PALMER STATION MONTHLY SCIENCE REPORT

FEBRUARY 2020

Sunrise over the Antarctic Peninsula as seen from the top of the glacier. *Image Credit: Randy Jones*

NEWS FROM THE LAB

Randy Jones, Summer Laboratory Supervisor

Heightened science activity continued throughout the month. Just prior to the arrival of the ARSV *Laurence M. Gould*, Andrew Thompson (W-222-P; Doherty/BBC) wrapped up filming embedded with the C-013-P (Fraser) group, and departed by tour ship on 5 Feb. The *Gould* arrived back to Palmer Station on 6 Feb following the 29^{th} annual LTER cruise. With the departure of the *Gould*, the C-020-P (Steinberg) group wrapped up their short, successful season, and members of B-005-P (Kohut), B-027-P (McClintock), C-013-P (Fraser), C-019-P (Schofield), C-024-P (Friedlaender), and C-045-P (Ducklow) groups departed station.

The Gould arrived back to Palmer Station on 24 Feb for the LMG20-02 cruise bringing members of B-027-P (McClintock) and C-013-P (Fraser) to station. During the 24-29 Feb port call, members of B-046-L (Teets; wingless midge research) and G-094-L (Yu/Beilman; moss research) worked in the Palmer Station Boating Areas – research groups that have been based at Palmer Station in recent seasons, but currently are working along the Peninsula across a wider geographic scope. It was a treat to host them back at Palmer Station.

It was another hugely successful month, full of collaborative efforts and lots of collected data points. Thanks to both grantees and ASC staff for supporting the science objectives at Palmer!

2019-20 GLACIER AND SNOW OBSERVATIONS
Marissa Goerke, Research Associate

GPS surveys of the glacier terminus and the glacier profile have been completed for the current season (Figs. 1, 2). Additionally, snow accumulation measured at the backyard snow stakes has been summarized for the current snow year (Fig. 3); the snow year defined as starting when the first snows of the winter occur and ending when the backyard snow stakes completely melt out.

Here are some quick facts from this year's measurements:

- The average easting of the glacier terminus receded 12.0m (39.4ft) over the last year
- We have lost 7.3m (24ft) of elevation at the glacier VHF repeater site in the last 15 years
- 2.6m (8.6ft) of snow accumulated over the snow year with the deepest snow day measuring in at 1.14m (45in) on 11 October 2019 (slightly-below-average accumulation year)

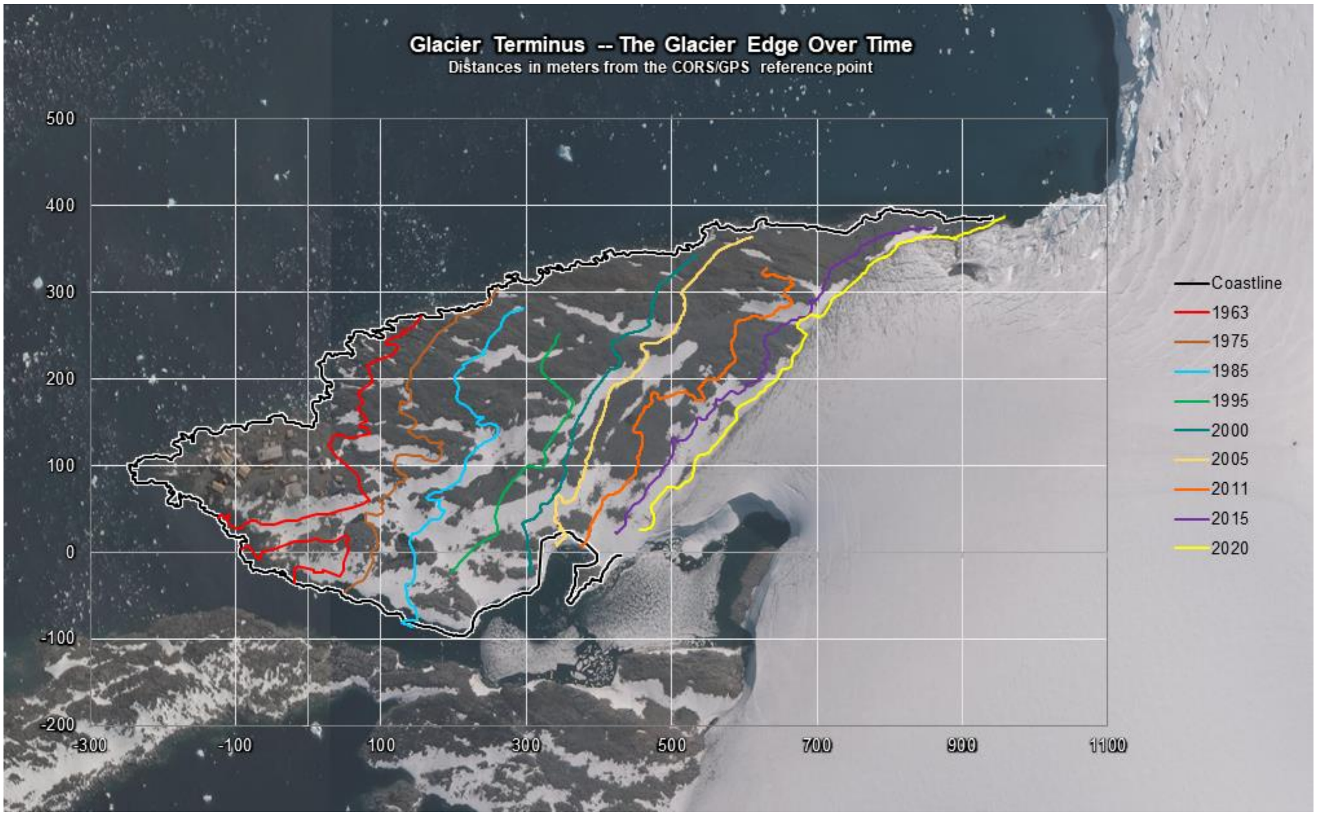


Fig. 1 – Glacier terminus GPS survey data from 1963 (red line) through 2020 (yellow line). The coastline is shown as a black line, and Palmer Station is located to the center-left of the image. Grid distances are in meters, referenced from the CORS/GPS reference point. *Image Credit: Marissa Goerke*

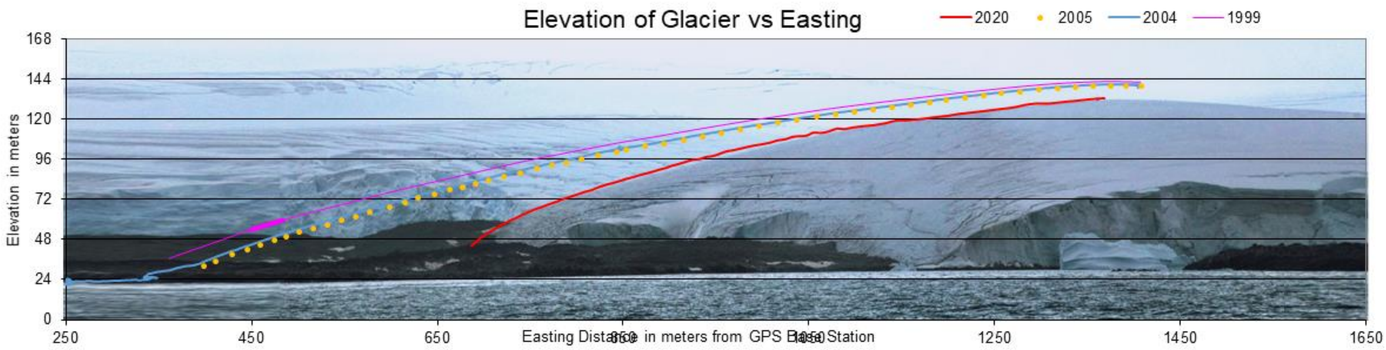


Fig. 2 – Glacier profile GPS survey data (m) for 1999 (pink line), 2004 (blue line), 2005 (dotted yellow line), and 2020 (red line). *Image Credit: Marissa Goerke*

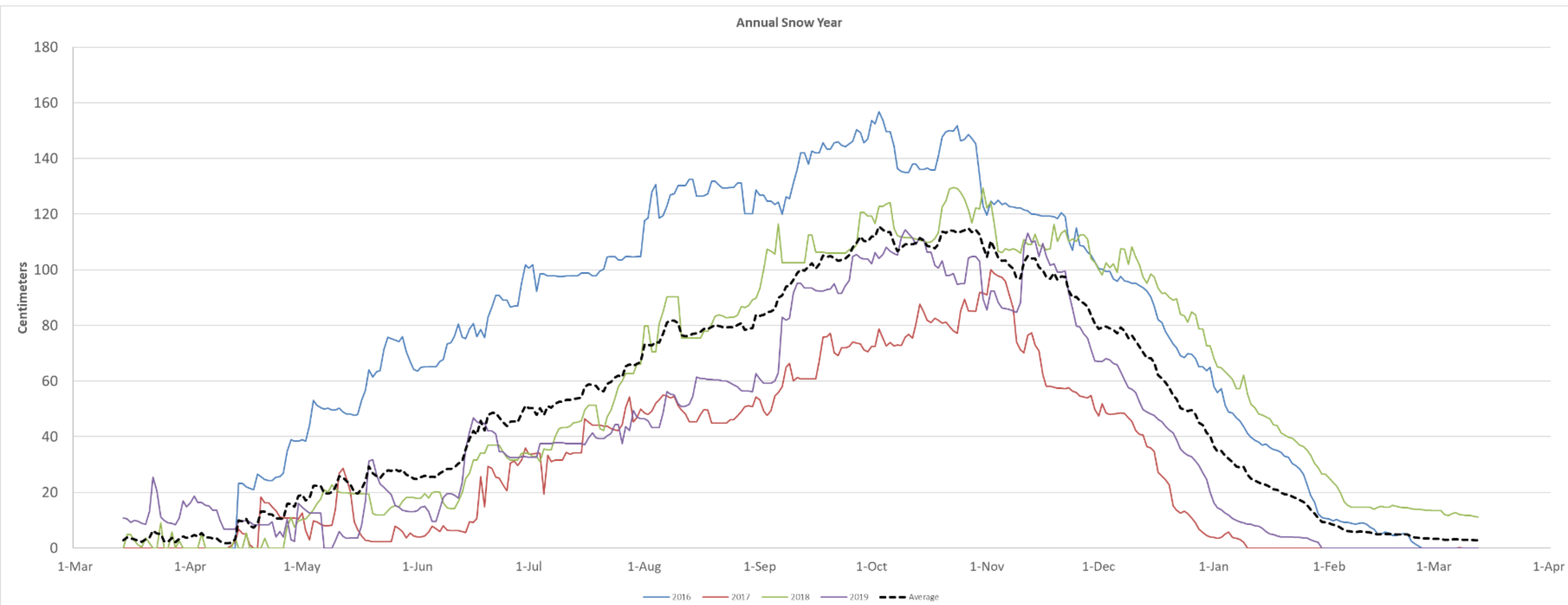


Fig. 3 – Snow accumulation (cm) across the snow year (March to March of subsequent years) for 2016-17 (blue line), 2017-18 (red line), 2018-19 (green line), and 2019-20 (purple line). Average 2016-2020 snow depth is shown as a black dotted line. *Image Credit: Marissa Goerke*

FEBRUARY 2020 WEATHER
Marissa Goerke, Research Associate

Temperature
Average: 2.7 °C / 36.8 °F
Maximum: 10.6 °C / 51.1 °F on 10 Feb 06:31
Minimum: -0.7 °C / 30.7 °F on 27 Feb 22:30
Air Pressure
Average: 990.0 mb
Maximum: 1013.1 mb on 8 Feb 18:57
Minimum: 969.2 mb on 29 Feb 23:42
Wind
Average: 7.2 knots / 8.3 mph
Peak (5 Sec Gust): 42.0 knots / 48.0 mph on 15 Feb 06:36 from ENE (73 deg)
Prevailing Direction for Month: NNW
Surface
Total Rainfall: 36.1 mm / 1.42 in
Total Snowfall: 0.0 cm / 0.0 in
Greatest Depth at Snow Stake: 0.0 cm / 0.0 in
WMO Sea Ice Observation: 6-10 bergs, bergy bits, growlers, brash ice
Average Sea Surface Temperature: 1.44 °C / 34.6 °F

The high temperature in February was 51.1° F and averaged 36.8° F. This high temperature is the third highest temperature recorded at Palmer and the highest ever recorded in February. Winds were calm and variable for most of the month with a few intermittent storms. All precipitation was rain except for one light dusting of snow near the end of the month that melted within the day.

B-005-P: COLLABORATIVE RESEARCH: PHYSICAL MECHANISMS DRIVING FOOD WEB FOCUSING IN ANTARCTIC BIOLOGICAL HOTSPOTS.

Dr. Josh Kohut, Principal Investigator, Rutgers University, Institute for Marine and Coastal Sciences; Dr. William R. Fraser, Co-PI, Polar Oceans Research Group; Dr. Kim Bernard, Co-PI, Oregon State University; Dr. Harper Simmons, Co-PI, University of Alaska, Fairbanks; Dr. Matthew Oliver, Co-PI, University of Delaware; Dr. John Klinck, Co-PI, Old Dominion University

Personnel on station: Ashley Hann, Josh Kohut, Matt Oliver, and Jackie Veatch.

This past month at Palmer Station we have continued the operation of our polar ocean observing system. This network includes autonomous underwater gliders, moorings, High Frequency Radar (HFR) stations, RHIB surveys, and a profiling LISST-HOLO holographic imaging sensor. With this ocean observatory, we are able to track the distribution of phytoplankton, zooplankton, and predators relative to the physical oceanographic features captured by the integrated network of platforms. Each resolving scales necessary to test our hypotheses. A summary of the activity across this effort follows in this report.

The month of February began with a first here at Palmer Station. Through an awesome collaborative effort between our local scientists, ASC, and NSF, we were able to recover one of our moorings with a RHIB deployed out of Palmer Station (Fig. 4). This is the first time a RHIB

Fig. 4 – Marine Technician Otto Neumuth and Kohut grantee Hank Statscewich bring a mooring alongside the RHIB in preparation for retrieval onboard. *Image Credit: Kohut group.*

has been tasked with a mooring recovery and shows another example of how the RHIBs enhance Palmer Station-based science support. We have been very impressed with the capabilities of these platforms, and they have been critical to the science goals of our project. Once recovered we were very excited to see the well resolved dataset including full water column velocities, full water column multi-frequency zooplankton acoustics, as well as bottom time series of temperature, salinity, pressure, and oxygen. The mooring equipment was provided by the NOAA/AMLR team who have deployed six identical moorings further north on the peninsula. We look forward to working with them to integrate these two moored data streams.

HF Radar: The three site HF radar network has operated continuously throughout the month. Data were delivered in real time through the Palmer Station network to our central processing machine in Terra Lab. These data (Fig. 5) have been critical to understand some of the variability seeing in the glider and ACROBAT data (see ‘Glider AUVs’ and ‘RHIB Surveys’ sections below).

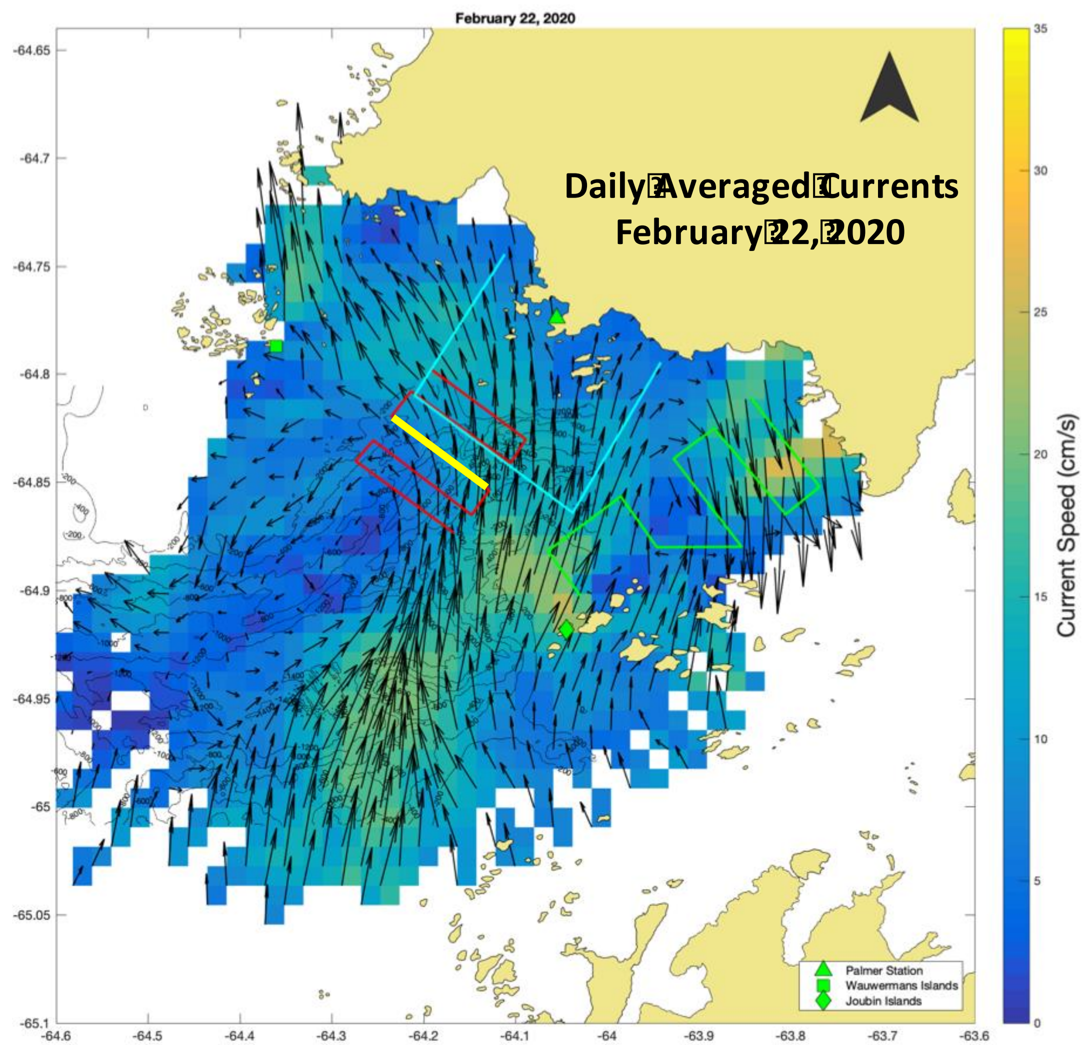


Fig. 5 – An example of the surface current maps generated through the HFR network for 22 February 2020. Current speed (cm s^{-1}) is shown with a color map, and spatially-binned averaged currents are shown as black vector arrows. *Image Credit: Kohut group.*

Glider AUVs: All three gliders have continued to operate as planned along our survey grid over Palmer Canyon and Palmer Deep. As of the draft of this report, the three gliders have been deployed for 128 glider days sampling over 2,100 km throughout the Palmer region. Over the last month, we were able to recover, repair, and redeploy one glider and recover the other two for brief 24-hour sampling breaks to download the acoustics datasets that are too big to send routinely over the satellite Iridium connection. During these planned recoveries, we were able to gather all the raw data and inspect the gliders before sending them back out on their missions. Transects in Figure 6 show the variability captured throughout the water column during these multi-month missions. The vertical black lines indicate the timing of our coordinated RHIB surveys that complement these data with higher resolution near the surface.

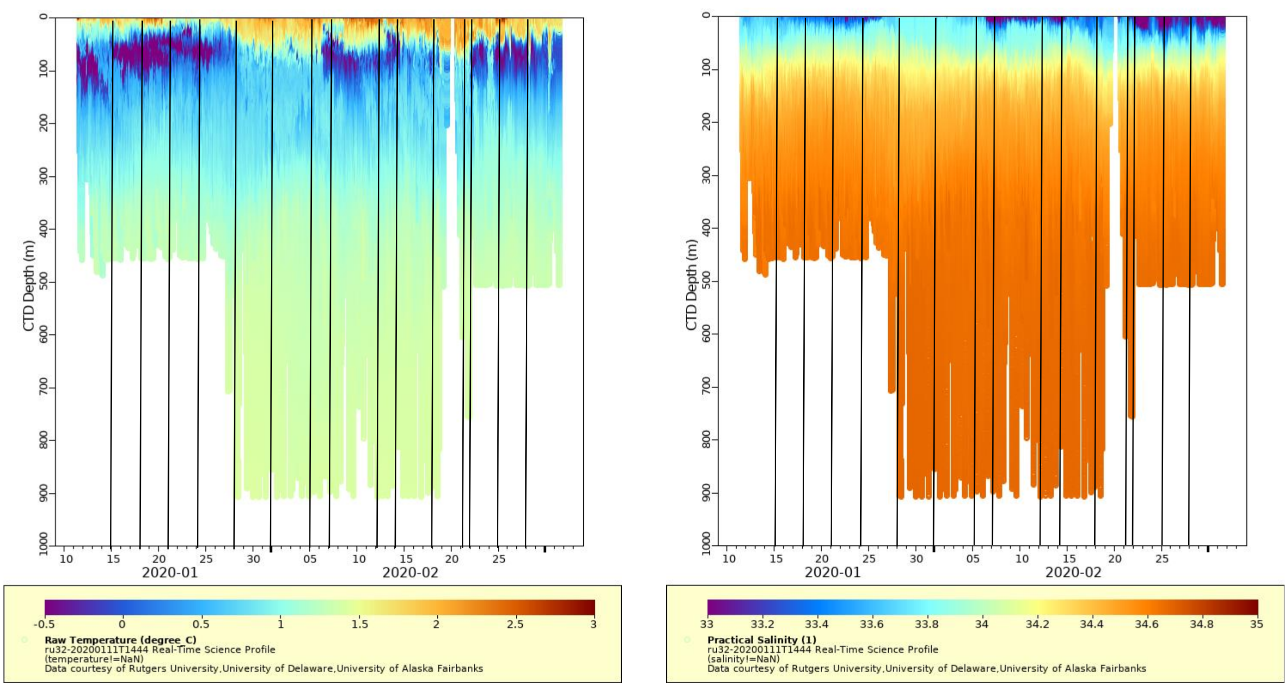


Fig. 6 – An example of glider transects for temperature (°C; left panel) and practical salinity (psu; right panel) from 11 Jan 2020 through 2 Mar 2020. *Image Credit: Kohut group.*

RHIB surveys: Coordinating with the LTER grantees and Palmer Station Marine Technicians, we have now conducted 15 surveys with both the towed ACROBAT instrument and EK-80 echosounder totaling over 1,100 km of sampling. Twelve of the fifteen surveys have been over the complete grids covering much of our Palmer Canyon and Bismarck Strait study site (Fig. 5, red and green grids). The others were modified surveys covering portions of these grids and one new survey line that included two cross-shore transects east and west of the Palmer boating area (Fig. 5, cyan line). The combination of the acoustics and towed system allow us to simultaneously map the hydrography, phytoplankton, and zooplankton structure along the transects. Over these 15 surveys we have captured remarkable variability in both time and space. An example of this variability is seen in two sections of surveys (Fig. 5, thick yellow line) repeated within 24 hours of each other (Fig. 7). In less than a day, freshwater advected over Palmer Canyon, dramatically stratified the surface ocean. Referring to the CODAR (HFR) surface current speed colormap averaged over the same time period (Fig 4), we can see that this

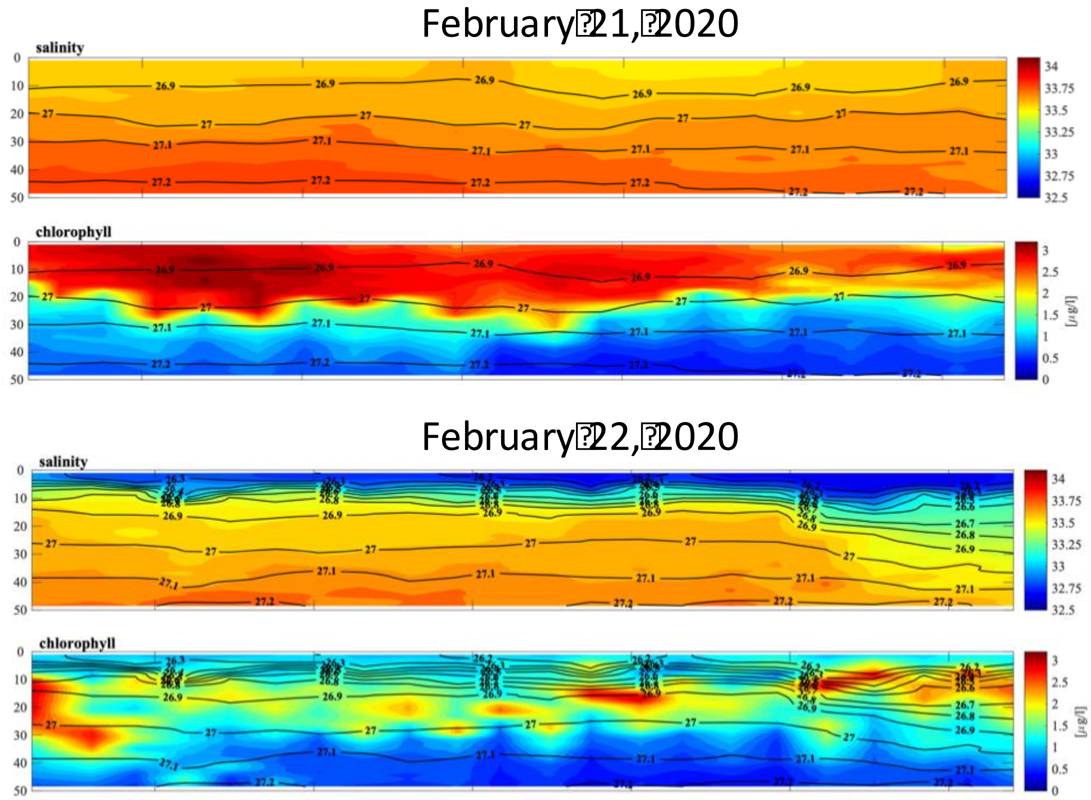


Fig. 7 – ACROBAT surveys conducted along the third limb of the Adélie transect (Fig 2; thick yellow line) for 21 Feb 2020 (top panels) and 22 Feb 2020 (bottom panels) displaying sections of colormapped salinity and chlorophyll (µg L^{-1}). All sections are from the surface to 50m and are oriented from west (left side) to east (right side) of the third limb of the Adélie transect. Note the variability between the two survey days, including the advection of freshwater into the surface of the 22 Feb 2020 section. *Image Credit: Kohut group.*

freshwater came from the south and was limited to a well-defined jet in the current map. In addition to these surveys, the SWARM/LTER teams have used the RHIB to support multiple adaptive activities including net tows to ground truth the acoustics, the mooring recovery described above, and along canyon LISST-HOLO surveys to image particles below the mixed layer. Working with the C-024-P (Friedlaender) whale team, we were also able to deploy a camera system on the zooplankton net survey to document the density of krill aggregations targeted by the net and to get a better understanding of how effectively different species avoid the net.

Penguin Telemetry: In collaboration with the C-013-P (Fraser) team, a total of 66 penguins were tagged across the Palmer Canyon and Palmer Deep foraging regions this season. These tagged animals included GPS archival tags (52 on Adélie and gentoo penguins) and presence/absence VHF radio tags (14 on Adélie penguins). As of the draft of this report, there will be no additional penguin tagging as most of the chicks have fledged. An initial review of the penguin foraging tracks indicates great overlap with the CODAR (HFR) and other platform sampling within our coastal observatory.

Broader Impacts: To date we have published four "data swarm" activities. These activities are designed to engage the middle and high school students in Delaware, New Jersey, and New York to investigate the same data plots we are looking at here at Palmer. These activities have focused on the RVIB *Nathaniel B. Palmer* transect of Palmer Canyon and Palmer Deep conducted during our November 2019 cruise, the HF radar surface current maps, our autonomous glider generated data, and finally the acoustics data collected by our moorings. The students following the "data swarm" activities have also interacted directly with the scientists through three 30-minute blackboard session VTCs.

We would like to thank all station staff for their support of our project. We recognize the significant logistical support required for our project, including boating, cargo, and information technology. We would also like to thank the LTER science team for their partnership and collaboration. This success we have accomplished so far this season would not have been possible without the coordination with the LTER team and ASC. This season we have been hosting science meetings every Sunday afternoon in which we discuss logistics for the upcoming week and share exciting results from all the groups. This is an open meeting in which we have had great participation from both the grantees and station support. All involved have been able to find every efficiency that enable the science objectives to be met. We are very happy to work in this collaborative environment and are seeing the direct benefits in what we have collectively accomplished. Through all the planning, the communication has been critical to this success.

Sunday afternoon science meeting in the BIO Galley. *Image Credit: Kohut group*

B-027-P: ASSEMBLAGE-WIDE EFFECTS OF OCEAN ACIDIFICATION AND OCEAN WARMING ON ECOLOGICALLY IMPORTANT MACROALGAL-ASSOCIATED CRUSTACEANS IN ANTARCTICA.

Dr. James McClintock and Dr. Charles Amsler, Principal Investigators, University of Alabama at Birmingham

Personnel on station: Charles Amsler, Margaret Amsler, James McClintock, Hannah Oswalt, and Julie Schram.

Personnel movements: Julie Schram sailed north with LMG20-01 on 8 February. James McClintock arrived with LMG20-02 on 24 February.

February was devoted primarily to daily maintenance of our large ocean acidification experiment in the aquarium which was described in detail in our January report. The experiment consists of 24 experimental buckets, with 12 in each of two of the round indoor aquarium tanks. There are three pH treatments including ambient (pH 8.0 to 8.1), near-future (pH 7.7), and more distant-future (pH 7.3) levels. The pH is maintained by bubbling CO_2 and/or air into PVC mixing tanks that feed water into the experimental buckets, with the pH level maintained by computer-controlled microprocessors that open and close solenoids to turn on and off the CO_2 and air flow. Each mixing tank has a pH electrode to enable this, and the computer control software records the pH every half hour, which allows us to make sure that the system is functioning as programmed.

During February, we completed counts of the initial numbers of crustaceans added to the experiment. The mean was 472 macroalgal-associated crustaceans per bucket – mostly amphipods, but also including smaller numbers of copepods, ostracods, and isopods.

Each day, a hand-held pH meter and probe, which is calibrated frequently, is used to check the pH in each of the 24 experimental buckets. More precise water chemistry measurements are

Margaret Amsler (left) siphons water from an experimental bucket for detailed daily analysis. Hannah Oswalt (right) determines the total alkalinity of daily water samples with a titrator. *Image Credit: McClintock group* made on water siphoned from six of the experimental buckets each day. This includes one of each pH treatment from both of the round tanks each day, rotating through the complete set of 24 buckets over four days. The water temperature in each of these buckets is also recorded daily along with the salinity reported by the station water wall.

The daily water samples are used to measure pH spectrophotometrically on the total hydrogen scale (different from pH probes) using *m*-cresol purple as our pH sensitive indicator dye. The total alkalinity of the seawater is determined by open cell potentiometric titration, using a Mettler-Toledo T50 open cell titrator equipped with a pH probe. From the total hydrogen scale pH, total alkalinity, temperature, and salinity we are able to calculate the other carbonate chemistry parameters that are critical to monitor and report in ocean acidification experiments. The detailed daily measurements also serve as a check on the hand-held pH probe and allow us to make small adjustments as needed to the pH levels in the mixing tanks to maintain our target pH levels in the experimental buckets.

In support of our activities, we made nine scientific SCUBA dives in February. All dives were within the standard Palmer boating limits.

We are grateful for the generous and professional assistance of numerous ASC staff in meeting our goals. Laboratory Supervisor Randy Jones and Instrument Technician Carolyn Lipke have provided outstanding support in the aquarium and lab. The Palmer Marine Technicians, Ken Block, Mike Burns, Otto Neumuth, and Patrick Riley facilitated our diving activities.

C-013-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE, AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM – APEX PREDATOR COMPONENT

Dr. William R. Fraser, Principal Investigator, Polar Oceans Research Group

Personnel on station: Megan Cimino, Bill Fraser, Donna Paterson-Fraser, Megan Roberts, Darren Roberts, and Leigh West

In early February 2020, the ARSV *Laurence M. Gould* made a brief return to Palmer Station with C-013-PL (Fraser) team members Anne Schaefer and Leigh West at the conclusion of a successful LTER cruise. In addition to ship based surveys and a week of intense data collection on Avian Island, the C-013 cruise team also succeeded in conducting shore based penguin surveys at the Fish Islands and Armstrong Reef. In addition to the Avian Island team's normal work, they also deployed 19 GDR (Geolocating Dive Recorder) tags on Adélie penguins. These long duration tags (1-2 years) record dive depth, and use light levels to determine location. They will help us better understand Adélie penguin movements over the winter. On 8 February, the *Gould* departed Palmer Station with C-013-P/L team members Bill Fraser, Megan Cimino, and Anne Schaefer. Donna Patterson-Fraser arrived to station on LMG20-02.

An Adélie penguin with a GDR tag. Deployed under ACA permit 2018-002. *Image Credit: Fraser group*

Back in the Palmer Station region, Adélie penguin studies concluded this month with beach counts and measurements of Adélie fledglings. Adélie penguin foraging ecology studies were also concluded in February with the completion of our radio transmitter study on Humble Island. Satellite tagging of Adélie penguins concluded in February. Gentoo penguin satellite tag deployments, fledgling measurements, and diet studies on Biscoe Island and in the Joubin Islands were conducted in February and will continue into March.

Skua work continued through February with monitoring and banding of brown skua chicks on local islands as well as on Dream, Biscoe, and in the Joubin Islands. South polar skua reproductive monitoring on Shortcut Island continued throughout February as did the monitoring of the blue-eyed shag colony on Cormorant Island. Kelp gull surveys and chick counts were completed in all of the local islands. Growth measurements of giant petrel chicks on Humble Island continued every other day during February and will continue until chick fledging in April.

Sediment traps were collected, processed, and returned in the local area, as well as at Biscoe, Dream, and in the Joubin Islands. These traps produce annual presence/absence data of fish and other prey in penguin diets. Each trap will often collect hundreds of otoliths over the course of a year. We would like to thank Laboratory Supervisor Randy Jones and the FMC team for facilitating the processing of those traps. We would especially like to thank Carpenter Ian Mannix for building new sediment traps to replace our ageing and degraded ones.

A new sediment trap deployed at Dream Island *Image Credit: Fraser group*

As always, ASC provided outstanding science support this month. Special thanks to all ASC and grantee field volunteers who assisted with Adélie fledgling measurements. Special thanks to Chefs Francis Sheil and John Musselman for excellent food throughout the course of the season.

C-019-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE, AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM – PHYTOPLANKTON COMPONENT

Dr. Oscar Schofield, Principal Investigator, Rutgers University, Institute for Earth, Ocean, and Atmospheric Sciences, Department of Marine and Coastal Sciences

Personnel on station: Quintin Diou-Cass, Katherine Hudson, Schuyler Nardelli, and Rachael Young

For the month of February 2020, we waved farewell to Schuyler Nardelli and welcomed back Rachael Young along with Rutgers University PhD student Quintin Diou-Cass. In addition to assisting with LTER sampling, Diou-Cass has been conducting phytoplankton incubation experiments on station as a continuation of his investigation into the effects of irradiance on natural phytoplankton assemblages.

February resulted in another productive month for the LTER with bi-weekly sampling at Stations B and E. After a spike in chlorophyll in late December to early January, chlorophyll levels have been relatively low. On 20 February, at Station B at 5m depth there was a slight increase in chlorophyll to 4.17 mg m^{-3}, however, overall chlorophyll concentrations for both stations remained low and steady (Fig. 8). Primary production experiments have corresponded to

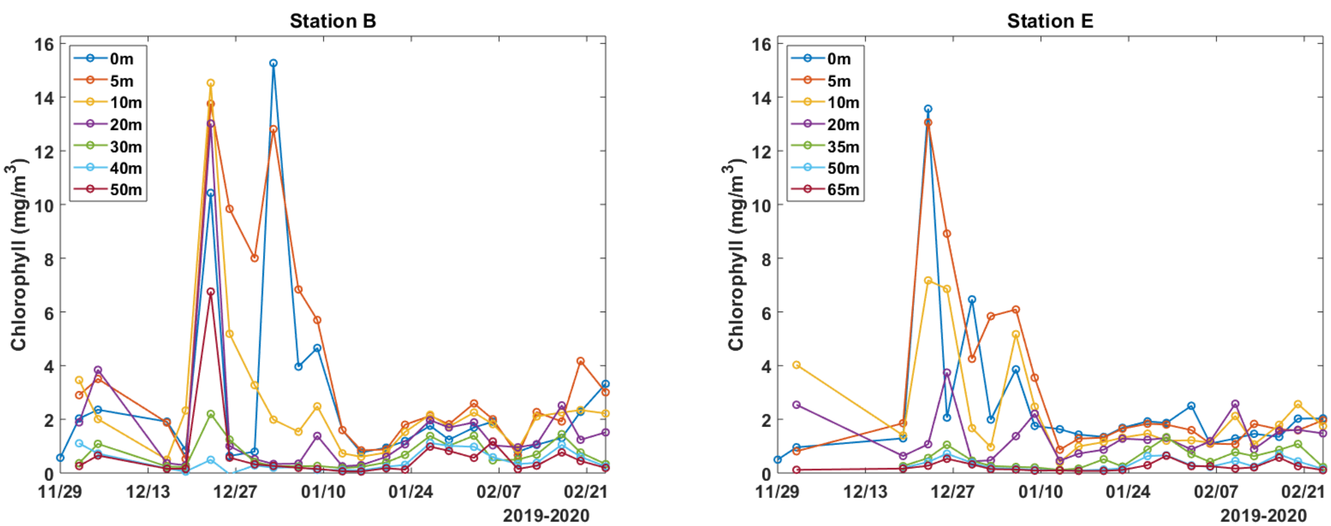


Fig. 8 – Chlorophyll concentrations (mg m^{-3}) for each sampling depth at Stations B (left panel) and E (right panel) from 25 Nov 2019 through 24 Feb 2020.

chlorophyll patterns, peaking in December, tapering off into January, and remaining relatively low throughout February (Fig. 9).

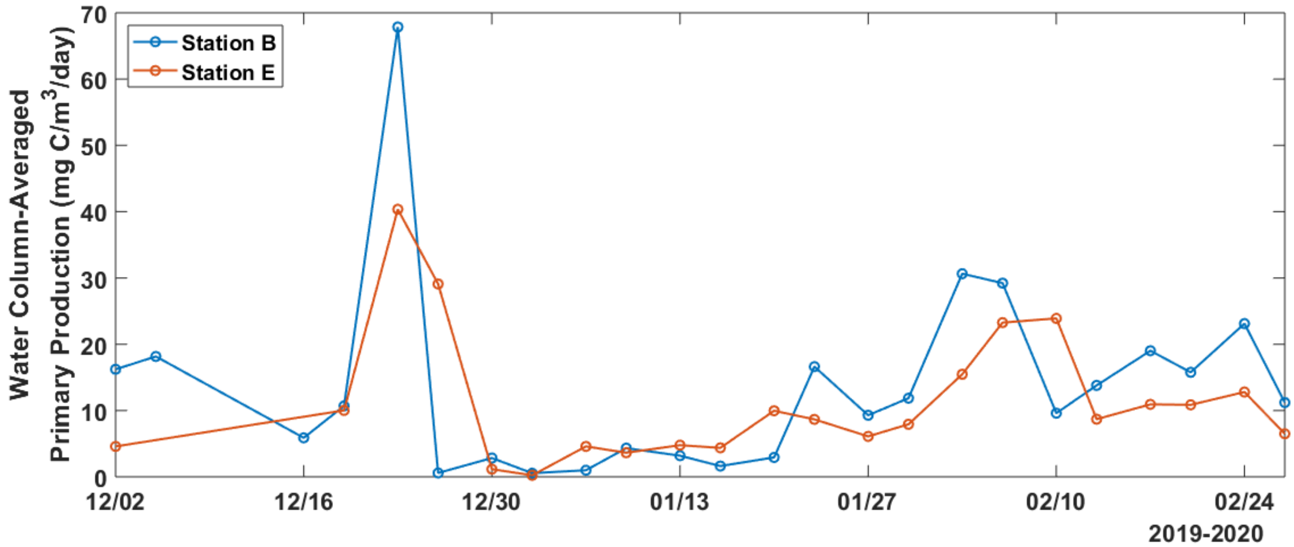


Fig. 9 – Water column-integrated primary productivity (mg C m^{-3} day^{-1}), sampled bi-weekly at Station B (blue line) and Station E (red line) from 2 Dec 2019 through 27 Feb 2020.

This February phytoplankton incubation experiment was the fourth of five total experiments, and the second of three to be conducted at Palmer Station. These *in situ* incubation experiments utilize mesh shading to expose natural phytoplankton assemblages from LTER Station E to three relative light levels: 100%, 60%, and 10% of *in situ* surface light. Incubated communities are kept in triplicate 20L clear carboys covered with mesh pouches and contained under *in situ* temperature conditions via an outdoor aquarium tank (Fig. 10). Nutrient, DNA, lipid, and

Fig. 10 – One of the outdoor aquarium tanks, depicted holding the nine 20L carboys used for the fourth light manipulation experiment.

community samples are collected routinely over the course of the 13-day incubations for use in classifying phytoplankton community diversity and quantifying phytoplankton health and function. Images of the communities captured with our Imaging Flow Cytobot (IFCB) show distinct differences in the diversity and size of the largest cells between different experiments in the later stages of the incubations (Fig. 11).

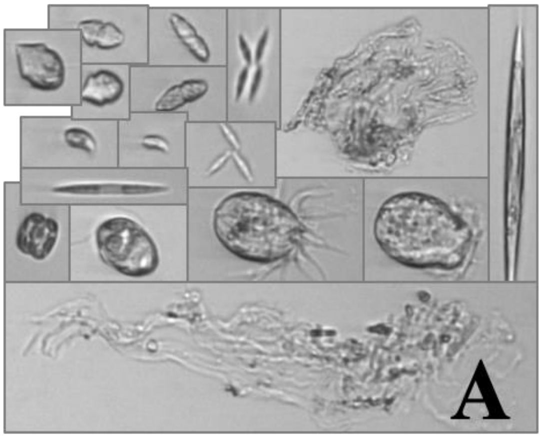
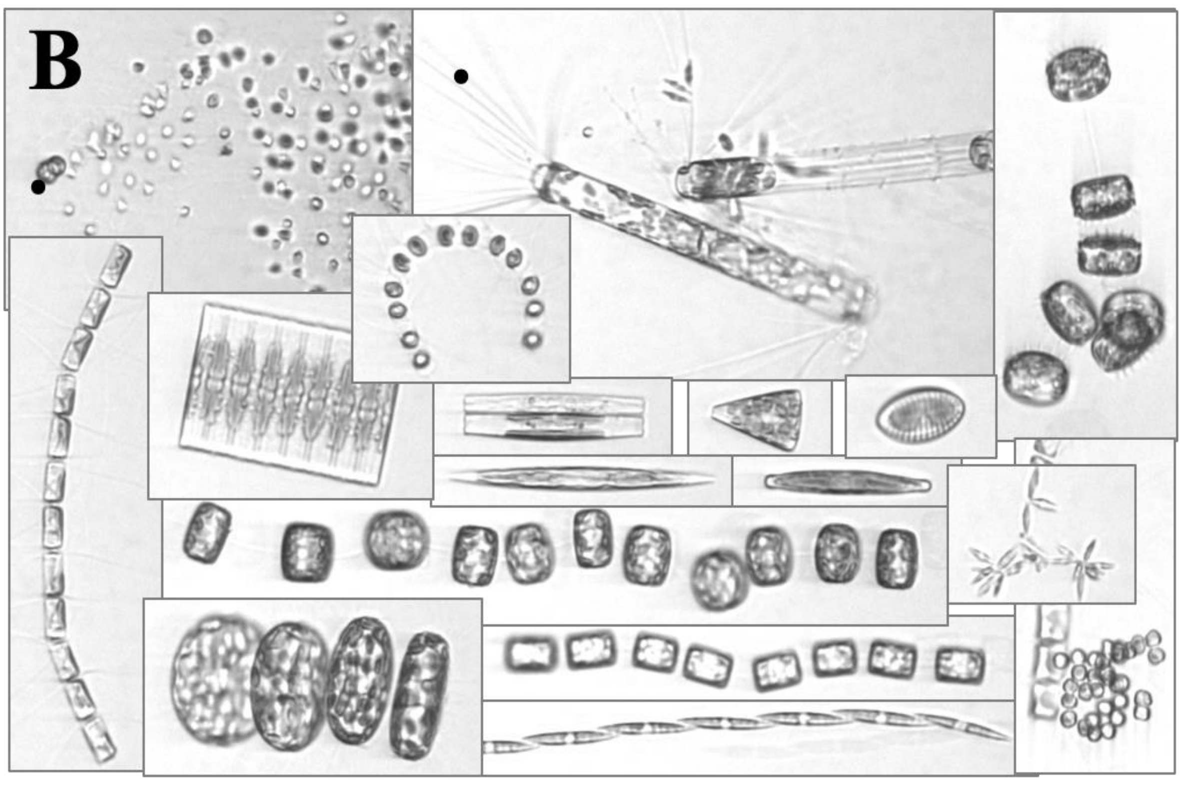


Fig. 11 – A collection of IFCB images selected from (A) Experiment Two aboard the Lawrence M. Gould, collected over the submarine canyon Palmer Deep, and (B) Experiment Four on Palmer Station, collected at Station E. Both sets of images are from the second half of the incubation (i.e. 7 days or more) and images between and within the two sets are accurately sized relative to each other. Experiment Two was conducted in early January, while Experiment Four was conducted in early February. These images are only a small sub-selection and do not represent the entire range of observably different species



Without the crucial and unwavering support of the ASC staff, a successful month of science would not be possible. We'd especially like to thank our Marine Technicians, Ken Block, Mike Burns, Otto Neumuth, and Patrick Riley, and Laboratory Supervisor Randy Jones and Instrument Technician Carolyn Lipke for playing an integral part to our success continually throughout the season.

C-024-P: PALMER, ANTARCTICA LONG-TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE, AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM – WHALE COMPONENT

Dr. Ari Friedlaender, Principal Investigator, University of California, Santa Cruz, Santa Cruz, CA

Personnel on station: Ari Friedlaender, Greg Larsen, and Ross Nichols

Whale Survey, Photo-ID, and Biopsy Efforts: February marked the second month of the 2020 season for the C-024-P group – with field team members Greg Larsen and Ross Nichols at Palmer Station under the leadership of PI Dr. Ari Friedlaender. The group's main research hypotheses are focused on understanding 1) the behavior, ecology, life history, and demography of baleen whales in the waters around Palmer Station and, 2) in the broader ecosystem, the potential for competition and partitioning between baleen whales and other krill predators. Primary research objectives are addressed through a combination of visual surveys, tissue biopsy sampling, photographic cataloging, drone-derived measurements, foraging and movement behavior from archival motion-sensing tags, and integration of these data with seasonal and oceanographic parameters (e.g., krill abundance measured from echosounders) and data on similar foraging and movement behaviors of local penguins.

We conduct daily visual surveys in the regular boating area around Palmer Station and utilize the "extended" and "beyond extended" boating areas whenever possible to expand our spatial range of observation. During these trips photo-ID, biopsies, and drone-derived measurements are collected opportunistically whenever whales are encountered. Whales have shown an inconsistently low but persistent presence near Palmer Station, yielding valuable but intermittent opportunities to collect data. As of 29 February 2020, we have conducted over 314 hours of surveys, during which time we have observed 177 humpback whales and 13 minke whales, collected 153 biopsy samples (134 humpback adults, 14 humpback calves, and 5 minke adults), cataloged 124 individual animal flukes for ID (in addition to 37 volunteered photo sets collected by on-station personnel before we arrived), and compiled aerial photo-sets of up to 73 humpback whales for later morphometric measurement and analysis (potentially fewer whales if we encountered unidentified repeats or if some flights failed to obtain adequate photo-sets). We have also deployed three motion-sensing archival tags on humpback whales.

The biopsy samples will be used for a suite of analyses regarding the health, demography, and reproductive rates of baleen whales as they recover from commercial whaling (humpback whales) and respond to the ecological and environmental changes taking place along the Antarctic Peninsula (humpback and minke whales). Demographic parameters such as pregnancy rates will be contextualized relative to interannual variability of regional environmental conditions including sea ice and krill availability to better understand how changes affect the ecology and population dynamics of humpback whales. A subset of these samples will be used to test for persistent organo-pollutants and the presence of endocrine disruptors that may indicate exposure to microplastic pollution. These samples will also be evaluated to determine the breeding stock of the population of whales feeding around Palmer Station. This is done by comparing haplotype frequencies with those collected from animals in Southern Hemisphere breeding grounds. Currently, we estimate that ~95% of the whales encountered around Palmer

Station are from Breeding Stock G, which winters on the west coast of Central and South America.

Cursory examination of our fluke catalog for this year has shown generally low residence times for most humpbacks in the Palmer Station survey area so far; however as the season has progressed we have noticed some animals revisiting the Palmer area weeks after their first visit. We do not yet have estimates on the frequency of these revisits (the requisite data examination is time-consuming and takes place outside of the field season), but we have anecdotally noticed more residency in the past month than we have in past seasons.

One particular humpback whale individual (Mn20_043A_P) has been seen consistently over the course of February (Fig. 12). Over a period of 19 days, we have been able to collect a variety of data from this highly re-sighted individual. We first sighted this whale in our survey area on 9 February and most recently re-sighted it on 28 February. Including those dates, we have now sighted this animal on nine separate days, biopsied it once, deployed a suction-cup tag on it once for ~12 hours, and obtained aerial photosets of the individual for photogrammetric measurement on four separate days. This is a uniquely plentiful data set collected on a single individual that will allow us to investigate this individual’s spatial movements, diverse social associations, and various behaviors in the Palmer Station vicinity, as well as potential changes in its body condition during the period in which it was aerially photographed.

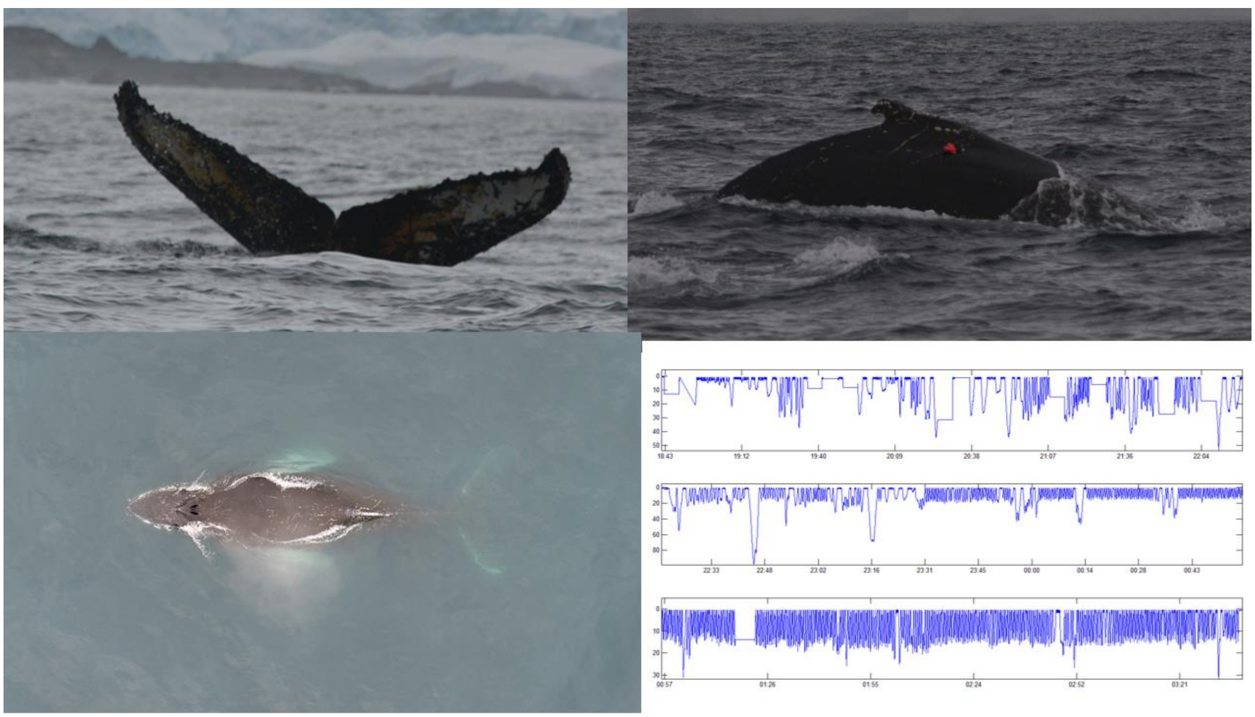


Fig. 12 – A diverse suite of data collected from a single whale over the course of its to-date 19-day residency in the Palmer Station vicinity. These data include a fluke image for individual identification and cataloging (top left panel), drone-derived photography of the animal’s bodily dimensions (bottom left panel), and various data collected from a motion-sensing archival tag attached by suction-cups to the right dorsal side of the animal (top right panel), such as depth measurements of the animal during the period when the suction cup tag was attached (plotted across time, bottom right panel). Images collected under ACA Permit 2020-016 and NMFS Permit 23095.

Extended boating surveys: The C-024-P team at Palmer Station this year has also completed several survey efforts in the "extended" and "beyond extended" boating areas. These have included trips to Dream Island, Biscoe Point, the Joubin Islands, and the Wauwermans Islands, which have enabled us to access whales at times and places when they are sparse in the local boating area. ASC staff and other science groups have provided the required support for us to boat in these areas, and we are grateful for this assistance.

Whale Suction Cup Tagging: In the month of February, we tagged three humpback whales using suction cup, motion sensing archival tags. The tags were deployed until suction was lost or released, resulting in attachment times of 9–24 hours. Once detached, tags float to the surface and begin transmitting their location via satellite systems for recovery. Once recovered and offloaded, data from one of these archival tags can be used to generate a georeferenced motion track of an individual humpback whale and an associated time-depth plot of the whale's dives. In the case of the tag deployed on 19 February (Figs. 13, 14), the beginning of this tag's recording (0900–1530 UTC -3) features variable dives with longer times spent at maximum depth, which occurred while the tagged whale was travelling between Wylie Bay and Dream Island. The latter part of the record (1530–1830 UTC -3) describes surface and bubble-net feeding while the whale was located just north of the Joubin Islands; these foraging behaviors are characterized by very rapid dives with minimal time being spent at the dive's maximum depth (Figs. 13, 14).

Fig. 13 – A georeferenced motion track of a humpback whale (yellow pins) that was tagged on 19 February 2020 (green pin). This track is calculated using the variety of motion sensors deployed on the archival suction cup tag. The tag remained on the animal for nine hours before it lost suction and floated to the ocean's surface for retrieval (red pin).

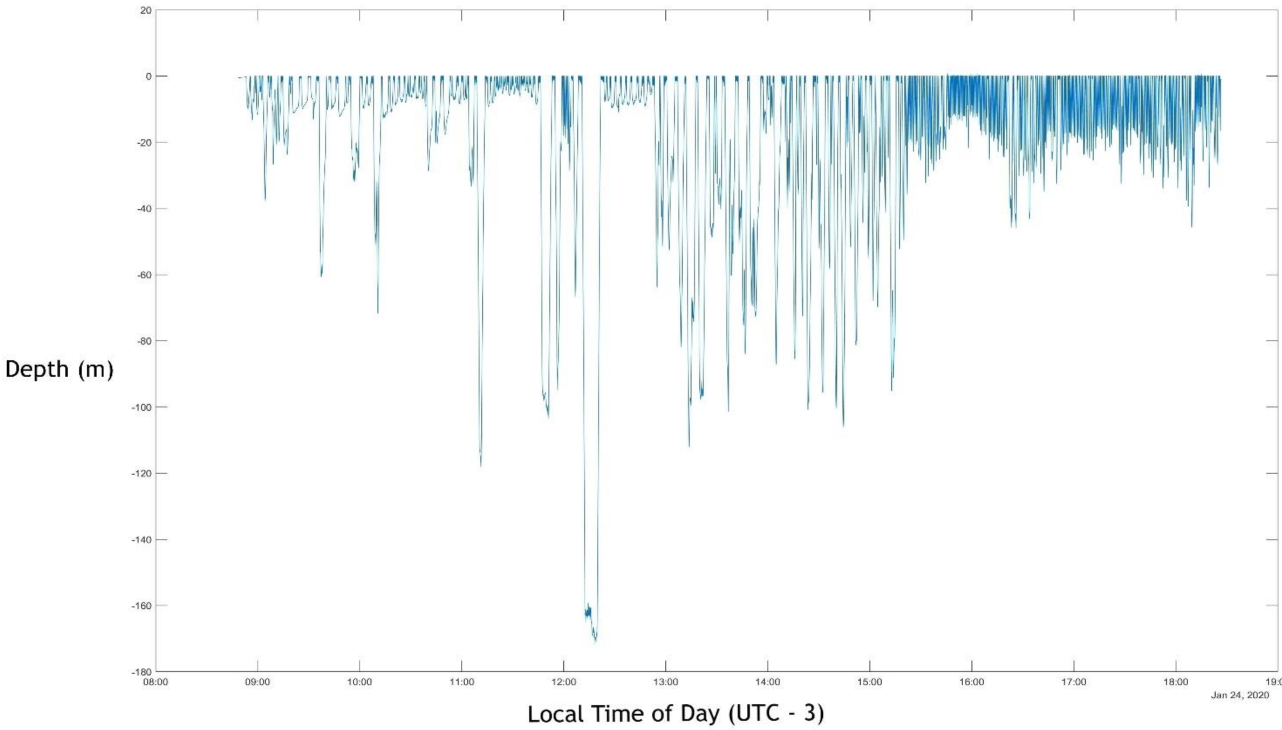


Fig. 14 – A dive profile of a humpback whale tagged on February 19th, 2020 (see also Figs 1, 2). Varying dive shapes (depth, duration, surface intervals) correspond to different behavioral states and foraging strategies. Deep foraging occurs during the first two thirds of the recording; the whale's behavior subsequently transitions to surface feeding during the final third of the recording.

UAS Operations: Unoccupied aircraft systems (UASs or drones) are a critical new tool in cetacean research at Palmer Station (and now in all areas where cetaceans are studied). Aerial photography, when paired with precise altitude measurements, enables analysts to measure dimensions of a whale's body with high precision and accuracy. These measurements contribute to analyses of whale anatomy and physiology, and comparisons across time and space can address broader questions of foraging ecology and prey consumption in different regions and periods of the feeding season. Though a secondary priority for our field team, occasionally aerial photography and video can also capture cetacean behaviors that are difficult to discern and describe from observations at sea-level.

In addition to whale photogrammetry (measurement by photography), drones can be used to map objects and regions in high resolution and three dimensions for scientific analysis, yielding orthomosaic maps and digital surface models of habitats and their physical terrain. This is accomplished through photo stitching and a process called 'structure from motion': a high volume of overlapping photographs are collected from different locations by an aerial platform (e.g., a drone flying a grid-shaped flight plan); photos are then stitched together based on common features and the known GPS location of the drone and camera; based on the displacement of objects when viewed from different known angles (parallax) their dimensions can be calculated. Here at Palmer, we are using drones to 1) locate seals and seabirds within their habitats by this mapping technique, 2) determine relative changes in species abundance by repeatedly mapping select sites throughout the summer season, 3) quantify the topographic characteristics of these habitats from our three-dimensional maps, and 4) estimate habitat affinities of these species based on their association and avoidance of different topographic characteristics.

UAS operations have continued successfully through February. So far this season we have carried out 153 successful UAS flights near Palmer Station: six test/maintenance flights, 51 flights for whale photogrammetry, and 96 flights for pinniped habitat mapping. The whale photogrammetry flights have captured 81 potential morphometric datasets, including repeat-flyovers of multiple individuals that have visited the Palmer area at different times in the season (Fig. 15). The habitat mapping flights constitute 58 site surveys over 11 regions of terrestrial pinniped habitat in the Palmer area, including seven sites that have been surveyed on a near-weekly basis. These flights have captured some of the major shifts in abundance and distribution that take place as local pinnipeds and seabirds undergo their annual cycles of breeding and molting on land (Fig. 16).

Fig. 15 – Compilation of raw aerial images collected of three whales that were seen multiple times during the month of February: Mn20_043A_P (left panels, center panel) and the mother-calf pair Mn20_033B_P and Mn20_033C_P (center panel, right panels). These (or other similar images) will later be corrected for lens-distortions, aircraft altitude, and other factors to yield standardized products that can be measured to determine whale body condition at each encounter and any growth that may have occurred between encounters. Images collected under ACA Permit 2020-016 and NMFS Permit 23095.

Fig. 16 – Scenes from aerial photographs captured over Torgersen Island (left) and Elephant Rocks (right) on 14 January 2020 (top panels) and 12 February (bottom panels) exemplify some of the major seasonal progressions that take place in the faunal populations of the Palmer Archipelago. In mid-January, Adélie penguins were located in tight clusters at their nest sites (top left panel) and predominantly southern elephant seals were found at pinniped haul-out sites (top right panel, bottom margin), but by mid-February the structure of Adélie penguin colonies was dissolving as fledglings began to wander from their nests (bottom right panel) and Antarctic fur seals were abundant at most pinniped haul-out sites (bottom left panel, top margin). Images collected under ACA Permit 2020-016 and NMFS Permit 23095.

Additionally, less-frequent intensive drone-mapping efforts are yielding precise maps that will allow us to quantify both groundcover and topography at these habitat sites (Fig. 17). Beginning this month, we have initiated an effort to ground-truth these UAS-derived maps, collecting high-accuracy GPS points of natural features of mapped sites that are visible in UAS imagery, using Palmer Station's survey-grade GPS unit with the gracious assistance of Research Associate, Marissa Goerke. These datasets will enable analysts to evaluate the accuracy of remote-sensing imagery at a range of scales, from the aforementioned UAS-derived orthomosaics to high-resolution satellite imagery products. This will critically inform subsequent spatial analyses for this project's habitat mapping and, potentially, any future projects that incorporate remote sensing at the same near-station sites. This GPS survey effort is still in the initial stages, and we have so far demonstrated our ability to 1) collect ground control points (GCPs) that are identifiable in drone imagery, and 2) process GPS records for very high-precision measurements using post-processing kinematic (PPK) corrections. In the next month we plan to combine these achievements to survey high-precision GCPs at mapped pinniped habitats near station.

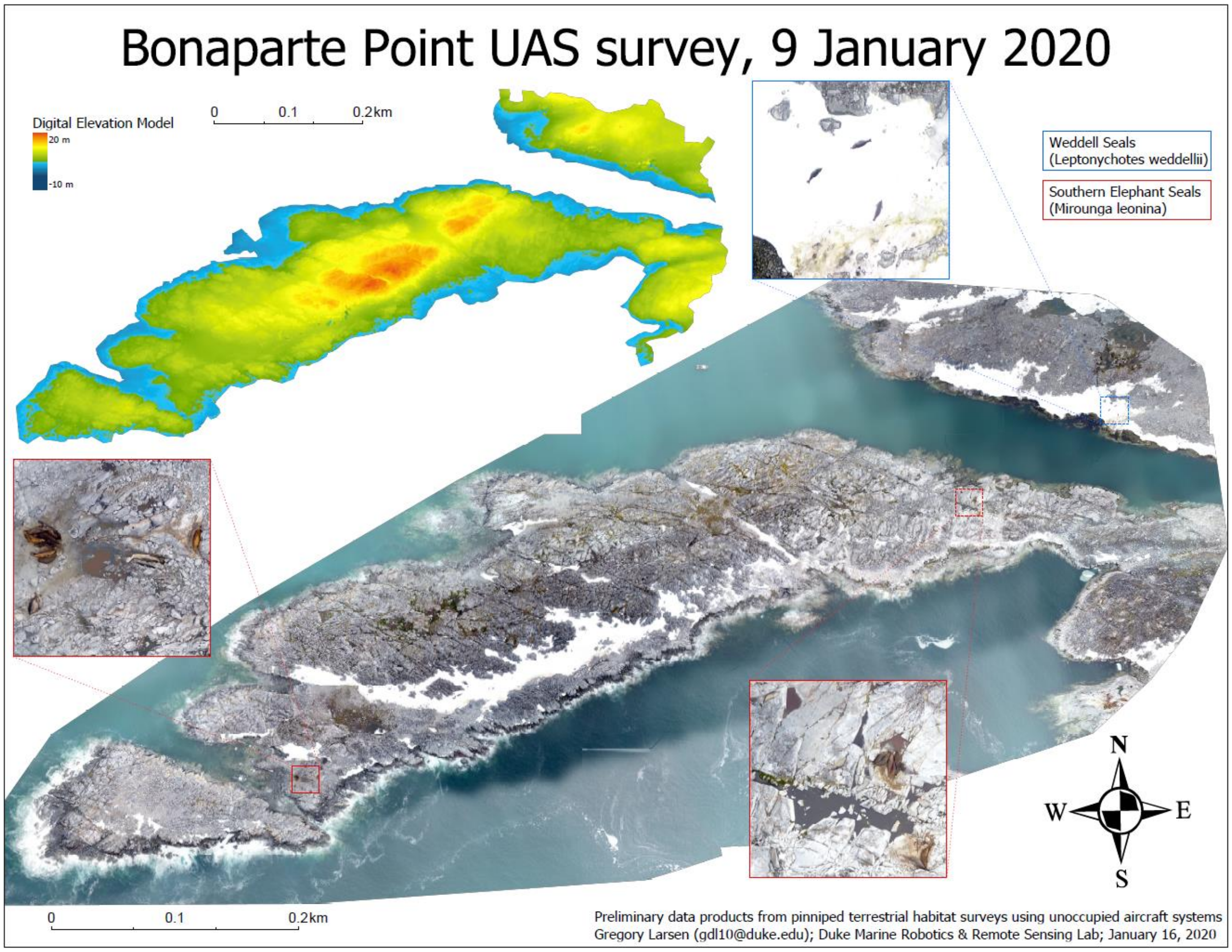


Fig. 17 – Example orthomosaic and digital surface model products from a UAS mapping survey of Bonaparte Point collected in 9 January 2020. High-resolution orthomosaic products can be used to classify land cover and identify the presence of animals in the landscape, whereas digital surface models can be processed to describe topographic characteristics such as elevation, slope, aspect, and more derived indices (e.g., wind exposure, solar irradiance) that might be ecologically relevant. Images collected under ACA Permit 2020-016 and NMFS Permit 23095.

C-045-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE, AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM – MICROBIAL, BIOGEOCHEMICAL COMPONENT

Dr. Hugh Ducklow, Principal Investigator, Columbia University, Lamont Doherty Earth Observatory

Personnel on station: Pablo Cardenas, Beth Connors, and Nick Mehmel

This month during the LTER northbound port call (6-8 February 2020), the C-045-P lab experienced a personnel turnover with lab members Pablo Cardenas and Nick Mehmel departing and Beth Connors taking over responsibilities. Although it was hard to lose all but one member of the team, the conclusion of the LTER cruise also brought back our most important resource: the Accuri flow cytometer. This month, Beth Connors finished running all of the preserved flow cytometry samples that were taken while the flow cytometer was at sea for the month of January. Additionally, sampling from Stations B and E continued as usual, without a single scheduled day missed due to weather or ice cover. The remaining lab member of C-045-P will end sampling and depart Palmer Station on 17 March 2020, so the remaining weeks will consist of packing up the samples and lab space. As we approach the end of another successful season of science, we want to say a huge thank you to our Marine Technicians, Laboratory Supervisor, Instrument Technician, and the rest of the ASC staff who keep the station and science operations running smoothly.

Ducklow lab member, Natalia Erazo, processing flow cytometry samples on the LTER cruise, 2 February 2020. While on the boat, the Accuri flow cytometer must be tied down with rope and bungee cords to prevent its movement in rocky seas. *Image credit: Ducklow group*

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT

February 2020
Marissa Goerke

A-111-P: THE NEXT GENERATION OF GEOSPACE RESEARCH FACILITIES AT PALMER STATION

Dr. Andrew Gerrard, Principal Investigator, New Jersey Institute of Technology

The ionosphere-thermosphere-magnetosphere (ITM) region of Earth's atmosphere, which is part of the larger geospace environment, is the portal through which the solar wind can enter and impact our planetary system. Though space weather research over the past decades has greatly increased our understanding of a wide variety of phenomena associated with ITM physics, the sum of these individual processes occurring in the geospace environment does not replicate the rich diversity and scope of this complex region. Thus, a more holistic approach to ITM research is necessary, one that integrates clustered instrumentation at multiple locations to simultaneously look at the interactions within the entire system. Using coordinated and collaborative instrumentation currently installed in Antarctica, researchers will study interrelated ITM phenomena observed at high latitudes. The goal of this research effort is a better understanding of the energy transfer and modulation of the geospace system.

Both the ELF/VLF operated normally throughout the month.

A-119-P: CONTINENTAL-SCALE STUDIES OF MESOSPHERIC DYNAMICS USING THE ANTARCTIC GRAVITY WAVE INSTRUMENT NETWORK (ANGWIN)

Dr. Michael Taylor, Principal Investigator, Utah State University

The Antarctic Gravity Wave Imaging Network (ANGWIN) is a cooperative effort of six international Antarctic programs to collect continent-wide gravity wave measurements. This network capitalizes on existing optical and radar measurement capabilities at McMurdo, Palmer, South Pole, and six other research stations: Halley (UK), Syowa (Japan), Davis (Australia), Rothera (UK), and Ferraz (Brazil). Infrared (IR) all-sky mesospheric OH (hydroxyl) imagers are installed at Davis, McMurdo, and Halley stations. The network quantifies the properties, variability, and momentum fluxes of short-period (less than one hour) mesospheric gravity waves and their dominant sources and effects over the Antarctic continent. An all-sky near-IR imager is also installed at Palmer Station to augment the existing instrumentation and create a capability for studying gravity wave properties at each site.

The camera and laptop have been shipped to Logan, UT for repair during the summer season.

G-090-P: GLOBAL SEISMOGRAPH NETWORK (GSN) SITE AT PALMER STATION

Mr. Kent Anderson, Principal Investigator, Incorporated Research Institutions for Seismology (IRIS)

Station PMSA is one of more than 150+ sites in the GSN, monitoring seismic waves produced by events worldwide. Real-time telemetry data is sent to the U.S. Geological Survey (USGS). The Research Associate operates and maintains on-site equipment for the project.

The system operated normally throughout the month.

O-264-P: A STUDY OF ATMOSPHERIC OXYGEN VARIABILITY IN RELATION TO ANNUAL DECADAL VARIATIONS IN TERRESTRIAL AND MARINE ECOSYSTEMS
Dr. Ralph Keeling, Principal Investigator, Scripps Institution of Oceanography

The goal of this project is to resolve seasonal and interannual variations in atmospheric O_2 (detected through changes in O_2/N_2 ratio), which can help to determine rates of marine biological productivity and ocean mixing as well as terrestrial and oceanic distribution of the global anthropogenic CO_2 sink. The program involves air sampling at a network of sites in both the Northern and Southern Hemispheres. The Research Associate collects samples fortnightly from Terra Lab.

Air samples were successfully taken twice this month despite the light and variable wind conditions that are common in February.

O-264-P: COLLECTION OF ATMOSPHERIC AIR FOR THE NOAA/GMD WORLDWIDE FLASK SAMPLING NETWORK
Mr. Don Neff and Dr. Steve Montzka, Principal Investigators, National Oceanic and Atmospheric Administration / Global Monitoring Division

The NOAA ESRL Carbon Cycle Greenhouse Gases (CCGG) group makes ongoing discrete measurements to document the spatial and temporal distributions of carbon-cycle gases and provide essential constraints to our understanding of the global carbon cycle. The Halocarbons and other Atmospheric Trace Species (HATS) group quantifies the distributions and magnitudes of the sources and sinks for atmospheric nitrous oxide (N2O) and halogen containing compounds. The Research Associate collects weekly air samples for the CCGG group and fortnightly samples for the HATS group.

CCGG samples were taken once a week during favorable winds and HATS Air samples were successfully taken within one week of their target sampling dates due to light and variable wind conditions that are common in February.

O-264-P: ULTRAVIOLET (UV) SPECTRAL IRRADIANCE MONITORING NETWORK
Dr. James Butler, Principal Investigator, National Oceanic and Atmospheric Administration / Global Monitoring Division

A Biospherical Instruments (BSI) SUV-100 UV spectroradiometer produces full sky irradiance spectra ranging from the atmospheric UV cutoff near 290nm up to 605nm, four times per hour. A BSI GUV-511 filter radiometer, an Eppley PSP Pyranometer, and an Eppley TUVR radiometer also continuously measure hemispheric solar flux within various spectral ranges. The Research Associate operates and maintains on-site equipment for the project.

The system operated normally this month. Bi-weekly absolute scans were completed without complications.

R-938-P: TERASCAN SATELLITE IMAGING SYSTEM

The TeraScan system collects, processes, and archives DMSP and NOAA satellite telemetry, capturing approximately 25-30 passes per day. The Research Associate operates and maintains on-site equipment for the project. The TeraScan weather and ice imagery is used for both research and station operations.

The system remained in its 75% operational configuration while Sea Space continues to engineer a solution to the problem. Several requests for technical support were fulfilled to aid in the search for a solution.

T-295-P: GPS CONTINUOUSLY OPERATING REFERENCE STATION.
Mr. Joe Pettit, Principal Investigator, UNAVCO

Continuous 15-second epoch interval GPS data files are collected at station PALM, compressed, and transmitted to the NASA-JPL in Pasadena, CA. The Research Associate operates and maintains on-site equipment for the project.

The system operated normally throughout the month. The survey equipment was used for ground truthing drone imagery, but issues arose in post-processing resulting in the need for a full firmware upgrade to the unit. Issues have been fully resolved and the survey equipment is back to normal operation.

T-998-P: INTERNATIONAL MONITORING STATION (IMS) FOR THE COMPREHENSIVE NUCLEAR TEST BAN TREATY ORGANIZATION (CTBTO)
Managed by General Dynamics

The IMS Radionuclide Aerosol Sampler and Analyzer (RASA) is part of the CTBTO verification regime. The automated RASA continually filters ambient air and tests for particulates with radioisotope signatures indicative of a nuclear weapons test. The Research Associate operates and maintains the instrument.

The system operated normally throughout the month. Processed filters and sent logs as needed.

OCEANOGRAPHY

Daily observations of sea ice extent and growth stage are also recorded, along with continuous tidal height, ocean temperature, and conductivity at Palmer’s pier.

Observations of sea ice around station were made daily.

METEOROLOGY

The Research Associate acts as chief weather observer, and compiles and distributes meteorological data. Weather data collected using the automated electronic system is archived locally and forwarded once per month to the University of Wisconsin for archiving and further distribution. Synoptic reports are automatically generated every three hours by the Palmer Meteorological Observing System and emailed to the National Weather Service for entry into the Global Telecommunications System.

The local weather station (PAWS) operated normally throughout the month. An attempt to visit the Gosslers weather station was made, but high swell prevented landing. Observations are archived on the AMRC website: ftp://amrc.ssec.wisc.edu/pub/palmer/.