Annual Report 25

Calendar Year 2018

Submitted by:
Dr. Brenda Konar, Director
University of Alaska Coastal Marine Institute

To:
U.S. Department of the Interior
Bureau of Ocean Energy Management Alaska OCS Region

February 2019
OCS Study BOEM 2019-005

Bureau of Ocean Energy Management

UNIVERSITY OF ALASKA FAIRBANKS

Contact Information:

Coastal Marine Institute
College of Fisheries and Ocean Sciences
University of Alaska Fairbanks
P. O. Box 757220
Fairbanks, AK 99775-7220
CMI-UAF@alaska.edu
Phone: 907.474.6782

This study was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM) Alaska OCS Region (Cooperative Agreement M13AC00003) and the University of Alaska Fairbanks. This report, OCS Study BOEM 2019-005, is available through the Coastal Marine Institute, select federal depository libraries and can be accessed electronically at *http://www.boem.gov/Alaska-Scientific-Publications*.

Table of Contents

Introduction

The University of Alaska Coastal Marine Institute (CMI) was established through a Memorandum of Agreement (MOA) between the University of Alaska and the US Department of the Interior Bureau of Ocean Energy Management (BOEM). Under BOEM, the Environmental Studies Program (ESP) is formally directed to provide information in support of the decisions involved in the planning and management of resource exploration, development, and production activities. The ESP research agenda is driven by specific issues, concerns, and information needs identified by federal decision makers and state and local stakeholders that participate in the process. Within that framework, the CMI creates a partnership between BOEM, the University of Alaska, and the State of Alaska to develop regional research goals and execute a research program. Through the CMI, BOEM supports highly qualified scientific expertise at the University of Alaska to study coastal topics associated with the development of natural resources in Alaska's outer continental shelf and to conduct research used to inform management of oil, gas, and marine mineral resources. The CMI has been funded through cooperative agreement with BOEM since 1993, initiating up to two million dollars of new research annually.

Funding and Cost Share Partners

All CMI funded projects require a one-to-one cost-share with non-federal partners to ensure stakeholders are participating in the CMI research program. The following partners supported CMI projects in 2018:

Pacific Gyre Naidu
Consulting Cook Inlet
RCAC Bigelow
Laboratories
EVOS Trustee Council
The Anchorage Museum
Oil Spill Response Institute
International Arctic Research Center, UAF

North Slope Borough
Geophysical Institute, UAF
Institute of Arctic Biology, UAF
The Arctic University of Norway
Institute of Northern Engineering, UAF College of
Fisheries and Ocean Sciences, UAF College of
Natural Science and Mathematics, UAF Alaska
Department of Environmental Conservation

Student Support

Projects funded as part of the CMI research program often support the primary dissertation or thesis work for graduate students and can provide learning opportunities for other students assisting in field or laboratory work. Fifteen students participated on CMI funded research projects in 2018.

CMI Projects Involving Students	FY Funded	# by degree *PhD*	*MS*	*BS*
Coastal community vulnerability index and visualizations of change in Cook Inlet, Alaska		1		
Identifying sources of organic matter to benthic organisms in the Beaufort and Chukchi OCS	16	1	1	
Microbial biodegradation of Alaska North Slope crude oil in Pacific Arctic marine sediment	17	2		1
Nearshore food web structure on the OCS in Cook Inlet	17		1	
High-frequency characterization of the physicochemical parameters of Cook Inlet	17	1		3
Using trace elements in Pacific walrus teeth to track the impacts of petroleum production in the Alaskan Arctic**	17	1		
Functional diversity of epibenthic communities on the Chukchi and Beaufort Sea shelves**	17		1	
Identifying Arctic cod hatch dates and locations in the Alaskan Arctic **	18		1	
The influence of water flow in structuring subtidal estuary communities in Cook Inlet**	18		1	

**student-led project

2018 Program Publications

Clark, C. 2018. Using Trace Elements in Pacific Walrus Teeth to Track the Impacts of Petroleum Production in the Alaskan Arctic, in CMI Graduate Student Projects: Volume 2, B. Konar (Ed.). Final Reports, OCS Study BOEM 2018-058, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Hauri, C., A. McDonnell, P. Winsor, B. Irving, and H. Statscewich. 2018. Development of an Autonomous Carbon Glider to Monitor Sea-Air CO2 Fluxes in the Chukchi Sea. Final Report, OCS Study BOEM 2018-016. University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Kasper, J., A. Mahoney, J. Arsenault, and P. Winsor. 2018. IceTrackers: Low-cost Tracking of Sea Ice in Remote Environments. Final Report, OCS Study BOEM 2017-076, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Konar, B. (Director). 2018. University of Alaska Coastal Marine Institute Program Administration 2013-2018. Final Report, OCS Study BOEM 2018-064, University of Alaska Fairbanks and USDOI, BOEM Alaska OCS Region.

Konar, B. (Director). 2018. University of Alaska Coastal Marine Institute Annual Report No. 24. OCS Study BOEM 2018-011, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Leigh, M.B., K. McFarlin, T. Gofstein, M. Perkins, and J. Field. 2018. Fate and Persistence of Oil Spill Response Chemicals in Arctic Seawater. Final Report, OCS Study BOEM 2018-036, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

McCartney, L., and K. Brewster. 2018. Northern Alaska Sea Ice Project Jukebox: Phase III. Final Report, OCS Study BOEM 2018-027, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Powell, A., R. Bentzen, and R. Suydam. 2018. Migration Trends for King and Common Eiders and Yellow-billed Loons past Point Barrow in a Rapidly Changing Environment. Final Report, OCS Study BOEM 2018-059, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Sutton, L. 2018. Functional Diversity of Epibenthic Communities on the Chukchi and Beaufort Sea Shelves, in CMI Graduate Student Projects: Volume 2, B. Konar (Ed.). Final Reports, OCS Study BOEM 2018-058, University of Alaska Coastal Marine Institute and USDOI, BOEM Alaska OCS Region.

Coastal Marine Institute Program Administration 2013 - 2017

Principal Investigator: Brenda Konar

College of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M13AC00003
Period of Performance: 04/09/13 – 12/31/19

Project Overview

The CMI is guided by a Technical Steering Committee (TSC) with members from the University, BOEM and the State of Alaska. With TSC input, the University of Alaska Fairbanks College of Fisheries and Ocean Sciences provides administrative management of the CMI program as a special project under the Office of the Dean. The CMI administrative responsibilities include the following:

- Providing program support for researchers
- Coordinating the CMI Annual Research Review
- Facilitating Technical Steering Committee activities
- Coordinating as liaison between BOEM and awardees
- Facilitating the annual research funding cycle from initial call to award
- Editing and publishing and submitting project final reports and project deliverables
- Monitoring cooperative agreements and assisting with administrative and funding issues

2018 Administrative Update

The Coastal Marine Institute Annual Research Review was held in January 2018 in Anchorage, Alaska, with 15 researchers presenting their ongoing research. This annual event follows a conference seminar format and is widely advertised to encourage public and stakeholder involvement.

Final reports were published for eight projects that ended in 2018 and for the 2013-2017 CMI Program Administration. At year end, CMI was supporting five active projects, two student projects, and two projects in the final reporting stage.

Due to a disruption in funding, the Coastal Marine Institute Memorandum of Agreement and cooperative agreement M13AC00003 were extended through 2019 to allow flexibility for potential program suspension or phase-out. Administrative staff was laid-off in May 2018 and replaced by a temporary position to manage essential program functions. A new MOA and cooperative agreement are anticipated in calendar year 2019.

New research programming was suspended in 2018 except for student support funded as special projects the administrative award. However, letters of intent and student proposals were solicited in fall 2018 for possible funding in FY2019. The CMI Technical Steering Committee met by teleconference in December 2018 and selected seven of twenty proposed project concepts for potential consideration in FY2019:

- Western Beaufort and Chukchi Sea surface current analysis
- Evaluating novel assessment approaches for coastal ice seal haulout areas and behavior in the Alaskan Beaufort Sea
- Tracking fish and marine mammal responses to Arctic change through the establishment of a community-based biological observing program in Arctic Alaska
- Kelp Restoration in the Boulder Patch
- Changing relationships among climate variables and cumulative climate stress on the Gulf of Alaska ecosystem
- Utilization of the under-ice habitat by Arctic Cod in the western Arctic Ocean: a multidisciplinary collaborative study
- Investigating marine movement and behavior of steelhead trout in and near OCS oil and gas lease areas

Additionally, CMI continued an administrative special project offering one-year competitive graduate student awards (≤$25,000). The initiative is intended to encourage new scientists and leverage BOEM investment and collaborative opportunities by funding a component of the student's larger research project that aligns with the CMI framework issues. Students present their results at the CMI Annual Research Review, and their final reports are published in a compilation. Two new student projects were awarded in 2018:

- The influence of water flow in structuring subtidal estuary communities in Cook Inlet, Alaska *Chris Guo, M.S. student, UAF CFOS*
- Using trace elements in Pacific walrus teeth to track the impacts of petroleum production in the Alaskan Arctic *Zane Chapman, M.A. student, UAF CFOS*

Identifying Sources of Organic Matter to Benthic Organisms in the Beaufort and Chukchi Outer Continental Shelves

Principal Investigator: Matthew Wooller

Institute of Northern Engineering
University of Alaska Fairbanks

Cooperative Agreement Number: M16AC00005
Period of Performance: 05/15/16– 5/14/19

Project Overview

This project provides a better understanding of the organic matter sources consumed by benthic organisms in the Beaufort and Chukchi Seas using a state-of-the-art essential "amino acid fingerprinting" approach (Figure 1). The resulting data is important as a benchmark to compare with future samples and can help assess if proportional contributions of organic carbon sources change as a result of offshore oil and gas exploration and extraction on the Outer Continental Shelf (OCS), coastal erosion, and other environmental changes. Although previously tested in marine systems, this project is the first to apply the approach in the Arctic. The method specifically allows the separation of microbial and terrestrial carbon sources from marine production, filling an information gap identified in previous work of benthic food webs on these Arctic OCS systems. Our project complements previous isotope research in the region by providing a finer ability to discern primary production sources of organic matter. Essential amino acids within a consumer create a pattern, termed "stable isotope fingerprint," which can be statistically compared with the fingerprints of the essential amino acids from primary producers. This project used samples from previous BOEM-funded projects. This move was cost-effective and will provide novel, quantitative baseline food web information to assist in management decisions related to OCS oil and gas activities.

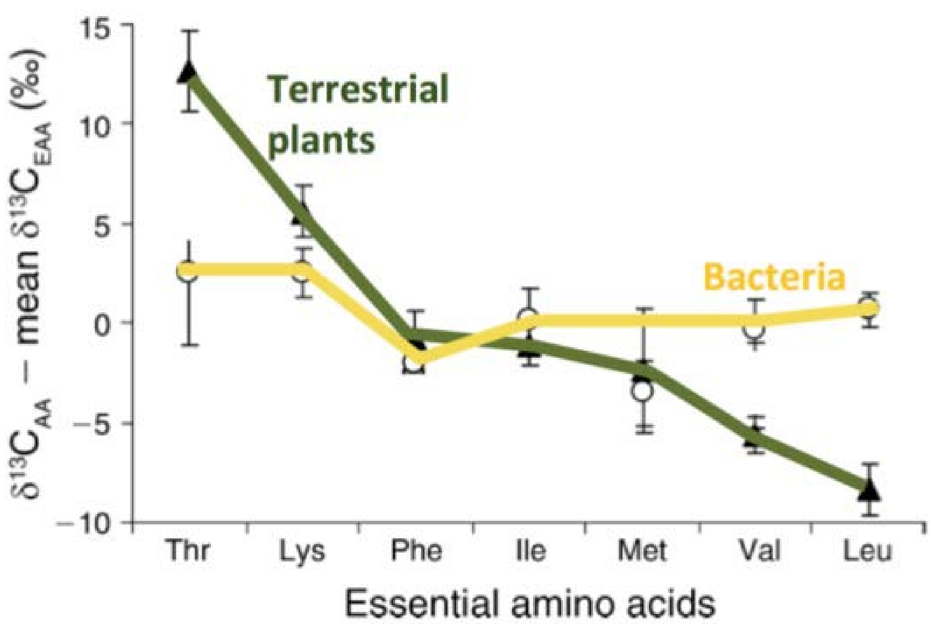

Figure 1. An example of the normalized stable carbon isotope composition of amino acids from bacteria and terrestrial plants (redrawn from Larsen et al., 2013).

2018 Project Update

Major activities during this third year have involved synthesizing the data and preparing the results for publications and presentations. Interesting patterns continue to emerge from the data analysis, including a preliminary relationship identified between the extents of bacterial-derived essential amino acids in the Beaufort Sea (Figure 2). Data analysis has included the application of the SIMMR mixing model package to quantify sources of essential amino acids to the invertebrates analyzed. The project activities are on schedule, and a final report is in production (Figure 3).

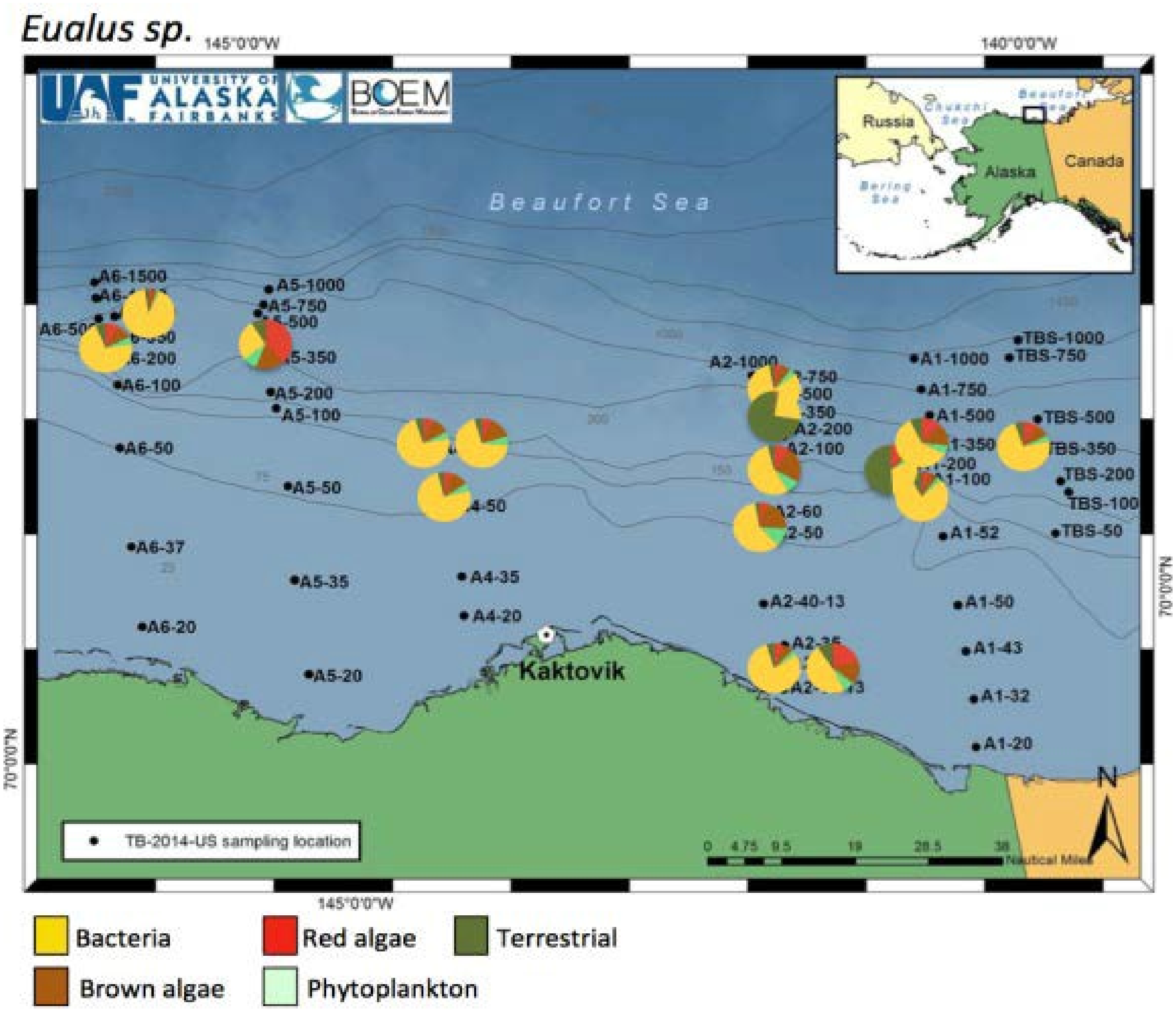

Figure 2. Proportional contributions of essential amino acid sources to *Eualus* spp. from the Beaufort Sea.

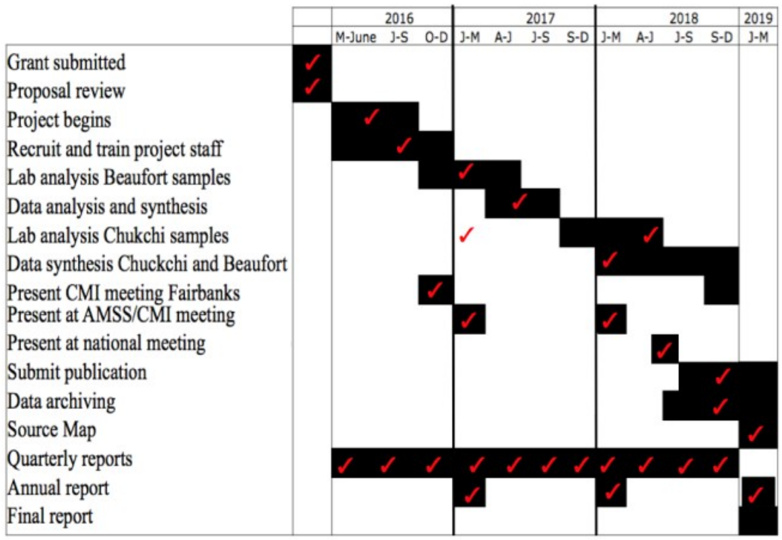

Figure 2. Project timeline with activities marked that are underway or completed (red tick mark).

2018 Publications/Presentations

Rowe, A. Estimates of primary production sources to Arctic bivalves using amino acid stable carbon isotope fingerprinting. International Isotope Ecology Conference, August 2018, Viña del Mar, Chile (poster presentation)

Zinkann, A.-C., Iken, K. B., O'Brien, D. M., and Wooller, M. J. Contribution of microbially-derived carbon to benthic invertebrates across the Chukchi Sea shelf using amino acid specific stable isotope analyses. Alaska Marine Science Symposium, January 2018, Anchorage, AK (poster presentation)

Zinkann, A.-C., Iken, K. B., O'Brien, D. M., and Wooller, M. J. Contribution of microbially-derived carbon to benthic invertebrates across the Chukchi Sea shelf using amino acid specific stable isotope analyses. Ocean Sciences Meeting, February 2018, Portland, OR (poster presentation)

Wooller, M. J., Blanchard, A. L., Zinkann, A.-C., Choy, K., Iken, K. B., O'Brien, D. M., and Rowe, A. Determining primary production sources to benthic organisms in the Arctic using stable isotope fingerprinting. Alaska Marine Science Symposium, January 2018, Anchorage, AK (oral presentation)

Measuring Wave Forces along Alaska's Coastal Sea Ice

Principal Investigator: Mark Johnson

College of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M16AC00006
Period of Performance: 05/15/16 – 12/15/19

Project Overview

Ocean waves can weaken, destabilize, and break drifting and grounded sea ice. Under certain conditions, ocean waves may precondition the ice for "break out" events when winds and/or currents act to remove ice from the coast. Our goal in this project is to measure ice motion under a variety of conditions and use that information to assess ice behavior that may help to improve human safety, mitigate marine hazards, and determine how wave energy affects the navigational window in the arctic region. Our approach may form the basis for an early warning system that would increase ice safety and reduce navigational hazards.

This three-year project is designing, constructing, and deploying sensors capable of measuring ice motion under the extreme winter conditions along Alaska's coasts. Prototype sensors have been deployed on ice in Elson Lagoon near Point Barrow, on the landfast ice off Utqiagvik, Alaska, and on the ice of the US Navy ICEX 2018 camp in the Beaufort Sea. At this time, we have four "Ice Wave Riders" (IWRs), designed around the VectorNav VN100 accelerometer, that are capable of measuring accelerations to 5×10^{-3} m s^{-2}. Following upgrades in 2019, they are now equipped with internal GPS/Iridium antennas for easier shipping and deployments on ice.

Two additional sensor designs have been developed under the direction of Jeffrey Simonson (UAF). The first adopts the SeaView SVS-603 sensor, which is widely used in ocean wave buoys to determine significant wave height, wave direction, dominant wave period, and other wave parameters. With a lower sensitivity than the VN-100, this sensor may prove useful to monitor relatively large ice-motion events. The other prototype uses the VN-100 in a smaller package than for the IWRs. Importantly, we are testing the applicability of inexpensive, commercially available Xbee radios (Figure 1) to relay large data sets over distances of several kilometers, such as from the landfast ice to shore. Communicating real-time telemetry data to shore allows it to be analyzed and displayed to inform stakeholders about ice conditions.

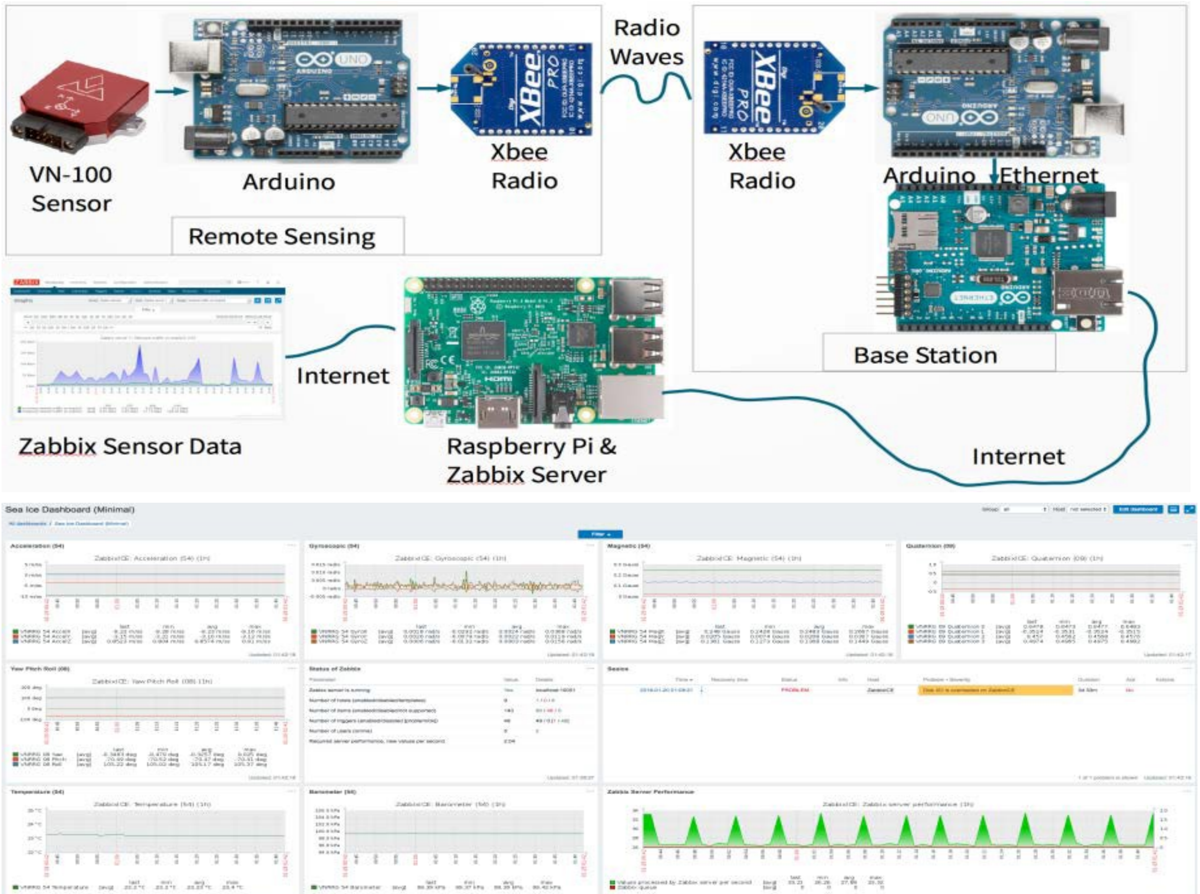

Figure 1. Sensor schematic for telemetry of large datasets and remote display. The VN-100 at 40 Hz is combined with Arduino, Raspberry Pi, and Xbee radios to communicate data to a base station and display it on a web page in real-time via a Zabbix server.

2018 Project Update

We have acquired hundreds of hours of sensor data from deployments near Point Barrow on Elson Lagoon ice (over shallow water), on the Chukchi Sea landfast ice north and west of Point Barrow (6–7 meter water depths), and on free-floating ice in deep water in the Beaufort Gyre during ICEX 2018.

What signals are being measured by these sensors? The Welch method (1967) is one approach to determining the temporal pattern of the frequency response. This approach subdivides time- series data into relatively short blocks, calculates the periodogram (an estimate of the spectral density, or frequency response, of a signal) for each block, and then averages or smooths the periodograms in time. For the data acquired here, we subdivided time series into three-minute long blocks with a 50% overlap between blocks, calculated the periodogram of each block, and then plotted the periodogram in time. Simply stated, the Welch method is a temporal smoothing of successive periodograms.

Figure 2 is an example of the Welch method using the Chukchi Sea landfast ice IWR1 data, plotted for frequencies up to 5 Hz, for our 10 Hz sampling. The Welch plot in Figure 2 shows time from 1–21 May 2018 (x-axis) versus frequency from 0 to 5 Hz (y-axis). The frequencies of the larger spectral amplitudes (circled in red) vary temporally between 0.6 and 3.2 Hz (~0.3 to ~1.7 seconds). Signals with smaller amplitudes (circled in blue) fall around 0.25 Hz (3–5 seconds), within the expected wave band from 1–30 seconds.

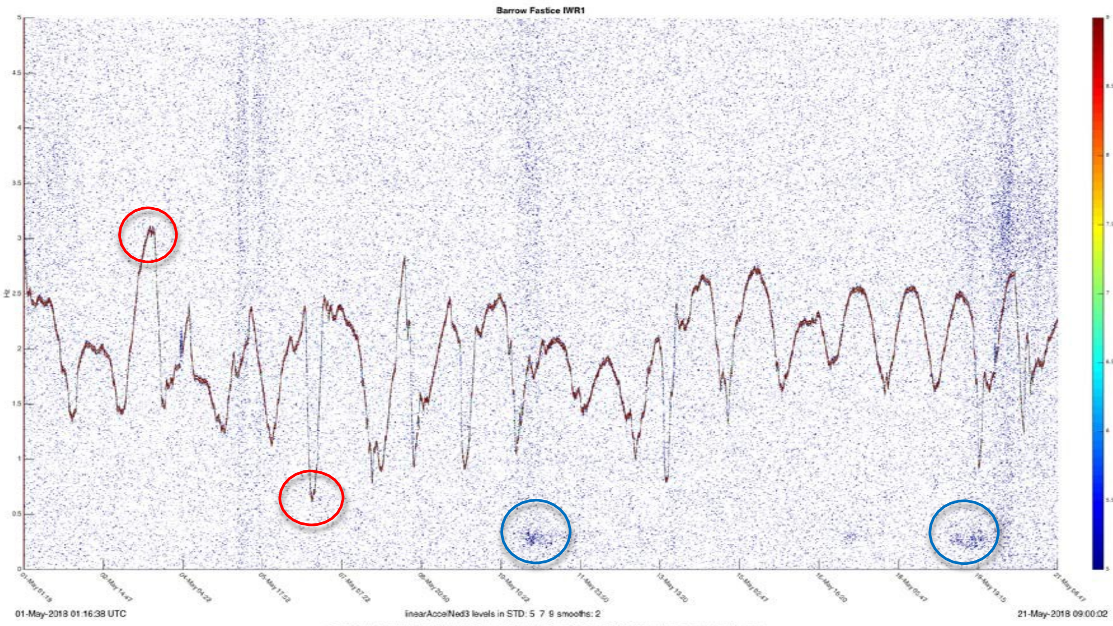

Figure 2. Welch plot using 50% overlap from the IWR1 Chukchi Sea landfast ice data: time (x-axis) and frequency in Hz (y-axis). The largest spectral amplitudes have frequency limits circled in red. The signal oscillates between 0.6 and 3.2 Hz (~0.3 to ~1.7 seconds). Smaller amplitude signals (circled in blue) around 0.25 Hz (3–5 seconds) correspond to waves with amplitudes up to 3 cm, within the expected wave band from 1–30 seconds.

What causes these two types of signals, one around 0.25 Hz, and the other varying between 0.6 and 3.2 Hz? Are they due to ice motion from waves, and if so, what is their amplitude?

Representative amplitudes and accelerations for waves in ice satisfy $A_z = a\omega^2$, where A_z is the vertical acceleration, ω is the frequency, and the corresponding period is $T=2\pi/\omega$ (Rabault et al. 2016). If we know the frequency, which can be estimated from the Welch plots, and we know the corresponding acceleration magnitude, measured directly by the sensors, we can estimate the wave amplitude. One can also calculate amplitude by double integration of the acceleration; we previously demonstrated that this approach agrees well with theory ($A_z = a\omega^2$) for amplitudes up to 3 cm and slightly underestimates larger amplitudes.

For the temporally varying signal around one second in period, the vertical acceleration amplitudes are up to 0.02 m s^{-2}, corresponding to a wave amplitude of 0.1 cm. This temporally variable frequency suggests non-wave motion. Periods of one second and less have been associated with vibrations due to winds on the sensor case (A. Marchenko 2018, personal communication).

The spectral amplitudes visible around a period of four seconds have a broad spectral character, evident in the periodograms on at least two occasions, as shown by the blue circles in Figure 2. Are these signals evident in the other IWR deployed at the same time, 0.26 km away? Figure 3 compares the periodograms from both IWR1 and IWR2 for frequencies between 0 and 1 Hz (periods greater than 1 second) from May 1–20, 2018. The spectral patterns for IWR1 and IWR2 are similar around 11 and 19 May between 0.15 to 0.4 Hz (2.5 to 6.7 seconds). These "events" lasted 30 and 48 hours, respectively. Are the signals measured by IWR1 and IWR2 responding to the same forcing, either from winds or ocean waves?

Figure 4 also compares the responses of IWR1 and IWR2 but restricts the time and frequency axes to focus on the two May 2018 events. The two IWR responses, based on the Welch plots, are visibly similar in both temporal and frequency space. The spectral pattern in both events shows decreasing in frequency in time. We are currently working to develop a physical understanding that explains the decay in frequency over time; one possibility is wave dispersion, a function of wave number and distance to the forcing atmospheric storm.

What are the possible vertical displacements associated with the measured accelerations for the signals between 2.8 and 5 seconds? The vertical accelerations for the first event in May, shown in Figures 3 and 4, were band-pass filtered between 1 and 10 seconds, and the results plotted in Figure 5. The calculated wave heights are 3 cm and less. The broad spectral response, however, may mean that the ice motion was in response to wind-driven ocean waves near the lead edge of the ice rather than from a coupled ice-ocean wave which has a narrow spectral response.

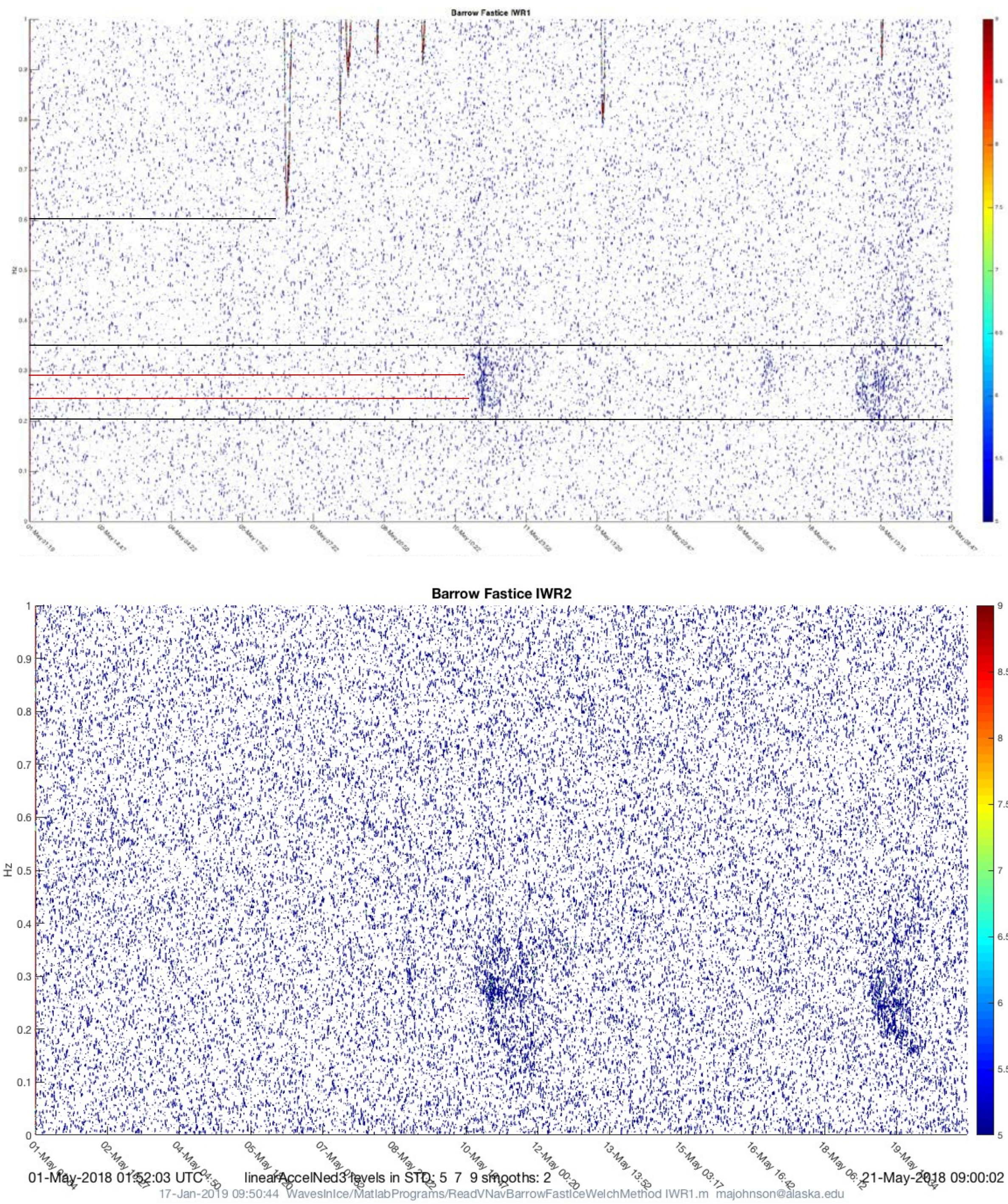

Figure 3. Acceleration periodograms from Chukchi Sea landfast ice for May 1–20, 2018. Top - Welch plot from IWR1 with event frequency range marked by black lines (0.2 and 0.35 Hz, or ~3 to 5 seconds) and frequency with maximum amplitudes marked by red lines (0.25 and 0.29 Hz, or ~3.8 seconds). Bottom - Periodogram as above but for IWR2 (bottom). Both IWR1 and IWR2 have visibly more power around 11 May and 20 May 2018. Event 1 lasted 30 hours and event 2 for 48 hours.

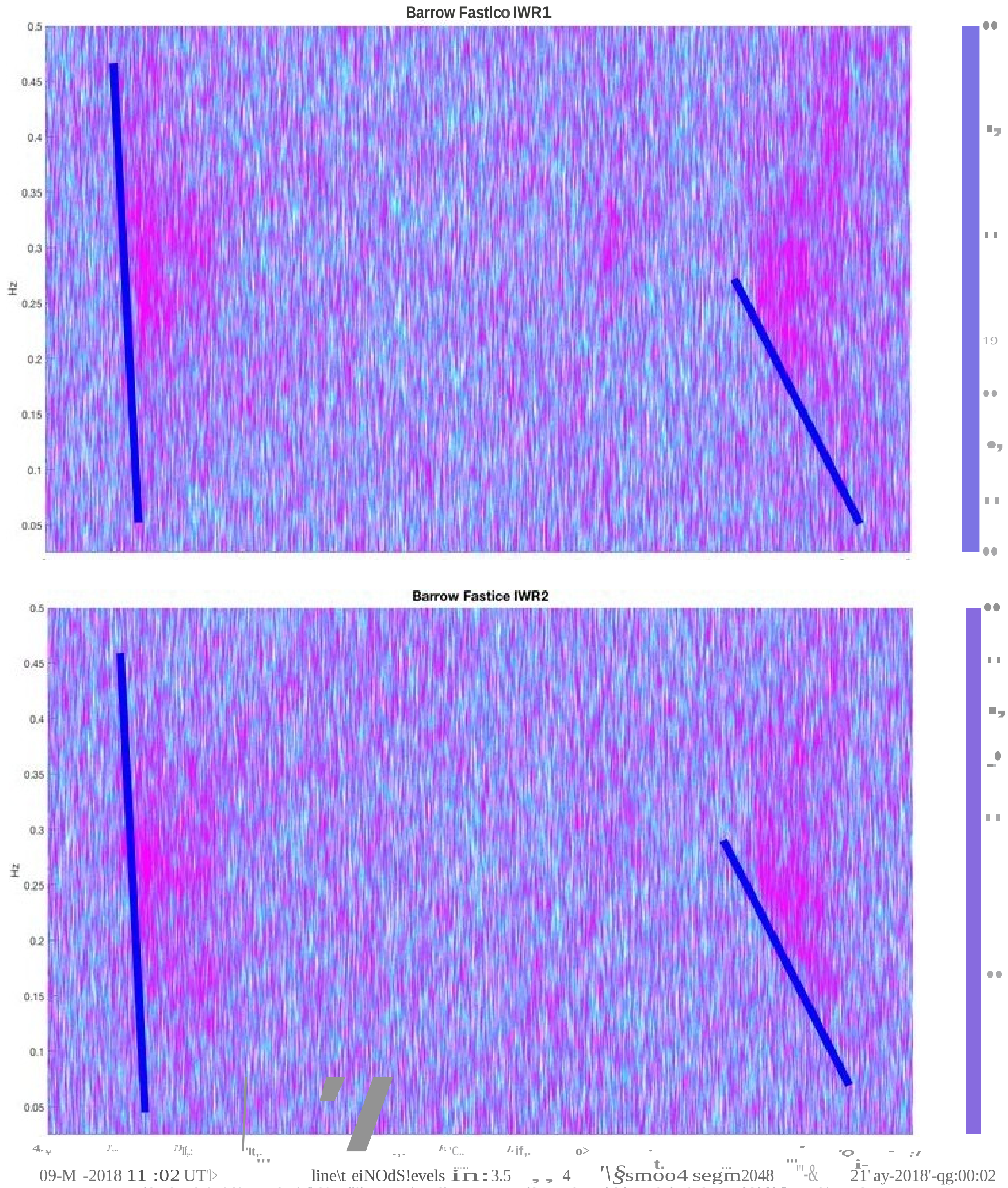

Figure 4. As in Figure 3 except time period is 9-21 May 2018 and frequency range is 0.025-0.5 Hz. The spectral response for both IWR1 (top) and IWR2 (bottom) suggests phenomena where frequency decreases with time. A possibly third but weaker event is visible on 17 May 2018, particularly in IWR1 (top).

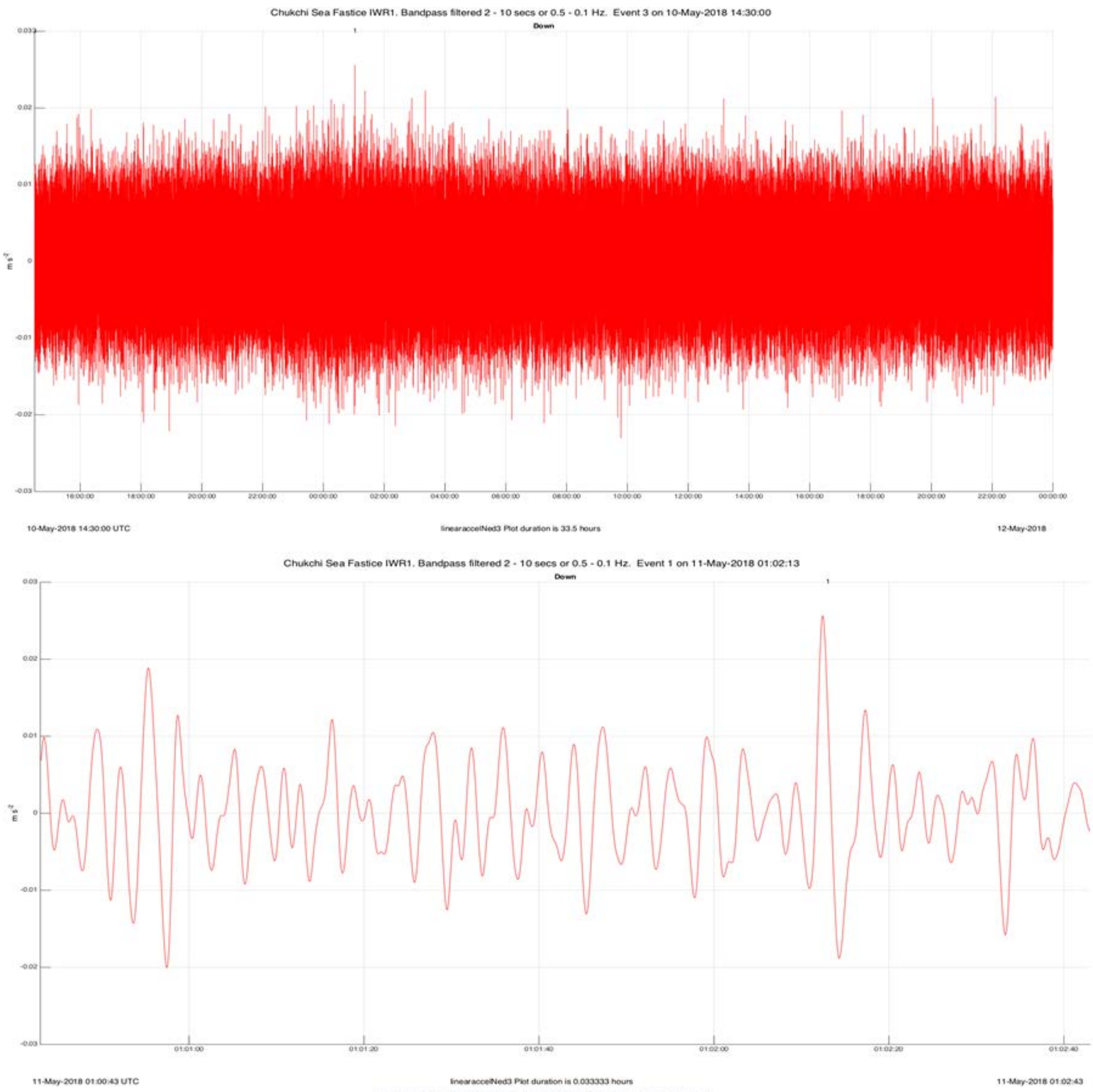

Figure 5. (Top) Time series for 1 to 10 second band-passed vertical acceleration measured by IWR1 for a 33.5 hour time span, and (Bottom) for a 2 minute time span, both surrounding event 1. The vertical acceleration range is from -0.02 (up) to 0.025 m s^{-2} (down). Based on the Welch plots, most of the energy is between 2.8 and 5 seconds which corresponds to wave amplitudes from 0.5 to 1.5 cm, or a wave height up to 3 cm. Because of the broad width of the spectral response, this is likely not a wave coupled to the ice. Rather, we speculate this is ice motion induced by wind-driven ocean waves.

If the ice motion was driven by wind forced ocean waves, is the ice responding over a broad area? There were two additional IWRs deployed west of Point Barrow, approximately 15 km from IWR1 and IWR2. Figure 6 shows the Welch plot for IWR4 for the same frequency and temporal bands as presented in Figure 4 for IWR1 and IWR2. Similarly to IWR1 and IWR1, there is more energy around 19 May, centered around periods between 2 and 4 seconds. The spectral signature shows no frequency decay in time.

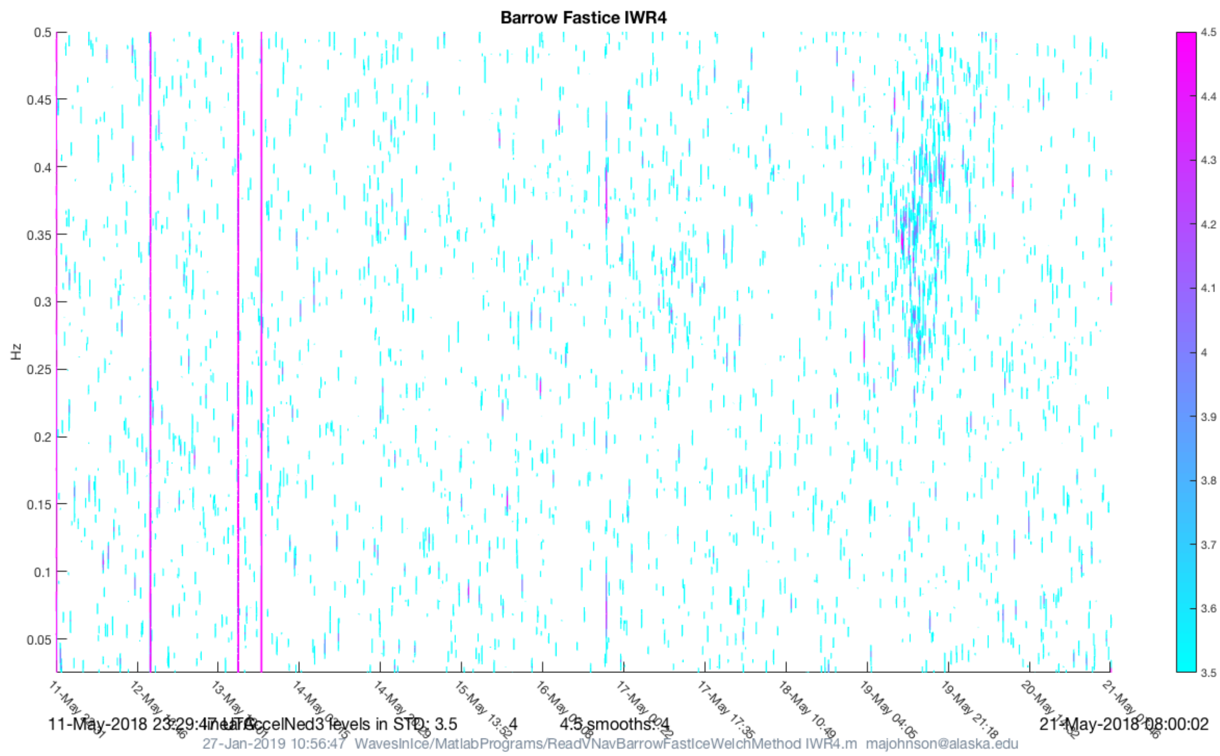

Figure 6. Welch plot from IWR4. There is increased energy, broadly centered around 3 seconds, beginning around noon on 19 May and persisting for about 40 hours, about the same frequency and time as event 2 from IWR1 and IWR2.

We speculate that the signals discussed above for the Point Barrow sensors are due to ice motion driven by wind waves. The next steps include analysis of satellite imagery for ice motion to assess collisions and to determine the presence of open water near the sensors at that time. Are these signals really from ice motion or just sensor noise? Figure 7 shows the Welch plot for

IWR1 and IWR2 that were sitting on a concrete floor in UAF's O'Neill building during a passive test of the sensor. Although there is an unexplained, steady band of "noise" in IWR1 at 0.2 seconds, there are no visible peaks in the spectra at frequencies less than 1 Hz, which strengthens our claim that the signals measured off Point Barrow in May 2018 are due to motion of the ice rather than sensor noise. We are continuing the signal analysis while preparing for the 2019 field season.

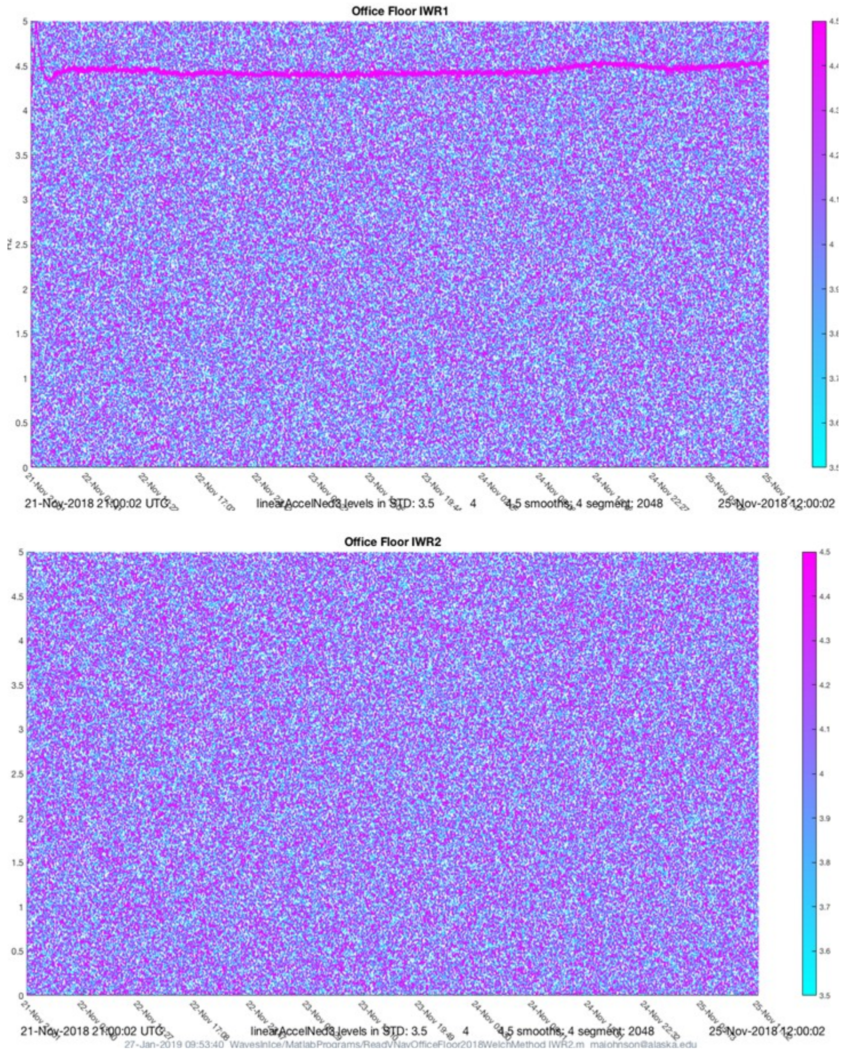

Figure 7. Welch plot from IWR1 (top) and IWR2 (bottom) placed on a concrete slab in the ground floor of O’Neill Building, UAF. There is an unexplained narrow, steady, large amplitude band in IWR1 at 0.22 seconds. At frequencies less than 1Hz, there is no significant pattern of energy above the background.

References

Welch, P.D. 1967. The use of fast Fourier transforms for the estimation of power spectra: A method based on time averaging over short modified periodograms. IEEE Transactions on Audio and Electroacoustics 15:70-73.

Rabault, J., G. Sutherland, B. Ward, K.H. Christensen, T. Halsne, and A. Jensen. 2016. Measurements of waves in landfast ice using inertial motion units. IEEE Transactions of Geoscience and Remote Sensing 54(11).

2018 Publications/Presentations

- Alaska Coastal Marine Institute 2018 Annual Research Review presentation
- 2018 CMI annual report, 2018 CMI quarterly reports

Nearshore Food Web Structure on the OCS in Cook Inlet

Principal Investigator: Katrin Iken

College of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M17AC00003
Period of Performance: 05/08/17 – 09/30/19

Project Overview

In high latitudes, nearshore benthic ecosystems are impacted by increased glacial melt and river discharge due to climate warming. How these systems respond to such impacts is still unclear. The overall goal of this project is to use Cook Inlet (northern Gulf of Alaska) as a case study of a high-latitude, glacially influenced ecosystem to describe and compare nearshore food web and community compositions exposed to different physical environments and climate stressors in two adjacent regions (Kamishak Bay and Kachemak Bay). We hypothesized that taxonomic and trophic diversity would be higher in the more oceanic-influenced Kachemak Bay. Ultimately, we aim to infer how nearshore food web resilience varies between the two regions using trophic and taxonomic diversity metrics. Increased trophic redundancy, greater niche space, and greater trophic evenness within a system typically indicate a more resilient food web, which should be more stable in the face of a changing climate and anthropogenic pressures. Key taxa, including benthic invertebrates and macroalgae, were analyzed for stable isotope composition (δC^{13} and δN^{15}) to determine carbon source use, trophic level of taxa, trophic redundancy, trophic niche space, and trophic evenness in the two systems. These trophic metrics are useful in forecasting the resilience of nearshore systems to future environmental perturbations. Contrary to our expectation, Kamishak Bay had higher values of trophic niche space, while Kachemak Bay had higher trophic redundancy and a more even trophic distribution of species. Results suggest that intertidal invertebrates in Kamishak Bay may be able to capitalize on the more diverse carbon sources in the region (e.g., terrestrial influx from rivers and glaciers) to increase trophic niche space, possibly representing a stabilizing mechanism on intertidal food webs.

However, the higher redundancy of food webs in Kachemak Bay may present a different mechanism to increase trophic resilience in an intertidal system. Despite an overall similar set of species occurring in both intertidal regions, actual community structure was found to be quite different and matched differences in trophic analyses. Going forward, this increased understanding of community function will allow us to better define expectations on how vulnerable or resilient nearshore communities will be to environmental stressors.

2018 Project Update

Activities this year included the completion of 2017 intertidal samples for stable isotope analysis. New intertidal samples collected in 2018 in both regions have been prepared for stable isotope analysis as have samples from the subtidal communities. We have started the data analysis for all samples with focus on those from the 2017 sampling.

The stable isotope data from the two regions differed in most metrics that describe food web relationships in the regions. The Kamishak Bay intertidal community had a higher range in δN^{15} values, representing a larger spread of trophic level diversity than the Kachemak Bay intertidal community (Figure 1, Table 1). This trend was driven by all members of the community, from primary producers to higher trophic levels, likely based in different nutrient usage in the different regions (see tighter grouping of algae in Kachemak Bay) as well as possible additional tropic steps from bacterial processes in Kamishak Bay. There was also a larger spread in δC^{13} values, indicating a broader use of different carbon sources, specifically in some of the basal food sources (Figure 1). For example, the lower carbon isotope values in particulate organic matter (POM) in Kamishak Bay are likely related to the influence of terrestrial matter in that system (Figure 2).

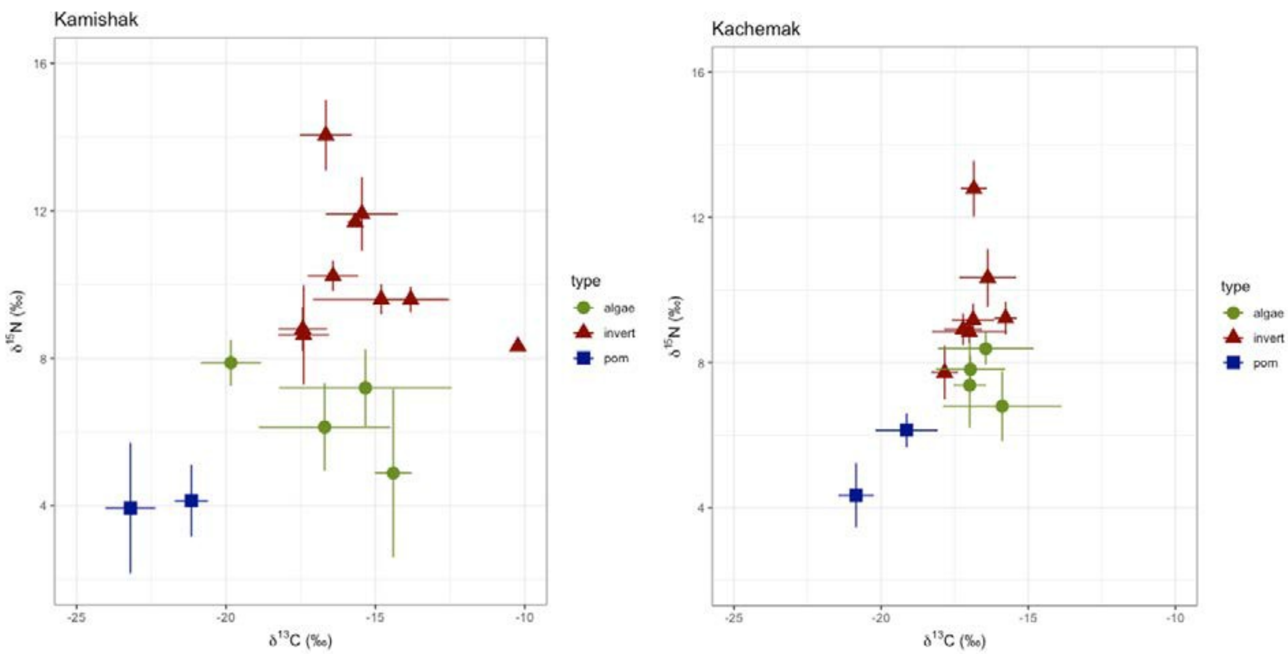

Figure 1. Stable carbon and nitrogen isotope values of primary producers and invertebrate consumers in the intertidal systems of Kamishak and Kachemak bays (green=algae, red=invertebrates, blue=POM).

Table 1. Measurements of trophic structure for the two regions.

Trophic metric	*Indicator for:*	*Kamishak*	*Kachemak*
N Range	Trophic level diversity	7.696	6.147
C Range	Carbon source diversity	6.763	3.379
Convex Hull Area	Trophic niche space	29.211	10.915
Distance to centroid	Average trophic diversity	2.352	1.593
Mean NND	Trophic redundancy	0.733	0.479
SD NND	Trophic evenness	0.591	0.359

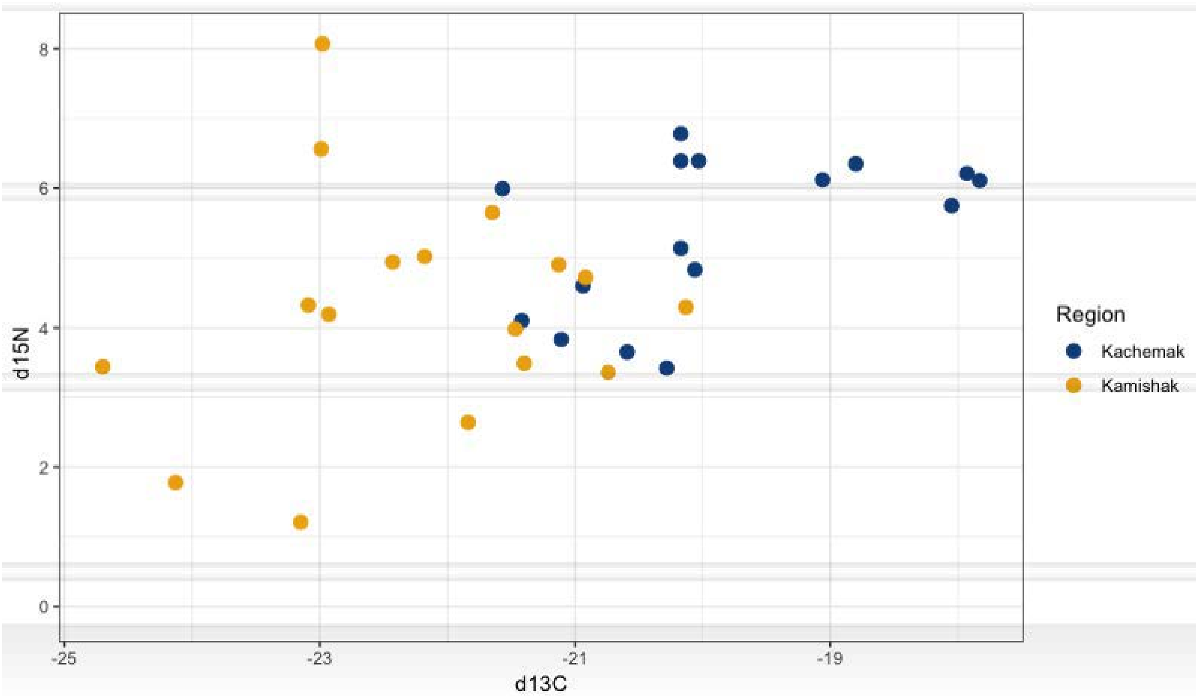

Figure 2. Stable carbon and nitrogen isotope values of particulate organic matter (POM) in the two study regions.

Convex Hull area is an indicator of niche space use, and distance to centroid is an indicator of average trophic diversity, both of which were larger in the Kamishak Bay system. A larger trophic redundancy, measured as the nearest neighbor distance (NND), is represented by a smaller value for this metric, meaning that trophic redundancy was greater in Kachemak Bay. The higher trophic diversity in Kamishak Bay and the higher trophic redundancy in Kachemak Bay likely represent two ecological strategies of increased resilience of a system. The broader use of trophic niche space in Kamishak Bay allows a more complete resource use that buffer the system against perturbations of some of these resources. The higher redundancy of species using the more limited amount of resources in Kachemak bay allow the continued use of these resources even if some species may be affected in their abundance by some perturbation.

Taxonomic diversity was overall similar in terms of number of taxa, and the overall regional species pool was similar, but intertidal taxa occurred in different abundances in the two regions (Figure 3). Some of the more dominant species in the two systems are ecological equivalents, such as *Neorhodomela aculeata* in Kamishak Bay and *Odonthalia floccosa* in Kachemak Bay, but the species composition in the two regions resulted in different overall community structures (Figure 4). In a next step of the analyses, we will investigate if what we perceive as ecologically similar species occupy similar roles in the respective trophic systems.

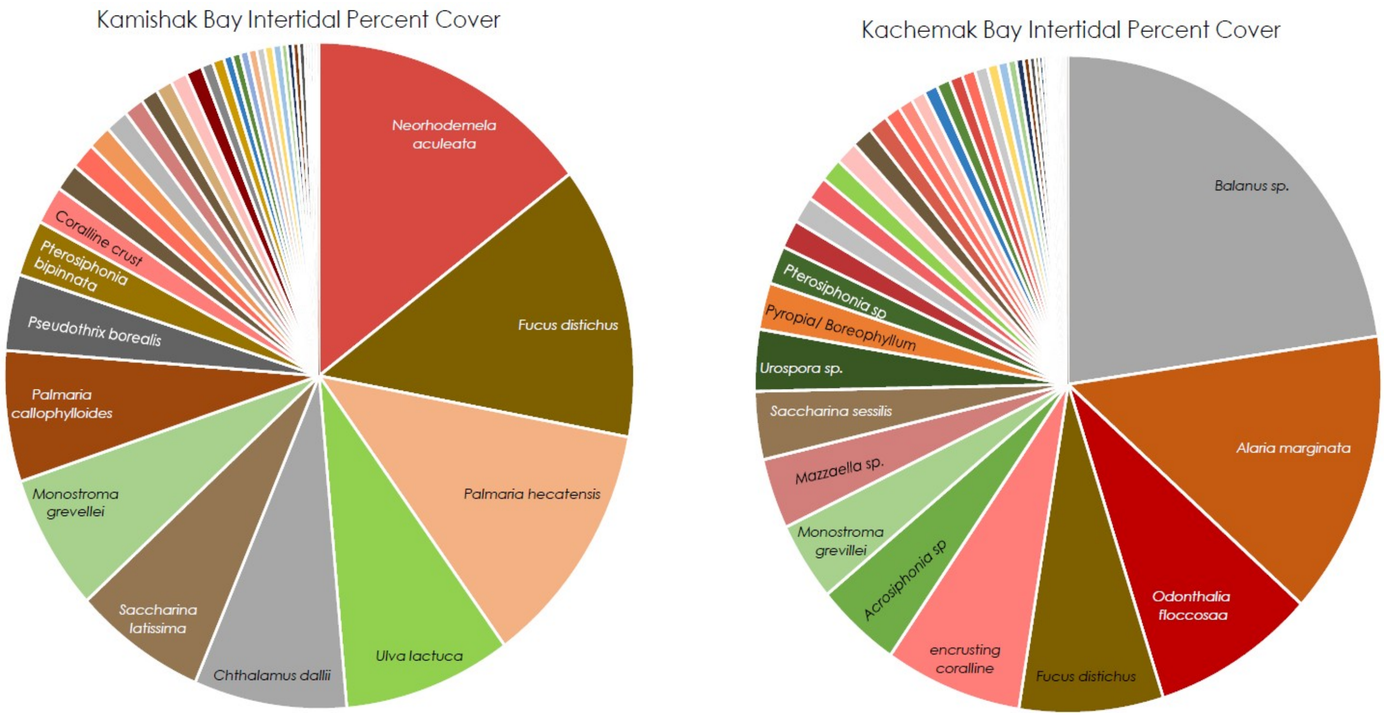

Figure 3. Abundance, based on percent cover estimate, of intertidal macroalgae and invertebrates in Kamishak and Kachemak Bays.

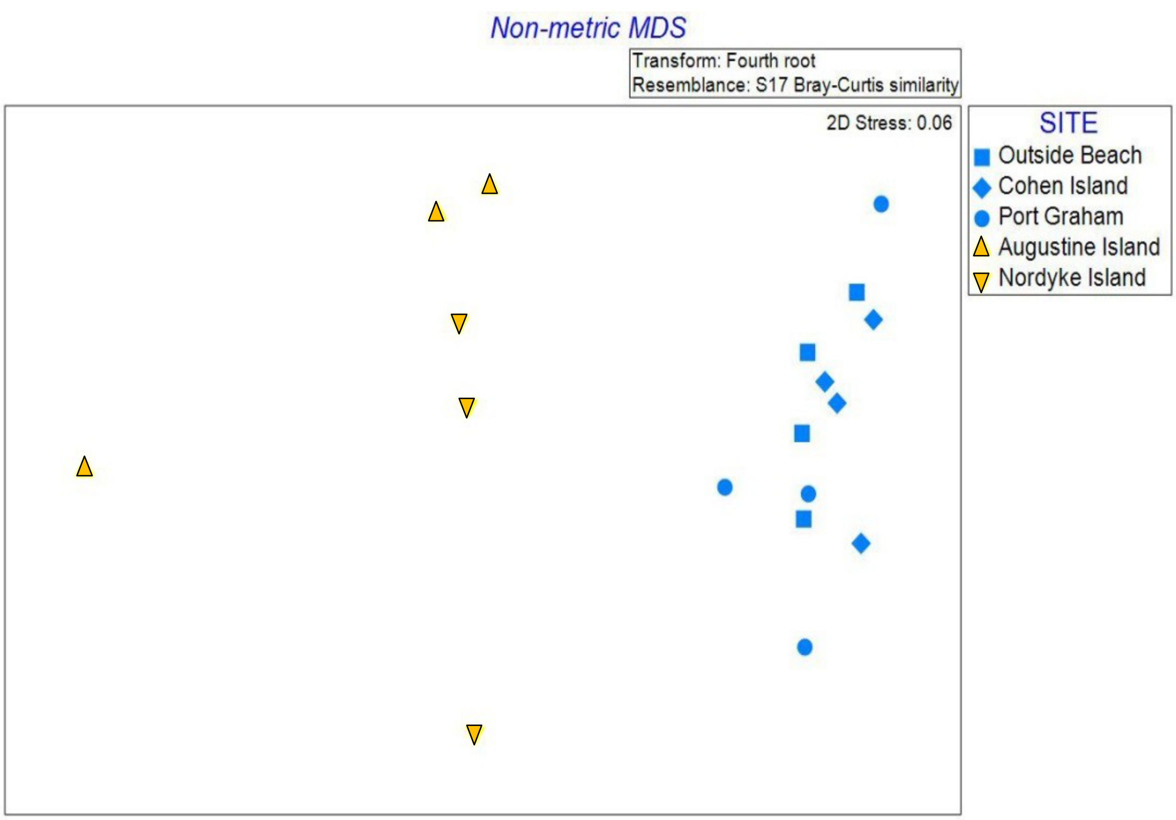

Figure 4. Multidimensional scaling plot of intertidal communities in Kachemak Bay (blue) and Kamishak Bay (orange). These two regions were well separated, indicating quite different community composition.

2018 Publications/Presentations

Danielle Siegert presented her work in poster format (Figure 5) at the Alaska Marine Science Symposium in Anchorage, Alaska (January 2018) and at the Kachemak Bay Science Conference in Homer, Alaska (March 2018). She also gave a project update during the CMI Annual Review in Anchorage on 26 January 2018. Ms. Siegert completed her comprehensive exam toward an M.S. degree in Marine Biology on 15 October 2018. The exam included a public presentation of her work and a closed-session oral exam by her graduate committee and an outside examiner.

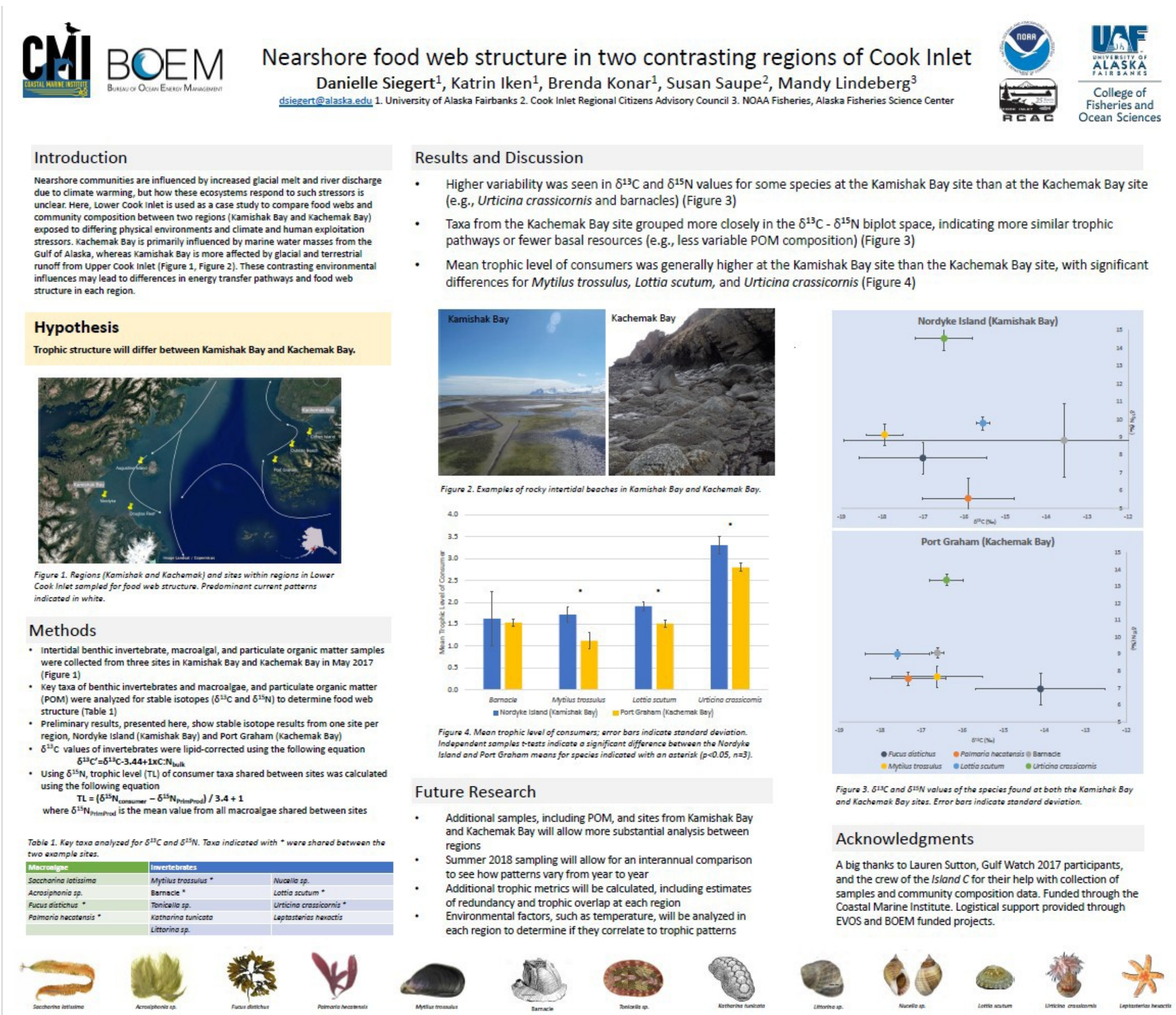

Figure 5. Poster presented by student Danielle Siegert at the AMSS and the Kachemak Bay Science Conference in 2018.

High-frequency Characterization of the Physicochemical Parameters of Cook Inlet, Alaska

Principal Investigator: Amanda Kelley

College of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M17AC00011
Period of Performance: 05/15/17 – 07/31/20

Project Overview

Nearshore ecosystems help to protect the coastline and provide important habitat for marine animals. Despite Alaska's vast coastlines and vital fisheries, little is known about how ocean acidification (OA), a decline in ocean pH due to the absorption of anthropogenic carbon dioxide by the world's oceans, affects the nearshore environment. Because these ecosystems are highly dynamic and complex, it has been challenging to accurately monitor changes in ocean chemistry in coastal waters, more so in places like Alaska. Furthermore, with few baseline ocean pH records in place, it is difficult to determine the anthropogenic and natural influences on ocean pH variability. Current advances in pH sensor technology have led to OA monitoring networks along the west coast of the United States. Such a sensor network was established in lower Cook Inlet, Alaska. In October, 2017, five pH sensors (co-deployed with salinity, oxygen concentration and temperature loggers) were deployed at five nearshore sites along Kachemak Bay's coastline (Figure 1).

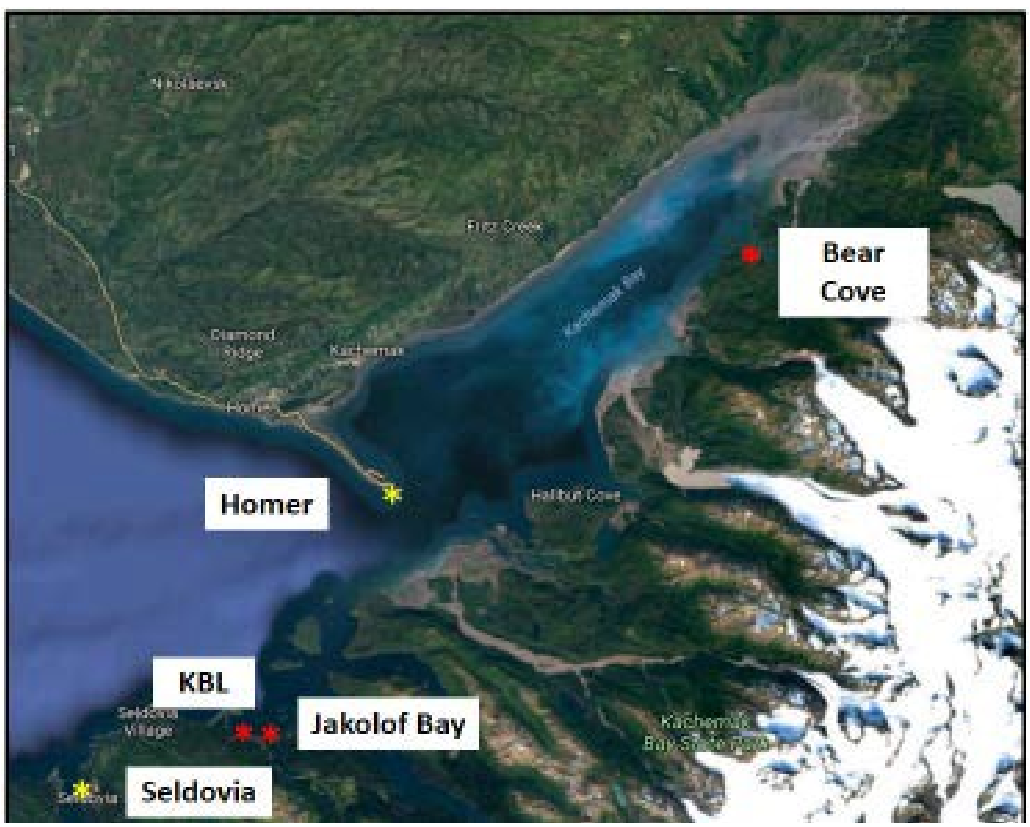

Figure 1. pH sensor sites in Kachemak Bay, Alaska: Kasitsna Bay, Jakolof Bay, Seldovia Harbor, Homer Harbor, and at the head of Kachemak Bay in Bear Cove. Red asterisk denotes CMI-funded SeapHOx sensors (pH, temperature, salinity and oxygen). Yellow asterisk denotes SeaFET sensors (pH and temperature, supplemented with salinity and oxygen sensors).

The aim of the project is to characterize the pH spatiotemporal variability in Kachemak Bay with an emphasis on determining what forcing factors are responsible for the observed variability. The benefits of this research are twofold. First, the collection of high- quality pH data can serve as a benchmark for understanding the severity and magnitude of future impacts of ocean acidification on the carbonate dynamics of nearshore environments. Second, manipulative OA experiments can include present-day pH variability as a means to adequately frame organismal responses providing a measure of ecological relevance to the results of such biological studies.

2018 Project Update

The study sites were visited Kachemak Bay four times in 2018 to collect reference water samples, download data, and conduct sensor maintenance. Due to inclement weather, the Homer site could not be accessed in December 2018. Over the last year, there were several times when the pH sensor electrodes were fouled with sediment, which impacted the overall pH readings at some sites. Bear Cove and Jakolof Bay had continuous pH time-series. The other sites collected fragmented pH data due to technical issue that arose from electrode fouling. Below is a review of all the data collected from each site. I am currently analyzing pH, temperature, salinity and oxygen data from Bear Cove and Jakalof Bay for publication (14-months total). All data analyses were completed using Matlab 2018. I plan to begin on the Seldovia-Homer datasets after May 2019 when there will be one year of time-series from each site.

Bear Cove

The figures below represent 14-months of continuous high-frequency time-series data from Bear Cove. I will run a Pearson’s r correlation for oxygen, pH, and tides for the highly variable months. The range for pH during the deployment period was 7.72–8.36, with total variability equaling 0.64. From September through December 2018, Bear Cove average pH was 7.85, with episodic events measuring < 7.73. Bear Cove monthly mean standard deviations are greater than 0.1 pH one month out of the year. Associated pH uncertainty for this time-series is 0.0227.

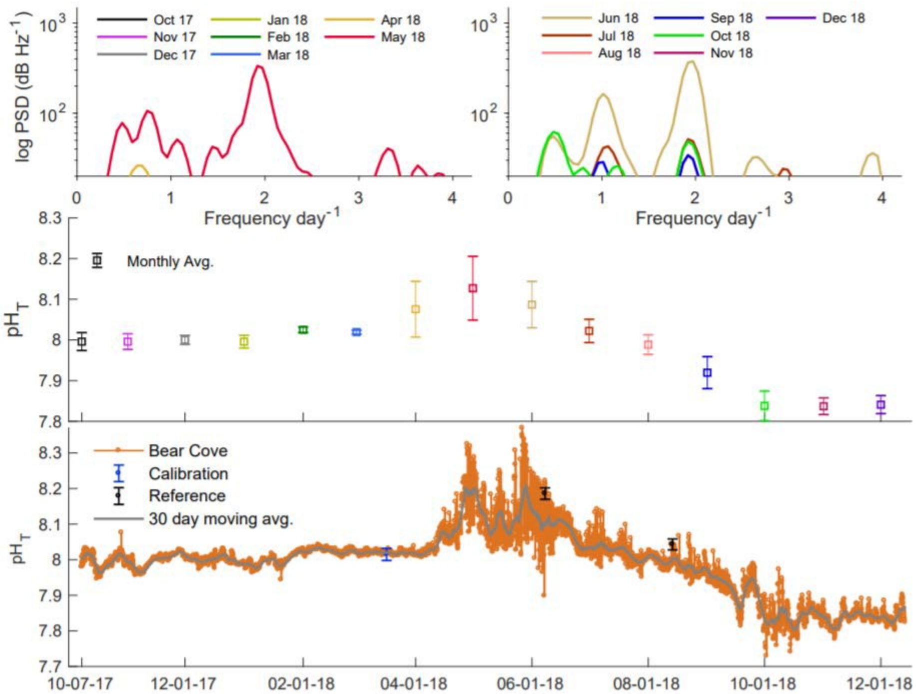

Figure 2. Power spectral analysis of pH by month (top), total pH variability per month (middle; error bars indicate total range of pH experienced darning that month), and high-frequency (3 hour) pH time-series data (bottom).

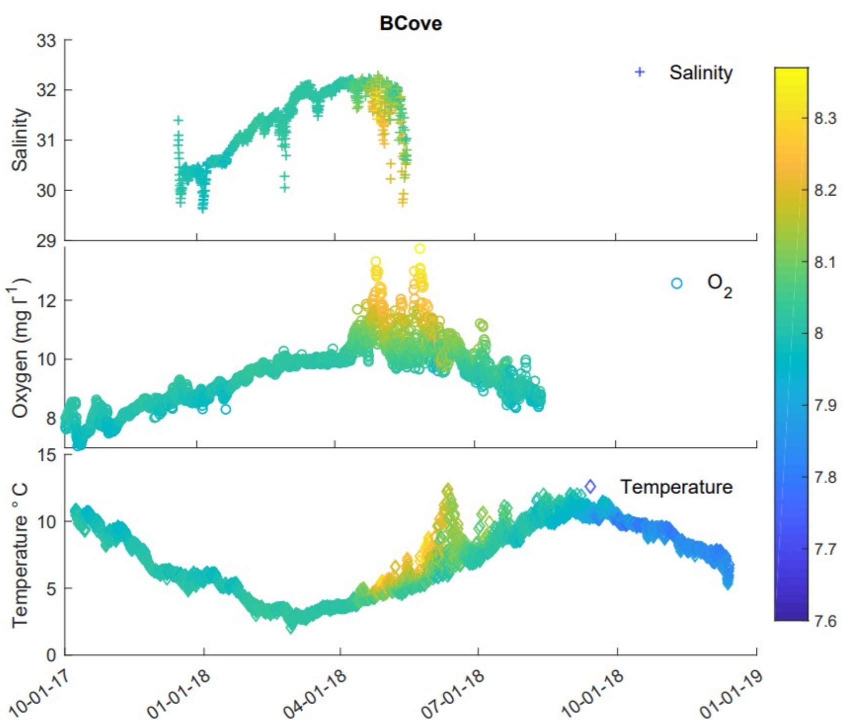

Figure 3. Salinity time-series (top), dissolved oxygen time-series (middle), and temperature time-series (bottom); color denotes pH value for each data point.

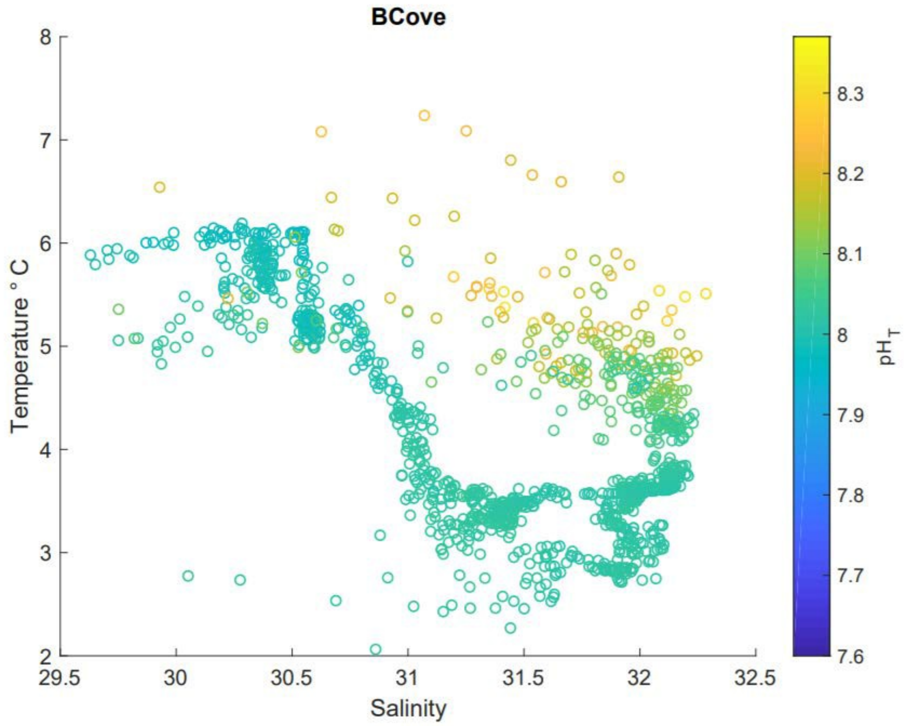

Figure 4. Temperature–salinity plot; color denotes pH.

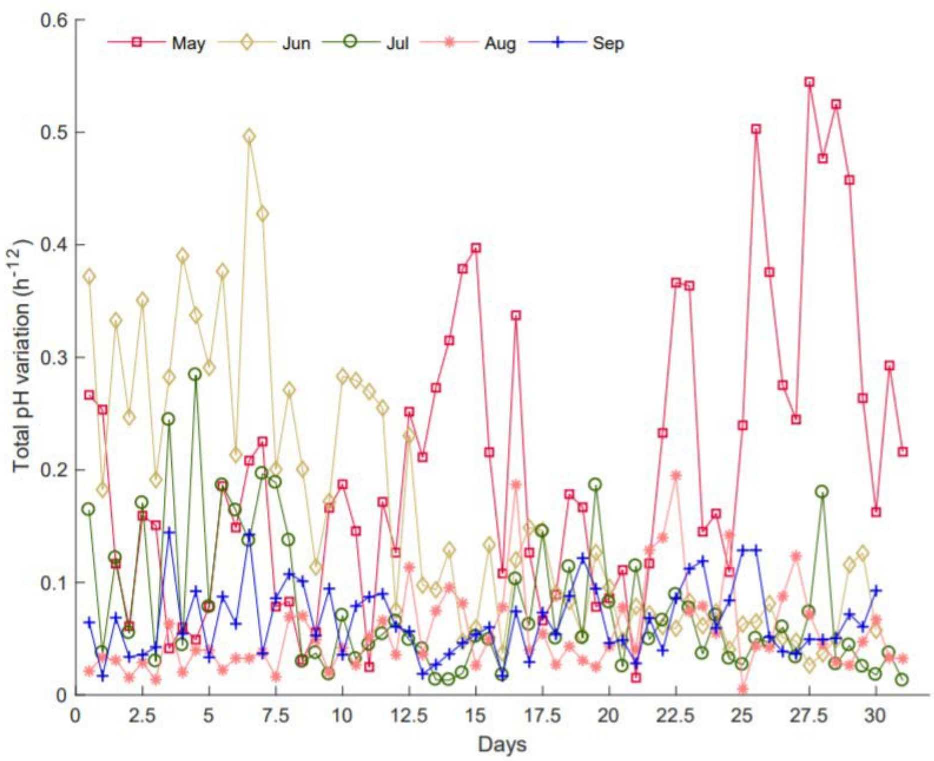

Figure 5. pH variability severity index (the additive accumulated pH variability experienced over a 12- hour period).

Jakolof Bay

The figures below represent 14-months of continuous high-frequency time-series data from Bear Cove. I will run a Pearson's r correlation for oxygen, pH and tides for the highly variable months. The range for pH during the deployment period was 7.62–8.31, equaling variability of 0.69 pH units. Jakolof Bay monthly mean standard deviations were greater than 0.1 pH units 4 months out of the year. Primary productivity (oxygen concentration as proxy) was largely responsible for peak pH values in summer and fall. The associated pH uncertainty associated with this time-series is 0.0192.

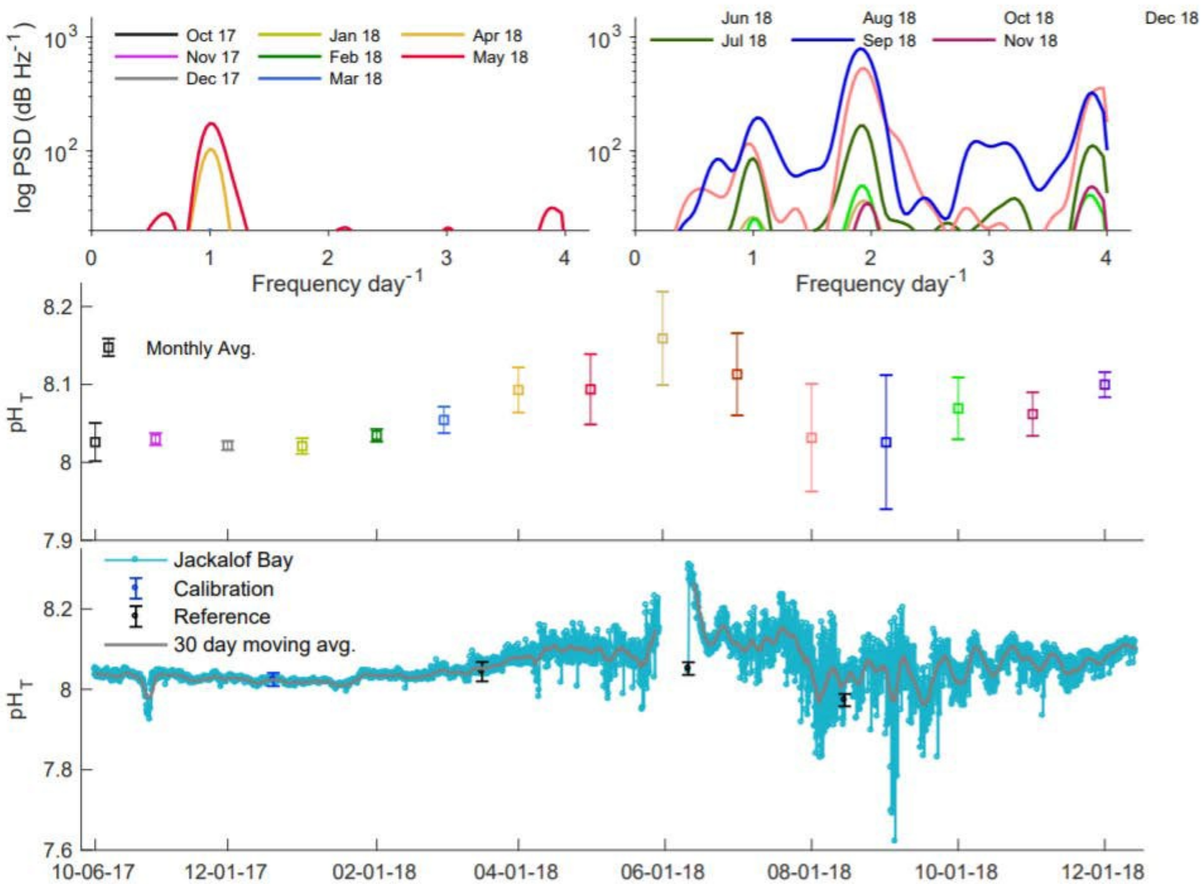

Figure 6. Power spectral analysis of pH by month (top), total pH variability per month (middle; error bars indicate total range of pH experienced darning that month), and high-frequency (3 hour) pH time-series data (bottom).

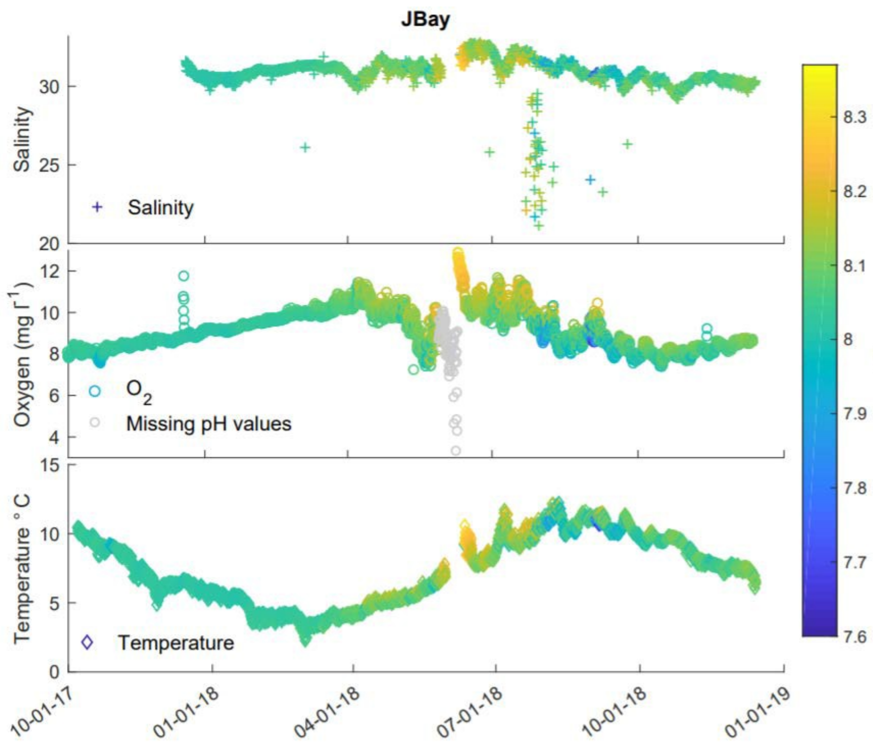

Figure 7. Salinity time-series (top), dissolved oxygen time-series (middle), and temperature time-series (bottom); color denotes pH value for each data point.

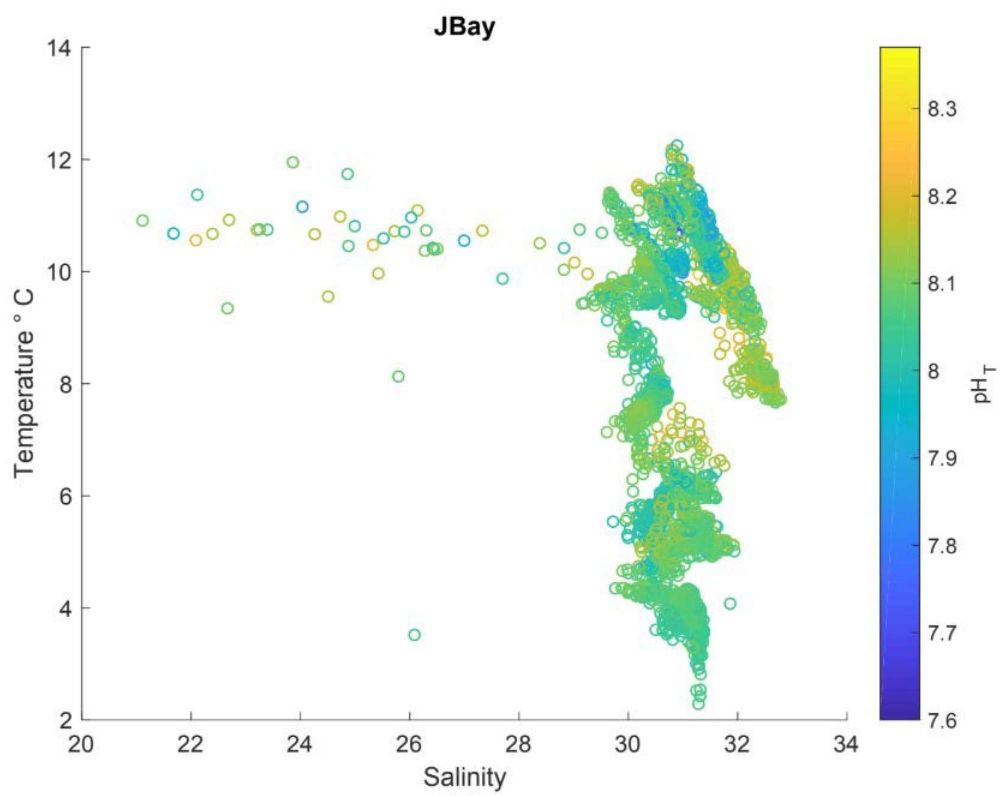

Figure 8. Temperature–salinity plot; color denotes pH.

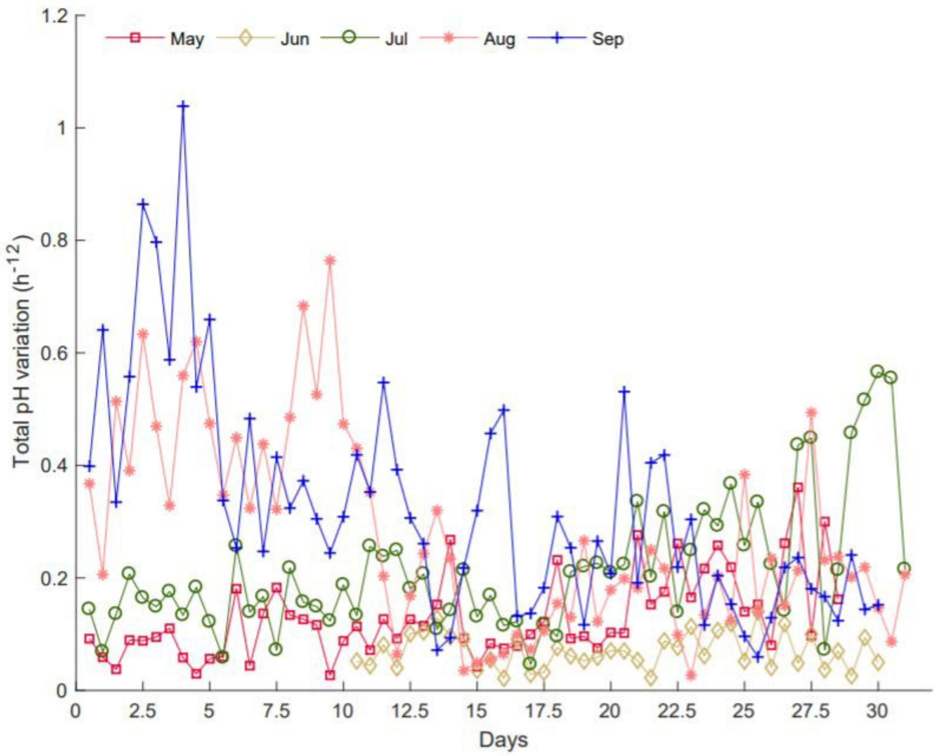

Figure 9. pH variability severity index (the additive accumulated pH variability experienced over a 12- hour period).

Seldovia

The Seldovia SeapHOx has collected intermittent pH data throughout the 14-month deployment period due electrode fouling and battery failure. As mentioned in previous reports, due to electrode fouling in March 2018, I have low confidence in the data prior to this point.

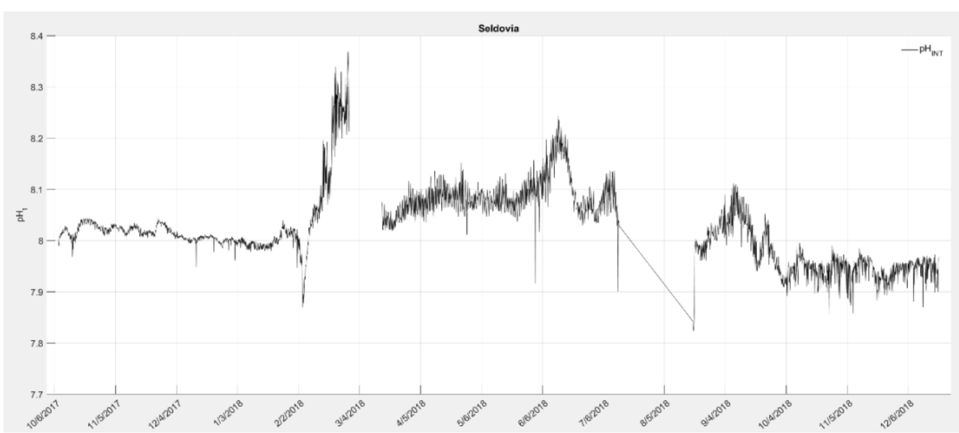

Figure 10. pH time-series.

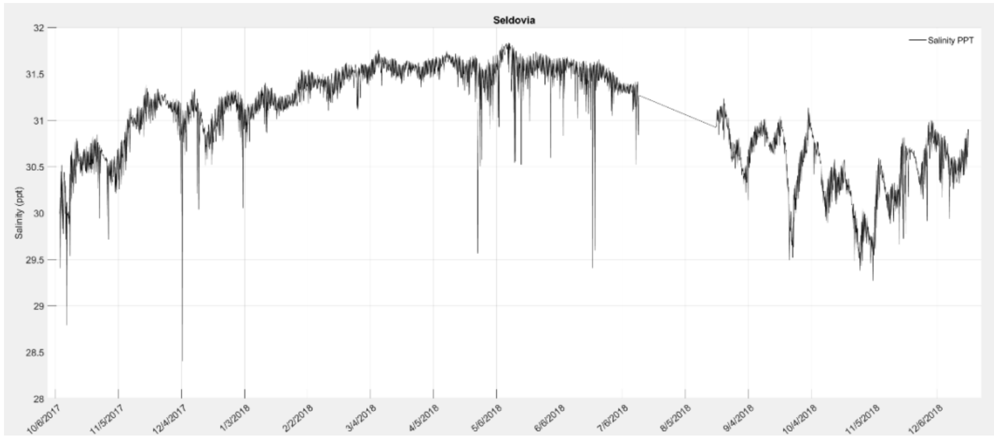

Figure 11. Salinity (ppt) time-series.

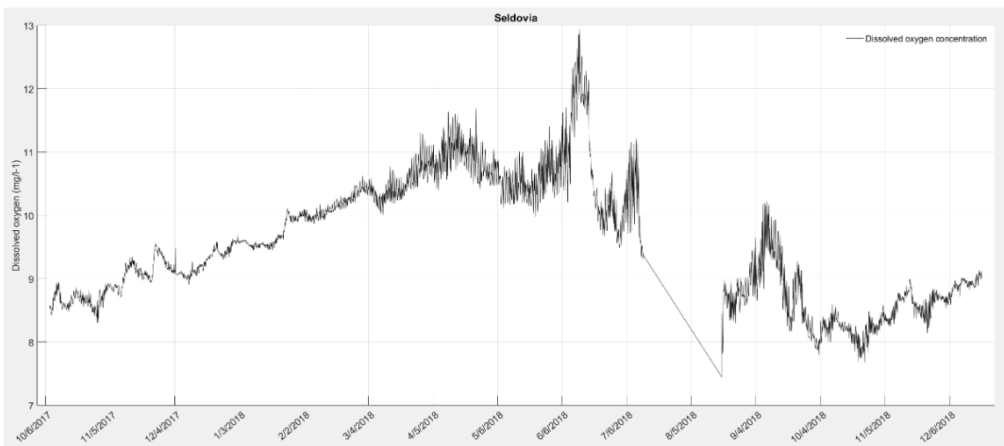

Figure 12. Dissolved oxygen concentration (mg/l^{-1}) time-series.

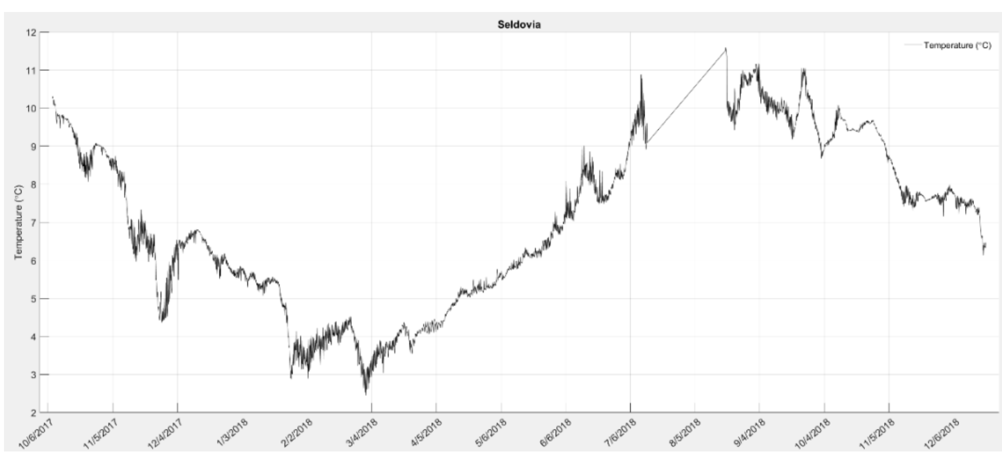

Figure 13. Temperature (°C) time-series.

Homer

The pH time-series from this site is very limited due to multiple mechanical issues and battery failure. The pH time-series was calibrated using a sample collected in March 2018. A reference sample was collected in June 2018, and the uncertainty term for this dataset is 0.06 pH units. This uncertainty term is much larger than is accepted within the scientific community, which is 0.03 pH units. Despite this, the summertime values dipped down to ~7.4, the lowest value recorded at any site in Kachemak Bay throughout the entire deployment period. This site also had the lowest upper pH value was 8.1, 0.3 units lower than the highest value recorded at Bear Cove (8.4 pH units). Homer experiences less extreme diel pH variability compared to other sites. I was not able to collect a seawater sample or download the data from this site due to inclement weather. I hope to collect both when I visit Kachemak Bay in March 2019. The associated pH uncertainty associated with this time-series is 0.079.

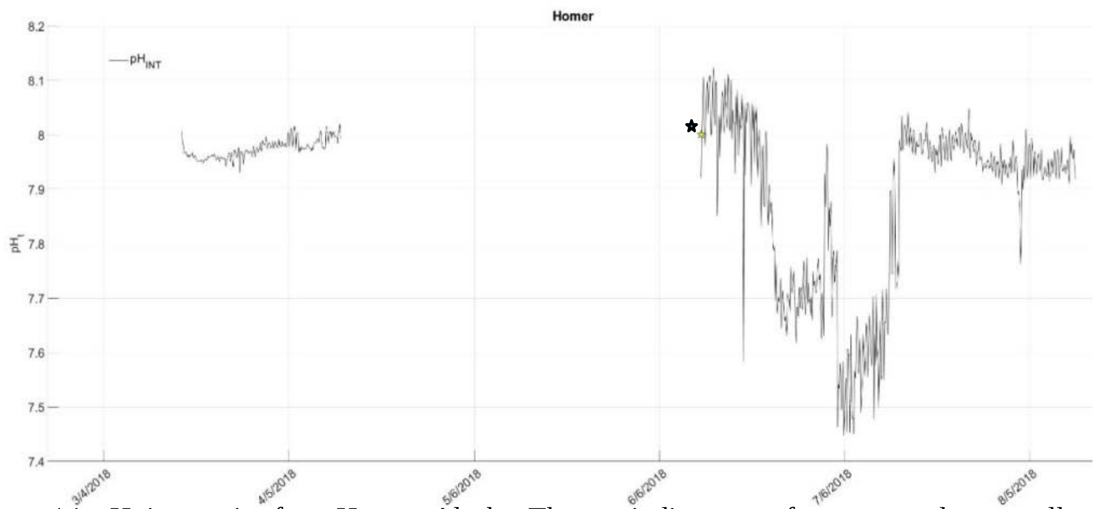

Figure 14. pH time-series from Homer, Alaska. The star indicates a reference sample was collected.

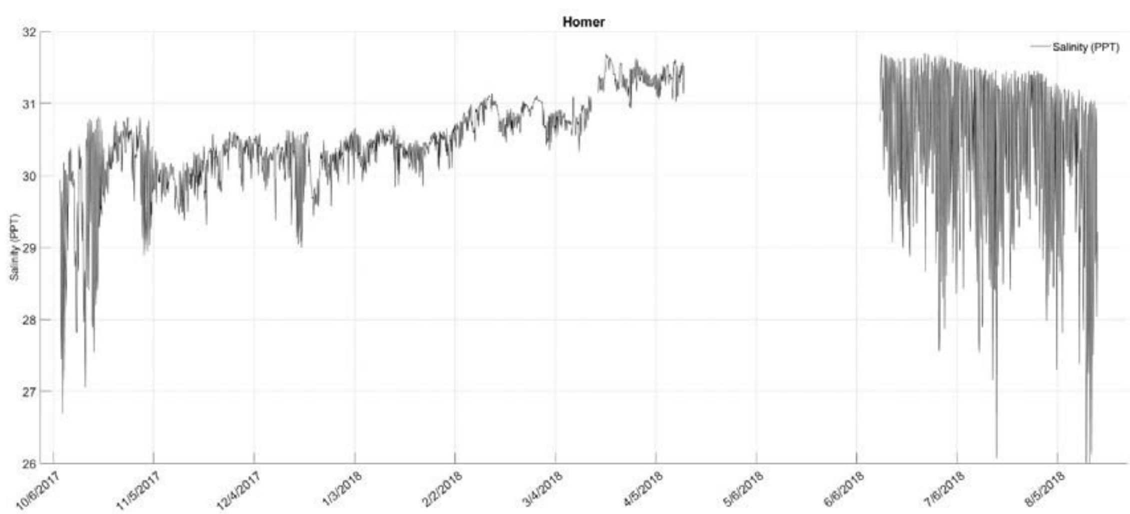

Figure 15. Salinity (ppt) time-series.

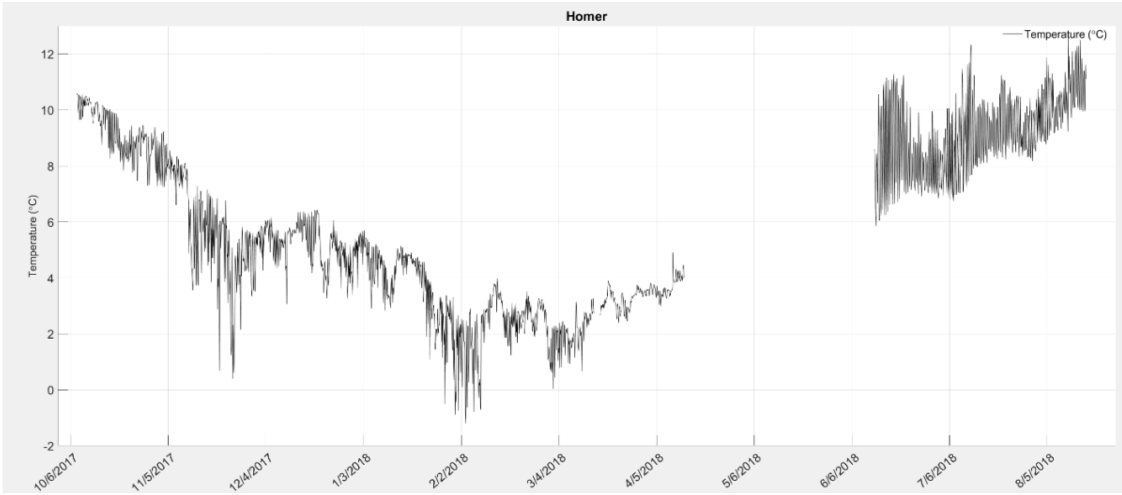

Figure 16 Temperature (°C) time-series.

2018 Publications/Presentations

Data from this project was presented several times in 2018:

- 2018 Kachemak Bay Science Conference, Homer, AK (oral presentation)
- North Slope Borough Department of Wildlife Management, Utqiagvik, AK (oral presentation)
- Community of Savoonga, St. Lawrence Island, AK (oral presentation)
- Community of Gambell, St. Lawrence Island, AK (oral presentation)

Coastal Community Vulnerability Index and Visualizations of Change in Cook Inlet, Alaska

Principal Investigator: Davin Holen

College of Fisheries and Ocean Sciences
University of Alaska Fairbanks

Cooperative Agreement Number: M17AC00008
Period of Performance: 06/14/17 – 09/30/18

Project Overview

This project will use a GIS platform to create a coastal vulnerability index. This will include a GIS layer on the AOOS data portal to visualize hunting, fishing, and gathering data that could be overlaid by layers on contaminants, vessel traffic, harmful algae blooms, ocean acidification, or other layers useful for planning oil and gas activities as well as responding to a technological disaster. Methods for this project include a partner on the project Axiom Data Sciences (Axiom) overlaying the data sets to create maps and visualizations. To ground-truth the harvest and use data, as well as to get a better understanding of coastal change over time, information sessions will be conducted in key communities in the Cook Inlet region to provide a broader synthesis of activities. This may include (but is not limited to) Nanwalek, Ninilchik, Seldovia, and Tyonek. These communities represent outer, lower, and upper Cook Inlet regions. A presentation on the tool as well as potential visualizations will be reviewed by participants in meetings. Maps will document coastal change as well as change in major harvest categories that residents attribute to climate, development, natural change processes, or other factors. The outcome of this project will be access to new visualizations through the AOOS data portal as part of the Cook Inlet Response Tool (CIRT) module, which allows a user to overlay a multitude of data sets by topic. The new layer, titled Wild Resource Harvest and Use by Cook Inlet Communities, is under the socio-economic category in the AOOS data catalog.

2018 Project Update

Prior to 2018, the main activities for the project focused on accessing Alaska Department of Fish and Game GIS data. This data was received in early August 2017 and uploaded and published on the AOOS CIRT data portal in late 2017 (Figure 1). Metadata was written for the GIS data to describe related data collection, analysis, and sampling.

The goals for 2018 were to finalize the data in the catalog, finish the metadata, and test the tool in community meetings. The community meetings would be an opportunity for feedback on 1) whether harvest and use of wild resources is was accurate as displayed, 2) the utility of the tool for communities, and 3) what data layers would be most useful to pair with the harvest and use layer. A secondary goal was to test the tool in a small geographic area with just a few communities to assess potential usefulness at a larger scale for the Bering Sea. The hope was to hold the community meetings in the spring of 2018, prior to the start of the fishing season; however, University of Alaska complications in hiring a research assistant delayed meetings until after summer and fall harvesting activities were complete.

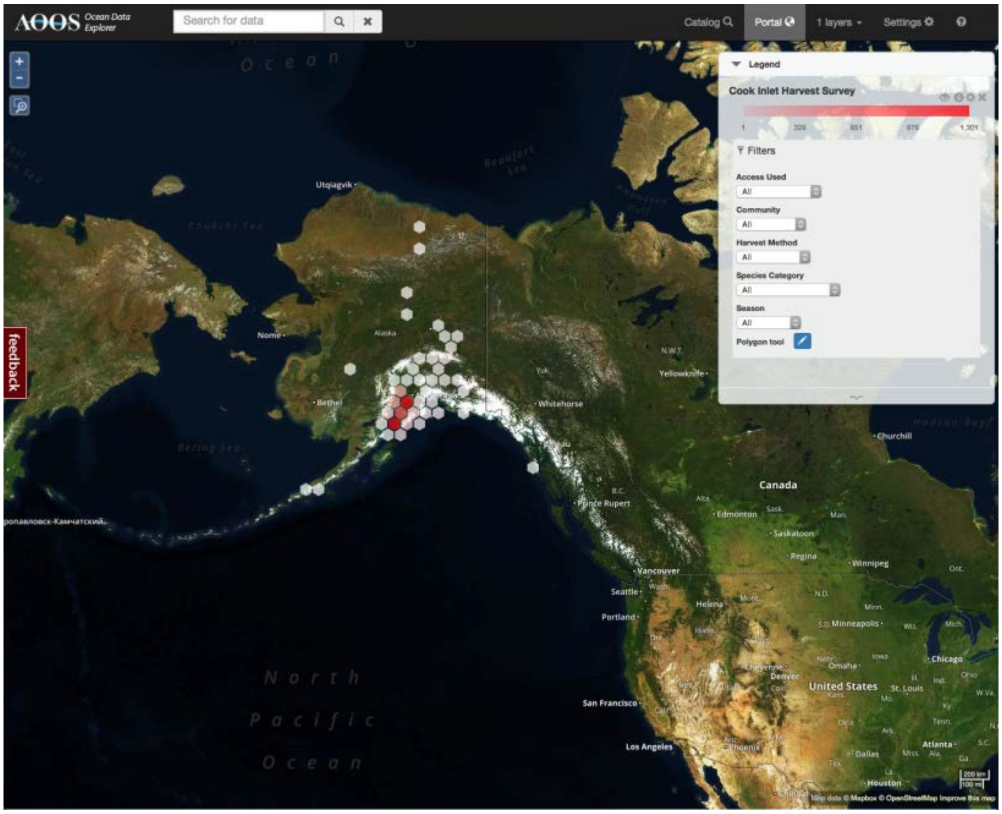

Figure 1. Website database access page with search features.

Community review meetings occurred in October 2018 in Seldovia and Nanwalek. Research assistant Emilie Springer took notes and summarized the meetings for review by PI Holen. Findings from community feedback included:

- The tool demonstrates the diversity and scope of resource harvesting activities and emphasizes local knowledge. Respondents agreed with the way the data was displayed and felt it was beneficial in having a GIS component that showed local use and the importance of resources to communities.
- Shellfish species have changed over time and harvest activities are not well represented in the data. Shellfish harvesting was historically important and one community is actively working with the Alutiiq Pride Shellfish Hatchery to seed beaches and reestablish the resource. This could be updated in the CIRT when resources become available.
- Harvest activities have changed with harvesters traveling further in summer and staying close by during winter. These dynamics are in response to competition with sport operators and a lack of locally available shellfish.
- Potential layers to include in the CIRT that could be overlaid on the harvest and use layers include: Contaminants, Vessel Traffic, Harmful Algae Blooms, Ocean Acidification, and Sea Bird Distribution

2018 Activities

- Refined the metadata and test the visualizations (with Axiom, January–March, 2018)
- Conducted community meetings in Seldovia and Nanwalek (October 2018)
- Produced an analysis of community discussions (November 2018)

2019 Activities Plan

- Submit draft final report (April)
- Submit final report (June 30)
- Link to Adapt Alaska, a tool for community planning, response, and adaptation (April)
- Finalize the data for the Cook Inlet Response Tool Module
- Present CIRT Module and static maps to communities

2018 Publications/Presentations

- The harvest data has been published on the Cook Inlet Response Tool available on the AOOS data portal (http://portal.aoos.org).
- CMI Annual Research Review, January 2018, Anchorage, AK (oral presentation)
- Bering Sea Data Synthesis Workshop, November 2018, Anchorage, AK (oral presentation)

Microbial Biodegradation of Alaska North Slope Crude Oil in Pacific Arctic Marine Sediment

Principal Investigator: Mary Beth Leigh

Institute of Arctic Biology
University of Alaska Fairbanks

Cooperative Agreement Number: M17AC00005
Period of Performance: 05/15/17 – 11/30/19

Project Overview

The objectives of this project are to investigate the biodegradation of crude oil in Arctic seawater and sediments in order to better predict the fate of spilled oil in the Arctic marine environment. We are performing incubation studies to investigate the biodegradation of fresh and weathered crude oil in sediments under both aerobic and anaerobic conditions in order to assess biodegradation rates and to identify oil-degrading microbes. Following the identification of putative oil-degrading bacteria in incubation tests, we will query our existing microbial community datasets from sediments across the Beaufort Sea to assess the biodegradation potential present in indigenous sediment microbial communities across the region. Additionally, we are capitalizing upon samples we have stored from oil biodegradation incubation studies previously performed using Arctic seawater by applying in-depth analyses of microbial community structure and petroleum degradation gene expression to gain a comprehensive perspective of microbes and genes active in the biodegradation of petroleum and of Corexit 9500 (a chemical dispersant) in Arctic seawater. Together, our findings will provide a complimentary, in-depth analysis of the crude oil biodegradation potential in an Arctic marine environment at a growing risk of contamination.

2018 Project Update

Sediment incubation studies

A major series of sediment oil biodegradation incubations were established by Ph.D. student Alexis Walker using the sediments freshly collected from the Chukchi Sea in August 2017. Serum bottles containing sediments, seawater, and either fresh or moderately weathered crude oil or no amendment were established under both aerobic and anaerobic conditions. Multiple replicates of each were prepared to enable the destructive harvesting of triplicates for each treatment over an extended time course for petroleum and microbial analyses. Additional replicates were sterilized to provide abiotic controls that will help distinguish biodegradation of oil from abiotic losses (e.g., volatilization, sorption). The incubations were completed and stored frozen for petroleum and microbial analyses, which were the focus of the efforts in this (2018) project year.

A draft petroleum extraction protocol for sediment incubations was by developed by adapting existing protocols for soils and seawater. Protocol development will continue in 2019.

For microbial analyses, sediment samples were freeze-dried and subjected to DNA extractions. From the DNA extracts, 16S rRNA amplicon libraries were prepared, and DNA sequencing was performed using Illumina MiSeq in the UAF Genomics Core Lab. These data were processed using the mothur bioinformatic pipeline, and preliminary statistical analyses were performed.

Based on preliminary analyses, sediment microbial community structure appears to shift in response to the addition of oil, with different responses to weathered vs. fresh oil (Figure 1). Sediment communities exposed to fresh oil and weathered oil are more similar at the first two time points (T0 & T1) and diverge between the third and final time points (T2-T5; Figure 2) indicating different community trajectories in response to different oil compositions. This is consistent with the fact that microbes tend to sequentially biodegrade petroleum components, beginning with more labile components, which are more abundant in fresh oil and moving on to the more recalcitrant components such as polyaromatic hydrocarbons (PAHs), which are more abundant in crude oil.

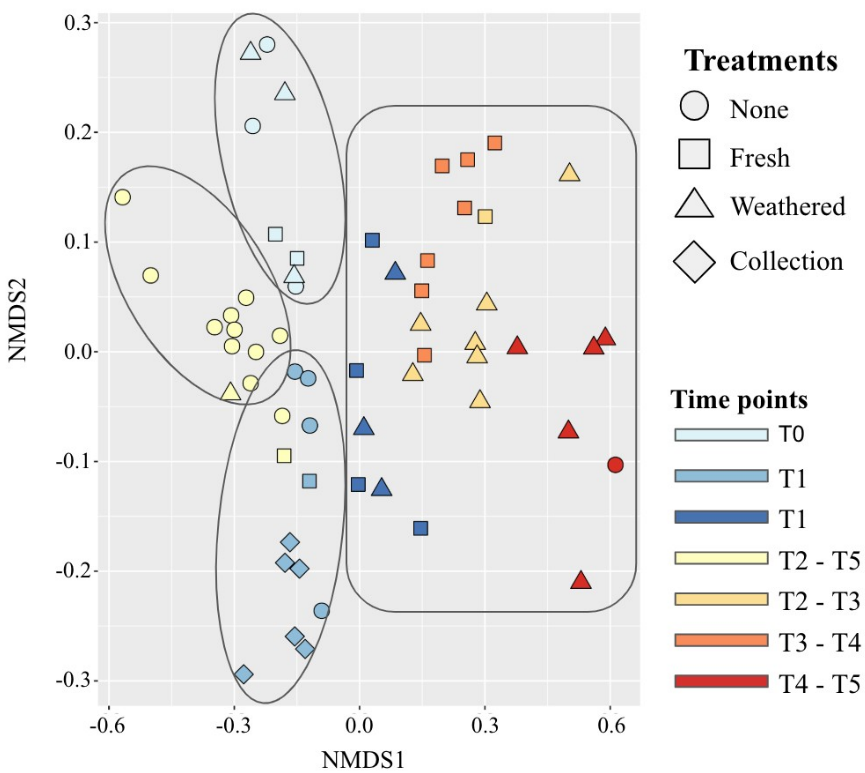

Figure 1. nMDS of microbial community structure in incubated sediment samples. The ordination plot above depicts the community structure for each time point at which bottles were harvested (color denotes time, shape denotes treatment). After time zero (T0), each time point represents an additional 12 days of incubation. “None,” “fresh,” and “weathered” refer to the experimental treatments of non-oil, fresh oil, and weathered oil, respectively. “Collection” is the in situ community present at the time of sample collection in the Chukchi Sea. Note that there are two colors for T1, in order to emphasize the difference between the non-oiled and oiled sediment communities at time point 1.

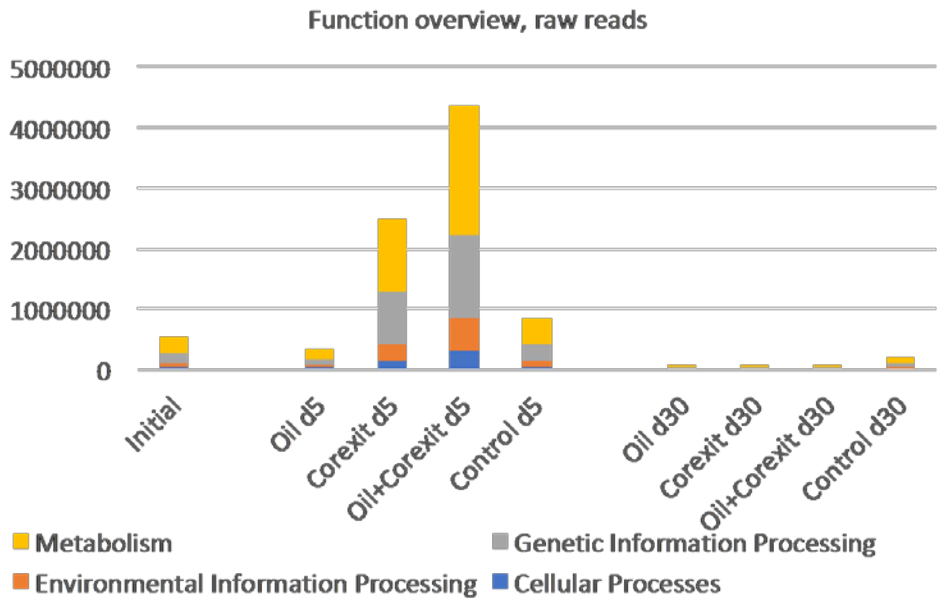

Figure 2. Summary of total number of RNA sequence reads associated with different gene categories at 5 and 30 days after exposure to oil and/or Corexit.

Delving further into the taxonomic differences in microbial community structure represented in Figure 1, we have found key indicator taxa representing these communities that warrant further attention, given that they likely represent oil degraders important to particular stages of biodegradation. Two indicator taxa were identified by indicator-species analyses oiled samples after extended incubation (T4-T5 = 24 days, red points in Figure 1). These two taxa were identified to genus level, *Cycloclasticus* spp., and only family level in the case of VHS-B4-70. *Cycloclasticus* spp. are reported to be important PAH degraders in marine systems, and are capable of degrading pyrene, naphthalene, and phenanthrene (Kasai et al. 2002; Teira et al. 2007; Wang et al. 2018). The indicator taxon found in the family VHS-B4-70, however, is an uncultured bacterium that has not been described in the literature.

Future analyses will more deeply examine the taxa associated with these stages in fresh and weathered oil degradation in sediments and, through combining the data analyses with petroleum analyses, can strengthen the linkages between them.

Sediment survey molecular analyses

Ph.D. student Alexis Walker performed an extensive analysis of the microbial community structure in sediment samples taken from multiple locations across the Beaufort Sea to Amundson Gulf as part of her separate CMI Graduate Fellowship-supported research. In the current study, these data are being queried for the presence of organisms identified as putative oil degraders based on their response (increase in relative abundance) in the oil incubation tests. The majority of this task will be performed next project year after completion of the sediment incubation microbial data analyses that are now in progress.

Seawater molecular analyses

Ph.D. student Taylor Gofstein has been performing microbial metatranscriptomic analyses of seawater incubation tests containing crude oil and/or the chemical dispersant Corexit 9500A in order to identify microbial taxa and genes active in response to oil and/or dispersant. Analyses were performed on samples stored from an August 2016 temporal incubation series of Arctic seawater with Alaska North Slope crude oil, Corexit 9500, or both. Sterile and microbial controls were also run. All samples were performed in triplicate. Microbes from various time points in these incubations had been collected onto filters and frozen at -80°C. RNA extractions were successful in yielding adequate quantities of high-quality RNA for metatranscriptomic analyses. RNA extracts were shipped to Oregon State University for analyses. Metatranscriptomic sequencing was performed using Illumina HiSeq, generating 155 GB of data. During this project year, bioinformatics methods were developed/optimized, and analyses of this RNAseq dataset were partially completed on the MG-RAST web server.

Preliminary analyses of RNA data showed that at 5 days, treatments containing Corexit had significantly higher overall gene expression than the oil only or control treatments. This indicates that more microbial metabolic activity occurred in response to Corexit compared to oil or no treatment, although expression for all treatments returned to basal levels at 30 days. This temporal pattern corresponds with our chemical analysis data from a previous CMI grant showing that many of the Corexit surfactant components are rapidly metabolized within the first 5 days, which the exception of DOSS, which persists longer. It is also consistent with our prior published data (McFarlin et al., 2014) showing a more notable increase in microbial respiration when Corexit is added to Arctic seawater compared to the addition of oil (when added separately). This might be explained by the fact that some Corexit components are more readily biodegradable than many crude oil components. Continued RNA data analyses will focus on the identification of genes and potential pathways active in crude oil and Corexit biodegradation.

References

Kasai, Y., H. Kishira, and S. Harayama. 2002. Bacteria belonging to the genus *Cycloclasticus* play a primary role in the degradation of aromatic hydrocarbons released in a marine environment. Applied and Environmental Microbiology, 68(11):5625–5633.

McFarlin, K.M., R.C. Prince, R. Perkins, and M.B. Leigh. 2014. Biodegradation of dispersed oil in arctic seawater at -1°C. PloS One, 9(1):e84297. doi:10.1371/journal.pone.0084297.

Teira, E., I. Lekunberri, J.M. Gasol, M. Nieto-Cid, X.A. Alvarez-Salgado, and F.G. Figueiras. 2007. Dynamics of the hydrocarbon-degrading *Cycloclasticus* bacteria during mesocosm-simulated oil spills. Environmental Microbiology, 9(10):2551–2562.

Wang, W., L. Wang, and Z. Shao. 2018. Polycyclic Aromatic Hydrocarbon (PAH) Degradation Pathways of the Obligate Marine PAH Degrader *Cycloclasticus* sp. Strain P1. Applied and Environmental Microbiology, 84(21):e01261-18. doi:10.1128/AEM.01261-18.

2018 Publications/Presentations

Leigh presented preliminary results of this project in a seminar entitled “Fate and effects of oil and oil spill response chemicals in Alaskan marine environments.” This talk was given to two different UAF seminar series this year:

- UAF Institute of Arctic Biology Life Sciences Seminar Series, November 9, 2018.
- UAF Institute of Marine Sciences

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the sound use of our land and water resources, protecting our fish, wildlife and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island communities.

The Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) works to manage the exploration and development of the nation's offshore resources in a way that appropriately balances economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.