis Jorgensen and NOAA fisheries biologist Libby Logerwell in Seattle to identify benthic invertebrates from the recent Arctic Integrated Ecosystem Survey (Arctic IES), which is part of NPRB's Arctic Integrated Ecosystem Research Program to ensure consistent taxonomy and prepare the addition of those data to the benthic dataset available to CBMP.

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

Hopcroft and Iken presented on their respective expert groups in a workshop entitled "*State of the Arctic - Circumpolar Biodiversity Marine Program progress*" that was held at the Alaska Marine Science Symposium in Anchorage January 25, 2018, and that provided a summary of the SAMBR report followed by public discussion of finding and their significance.

Partner organizations and collaborators

Circumpolar Biodiversity Monitoring Program (CBMP)

Conservation of Arctic Flora and Fauna (CAFF)

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

Pacific Marine Environmental Laboratory

Feeding habits of juvenile salmon, forage fish and scyphozoan jellyfish

Alexei Pinchuk, PI ***CIFAR theme(s): Ecosystem Studies and Forecasting***
University of Alaska Fairbanks

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendment 60 NOAA Office: NMFS, Kristen Cieciel, Sponsor
Budget Amount: Cumulative $27,247, This year $0
This project is complete.

Primary objectives

This work addresses the gap in our understanding of feeding ecology of juvenile salmon and forage fish as well as scyphozoan jellyfish, key pelagic predators in the Northern Bering Sea and Gulf of Alaska, where they are an integral component of local food webs. Fish stomachs from fish and individually preserved jellyfish are being analyzed for prey content. Samples of individually preserved jellyfish are examined for regurgitated prey and gastric pouches are inspected for prey leftovers.

1. For fish, stomach contents identified to the lowest feasible taxonomic group. Individual prey groups are weighed and divided by the total weight of prey contained in the stomachs to calculate proportional contributions of each prey group to the diet.
2. For jellyfish, prey items are identified to the lowest taxonomic level possible, counted and weighed to obtain estimates of individual and total prey weights.
3. We will generate a relational MS ACCESS data base for stomach contents which can be linked to physical and zooplankton data collected simultaneously.
4. We will analyze diversity in fish and jellyfish diets in relation to physical conditions and prey fields observed in the study area.
5. We will provide assistance as requested to Dr. Farley as he prepares his final report for this program. This assistance will include data interpretation (as necessary) and review of the final report.
6. We will share analytical software, if requested, with Dr. Farley to help expedite analyses that he elects to pursue with the data.

Research accomplishments/highlights/findings

<u>Jellyfish</u>. Up to date over 100 individual scyphozoan jellyfish (*Chrysaora melanaster*) collected during late summer from the southeastern Bering Sea (Fig. 1) have been analyzed for prey content. In addition, 64 individual jellyfish used in shipboard digestion experiments have been analyzed for prey content to provide initial data on their feeding efficiency. The jellyfish ranged between 15-100 cm (bell diameter). The jellyfish prey comprised of 51 taxa (including juvenile stages). Neritic and nearshore copepods (*Oithona simils, Centropages abdominalis, Pseudocalanus spp, Acartia spp,*), cladocerans and newly hatched pteropods *Limacina helicina* dominated jellyfish diet (75% by number and 60% by weight, Fig 2). The taxonomic composition of the prey is indicative of the Alaska Coastal water mass. The copepods were represented by adult and

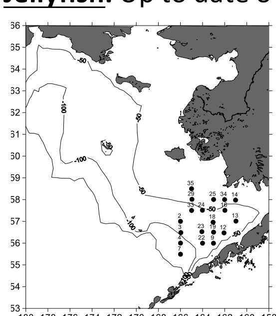


Figure 1. Map of stations where jellyfish were collected.

copepodite stages which is typical for the late summer condition. Generally low numbers of prey (Mean=27.4±10.3(95% CI); Median=12, ranging from 1 to 307 prey item per individual) indicate less than the optimal feeding conditions for the jellyfish in the Alaska Coastal water on the southeastern Bering Sea shelf in August 2016.

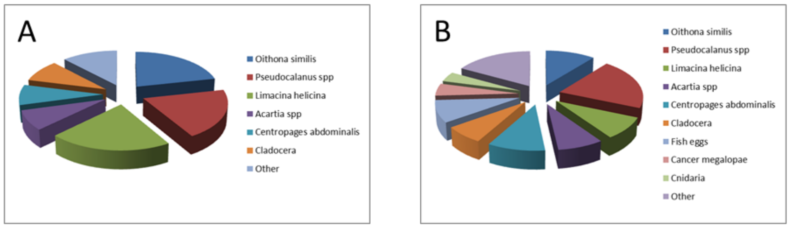


Figure 2. Contribution of various prey taxa to jelllyfish diet (A – percentage by number; B – percentage by weight)

The jellyfish diet data stored in an MS ACCESS relational data base were transferred to NOAA NIMFS for future analysis.

Fish. Total of 236 fish stomachs were analysed for prey content. The fish species included five salmon species (*Oncorhynchus tshawytscha, O. keta, O. nerka, O.kisutch, O. gorbusha*) and a number of forage fish (e.g. *Mallotus vilosus, Clupea pallasii* etc.). Total of 65 *O. tschavytscha* stomachs were processed individually, while other stomachs were pooled by location and species and treated as separate samples according to NOAA technique used for fish surveys. The majority of salmon diet comprised large numbers of crab megalopa larvae (*Chinoecetes* spp. and *Hyas* spp.), and small fish (*Ammodytes hexapterus, Mallotus villosus, Clupea pallasii, Gadus chalcogrammus*). Predatory juvenile salmon apparently can have a substantial predation impact on the Southeastern Bering Sea crab population consuming their planktonic larvae. The diet of *O. gorbuscha* consisted mainly of soft-bodied zooplankton (Larvacea, Cheatognatha and Cnidaria) with addition of neretic (*Epilabidocera amphitrites*, *Centropages abdominalis*) and, occasionally, shelf (*Calanus marshallae*) copepods and juvenile hyperiids (*Themisto pacifica*), indicating near-surface feeding.

The fish diet data stored in an MS EXCEL spread sheet were transferred to NOAA NIMFS for converting into their customized data base format and storing for future analysis.

NOAA relevance/societal benefits

Commercially harvested salmon, as well as forage fish and jellyfish play a central role in the food web of the southeastern Bering Sea and Gulf of Alaska, where they potentially compete for available zooplankton prey. A better understanding of their feeding ecology and their interactions with different ecosystem components would enhance our ability to success fully model these populations via changing prey and prey quality as they are mediated by changing climatic conditions.

Partner organizations and collaborators

none

Education

Not applicable.

Outreach

Not applicable.

Publications

Not applicable.

Conference presentations

Not applicable.

Other products and outcomes

Not applicable.

Acidification in the Distributed Biological Observatory

Amanda Kelley, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting
Climate Change and Variability

Other investigators/professionals associated with this project:
Natalie Monacci, *University of Alaska Fairbanks*

NOAA Goal(s): Climate Adaptation and Mitigation

Amendment 66 NOAA Office: OAR, Jessica Cross, Sponsor
Budget Amount: Cumulative $37,222, This year $37,222 (Amendment 66)
This project is new and set to end 03/31/2019.

Primary objectives

This project provides support for discrete samples collected as part of the Distributed Biological Observatory – Northern Chukchi Integrated Study mission. Discrete samples are collected by NOAA and analyzed by the Ocean Acidification Research Center at the University of Alaska, Fairbanks. This project also provides support for the analysis of data collected by the Saildrones during this mission by the Ocean Acidification Research Center at UAF.

Research accomplishments/highlights/findings

Sampling

The primary effort in FY 2017 was the completion of carbonate chemistry sampling during the US DBO field program aboard USCGC *Healy* during August-September 2017 (HLY1702). In our original work plan, we proposed collection of 250 samples. Fortunately, we achieved considerable cost savings per sample by leveraging the resources of the Ocean Acidification Research Center (OARC) at the University of Alaska Fairbanks (UAF), which loaned us use of two instruments (Versatile Instrument for the Detection of Total Alkalinity (VINDTA), and Automatic Infrared Carbon Analyzer, AIRICA, from Marine Analytics and Data (MARIANDA)) for the duration of the cruise. By analyzing our DIC and TA samples at sea, this critical partnership enabled us to double our sampling rate by reducing salary costs of running samples in the lab. We collected a total of 511 samples across 90 different stations, sampling DBO regions 1, 3, 4, and 5, and significant sampling over Hannah Shoal. The Arctic Research Program pairs the DBO program with the hypothesis-driven Northern Chukchi Integrated Study (NCIS), which seeks to amplify our monitoring efforts with new data and discoveries.

During HLY1702, our preliminary results indicate that we observed corrosive waters along the southeast edge of Hannah Shoal, as expected. In this area, corrosive Pacific Winter Water (PWW) is formed as late-season cooling and ice formation start to densify bottom waters over the Chukchi Sea shelf, and simultaneous respiration of organic matter exported during the highly productive spring and summer seasons causes a buildup of carbon dioxide in the same water mass. This respiration signal is maintained by intense stratification and the slow movement of water through this area, which limits diffusion, gas exchange, and dilution that may otherwise mitigate the buildup of CO_2. When anthropogenic CO_2 is added to this concentrated respiration signal, the total amount of CO_2 is enough to cause carbonate mineral corrosivity. The 'leading edge' of winter water formation was located between the northwest side of Barrow Canyon and the southeast edge of Hannah Shoal.

As evidenced by other members of the cruise team, this area is a highly productive benthic habitat especially for shelled marine organisms vulnerable to ocean acidification, such as clams. These clams and mussels form an important food source for the declining population of pacific walrus in the area. Importantly, these areas can still be reached from shore, where large groups of walrus are forced to haul out and rest due to significant ice losses. Previous work has shown that acidification pressure can reduce the size of these important prey species, perhaps resulting in reduced prey quality.

HLY1702 encountered good weather and good planning at the start of the cruise, which left ample time for opportunistic sampling. One of the key areas we chose to visit with our extra time was DBO1. In this area of the Bering Sea, circulation is also relatively sluggish, the biological pump is extremely efficient, and bottom waters are home to important benthic populations of shelled marine organisms. Previous occupations near this area have indicated that corrosive conditions can be so severe and prolonged that evidence of carbonate mineral dissolution is apparent. Our preliminary results did identify severe bottom water corrosivity at DBO1, but it does not appear that any buildup of alkalinity was recorded during this occupation. Investigations into the source of this conservative behavior are ongoing.

We have already achieved preliminary success with each of the deliverables proposed for FY2017; we collected high-quality DIC and TA samples, used these to calculate extended carbon parameters, and have generated cross-sectional and surface maps of important carbonate variables. We also collected calibration samples for Arctic Glider Program. These preliminary results were provided to the cruise participants in the cruise report, and will be presented at a DBO workshop in Seattle, WA in November of 2017. Analyses of the carbon chemistry data and correlations with population trends of marine organisms in the DBO are ongoing as of this writing. Importantly, calculation of extended carbon system parameters such as measures of carbonate corrosivity will be corrected for nutrient values before final numbers are submitted.

<u>Saildrones</u>

Two saildrones were launched from Dutch Harbor in mid-July and initial calibration activities were conducted at the M2 mooring site in the Bering Sea alongside a long-term time series mooring that measures $p\mathrm{CO_2}$. During this comparison, the ASVCO2 systems on the Saildrone and the MAPCO2 system at the M2 mooring matched closely, with a difference averaging < 5 µatm CO_2.

The saildrones then proceeded through Bering Strait, arriving in early August. From there, one saildrone SD1003 conducted six repeat observations of the DBO4 hydrographic line from August 10 – 12, and 7 repeat observations of the DBO5 hydrographic line from August 14-21. The other saildrone, SD1002, proceeded north across the center of Hanna Shoal and into the basin, reaching approximately 75 °N, approximately 7 nm from the ice edge. This transit was made safely using publically available ice products from the National Snow and Ice Data Center (NSIDC; MASAM-2) and a custom ice product from the U.S. National Ice Center (NIC). Together, these products help show a daily ice concentration and a 24-hour forecast for the 0% ice edge. SD1002 returned south to the outside edge of DBO5, and then proceeded west across the center Hannah Shoal, and south through the central channel in the Chukchi Sea.

Following these surveys, the saildrones each proceeded to DBO3 for a ship-to-saildrone calibration activity from USCGC *Healy*. Six repeat transects of DBO3 were conducted between August 25 and August 28. On August 29, the saildrones rendezvoused with *Healy* near 68 °N. Calibration samples were collected from the hydrolab underway system on *Healy* at 68° 00.867' N, 167° 52.066' W on 30 August 2017 01:38:06 UTC. All calibration samples were analyzed at the OARC at UAF when the analytical instrumentation was returned.

Following this activity, the Saildrones proceeded south through Bering Strait. Assistance with safety and operations of this crossing was provided by R. Pickart and M. Pisareva at Woods Hole Oceanographic Institute, who provided mean winds and currents as well as an ADCP transect of Bering Strait to show the ideal crossing point, and provide confirmation that wind direction is mostly southerly during this time of year, which aided us in navigation. The southerly crossing was made in approximately 17 kts of wind directly to the south.

After crossing through Bering Strait, the drones conducted a brief survey of the inner shelf of the Bering Sea north of Nunivak Island. Recovery took place in Dutch Harbor on 29 September 2017.

NOAA relevance/societal benefits

A primary NOAA OAR mission requirement is to understand and predict changes in climate, weather, ocean, and coasts. With the increase in human and maritime activity in the Arctic alongside extreme physical changes, the collection of actionable environmental intelligence is especially integral to good stewardship of these ecosystems and communities. Climatic pressures are causing sea ice to melt back earlier, retreat over increasingly large areas, and freeze later. The resulting loss of multiyear sea ice and an overall thinning of the ice matrix has complex implications for marine environment and ecosystem services. Understanding these environmental transitions, and how these transitions will impact keystone ecosystem species, are central goals for the NOAA Arctic program.

One of the programs currently supported by the NOAA Arctic Research Program is the Distributed Biological Observatory (DBO), a network of rapidly changing and biologically important sites designed as a change detection array from the northern Bering Sea to the Arctic Basin (Figure 1). Since 2010, the DBO has provided a framework to focus and coordinate sampling and analytical efforts that link biological changes to physical drivers in a rapidly changing Arctic. DBO activities have already connected shifts in benthic community biomass to trends in annual sea ice persistence.

For this project, the NOAA Arctic Research Program partnered with the Innovative Technology for Arctic Exploration testbed with support from the NOAA Ocean Acidification Program to deploy two wind- and solar-powered autonomous surface vehicles ASVs in conjunction with the DBO-NCIS mission. These ASVs were equipped with a new sensing technologies for sea-air carbon dioxide (CO_2) flux measurements. Adding this capability to ASVs is key to the NOAA Climate Observation Division's central goal to constraining global anthropogenic CO_2 storage. Like ocean heat, increased open water area allows for great exchange of CO_2 between the atmosphere and upper ocean, contributing to accelerating rates of ocean acidification and decreases in ocean pH. Saildrone CO_2 flux measurements represent a clear technological breakthrough that could fully survey the regional CO_2 sink and constrain the extent, duration, and intensity of ocean acidification events.

Partner organizations and collaborators

This project represents a close collaborative relationship between the Pacific Marine Environmental Laboratory and the Ocean Acidification Research Center at the University of Alaska, Fairbanks. These mooring data also contribute to the International Ocean Observing System (IOOS) program and the Global Ocean Acidification Observing Network (GOA-ON).

Impact

Previous research efforts have observed acidification-mediated corrosivity in important macroecological environments targeted by the DBO, including the seasonal ice zone in the northern

Chukchi Sea, and the advective pathways between the Pacific and the Arctic Oceans. In these areas, the local ecosystem structure is highly vulnerable to stress: food web linkages between trophic levels in Arctic ecosystems are naturally short, meaning that OA impacts on some organisms can easily and quickly propagate through the food web. Given that these vulnerable ecosystems are experiencing sustained exposure to corrosive waters every year, it is important to characterize how this OA is impacting Arctic communities.

Ultimately, the main mission and deliverable of the overall DBO-NCIS program is to support co-located biological sampling and carbonate chemistry measurements. Adding Ocean Acidification to the DBO 'Change Detection Array' may not only help to identify important ecosystem vulnerabilities, but may also uncover areas of unexpected resilience.

The saildrone, a novel wind- and solar-powered ASV has been used with great success by the ITAE program during several development missions. ITAE scientists have co-developed this platform with Saildrone, Inc. to tailor its capabilities to NOAA's unique observational needs. Dramatically enhanced speed, endurance, and maneuverability allow the saildrone to launch and recover from shore and cover extremely large areas over extended research missions. These types of platforms are critical for growing Arctic research and monitoring needs.

The researchers involved with this project also work closely with the Alaska Ocean Acidification Observing Network, an impact-driven group designed to connect scientists to stakeholders. Through that group, these monitoring activities support a number of cross-cutting research efforts.

Press:

Saildrone mission blog for 2017 available at: https://www.pmel.noaa.gov/itae/follow-saildrone-2017

Saildrone press:

27 October - These ocean drones are trawling for climate change data (Katy Scott, CNN Tech)
22 August - NOAA scientists set sail on Coast Guard icebreaker to measure change in the Arctic (NOAA)
7 August - Sailing drone captures dawn while crossing the Bering Strait (NOAA)
31 July - Two Saildrones collecting OA data are on their way to the Bering Strait (Alaska Ocean Observing Network)
13 July - Saildrones will aide NOAA research this summer (Cordova Times)
12 July - NOAA is Gathering Data with Captain-less Sailboats (GovernmentCIO)
11 July - Summer of Sailing Drones (NOAA Research)
11 July - Drones at sea: Unmanned vehicles to expand data collection from far-flung locales (NOAA)
14 June - The Most Exciting Drones Aren't in the Air--They're in the Ocean (Will Yakowicz, Inc. Magazine)

DBO-NCIS mission dispatches available at:

• https://research.noaa.gov/InDepth/MeetOurScientists/CurrentScientist/TabId/546/ArtMID/2688/ArticleID/12301/Why-We-Go-North.aspx

• https://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/12303/No-ice-to-break.aspx

• https://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/12304/What-the-mud-tells-us-about-a-changing-Arctic.aspx

• https://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/12305/Fishing-in-the-Arctic.aspx

• https://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/12308/Why-is-it-getting-cloudier-in-the-Arctic.aspx

Publications

Cross, J.N., Mathis, J.T., Pickart, R.S., and Bates, N.R., 2018. Formation and transport of corrosive water in the Pacific Arctic Region. Deep Sea Research II, in press.

Pickart, R.S., Grebmeier, J.M., McRaven, L., Mordy, C.W., Stabeno, P.J., Cross, J.N., Cooper, L.W.,Busy, M., Creamean, J., Bourbonnais, A., Collins, E., Moore, S., Wright, C., Hoover, B., and Kuletz, K., 2017. Distributed Biological Observatory – Northern Chukchi Integrated Study. Healy 1702 Cruise Report. Available at: https://web.whoi.edu/healy-2017/wp-content/uploads/sites/101/2017/11/HLY1702_cruise_report.pdf.

Conference presentations

Cross, J.N., Pickart, R.S., Mathis, J.T., Mordy, C.W., Meinig, C., and Grebmeier, J.M., 2018. Ocean acidification in the Pacific Arctic and the Distributed Biological Observatory, 2011-2017. American Geophysical Union Ocean Sciences Meeting, Portland, OR, February 2018.

Cross, J.N., Mathis, J.T., Bates, N.R., and Pickart, R.S., 2017. Formation and transport of corrosive water in the Pacific Arctic Region. Ecosystem Studies of Arctic and Sub-Arctic Seas Open Science Meeting, Tromsø, Norway, June 2017.

Evaluating the effects of habitat quality on YOY sablefish physiological condition to inform estimates of recruitment in the stock assessment

Anne Beaudreau, PI

University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

Other investigators/professionals associated with this project:

Ron Heintz, *NOAA, AFSC*

Joseph R. Krieger, *University of Michigan*

NOAA Goal(s): Healthy Oceans

Amendment 72 NOAA Office: NMFS, Tony Marshak, Sponsor

Budget Amount: Cumulative $15,321, This year $15,321 (Amendment 72)

This project is new and set to end 06/30/2018.

Primary objectives

The overall goal of this research is to link habitat conditions to sablefish overwinter survival by modeling the relationship between habitat condition (temperature, resource availability and quality) and YOY sablefish growth during their first year of life. Determining factors affecting early life survival as it relates to subsequent recruitment is a key question for the sablefish stock assessment in Alaska.

Our objectives are to (1) Conduct laboratory experiments that measure the influence of temperature, ration, and body size on YOY sablefish growth and overwinter energy depletion; (2) Develop a mass balance model for growth and energy depletion that incorporates covariates of size, condition, temperature and ration for YOY sablefish; and (3) Use the model to index habitat conditions for recruiting year classes and to identify environmental parameters likely to be important in determining growth and overwintering success of YOY sablefish.

Research accomplishments/highlights/findings

Joe Krieger started as a postdoc on the project in July 2017 and is leading the work for all objectives. The laboratory experiments (Objective 1) were completed in 2017 and we have made substantial progress towards completion of a manuscript that includes results from those experiments (paper 1, below). In addition, substantial progress has been made towards development of the bioenergetics model, including code development and parameter estimation.

In our laboratory trials, we measured the effects of temperature on growth and consumption rates of YOY sablefish (218 – 289 mm TL) with fish (n = 420) held over 5 temperature treatments (5°C, 8°C, 12°C, 16°C and 20°C) and maintained on high, medium, or low ration for 7 weeks (5 temperatures x 3 ration treatments x replicate tanks = 30 total tank treatments). Specific growth rate (SGR; % wet weight gain (g) per day) was used to derive a temperature-dependent growth model, and consumption rates were used to derive species specific parameters for the consumption function of a Wisconsin-type bioenergetics model. Daily growth in length varied from 0.13 mm d^{-1} to 1.74 mm d^{-1} and SGR ranged from 0.52 to 2.31. SGR peaked at 15.4°C, remained high at 12°C and 16°C, and steadily declined as temperatures shifted outside this range. Residuals of length-weight regressions showed YOY sablefish condition was positive at 12°C and 16°C, and negative at 5°C, 8°C, and 20°C.

Consumption rose sharply with temperature, peaking at 18.6°C. The narrow thermal range of positive condition and optimal SGR indicates YOY sablefish growth and development may be dramatically influenced by relatively small shifts in water temperatures. Further, when compared to similar studies of smaller sized sablefish, we observed a shift with size in thermal performance with larger fish optimizing physiological response at colder temperatures compared to smaller fish (see Figures below). The shift in thermal performance with size is an important consideration for future management initiatives. While traditional recruitment models rely heavily on information from a single life-stage, resource use and physiological requirements often change with development. Given the widespread occurrence of anomalous thermal events in the GOA, a life-stage specific understanding of the effects of varying temperatures is crucial.

Dr. Beaudreau contributed to the experimental design and conceptual framework for all objectives, provided advice regarding modeling, and provided mentorship to the postdoc. In addition, she is leading a field-based project on sablefish (funded by NPRB) that will contribute diet, energy density, and temperature data to the bioenergetics model (Objectives 2 & 3).

All together, we have three manuscripts pending or in progress that summarize project results:

1. Krieger, J., A. Sreenivasan, R. Heintz. Growth and consumption of young-of-the-year sablefish in captivity.

2. Krieger, J., R. Heintz, A. Beaudreau. Parameterization and testing of a bioenergetics model for young-of-the-year and post-settlement juvenile sablefish.

3. Krieger, J., A. Beaudreau, R. Heintz, M. Callahan. Factors affecting overwinter condition and growth of juvenile sablefish: Application of a bioenergetics model

NOAA relevance/societal benefits

Sablefish are among the highest valued commercial species in Alaska. They were identified as one of the top priority stocks for habitat science through the West Coast Regional Habitat Assessment Prioritization (Blackhart 2014). While Alaskan stocks were not included in this assessment, tagging studies indicate evidence of exchange between Alaska and Pacific Northwest sablefish stocks (Hanselman et al. 2015). Hence, findings from this study will contribute to science and management of sablefish in both the Alaska and the Pacific Northwest regions. Moreover, the approach we describe can be applied to other high latitude Fish Stock Sustainability Index species. This work will also address both areas of emphasis as identified in the National Marine Fisheries Service Habitat Assessment Improvement Plan by reducing habitat-related uncertainty in current sablefish stock assessments and by identifying key species-habitat relationships to better characterize essential fish habitat for successful sablefish recruitment (NMFS 2010).

Our results will fill a gap in knowledge about the ecological and environmental factors affecting overwinter energy depletion and, ultimately, survival of YOY and juvenile sablefish. This is essential to improving NOAA's understanding of the factors affecting recruitment success and identification of environmental indicators that could explain recruitment variation. Furthermore, the research is addressing fundamental ecological questions about the early life history of sablefish, information that is of interest and value to the fishing industry and research community more broadly.

References

Blackhart, K. 2014. Habitat assessment prioritization for West Coast stocks. Report of the Northwest and Southwest Regional Habitat Assessment Prioritization Working Groups. Internal report, NMFS White Paper. Office of Science and Technology, NMFS, NOAA. Silver Spring, MD. 199 p.

Hanselman, D.H., J. Heifetz, K.B. Echave, & S.C. Dressel. 2015. Move it or lose it: Movement and mortality of sablefish tagged in Alaska. Can. J. Fish. Aquat. Sci. 72(2): 238-25.

NMFS. 2010. Marine fisheries habitat assessment improvement plan. Report of the National Marine Fisheries Service Habitat Assessment Improvement Plan Team. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-108, 115 p.

Partner organizations and collaborators

This project is a close collaboration between the Recruitment Energetics and Coastal Assessment group at NOAA Auke Bay Laboratories (PI Ron Heintz) and the Coastal Fisheries Ecology Lab at the University of Alaska Fairbanks (PI Anne Beaudreau) in Juneau, Alaska. Beaudreau and Heintz are leads on two complementary projects on juvenile sablefish, funded by NOAA/CIFAR and the North Pacific Research Board (NPRB). Postdoc Joe Krieger (NOAA) and MS student Matt Callahan (UAF) are involved in all aspects of the research and leading components of the work.

Impact

This project is resulting in greater collaboration between NOAA and UAF, including new partnerships among early career scientists (postdoc, MS student, and technicians). Additionally, it is addressing priority research needs for sablefish identified by NOAA.

Education

This project has resulted in training and professional development of a postdoctoral researcher. It is also closely tied to a complementary project funded by NPRB (PI Beaudreau) that involves a Master's student (Callahan) and multiple undergraduate student technicians. Beaudreau is providing mentorship and training to the postdoc and students.

Outreach

None to date.

Publications

None to date.

Conference presentations

We presented a poster at two conferences:

Krieger, J., A. Sreenivasan, R. Heintz, A. Beaudreau. 2018. What came first, the lipid or the length? Effects of Habitat Quality on YOY Sablefish (*Anoplopoma fimbria*) Physiological Condition. (Poster). Alaska Marine Science Symposium, Anchorage, AK and Western Groundfish Conference, Monterey, CA.

Other products and outcomes

Joe Krieger, Anne Beaudreau, and Ron Heintz organized and facilitated a one-day "Sablefish Summit" workshop with state and federal agency and university researchers on Tuesday, September 26, 2017 at NOAA's Ted Stevens Marine Research Institute in Juneau. The event featured a series of talks in the morning on current sablefish research, including presentations by Beaudreau and Krieger. An afternoon discussion session was held to identify common research goals and potential collaborations, coordinate sampling efforts and resource sharing, and outline data gaps.

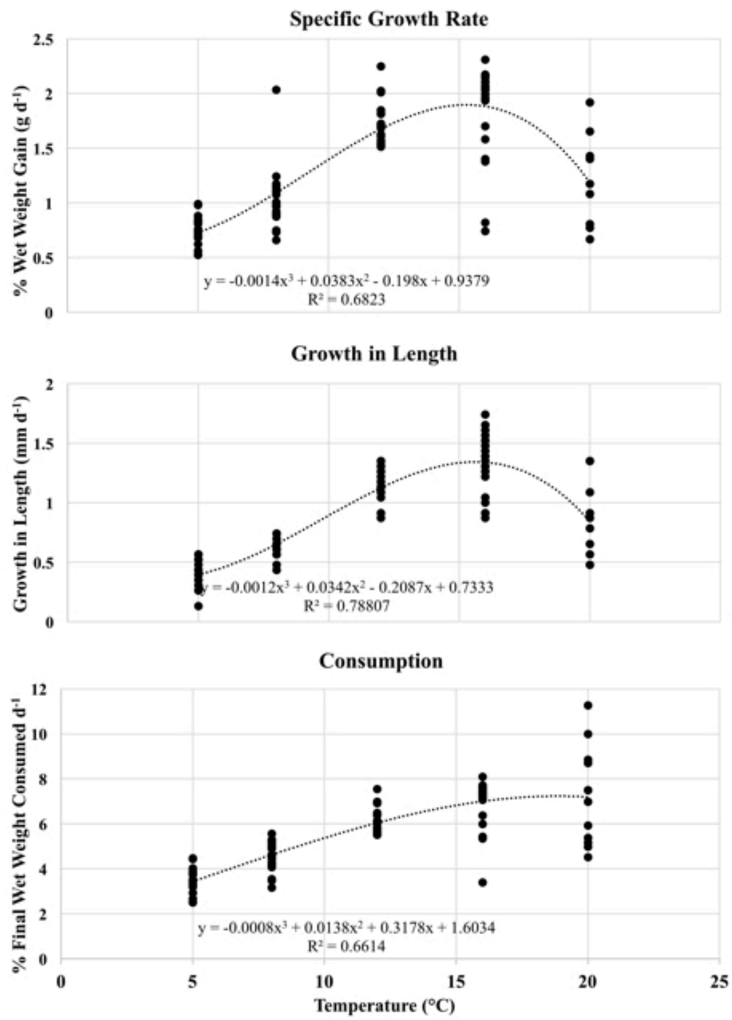


Figure 1 Temperature-dependent specific growth rate (SGR), growth in length, and consumption, for YOY Sablefish (218 - 289 mm TL). Points show individual fish exposed to each temperature treatment following 3 weeks of growth. A third-order polynomial function describing the temperature-dependent physiological response of each parameter is shown.

Trophic Interactions in Subarctic Pelagic Ecosystems: Fish, Medusae and Zooplankton

Alexei Pinchuk, PI
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

Other investigators/professionals associated with this project:
Kristin Cieciel, *NOAA, AFSC*

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation

Amendment 74 NOAA Office: NMFS, Kristin Cieciel, Sponsor
Budget Amount: Cumulative $82,695, This year $82,695 (Amendment 74)
This project is new and set to end 06/30/2019.

Primary objectives

This work will improve our understanding of the feeding ecology of major planktivorous predators in Alaskan subarctic pelagic ecosystems of the Northern Bering Sea (NBS) and Eastern Gulf of Alaska (EGOA). The major goal of this project is to analyze and interpret data on fish and scyphozoan jellyfish diets in relation to zooplankton prey fields collected by NOAA. These samples will be collected by NOAA scientists during Northern Bering Sea (NBS) and Eastern Gulf of Alaska (EGOA) pelagic trawl surveys in summer 2017. Up to 180 zooplankton samples from EGOA will be analyzed to determine taxonomic composition, population structure, abundance, and biomass of zooplankton prey available to predators. The entire size spectrum of the zooplankton population will be targeted using an array of nets with different mesh sizes. Up to 800 pooled fish stomach samples and up to 100 individually preserved jellyfish will be analyzed for prey content. These include a variety of planktivorous species such as juvenile salmon, pollock, and herring. Stomach samples will be examined to determine their local and seasonal dietary preferences, and to estimate predation pressure on zooplankton standing stock. The obtained information will substantially increase our knowledge of environmental mechanisms which facilitate biological production in Alaskan waters, and the success of commercially harvested species. The following specific tasks will be conducted by UAF:

1. Each mesozooplankton sample will be poured into a sorting tray and large organisms, primarily shrimp and jellyfish, will be removed and counted. The remaining sample will be sequentially split using a Folsom splitter until the smallest subsample contains 200-300 specimens of the most abundant taxa. All taxa in the smallest subsamples will be identified, staged, counted and weighed or measured. Each larger subsample will be examined to identify, count and weigh the larger, less abundant taxa. Blotted wet weights for each taxa and stage will be determined and the coefficient of variation in average wet weight will be computed. Wet weight of small taxa will be derived from their lengths using established allometric equations. The wet weight biomass for copepods in all subsequent samples will be estimated by multiplying the specimen count by the mean wet weight. Wet weights on chaetognaths, decapod larvae and other larger and soft-bodied taxa will be measured and recorded for each sample. All animals in the samples were identified to the lowest taxonomic category possible.

2. We will open all the fish stomachs and extract all contents. Samples of individually preserved jellyfish will be examined for regurgitated prey and gastric cavities will be inspected for prey leftovers.
3. For fish, the contents of up to 10 pooled individuals of each target species will be examined per station. Individual prey taxa will be identified to the lowest taxonomic group possible and weighed to the nearest 0.001 g. Information about the number of stomachs processed within pooled samples, number of empty stomachs, a stomach fullness index SFI = (total pooled prey weight/total pooled predator weight)*10,000m and an individual prey category stomach content index SCI = (total weight of individual prey category/total predator body weight)*10,000. SCI will sum to SFI.
4. For jellyfish, prey items will be identified to the lowest taxonomic level possible, counted, and weighed to obtain estimates of individual and total prey weights.
5. We will generate a relational MS ACCESS data base for stomach contents and zooplankton which can be linked to physical and zooplankton data.
6. We will analyze diversity in fish and jellyfish diets in relation to physical conditions and prey fields observed in the study area.
7. We will provide assistance as requested to NOAA personnel as they prepare final reports for their program. This assistance will include data interpretation (as necessary) and review of any final reports.
8. We will share analytical software and expertise, if requested, with Kristin Cieciel to help expedite analyses that she elects to pursue with the data.

Research accomplishments/highlights/findings

Salinity appeared to be the largest factor influencing distribution and biomass in the mesozooplankton community in the Gulf of Alaska in summer 2017. Additionally, the lack of a distinct frontal structure and the ability of certain species to rapidly react to temperature and salinity differences appeared to have shaped the zooplankton community in July of 2017. Nearshore communities over the northern portion of the grid were shaped by a freshwater plume emanating from the Alsek River, south of Yakutat. The largest proportion of cnidarian (hydrozoan jellyfish; Figure 1) biomass was within and bordering this freshwater influence. Total zooplankton biomass (Fig. 2) had two large peaks, one oceanic and one over the shelf. The oceanic peak was due to a very high biomass of tunicates (doliolids and salps, Fig. 2), while the nearshore biomass peak was due to a high number of small (<0.25 mm) juvenile shelled pteropods, *Limacina helicina*, at a single station (Fig. 1). Other selected species were influenced by salinity above the pycnocline, with increased biomass in offshore and shelf areas along with intrusions of oceanic water (Fig. 3-5). Some mixing of oceanic and shelf species assemblages occurred during July of 2017, likely resulting from weak horizontal density gradients (Mundy, 2005), and an underdeveloped Alaska Coastal Current.

Approximately 40% of the total zooplankton biomass was attributable to Cnidaria and Tunicata (hydrozoan jellyfish, doliolids, and salps). Above average sea surface temperatures (July) have been observed on this survey since 2014. Asexual and sexual reproduction may increase with temperature in many cnidarian and tunicate species, allowing these zooplanktors to quickly respond to favorable conditions. This is exemplified by the peak in biomass centered on the outflow of the Alsek River (Cnidaria, Fig. 1). We have qualitatively observed a large increase in the abundance and prevalence of pelagic tunicates (doliolids and salps) during the summer season in the past few years. This may have been caused by advection from offshore during the warm blob, or from the south. In addition to the high proportion of gelatinous biomass, other ecologically important species have markedly declined. As an example in critical species abundance reduction, the average abundance per cubic meter for *Calanus marshallae* in 2012 was nearly 500% more than the average abundance in 2017 (similar survey grid and timing). Abundance in 2012 was regularly above 100 individuals per cubic meter, a level not reached in any of the 2017 samples. In fact, 22 of 32 stations processed from the 2017 survey had an abundance of less than 10 individuals per cubic meter, which is likely a negative temperature response.

The elevated biomass of cnidarians and tunicates suggests the potential for a large proportion of primary production to be consumed by these animals. Trawl samples (and other anecdotal evidence) included pyrosomes in 2017 and increased numbers of gymnosomes since 2014. Both of these are highly efficient filter feeders, likely advected from other areas. Shunting of pelagic production to the benthos occurs via fecal pellets and dead falls. Given the prevalence of these species, there is a high potential for the removal of a large fraction of primary productivity from the pelagic ecosystem. Removal of the base of the food chain may have large implications for zooplankton, forage fishes, age-0 marine groundfishes, juvenile and immature salmon, and other consumers such as seabirds and marine mammals. It is likely that these patterns in zooplankton have existed since the summer of 2014, when the shift to warmer conditions occurred. The catch of juvenile salmon and age-0 marine groundfishes during the July 2017 survey was very low. While some of this difference is possibly attributable to a trawl gear change (summer 2017), it is likely to be the result of this shift in prey fields and primary producers. In contrast, the shunting of pelagic primary production to the benthos may stimulate benthic production and growth in demersal species of fishes.

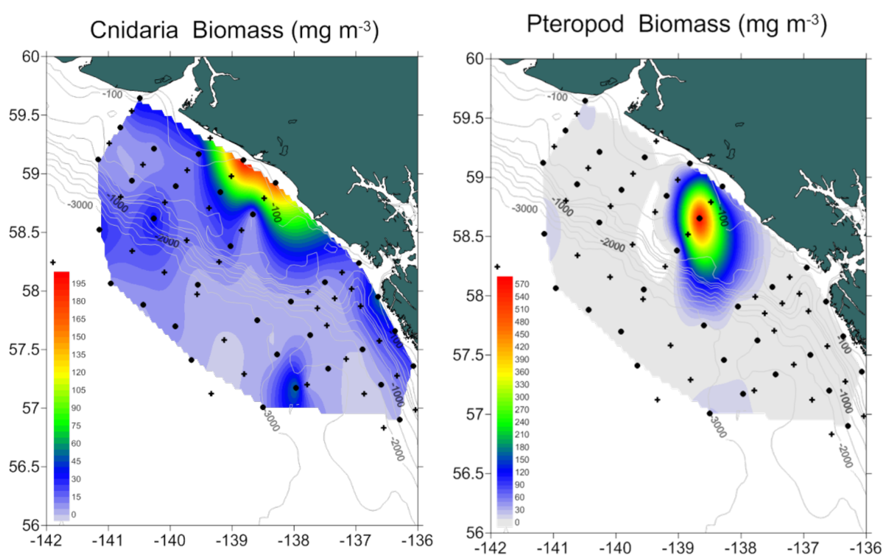


Figure 1. Kriging surface of biomass for Cnidarians (hydrozoan jellyfish) and all pteropods in the eastern Gulf of Alaska, July 2017. Note the difference in scale by species. Circle points were processed in the lab, plus signs are under way.

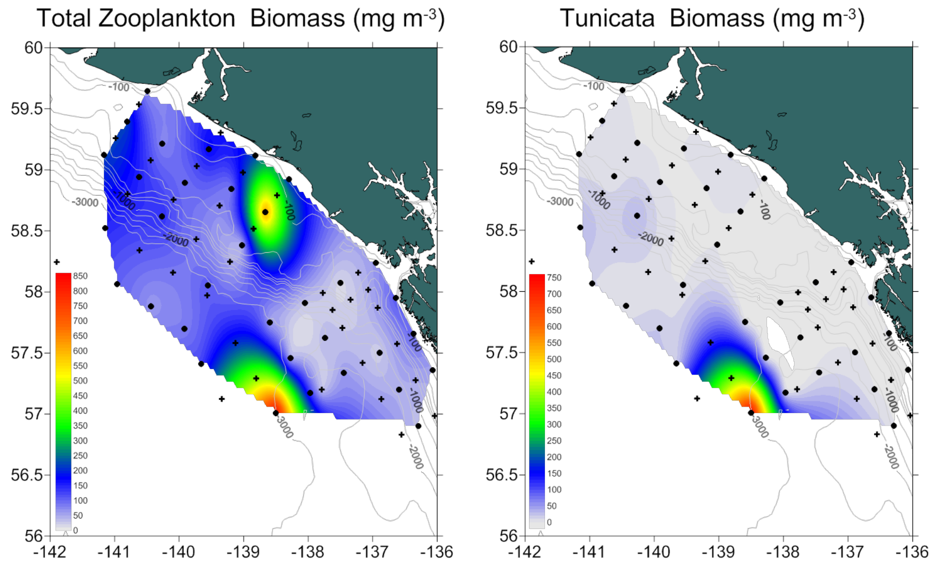


Figure 2. Kriging surface of biomass for total zooplankton and tunicates (salps) in the eastern Gulf of Alaska, July 2017. Note the difference in scale by species. Circle points were processed in the lab, plus signs are under way.

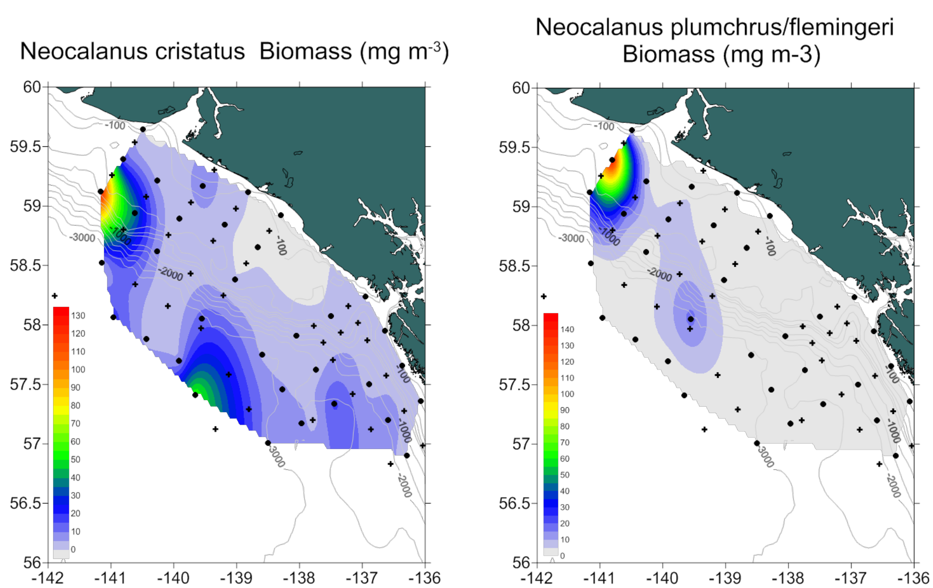


Figure 3. Kriging surface of biomass for Neocalanus cristatus and Neocalanus plumchrus/flemengeri in the eastern Gulf of Alaska, July 2017. Note the difference in scale by species. Circle points were processed in the lab, plus signs are under way.

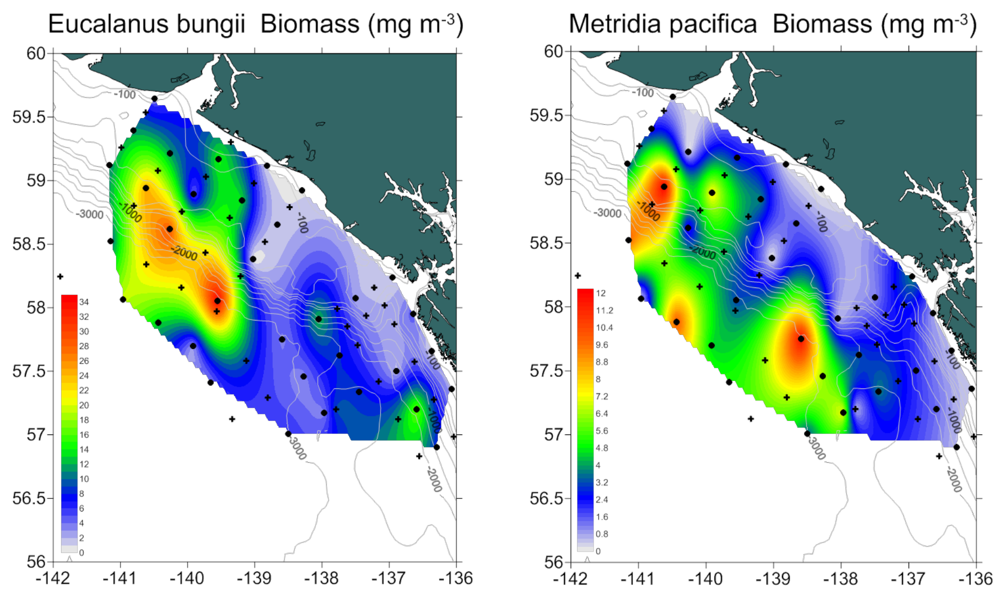


Figure 4. Kriging surface of biomass for Eucalanus bungii and Metridia pacifica in the eastern Gulf of Alaska, July 2017. Note the difference in scale by species. Circle points were processed in the lab, plus signs are under way

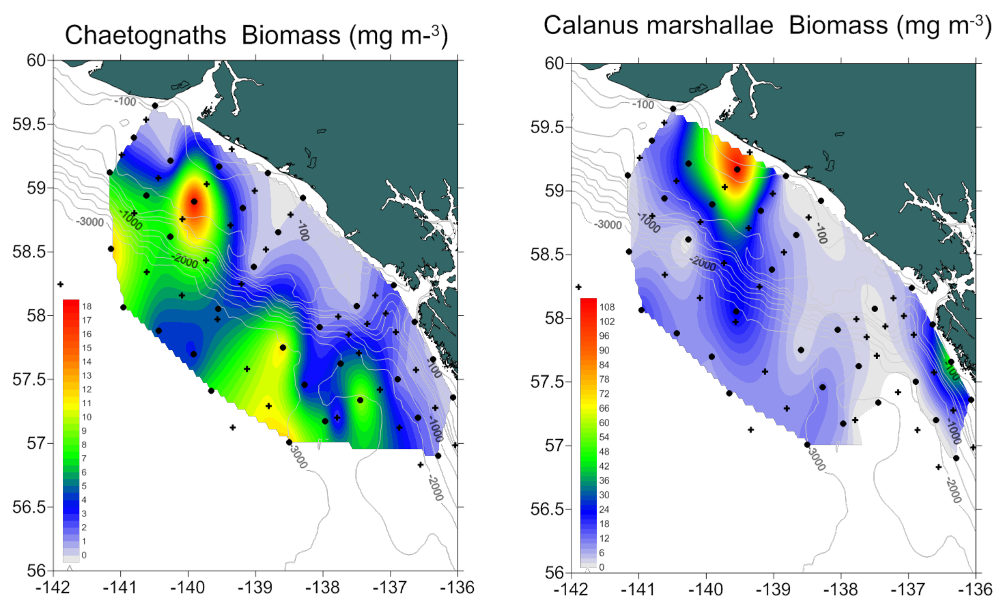


Figure 5. Kriging surface of biomass for Chaetognaths and Calanus marshallae in the eastern Gulf of Alaska, July 2017. Note the difference in scale by species. Circle points were processed in the lab, plus signs are under way.

NOAA relevance/societal benefits

Commercially harvested salmon, as well as forage fish and jellyfish play a central role in the food web of the southeastern Bering Sea and Gulf of Alaska, where they potentially compete for available zooplankton prey. A better understanding of their feeding ecology and their interactions with different ecosystem components would enhance our ability to success fully model these populations via changing prey and prey quality as they are mediated by changing climatic conditions. The scientific objectives of this project are to assess age-0 groundfish, juvenile salmon, zooplankton, and oceanographic conditions in the coastal, shelf, slope, and offshore waters of coastal Alaska. This information will be used to describe species distributions, ecosystem processes, marine productivity, and recruitment processes in response to changes in climate patterns and temperature anomalies (i.e., “The Blob”, and El Niño).

Partner organizations and collaborators

none

Education

No funds were provided for education.

Outreach

No funds were provided for outreach activities.

Publications

N/A

Conference presentations

N/A

Other products and outcomes

N/A

Alaska Direct Broadcast – Sandy Sustainment and Bridge to Operations

Lisa Wirth, PI ***(formerly Thomas Heinrichs)***
University of Alaska Fairbanks

CIFAR theme(s): Ecosystem Studies and Forecasting

Other investigators/professionals associated with this project:
Dayne Broderson, *University of Alaska Fairbanks*

NOAA Goal(s): Weather Ready Nation

Amendment 77 NOAA Office: NESDIS, Mitch Goldberg, Sponsor
Budget Amount: Cumulative $733,450, This year $733,450 (Amendment 77)
This project is new and set to end 06/30/2019.

Primary objectives

This one-year project will transition equipment ownership and operations of the Sandy Supplemental Alaska Direct Broadcast (DB) systems and services from UAF to NOAA. The project will perform operational and security design in preparation for transfer of ownership to NOAA. It will lead to the long-term operation of the Sandy Supplemental DB systems by UAFGINA in partnership with NWS and NESDIS.

Due to a number of staff vacancies at GINA since August of 2017, we have been unable to complete certain portions of this project, particularly Task 1A and 1B. We have applied for and received a no-cost-extension from CIFAR for this project through June 30, 2019. GINA has hired a new director, John Pace, who will be starting his position on June 11, 2018. Once he is on staff, we will begin the process of filling other vacant positions and will be able to complete tasks 1A and 1B.

Research accomplishments/highlights/findings

Task 1A. Establish FISMA compliance plan with NWS IT security staff

UAF-GINA received funding for this project in September 2017. On October 4, 2017, GINA staff met with FCDAS and NWS representatives for a project kick-off meeting. GINA staff identified software and online resources to facilitate the writing of the System Security Plan. We also obtained a template Interconnection System Agreement from NOAA. The GINA staff member that was responsible for completion of this task left GINA on December 8, 2017. Until this position is filled, no progress can be made for this task.

Task 1B. Migrate system ownership to approved operations procedures

During the project kick-off meeting in October 2017, it was decided that system ownership would be transferred to the NWS. The NWS has a network connection at FCDAS that will facilitate the needs. GINA edited the pre-existing Memorandum of Understanding between UAF and NOAA to bring it to a current status and gave copies to NWS and NESDIS for review.

Task 2A. Maintain and coordinate the Direct Reception System (antenna and control and capture computer)

- GINA staff added additional drive storage to the Sandy Dog receiving station server.

- FCDAS purchased a new air cooling unit to have on hand as backup in the event that the current unit fails.
- GINA staff worked with Orbital software vendors to update the Sandy Dog software to enable new NOAA-20 data receiving capabilities.
- GINA staff worked with JPSS and NWS to shift reception priorities to SNPP and NOAA-20. The FCDAS-housed antenna now has that tasking priority.

Task 2B. Patch and upgrade operating systems and maintain system hardware

- An inventory of the hardware was completed and the Silicon Mechanics server health scripts were run on all servers.
- All servers reported as healthy and Silicon Mechanics extended the hardware warranty coverage through Oct 14, 2019.
- The warranty coverage for the Brocade 10 Gigabit Ethernet switches was also extended through 12/31/2018.
- Firmware and operating system updates are in progress and could be complete on all 27 servers by June 30, 2018.

Task 2C. Maintain processing software

- Updates were made to CSPP for processing of NOAA-20 and were updated to the most recent version.
- SeaDAS processes for MODIS data were updated to the current version in December 2017.
- The AAPP will be updated by June 30, 2018.

Task 2D: Maintain processing framework

GINA staff have successfully stepped through the process for updating the test and production NRT software stacks. New processors in the form of virtual machines have been created to support the incoming data processing needs of the production NRT stack.

Specifically:

- Added the support of including AWIPS and geotiff product generation for NOAA-20.
- Added MIRS, NUCAPS, and ACSPO SST processing suites to process data into geotiffs and products for AWIPS.
- Added the processing of NOAA POES with AAPP in addition to terascan.
- Updated the processing queuing system for security updates.

Task 2E: Maintain the data distribution network

Raw data feeds and products were maintained to the Cooperative Institute for Meteorological Satellite Studies (CIMS), Cooperative Institute for Research in the Atmosphere (CIRA), the Alaska Fire Service (AFS), NASA Short-term Prediction Research and Transition Center (SPoRT), NOAA Earth System Research Laboratory (ESRL), the National Center for Atmospheric Research, Forest Service Remote Sensing Applications Center (RSAC), George Mason University (GMU), and the general public.

Data feeds and products were also maintained to NWS groups: River Forecast Center (RFC), the Alaska Sea Ice Program (ASIP), the Alaska Aviation Weather Unit (AAWU), and the Center Weather Service Units (CWSU)

New Activities:

- GINA is distributing NOAA-20 and MIRS data via LDM to the NWS Alaska Region.
- GINA is providing NOAA-20 data in geotiff format to the Alaska Sea Ice Program.
- GINA reconfigured and updated the underlying storage that hosts the Puffin Feeder website, which is the data distribution system for geotiff GIS data products.
- GINA staff are actively working to incorporate NOAA-20 data products into the Puffin Feeder website for distribution to users that prefer geotiff format.

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.

Partner organizations and collaborators

NOAA National Weather Service

NOAA NESDIS, Fairbanks Command and Data Acquisition Station

NOAA NESDIS Center for Satellite Applications and Research (STAR)

UW-Madison CIMSS

UW-Madison Space Science and Engineering Center (SSEC)

Colorado State University CIRA

NASA Direct Readout Laboratory

NASA SPoRT

George Mason University

Alaska Fire Service

Outreach

In March 2018, Carl Dierking and Jay Cable visited the NWS Regional office in Anchorage, Alaska for the SOO-DOO conference. During the visit, they met with weather forecast office personnel to discuss data uses, problems to resolve, and data access of NOAA-20.

In March 2018, Carl Dierking visited the Juneau weather forecast office to discuss data uses, problems to resolve, data access and potential future projects.

Other products and outcomes

GINA partners with the UAF department Research Computing Systems (RCS) for long-term data storage of the raw data that is received from the Big Dog and Sandy Dogs Antennas. This service is provided by a fee of $50/TB/Year and our current archive holds 108 TBs.

CLIMATE CHANGE & VARIABILITY

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

Lisa Wirth, PI ***(formerly Thomas Heinrichs)***
University of Alaska Fairbanks

CIFAR theme(s): Climate Change and Variability, Coastal Hazards

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

NOAA Goal(s): Climate Adaptation and Mitigation

Amendments 8, 19, 42, 50, 62
NOAA Office: NESDIS, Mitch Goldberg, Sponsor
Continues research from NA08OAR4320751
Budget Amounts: Cumulative $1,016,547, This year $0
This project is set to end 06/30/2018.

Primary objectives

Based on needs of the National Weather Service, the Geographic Information Network of Alaska (GINA) at the University of Alaska Fairbanks, performs 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 include the NWS Weather Forecast Offices (WFOs), the Alaska Pacific River Forecast Center (APRFC), the Alaska Aviation Weather Unit (AAWU), and the Alaska Sea Ice Program (SIP), and the NOAA research partners: Cooperative Institute for Meteorological Satellite Studies--CIMSS, Cooperative Institute for Research in the Atmosphere—CIRA, NOAA Center for Satellite Applications and Research--STAR, Short-term Prediction Research and Transition and Center--SPoRT, and the NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC).

Research accomplishments/highlights/findings

GINA has been making many preparations anticipating the arrival of GOES-17 data to Alaska. These activities will continue through 2018.

1. Alaska Fire Weather

There are two new multispectral Fire Weather RGB products developed by Curtis Seaman that have been demonstrated to be very helpful for Fire Weather forecasters with NWS and Alaska Fire Service (AFS) forecasters. They are the Natural Fire Color RGB and the Fire Temperature RGB, currently produced only with VIIRS and MODIS data, but they are completely applicable to ABI data. This work will enable forecasters to be immediately productive with similar versions from GOES-17 ABI data with the added value of greater image frequency for monitoring fire evolution.

2. Alaska Sea Ice Program

The Day Land Cloud RGB (formerly known as Natural Color) and other Snow vs Cloud identification products from polar data have been refined and used extensively by the Alaska Sea Ice Program desk. The application of these products with the high temporal resolution of GOES-17 will enable much more precise measurement of ice movement and evolution. GINA liaisons will provide training and demonstrations on the effective use of GOES-17 data that supports the Alaska Sea Ice Program. GINA will also continue to explore new products that will help to improve Sea Ice analysis and forecasting in Alaska.

3. "On the fly" RGBs in AWIPS

GINA continues to provide strong leadership, in developing AWIPS configurations, and training to Alaska NWS forecasters in the use of RGB products generated directly in AWIPS. This is known as "client-side" RGB production, or RGB production "on the fly." The advantages of this approach include greater flexibility in customized product generation at the forecast offices, more meaningful mouse roll-over information in the RGBs on AWIPS, and greater bit-depth of the resulting RGBs. This capability will be especially important as we move into the GOES-17 era with the many new spectral bands from the Advanced Baseline Imager (ABI). There are too many possible band combinations to generate remotely and transmit to WFOs. GINA will continue to work with partners and NWS IT and science staff to deploy relevant RGB configurations to WFO AWIPS workstations in Alaska. Those that are currently in use for VIIRS and MODIS data are completely applicable to ABI data.

4. GINA supports Dr. Sanmei Li of George Mason University with river ice and flooding software and product generation.

The production of river ice and flooding products from the SNPP VIIRS sensor direct readout data has been very successful in Alaska. The product is used during spring break-up to monitor for the potential for flooding by the NES Alaska-Pacific River Forecast Center and has reviewed favorably by the operational hydrologists and forecasters. These products are generated in near real-time using direct readout data captured by GINA. GINA is now supporting Dr. Li in integrating the flood mapping software for GOES-R ABI data.

5. GINA science liaisons Eric Stevens and Carl Dierking are working with NWS Alaska region to set-up a NOAA Port device that will allow them to gain access to additional data that the NWS has at their disposal. Currently, GINA does not have access to GOES data and getting this device functional will allow us to identify how the GOES and JPSS data can work synergistically to advance forecast tools in Alaska. Eric and Carl will then use that information to educate and train the different user groups on the GOES data applications in Alaska.

NOAA relevance/societal benefits

The focal areas of sea ice, river ice/flood, and aviation weather were directly targeted at weather and environmental hazards to people and property in Alaska. Improvements to forecasting these hazards have a significant benefit here in our state.

The National Weather Service Alaska Region is much more dependent on satellite data than CONUS NWS regions due to the sparse network of radars, surface observations, and balloon launches. The forecast area of responsibility for the Alaska Region is vast and includes large ocean areas, including the Bering Sea and Strait, North Pacific, and Arctic Ocean. The Alaska 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 and extensively in southeast Alaska and the Aleutians and as a synoptic tool for the rest of the state. With the much enhanced spatial, spectral, and temporal resolution of ABI data, it is certain that the GOES-West/17 ABI will be a critical forecasting support tool in Alaska.

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

NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC), 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

Outreach

GINA participated in the "Arctic Interchange" meeting held in Fairbanks the week of May 8-12, 2017.

GINA staff participated in a workshop hosted by the Alaska Fire Science Consortium on the topic of "Opportunities to Apply Remote Sensing in Boreal/Arctic Wildfire Management and Science."

Former GINA director Tom Heinrichs and science liaison Eric Stevens attended this workshop at the University of Alaska Fairbanks and at Alaska Fire Service in early April just weeks before Alaska's wildfire season began. While a number of representatives from the satellite proving ground community participated in this workshop, the majority of attendees came from the wildfire community and were not overly familiar with the newest generation of satellite products. Eric gave two presentations to this group concerning GINA's work with the satellite proving ground and how satellite imagery is applicable in the wildfire context. Recordings of these presentations are available at the following links. https://vimeo.com/216555022, https://vimeo.com/216557948.

Conference presentations

Former GINA director Tom Heinrichs, former GINA technical manager Dayne Broderson, and science liaison Carl Dierking represented GINA at the NOAA Satellite Conference in July 2017.

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

***Lisa Wirth, PI** (formerly Thomas Heinrichs)*
University of Alaska Fairbanks

CIFAR theme(s): Climate Change and Variability, Coastal Hazards

Other investigators/professionals associated with this project:

Oralee Nudson, Eric Stevens, Carl Dierking, Jiang Zhu, Jay Cable, Will Fisher, Dayne Broderson,
University of Alaska Fairbanks

NOAA Goal: Climate Adaptation and Mitigation

Amendments 18, 33, 48, 64
NOAA Office: NESDIS, Steve Goodman, Sponsor
Continues research from NA08OAR4320751
Budget Amounts: Cumulative $761,416, This year $151,152 (Amendment 64)
This project is set to end 06/30/2018.

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 (CIMSS), 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/findings

1. In collaboration with NWS Alaska, GINA facilitated an assessment of MIRS microwave products.

Science liaison Carl Dierking and system analyst Jay Cable led an effort wherein GINA generated and delivered prototype MIRS microwave products to National Weather Service Alaska. In preparation for this assessment, Carl also developed and delivered customized training for meteorologists at NWS Alaska concerning the basics of microwave imagery and the aspects of this imagery that the assessment was intended to investigate. Meteorologists with the NWS Alaska Sea Ice Program (ASIP) evaluated the products related to sea ice and, in general, found them to contribute additional useful information beyond what was already available via legacy products. However, GCOM AMSR2-based sea ice products accessed via the Internet were found to be more valuable due to AMSR2's finer spatial resolution. There are now plans in place to upgrade the capability of MIRS to produce AMSR2 products in a future build. Microwave-based snow water equivalent, rain rate, and total precipitable water (TPW) products were well received by NWS forecasters, and based on this positive feedback GINA's generation and delivery of these products to NWS Alaska has continued after the conclusion of the assessment. Figures 1-3 below offer examples of data products delivered and evaluated as part of this assessment.

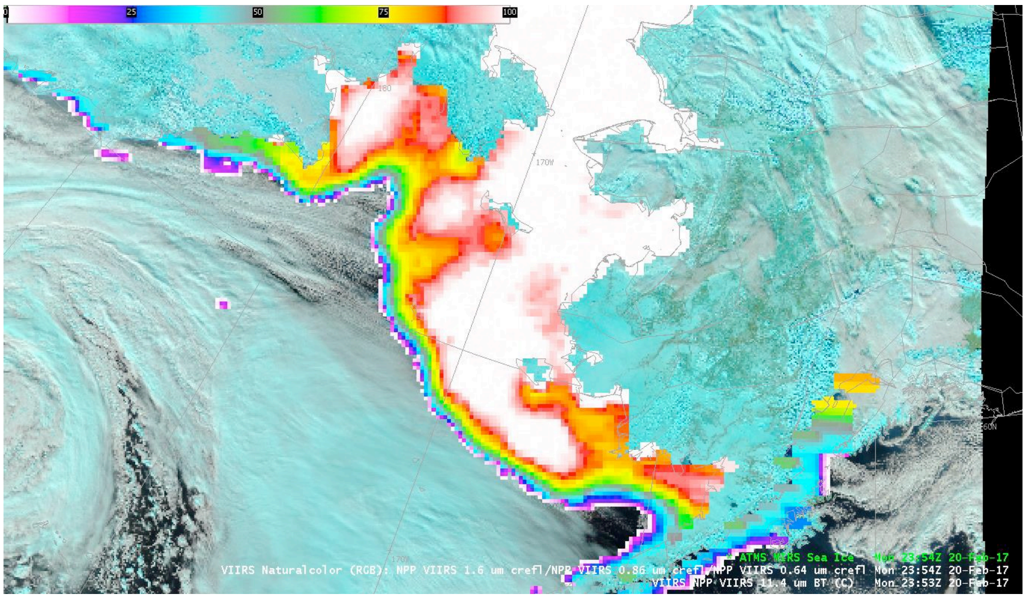


Figure 1. Overlay of ATMS MIRS sea ice concentration and VIIRS longwave infrared imagery over the Bering Sea.

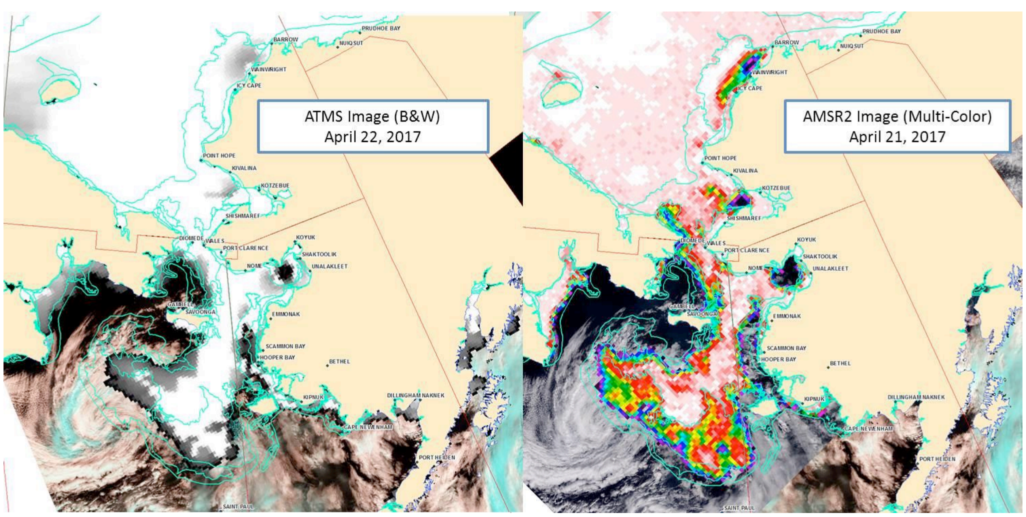


Figure 2. Comparison of ATMS-derived sea ice image with an AMSR2 image. Note the finer spatial resolution of the AMSR2 product.

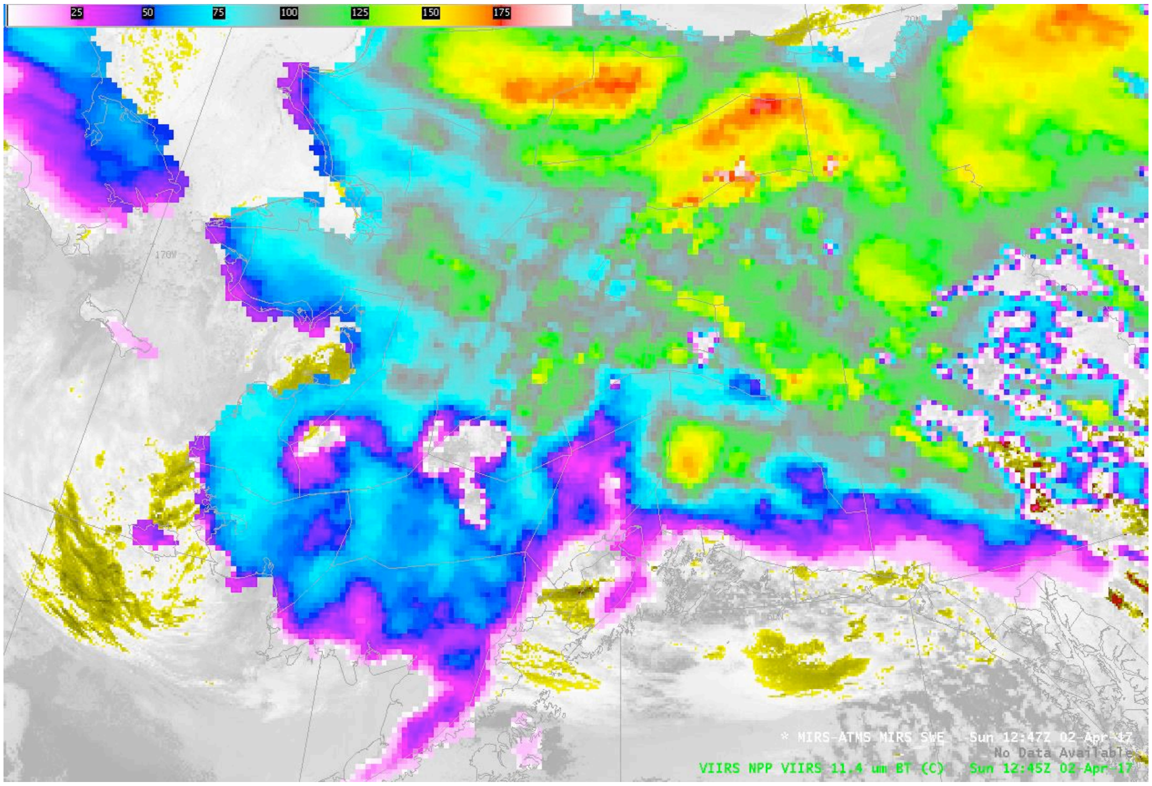


Figure 3. AWIPS screen capture of MIRS-based snow water equivalent (SWE) overlaid on VIIRS longwave infrared imagery from early April just as the spring break-up season began.

2. GINA began generating and delivering two new VIIRS-based multispectral products to Alaska Fire Service for use during the 2017 wildfire season.

After close collaboration with Curtis Seaman of Colorado State University, GINA began generating and delivering two new VIIRS-based multispectral products to Alaska Fire Service (AFS). Staff at AFS were particularly enthusiastic to receive this imagery in a GeoTIFF format for use in GIS environments. In early June, Jennifer Jenkins, chief of the GIS group at AFS said, "…we are HUGE fans!!! Seriously, it is just about the closest thing we have to real-time information on fire growth and behavior. Over the past few days we (AFS GIS) have been checking the page multiple times a day and grabbing new images. I am partial to the I-Band combo due to the better resolution." Figure 4 illustrates an example of the RGB data product from June 8, 2017.

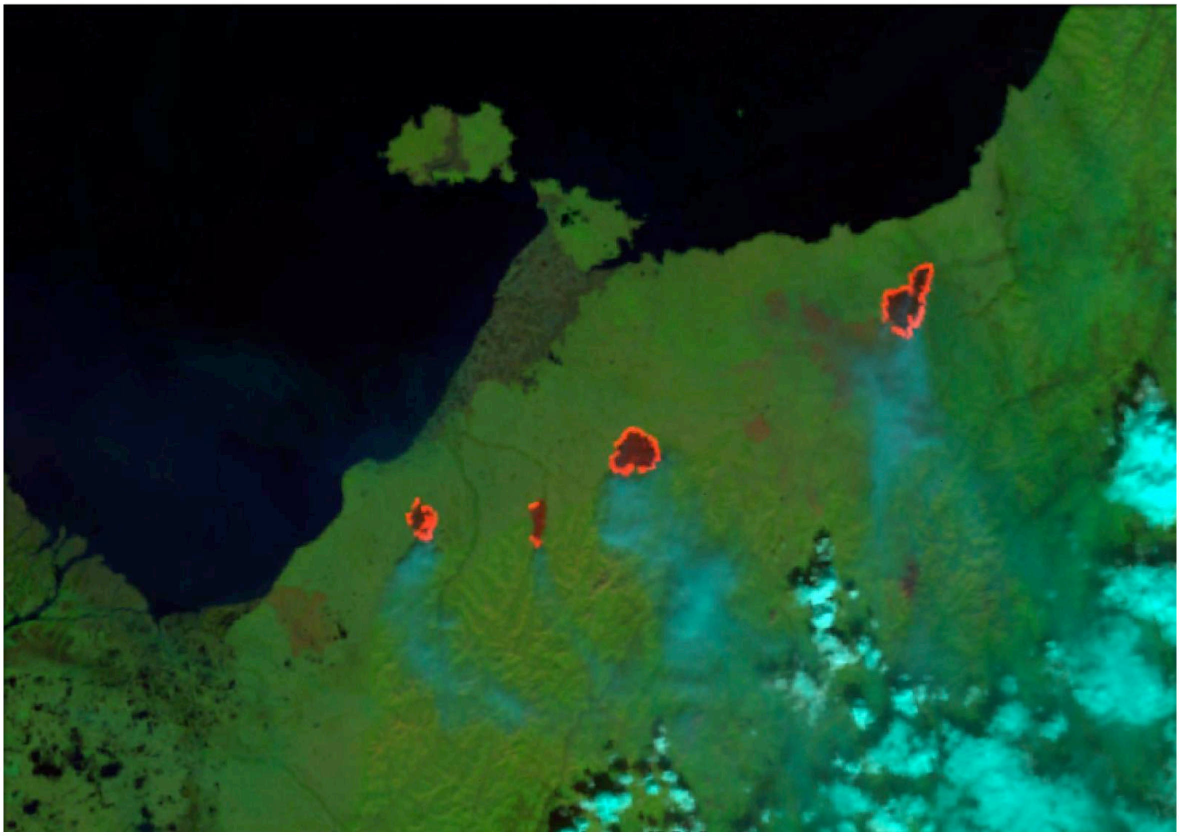


Figure 4. The VIIRS-based Natural Fire Color RGB, highlighting fires near the southeastern coast of Alaska's Norton Sound. This example is from 2325Z June 8, 2017.

3. Staff from CIMSS visited Alaska in May to address a number of technical issues.

Jordan Gerth, Kathy Strabala, and David Hoese of CIMSS joined GINA's Carl Dierking to meet with NWS Regional staff in Anchorage. Discussions centered on upcoming developments with polar2grid, with special emphasis on CLAVR/x, sea surface temperature, and microwave products. Carl and the CIMSS staff also met with GINA staff in Fairbanks to address technical challenges related to file formats and spatial resolution as well as ensuring GINA's readiness for the upcoming launch of JPSS-1. Lastly, Carl led the group with discussions at NWS Juneau regarding the MIRS-based total precipitable water and rain rate products.

4. Development of improved data assimilation in short-term WRF modeling of Alaska's weather continues to advance.

GINA continues to study how to improve the WRF short-term forecast for Alaska by using satellite data assimilation. NUCAPS profile data and ACARS aircraft data have been included in the assimilation scheme previously, with preliminary results indicating that these profiles improve the short-term forecast. New efforts focus on how satellite wind product assimilation impacts the WRF short-term forecast. We dockerized the GINA-WRF model and implemented a program to append VIIRS wind data into conventional observation data (gdas prepbufr data file) during the third quarter of calendar year 2017. Now we are doing 24-hour forecast 4 times a day for one month, and statistical analyses will be performed on these simulations.

5. GINA completed work to make VIIRS imagery from NOAA-20 available to NWS Alaska via LDM.

Using lessons learned from GINA's work with direct broadcast data from the S-NPP satellite, and in coordination with the JPSS Program Office, the CSPP developers at University of Wisconsin, and officials at NWS Alaska, GINA is now routinely processing NOAA-20 data and generating VIIRS products in AWIPS-ready formats and making these products available to the NWS via LDM. A sample image is shown in figure 5. We are producing VIIRS imagery for the Alaska Sea Ice Program (ASIP) from NOAA-20, which they are using in their operational ice analysis.

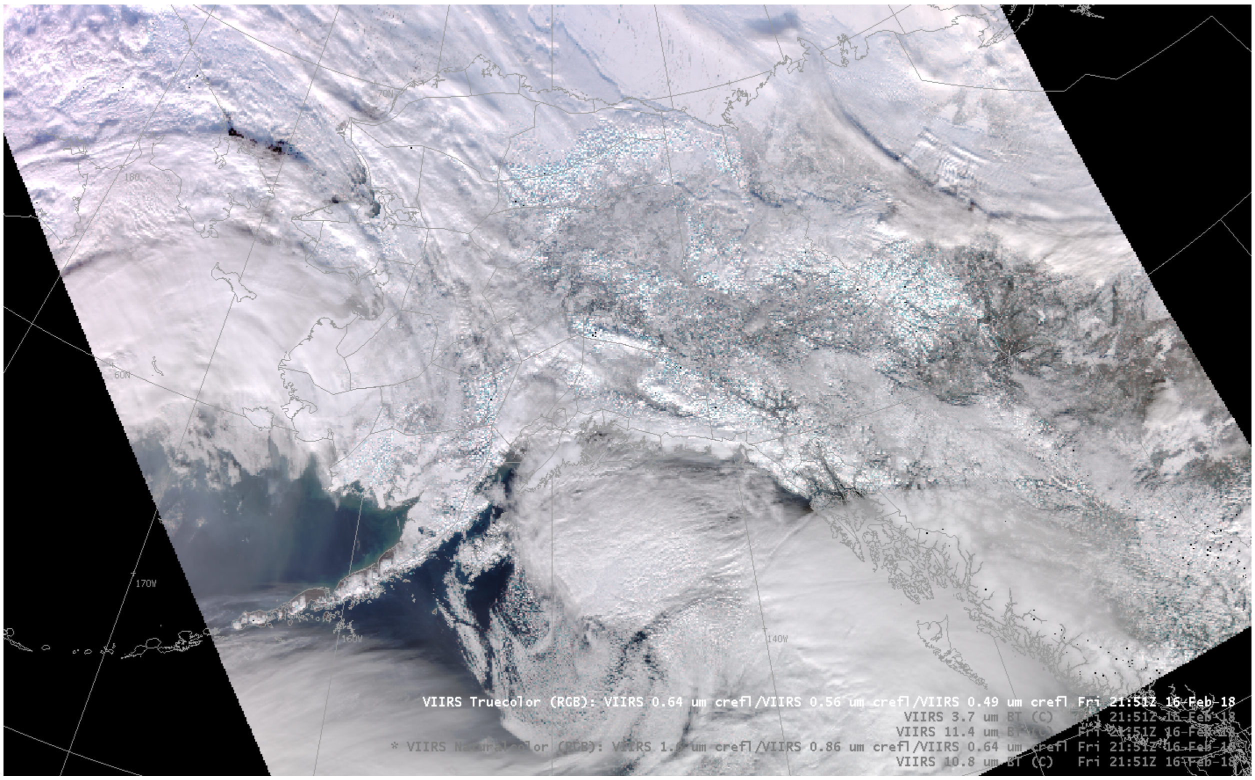


Figure 5: VIIRS True Color RGB made from NOAA-20 data received on the afternoon of February 16, 2018 by GINA's direct broadcast antennas and processed via CSPP. Such imagery is now available in near real time via LDM in AWIPS-ready formats for use by NWS Alaska.

6. NASA-SPoRT facilitated an assessment of NUCAPS data applied to the "cold air aloft" challenge in Alaska.

During the early months of 2018, NASA-SPoRT gathered feedback from meteorologists at the Central Weather Service Unit (CWSU) in Anchorage to assess the utility of NUCAPS in identifying areas of cold air aloft and confirming the quality of NWP model forecasts of temperatures aloft. A handful of cold air events did occur and were documented. A final report will be released in coming months.

7. GINA now generates several VIIRS products in AWIPS-ready formats at the instrument's native resolution.

GINA Science Liaison Carl Dierking and Systems Analyst Jay Cable collaborated with the CSPP developers at the University of Wisconsin to generate AWIPS-ready VIIRS imagery at full resolution. Until now, VIIRS I-bands and M-bands were generated at a spatial resolution of 1-km to reduce the size of the files and make the files easier to handle when bandwidth and storage are limited. The improvement of spatial resolution from 1-km to 750m or 375m and the retention of full floating-point precision enhances the usefulness of this imagery on the forecast desk. Figures six and seven below show a comparison between the two spatial resolutions. Unfortunately, these images are not yet available to Alaskan NWS meteorologists in AWIPS due to temporary issues internal to the NWS. It is expected these issues will soon be resolved.

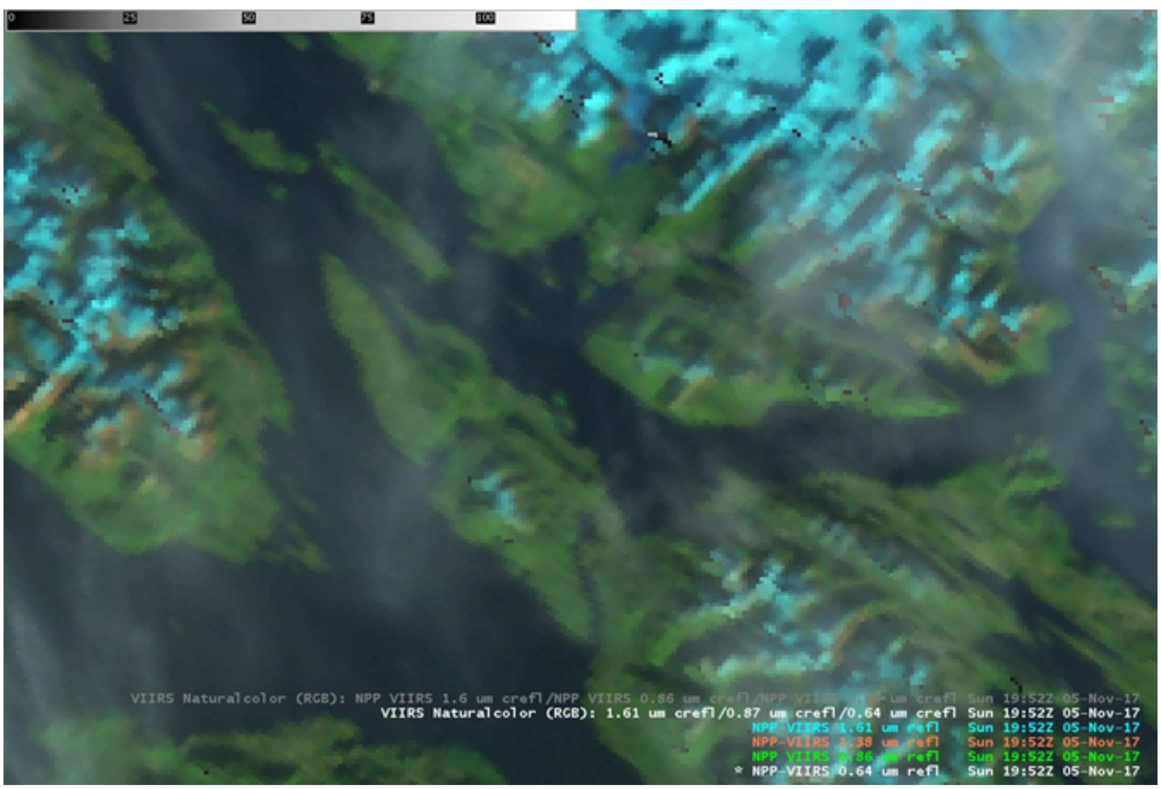
8. Jiang Zhu worked on VIIRS wind data assimilation on a standard WRF model called GINA-WRF as well as a HRRR-like model. We did comparison of GDAS observation and GDAS plus wind data assimilation runs. The initial result shows that two assimilation runs have almost the same performance because of that valid wind data is too coarse. This preliminary study has been reported on the 2018 AMS annual meeting. We will compare control run and wind data only assimilation run forecasts, and evaluate monthly forecasts.

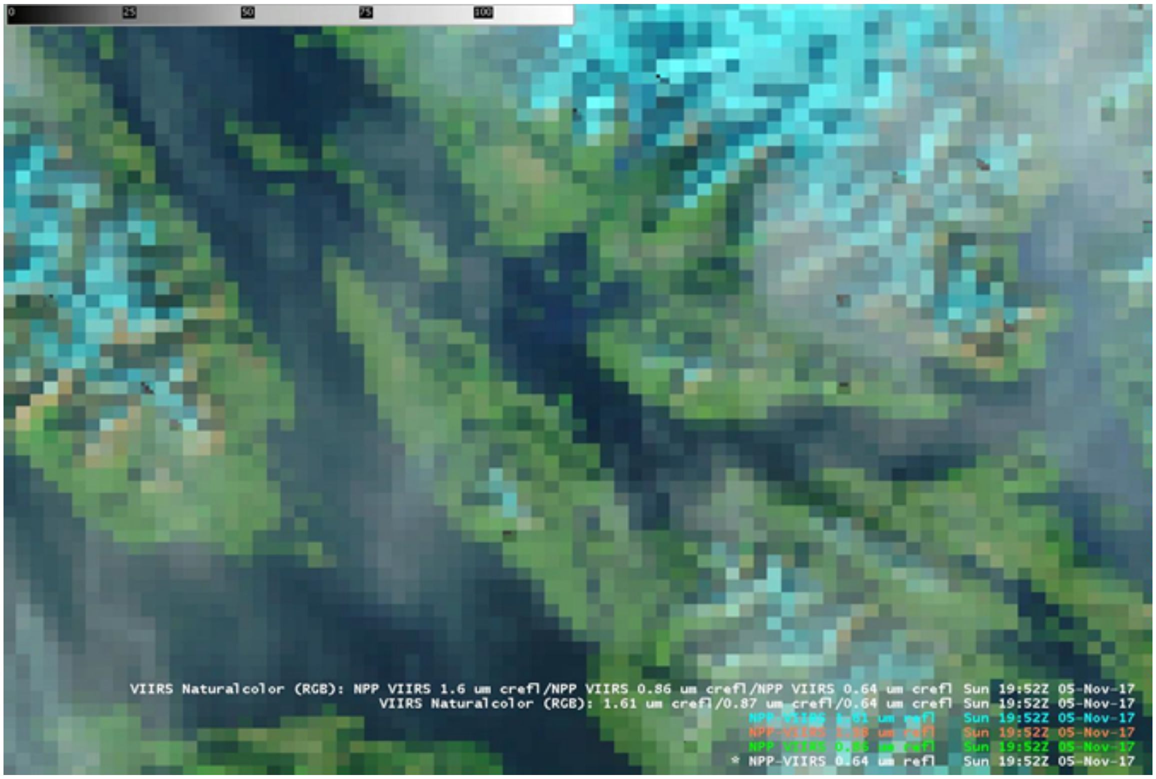
9. The GINA team has upgraded the virtual machine hosting the processing of the NUCAPS data. This workflow was included into the Direct Broadcast operational environment in February.

10. The GINA team has been participating in planning calls for the Arctic Summit that is being held in Anchorage and Fairbanks in May. We are helping the JPSS team prepare and several key members of the GINA team will be presenting at the summit.

11. The GINA team is producing sea surface temperature data products from MODIS and VIIRS and are working with the NWS to evaluate the product usefulness to the ASIP and other NWS forecasters.

12. The GINA team is producing a specialty product, called binary slices, for NASA SPoRT to reduce the latency for NASA SPoRT to generate and deliver their products to the NWS.





Figures 6 (above) and 7 (below) showing a VIIRS-based Day Land Cloud RGB over Southeast Alaska at 375m spatial resolution in figure 6 and 1-km spatial resolution in figure 7.

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.

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

Education

Science liaison Carl Dierking represented GINA at the JPSS training workshop in Colorado in August 8-10. The meeting was quite productive with a number of excellent discussions on training. A white paper with a number of training recommendations was produced as well as an updated STAT 11/03/2017 Page 2 of 6 Tracking Sheet. GINA committed to produce some of the training videos and quick guides that were identified in the Tracking Sheet.

Outreach

Eric Stevens gave a TEDx talk addressing the capabilities of the VIIRS imager and why satellite imagery is helpful to all Alaskans.

GINA participated in the "Arctic Interchange" meeting held in Fairbanks the week of May 8-12, 2017.

GINA staff participated in a workshop hosted by the Alaska Fire Science Consortium on the topic of "Opportunities to Apply Remote Sensing in Boreal/Arctic Wildfire Management and Science."

Former GINA director Tom Heinrichs and science liaison Eric Stevens attended this workshop at the University of Alaska Fairbanks and at Alaska Fire Service in early April just weeks before Alaska's wildfire season began. While a number of representatives from the satellite proving ground community participated in this workshop, the majority of attendees came from the wildfire community and were not overly familiar with the newest generation of satellite products. Eric gave two presentations to this group concerning GINA's work with the satellite proving ground and how satellite imagery is applicable in the wildfire context. Recordings of these presentations are available at the following links. https://vimeo.com/216555022, https://vimeo.com/216557948.

The publication Aerospace America interviewed Eric Stevens for an article about cold air aloft.

Emily Berndt of NASA-SPoRT gave a webinar about NUCAPS as part of the Virtual Alaska Weather Symposium (VAWS).

The Virtual Alaska Weather Symposium is a series of webinars hosted by the University of Alaska Fairbanks and GINA in which a guest scientist or forecaster shows work and leads a discussion about a topic of interest to operational meteorologists in Alaska. On March 21 Emily led a webinar titled, "An Overview of NUCAPS Soundings Research to Operations Activities to Support Operational Forecast Challenges." The slides and a recording of Emily's webinar are available at https://accap.uaf.edu/March2018_VAWS

Conference presentations

Dr. Curtis Seaman of CIRA visited GINA in April and give a webinar for the "Virtual Alaska Weather Symposium" on the topic of using VIIRS imagery in a fire weather context at high latitudes.

GINA staff gave two presentations at CSPP/IMAPP Users' Group Meeting inn Madison in June.

Former GINA director Tom Heinrichs, former GINA technical manager Dayne Broderson, and science liaison Carl Dierking represented GINA at the NOAA Satellite Conference in July.

Eric Stevens attended and gave presentations at the JPSS Annual Science Team meeting in August and the National Weather Association annual meeting in September.

Research Scientist Jiang Zhu and Science Liaison Eric Stevens presented some of GINA's latest work with JPSS data in the High Latitude Proving Ground at the annual meeting of the American Meteorological Society in Austin, TX in January.

Fish and fisheries research in the central Arctic Ocean

Franz Mueter, PI ***CIFAR theme(s): Climate Change and Variability***
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Jennifer Marsh, College of Fisheries and Ocean Sciences, *UAF*

NOAA Goal(s): Climate Adaptation and Mitigation

Amendment 56 NOAA Office: NMFS, Phil Mundy, Sponsor
Budget Amount: Cumulative $15,704, This year $0

This project is complete.

Primary objectives

One of the main objectives of initial proposal *Fish and fisheries research in the central Arctic Ocean* was to synthesize what is known about the distribution and abundance of Arctic fishes in seas adjacent to the Arctic Ocean with a focus on the most abundant fish, Arctic cod. Currently, there is a limited understanding of the abundance, population dynamics and drivers of distribution for Arctic cod. While working on her dissertation, student Jennifer Marsh will fill some of these knowledge gaps. With supplemental funding, we expanded the original objectives to include analyses of the life history of Arctic cod in the Chukchi Sea and in other marginal seas, which is the subject of Jen's final two dissertation chapters, entitled *Environmental and biological influences on the distribution and population dynamics of Arctic cod (Boreogadus saida) in the US Chukchi Sea* and *Environmental influences on the southern distribution of Arctic cod: a comparison between Pacific and Atlantic sectors.* The objectives in the first chapter are (1) to improve our understanding of the factors driving variations in the distribution and abundance of Arctic cod in the US Chukchi Sea and (2) to assess the current status and dynamics of Arctic cod in the Chukchi Sea. In the second chapter, the objectives are (1) to quantify variability in the southern extent of Arctic cod and explore potential mechanisms (temperature, predators and competitors) driving such variability and (2) to compare the spatial dynamics of Arctic cod among different subarctic seas to determine what limits their southern distribution

Research accomplishments/highlights/findings

Under the original objectives, a section on "Occurrence, distribution and abundance of fish and shellfish of the central Arctic Ocean and Adjacent Waters" was completed as part of the *Synthesis of Knowledge on Fisheries Science in the Central Arctic Ocean.* With the additional funding, Jen Marsh has recently completed a draft manuscript that is currently undergoing review by co-authors. In the manuscript, we estimated eastern Chukchi Sea Arctic cod age-structure, abundance, biomass, natural mortality, and reproductive potential using data from recent surveys conducted as part of the Arctic Ecosystem Integrated Survey (Arctic Eis) in 2012 and 2013, combined with available estimates of biological parameters from the literature. Results indicate that temperature is an important driver for the distribution of both age-0 and age 1+ Arctic cod with age-0 cod less likely to be present in warmer waters. Due to low adult biomass and ecological importance, we concluded that Arctic cod are unlikely to support a fishery in the area. Estimates of egg production and early survival suggest that the number of mature Arctic cod present in the survey area during summer are unlikely to produce the observed high abundances of age-0 Arctic cod in the US Chukchi Sea. This could imply that either mature Arctic cod migrate to the Chukchi Sea to spawn in the winter, that age-0 fish are advected from outside the study area, or that we are underestimating adult Arctic cod abundance. These results highlight the need for additional systematic surveys and further research to resolve the origins of age-0 Arctic cod, identify nursery areas and estimate early life survival.

Writing and analyses are ongoing for the last chapter. Preliminary analysis of survey data at the southern edges of Arctic cod's range in the Bering Sea, Newfoundland/Labrador shelf, NE Iceland and Barents Sea indicate that Arctic cod tend to occupy and a smaller area in years when mean bottom temperatures were higher. They were also less likely to be present in warmer years indicating as temperatures increase with climate warming, the range of Arctic cod is likely to contract. Bering Sea specific results, which incorporate the influence of temperature, ice concentration and predator/competitor presence on Arctic cod will be presented at the American Fisheries Society Western Division Conference in May. In June, results of a broader analysis from all regions will be presented at Annual Science Meeting of the Ecosystem Studies of Subarctic and Arctic Seas.

NOAA relevance/societal benefits

The focus of this project is to contribute to synthesis of what is known and unknown about fish stocks in the central Arctic Ocean and adjacent seas. The synthesis will help guide future research, management and conservation measures by the countries that are party to the Central Arctic Ocean agreement on fisheries, including the Kingdom of Norway, the Russian Federation, the United States of America, Canada, the Kingdom of Denmark, the People's Republic of China, the Republic of Korea, Japan, Iceland and the European Union. Results from the additional work on Arctic cod in the Chukchi Sea contribute to the management of Arctic cod and saffron cod, which have been identified as potential target species for a commercial fishery, by providing information on Essential Fish Habitat for early life stages and by assessing the current status of the Arctic cod stock with updated information from comprehensive fisheries surveys conducted in 2012 and 2013 in the US portion of the Chukchi Sea.

Partner organizations and collaborators

We collaborated extensively with coauthor Terrance J. Quinn from the UAF College of Fisheries and Ocean Sciences on the draft manuscript. The manuscript used data from Arctic Ecosystem Integrated Surveys (Arctic Eis) conducted by NOAA and UAF with funding from the Coastal Impact Assistance Program through the US Fish and Wildlife Service and from the Bureau of Ocean Energy Management.

Impact

The earlier report *Synthesis of Knowledge on Fisheries Science in the Central Arctic Ocean* was submitted to the Fourth Meeting of Scientific Experts on Fish Stocks in the Central Arctic Ocean. The report will be used to help identify research priorities and inform management and conservation of living marine resources in the Central Arctic Ocean. The draft manuscript currently in preparation will be central to informing and updating NOAA's Arctic Fishery Management Plan, which was originally developed in 2009 and will be amended to incorporate guidance on exploratory fishing in the future.

Education

Not applicable.

Outreach

Franz Mueter organized and Jen Marsh participated in a public workshop on Arctic Gadids, aimed primarily at researchers, that was held in conjunction with the Alaska Marine Science Symposium in Anchorage, Alaska, on January 24, 2018.

Publications

Mundy, P. R., Sunnanå, K., Ingvaldsen, R., Marsh, J., Jarvis, T., Astthorsson, T., Hoel, A.H. (2017) *Synthesis of Knowledge on Fisheries Science in the Central Arctic* Fourth Meeting of Scientific Experts on Fish Stocks in the Central Arctic Ocean (4th FiSCAO), Tromso, Norway, September 26 - 28, 2016

Marsh, J.M., Mueter, F.J., Quinn II, T.J. Environmental and biological influences on the distribution and population dynamics of Arctic cod (*Boreogadus saida*) in the US Chukchi Sea. Prepared for submission to the Canadian Journal of Fisheries and Aquatic Sciences.

Conference presentations

Mueter, F.J. Arctic Gadids in a Changing Climate. Alaska Marine Science Symposium, Workshop on Arctic Gadids, Anchorage, Alaska, January 24, 2018.

Marsh, J.M. and F.J. Mueter. Environmental and biological influences on Polar cod (*Boreogadus saida*) in the eastern Chukchi Sea. ESSAS Open Science Meeting, Tromsø, Norway, June 12-15, 2017.

Marsh, J.M. and F.J. Mueter. Environmental influences on the southern distribution of Arctic cod. 31st Lowell Wakefield Symposium, Anchorage, Alaska, May 10, 2017.

Further results will be presented during upcoming presentations at the Western Division AFS meeting (Mueter et al., and Marsh and Mueter) and at the Annual Science Meeting of the Ecosystem Studies of Subarctic and Arctic Seas in Fairbanks, Alaska, June 12-14, 2018 (Marsh and Mueter abstract not yet submitted):

Mueter, F, Vestfals, C., Marsh, J., Divine, L., Weems, J., Iken, K., Bluhm, B. Arctic cod, *Boreogadus saida*, and snow crab, *Chionoecetes opilio*, in Alaska's Arctic. Western Division of the American Fisheries Society, Anchorage, Alaska, May 21-25, 2018.

Marsh, J., Mueter, F. Environmental and biological influences on the southern distribution of Arctic cod (*Boreogadus saida*) in the Bering Sea. Western Division of the American Fisheries Society, Anchorage, Alaska, May 21-25, 2018.

Other products and outcomes

Not applicable.

Week of the Arctic – Conference Support

Larry Hinzman, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Hajo Eicken *and* ***T. Scott Rupp****, University of Alaska Fairbanks*

CIFAR theme(s): Climate Change and Variability

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation; Weather Ready Nation; Resilient Coastal Communities and Economies

Amendment 69 NOAA Office: OAR, Brenda Alford, Sponsor
Budget Amount: Cumulative $73,333, This year $73,333 (Amendment 69)

This project is new and complete.

Primary Objectives

Through CIFAR, NOAA provided funding support to convene 2017 Week of the Arctic (WoA) at the University of Alaska in Fairbanks, Alaska, USA. The primary objective was to create a venue that enabled dozens of different groups to host important arctic-related workshops, conferences, formal and informal meetings in one place at one time. This confluence of events provides the opportunity to share ideas widely as very distinct communities converged for open discussions, sharing of understanding, and planning and coordination of future collaborative efforts. Each of these events helped advance Arctic science, engineering, technology and/or policy, but allowing participants to participate in numerous other meetings enabled broader dissemination of knowledge, crossing disciplines and exposing varied groups to new research fields. Scientific discovery and advancement is usually a stepwise process where understanding and enlightenment comes in small bundles and the accomplishment of one research group can eliminate the obstacle limiting progress of others. We focused upon facilitating workshops and panels to engage Arctic field researchers and modelers to ensure that the knowledge and process understanding gained from these studies were translated to the policy community and to the broader public through the participation of many journalists from across the nation and around the world.

Research Accomplishments/highlights/findings

AIEA Thematic Forum: U.S. as an Arctic Nation—Opportunities for collaboration in internationalization

The primary goal of this event was to establish awareness and generate interest in the Arctic and Arctic issues among international educators and university leaders. As the Arctic is largely unrepresented U.S. international education, this forum presented the Arctic as a destination for student mobility, showcasing opportunities for education and research, and encouraging engagement of U.S. institutions.

Arctic Broadband Forum

The Arctic Broadband Forum brought together educators, researchers and industry from across the World to discuss the challenges, successes and potential of telecommunications and broadband deployment in the Arctic. Specific emphasis was placed on the role of broadband and digital technologies on the cultural preservation and self-determination of indigenous populations throughout the Arctic.

Arctic Economic Council

This was the annual meeting of the Arctic Economic Council and an opportunity for the AEC representatives and working groups to meet and strategize, developing the next steps to successfully promote responsible development in the Arctic.

Workshop: Community Healing & Wellness

This workshop included research and practitioner presentations on current work to address intergenerational trauma and associated social outcomes through integration of Indigenous knowledge and cultural practices. Presentations were followed by an interactive conversation among attendees. It was a very moving and impactful event that participants still proclaim as effective in helping Arctic residents reconcile conflicted feelings.

Arctic Seas in a Time of Change: Status, Trends and Implications Within and Beyond the Arctic

Arctic researchers, policymakers and community and cultural leaders discussed key themes of Arctic interest. Community members, interested Alaskans and visiting delegations were invited to attend. These informal sessions offered meaningful insight into priority issues of the Arctic, highlighted researcher expertise, and engaged community members.

International Arctic Assembly

The International Arctic Assembly demonstrated an innovative approach to multi-disciplinary, cross-sectoral dialogue that featured local, national and international speakers from business, policy and research. Plenary panel discussions focused on Arctic policy, Alaska's unique role in informing and influencing state, national and international policy, scientific research, indigenous leadership and culture, and social-economic development. These international discussions helped improve understanding of the role of science in addressing gaps, in enabling understanding of the Arctic system, and in implementing policy that benefits all nations.

"We Breathe Again" Premiere Documentary Screening

In a landscape as dramatic as its stories, *We Breathe Again* intimately explored the lives of four Alaska Native people, each confronting the impacts of intergenerational trauma and suicide. A co-production of UAF, Native Movement, and Crawl Walk Run.

Arctic Council Showcase & Arctic Highlights Forum

Speakers presented projects delivered during the U.S. Chairmanship, with Alaska leaders interpreting the implications for and importance to the state.

Workshop: INTAROS—Community-Based Monitoring

This workshop was developed for those involved in community-based monitoring (CBM) to build this community of practice and increase the effectiveness of CBM in decision-making. The workshop introduced participants to INTAROS and other relevant initiatives that support development of CBM networks.

Energy: Northern Challenge, Alaskan Expertise, Global Opportunity

This session explored the contributions Alaska companies and agencies were making to advance innovative cold climate design, architecture, engineering and construction. Discussants evaluated best practices, identified cooperative pan-Arctic approaches, and advanced recommendations with impact in Alaska and across the North.

Workshop: One Health—Concerns in a changing Arctic

Changes in climate, economics, and policy have altered the availability safety and subsistence food sources as well as promoting the invasion and expansion of zoonotic diseases in the Arctic. This session discussed root causes, management approaches, and concerns for the future.

Workshop: Arctic 2030—Projecting challenges facing Arctic maritime operators

Jointly hosted by the Arctic Domain Awareness Center (ADAC) and the US Coast Guard HQ (HQ USCG) Future Concepts Division, this workshop attempted to project the challenges facing the Arctic Maritime Operator community in the Year 2030 in order to identify gaps and shortfalls that can orient the United States Department of Homeland Security, HQ USCG, ADAC and others and help inform strategy, policy, and research.

Workshop: What is the Arctic we need to sustain the global climate system?

This Arctic 21 workshop examined the overall impact of climate warming on the Arctic, the impacts of climate change on the Arctic and the rest of the world and the responses of institutions that are responding including the Paris Agreement of the UN Framework Convention on Climate Change, the Arctic Council and the Intergovernmental Panel on Climate Change. The workshop looked at five areas of change in the Arctic that impact permafrost, sea ice, snow cover, the Greenland ice sheet and the Canadian and Alaskan glaciers. The workshop discussions focused upon the question, "What is the Arctic we must have, and how do we get there?"

NOAA relevance/societal benefits

These meetings were intended to advance Arctic science, technology, policy and stakeholder issues. Convening these meetings at one time enabled free and open interaction between scientists, policymakers, journalists and the public — all of whom were concerned with promoting and facilitating understanding, coordination, cooperation and collaboration in the Arctic region.

Publications, Conference Papers and Presentations

Hinzman, L.D. University of Alaska to Host the 2017 Week of the Arctic**.** Witness the Arctic. Spring 2017 issue. https://www.arcus.org/witness-the-arctic/2017/5/highlight/1

Partner Organizations and Collaborators

Institute of the North

Arctic Council Senior Arctic Officials

NOAA State of the Arctic

Jacqueline Richter-Menge, PI
University of Alaska Fairbanks

CIFAR theme(s): Climate Change and Variability, Ecosystem Studies and Forecasting

Other investigators/professionals associated with this project:
J. Overland, J. Mathis, E. Osborne, *NOAA*

NOAA Goal(s): Climate Adaptation and Mitigation; Resilient Coastal Communities and Economies

Amendments 63, 80 NOAA Office: OAR, Monique C. Baskin, Sponsor
Budget Amount: Cumulative $55,609, This year $55,609 (Amendments 63 and 80)
This project is new and set to end 06/30/2018.

Primary objectives

To provide a timely and peer-reviewed source for clear, reliable and concise environmental information on the state of the Arctic in a way that is accessible to a wide audience, including scientists, students, teachers, decision-makers and the general public interested in Arctic environment and science.

Research accomplishments/highlights/findings

Consistent with the work plan, the project has two major accomplishments: the annual publication of (1) the web-based NOAA Arctic Report Card (ARC) and (2) the Arctic chapter in the BAMS State of the Climate Report. The first ARC was produced in 2007. The ARC 2017, released on 12 December 2017 at the 2017 Fall American Geophysical Union meeting, marked the 12th update. The BAMS State of the Climate in 2017 report is currently under production and is scheduled for release in July 2018. Taking advantage of the production timeline of the ARC, much of the content of ARC2017 provides the foundation for the Arctic chapter of the BAMS State of the Climate in 2017 report.

A key finding in the reports is that the Arctic shows no sign of returning to reliably frozen region of past recent decades. Despite relatively cool summer temperatures, observations in 2017 continue to indicate that the Arctic environmental system has reached a 'new normal', characterized by long-term losses in the extent and thickness of the sea ice cover, the extent and duration of the winter snow cover and the mass of ice in the Greenland Ice Sheet and Arctic glaciers, and warming sea surface and permafrost temperatures. Highlights include:

- The average surface air temperature for the year ending September 2017 is the 2nd warmest since 1900, however cooler spring and summer temperatures contributed to a rebound in snow cover in the Eurasian Arctic, slower summer sea ice loss, and below-average melt extent for the Greenland ice sheet.
- The sea ice cover continues to be relatively young and thin with older, thicker ice comprising only 21% of the ice cover in 2017 compared to 45% in 1985.
- In August 2017, sea surface temperatures in the Barents and Chukchi seas were up to 4 °C warmer than average, contributing to a delay the autumn freeze-up in these regions.
- Pronounced increases in ocean primary productivity, at the base of the marine food web, were observed in the Barents and Eurasian Arctic seas from 2003 to 2017.

- Arctic tundra is experiencing increased greenness and record permafrost warming.
- Pervasive changes in the environment are influencing resource management protocols, including those established for fisheries and wildfires.
- The unprecedented rate and global reach of Arctic change disproportionally affect the people of northern communities, further pressing the need to prepare for and adapt to the new Arctic.

NOAA relevance/societal benefits

This work directly supports NOAA Climate Program Office objectives to (a) describe and understand the state of the climate and (b) improve society's ability to plan and respond to climate variability and change by providing an integrated summary of the state of the Arctic. This goal also supports the guiding principles of NOAA's Arctic Vision & Strategy.

Partner organizations and collaborators

Both reports are the work of a large international team. For instance, the ARC 2017, represents the collective effort of 85 researchers in 12 countries. On the editorial staff, the PI (Richter-Menge) is joined by members of the NOAA (Mathis and Osborne, OAR, and Overland, PMEL) and ONR (Jeffires) staffs. A full list of collaborators is available at: https://www.arctic.noaa.gov/Report-Card/Report-Card-2017/ArtMID/7798/ArticleID/689/Authors-and-Affiliations

Impact

Both reports involve a widely-publicized public release, coordinated through NOAA PAO. The release of the ARC2017 took place on 12 December 2017, at the 2017 Fall AGU meeting. Because of the public rollout, highlights from the reports are picked up by key news organizations (e.g. Reuters and AP) and quickly and widely spread to local, regional, national and international news media appearing in hundreds of articles around the world. The Report Card and the BAMS State of the Climate report are featured resources on NOAA Climate.gov.

Education

See 'Impacts'.

Outreach

See 'Impacts'.

Publications

Richter-Menge, J., J. E. Overland, J. T. Mathis, and E. Osborne, Eds., (2017) Arctic Report Card 2017, http://www.arctic.noaa.gov/Report-Card..

Richter-Menge, J. A. and J.T. Mathis, Eds., 2017: The Arctic [in "State of the Climate in 2016"]. Bull. Amer. Meteor. Soc., 98 (8), S129–S154, doi:10.1175/2017BAMSStateoftheClimate.1.

Conference presentations

None to report.

Other products and outcomes

None to report.

High Latitude Proving Ground – GOES-R River Ice and Flood Product Support

Lisa Wirth, PI ***(formerly Thomas Heinrichs)***
University of Alaska Fairbanks

CIFAR theme(s): Climate Change and Variability

Other investigators/professionals associated with this project:
Oralee Nudson, Eric Stevens, Jay Cable, Carl Dierking, Dayne Broderson*, University of Alaska Fairbanks*

NOAA Goal(s): Weather Ready Nation

Amendment 65 NOAA Office: NESDIS, Dan Lindsey, Sponsor
Budget Amount: Cumulative $18,479, This year $18,479 (Amendment 65)
This project is new and set to end 06/30/2018.

Primary objectives

The production of river ice and flooding products from the SNPP VIIRS sensor direct readout data has been very successful in Alaska. The product is used during spring break-up and floods by the NWS Alaska-Pacific River Forecast Center and has reviewed favorably by the operational hydrologists and forecasters. Currently, the products are generated in near-real-time using direct readout data captured by UAF-GINA in Fairbanks and processed and distributed to the NWS through a collaboration of UAF-GINA, George Mason University, and the University of Wisconsin Madison Space Science and Engineering Center (SSEC).

This project extends and leverages the success of the river ice and flooding initiative VIIRS products (developed under JPSS program sponsorship) by creating systems to generate similar products using GOES-R Advanced Baseline Imager (ABI) data.

Research accomplishments/highlights/findings

1. GINA has provided system administration support for the physical server that supplies the data for the river ice and flood products.

2. GINA has purchased a new physical server and is configuring it with the programs, libraries, and tools necessary for data generation. This is expected to be completed and operational by the end of April 2018.

3. In March 2018, Jay Cable and Carl Dierking attended a meeting at NWS Alaska Region headquarters in Anchorage, Alaska to meet with the ice desk and river forecast center staff. Recent problems have arisen with data formats for the use of NOAA-20 with the river ice and flood software. Jay and Carl discussed this with the RFC and the issue was resolved and is discussed below.

4. With the successful launch of NOAA-20, this data was added to the processing stack. The naming conventions of the files coming from the NESDIS facility at Gilmore Creek was not compatible with the current software. GINA staff, Oralee Nudson and Jay Cable, created and deployed a script to make a wrapper for the date on the data files to appear as needed for the software to process and generate data products.

NOAA relevance/societal benefits

Flooding caused by ice jams damming a river during spring break-up is a major hazard for communities along Alaska's rivers. Many of the most destructive floods in Alaska history were caused by ice jams. Being able to monitory large reaches of river using satellite data gives NWS forecasters and hydrologists valuable information for issuing warnings and forecasts. Without satellite observations hydrologists must rely upon observations of very limited spatial extent, such as observers on the river bank and small aircraft flights. For scale, more than 1200 miles of the Yukon River is in Alaska and it is just one of dozens of rivers subject to ice jam flooding.

Partner organizations and collaborators

NWS Alaska Pacific River Forecast Center

George Mason University

JPSS Program Office

GOES-R Program Office

Yukon River Breakup 2017

Catherine Cahill, PI
University of Alaska Fairbanks

CIFAR theme(s): Climate Change and Variability

Other investigators/professionals associated with this project:
John Coffey*, NOAA UAS Program*
Eyal Saiet*, University of Alaska Fairbanks*
Peter Webley*, University of Alaska Fairbanks*

NOAA Goal(s): Climate Adaptation and Mitigation

Amendment 73
NOAA Office: OAR, John Coffey, Sponsor
Budget Amount: Cumulative $23,461, This year $23,461 (Amendment 73)
This project is new and complete.

Primary objectives

The National Oceanic and Atmospheric Administration (NOAA)'s, National Weather Service (NWS), unmanned aircraft systems (UAS) Program Office and the River Forecast Center (RFC), have partnered with the University of Alaska Fairbanks (UAF) Alaska Center for UAS Integration (ACUASI) to evaluate the use of UAS to augment monitoring river-ice conditions and breakup with significantly higher temporal and spatial resolution than presently available from satellite imagery. The objectives of this proof of concept were to examine near real-time operational forecaster Decision Support Services (DSS), provide rapid response surveillance of river ice and flooding, and to validate and calibrate derived satellite river ice and flood products. The Yukon River near the village of Circle, Alaska located approximately 150 miles northeast of Fairbanks was selected for the mission for several reasons: the community is on the road system; this reach has a history of ice jams and consequently flooding events; and the RFC team monitors this reach of the Yukon River via manned aircraft. The ongoing communication between the RFC and ACUASI enabled the UAS crew to effectively be ready to deploy at a moment's notice, and within 48 hours at the site, defined as "Alert 48". Though Alert 48 was called on April 28, but due to cooler conditions, the team was only deployed on May 4. The crew deployed with ACUASI's ING Responder, Figure 1, and flew eleven flights over four days, providing near-real-time data utilized by the Alaskan NWS RFC to help with the Yukon River flood forecasting.

Figure 1. ACUASI's ING Responder ready for launch alongside the Yukon River.

Research accomplishments/highlights/findings

Through this project, ACUASI developed a river-ice breakup UAS monitoring Concept of Operations (CONOPS). At the end of each survey, four types of data products were produced; (1) geotagged imagery; (2) orthorectified data (mosaics and Digital Elevation Models); (3) processed classification products including open water, snow, ice, and open-water ice mix; (4) and a derived water-height levels product from imagery. The classification capability developed for this research project is a new standalone algorithm built to analyze UAS imagery and mosaics for river data analytics and change detection, and is showcased in the NOAA Environmental Response Management Application (ERMA) portal, https://erma.noaa.gov/arctic/erma.html and Figure 2. ERMA, a web Geospatial Information System (GIS) portal, was utilized to host and share the data with the RFC and NWS DDS at near real time. Geotagged images were uploaded within a half hour after the Responder aircraft landed, and mosaics about six hours. The classification change detection algorithm and water heights were developed after the field campaign and have not yet been tested during operations. Comparison between the UAS classification product and the operational ice-open water classification product from the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor onboard NOAA-20 and Suomi satellites showcased good agreement, Figure 3, and even augmented DSS during extensive cloud cover obscuring the satellite view. Following the development of the operational data products, we are ready to expand the survey area to the scale of manned aircraft, and become operational.

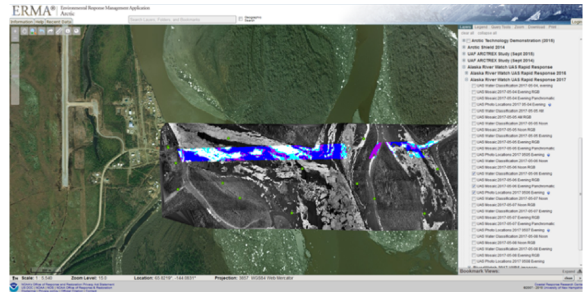


Figure 2. Demonstration of the Ice and liquid water classification scheme product in the ERMA portal.

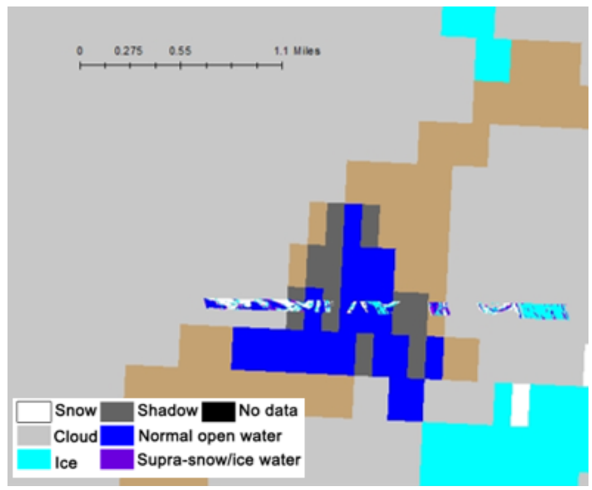


Figure 3. VIIRS and UAS classified liquid water-ice product, from data collected on May 5. The large gray areas correspond to cloud cover obstructing the satellite scene.

Analysis of the orthomosaics during river ice breakup and derived DEM from low-level water riverbank DEM prior or after breakup, enabled the team to derive water height at two nearby sites. Between the evening of May 6th and noon on May 7th, water height rose by about 30 cm, then dipped in the evening, and peaked during the May 8th noon flight, before subsiding by the evening of May 8th to similar heights as on the May 6th. Peak water height was 60 cm above prior breakup measurements. This analysis proved that water height measurements can be derived to accuracies of tens of centimeters, which provides high confidence on the ability to measure at much higher values in the future.

NOAA relevance/societal benefits

During spring 2013, a destructive mechanical river break up led to the demolition of the Galena town along the Yukon River in Alaska. About 20 miles downriver from Galena an ice jam formed, causing water to back up all the way to Galena. Rising water with large river icebergs quickly closed on the town's (300 residents) only escape route to the nearby airport. As the only option left, the Alaska Air

National Guard and the National Army Guard, evacuated the town residents with helicopters. A colossal damage to the village in the form of 169 destroyed houses as well damage to public infrastructure, left a heavy price tag of $10 million worth of damage. The flooding accrued on a short time frame hence residents had little to no warning, and for the most part residents did not have a chance to pack or salvage any valuables or even family heirlooms.

The Alaska NWS is responsible for providing weather forecast to the largest state, 663,268 square miles, with some of the most formidable weather in the United States. With only a few offices [Fairbanks, Anchorage, and Juneau], the local NWS has a lot on its plate. In winter, NWS is responsible for monitoring and forecasting weather conditions, dangerous and powerful storms, sea-ice, and river ice. In spring, when the state transitions from winter to summer, the NWS with its RFC focus on snowmelt and river break up with an effort to inform the public of potential risk to people and property. The vast extent of the state, with limited ground instruments and observations (i.e. there are no water gages along the rivers during breakup), offers sparse ground-truth data coverage, and perhaps sometimes outdated, making it difficult for the NWS and RFC forecasters to provide timely and accurate forecast. The challenge of monitoring and forecasting environmental risks of such large scale, and particularly not missing rapid changes such as the flooding of a village are immense, and hard to comprehend.

Figure 4. ACUASI's UAS crew with the local Circle school students and staff along with the ING Responder and additional UAS Aeromapper in the foreground.

Integrating UAS into the NOAA DSS, supports the NWS and RFC monitoring. As proven through this project, UAS augments DSS with new data, such as; water height levels, presence of ice and open water, as well applying change detection.

Partner organizations and collaborators

John Coffey, NOAA Unmanned Aircraft Systems (UAS) Program

Impact

The research developed here will assist NOAA in developing a step-wise approach to respond and generate products that meet the NWS and RFC requirements. Transition from research to operations takes time and with a systematic approach and clearly defined goals new products can be developed for use in NWS and RFC operations.

Education

N/A

Outreach

The UAS crew has conducted multiple talks and demonstrations at the local school. Figure 4 highlights the visit of the ACUASI UAS crew to the school in Circle, Alaska where both the teachers and students were able to see the aircraft being used to map the ice and river.

Publications

A report titled Developing UAS CONOPS in support of NWS monitoring and forecasting of river ice breakup in Alaska, to be published in the NOAA UAS library is in progress.

Conference presentations

Presentation at the Alaska Section American Water Resources Association (AWRA), http://state.awra.org/alaska/ameetings/2018am/

Other products and outcomes

Processed data at University of Alaska Fairbanks's Geophysical Institute are housed at: ftp://ftp.gi.alaska.edu/pub/acuasi/Circle_River_breakup/processed_data

NOAA's Arctic Environmental Response Management data layers are housed at: https://erma.noaa.gov/arctic/erma.html#/layers=2+37455+37447+37446&x=-144.02102&y=65.82613&z=14&panel=layers

Regional Rapid Response for Weather and Sea Ice Mapping

Catherine Cahill, PI
University of Alaska Fairbanks

CIFAR theme(s): Climate Change and Variability

Other investigators/professionals associated with this project:
John Coffey, *NOAA UAS Program*
Greg Foscue, *Unmanned Systems Alaska*
Robert Parcell, *University of Alaska Fairbanks*
Joseph Rife, *University of Alaska Fairbanks*
Eyal Saiet, *University of Alaska Fairbanks*

NOAA Goal(s): Resilient Coastal Communities and Economies; Climate Adaptation and Mitigation

Amendment 76 NOAA Office: OAR, Robbie Hood, Sponsor
Budget Amount: Cumulative $368,652, This year $368,652 (Amendment 76)

This project is new and set to end 06/30/2018.

Primary objectives

The Alaska Center for UAS Integration (ACUASI) in the Geophysical Institute at the University of Alaska Fairbanks will conduct a multi-week flight campaigns during late summer/early fall of 2018 using their Griffon Aerospace Outlaw SeaHunter UAS platforms (a UAS with a 16' wingspan, a maximum take-off weight of approximately 300 lbs, and an endurance of up to 10 hours). The campaign will be focused on supporting the Office of Naval Research's Stratified Ocean Dynamics of the Arctic (SODA) experiment by mapping sea ice and collecting meteorological measurements. The flights will be launched from the North Slope of Alaska, potentially from Oliktok Point or Kuparuk, AK. This campaign will leverage ACUASI's 16-year history of flying UAS in Alaska and the Arctic, including beyond-visual-line-of-sight (BVLOS) operations over the Arctic Ocean from Oliktok Point and Wainwright, AK, and over the Bering Sea from various research vessels, to create a concept of operations and operational system for collecting information important to NOAA scientists from locations over the Arctic Ocean. The potential payloads for these missions will include cameras, meteorological sensors, and other instruments depending on the conditions and the needs specified by remote sensing and sea ice scientists. High-resolution surface roughness, albedo, ridging, sea ice motion, percentage of ice covered by water, etc. are among the variables desired by sea ice experts to understand the ice dynamics and validate satellite retrievals of ice surface parameters.

Research accomplishments/highlights/findings

The timing of this flight campaign was shifted into 2018 to support the SODA experiment, so the research to date has been limited. However, a portion of a SeaHunter wing was tested in NASA's Glenn Research Center's Icing Research Tunnel to determine aircraft icing potential and maritime Arctic survivability, test the PEMDAS Atmospheric Sensing and Prediction System's (ASAPS) ability to identify when aircraft are in icing and cloud conditions, and validate the NASA LEWICE model for predicting aircraft icing. Under severe icing conditions, the ASAPS correctly characterized the conditions, ice formed on the SeaHunter wing and was scanned for comparison with the LEWICE predictions. The results of these tests should help NOAA improve the survivability of their aircraft in the Arctic. The results of the testing are being prepared for conference presentations and journal articles.

NOAA relevance/societal benefits

The efforts planned for this project will provide NOAA support to a multi-agency arctic science endeavor. Additionally, the testing of the effectiveness of the unmanned aircraft system, payloads, and concepts of operations under real-world conditions will assist NOAA with developing unmanned aircraft systems as tools for: 1) the collection of NOAA-relevant scientific information in remote or hazardous locations and 2) support of NOAA maritime operations such as oil spill response and marine mammal surveys. The data obtained from these systems will assist in validating weather and climate models and improving weather forecasting.

Partner organizations and collaborators

John Coffey, NOAA Unmanned Aircraft Systems (UAS) Program

Gijs de Boer, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder

Janet M. Intrieri, NOAA/ESRL Physical Sciences Division

Robert P. Dahlgren, NASA-Ames

Impact

The impact of this work is to help develop NOAA a tool capable of supporting NOAA science and operational missions in remote and hazardous locations.

Education

N/A

Outreach

N/A

Publications

N/A

Conference presentations

N/A

Other products and outcomes

N/A

Enhanced Tools and Training for Subseasonal to Seasonal Outlooks to Support Decision Makers for Potential High Impact Events at Higher Latitudes

John Walsh, PI
University of Alaska Fairbanks

Other investigators/professionals associated with this project:
Nathan Kettle, Peter Bieniek, Soumik Basu, Casey Brown, *University of Alaska Fairbanks*, ***Richard Thoman,*** *National Weather Service*

CIFAR theme(s): Climate Change and Variability

NOAA Goal(s): Weather Ready Nation; Climate Adaptation and Mitigation

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Amendment 79 NOAA Office: NWS, Eugene Petrescu, Sponsor
Budget Amount: Cumulative $147,465, This year $147,465 (Amendment 79)
This project is new and set to end 06/30/2018.

Primary objectives

- Develop a climatology of storm tracks (locations and intensity) in the hindcasts of 1982-2010 by forecast models (CFSv2 and other NMME models if available) based on a sea-level-pressure-based algorithm applied at 6-hourly intervals
- Develop anomalies of storm tracks (location and intensity) in the Alaska sector from forecast models (CFSc2 and other NMME models if available)
- Develop web pages for display of anomalies and ensemble variance measures (and possibly other variables, e.g., raw tracks)
- For a demonstration set of variables based on services needs and priorities as well as available resources, develop hindcast-based climatologies and bias statistics, together with anomalies and bias-corrected metrics from real-time models (e.g., CFSv2)
- Compile an assessment of Alaska and Arctic user needs, primarily a review of current literature and ongoing projects of the Alaska Center for Climate Assessment and Policy
- Deliver a set of recommended climate tools needed for selected decision support services

Research accomplishments/highlights/findings

Activity 1: Storminess potential for Alaska

We have compiled a climatology and a documentation of the interannual variations of storm activity in Alaskan waters over the period spanned by the CFSv2 hindcasts, 1982-2010. In all cases, the CFSv2 output was for the first full calendar month after the start of a CFSv2 forecast run. The storms were identified and tracked using a criterion of a local minimum of sea level pressure (Zhang et al., 2004, *J. Climate*). Successive positions of each cyclone represent its "track". Thresholds of intensity (central pressure of the storm) can be prescribed by the user in order to extract only storms of a desired intensity (e.g., 980 hPa).

Figure 1 shows the time series of the number of storms in each season of each year in for Alaskan seas: the Gulf of Alaska, the Bering Sea, the Chukchi Sea and the Beaufort Sea. While there are no systematic trends spanning seasons and/or regions, interannual variations are prominent, with the number of storms varying by more than a factor of two in essentially every region/season combination.

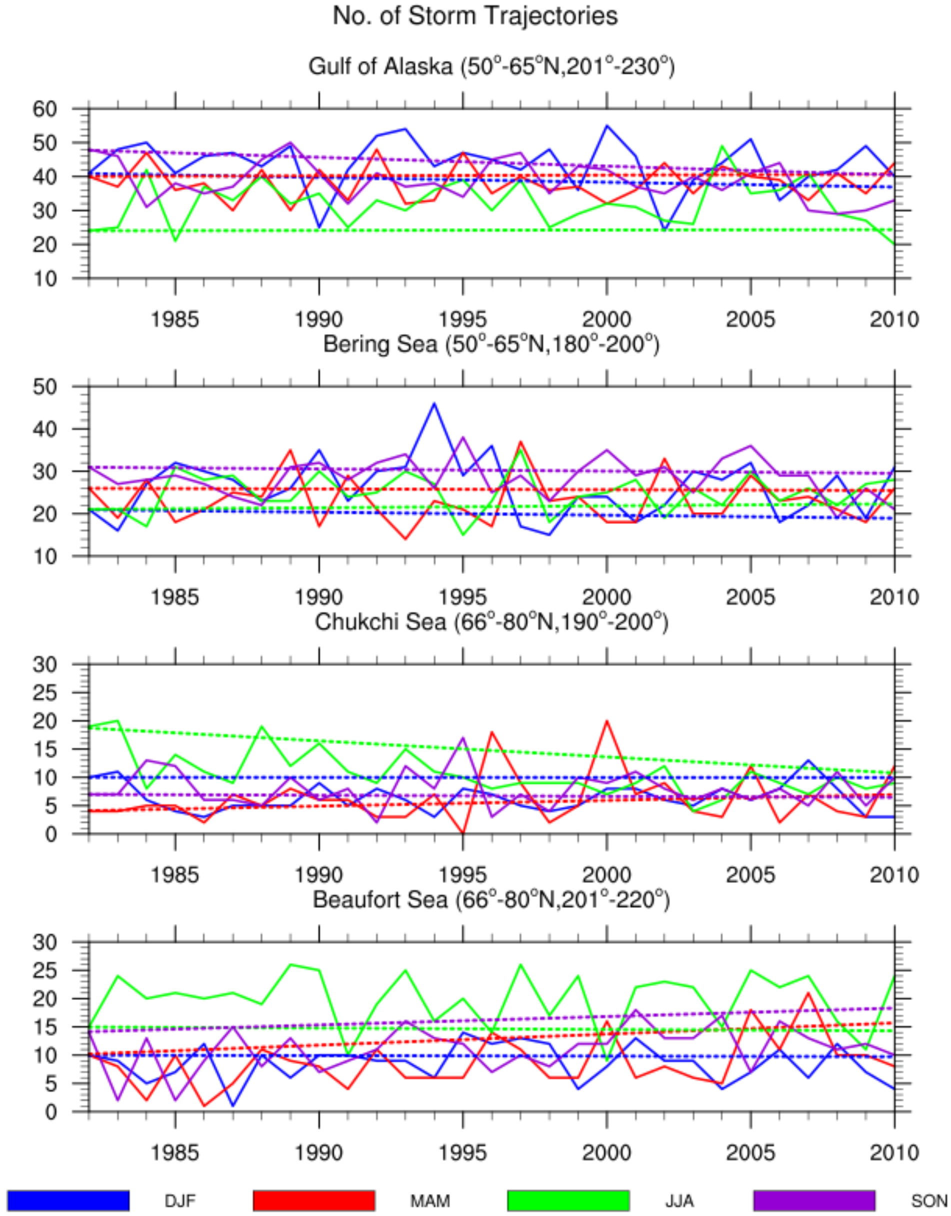

Figure 1. Time series of cyclones passing through Alaskan seas in different seasons (colors) of each year of the CFSv2 forecasts.

A surprising outcome of the analysis of interannual variations is a correspondence between wintertime sea ice conditions in the Alaskan waters and the number of storms in the general vicinity of the ice anomalies. Figure 2, for example, shows that storms tend to track farther westward, increasing their frequencies in the Bering Sea (vis-à-vis the Gulf of Alaska) during years of minimum Bering Sea ice cover. By contrast, the figure suggests (and it is known from past studies) that Bering Sea ice is heavier when storms track primarily through the Gulf of Alaska. Given that the time series in Figure 1 are from month-2 forecasts of the CFSv2 (i.e., December storms were forecast from CDFv2 forecasts generated in early November), the results are highly encouraging from the standpoint of CFSv2 forecast skill beyond the deterministic timeframe of one to two weeks. The implications for seasonal forecasting are especially intriguing because the ice cover in the selected years is for late February, while the storms plotted in Figure 2 occurred in December, January and February. Together with Richard Thoman of the NWS Alaska Region, we are exploring this apparent correspondence for potential utility in winter sea ice forecasting.

Activity 2: Threshold-based products for 2-week forecasts

We have also used station data to analyze the frequencies of occurrence of wind speeds exceeding various thresholds at Alaskan coastal stations. An example is shown in Figure 3, which illustrates the seasonality of hourly occurrences of winds exceeding 25 knots (about 30 mph) at Barrow, Nome and St. Paul. In all cases, winds exceeding the 25-knot threshold are more common in the cold season than in the warm season. These frequencies provide a baseline for assessing real-time forecasts of storminess from the CFSv2 model. Specifically, a comparison of forecast frequencies with those in Figure 3 will enable outlooks for above-, near- or below-normal storminess in the Bering, Chukchi and Beaufort Seas as well as the Gulf of Alaska.

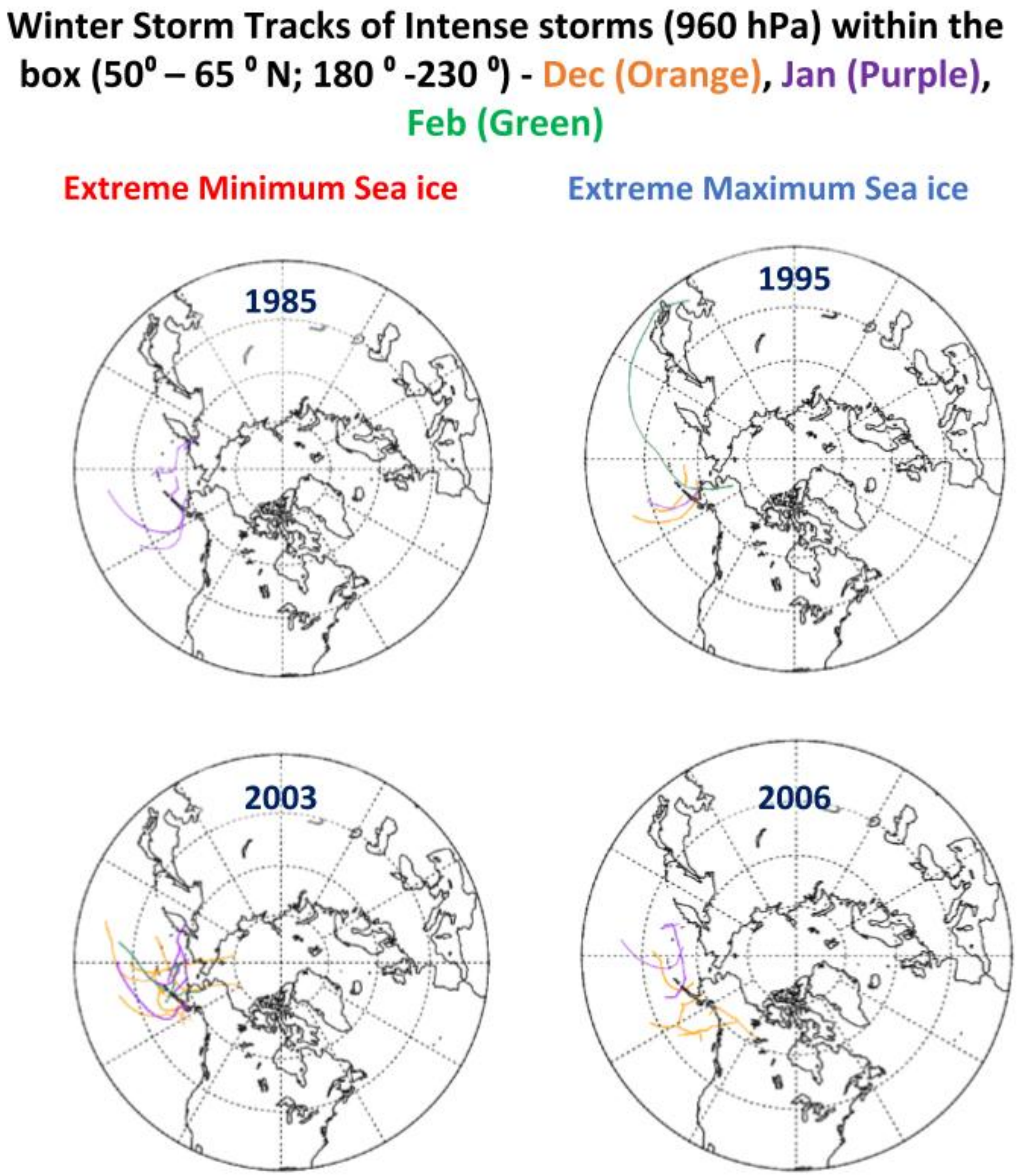

Figure 2. Tracks of storms with central pressures below 960 hPa during December (orange), January (purple) and February (green) in years with extreme minimum ice cover (left column) and extreme maximum ice cover (right column) in the Bering Sea. Years of extreme ice cover are based on Bering Sea ice extent of late February.

Number of hourly time-steps exceeding wind speed of 25 knots

1 - 15 of the month; 16 - end of the month

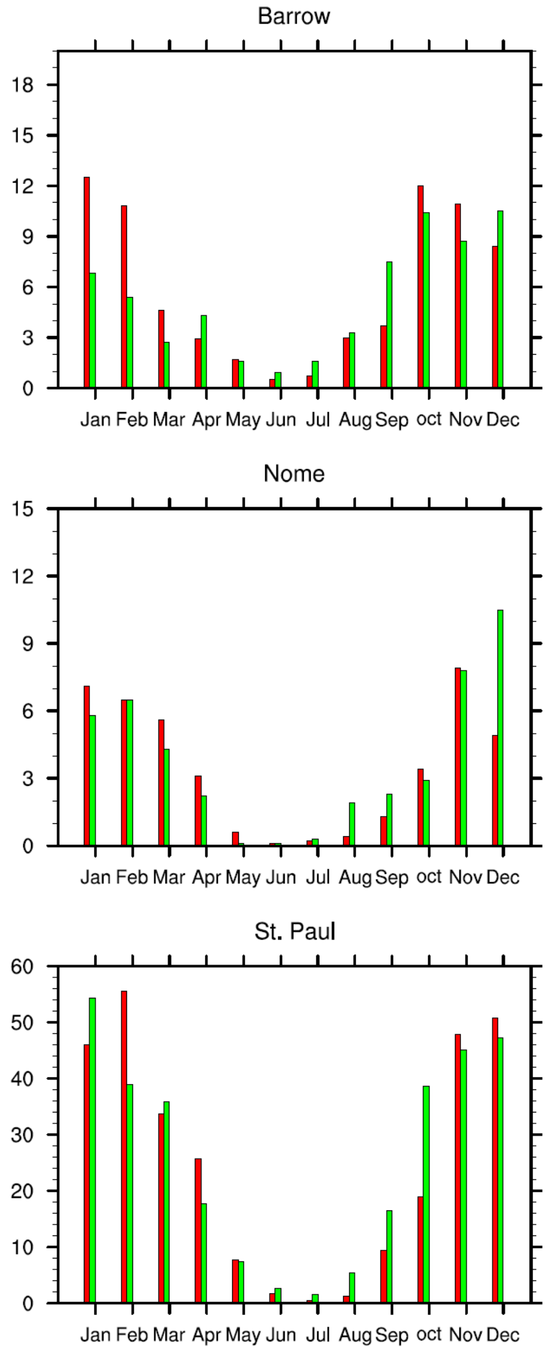

Figure 3. Average yearly number of hours with winds exceeding 25 knots in each calendar month at Barrow (upper panel), Nome (middle panel) and St. Paul (lower panel). Months are broken down into the first halves (red bars) and second halves (green bars). Frequencies are based on hourly observations from stations.

Activity 3: Distance learning modules on climate decision support in the Arctic.

The primary goals of this activity are to (1) compile an assessment of Alaska and Arctic user needs, primarily from a review of current literature and (2) deliver a set of recommended climate tools needed for selected sector decision support services. Two primary datasets are being developed and assessed to achieve these goals: a review of the literature and questionnaires.

Literature Review

We are a conducting a review and synthesis of climate information needs assessment documents in Alaska. 103 documents have been identified so far via web-based searches and conversations with local experts. A document was included in the analysis if: 1) the document was generated by a stakeholder group, 2) it related to climate change and 3) it identified one or more climate change research needs. Scholarly articles or science plans were not included in the analysis. Coding of existing climate research needs assessments and documents have followed methods outlined in Knapp and Trainor 2013, Knapp and Trainor 2015. Coding includes specific identifiers for coastal storms and changing weather patterns to help guide future planning efforts for the selection of NWS weather products.

Questionnaires

Information from the literature review is being supplemented by data gathered from two surveys. One survey targets NWS Alaska Staff. This questionnaire has been developed, will undergo review by UAF's Institutional Review Board (IRB), and is anticipated to be administered in the next 2 months. The questionnaire covers topics related to (1) challenges in data monitoring, analysis and prediction in Alaska; (2) desired tools to carry out tasks more efficiently and effectively; (3) how to improve the customer-interface; and (4) desired trainings. A second survey targets individuals who have attended trainings on tribal climate adaptation planning, sponsored by the Alaska Native Tribal Health Consortium (ANTHC) and Institute for Tribal Environmental Professionals (ITEP). The survey has been developed, is under review by ANTHC and ITEP, will be reviewed by IRB, and is anticipated to be administered in by May.

NOAA relevance/societal benefits

The project is targeting storms and other extreme events that represent environmental hazards to people and property in Alaska. Protection of life and property is a primary mission of NOAA. Storminess outlooks at time scales of weeks to months are frequently requested in Alaska because of the high impacts (flooding, erosion) of coastal storms, especially during the summer and autumn (and increasingly the winter) when sea ice is not present to buffer the coast. Alaska's north and west coasts are especially vulnerable due often to single points of failure of community infrastructure and isolated location, with no road connections to the outside world. These constraints make long lead times necessary for both tactical decisions and strategic planning. Higher storminess than average is understood by core partners as being in some sense proportional to the risk of significant coastal flooding. Preliminary work by the NWS Alaska Region suggests that significant coastal flooding events in the past 60 years have occurred primarily, although not exclusively, in seasons with above-average numbers of storms.

A second benefit of the proposed work is the direct engagement of stakeholders (Activity 3, see above) in guiding the products and methods of communication that will most benefit users of the information. This engagement is already providing guidance on relevant thresholds and metrics for enhanced utility of the forecasts and outlooks.

Partner organizations and collaborators

NOAA National Weather Service (Alaska Region)

Alaska Center for Climate Assessment and Policy (ACCAP)

Alaska Native Tribal Health Consortium (ANTHC

Institute for Tribal Environmental Professionals (ITEP).

Impact

Utilization of long-lead outlooks for hazards such as storms will enable advance preparation by coastal communities and industries active in Alaska's coastal waters. Planning can include strengthening of coastal protection (e.g., coastal berms), movement of vehicles and other equipment, and secure storage of provisions. Offshore activities (e.g., barge operations, commercial, resource exploration/extraction, subsistence fishing and hunting) can also be rescheduled by operators to minimize risks to life and property. Finally, longer-term trends in storms and other hazards can be incorporated into adaptation plans by coastal communities and other affected stakeholders.

Education

Products developed here are intended primarily to meet the needs of stakeholders, decision-makers, and planners.

Outreach

A major goal of Activity 3 is to deliver a set of recommended climate tools needed for selected sector decision support services. Our elicitation of user needs via questionnaires and literature reviews represents a key step in bridging NOAA operational activities and user needs.

A second phase of outreach can take place after the products identified in this project have been transitioned to operations. This phase, which will consist of user feedback on the products, is beyond the 9-month timeline of the present project.

Publications

No publications have been produced yet, but a manuscript on the storm climatology and storminess predictability is in preparation.

Conference presentations

No conference presentations since the project began in October.

Other products and outcomes

The high-wind climatology (Figure 3) and CFSv2 forecasts were used in support of the U.S. Navy's ICEX field program in the Beaufort Sea during February-March 2018. This information augmented the short-range forecasts provided to the ICEX project by the National Weather Service. The broad pattern of surface winds forecast by the CFSv2 in early February was found to correspond with the observed March winds (and drift of the ice camp). However, the CFSv2 forecast of March sea ice thickness showed a geographical pattern different from the March sea ice thickness derived from CryoSat measurements: the former had the thickest ice along the northeastern Russian coast, while the thickest ice measured by CryoSat was offshore of the Canadian Archipelago.

COASTAL HAZARDS

GOES-R Volcanic ash risk reduction: Operational decision support within NOAA's Rapid Refresh (RAP)

Martin Stuefer, PI
Peter Webley, co-PI
University of Alaska Fairbanks

CIFAR theme: Coastal Hazards

Other investigators/professionals associated with this project:
Georg A Grell (NOAA-ESRL

NOAA Goal: Weather Ready Nation

Amendments 21, 37
NOAA Office NESDIS; Andrew Heidinger, Sponsor
Budget Amount: Cumulative $194,364, This year $0
This project is set to end 06/30/2018.

Primary objectives

We aim to test the ability to use GOES-R Advanced Baseline Imager Volcanic Ash Algorithm (ABI-VAA) data to define volcanic Eruptions Source Parameters (ESP) for volcanic activity. The GOES-R derived ESP data are necessary to initialize the volcanic emission parameterization routine within our fully automated University of Alaska Fairbanks (UAF) based Weather Research Forecast model coupled to Chemistry (WRF-Chem) environment and the modern data assimilation within NOAA's ESRL High Resolution Rapid Refresh (HRRR) modelling system. We have used aerosol aware physics packages within WRF-Chem to simulate volcanic aerosol-radiation-cloud feedback. Case studies have been performed running the model with and without aerosol feedback processes. The potential of aerosols from volcanic eruptions to alter the physical structure of the atmosphere has been evaluated during the reporting period for the well-documented historic case study of Eyjafjallajökull eruption in Iceland in April and May 2010. Based on this case study we can show that weather is regionally affected by airborne volcanic ash. Inclusion of volcanic aerosol within the numerical weather model improved the weather prediction. Further evaluation follows for GOES- R ABI-VAA ash detections in the future. Initial volcanic ash model initialization routines have been implemented into NOAA's HRRR system. The routines are ready to accept volcanic plume characteristics as derived from the GOES-R ABI-VAA. We are working in close collaboration with our colleagues from NOAA's ESRL, conduct benchmark tests and comparisons of the best ESP to be used by the HRRR - and UAF WRF-Chem models.

Research accomplishments/highlights/findings

Significant progress has been achieved to complete several proposed milestones.

Work has started to develop and generalize the WRF-Chem source data ingest routines for ABI-VAA data; as well as example routines have been provided to our colleagues from NOAA ESRL for the experimental HRRR setup.

A case study has been conducted to implement volcanic ash parameters within NOAA's experimental HRRR environment. An initial test with the HRRR model including volcanic ash parameterization has been performed for Alaska's Bogoslof volcano, which erupted on May 29, 2017. The Bogoslof eruption created an ash plume extending up to 35,000 feet above ground level into the lower stratosphere. Aviation alerts were disseminated through the Anchorage volcanic ash advisory centre and air traffic re-routed during the eruptive activity. The modeling case study allowed us to test the compatibility between our volcanic ash parameterization routines and the HRRR environment, and accounted for a first benchmark to evaluate computing expenses.

We further tested the WRF-Chem setup for aerosol feedback. Various alterations and improvements have been implemented into the model and evaluated for the historic test case of the Icelandic Eyjafjallajökull eruption in April and May 2010. The Eyjafjallajökull case was selected due to the availability of the high-quality observational data. The ash cloud was observed by different measurement networks across the European continent providing an unprecedented database to conduct a comprehensive WRF-Chem model evaluation. Meteorological and air quality observations have been analysed to evaluate the WRF-Chem performance (Fig. 1). Ash aerosol reduces downward shortwave fluxes and influences cloud microphysics through the direct and indirect radiative effects. The effects of the reduced downward shortwave fluxes on atmospheric temperature and wind speed may be regionally significant; where an inclusion of these effects within numerical weather models may improve the quality of the weather prediction. We investigated the changes on the meteorological parameters when aerosol feedback effects are considered. Two simulation scenarios were conducted over 40 days of the considered volcanic episode. A meteorology-only simulation without chemistry ('onlyMET') provided the base case scenario and has been compared to the results obtained from a WRF-Chem ('VOLC') model simulation with ash aerosol aware physics and chemistry.

The VOLC runs considered gas-phase- and aerosol-chemistry using anthropogenic, biogenic- and natural emissions (e.g. volcanic and desert dust). The parameterized geometry of the volcanic emission source included in our previous WRF-Chem version had to be changed for the Eyjafjallajökull case. As the real volcanic vent height differed from the model-derived topography, the WRF-Chem code was corrected to improve the representation of the base of the ash plume as well as the vertical plume parameterization was adjusted to account for the increased high-altitude mass concentrations during the explosive eruption periods. The temporal and spatial location of the volcanic cloud simulated by the model was evaluated with satellite data from Meteosat Second Generation SEVIRI sensor (Fig. 2) and vertical profiles of extinction coefficients from EARLINET network stations. In addition, ground measurements of PM10 (particle matter < 10 µm) were used to evaluate the WRF-Chem model performance for times when the dispersing ash cloud was constrained to lower altitudes. The results show, in general, that the model is able to accurately represent the horizontal and vertical location of the ash cloud. The comparison with ground PM10 measurements also reveals that the parameterization of the volcanic emissions in the model produces quantitative and qualitative realistic aerosol distributions (Fig. 3).

For the surface measurements, our evaluations show that for the 10 m above ground level (AGL) wind speed the observations are over-estimated by the VOLC model run by approx. 0.8 m/s while the average temperature is under-estimated by more than 2 °C when the whole period of 40 days and all stations are averaged. The correlation for the temperature of R2 = 0.72 is greater than for the wind speed, (R2= 0.44). In the vertical, the average wind speed (over the whole time and all stations at 00:00 and 12:00 UTC) shows good agreement at higher altitudes but appears to be overestimated by both (onlyMET and VOLC) model runs at lower altitudes by up to 3 m/s. In the vertical, the model simulations represent the average temperatures over all radiosonde locations and all time steps very well. Only at lower model levels (lower altitudes) the model runs differ by about 0.5 °C with larger deviations from the observations for the onlyMET run. In this case, the VOLC run fits better to the observations. The surface temperature distribution is in good agreement with the observations. As for the average temperature profiles over the 40 days and all stations for most of the profiles, the model runs at higher altitudes have similar values and also represent the observed temperature very well.

The highest differences between the model runs and also between model and observations occurs at lower altitudes and show that, for many cases, the presence of the volcanic ash cloud and the consideration of the feedbacks leads to improved results compared to the observational measurements. Also, through the presence of the volcanic ash the radiation on the surface is reduced and the warming is prevented in the VOLC run. We can show that for these situations the VOLC run leads to better representations of inversions then the onlyMET run. The differences between onlyMET and VOLC, for the average daily values, can be both negative and positive and show a good spatial match to the location of the cloud. The differences reach between -0.5 m/s and +0.5 m/s. The maximum daily differences for surface wind speed between the two model runs exceed 2 m/s in some regions. The daily average temperature differences can exceed 1 °C, while the daily maximum absolute differences of ground level temperature occur over mainland and reach values above 2 °C (Fig. 4).

The WRF-Chem modeled aerosol processes as well as interactions between meteorology and air quality result in realistic prediction of main meteorological variables such as temperature and wind speed. The coupled VOLC WRF-Chem model runs simulates a more realistic atmospheric state and highlights that the current aerosol parameterization within WRF-Chem is both useful and provides equivalent results to observational data. Our evaluation shows that the observed meteorology is regionally affected by the source of the emissions and the initial plume distribution.

Further accomplishments are described in the report for our continuing and overlapping project, GOES-R Volcanic Ash Risk Reduction (R3): New operational GOES-R decision support within NOAA's High Resolution Rapid Refresh.

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.

Partner organizations and collaborators

Georg Grell, NOAA Earth Systems Research Laboratory

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

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 highlighted 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.

Education

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

Marcus Hirtl is a Ph.D. candidate student within the Interdisciplinary Program at UAF working on this project.

Publications and Presentations

2017 Fall Meeting American Geophysical Union: Invited presentation entitled 'Improved Near Real Time WRF-Chem Volcanic Emission Prediction and Impacts of Ash Aerosol on Weather', presenter Martin Stuefer, co-authors Peter W Webley and Marcus Hirtl.

2018 European Geosciences Union (EGU) Annual Meeting: 'Simulating the influence of aerosol feedback effects with WRF-Chem on surface- and vertical distributions of wind speed and temperature during the Eyjafjallajökull 2010 eruption', Authors: Marcus Hirtl, Martin Stuefer, Dèlia Arnold, Claudia Flandorfer, Christian Maurer, Stefano Natali, Barbara Scherllin-Pirscher.

Figures:

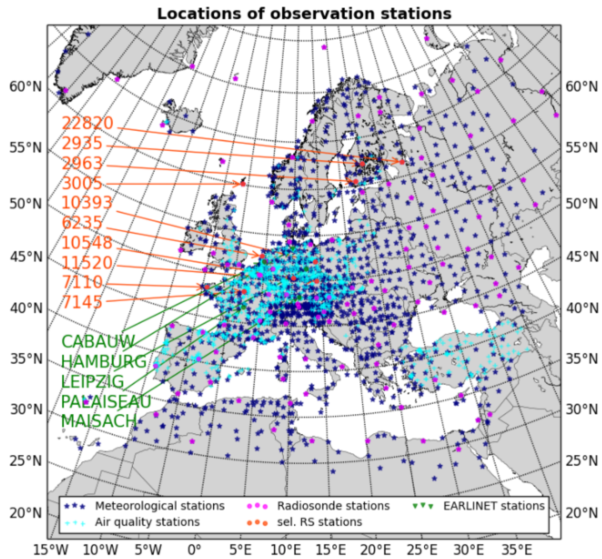

Figure 1: Location of air quality (red), meteorological (black) ground stations, EARLINET LIDAR (green) and radiosonde (purple and orange) observations used to evaluate the WRF-Chem modeling simulations.

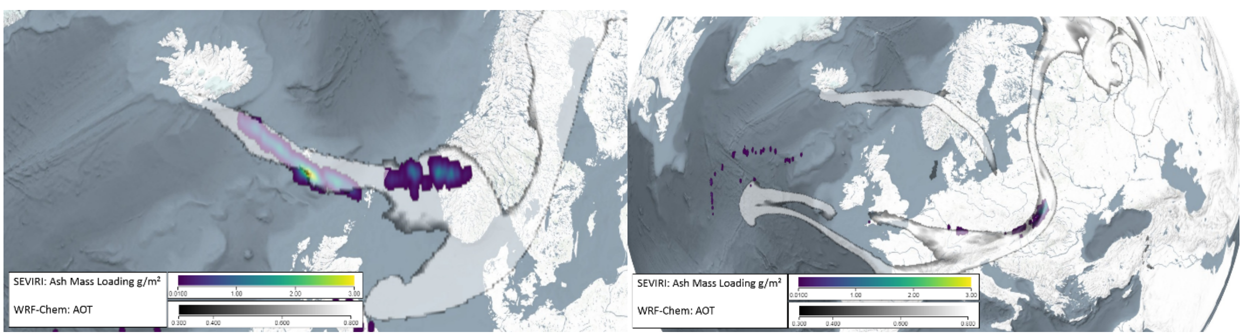

Figure 2: WRF-Chem simulated AOT values for selected consecutive days in April during the eruption phase I compared to total ash load observations from SEVIRI.

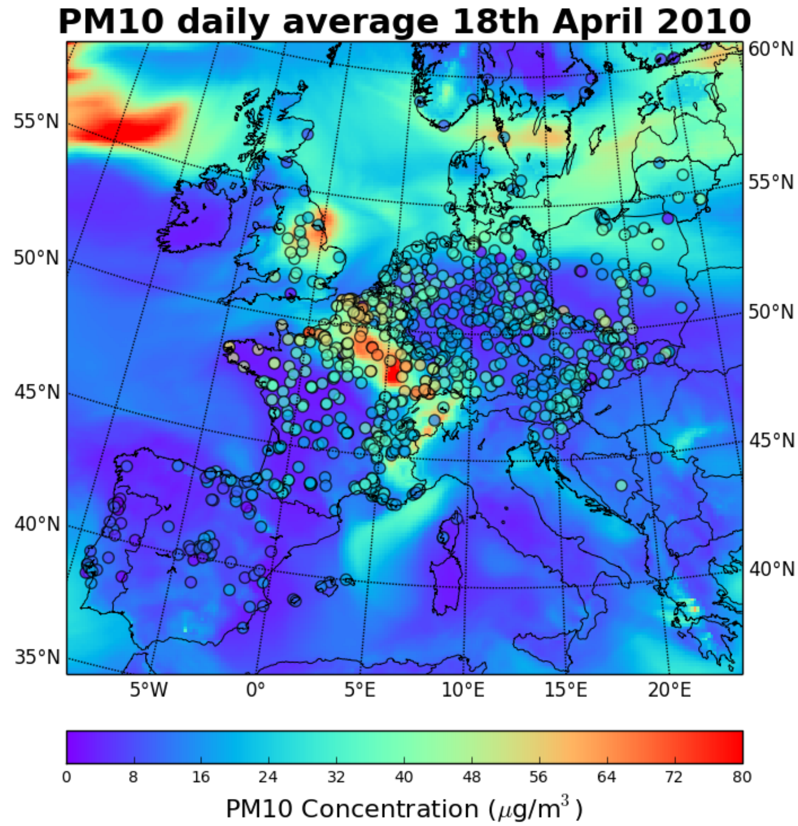

Figure 3: Daily average PM10 WRF-Chem simulated ground concentrations compared to measurements at air-quality stations in central Europe.

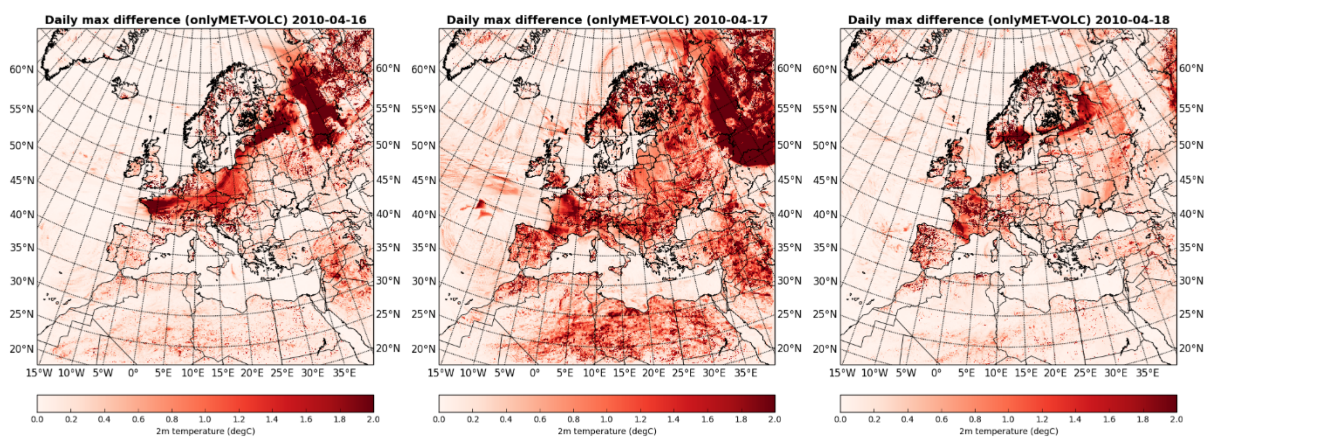

Figure 4: Daily absolute maximum differences between the two model runs (onlyMET-VOLC) of the 2m-temperature distribution for 3 consecutive days during the Eyjafjallajökull eruption in April 2010.

Alaska Earthquake Center seismic station operations and maintenance

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

CIFAR theme(s): Coastal Hazards

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

NOAA Goal(s): Weather Ready Nation

Amendments 7, 26, 41, 61, 71
NOAA Office: NWS, Michael Angove, Sponsor
Budget Amount: Cumulative $1,094,981, This year $240,000 (Amendment 71)
This project is set to end 09/30/2018.

Primary objectives

- Maintain NOAA-sponsored seismic stations in the integrated Alaska Seismic Network
- Upgrade stations to Advanced National Seismic System (ANSS) standards for modern broadband equipment and telemetry. Maintain data flow of selected stations to the National and Pacific Tsunami Warning Centers.
- Detect seismic events occurring in Alaska as a means of seismic data quality control and to support improved knowledge of tsunamigenic earthquake sources.

Research Accomplishments/highlights:

The average return rate for the 17 NOAA-funded stations (minus DCPH) was 94%; 96% for eight sites that are currently supported and 92% for 9 de-scoped sites (not counting DCPH). DCPH, remains out of service due to ongoing discussions with USCG regarding site co-location. This data return metric is 1% better than in the previous reporting period. Three sites had data return rates less than 90%: ATKA, BMR and DOT. The station in Atka experienced a prolonged outage due to telecommunications and networking issues. We made multiple attempts to get to Atka to service the site, but many of the attempts were prevented by the eruption of Bogoslof Volcano and other unfavorable weather conditions. Station BMR in Chugach National Forest was damaged by a bear in the fall of 2016 and eventually succumbed to the elements in the spring of 2017. We were able to repair the damage in August of 2017. Both sites have operated without any major interruptions since the repairs were completed. The station in Dot Lake (DOT) experienced broadband sensor failure. It is currently operating with a strong motion sensor only. A new sensor was ordered in the fall of 2017 and received March 2018; it will be installed as soon as weather permits.

Between April 1, 2017 and March 12, 2018, the Alaska Earthquake Center reported 42,246 events, with magnitudes ranging between -1.3 and 7.9 and depths between 0 and 300 km (Figure 1). This represents an increase of nearly 5,000 events over the previous reporting period. Seven earthquakes had magnitudes of 6 or greater. The largest earthquake, of magnitude 7.9, occurred on January 23, 2018 south of Kodiak Island. This earthquake caused minor damage on Kodiak Island, but no destructive tsunami was generated. More than 1,500 aftershocks have been recorded to date. These aftershocks are critical to assessing the mechanics of the earthquake and the ensuing tsunami.

The addition of EarthScope USArray stations throughout Alaska has vastly improved the accuracy and detection thresholds for earthquakes. The distribution and fidelity of USArray stations has significantly improved the ability to quickly determine the tsunamigenic potential of earthquakes occurring offshore Alaska.

With the assistance from the Earthscope USArray program, The Earthquake Center was able to replace broadband sensors at all Crestnet borehole sites in recent years. However, equipment at other sites, including dataloggers, are approaching fifteen years in the field. Recent budgets do not cover replacement of sensors and dataloggers. While several sites have benefitted from EarthScope- or state-provided instruments, other NOAA-funded sites will require additional support to replace aging equipment.

During the reporting period, we visited 9 NOAA-funded sites and performed the following work:

- ATKA (Atka) April 14-15, 2017 – Visited to assess networking problem and inspect the site. June 16-19, 2017 – Visted and attempted to address the networking problem again.
- BMR (Bremner, Chugach Mountains) June 18, 2017 – Arrived to replace batteries and investigate power outage, determined it to be bear. August 16, 21-22, 2017 – Repaired bear damaged door, replaced radio, power switcher, installed new instrument mounts and buried conduit.
- COLD (Coldfoot) August 3-4, 2017 – Installed a new external mast and a pair of stacked antenna to address signal strength problems.
- DOT (Dot Lake) August 4, 2017 – Replaced fuses to sort out power issues. August 31, 2017 – pulled a router believed to be causing short circuits. September 29, 2017 – Installed a new Q330 datalogger and router.
- EYAK (Eyak Ski Hill, Cordova) August 24, 2017 – Visited to update the IP address and inspect for upcoming borehole install. September 29, 2017 – Installation of a new borehole and instruments as part of the EarthScope USArray, and removal of legacy wiring.
- NIKH (Nikolski) April 18-19, 2017 – Installed 23 new batteries.
- PAX (Paxon Lake) September 14, 2017 – Inspection to determine the source of a power outage. September 29, 2017 – Swapped out the older Q330 digitizer for a Q330s and replaced the GPS antenna.
- PIN (Pinnacle, Yakutat Bay area) July 22, 2017 – Inspection, no problems found and no changes made.
- SWD (Seward) September 6, 2017 – Replacement of two routers, a Mikrototlik to standardize the network connection and a DSL modem as part of a telecom network overhaul.

NOAA relevance/societal benefits

- Faster and more accurate detection of tsunamigenic earthquakes by the NOAA tsunami warning centers and the Alaska Earthquake Center.

- Data that support the development of geologically plausible earthquake scenarios for tsunami hazard modeling under NOAA's National Tsunami Hazard Mitigation Program.

Outreach

AEC continues to provide real-time and reviewed earthquake information to local emergency service offices and to the public. The primary means for this is the Earthquake Center website, earthquake.alaska.edu. The support and collaboration with NOAA is reiterated in several places across the site.

While not an explicit part of this project, the earthquake catalog shown in Figure 1 is critical information used in the development of the tsunami inundation hazard products.

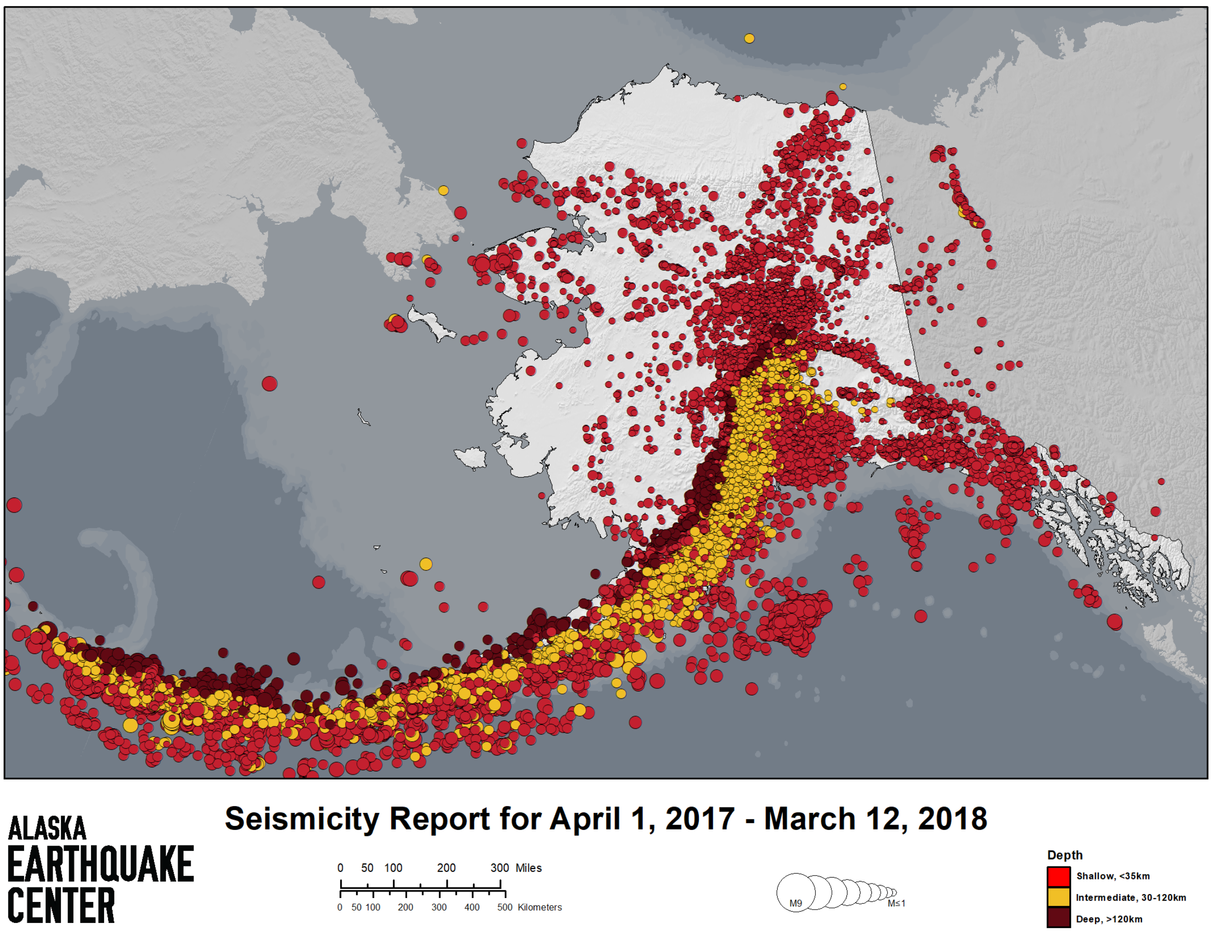

Figure 1. Map of seismicity from April 1, 2017 through March 12, 2018.

GOES-R Volcanic Ash Risk Reduction (R3): New operational GOES-R decision support within NOAA's High Resolution Rapid Refresh

Martin Stuefer, PI
Peter Webley, co-PI
University of Alaska Fairbanks

CIFAR theme: Coastal Hazards

Other investigators/professionals associated with this project:
Marcus Hirtl *(UAF)*
Georg A Grell, Ravan Ahmadov, Trevor Alcott *(NOAA-ESRL)*
Mike J Pavolonis *(NOAA-NESDIS)*

NOAA Goal: Weather Ready Nation; Resilient Coastal Communities and Economics

Amendments 67 NOAA Office NESDIS; Dan Lindsey, Sponsor
Budget Amount: Cumulative $45,657, This year $45,657 (Amendment 67)
This project is new and set to end 06/30/2018.

Primary objectives

We aim to test the ability to use GOES-R Advanced Baseline Imager Volcanic Ash Algorithm (ABI-VAA) data to define volcanic Eruptions Source Parameters (ESP) for volcanic activity. The GOES-R derived ESP data are necessary to initialize the volcanic emission parameterization routine within our fully automated University of Alaska Fairbanks (UAF) based Weather Research Forecast model coupled to Chemistry (WRF-Chem) environment and the modern data assimilation within NOAA's ESRL High Resolution Rapid Refresh (HRRR) modelling system. We have used aerosol aware physics packages within WRF-Chem to simulate volcanic aerosol-radiation-cloud feedback. Case studies have been performed running the model with and without aerosol feedback processes. The potential of aerosols from volcanic eruptions to alter the physical structure of the atmosphere has been evaluated during the reporting period for the well-documented historic case study of Eyjafjallajökull eruption in Iceland in April and May 2010. Based on this case study we can show that weather is regionally affected by airborne volcanic ash. Inclusion of volcanic aerosol within the numerical weather model improved the weather prediction. Further evaluation follows for GOES- R ABI-VAA ash detections in the future. Initial volcanic ash model initialization routines have been implemented into NOAA's HRRR system. The routines are ready to accept volcanic plume characteristics as derived from the GOES-R ABI-VAA. We are working in close collaboration with our colleagues from NOAA's ESRL, conduct benchmark tests and comparisons of the best ESP to be used by the HRRR - and UAF WRF-Chem models.

Research accomplishments/highlights/findings

Significant progress has been achieved to complete several proposed milestones. Many of these are described in the report for our previous and overlapping project, GOES-R Volcanic ash risk reduction: Operational decision support within NOAA's Rapid Refresh (RAP) year 1 of 2. Further accomplishments are described below.

Model Development: The following main key tasks are currently addressed:

- Refine ABI-VAA Data ingest and ESP generation.

- Comparison of ESP and best estimates based on our WRF-Chem and HRRR output evaluation.
- Continue with automated runs (orange and red alert levels for volcanic activity) and output graphics on a dedicated webpage. The near real time UAF WRF-Chem runs will be configured with volcanic aerosol physics.
- Continued collaboration with NOAA ESRL to refine volcanic ash inclusion within HRRR.

We will work to further develop our WRF-Chem volcanic ash ingest to create standard routines that are easy to adapt in new versions of WRF-Chem (i.e. WRF-Chem V3.9 and future versions). Benchmark tests will be performed including a case study with identical eruption source initialization using our WRF-Chem and NOAA's HRRR model. The volcanic ash variables will be reduced from the currently available 10 to just 2 variables to account for reduced computing expenses within the HRRR environment. The two HRRR ash variables will include very fine ash and coarse ash bins to predict the afar plume dispersion as well as the ash deposition near the volcano respectively. The case studies will be a step towards the implementation of volcanic ash simulations within NOAA's real time HRRR setup (http://rapidrefresh.noaa.gov).

We will exploit and analyze GOES-16/GOES-R ABI-VAA alerts. While the GOES-16 (East) position does not account for volcanic activity alerts within the Alaska HRRR domain, we will keep track of any eruptive activity within the GOES-16 footprint, and use proxy infrared (IR) data for GOES-R ABI-VAA equivalent products for Alaska. Our automated domain generator implemented into the UAF WRF-Chem environment allows us to run volcanic plume simulations anywhere on the globe in near-real time. In collaboration with our colleagues from NOAA/NESDIS, we aim to validate the baseline volcanic ash products that are available through NOAA's Comprehensive Large Array-data Stewardship System (CLASS).

We will maintain the routine WRF-Chem volcanic plume alerts and disseminate information and output graphics on the web. Once included into HRRR, NOAA ESRL will make volcanic ash prediction output available for the Alaska domain (https://rapidrefresh.noaa.gov/hrrr/alaska). We will compare the HRRR output with the UAF WRF-Chem output, which will have the aerosol feedback on weather included in the modeling environment. A journal article on the volcanic ash aerosol feedback effects will be submitted.

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.

Partner organizations and collaborators

Georg Grell, NOAA Earth Systems Research Laboratory

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

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.

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 all VAAC offices and Alaska Meteorological Watch Office and Alaska Aviation Weather Unit.

Education

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

Marcus Hirtl is a Ph.D. candidate student within the Interdisciplinary Program at UAF working on this project.

Publications and Presentations

PhD student Marcus Hirtl is the lead author of a journal article entitled ‘Simulating the influence of aerosol feedback effects with WRF-Chem on surface- and vertical distributions of wind speed and temperature during the Eyjafjallajökull eruption, April & May 2010’. The draft is in its final stage and will be submitted to the Journal of Atmospheric Environment. Submission will be in late spring 2018.

Implementing Interdisciplinary Approaches to Solve Societally Relevant Problems in Alaska through Education, Workforce Development and Partnerships

Vladimir Alexeev, PI
University of Alaska Fairbanks

CIFAR theme(s): Coastal Hazards

Other investigators/professionals associated with this project (w/affiliation):
Megan Hillgartner, Sorina Seeley, *University of Alaska Fairbanks*

NOAA Goal(s): Healthy Oceans; Climate Adaptation and Mitigation; Weather Ready Nation; Resilient Coastal Communities and Economies

Amendment 75
NOAA Office: NMFS, Kaja Brix, Sponsor
Budget Amount: Cumulative $184,222, This year $184,222 (Amendment 75)
This project is new and set to end 06/30/2018.

Primary objectives

The project supports NOAA efforts to improve relationships between the agency and the communities they work in. This project will foster a better fit between decisions being made and the ecological and social processes happening on the ground by integrating the necessary diverse expertise and developing and implementing societally relevant and sustainable solutions to complex socio-ecological problems. It also cultivates a pathway for professional development in Alaska youth and helps expand the knowledge base and working approaches of agency professionals.

Research accomplishments/highlights/findings

Report on recruitment of minorities in science is under preparation. Highlight of the report include:

Key findings on the landscape of barriers and challenges to Alaska Native and rural Alaskan participation in NOAA's workforce. Findings on key barriers are centered around 5 main themes:

(1) Localized opportunities
(2) Messaging and outreach
(3) Engagement and Investment
(4) Social and cultural barriers
(5) Internal NOAA barriers

Practical and implementable recommendations to increase Alaska Native and rural Alaskan participation in NOAA's workforce. We have developed five categories of recommendations:

(1) Create more opportunities for undergraduate and graduate students
(2) Address the federal hiring process
(3) Direct and targeted international with undergraduate and graduate students
(4) Increase engagement with middle and high school students
(5) Create and strengthen support structures to build a more inclusive work environment

Each recommendation includes courses of action, a justification and recommendations for implementation.

Proposal to NOAA Fisheries AK Region:

Proposal to develop a program for Alaska and the West Coast that unites a network of institutions involved in marine resource management and education in a transferable academic and workforce development model. This model will be piloted at the University of Alaska Fairbanks (UAF) and will later be replicated throughout the West Coast Region, including the Western Pacific and Pacific Islands.

NSF Conference Proposal

The collaborators submitted a proposal to NSF INCLUDES Conferences (Inclusion Across the Nation of Communities of Learners Underrepresented Discoverers in Engineering and Science). This call will provide conference funding for proposals that generate novel ideas for how new and existing collaborations and organizations can help shape opportunities for connecting to the NSF INCLUDES National Network.

Development of the NOAA Diversity Coalition Meeting in Anchorage

In January 2018, a meeting was held in Anchorage, Alaska: *Diversity Brainstorm and Action Planning for the National Oceanic and Atmospheric Administration (NOAA)*. This meeting arose out of the agency's strong need for a diverse workforce equipped to address complex and rapidly changing marine science and resource management challenges. Building off the existing partnership agreement between NOAA Alaska Region and the University of Alaska Fairbanks, agency personnel from NOAA's National Marine Fisheries Service (NMFS) Alaska Region organized a meeting with staff from the University of Alaska Fairbanks to consider ways in which both parties could take more actionable and meaningful steps towards fostering greater diversity in STEM degree tracks and the federal workforce. This meeting led to the development of a transformative diversity STEM academic model: the *Partnership Education Program Alaska/West Coast for* increasing diversity in the federal workforce and marine science careers. This structured, systematic, and interdisciplinary workforce-development education model for Alaska and the West Coast unites a network of institutions and entities involved in marine resource management and education.

NOAA relevance/societal benefits

Efforts to better understand partnerships between diverse entities have shown that more work is needed to jointly identify issues and priorities. To develop truly sustainable solutions to our shared problems, we must rethink the way we educate and train professionals entering the workforce. We must also consider ways in which we continue and enhance education and learning for the current workforce, to ensure they are equipped to address such challenges. We connect leading scientists with experienced NOAA professionals to develop an education/workforce model connecting science and policy making in education via a classroom model. In action this model will prepare students to be effective members and leaders in multidisciplinary teams that are able to design, evaluate, and implement responses to complex socio-environmental challenges. Such an approach will also help expand the knowledge base and working approaches of agency professionals and provide ongoing opportunities for professional development.

Partner organizations and collaborators

NOAA Fisheries AK Region

Education and outreach

Megan Hillgartner and Sorina Seeley contributed to an NSF REU project conducted at the International Arctic Research Center

Publications

Komatsu, KK, Alexeev, VA, Repina IA and Tachibana Y, 2018. "Poleward upgliding Siberian atmospheric rivers over sea ice heat up Arctic upper air", Scientific Reports, DOI: 10.1038/s41598-018-21159-6

Conference presentations

147th American Fisheries Society Meeting as a part of the symposium: Game Changing Solutions for Enhancing Diversity and Inclusion in the Fisheries Profession. Aug 2017

Utilizing Partnership for Greater Diversity and Inclusion in Natural Resource Management, NOAA EPP/MSI 9th Biennial Education and Science Forum Howard University. March 2018

Diversity in Action: Partnership for Education Program (PEP) for Alaska and the West Coast

Other products and outcomes:

- Co-Instructor for graduate level UAF Course: Navigating Interpersonal Interactions in Science Careers
- 2018 American Fisheries Society. Organizing committee for symposium on creating actionable steps to increase diversity and inclusion in fisheries professions. In Prep.
- Partnership Education Program Alaska/West proposal. In Prep.
- Policy Analysis on the landscape of opportunities and limitations rural and Alaska Natives face entering into NOAA's workforce. In Prep.

APPENDIX 1 AWARDS THROUGH CIFAR 1 APRIL 2017-31 MARCH 2018

CIFAR Projects Awarded in Cooperative Agreement NA13OAR4320056
1 April 2017 to 31 March 2018

Last	First	Proposal Title	Amend	Project Budget	Theme Description	Funding Source	NOAA PM
Task 1 Activities: CI Administration and Education & Outreach							
Bhatt	**Uma**	Task 1 Request for S23911- Richter-Menge	63	$2,350	Administration	OAR	Baskins
Bhatt	**Uma**	Task 1 Request for S23993- Heinrichs	64	$12,848	Administration	NESDIS	Goodman
Bhatt	**Uma**	Task 1 Request for S23482R1 - Heinrichs	65	$1,571	Administration	NESDIS	Lindsey
Bhatt	**Uma**	Task 1 Request for S23898 - Kelley	66	$3,164	Administration	OAR	Cross
Bhatt	**Uma**	Task 1 Request for S23490R1 - Stuefer	67	$3,881	Administration	NESDIS	Lindsey
Bhatt	**Uma**	Task 1 Request for S23894- Kelley	68	$8,665	Administration	OAR	Cross
Bhatt	**Uma**	Task 1 Request for S23885 - Hinzman	69	$6,267	Administration	OAR	Alford
Bhatt	**Uma**	Task 1 Request for S20088 - Iken (multi year)	70	$1,316	Administration	NOS	Canonico
Bhatt	**Uma**	Task 1 Request for S24004 - West	71	$20,400	Administration	NWS	Angove
Bhatt	**Uma**	Task 1 Request for S24171 - Beaudreau	72	$1,303	Administration	NMFS	Marshak
Bhatt	**Uma**	Task 1 Request for S23944 - Cahill	73	$2,009	Administration	OAR	Hood
Bhatt	**Uma**	Task 1 Request for S24038 - Pinchuk	74	$7,029	Administration	NMFS	Cieciel
Bhatt	**Uma**	Task 1 Request for S24271 - Alexeev	75	$15,659	Administration	NMFS	Brix
Bhatt	**Uma**	Task 1 Request for S24085 - Cahill	76	$31,336	Administration	OAR	Hood
Bhatt	**Uma**	Task 1 Request for S24191 - Heinrichs	77	$62,345	Administration	NESDIS	Goldberg
Bhatt	**Uma**	Task 1 Request for S24002- Gordon (part 1)	78	$5,515	Administration	NMFS	Moss
Bhatt	**Uma**	Task 1 Request for S24431 - Walsh	79	$12,535	Administration	NWS	Petrescu
Bhatt	**Uma**	Task 1 Request for S24688 - Richter-Menge	80	$2,041	Administration	OAR	Baskins
Bhatt	**Uma**	Task 1 Request for S24002- Gordon (part 2)	81	$5,811	Administration	NMFS	Moss
Iken	**Katrin**	Arctic Marine Biodiversity Observing Network (AMBON) Graduate Student Traineeships (year 4 of 4)	70	$14,785	Education & Outreach; Ecosystem Studies & Forecasting	NOS	Canonico

NOAA Non-Competitive Projects (NA13OAR4320056)							
Richter-Me	Jacqueline	NOAA State of the Arctic Report - Year 1	63	$27,650	Climate Change & Variability; Ecosystem Studies & Forecasting	OAR	Baskins
Heinrichs	Thomas	High Latitude Proving Ground for GOES-R: Advanced data products and applications for Alaska	64	$151,152	Climate Change & Variability; Coastal Hazards	NESDIS	Goodman
Heinrichs	Thomas	High Latitude Proving Ground – GOES-R River Ice and Flood Product Support (year 1 of 3)	65	$18,479	Climate Change & Variability	NESDIS	Lindsey
Kelley	Amanda	Acidification in the Distributed Biological Observatory	66	$37,222	Ecosystem Studies & Forecasting; Climate Change & Variability	OAR	Cross
Stuefer	Martin	GOES-R Volcanic Ash Risk Reduction (R3): New operational GOES-R decision support within NOAA's High Resolution Rapid Refresh (Year 1 of 3)	67	$45,657	Coastal Hazards	NESDIS	Lindsey
Kelley	Amanda	Supplemental AFSC 339775	68	$101,939	Ecosystem Studies & Forecasting	OAR	Cross
Hinzman	Larry	Week of the Arctic - Conf Support	69	$73,733	Climate Change & Variability	OAR	Alford
West	Michael	Alaska Earthquake Center (AEC) Seismic Station Operations and Maintenance (CRESTnet)-Supplemental	71	$240,000	Coastal Hazards	NWS	Angove
Beaudreau	Anne	Evaluating the effects of habitat quality on YOY sablefish physiological condition to inform estimates of recruitment in the stock assessment	72	$15,321	Ecosystem Studies & Forecasting; Climate Change & Variability	NMFS	Marshak
Cahill	Cathy	Yukon River Breakup - 2017	73	$23,641	Climate Change & Variability	OAR	Hood
Pinchuk	Alexei	Trophic Interactions in Subarctic Pelagic Ecosystems: Fish, Medusae and Zooplankton	74	$82,695	Ecosystem Studies & Forecasting	NMFS	Cieciel
Alexeev	Vladimir	Implementing Interdisciplinary Approaches to Solve Societally Relevant Problems in Alaska through Education, Workforce Development and Partnerships	75	$184,222	Coastal Hazards	NMFS	Brix
Cahill	Cathy	Regional Rapid Response for Weather and Sea Ice Mapping	76	$368,653	Climate Change & Variability	OAR	Hood
Heinrichs	Thomas	Alaska Direct Broadcast - Sandy Sustainment and Bridge to Operations	77	$733,448	Ecosystem Studies & Forecasting	NESDIS	Goldberg
Kruse	Gordon	Gulf of Alaska Integrated Ecosystem Assessment Postdoctoral Research - Year 2 (part 1)	78	$64,878	Ecosystem Studies & Forecasting	NMFS	Moss
Walsh	John	Enhanced Tools and Training for Subseasonal to Seasonal Outlooks to Support Decision Makers for Potential High Impact Events at Higher Latitudes	79	$147,465	Climate Change & Variability	NWS	Petrescu
Richter-Me	Jacqueline	NOAA State of the Arctic Report - Year 2	80	$27,959	Climate Change & Variability	OAR	Baskins
Kruse	Gordon	Gulf of Alaska Integrated Ecosystem Assessment Postdoctoral Research - Year 2 (part 2)	81	$68,361	Ecosystem Studies & Forecasting	NMFS	Moss
		Total projects funded (including CI administration)		**$2,633,305**			
		Task I - Recovery		$206,045			
		Task I - Project Awards		$14,785			
		Task II & III awards		$2,412,475			

APPENDIX 2 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	12		12	12	12
Visiting Scientist	0				
Postdoctoral Fellow					
Research Support Staff	43	5	17	15	6
Administrative	3		1		2
Obtained NOAA employment within last year	2			1	1
Total (≥50 % NOAA Support)	9		3	6	3
Total		**5**	**33**	**34**	**24**
Employees (≥50 % NOAA Support	3	1	2		
Located in NOAA Lab	0				
Obtained NOAA employment within last year	0				
Undergraduate students	2	2			
Graduate students	7		6	1	
Total		**3**	**8**	**1**	**0**

APPENDIX 3 PUBLICATIONS

Summary table of publications during the current cooperative agreement NA13OAR4320056

	Institute Lead Author				
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Peer-reviewed	0	1	1	1	4
Non Peer-reviewed	0	0	1	0	10
Accepted for publication	0	1	1	0	0
	NOAA Lead Author				
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Peer-reviewed	0	0	2	1	1
Non Peer-reviewed	0	0	0	0	5
Accepted for publication	0	0	0	1	1
	Other Lead Author				
	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Peer-reviewed	0	1	12	4	3
Non Peer-reviewed	0	0	4	0	3
Accepted for publication	0	1	1	0	0

"Accepted" indicates in press peer-reviewed publications.

Year 1 = 1 July 2013-31 March 2014; Year 2 = 1 April 2014-31 March 2015; Year 3 = 1 April 2015-31 March 201; Year 4 = 1 April 2016 – 31 March 2017; Year 5 = 1 April 2017 – 31 March 2018

Peer-reviewed papers published, in press, or accepted for publication during the reporting period (submitted publications indicated by *)

2018

*Ahn, S.H., S.H. Lee, T.E. Whitledge, D.A. Stockwell, J.H. Lee and H.W. Lee. Submitted. Biochemical composition of phytoplankton in the Laptev and East Siberian seas during the summer, 2013. Journal of Geophysical Research Oceans.

Cross, J.N., Mathis, J.T., Pickart, R.S., and Bates, N.R., 2018. Formation and transport of corrosive water in the Pacific Arctic Region. Deep Sea Research II, in press.

*Iken K, Mueter F, Grebmeier JM, Cooper LW, Danielson S, Bluhm B. 2018: Does one size fit all? Observational design for epibenthos and fish assemblages in the Chukchi Sea. Submitted to Deep-Sea Res II.

*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, 2018: Submitted. Light-limited uptake rates of carbon and nitrogen of phytoplankton in the Laptev and the East Siberian seas. Geophysical Research Letters.

*Marsh, J.M., Mueter, F.J., Quinn II, T.J. Environmental and biological influences on the distribution and population dynamics of Arctic cod (*Boreogadus saida*) in the US Chukchi Sea. Prepared for submission to the Canadian Journal of Fisheries and Aquatic Sciences.

Shen, Y., R. Benner, K. Kaiser, C. Fichot and Terry E. Whitledge. 2018. Pan-Arctic distribution of bioavailable dissolved organic matter and linkages with productivity in ocean margins. Geophysical Research Letters, 45. https//doi.org/10.1002/2017GL076647.

Schollmeier T, Oliveira ACM, Wooller MJ, Iken K (2018) Tracing sea ice algae into various benthic feeding types on the Chukchi Sea shelf. Polar Biol 41(2):207-224.

2017

Cates, K., D.P. DeMaster, R.L. Brownell Jr, G. Silber, S. Gende, R. Leaper, F. Ritter, and S. Panigada. 2017. Strategic Plan to Mitigate the Impacts of Ship Strikes on Cetacean Populations: 2017-2020. IWC/66/CC20 CC Agenda Item 5.2. , available online: https://iwc.int/private/downloads/dr1UJzeCuNpAWs9Xf9caBw/IWC_Strategic_Plan_on_Ship_Strikes_Working_Group_FINAL.pdf.

Mundy, P. R., Sunnanå, K., Ingvaldsen, R., Marsh, J., Jarvis, T., Astthorsson, T., Hoel, A.H. (2017) *Synthesis of Knowledge on Fisheries Science in the Central Arctic* Fourth Meeting of Scientific Experts on Fish Stocks in the Central Arctic Ocean (4th FiSCAO), Tromso, Norway, September 26 - 28, 2016

Pickart, R.S., Grebmeier, J.M., McRaven, L., Mordy, C.W., Stabeno, P.J., Cross, J.N., Cooper, L.W.,Busy, M., Creamean, J., Bourbonnais, A., Collins, E., Moore, S., Wright, C., Hoover, B., and Kuletz, K., 2017. Distributed Biological Observatory – Northern Chukchi Integrated Study. Healy 1702 Cruise Report. Available at:
https://web.whoi.edu/healy-2017/wp-content/uploads/sites/101/2017/11/HLY1702_cruise_report.pdf.

Richter-Menge, J., J. E. Overland, J. T. Mathis, and E. Osborne, Eds., (2017) Arctic Report Card 2017, http://www.arctic.noaa.gov/Report-Card..

Richter-Menge, J. A. and J.T. Mathis, Eds., 2017: The Arctic [in "State of the Climate in 2016"]. Bull. Amer. Meteor. Soc., 98 (8), S129–S154, doi:10.1175/2017BAMSStateoftheClimate.1

Theses

Ganz, P.D. 2017. Estimability of time-varying natural mortality in groundfishes: covariates and hierarchical models. M.S. Thesis, University of Alaska Fairbanks, Fairbanks AK.

Presentations and other publications

2018

Cross, J.N., Pickart, R.S., Mathis, J.T., Mordy, C.W., Meinig, C., and Grebmeier, J.M., 2018. Ocean acidification in the Pacific Arctic and the Distributed Biological Observatory, 2011-2017. American Geophysical Union Ocean Sciences Meeting, Portland, OR, February 2018.

Komatsu, KK, Alexeev, VA, Repina IA and Tachibana Y, 2018: Poleward upgliding Siberian atmospheric rivers over sea ice heat up Arctic upper air, Scientific Reports, DOI: 10.1038/s41598-018-21159-6.

Krieger, J., A. Sreenivasan, R. Heintz, A. Beaudreau. 2018. What came first, the lipid or the length? Effects of Habitat Quality on YOY Sablefish (Anoplopoma fimbria) Physiological Condition. (Poster). Alaska Marine Science Symposium, Anchorage, AK and Western Groundfish Conference, Monterey, CA.

Hirtl, M., M. Stuefer, D. Arnold, C. Flandorfer, C. Maurer, S. Natali, B. Scherllin-Pirscher, 2018: Simulating the influence of aerosol feedback effects with WRF-Chem on surface- and vertical distributions of wind speed and temperature during the Eyjafjallajökull 2010 eruption, 2018 European Geosciences Union (EGU) Annual Meeting.

Monacci, N.M., Musilewicz, S., Cross, J.N., Evans, W., and Mathis, J.T., 2018. Alaska Ocean Acidification Mooring Network: 2013 – 2015. American Geophysical Union Ocean Sciences Meeting, February 2018.

Mueter, F.J. Arctic Gadids in a Changing Climate. Alaska Marine Science Symposium, Workshop on Arctic Gadids, Anchorage, Alaska, January 24, 2018.

2017

Cross, J.N., 2017. Ocean acidification in Alaska: Ecosystems and Economies. Southeast Alaska Fisheries Habitat Partnership, Southeast Alaska Watershed Coalition, and United Fishermen of Alaska, Juneau, AK, November 2017.

Cross, J.N., Mathis, J.T., Bates, N.R., and Pickart, R.S., 2017. Formation and transport of corrosive water in the Pacific Arctic Region. Ecosystem Studies of Arctic and Sub-Arctic Seas Open Science Meeting, Tromsø, Norway, June 2017.

Cross, J.N., Mathis, J.T., Foy, R., Hurst, T., Sigler, M., Dalton, R., Stone, R., 2017. US Arctic and Alaska Ocean Acidification: Current monitoring efforts, trends, and areas of highest concern. NOAA Ocean Acidification Program PI Meeting, Seattle, WA, January 2017.

Cross, J.N., Mathis, J.T., Monacci, N.M., 2017. Ocean acidification in Alaska: Ecosystem and Economies. Alaska State Legislature House Resources Committee, Juneau, AK, February 2017.

Ganz, P.D. 2017. What the heck are random effects? American Fisheries Society Alaska Chapter, Annual Meeting, March 21,2017.

Hinzman, L.D. University of Alaska to Host the 2017 Week of the Arctic. Witness the Arctic. Spring 2017 issue. https://www.arcus.org/witness-the-arctic/2017/5/highlight/1

Marsh, J.M. and F.J. Mueter. Environmental and biological influences on Polar cod (Boreogadus saida) in the eastern Chukchi Sea. ESSAS Open Science Meeting, Tromsø, Norway, June 12-15, 2017.

Marsh, J.M. and F.J. Mueter. Environmental influences on the southern distribution of Arctic cod. 31st Lowell Wakefield Symposium, Anchorage, Alaska, May 10, 2017.

Schollmeier T, Iken K, Wooller MJ, Belt S. 2017 Tracing the presence of sea ice algae in Arctic benthic consumers using the biomarker IP25. Poster at Alaska Marine Science Symposium, 22-25 Jan 2018, Anchorage AK.

Stuefer, M., P.W. Webley and M. Hirtl 2017: Improved Near Real Time WRF-Chem Volcanic Emission Prediction and Impacts of Ash Aerosol on Weather, Fall American Geophysical Union Meeting.

Sutton L, Iken K, Bluhm B. 2017. A comparison of functional diversity of two Alaskan arctic shelf systems. Poster at Alaska Marine Science Symposium, 22-25 Jan 2018, Anchorage AK.

Veerhusen, B., Cross, J.N., Williams, C., and Grondin, A., 2017. Is Ocean Acidification taking a toll on salmon? Panel, Pacific Marine Expo, Seattle, WA, November 2017.

APPENDIX 4 INDEX OF LEAD PRINCIPAL INVESTIGATORS

APPENDIX 5 LINKED PROPOSALS

Table of linked proposals during the current cooperative agreement NA13OAR4320056

Last Name	First Name	Project Title
Bhatt	**Uma**	**Seasonal Climate Forecasting Applied to Wildland Fire Management in Alaska**
Wirth	**Lisa**	**Adaptive, High Resolution Modeling for the Arctic Test Bed at NWS Alaska**
Hopcroft	**Russell**	**Long-term observations of Pacific-Arctic Zooplankton communitites**
Lovecraft	**Amy**	**Arctic Sustainability Research in support of the Arctic Policy and Governance Educational Partnership**
Walsh	**John**	**Arctic Indicators for Assessment and Enhanced Understanding**

Linked proposal annual reports as submitted to their respective program managers

Seasonal Climate Forecasting Applied to Wildland Fire Management in Alaska Progress Report

1. General Information

Project Title: **Seasonal Climate Forecasting Applied to Wildland Fire Management in Alaska**
PI/co-PI names and institutions: **Uma Bhatt, Peter Bieniek, Allison York (University of Alaska) and Peitao Peng (CPC/NOAA)**
Report Year: **Progress Report Fiscal Year 1 FY16**
Grant #: **NA16OAR4310142**

2. Main goals of the project, as outlined in the funded proposal

The overall project goal is to create, test, and provide specific forecast products that are not currently available for fire managers in Alaska on the 2-week to seasonal time scale.

- Increase the forecast lead-time for the Canadian Forest Fire Weather Index System (CFFWIS) in Alaska from the current 48-hours to several months by utilizing state-of-the-art seasonal forecast models (NMME) and sub-seasonal forecasts (GEFS).
- Evaluate lightning ignition risk (LIR) in Alaska and its forecast potential.

3. Results and accomplishments

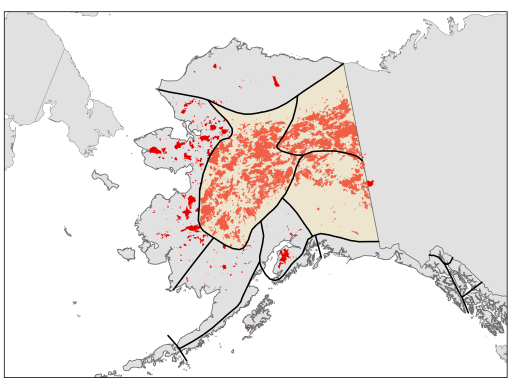

Figure 1. Map delineating Boreal Alaska (tan) identifies the study region for which forecasts are being developed. Fire history of acres burned from 1950-2016 are shown in red.

In 2015, Alaska fires constituted more than half the total acreage burned in the United States (9.2 million acres). While the impacts to humans in this sparsely populated state were not as devastating as in the western US, the costs were still quite high. The aim of this project is to employ seasonal forecasts to create products that help fire managers better prepare resource allocations for the upcoming wildland fire season. We employ the NMME over Boreal Alaska (Figure 1) to construct seasonal CFFWIS, which are widely used by the fire management community in Alaska. Currently, only 48-hour forecast CFFWIS are available and this study will expand available information from the 2-week to seasonal time scale.

The key index from the CFFWIS that we have investigated is the Buildup Index (BUI; Lawson and Armitage 2008) and represents potential fuel availability and flammability, based on cumulative scoring of daily temperature, relative humidity, and precipitation. High BUI values generally represent periods of high fire danger and BUI is often derived from meteorological station observations; however, gridded downscaled data are used here because observations in Alaska are temporally and spatially spotty. As part of another project, our group has dynamically downscaled ERA-Interim to 20-km over Alaska for the period 1979-2015. This data has been evaluated for temperature and precipitation, two key variables used in the CFFWIS. Downscaled temperature and precipitation were found to be more realistic compared to the coarse ERA-Interim because the complex terrain in Alaska (Bieniek et al. 2016) is better resolved at 20-km. The CFFWIS based on the 20-km dynamical downscaled ERA-Interim data serve as gridded 'observations' against which the forecasts are evaluated.

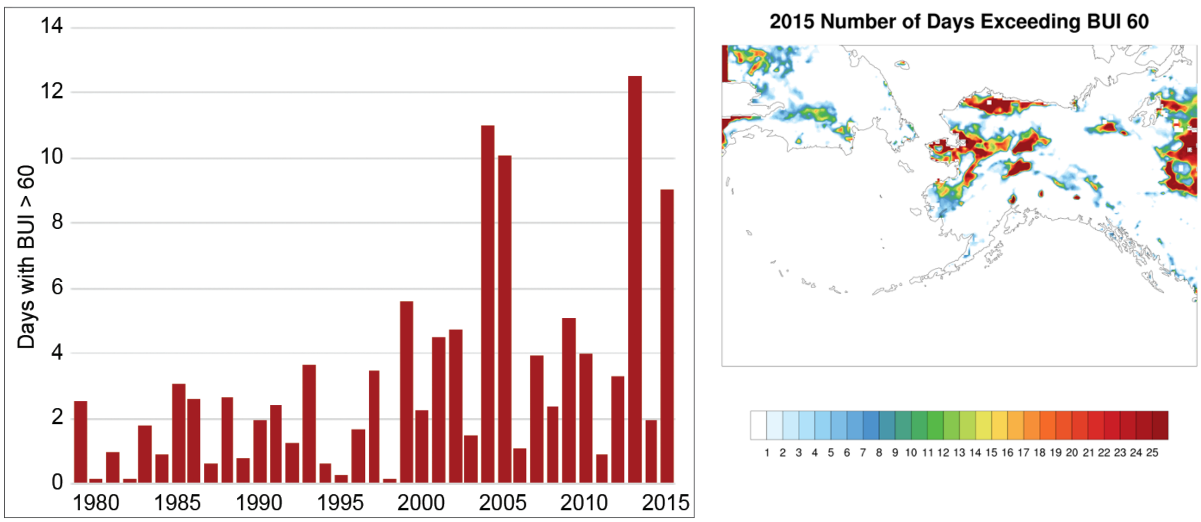

Figure 2. The left panel (Partain et al. 2016) shows a time series over Boreal Alaska of the average number of days that the BUI was above 60. Both panels use ERA-Interim dynamically downscaled data (Bieniek et al. 2016). The right panel displays the number of days in the summer of 2015 that the BUI exceeded 60.

BUI is well suited for describing most fire seasons in northern boreal regions so is widely used by managers in Canada and Alaska. BUI begins to increase after the snowmelt, reaches its peak in June–July, and declines thereafter. Figure 2 (left panel) displays a measure of seasonal BUI from April–September averaged over Boreal Alaska (Figure 1) lowlands (<600 m elevation) from 1979–2015. The BUI measure represents the number of days (averaged over forest grids) that BUI exceeded 60, which marks the threshold for high fire danger in Alaska (Ziel et al. 2015). The spatial pattern for 2015 is shown in Figure 2 (right panel). As an integrated metric, BUI effectively captures seasonal fire danger in Alaska, as per the large areas burned in 2004, 2015, and 2005 as is evident in the annual cycle of BUI (Figure 3). The exception is 2013, which, despite an extremely high BUI, had low fire activity because of few lightning strikes, highlighting ignitions as a necessary prerequisite for fires. This reinforces the need to focus on weather, fuels, and ignition provided by lightning when evaluating climate drivers of fire danger.

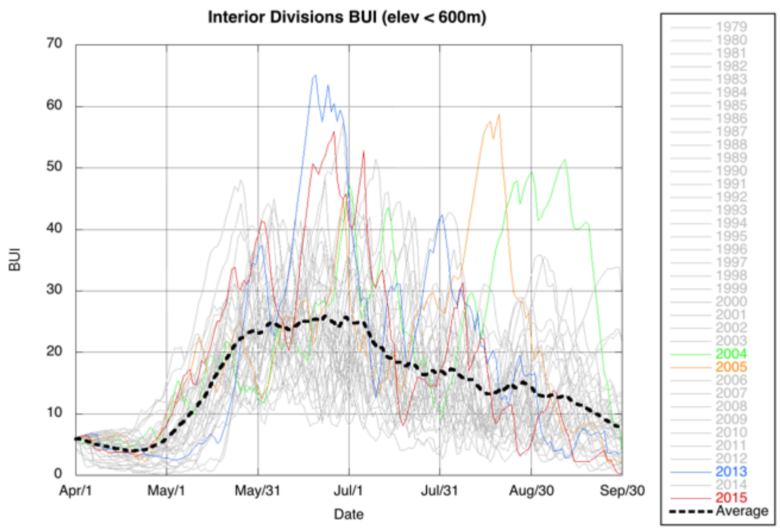

Figure 3. Annual curves of the seasonal cycle of BUI averaged over Boreal Alaska from the downscaled ERA-Interim.

We have evaluated the CFSv2 from the NMME suite of models for the March forecast, a decision driven by an important need for information by fire managers for resource use planning in spring. All of the CFFWIS indices (FFMC, DMC, DC, ISI, BUI, and FWI) have been calculated for the CFSv2 March forecasts from 1982-2017 and BUI has been evaluated in detail thus far.

The annual observed seasonal cycle of BUI (Figure 3) displays large variations throughout the season. Similarly, ensemble average seasonal curves from the March CFSv2 forecast (Figure 4, top panel) display similar large variability. High acreage burned years are highlighted in color and the climatological curve is shown in dashed black. Some features agree with observed acres burned: above average BUI late (early) in the season in 2004 (2015). The year 2013 stands out as above normal for BUI in both the observations and the forecasts. The CFSv2 BUI magnitudes are smaller than the observed (Figure 4, bottom panel) which is in part attributed to ensemble averaging. The peak of the BUI is shifted to July in the CFSv2 compared to the observed seasonal cycle. The shift in the peak is likely because the early season BUI is too low in the CFSv2. We think it is because the spring temperatures in the boundary layer have a negative bias over Alaska in the CFSv2. The next step to providing a more robust March forecast is to bias correct the temperature and precipitation prior to calculating the CFFWIS. The next steps are discussed in the Section 9 Future Work of this document.

Alaska has a several decade-long record of lightning observations but the time series have discontinuities due to system upgrades. The current stations are shown in Figure 5 (top panel) and provide adequate coverage and fairly high accuracy of strike location. The major system upgrade in 2012 began counting individual flashes so strike multipliers retained in the historical data 1986-2011 were used to combine the periods (Figure 5, lower left panel). The monthly strike counts were placed on the 20km downscaling grid for ease of comparison and analysis. Additional improvements in the homogenization approach are still being explored since the trends are preliminary.

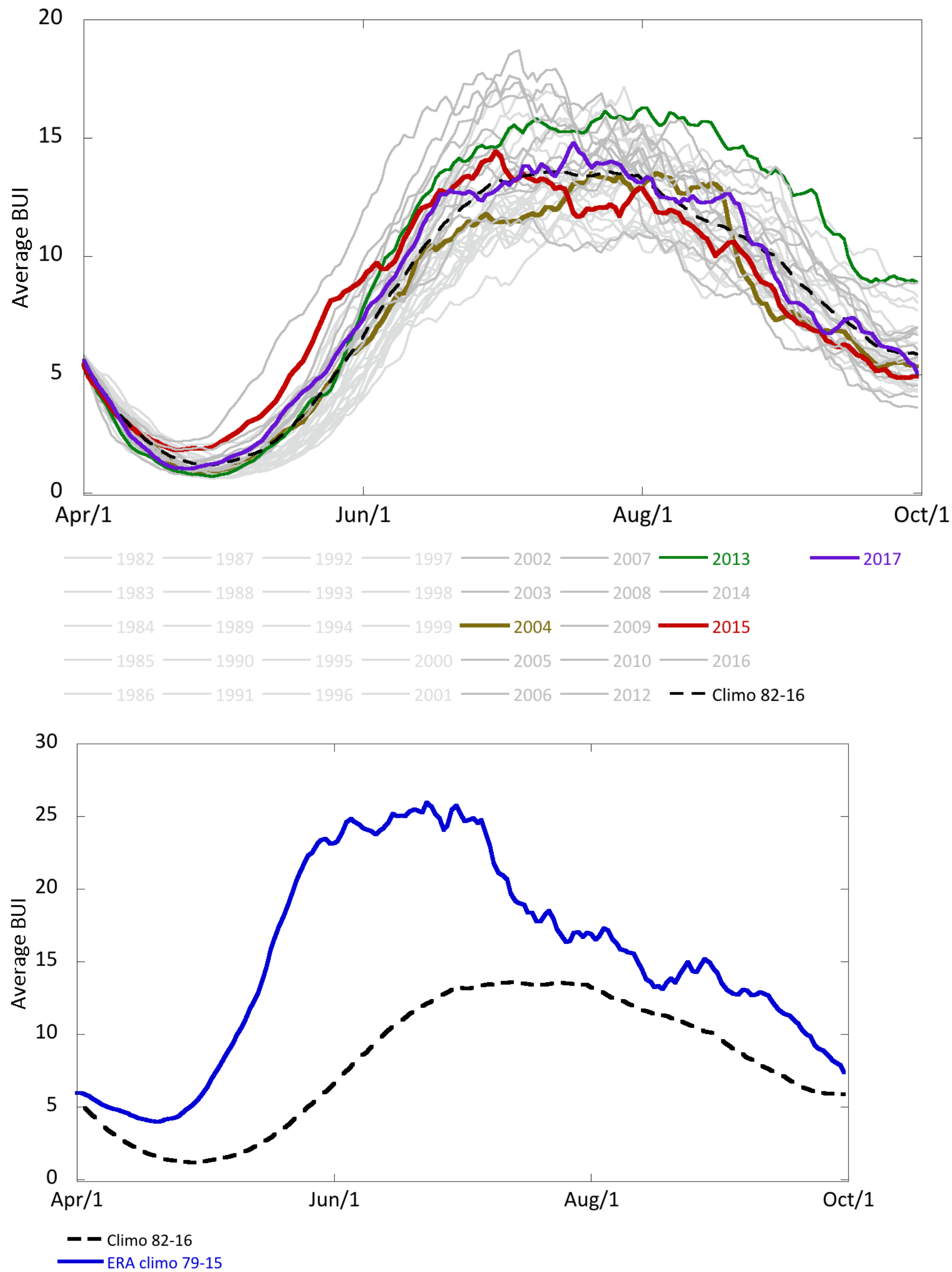

Figure 4. Top panel shows annual curves of the seasonal cycle of BUI averaged over Boreal Alaska from the March CFSv2 forecasts of the NMME. The bottom panel compares the climatological curves BUI from the March CFSv2 forecasts (blue) to downscaled ERA-interim (black dashed).

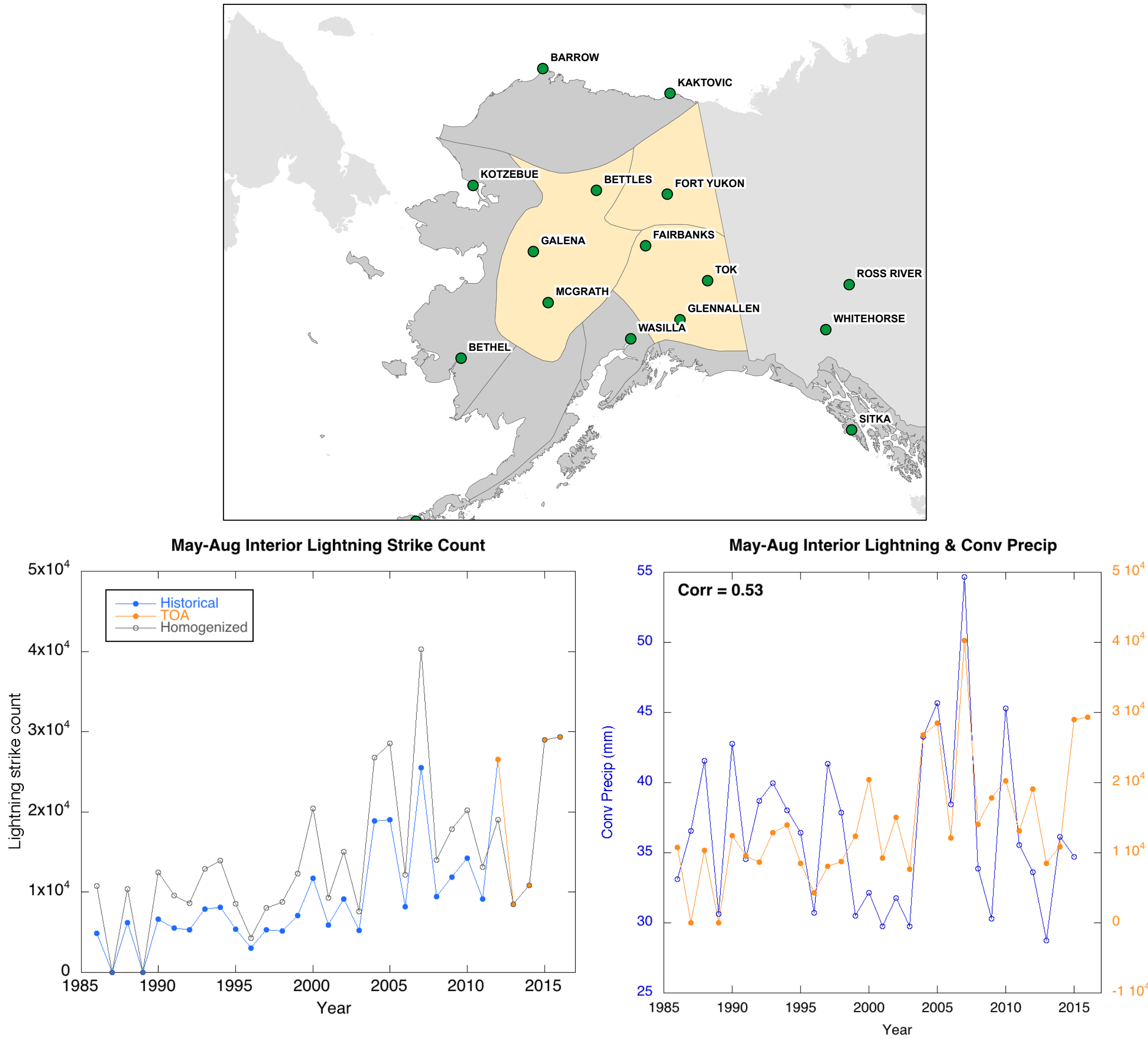

Figure 5. Top panel shows the location of lightning observation system. Bottom left shows the time series of lightning strike counts for Alaska. The bottom right panel shows the homogenized lightning strike count (orange) along with convective precipitation.

The homogenized lightning strike data compares favorably with the convective precipitation from ERA-Interim downscaled data (Figure 5, bottom right panel). More specifically, May-Aug Interior average convective precipitation is correlated at 0.53 with seasonal lightning totals. The years with highest lightning activity in 2004-5 were also high fire years while 2006 corresponded to high convective precipitation. This research will explore whether convective precipitation from the forecast models can be used to forecast summer lightning potential. Further details on the next steps are in Section 9.

With the goal of producing an operationally useful product our team met with fire managers several times in the past year and the interactions are summarized below.

- October 2016: Interagency Fall Review and Fire Science Workshop. Uma Bhatt, Peter Bieniek, Robert Ziel, Sarah Mitchell (MS student) and Alison York attended the meetings and discussed project plans informally with agency personnel.

- March 2017: Spring Interagency Fire Management Officers Meeting and Fire Science Workshop. Peter Bieniek presented preliminary results from the prediction project for the 2017 fire season. Uma Bhatt, Robert Ziel, Akila Sampath (PhD student) and Alison York also attended and updated agency personnel on project plans.

References

Bieniek, PA, US Bhatt, JE Walsh, TS Rupp, J Zhang, JR Krieger, and RT Lader, 2016: Dynamical downscaling of ERA-Interim temperature and precipitation for Alaska, J. Applied Meteorology and Climatology, 55, 635–654.

Bieniek, PA, JE Walsh, RL Thoman, and US Bhatt, 2014: Using climate divisions to analyze variations and trends in Alaska temperature and precipitation. *J. Climate*, 27, 2800–2818, doi:10.1175 /JCLI-D-13-00342.1.

Lawson, BD and OB Armitage, 2008: Weather guide for the Canadian forest re danger rating system. Canadian Forest Service, 73 pp. [Available online at http:// re.ak.blm.gov/content/weather /2008%20CFFDRS%20Weather%20Guide.pdf.]

Partain, JL, S Alden, US Bhatt, PA Bieniek, BR Brettschneider, RT Lader, PQ Olsson, TS Rupp, H Strader, RL Thoman, JE Walsh, AD York, and RH Ziel, 2016: *An assessment of the role of anthropogenic climate change in the Alaska fire season of 2015*, Bulletin of the American Meteorological Society Special Report Explaining Extreme Events of 2015 from a Climate Perspective, S14-S18 pp.

Ziel, RH., and Coauthors; 2015: Modeling re growth potential by emphasizing significant growth events: characterizing climatology of re growth days in Alaska's boreal forest. *11th Symp. on Fire and Forest Meteorology*, Minneapolis MN, Amer. Meteor. Soc., 1.2. [Available online at https://ams.confex.com /ams/11FIRE/webprogram/Paper272864.html.]

4. Highlights of Accomplishments

- We validated the CFFWIS code (NCL + FORTRAN) with fire managers excel calculations based on station data.
- We applied CFFWIS to CFSv2 forecasts initialized in March as part of NMME 1982-2016 to develop a climatology of Interior Alaska indices.
- P. Bieniek homogenized the Alaska lightning data and found a robust relationship with convective precipitation.
- We participated in several project and stakeholder meetings. In October 2016 U. Bhatt, P. Bieniek, R. Ziel, S. Mitchell and A. York attended the Interagency Fall Review and Fire Science Workshop to discuss project plans informally with agency personnel. In March 2017 at the Spring Interagency Fire Management Officers Meeting and Fire Science Workshop, P. Bieniek presented preliminary results from the prediction project for the 2017 fire season. U. Bhatt, R. Ziel, A. Sampath and A. York also attended and updated agency personnel on project plans. We also had a project team meeting at CPASW including P.

Peng (CPC/NOAA) to provide all with an overview of the project.

- We presented results on the BUI with downscaled ERA Interim and NMME CFS at the Climate Diagnostics Workshop (September 2016), AGU (December 2016), and at 15th annual Climate Prediction Applications Science Workshop (CPASW).
- U. Bhatt incorporated material from this project in a course *Applied Arctic Climate Problems: From Science to Actionable Policy* in Spring 2017. Some of the students were able to attend the CPASW meeting and present their final project on the recommendation to update the fire management plan for Arctic National Wildlife Refuge

5. Transitions to Applications

We presented some visual products at the March 2017 wildland fire management meeting in Fairbanks. It was informative because we learned that we must plot the ensemble spread for the 2017 forecast differently as the managers found it confusing. We will continue to work with fire managers to assess their need and match them with what we can provide from the 2 week to seasonal forecasts to identify products. We will also work with CPC through Dr. P. Peng to operationalize identified products.

6. Publications from the Project

Published

Partain, JL, S Alden, US Bhatt, PA Bieniek, BR Brettschneider, RT Lader, PQ Olsson, TS Rupp, H Strader, RL Thoman, JE Walsh, AD York, and RH Ziel, 2016: *An assessment of the role of anthropogenic climate change in the Alaska fire season of 2015*, Bulletin of the American Meteorological Society Special Report Explaining Extreme Events of 2015 from a Climate Perspective, S14-S18 pp.

In-Prep

PA Bieniek et al. 2017: Linking Alaska lightning data to large-scale climate drivers. in prep for J. Climate.

A Sampath et al. 2018: Application of Canadian Fire Indices using NMME to seasonal wildland fire in Alaska. in prep for J. Applied Meteorology and Climatology.

7. PI Contact Information

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8. Budget for Coming Year

We do not anticipate any changes to the budget for the next year from what was submitted with the proposal. The key personnel will continue to work on the project (Bhatt, Bieniek and York) and there is a student in place (A. Sampath).

We hired an MS student (S. Mitchell) in Fall 2017 who decided to leave graduate school for personal reasons at the end of the semester in December 2016. Fortunately, we were able to hire a PhD student (A. Sampath) who started in January 2017 to work on this project. The level of computing required for this research necessitated a student who already had an MS, so the change has benefitted the project. We had budgeted for an MS student and PhD students are paid a bit more so we will have support for Ms. Sampath through most but not all of the summer of 2018 on this project. This work will form one of the components of her PhD thesis, which will be a paper thesis (published or submitted manuscripts).

9. Future Work

The next steps in this research is to develop a bias correction method to apply to the CFSv2 BUI forecasts by correcting the temperature and precipitation data for the March initialized forecast. Next the April and May CFSv2 forecasts will be investigated by applying the bias correction method from the beginning. There is another technical challenge of how to initialize BUI values on May 1 and June 1 since BUI is a cumulative index. This will be followed by analyzing the other models in the NMME suite, which should be faster since we will have had worked through the trouble spots using the CFSv2. We will continue to work with the fire managers through the boundary organization (Alaska Fire Science Consortium) to determine the most useful types of products. Our goal is to work with CPC to make the chosen products operationally available for the CFSv2 seasonal forecasts. The skill of the forecasts will be evaluated.

The 2-week forecasts of the CFFWIS will be developed beginning this summer using the GEFS model (originally, we planned on using CFS). The hindcast will be evaluated and then the forecasts for 2017 will be investigated to determines the skill.

The risk of ignition due to lightning will be developed further to include the forecast models after a thorough analysis with the observations has been completed. A product will be developed for the fire managers if the skill is sufficiently high.

CSTAR Progress Report

Adaptive, High Resolution Modeling for the Arctic Test Bed at NWS Alaska

Reporting Period: 01 May - 31 October 2017

Grant number: NA16NWS4680006

PI: Lisa Wirth (University of Alaska Fairbanks)

Co-I's: Don Morton (Boreal Scientific Computing, LLC); Jiang Zhu (UAF)

Highlights

- The project continues to make progress amidst significant technical hurdles. A diversion of our computational efforts from the Amazon Cloud to NCAR's cheyenne has been problematic, and we are charting a long-term course back to AWS for our stable computing needs. The extra efforts required to resolve these issues have detracted from other key project goals.
- The deployment of the automated HRRRAK Verification system has progressed to the point where we are now batch processing the creation of Matched Pair (MPR) statistics files from observations and HRRRAK forecasts dating back to last summer. This is all being done in the Amazon Cloud.
- As an integrated part of this project, we do satellite data assimilation for regional weather models. We developed and implemented codes to append NUCAPS profile data and VIIRS wind data to prepbufr file.
- Dr. Zhu reported to Developmental Testbed Center to begin his visiting scientist project, related to this project.
- Dr. Morton presented a poster at the 2017 annual meeting of the National Weather Association, with material that relates to the computational infrastructure for this project.

CSTAR Progress Reporting Items

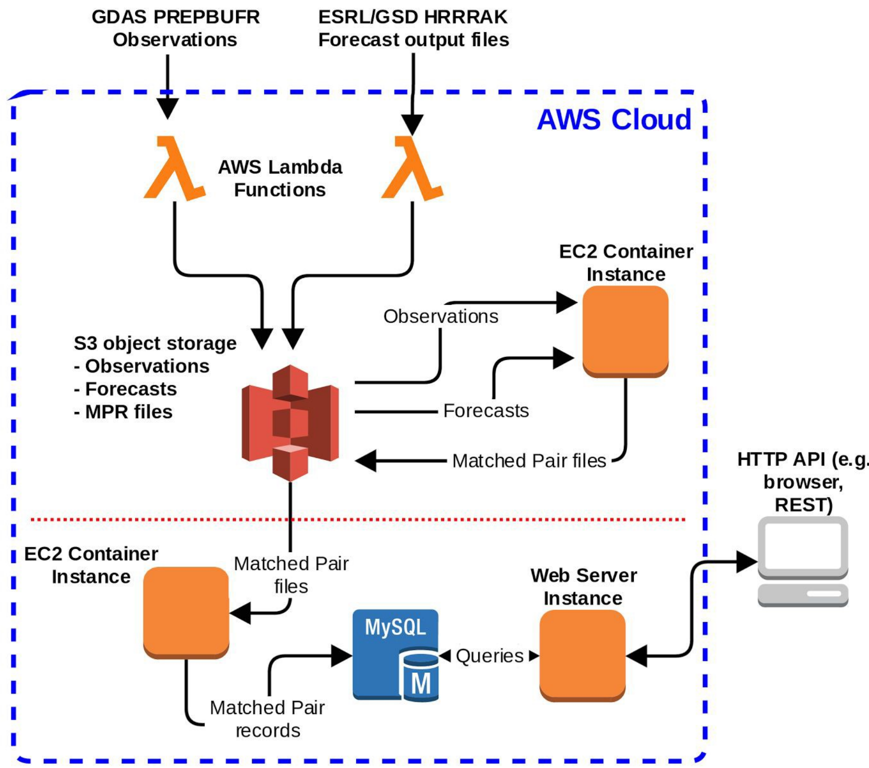
Key scientific accomplishments

1. Despite a number of computational issues discussed in Section 2 of this report, additional progress has been made in the provisioning of complete WRF systems in a standardized way on multiple architectures, so that researchers are communicating with respect to a common modeling environment. The provisioning work was extended to the CISL supercomputer, *cheyenne*, in the form of a Python program (given the lack of support for more popular provisioning tools). The HRRR collaborators at ESRL/GSD thought this was a great idea and expressed interest in using it themselves. The software is currently versioned in a private github repository, but a snapshot of the system is available at

   http://borealscicomp.com/CSTAR_HRRRAK/hrrr-provision-snapsh ot-2017-10-28/

   Again, with reference to computational problems discussed in Section 2 of this report, we are planning to backtrack some and place additional emphasis on the provisioning of these systems in the Amazon Web Services (AWS) cloud environments. Recent discussion with others in the NOAA R2O and O2R community suggests that this ability to replicate modeling environments in a standard and portable way is of increasing interest, and viewed as a way to better connect the research and operations computational activities. Therefore, in addition to performing this exploratory work out of necessity, we are hopeful that the broader community will benefit from our experiences and products.

2. Though behind schedule (due to need to concentrate effort on computational issues listed below), we have made significant progress in the last six months towards implementing the HRRR-Alaska automated verification system within the AWS environment. The status at this point is that we have completed development of the software ecosystem that allows us to regularly perform comparisons of observations and HRRR-Alaska forecasts, producing and storing the Matched Pair (MPR) statistics files for each forecast. This is depicted in the following graphic - everything above the red-dashed line has been implemented, and is currently being used to process HRRR Alaska forecasts dating back to Summer 2017.



The components of this ecosystem are designed to operate independently of each other, increasing potential flexibility. Components include:

- Scheduled Lambda functions that retrieve observation and forecast files on a timely basis, and save them as S3 storage objects for later processing. This staging is especially important because HRRR-Alaska forecast files are typically available for less than 24 hours after a model run and the observations needed to verify the last hours of a forecast are generally not available for well over 36 hours. Storage of these objects is relatively low-cost using S3, and is significantly cheaper if the objects are migrated to Amazon's Glacier storage for archiving.

- A *hrrrak_postproc* Docker container service that, given a forecast file and observation file (available in S3, or elsewhere), will run tools in DTC's Model Evaluation Tools

(MET) package to produce matched pair statistics, and then store resulting files in S3 for further downstream processing (insertion into database, possible plotting, etc.). The container service leverages the substantial work performed by DTC in publicly distributing a fully functional Docker container with the MET environment. This is easily used as a base image for our own system, eliminating any need for us to configure our own MET environment.

Through this containerization and virtualization, the software environments can be deployed on a wide range of environments, including Windows, Mac OS, Linux, and numerous cloud providers.

In the AWS system, a virtual machine is first deployed as a container instance (a virtual host capable of running containers), and containers may be launched on this instance - from a variety of internal or external hosts - to perform the actions required to generate a single observation/forecast comparison, as follows:

```
$ docker-machine ls
NAME              ACTIVE   DRIVER      STATE     URL
SWARM   DOCKER    ERRORS
hrrrak-postproc   *        amazonec2   Running   tcp://34.214.223.197:2376
v1.13.0

$ docker run -it borealscicomp/hrrrak_postproc /postproc_code/verify.py --obs
s3://ginacstar-operational-input/gdas_prepbufr_obs/20170708/gdas1.t00z.prepbufr.
nr --fcst
s3://ginacstar-operational-input/gsd_hrrrak_wrfprs/2017070800/1718900000000
--timestamp 201707080000 --fcststart 2017070800
```

- (Still needs full implementation) A Lambda function or Docker container service to go through a specified MPR file (stored on S3 as a result of the hrrrak_postproc action described above) and inject the comparisons into an Amazon RDS database. We have prototyped this already, and understand how to set up the RDS databases and interface with them programmatically through Python tools. An initial implementation will be somewhat simplistic in database design, but GINA will be contributing efforts to a more sensible database design.
- (Still needs implementation) A simple web server running - presumably - in AWS to serve as a RESTful interface to the database.

3. Implemented codes to append NUCAPS and VIIRS wind data to

observation prepbbufr file. GSI calculates the updated model initial field by intaking a background initial field, a global or regional prepbufr-format observation file, and many other observation files. NUCPAS profile and wind data, both are NETCDF format, can not be accepted by GSI directly. We can treat these satellite retrieval data as observation data, append these retrieval data into the observation data. The codes read NETCDF-format NUCPAS profile and VIIRS wind data file, and append these retrieval data into a prepbufr-format observation file.

Any issues delaying current or future progress

4. Coordination with ESRL/GSD to run their highly customized HRRR-Alaska on our own has proven to be difficult. We had made substantial progress in building Amazon Cloud (AWS) images based on their most recent code base, but the dynamic nature of the code resulted in a number of ongoing porting issues, along with the tedious process of getting data from the HRRR Alaska computers at ESRL/GSD to AWS storage. With Dr. Zhu's award of a Developmental Testbed Center visiting researcher opportunity, we were able to gain access to the NCAR CISL computing systems (*yellowstone* and *cheyenne*) - it was assumed that using these systems would provide us with a more GSD-like environment so that we could more closely collaborate with GSD, and that file transfers would be more straightforward.
5. The experiences in the CISL environment, however, have been difficult, and we are preparing to partially backtrack to our initial plan of using the Amazon Cloud environment. A sizable amount of time was spent trying to replicate the ESRL/GSD system (run on NOAA's *theia*) on *yellowstone*. The porting was further complicated by the need to accommodate additional customizations in the continually evolving HRRR code. Finally, when things were beginning to come together, it was determined that we should be working on the newer, but not fully-tested, *cheyenne*, given that *yellowstone* is being retired at the end of this calendar year. Further difficulties in deploying the HRRR code on *cheyenne* for the first time became too problematic, that we reached a decision with ESRL/GSD that we would try to run our case studies with "standard" WRF software, at least until we had been able to do something successful.
6. The experience we had gained in provisioning WRF systems in AWS came to fruition on *cheyenne*, allowing us to standardize the provisioning and testing of the WRF systems. Through this standardization we could all be assured that we were using exactly the same environment, eliminating

the confusion that can result when different users have even slightly different software configurations. The current status of the work on *cheyenne* is that we have finally been able to start configuring and running our initial ceiling and visibility test cases on a HRRR-Alaska domain. Unfortunately, *cheyenne* itself has been experiencing long and severe outages, and this has stalled us in our continued progress on the case studies. The current status is that cheyenne came back up in mid-November, and we have been able to start running test cases. Procedures are documented at

7. https://sites.google.com/a/borealscicomp.com/hrrrak/home/shared-spaces/computational-resources/installing-and-running-a-standard-wrf-system-on-cheyenne

Given the frustrations, along with the realization that we only have access to CISL resources because of Dr. Zhu's DTC award, which ends in April 2018, we will continue the work we had started last year towards using AWS as our modeling platform. We will continue to utilize *cheyenne* when possible, given its vast computational and storage resources, but we need to insure that we can continue without access to such resources and, experience has suggested that the AWS resources, though not perfect, present the most stable and flexible environment for us to proceed.

Interactions with NOAA scientists at WFO's, NCEP Centers, Regional Offices, etc.

8. Dr. Zhu received a visiting scientist award from NOAA DTC. The goal is to study polar wind data assimilation in the HRRR-Alaska model. Dr. Zhu did the first visit to DTC from May 22 to June 2, 2017. The purpose of this trip was to set up the HRRR-Alaska model to run in retrospective mode on UCAR HPC systems, Yellowstone and Cheyenne. During his two week visiting period, Dr. Zhu worked on building the HRRR-Alaska model on Yellowstone and Cheyenne HPC system with the help of NOAA staff Ming Hu, Trevor Alcott, and Chunhua Zhou. Dr. Zhu also learned to run the model with rocoto scheduler. Due to the consistent change of source code of HRRR-Alaska, Dr. Zhu was not able to build a complete model on Cheyenne while he was there. For the purpose of continuation of the study, we agreed to implement HRRR-Alaska model on AWS cloud.

9. Morton presented a poster, *Cloud-based NWP for multiple on-*

demand experiments, ensembles and rapid event response, at the 2017 annual meeting of the National Weather Association in September 2017. The specific work presented in the poster was outside the realm of this CSTAR project, but many of the computational issues behind the work have been addressed while dealing with the computational needs of the project. The poster is available at

http://www.borealscicomp.com/Miscellaneous/MortonPubs/NWA2017/Morton-NWA2017.pdf

10. Morton also attended on his own, but with ties to the CSTAR project, *Building a Weather-Ready Nation by Transitioning Academic Research into Operations Workshop*, held on November 1-2, 2017, at the National Center for Weather and Climate Prediction, College Park, Maryland.

11. The group continues to interact with forecasters in the Alaska Region, posting reports of HRRR-Alaska performance in the project web pages - https://sites.google.com/a/borealscicomp.com/hrrrak/home/model-assessments-by-users

Progress against milestones/schedules in proposal

Original and modified milestones are presented at the bottom of https://sites.google.com/a/borealscicomp.com/hrrrak/home/shared-spaces/project-planning-documents/summer-2016-initial-planning

Tasks and outcomes -- status summary

- [in progress; 90% complete] Scoping, understanding visions and directions of the CSTAR / ARH / NOAA team
- [in progress; 80% complete] Decide on and deploy and test any of the computational resources we are going to be using
- [in progress; 90% complete] Initial deployment of model verification structure
- [pending; 0% complete] Development of additional post-products from the HRRRAK, of interest to Alaska entities
- [in progress; 90% complete] Development of a workflow for performing case studies - in particular, data acquisition and storage
- [in progress; 30% complete] Pre-processing workflow for any potential data to be test-assimilated.
- [in progress; 60% complete] Performance of an initial "shakedown"

case study to understand current strengths and weaknesses for execution of future case studies

Any previously unreported changes to the execution of the originally submitted proposal

None to report

Any outcomes that could be transitioned or offered to operations (previous outcomes can be repeated)

Although "not ready for prime time," the work being performed in containerization, virtualization, and provisioning appears to be in line with the vision that others in NOAA IT seem to have about building common, standardized environments that allow research and operations to work together without having to undergo the difficulties in sharing a common physical computing environment. Like the work being done at DTC in containerization, our work allows for models and atmospheric software to be run on a wide range of platforms, including the Amazon Cloud.

Operating environments are provisioned in a way that allows new users to access well-tested, functional systems, just as if they had bought a new computer with all software installed, configured and tested.

The extension of our work into the Amazon Cloud, though born of necessity, is a continuing demonstration of the flexibility and economy of many R2O and O2R activities that can be supported in these environments. Users are no longer dependent on custom configurations of machines like *cheyenne*, and have the flexibility to scale their computations up and down as needs dictate.

As we proceed in this project, we believe the products we can offer will be more concrete.

Critical budget issues (separate financial forms are required)

None to report

Long-term observations of Pacific-Arctic zooplankton communities 2015-2020

Russell Hopcroft (lead PI)
Institute of Marine Science, University of Alaska Fairbanks

Ksenia Kosobokova (Russian Partner)
PP Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow

NOAA Goals: Healthy Oceans; Climate Adaptation & Mitigation

Total funding request: $75,000 ($33,000 returned to NOAA)

Budget period: 01-Aug 2016 to 31-July-2017

Objectives

We originally proposed repeated comprehensive surveys of zooplankton communities in the Bering Strait and Chukchi Sea to understand the transport patterns of Pacific zooplankton into the Arctic and build time-series to assess ecosystem change in this climatically sensitive region. The census was to involve a combination of traditional taxonomic enumeration and identification, along with continued molecular sequencing and photographic documentation of the species collected by several types of plankton nets. This proposal built on work conducted since 2003 in collaboration with US and Russian investigators during the previous, multi-disciplinary RUSALCA field program and the RUSALCA synthesis effort. The synergy with the established RUSALCA program added special strength to the proposal because it (1) capitalized on established working relationships between the PI and both US and Russian collaborators; (2) maintained consistency in sampling approaches; (3) sustained unified group interest in targeted regions for continued time-series sampling; and (4) established new regions of interest for the "next generation RUSALCA program" such as an extension of sampling on the northern Chukchi shelf and exploration of the shelf/slope region in the western Chukchi Sea and eastern East Siberian Sea.

Shifts in ARP priorities mid-2016, required adjustment to the original statement of work submitted in 2014, in particular a shift from the stations utilized by the RUSALCA program to those employed by the Distributed Biological Observatory (DBO). Secondarily, a shift in the funding duration limited this effort to a single year, after which NOAA choose to use their own investigators to continue zooplankton studies. Due to NOAAs cancellation of cruises proposed for 2015 and 2016, we collaborated with colleagues at NOAA to obtain samples in the northeastern Chukchi occupying an extended DBO-4 during early September 2016 (Fig. 1). We continued use of the same plankton mesh sizes as in previous years, but using tandem 150/505um Bongo-style plankton nets. One side of each Bongo was retained by Janet Duff-Anderson at AFSC for larval fish analysis, and the other side was sent to UAF for zooplankton processing. Analysis procedures were the same as shared by AMBON, CSESP and RUSALCA. Both space and ship time limitations lead to reduced sampling effort and elimination of the rate measurements described in the original proposal.

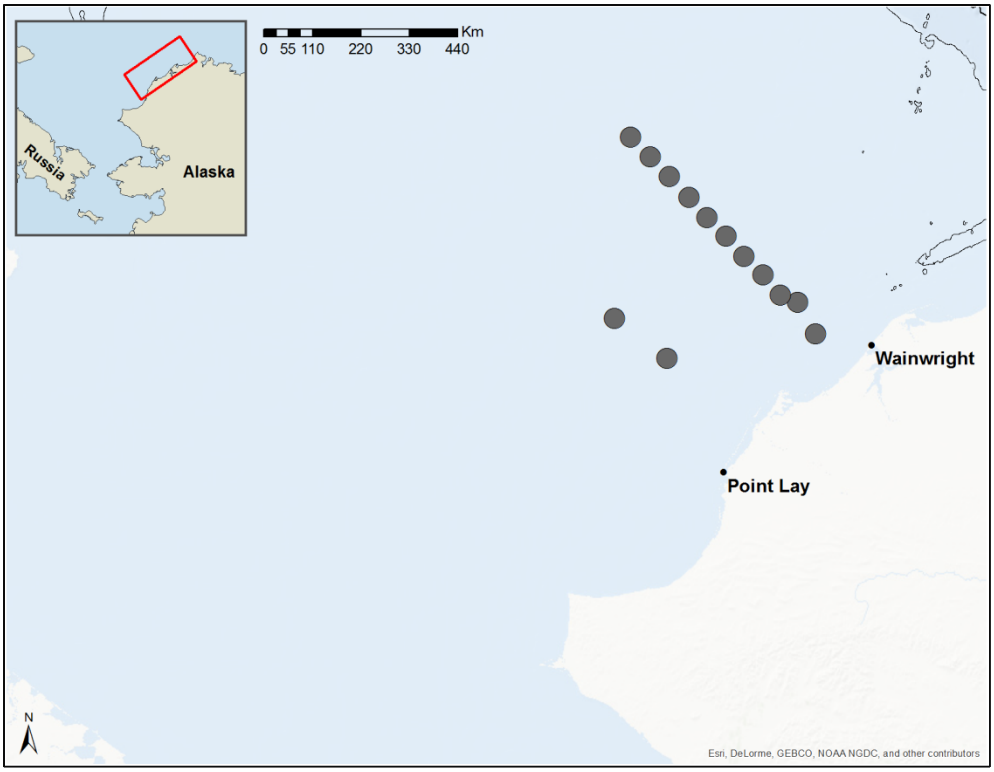
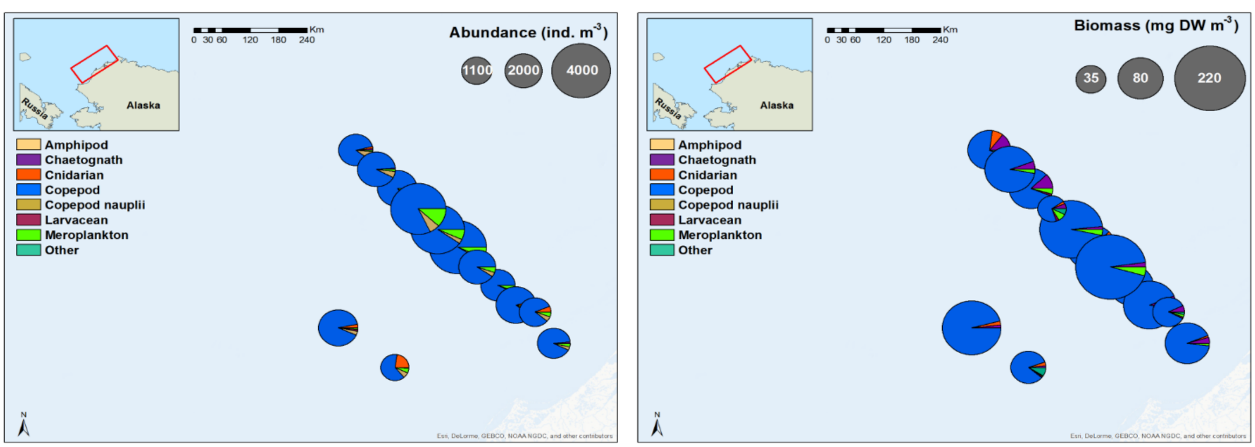


Figure 1. Map showing NOAA's *Altima* 2016 collections available for this report.

Research accomplishments/highlights

The community captured by the 150 µm net was dominated by copepods in terms of both abundance and biomass (Fig. 2). The copepod community primarily consisted of *Oithona similis*, *Pseudocalanus* spp., and *Calanus* sp. (Fig. 3). Less dominant copepod taxa included *Acartia longiremis*, *Centropages abdominalis*, and *Triconia borealis*.

Figure 2. Total abundance (left) and biomass (right) from the 150 µm net superimposed with relative



contributions of major zooplankton groups.

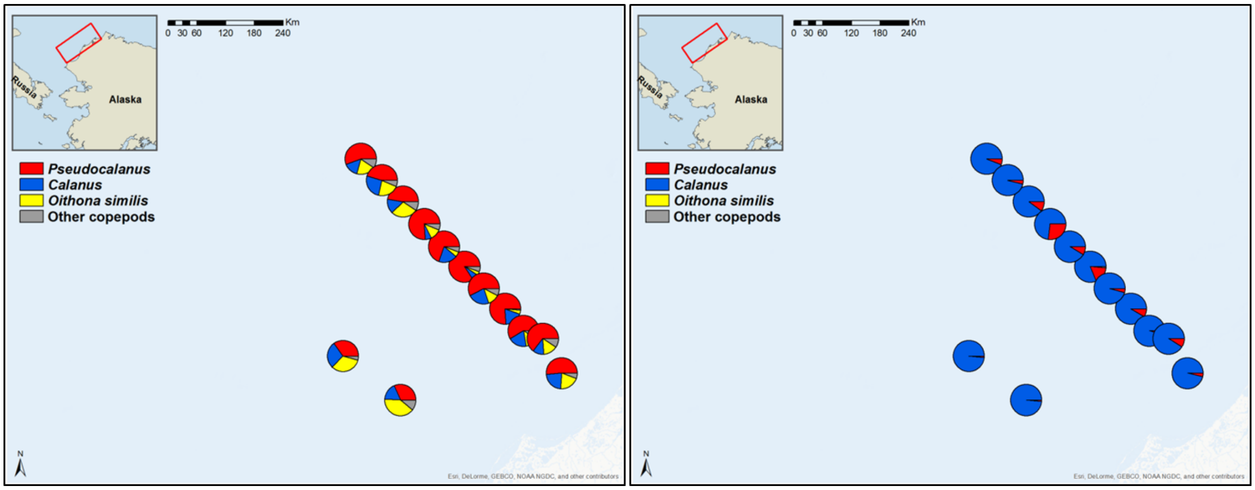


Figure 3. Relative contributions of dominant copepod taxa in terms of abundance (left) and biomass (right) from the150 µm net.

The community captured by the 505 µm net was dominated by copepods (Fig. 4), primarily *Calanus* sp. (Fig. 5), with a mean abundance of 302 ind. m^{-3}. *Calanus* was fairly evenly distributed across the study area with no immediate spatial pattern (Fig. 6). The Pacific expatriate *Eucalanus bungii* was detected at extremely low densities at a few stations. Other contributors to the community captured by the 505 µm net included decapod larvae and the euphausiid *Thysanoessa raschi*. We also observed several amphipod taxa, including *Themisto pacifica, T. libellula*, *Eusirus* sp., *Hyperoche* sp., *Onisimus* sp., and *Apherusa* sp. Dominant non-crustacean taxa included *Oikopleura vanhoeffeni*, *Aglantha digitale*, and *Parasagitta elegans*.

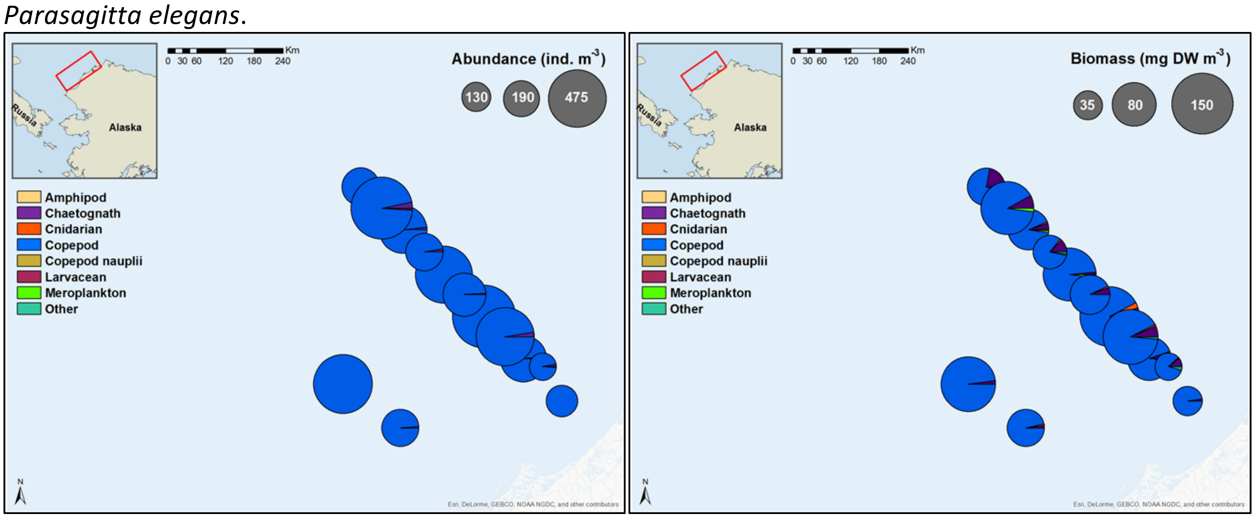


Figure 4. Total abundance (left) and biomass (right) from the 505 µm net superimposed with relative contributions of major zooplankton groups.

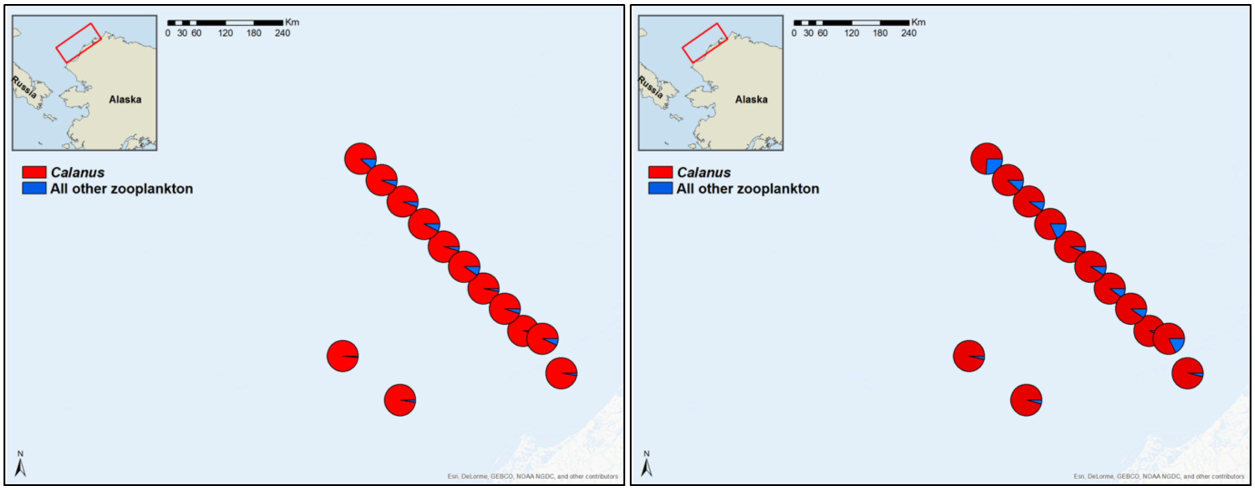


Figure 5. Relative contribution of *Calanus* to zooplankton community in terms of abundance (left) and biomass (right) from the 505 μm net.

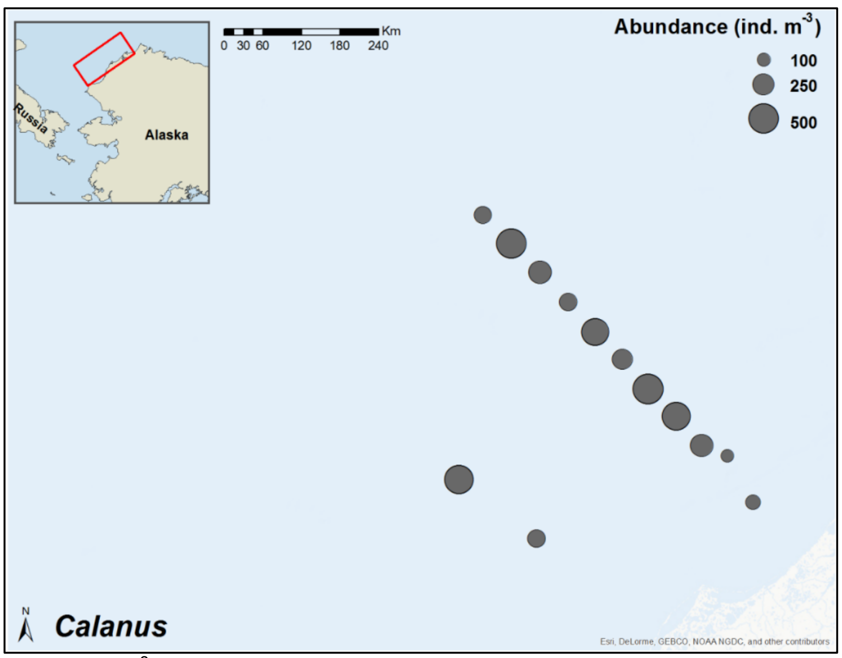


Figure 6. Abundance (ind. m^{-3}) of *Calanus* from the 505 μm net across the 2016 survey area.

Overall, the faunal character observed during the 2016 field season was generally of a sub-Arctic Pacific/Bering Sea affinity, consistent with that observed during previous surveys in this northeastern Chukchi Sea (Questel *et al.*, 2013) and the greater Chukchi region (Ershova *et al.*, 2015a; Eisner *et al.*, 2013; Pinchuk & Eisner, 2017). All of these studies demonstrate the strong relationship between zooplankton community composition and water masses. These samples extend observations collected during the industry-sponsored CSESP building a multi-year dataset in the northeastern Chukchi Sea spanning from 2008-present (Fig. 7) to which the 2017 AMBON cruise will add a tenth year of observations. Our data shows that both of keystone species in this region (*Calanus glacialis* and *Pseudocalanus* spp.) had high abundance during 2016. Although the northeastern Chukchi has seen an explosion in oceanographic study over the past decade, long-term zooplankton datasets in this region are rare, and essential during this period of rapid climactic change to place each year into perspective.

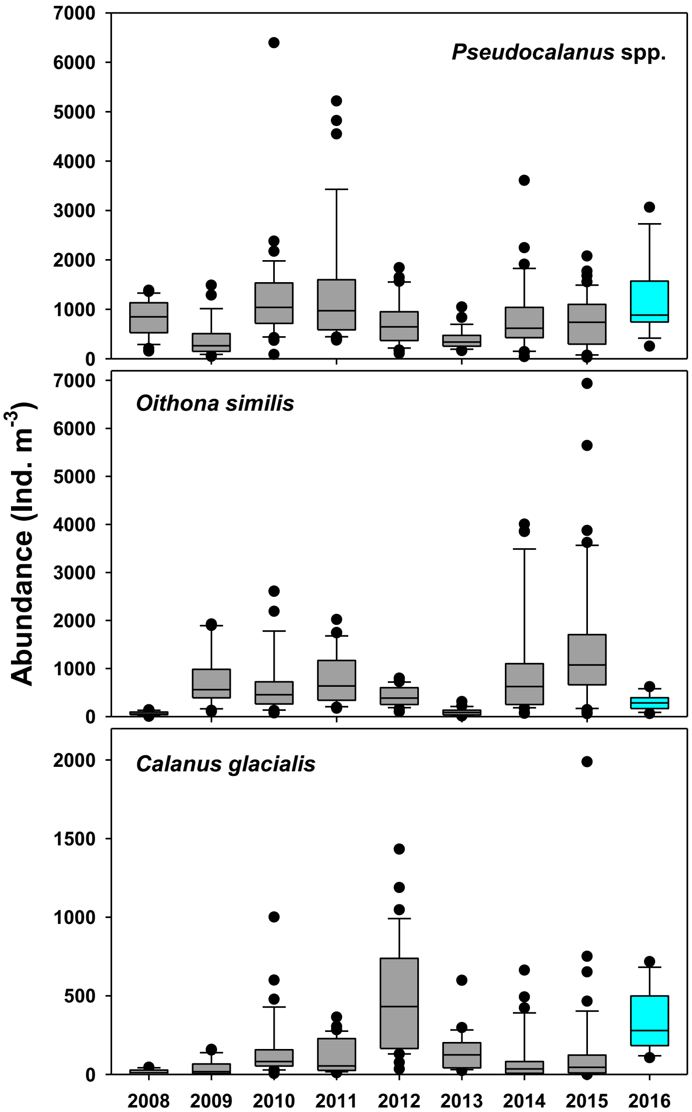


Figure 7. Box and whisker plots of key copepod taxa abundance during August 2008-2016 from the 150 μm net. Data from 2016 cruise are highlighted in blue.

Our observations show the biological signal associated with the Bering/Chukchi oceanographic front that progresses northward from Bering Strait each summer. This front typically reaches the northeast Chukchi study area sometime during August or September, creating distinct communities on each side of the front: a more Bering/Pacific community to the south and a more Arctic fauna to the North. Variability in the composition of the zooplankton community advected from the south and the position of the front at the time of sampling contribute to the high degree of interannual variability observed in this region (Blanchard *et al.*, 2017). Thus far, the long-term reductions in sea ice over the past 70 years have resulted in an overall increase in zooplankton biomass within the Chukchi Sea (Ershova *et al.*, 2015b). It is likely that continued sea ice reductions will lead to increased prevalence and persistence of Pacific zooplankton fauna, that will ultimately lead to and overall reduction in overall zooplankton biomass. Process-oriented studies will be required to determine how annual primary and secondary production will be affected.

References cited

Blanchard, A.L., Day, R.H., Gall, A.E., Aerts, L.A.M., Delarue, J., Dobbins, E.L., Hopcroft, R.R., Questel, J.M., Weingartner, T.J., Wisdom, S.S. (2017) Ecosystem variability in the offshore Northeastern Chukchi Sea. *Prog. Oceanogr.,* **159,** 130-153.

Eisner, L., Hillgruber, N., Martinson, E., Maselko, J. (2013) Pelagic fish and zooplankton species assemblages in relation to water mass characteristics in the northern Bering and southeast Chukchi seas. *Polar Biol.,* **36,** 87-113.

Ershova, E.H., Hopcroft, R.R., Kosobokova, K.N. (2015a) Inter-annual variability of summer mesozooplankton communities of the western Chukchi Sea: 2004-2012. *Polar Biol.,* **38,** 1461-1481.

Ershova, E.A., Hopcroft, R.R., Kosobokova, K.N., Matsuno, K., Nelson, R.J., Yamaguchi, A., Eisner, L.B. (2015b) Long-term changes in summer zooplankton communities of the western Chukchi Sea, 1945-2012. *Oceanography,* **28,** 100-115.

Questel, J.M., Clarke, C., Hopcroft, R.R. (2013) Seasonal and interannual variation in the planktonic communities of the northeastern Chukchi Sea during the summer and early fall. *Cont. Shelf Res.,* **67,** 23-41.

Pinchuk, A.I., Eisner, L.B. (2017) Spatial heterogeneity in zooplankton summer distribution in the eastern Chukchi Sea in 2012–2013 as a result of large-scale interactions of water masses. *Deep Sea Res. II.,* **135,** 27-39.

NOAA relevance/societal benefits

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

Education

None

Outreach

None

Publications, conference papers, and presentations

Poster presentation accepted

Hopcroft RR, Questel JM, Smoot CA, Clarke-Hopcroft C (2018) Inter-annual Variability of the Zooplankton Communities in the Northeastern Chukchi Sea: a Decadal Perspective. Ocean Sciences Meeting, February 2018, Portland OR.

Other products and outcomes

Hopcroft works in conjunction with NOAA as a representative on the Circumpolar Biodiversity Monitoring Program (CBMP) under the International Arctic Council. Although a stand-alone publication of the 2016 observation is not possible, a manuscript describing the 10 year time-series of CSESP, AMBON and NOAA sampling is anticipated to be submitted in late 2018.

Partner organizations and collaborators

Arctic Marine Biodiversity Observing Network (AMBON)

Changes/problems/special reporting requirements

Overall scope as noted above. Poor administrative oversight at UAF reported incorrect end-dates to the PI, ultimately resulting in the return of unspent funds to NOAA.

Arctic Sustainability Research in support of the Arctic Policy and Governance Educational Partnership

PI – A. Lovecraft

This project was contracted for professional academic expertise for the development of the Arctic Policy Partnership and no annual report was required. There is a project report in preparation and will be a key product of this project.

Arctic Indicators for Assessment and Enhanced Understanding

PI – J. E. Walsh

No project report is available for inclusion for this linked proposal since their first report is due in June 2018.