# PALMER STATION MONTHLY SCIENCE REPORT

## February 2023


**The ECO-Rosette suite of instrumentation for water sampling on board RHIB HADAR at Station E on a calm day, prior to deployment.** *Image Credit: Hannah James.*

### NEWS FROM THE LAB

Hannah James, Summer Laboratory Supervisor

Although it may be the shortest month of the year, February was certainly one of the most productive both out in the field and within the labs at Palmer Station. With eight groups remaining on station and boating hours still stretching well past dinner, every day-lit hour of good weather was taken advantage of. The diving team was well into their routine of getting out in the field and into the water, the birders were busy weighing penguin fledglings before they took the plunge and left for the season, and the moss team took advantage of any good, sunny weather to measure respiration both in the backyard and on Litchfield Island. As the sea state allowed, RHIB HADAR was out on the water visiting Station E for CTD casts and net tows, or further afield doing an acoustic transect. The whalers were out on their SOLAS getting photo IDs and biopsies of whales, as these gentle giants transited through the Palmer Station boating area.

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

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

Personnel on station: Charles Amsler, Margaret Amsler, Jami de Jesus, Addie Knight, Hannah Oswalt.

Personnel movements this month: Jami de Jesus arrived with R/V LAURENCE M. GOULD 23-02 on 15 February.

February was a busy month spent collecting amphipods via diving for and then initiating our main ocean acidification experiment. The experiment makes use of two of the indoor round aquaria which function as large, ambient temperature water baths surrounding the other components. For the experimental manipulations, water from a header tank flows through heavily insulated tubing to a water distributer above each large aquarium and from there into 12 PCV mixing tanks. Each mixing tank is also plumbed with a line that bubbles outside air and one that bubbles $CO_2$-enriched air. Each mixing tank has a pH electrode connected to a microprocessor (small blue boxes on boards in photograph below). The microprocessors control solenoids (behind boards and out of view in photograph below) which turn on or off the flows of outside air and $CO_2$-enriched air to control the pH in the mixing tanks. Adding $CO_2$-enriched air decreases pH (mimicking what is driving ocean acidification in nature) while the outside air increases the pH. The pH levels are ambient (varies slightly between 8.0 and 8.1), near-future ocean acidification pH of 7.7, and longer-term pH of 7.3. Water from each mixing tank flows into an experimental bucket containing amphipods, plastic aquarium plants seeded with microalgae that the amphipods eat (replenished regularly), and pieces of a macroalga species that is consumed by two of the amphipod species. The presence of the mixing tanks buffer pH variation to the experimental buckets and separate the air bubbling from the amphipods, which otherwise could be caught in the bubbles. The bucket lids seal tightly to limit gas exchange with the ambient room atmosphere and have Plexiglas windows to allow in light (with screening on some to even out light levels across the experiment). The total sample size is eight buckets of each pH treatment, with positions randomly assigned in each large aquarium.

**Figure 1**- B-027 Ocean acidification experiment. See text for a description of components.

Amphipod collection took longer than expected because one of our focal species was less abundant than it often has been in past years and because two independent laboratory mishaps required recollection of approximately 1000 of them. To facilitate daily checks for deaths and molts, we decided not to separate the amphipods in the experimental buckets. This meant that

one of the intended amphipod species, which is a predator of the others, could not be used but allowed us to add a macroalga (*Palmaria decipiens*) to the experimental design. The three amphipod species are *Djerboa furcipes*, which in the photograph below is in focus in the center with a clear body other than its dark digestive tract, *Prostebbingia gracilis*, the orange species which is not in focus below, and *Gondogeneia antarctica*, the darker species not in focus.

**Figure 2-** The three focal amphipod species, *Djerboa furcipes*, *Prostebbingia gracilis*, and *Gondogeneia Antarctica.*

We are grateful for the generous and professional assistance from numerous ASC staff in facilitating our activities. In particular, Hannah James and Lance Roth facilitated our laboratory operations and coordinated our overall station support while Barb Krasinski, Matt Gosselin, and Matt Cabell facilitated our boat diving activities.

## B-086-P: Antarctica as a Model System for Responses of Terrestrial Carbon Balance to Warming

*Dr. Natasja van Gestel, Principal Investigator, Department of Biological Sciences, Texas Tech University.*
Personnel on station: Dr. Natasja van Gestel and Sara Bohi Goulart.

The month of February was even busier than January. We continued measuring carbon fluxes once weekly in the plots, but we had several other major research activities in addition to that. First, in early February we had sampling campaigns (see Figure 3) to collect samples from site 1 (closest to the glacier) and site 4 (Litchfield) for a lab experiment that will be conducted at Northern Arizona University by postdoc Dr. Alicia Purcell. In Arizona, Alicia will be mimicking the growth chamber setup that we had at Palmer Station (see January report). Whereas the lab temperature incubation experiment conducted at Palmer Station was focused on moss physiological responses and acclimation to temperatures, Alicia will be examining the microbial responses to warming. She will use a technique called quantitative stable isotope probing to examine what microbial taxa grow more with warming, and whether these are the same taxa that are also growing in the "control" chamber or new taxa that only start growing in the "warmed"

environment. This is a novel microbial tool that was developed at Northern Arizona University. This technique is far more sensitive for detecting responses to warming, than determining responses based on abundance data, and a powerful way to elucidate the microbial black box. Her work will provide more detailed insight into soil microbial growth responses to warming and changes to the microbial communities overall.


**Figure 3-** Soil sampling using sterile technique at site 1 *(top panel)*, close to the glacier edge and site 4 *(bottom panel)* at Litchfield Island. Thank you Doc Shubert and Keri Nelson for helping at site 1 and Hannah James at site 4. What an amazing team! We are thankful for their time and dedication in the field. ACA permit 2023-007 (for Litchfield, ASPA 113)

In early February we also replaced the Plant Root Simulator® sticks (see Figure 4) that had been in the ground since early January. During the burial period, nutrients have adhered to the ion exchange resin strips that are part of the sticks, and therefore provide a measure of soil fertility over that 30-day timespan. This method is more informative than a spot measurement based on a one-time sampling of soil.

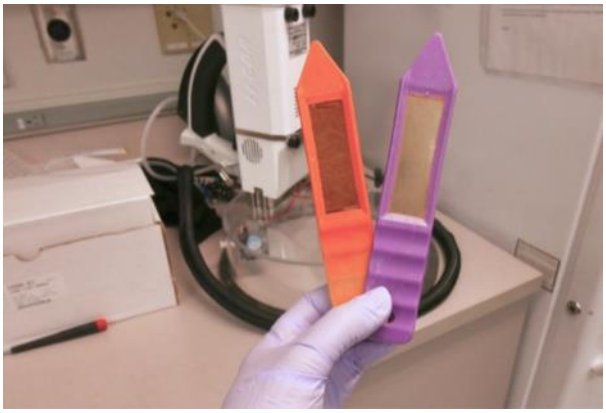

**Figure 4-** Plant Root Simulator® sticks containing ion exchange resin membrane to which nutrients will attach. The orange stick has a positively charged membrane to which negatively charged ions will adhere to (e.g. $NO_3^-$) and the purple stick has a negatively charged membrane to which cations will adhere to (e.g. $NH_4^+$). These provide a measure of soil fertility for the time period they reside in the soil, with minimal soil disturbance.

Towards the end of February, we measured the physiology of several species of moss that had been incubating for six weeks in the growth chambers (see Figure 5). In short, the lab warming experiment involved two growth chambers: one growth chamber was set to mimic the daily temperature cycle of the microclimate for the month of January. We based the microclimate data on the field temperature data collected in 2019. The other growth chamber had the same daily cycle, but shifted upwards by 2°C; for more detail on the growth chamber temperature and light settings, please see the January report. This way, we mimicked warming effect that the open-top chambers had in the field. The lab warming experiment was set up to complement the field warming experiment. We are currently analyzing the data from the field and the lab.

**Figure 5-** Natasja van Gestel and Sara Bohi Goulart measuring moss photosynthesis with the LI-6800 gas exchange system.

My Antarctic blog (https://www.nvangestel.com/antarctica) and Instagram page (https://www.instagram.com/antarcticresearchadventures/) has attracted the attention of schools globally. On February 20 we held our third of four Zoom sessions with schools, but this time with schools in the United Kingdom. Because of the time difference, the first two Zoom sessions were too late for schools in the UK.

**B-285-P: CAREER: IM-HAPPIER: INVESTIGATING MARINE HETEROTROPHIC ANTARCTIC PROCESSES, PARADIGMS, AND INFERENCES THROUGH EDUCATION AND RESEARCH**
*Dr. Jeff Bowman, Principal Investigator, Scripps Institution of Oceanography, University of California San Diego*
Personnel on station: Elizabeth Connors

Project B-285-P continued biweekly sampling in collaboration with the Palmer LTER program for our bacterial grazing experiments. Despite continuing inclement weather, we were able make collections from Station E or alternate locations on February 2, 6, 8, 12, 16, 20, 24, and 27. This is an optimal cadence as each experiment takes approximately 72 hours to execute. As in January, the boathouse staff continue to operate with an exceptional level of professionalism and dedication, and we've met our target of sampling twice weekly. The water we collected was used to conduct eight successful grazing experiments over the course of February.

**Figure 6-** Water sampling from RHIB HADAR at Station E on February 24. With, from left to right: Hannah James (ASC Lab Manager), Sneha Sivaram (C-019 team member) and Elizabeth Connors. *Image credit: Sneha Sivaram.*

We also carried out 8 additional experiments with the WOLF cell sorter to determine the taxonomic structure of actively respiring bacterial cells. These experiments involve incubating seawater in the presence of the fluorescent stain Redox Sensor Green (RSG). This stain is converted to its fluorescent form intracellularly in actively respiring cells. In addition to staining for active bacterial cells, we carried out 4 additional experiments with the WOLF cell sorter to determine which cells are potentially mixotrophic. For this experiment, we incubated seawater with the stain Lystotracker Green (LTG), which stains acidic food vacuoles. Once the cells are stained, we sorted for cells that are high in chlorophyll and have food vacuoles to determine which phytoplankton have the potential to consume bacteria. Because RSG and LTG do not harm the cells we are also able to single-cell sort members of the active cell population for culturing and future genomic work.

**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, SEABIRD COMPONENT**
*Dr. Megan Cimino, Principal Investigator, University of California at Santa Cruz.*
Personnel on Station: Megan Cimino, Helena Dodge, Darren Roberts

In early February the R/V LAURENCE M. GOULD made a brief return to Palmer Station with C-013-L team members Megan Roberts and Allison Northey at the conclusion of a successful LTER cruise. In addition to the Avian Island team's normal work, they also deployed two GPS

tags on Adélie penguins, and mapped all of the south polar skua breeding locations. The R/V LAURENCE M. GOULD departed Palmer Station with C-013 team members Helena Dodge and Allison Northey.

**Figure 7-** The C-013-L camp with an expanse of Adélie penguins in the background at Avian Island. *Image Credit: Allison Northey.*

Back in the Palmer Station area 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 third day during February and will continue until chick fledging in April.

Sediment traps were collected locally, 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. Additionally we have been

collecting marine debris throughout the season and we collected more debris in February than in any other month.

**Figure 8-** Marine debris collected in the Joubin Islands. *Image Credits: Megan Cimino*

As always, ASC provided outstanding science support this month. Special thanks to all the ASC and grantee field volunteers that assisted with Adélie fledgling measurements. Special thanks to Francis Sheil, and Aleia Greene for providing extra field food for us throughout our busiest months. We would especially like to thank Ian Mannix for his carpentry support.

## 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 currently on station: Michael Chen and Sneha Sivaram

The Schofield lab gained a new member this month, Michael Chen. Michael is originally from Ohio and received his BA in biology at Williams College. He is currently a master's student at Rutgers University-New Brunswick, working with Oscar Schofield, where his research focuses on eddy subduction and carbon export in the Southern Ocean. At Palmer Station, Michael will assist in understanding phytoplankton community dynamics at Station E for the Long-Term Ecological Research (LTER) time series as well as the collaborative acoustic transects. He will be an integral part of the team to finish out the field season strong.

This month, the Schofield Lab continued sampling at Station E in conjunction with the C-045 (Van Mooy) and B-285 (Bowman) groups. Weather has been the most limiting factor, and Station E often featured a turbulent sea state which makes it unsafe for CTD casts. However, the group successfully sampled station E a total of 7 times out of a possible 8 sampling events, so despite the weather minimal science was lost. These measurements continue to be important to the LTER in capturing seasonal trends and dynamics.

The acoustic transects are a collaborative effort of the LTER that focus on how krill distributions affect predator distributions. In addition to the use of the EK80 echo sounder, CTD casts are also taken along the transect to make measurements about the water column. There are two transects, one in the Wauwerman Islands area known as the Gentoo and one over the Palmer Canyon known as the Adelie, named for the species of penguins that forage in each area respectively. The transects take roughly 6-8 hours to complete and can be completed in a variety of sea states. There is a special interest this field season in the way the many weather events will affect the distributions of krill and the subsequent distributions of the predators, and whether or not these weather events will affect seasonal predator-prey relationships. There were five surveys conducted this month: three in the Gentoo area and two in the Adélie area.

For the next month, the Schofield lab has much to do in the way of cleaning up the lab and sending samples home. We are looking forward to completing another successful season as part of the LTER.

**Figure 9-** Michael Chen and Sneha Sivaram sail north on the R/V LAURENCE M. GOULD Schofield field team at the end of the Antarctic season.

**C-020-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM, ZOOPLANKTON COMPONENT**

*Dr. Deborah Steinberg, Principle Investigator, Virginia Institute of Marine Science, Department of Biological Oceanography*

Personnel currently on station: Andrew Corso and Maya Thomas

The Steinberg Lab has officially doubled the amount of people on station! Maya Thomas was dropped off at the end of the Palmer LTER research cruise and both she and Andrew Corso will spend of the rest of the summer season conducting research from Palmer Station. Like Andrew, Maya is also a PhD student at the Virginia Institute of Marine Science advised by Dr. Deborah Steinberg. This will mark her second time in Antarctica and first time at Palmer Station. Her work on the cruise focused around zooplankton biogeochemical cycling including krill and salp fecal pellet production experiments and sinking particulates (including fecal pellets) captured by sediment traps.


**Figure 10**- Maya Thomas deploying a ring net from RHIB HADAR. *Image Credit: Andrew Corso.*

Taxonomic trends from January have continued into February. We have seen a remarkable lack of diversity and biomass in the animals we are catching in our nets. In our 1-$m^2$ frame metro net we are catching mostly larval stages of the krill *Thysanoessa macrua* (see Fig. 11). While in our 1-m ring net, the most common zooplankton we are catching is copepods, but we have often caught a large volume of phytoplankton as well. Samples of the phytoplankton were given to the C-045 (Van Mooy) and C-019 (Schofield) groups for identification.

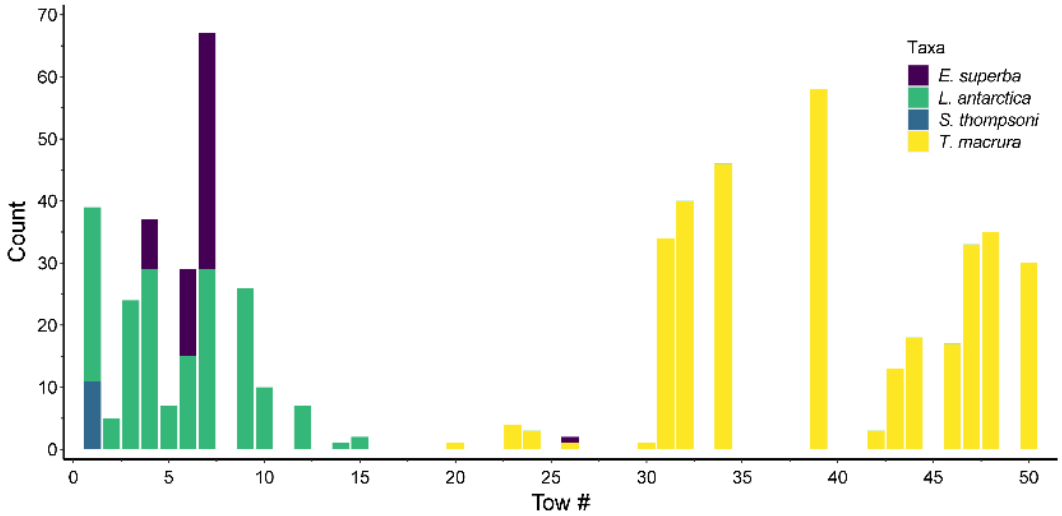


**Figure 11-** Taxonomic composition of 1-$m^2$ metro and ring net tows from January through the end of February. Only the four most abundant species are displayed: *Euphausia superba*, *Limacina antarctica*, *Salpa thompsoni*, and *Thysanoessa macrura*.

In addition to our regular biweekly Station E sampling we have expanded the scope of our data collection this month to include "krill hunting." For krill hunting we have been going out on the RHIB HADAR, and using the EK-80 to do targeted tows to catch Antarctic krill. So far we have had one successful attempt wherein we caught ~30 adult krill and froze them for the C-045 (Van Mooy) group to analyze for lipid content.

We are getting close to the end of our time at station for the 2022-2023 season, but we're looking forward to finishing strong!


**Figure 12-** Maya Thomas filtering samples from a net tow to study the dynamics of zooplankton size classes. *Image Credit: Andrew Corso.*

**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, California*
Personnel currently on station: Ross Nichols and Arianna Torello

**Survey Efforts and Data Collection Summary**

February marked the middle of the 2023 season for the C-024 group. After the conclusion of the LTER cruise, team member Jenny Allen departed Palmer station to return home. Arianna Torello, previously on the cruise, took her place as the C-024-P member at Palmer Station along with Ross Nichols.

The station team conducted daily visual surveys aboard the SOLAS vessel Bellatrix and Avior, primarily in the local boating area around Palmer Station. As opportunity permitted, we additionally utilized the extended and distant boating areas whenever possible to expand our spatial range of observation. For each survey photo-ID, biopsies, and drone-derived measurements are collected opportunistically whenever whales are encountered. As of February 28th, we have conducted over 108 hours of surveying, during which time we have observed 152 humpback whales (110 non-mother adults, 11 juveniles, 12 mothers calf pairs). We have collected 95 biopsy samples (89 humpback whale, 6 Antarctic minke whale samples. We have 89 individual animal flukes for individual ID and drone-derived morphometrics for 45 humpback whales and five Antarctic minke whales. We deployed one animal-borne suction cup tag from station and successfully recovered the tag later that day.

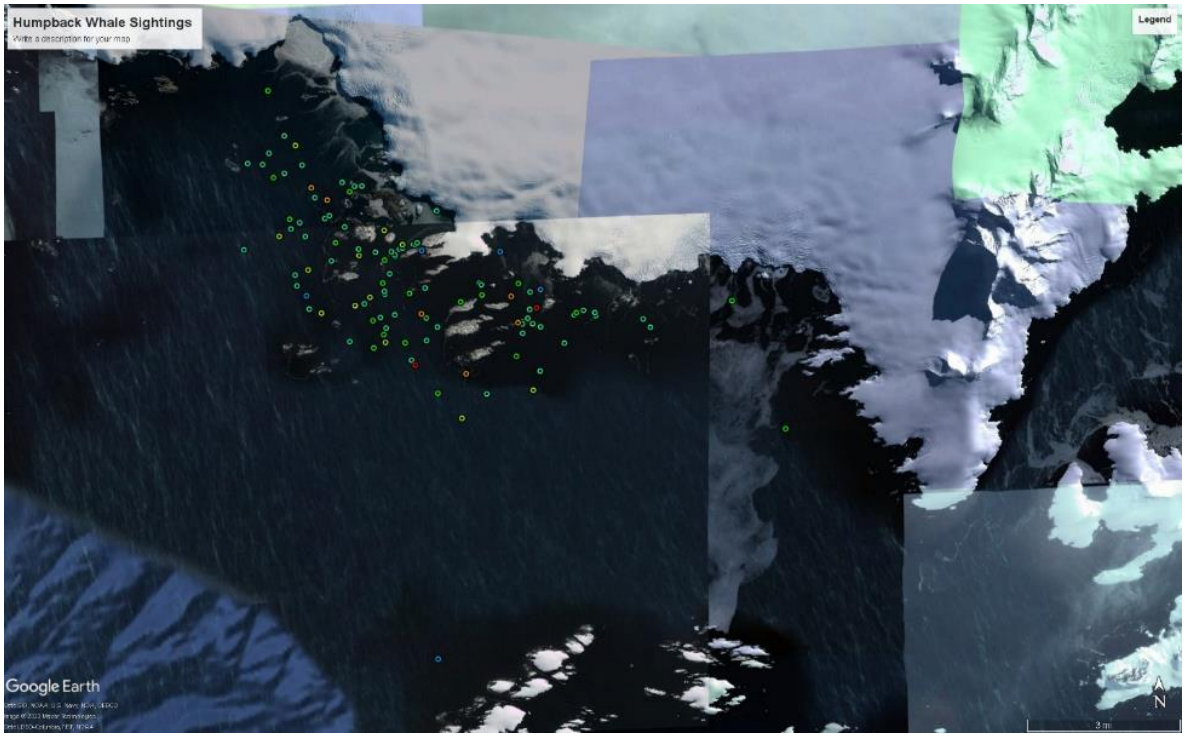


**Figure 13-** A map of all humpback whale sightings between January 3rd and February 28th by C-024-P. Color indicates group size, with green representing solo individuals, yellow is groups of two, orange groups of three, and red is four+ individuals. Blue indicates UAS flights where no animals were present.

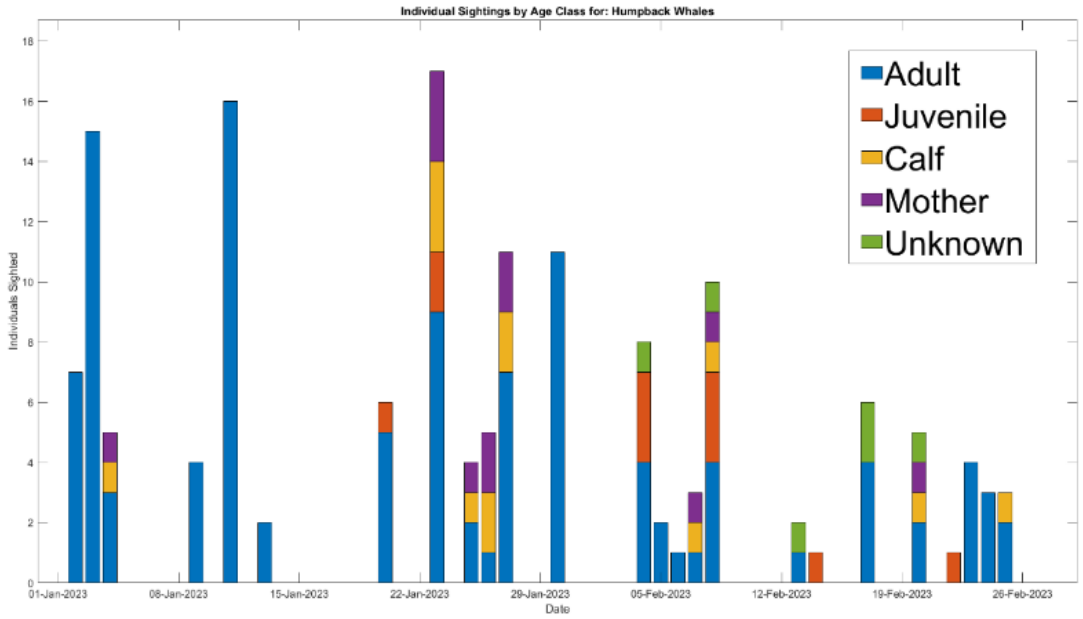


**Figure 14-** Total number of Humpback whale individuals sighted in the Palmer Area over time, color indicates the age class of the individual.

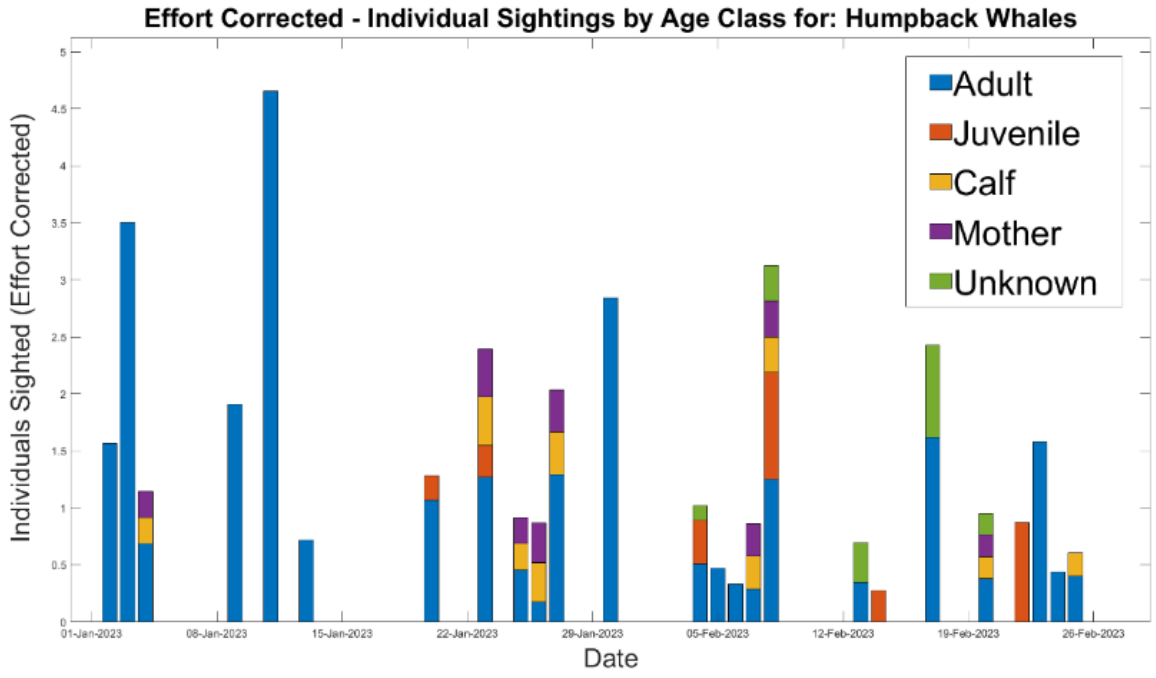


**Figure 15–** Number of Humpback whale individuals sighted relative to the amount of effort performed (aka effort corrected) in the Palmer Area over time, color indicates the age class of the individual.

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

*Dr. Benjamin Van Mooy, Senior Scientist, Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution*
Personnel on station: Benjamin Van Mooy, Shavonna Bent

February was an immensely productive month for C-045-P. After an intense and productive LTER cruise, MIT/WHOI graduate student Shavonna Bent joined the team on station, while Daniel Lowenstein headed back after a successful January. Sampling for analysis of the lipid, carbohydrate, and total carbon content of the planktonic community continued semi-weekly on RHIB HADAR cruises to LTER Station E and daily from the Palmer Station pumphouse. These samples will be analyzed back in the lab at WHOI and the resultant data will be the basis of the collaboration with the Schofield group. The overall goal of this work is to understand the relationship between light and the production of lipids and carbohydrates by phytoplankton. These classes of biochemicals are energy-rich (i.e., they are high in calories), and we hypothesize that phytoplankton produce the most when they are near the surface on clear days when they receive the most energy from the sun. Since phytoplankton form the base of the food web, carbohydrates and lipids provide fundamental fuel for the entire ecosystem.

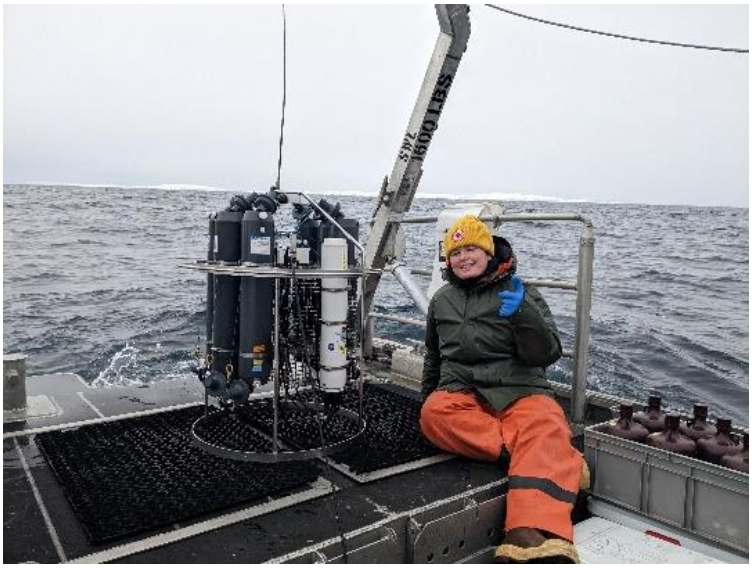

**Figure 16**- Shavonna Bent on RHIB HADAR at LTER Station E collecting plankton samples. Many thanks to Palmer Station support team and other grantees for a productive month. *Image Credit: Ben Van Mooy.*

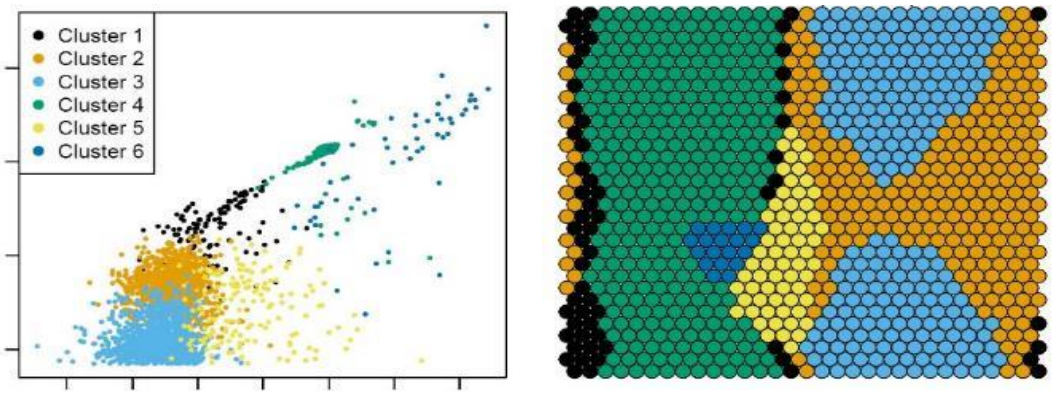


**Figure 17**- *Left:* Flow cytometry scattergram with fluorescence on the y-axis and forward scatter on the x-axis. The clustering model has identified distinct populations of particles; e.g., Cluster 4 is our internal standard beads, while Cluster 2 are likely heterotrophic bacteria. *Right:* Model output showing excellent cluster continuity.

Although the results of the analysis back at WHOI will not be known for many months, the data we collected on basic phytoplankton abundances at Station E provided some early insights on the connections between light and phytoplankton, which we presented last month. However, during the course of comparing Station E samples with those collected on the LTER cruise, Ms. Bent recognized that it is important to account for shifts in the community, as well as differing cell preservation methods. To tackle this complex issue she used a model designed by the B-285 (Bowman) lab and updated by Beth Connors for the Accuri C6 (the instrument the C-045 (Van Mooy) group uses for flow cytometry analysis). We fed the model approximately 10% of randomly selected samples, ensuring that these were representative of environmental gradients. The best output was found using a k-means clustering algorithm with six clusters, as shown in the flow cytometry scattergram. The model visually affirms the similarity of the clusters the colored hexagon plot: the continuity of the colors suggests that most of the data is accurately clustered by this model. Finally, cluster 4, which represents the calibration beads, has the best continuity, providing further proof that this model is effective in grouping these data.

We continued collaborating with the C-013-P (Cimino) group to understand the importance of lipids and carbohydrates to penguins. Krill are the primary food source for penguins. They have been shown by other research groups to be very rich in lipids, which originate from phytoplankton that they consume. Furthermore, their exoskeletons are made of carbohydrates. Our goal is to understand how efficiently penguins digest these two classes of biochemicals. We also conducted an experiment in the field to understand whether the "digestion" of lipids continues after the samples are obtained. The results of this experiment will identify and constrain any limitations in our analytical method, but could also elucidate new details on the fate of energy-rich lipids in penguins' digestive tracks.

**PALMER STATION**
**RESEARCH ASSOCIATE MONTHLY REPORT**
**February 2023**
Marissa Goerke

**The R/V LAURENCE M. GOULD as seen from the Joubins weather station, February 21, 2023.** *Image credit: Marissa Goerke.*

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

Andrew Gerrard, Principal Investigator, New Jersey Institute of Technology

Extremely Low Frequency/Very Low Frequency (ELF/VLF) radio wave observations at Palmer Station are used to provide a deeper understanding of lightning and its effects on the Earth's inner radiation belt. Lightning source currents are estimated or directly measured by experimental observations of individual natural and rocket−triggered lightning flashes in North America. Together, the North American and Antarctic data sets are used to experimentally identify and analyze the components of lightning and the effects of lightning, such as lightning-induced electron precipitation (LEP), that are observed in the Antarctic, more than 10,000 km away.

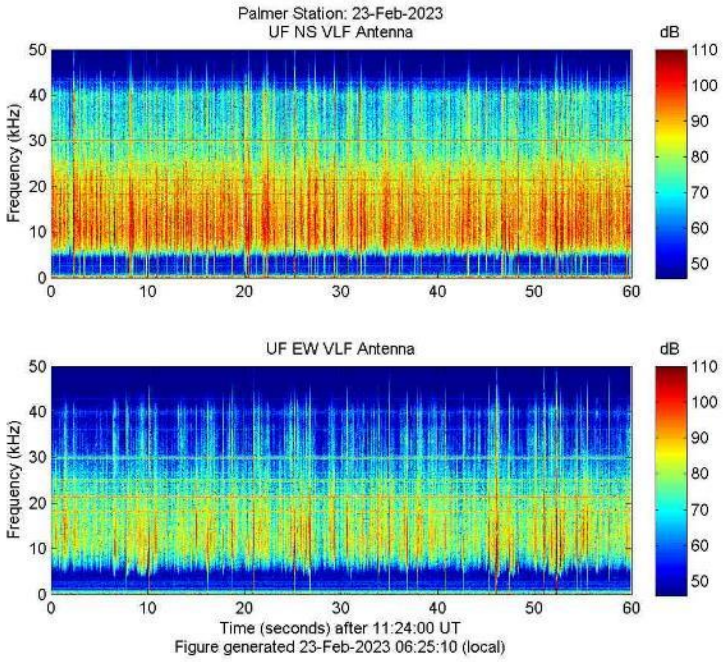


**Figure 18-** Real-Time broadband VLF Spectrogram from Palmer Station, Antarctica.

Both the Extremely Low Frequency and Very Low Frequency systems operated well this month. The spectrograms were reviewed daily and bi-weekly antenna inspections were done as weather allowed.

Current VLF/ELF data from Palmer Station can be observed at: http://halo.ece.ufl.edu/realtime_palmer_bb.php.

## A-111-P: SAMBA MAGNETOMETER

Andrew Gerrard, Principal Investigator, New Jersey Institute of Technology

The three-axis fluxgate magnetometer at Palmer is one in a chain of eleven longitudinal, ground-based magnetometers extending down though South America and into Antarctica. The primary scientific goals are the study of Ultra Low Frequency (ULF) waves and the remote sensing of mass density in the inner magnetosphere during geomagnetically active periods. Palmer's magnetometer is also a conjugate to the Canadian Poste de la Baleine Station, allowing the study of conjugate differences in geomagnetic substorms and general auroral activity.

SAMBA stands for South American Meridional B-field Array. The sites are approximately along the 0° geomagnetic longitude and ranging from -5° to -48° geomagnetic latitude. In combination with other magnetometer chains, including the AGO (Automated Geophysical Observatory) systems elsewhere in Antarctica, the stations create an almost complete, cusp-to-cusp-long meridional chain at approximately 0° magnetic meridian.

The magnetometer was originally installed at Palmer in 2005, and a replacement installed in April of 2008. In 2017 the project was taken over by Andrew Gerrard. On February 27th, 2017 the USAP IT blocked all northbound VPN traffic under a larger umbrella of blocking all northbound encrypted-tunnel traffic. Since that time there has been much discussion, but the magnetometer is still considered a security vulnerability. The Research Associate has been

working with the home institution at the University of California, Los Angeles to resolve this issue. As of September 30th, 2020 at 7:45am local time, the magnetometer was removed from the network. The instrumentation and computer are still operational. Data will continue to be collected and stored locally. The RA is working with the IT department to send out the data to UCLA when requested. More information can be found at: http://magnetometers.bc.edu/index.php/palmer.

**B-005-P: COASTAL OCEAN DYNAMICS APPLICATIONS RADAR (CODAR)**
Josh Kohut, Principal Investigator, Rutgers University Department of Marine

Coastal Ocean Dynamics Applications RADAR (CODAR) was developed between 1973 and 1983 by NOAA's Wave Propagation Laboratory. It is a high frequency radar that operates at 12 MHz so can receive signals from over the horizon. There are CODAR antennas at Palmer (just below Terra Lab near Hero Inlet) and also at the Joubins and the Wauwerman Islands. Each system measures the radial component of ocean wave velocity by transmitting a fundamental frequency at 12 MHz and receiving a reflected signal at twice the fundamental frequency (half the wavelength). By combining the measured velocity components from the three stations, the total wave velocity can be determined. The Doppler shifts of the reflected signals can be used to measure surface currents. Wave velocity can be affected by currents at depths of 1 meter and shallower and thus a measureable with CODAR.

**Figure 19-** CODAR team in the pit where the antenna once stood at the Wauwermans. *Image credit: Josh Kohut.*

All CODAR equipment has been recovered and removed from all sites by the PI in February. This will be the last appearance of the CODAR project in this report.

**G-090-P: GLOBAL SEISMOGRAPH NETWORK (GSN) SITE AT PALMER STATION.**
Kent Anderson, Principal Investigator, Incorporated Research Institutions for Seismology (IRIS)

Palmer's seismic station, code named PMSA, is part of the Global Seismic Network (GSN), a collection of 150+ sites worldwide, operating under the aegis of the Incorporated Research Institutions for Seismology (IRIS), and managed by the United States Geological Survey's Albuquerque Seismological Laboratory (ASL). The site was installed in March 1993. As of August 2006, PMSA is also used as an ancillary seismic system for the CTBT/IMS installation; CTBT-specific protocols for the seismic system are covered in the CTBT (T-998) section this document.

A standard seismic station consists of three seismometers oriented to detect ground motion along three mutually perpendicular lines. Most of the time the directions chosen are north-south, east-west, and up-down. The seismometers in the Palmer Station installation are “forced balanced” instruments, which means that they work by keeping an inertial mass stationary with respect to the instrument (and the earth). When a seismic wave arrives, the ground moves, carrying along the housing of the seismometer. The inertial mass tends to remain stationary and not move with the instrument, but it is electronically “forced” to travel along with the instrument (and the earth). The amount of “force” necessary to make it move with the rest of the instrument is proportional to the ground acceleration and is recorded as the raw data from the seismometer.

By examining time of arrival, azimuth, magnitude, frequency and wave type of the incoming waves, seismologists can determine the location, depth of focus, magnitude, type of faulting that occurred, ground acceleration in gravitational force and the structure of the medium (the earth) through which the waves traveled to reach the station. The Research Associate operates and maintains on-site equipment for the project.

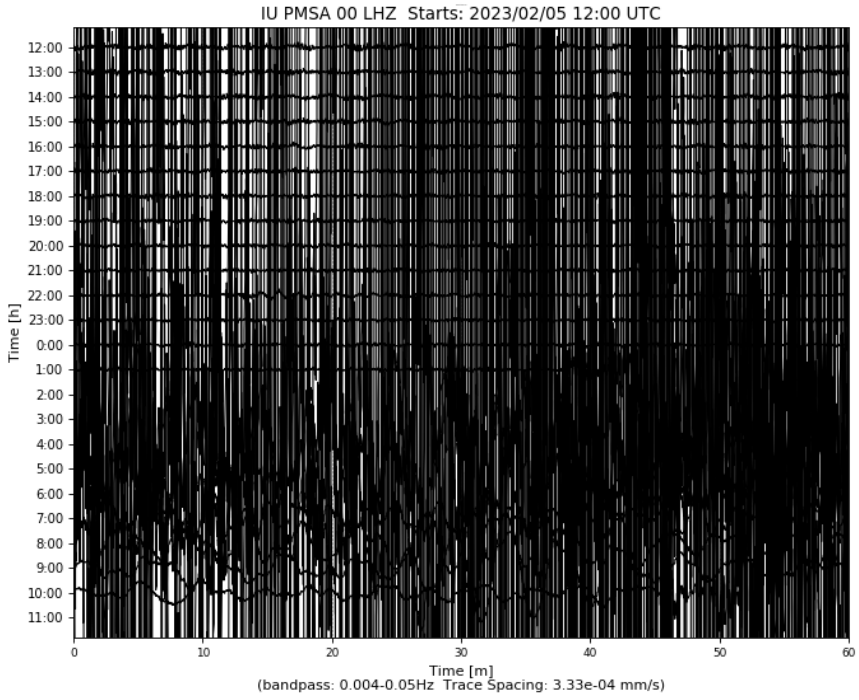


**Figure 20-** A magnitude 7.8 earthquake on February 6, 2023 in Central Turkey as recorded from the Palmer seismic sensor.

The system operated consistently throughout the month. The time stamp and seismic activity found on the Heliplot was checked daily. New computers were received on R/V LAURENCE M. GOULD 23-02 and installed in the seismic shelter in preparation for the G-090 site visit. Current data from Palmer station can be found on the USGS site: https://earthquake.usgs.gov/monitoring/operations/stations/IU/PMSA/#heliplot.

**O-264-P: A STUDY OF ATMOSPHERIC OXYGEN VARIABILITY IN RELATION TO ANNUAL DECADAL VARIATIONS IN TERRESTRIAL AND MARINE ECOSYSTEMS.**

Ralph Keeling, Principal Investigator, Scripps Institution of Oceanography

The goal of this project is to resolve seasonal and inter-annual 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 Scripps Institution of Oceanography flask sampling project analyzes air samples to assess variations in the atmospheric oxygen content caused by exchanges of $O_2$ between the atmosphere and the Southern Ocean. The oceans tend to be a source of oxygen to the air in the spring and summer, and a sink for oxygen in the fall and winter. The spring emissions are mostly due to photosynthesis in the water, while the winter uptake is due to mixing processes, which bring oxygen depleted waters from depth up to the surface. These exchanges lead to variations in the oxygen content of the air above the water, and these changes are rapidly mixed around the latitude band by zonal winds. Measurements of the seasonal variations in oxygen content at Palmer and other sites may be valuable for documenting changes in the biological productivity of the southern oceans over time.

The percentage changes in oxygen are very small. Relative to the 20.95% background, the summer-winter differences are only about 0.01%. Some special precautions are necessary so that the $O_2$ content of the samples isn't perturbed at this low level. Among these precautions are maintaining a constant pressure and temperature in the flasks during sampling. This dictates the installation of the sampling station indoors and the use of a pump module with a bypass valve for avoiding pressure buildup. The Research Associate collects samples fortnightly from Terra Lab.

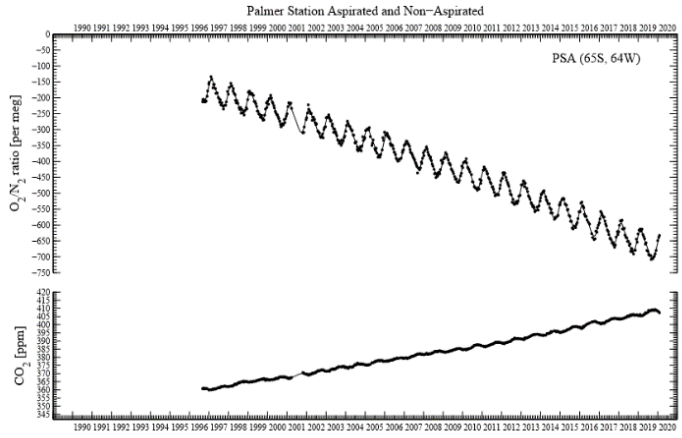


**Figure 21**- Historical plot of $\mathbf{O_2/N_2}$ ratio per meg and $\mathbf{CO_2}$ ppm updated on July 29, 2020.

Air samples were collected on February 17. Wind conditions must equal or exceed 5 knots from a direction between 5° to 205° constantly for over an hour with no interference from human traffic on foot or in vessels. These air samples will be shipped to Scripps Institution of Oceanography in California for analysis. More information and data can be found at: https://scrippso2.ucsd.edu/osub2sub-data.html.

## O-264-P: COLLECTION OF ATMOSPHERIC AIR FOR THE NOAA/GMD WORLDWIDE FLASK SAMPLING NETWORK

Don Neff and Steve Montzka, Principal Investigators, National Oceanic and Atmospheric Administration / Global Monitoring Division; Boulder, CO

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 ($N_2O$) and halogen containing compounds. The Research Associate collects weekly air samples for the CCGG group and fortnightly samples for the HATS group. Wind must be between 5 and 15 knots and consistently blow from one sector with no people, equipment, or boats upwind of the sampling location.

Carbon Cycle Greenhouse Gases (CCGG) samples were collected on February 6, February 13, February 20, and February 28 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: https://www.esrl.noaa.gov/gmd/ccgg/trends/.

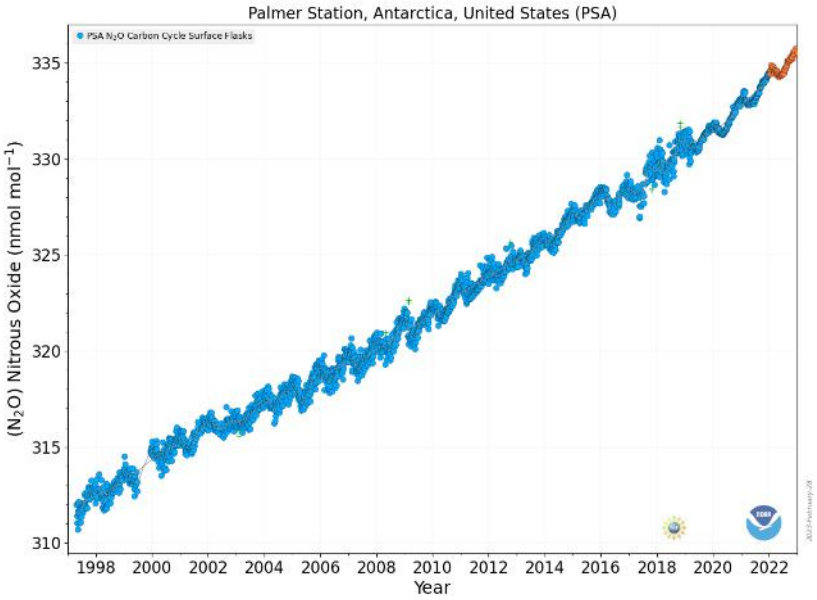


**Figure 22-** Nitrous Oxide ($N_2O$) levels at Palmer Station dating back to 1997. Orange dots are preliminary data.

Halocarbons and other Atmospheric Trace Species (HATS) samples were collected on February 8 and February 24 during favorable wind conditions. You can visit https://www.esrl.noaa.gov/gmd/hats/ for more information about the Halocarbons and other Atmospheric Trace Species group.

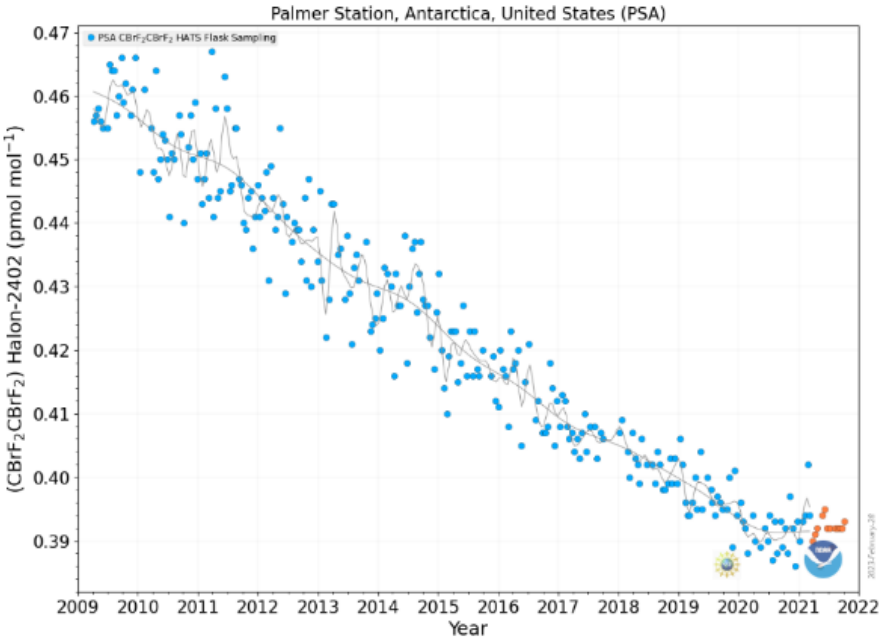


**Figure 23-** Halon-2402 ($CBrF_2CBrF_2$) levels at Palmer Station dating back to 2009, one of the Halocarbon and Trace Gases measured at Palmer Station.

All samples collected on station are sent back to the Earth System Research Laboratories in Boulder, Colorado for analysis.

## O-264-P: ULTRAVIOLET (UV) SPECTRAL IRRADIANCE MONITORING NETWORK

Scott Stierle, Principal Investigator, National Oceanic and Atmospheric Administration / Global Monitoring Division; Boulder, CO

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 Ground-based Ultraviolet (GUV-511) filter radiometer, an Eppley Precision Spectral Pyranometer (PSP), and an Eppley Total Ultra Violet Radiometer (TUVR) also continuously measure hemispheric solar flux within various spectral ranges. The Research Associate operates and maintains on-site equipment for the project.

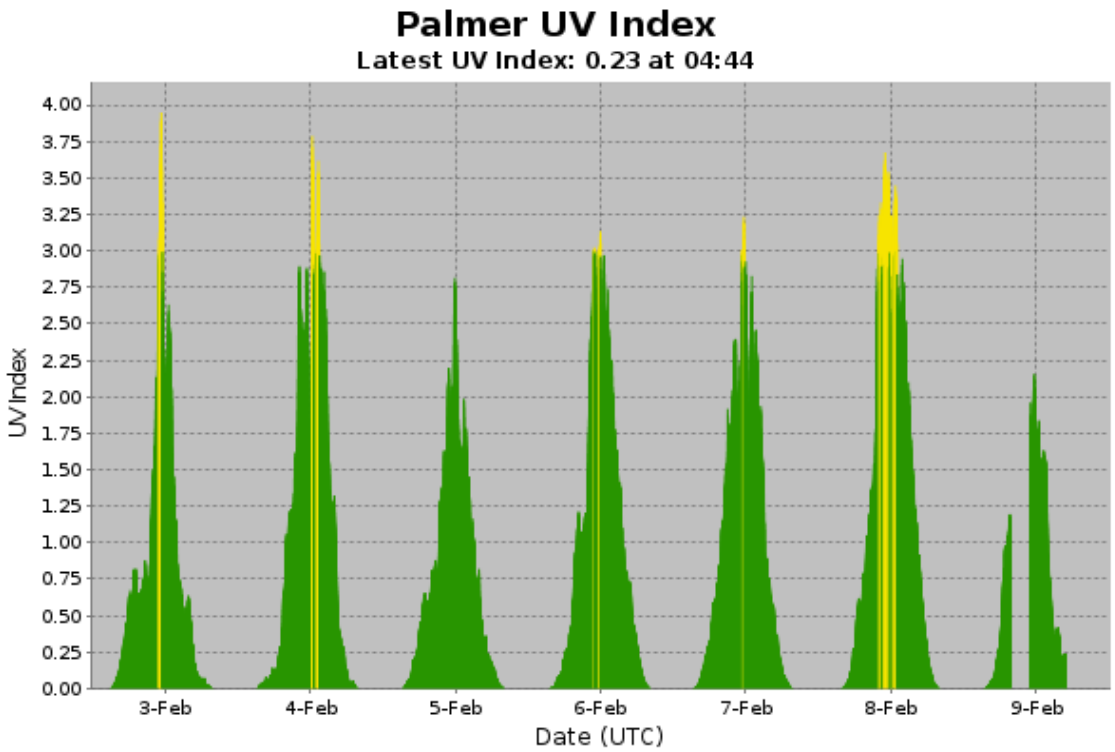


**Figure 24-** UV index generated from the GUV-511 radiometer in real time.

The log was filled out and collectors were cleaned on a daily basis. Once a week level checks were performed to confirm that the instrumentation was within +/- 0.2 degrees. The weekly log was sent out each Monday and bi-weekly SUV-100 UV Absolute Scans were performed on February 13 and February 27 without issues. The highest UV levels for December were reached on February 3 at 4.0 on the UV index.
For more information visit: https://esrl.noaa.gov/gmd/grad/antuv/.

**R-938-P: TERASCAN SATELLITE IMAGING SYSTEM**
Justin Maughmer, Principal Investigator, System Administrator, United States Antarctic Program

TeraScan is an integrated system of hardware and software designed for automated reception of data from meteorological/environmental satellites and for processing the data into images and data overlays. The system collects, processes, and archives DMSP and NOAA satellite telemetry, capturing approximately 25-30 passes per day. The data files for these images and overlays are of a special format called TeraScan Data Format (TDF). 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.

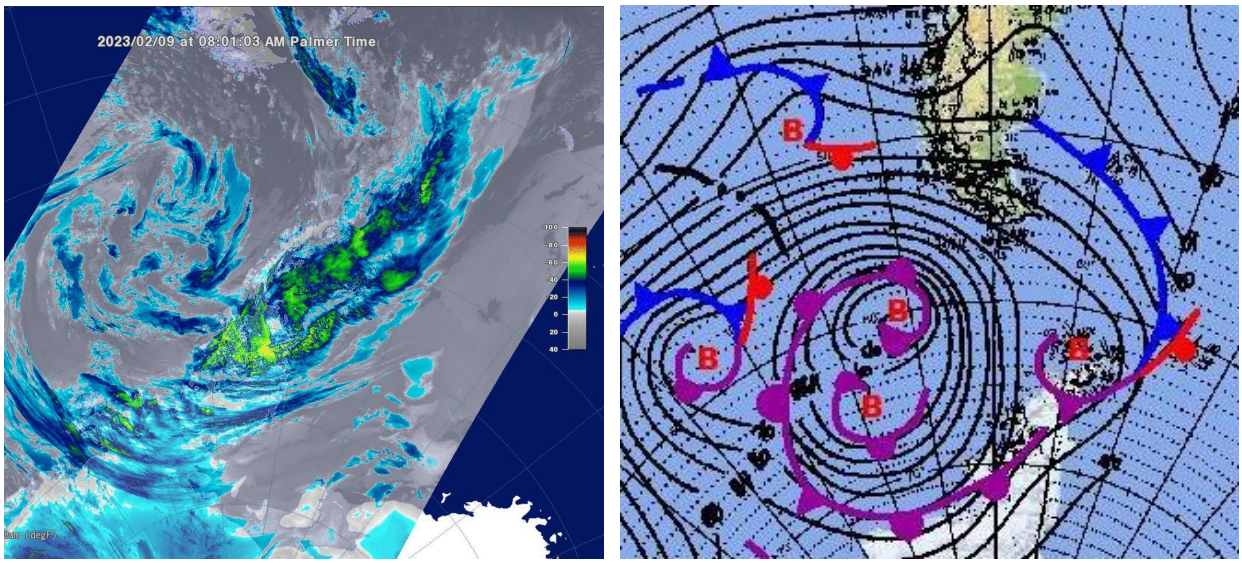


**Figure 25-** NOAA-19 February 9 satellite pass *(left)* explained by the Chilean meteorological chart *(right)* which resulted in the highest winds for the month.

The imagery was checked daily. Both the METOP and NOAA satellite passes were captured normally.

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

The National Science Foundation (NSF) tasked and funded the USGS Antarctic Program to establish a GPS (Global Positioning System) Continuous Operation Reference Station (CORS) at Palmer to serve a variety of scientific investigations in Antarctica. A permanent GPS CORS known as PALM (1003) was established during April and early May of 1997. Four reference marks were set and, along with 10 existing survey marks, PALM was tied in by differential GPS methods.

The GPS data collected supports the International GPS Service (IGS). This system is used for global geophysical studies such as crustal motion monitoring and determination of the global frame. PALM also provides Palmer scientists with real-time differential GPS positioning capabilities. Continuous 15-second epoch interval GPS data files are collected at station PALM, compressed, and transmitted to the NASA-JPL in Pasadena, CA.

JPL/NASA is contracted to maintain the system, and they have sub-contracted to UNAVCO. While operation and maintenance of the GPS/CORS base station is the responsibility of the Research Associate, it is available for grantees who wish to use the roving systems and/or differential post-processing using data from the fixed reference station. Users are expected to have proper training prior to deployment to Palmer. The Research Associate may offer support to visiting grantees at their discretion.

The system operated consistently throughout the month. The lights on the Trimble and Septentrio receivers were all illuminated in the correct pattern and showed no signs of interruption. The annual glacier terminus survey was completed on February 23.

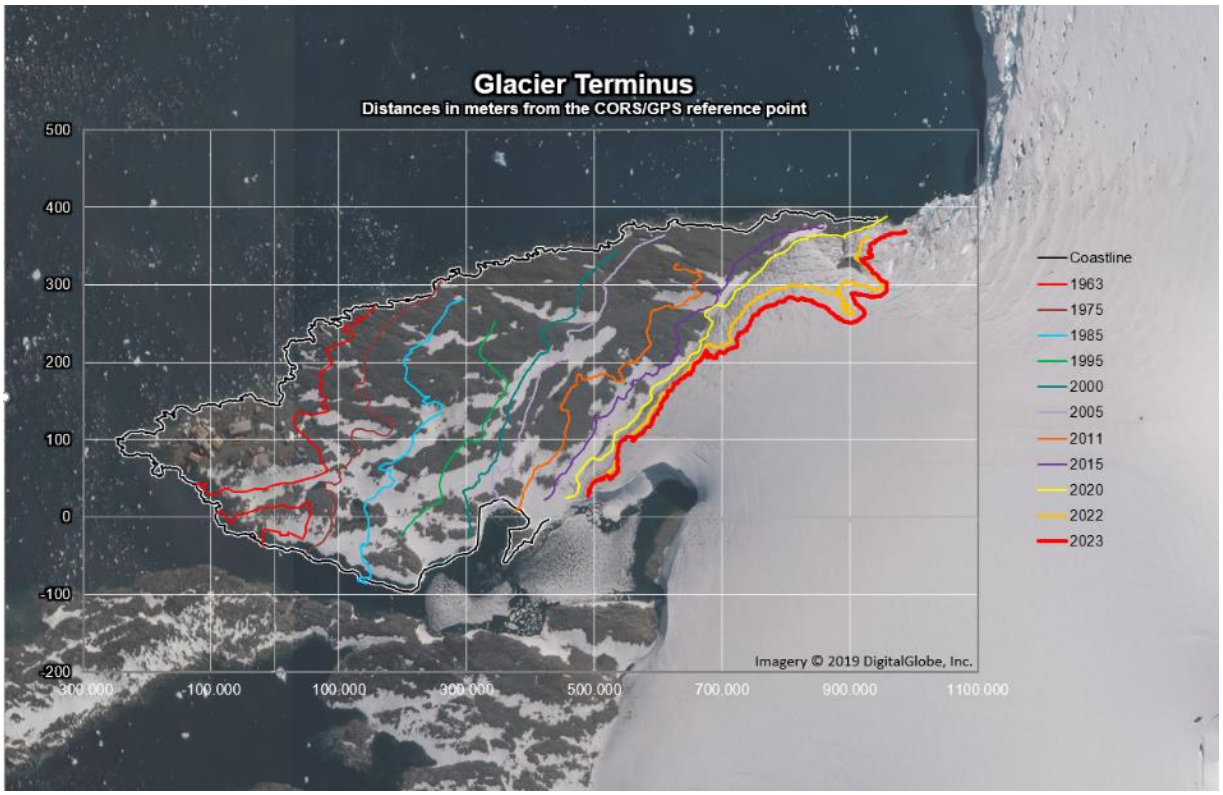


**Figure 26**- The glacier terminus with the new 2023 survey line.

More information can be found at the following website: https://www.unavco.org/projects/project-support/polar/base_stations_and_survey_systems/palmer/base.html.

## T-998-P: INTERNATIONAL MONITORING STATION (IMS) FOR THE COMPREHENSIVE NUCLEAR TEST BAN TREATY ORGANIZATION. (CTBTO)

Managed by General Dynamics

The Comprehensive Nuclear Test Ban Treaty (CTBT) bans all nuclear explosions. Although not ratified, the U.S.A. is following through with the treaty, including the installation monitoring stations around the world. The global verification regime for monitoring compliance is called the International Monitoring System (IMS). The radionuclide air particulate sampling station was installed at Palmer in October of 2005. Palmer's radionuclide sampler/analyzer (RASA) is a primary station in the IMS, known by its treaty code USP73 (and RN73). The pre-existing USGS seismic system is an auxiliary station, treaty code AS106.

Data collected by Palmer's RASA unit is relayed real-time via a virtual private network (VPN) across the Internet back to the CTBT Organization (CTBTO) in Vienna. As of August 2006, both the RASA and seismic systems have been certified by CTBTO. Palmer is now officially part of the IMS. 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 consistently this month. The RASA GUI was checked daily. The amount of filter material was checked as needed and no anomalies were heard coming from the blower.

Daily filters were processed as needed and the monthly log was sent on time. Additional details about the treaty and monitoring stations can be found on the CTBTO web site, http://ctbto.org/.

## PHYSICAL OCEANOGRAPHY

Palmer Station has a tide and conductivity gauge located on the west side of the pier at -64.774558° -64.055580° at a height of 11.46 meters (WGS-84). It was reinstalled at this deeper depth after the completion of the Palmer Pier.

The Research Associate acts as the station's physical oceanography observer by maintaining and observing the sea state. Observations of sea ice extent and growth stage is recorded along with continuous tidal height, ocean temperature, and ocean conductivity.

Observations of sea ice around station were made daily. Current tide level and tide trend added to the local weather radio broadcast service.

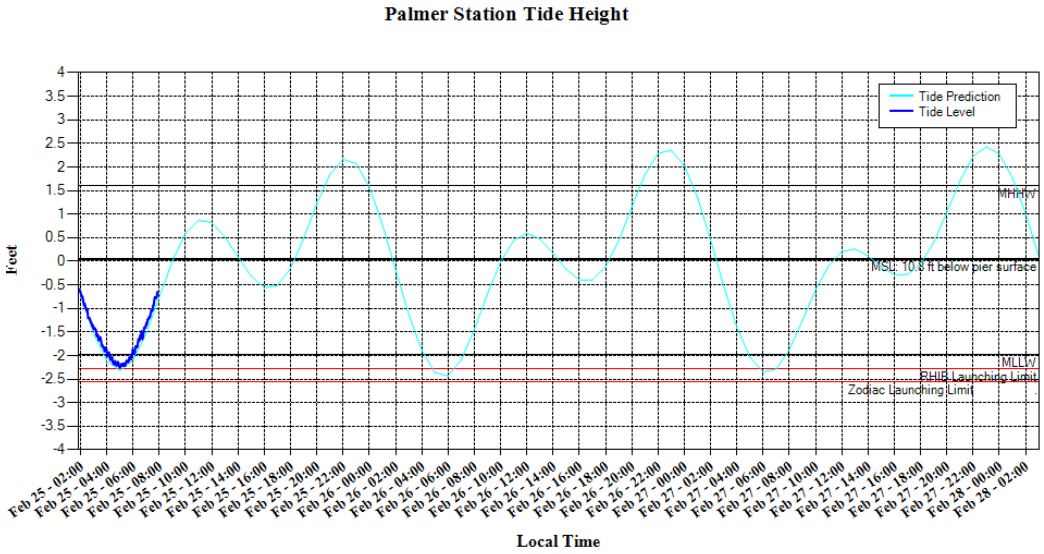


**Figure 27-** Tide charts were added to the twice daily weather conditions vessel email.

Tide level, sea water conductivity, and sea water temperature data is archived on the AMRC website: http://amrc.ssec.wisc.edu/data/ftp/pub/palmer/.

## METEOROLOGY

Mike Carmody, Principal Investigator, United States Antarctic Program

Palmer Station is Station 89061 in the World Meteorological Organization (WMO) Worldwide Network. Automated surface synoptic observations are made 8 times each day and emailed to the National Atmospheric and Oceanographic Administration (NOAA) for entry into the Global Telecommunication System (GTS).

The Palmer Automatic Weather Station (PAWS) is a collection of sensors, computers, and software that records the meteorological data and generates synoptic reports. PAWS began recording data in September of 2015. It was a replacement for the Palmer Meteorological Observing System (PalMOS) that was taken down in November 2017. The PAWS sensors and data acquisition hardware are located on a ridge in the backyard at -64.774130° -64.047440° at

an elevation of 38.3 meters above sea level using the World Geodetic System-84. In addition to the synoptic and METAR reporting, PAWS also archives the current conditions at one-minute intervals and displays both raw data and graphs of the sensor data on our local intranet.

The Research Associate acts as Chief Weather Observer on station, measuring, compiling and distributing all meteorological data. Snow accumulation is physically observed by taking an average of five accumulation stakes found near the PAWS system. All weather data is archived locally and forwarded once per month to the University of Wisconsin on the first day of each month for archiving and further distribution.

The local weather station (PAWS) operated well throughout the month. The Joubins weather station was visited on February 21 and February 24 and functionality was restored. The battery enclosure was removed and replaced with a more waterproof version. We visited the Gosslers weather station on February 25. The temperature sensor was corroded beyond salvation and the battery box needs to be replaced due to heavy corrosion.

One minute weather data is archived on the AMRC website: http://amrc.ssec.wisc.edu/data/ftp/pub/palmer/.

## Palmer Monthly Met summary for February, 2023

| |
|---|
| **Temperature** |
| **Average:** 2.3 °C / 36.2 °F |
| **Maximum:** 7.5 °C / 45.5 °F on 10 Feb 16:49 |
| **Minimum:** -1.7 °C / 28.94 °F on 27 Feb 03:31 |
| **Air Pressure** |
| **Average:** 983.1 mb |
| **Maximum:** 1006.1 mb on 16 Feb 17:21 |
| **Minimum:** 966.8 mb on 21 Feb 16:53 |
| **Wind** |
| **Average:** 11.1 knots / 12.8 mph |
| **Peak (5 Sec Gust):** 57 knots / 65 mph on 8 Feb 21:56 from ENE (62 deg) |
| **Prevailing Direction for Month:** NNE |
| **Surface** |
| **Total Rainfall:** 55.4 mm / 2.18 in |
| **Total Snowfall:** 0 cm / 0 in |
| **Greatest Depth at Snow Stake:** 0 cm / 0 in |
| **WMO Sea Ice Observation:** 1-5 bergs, bergy bits, growlers, and brash ice |
| **Average Sea Surface Temperature:** 1.82 °C / 35.3 °F |