PALMER STATION MONTHLY SCIENCE REPORT

March 2024

Ice growlers left from high tide scattered about Litchfield Island's tidal flats, witnessed while servicing the B-086-P (van Gestel) sites. Accessed via permit ACA 2023-007. *Image credit: Hannah James*

NEWS FROM THE LAB

Hannah James, Summer Laboratory Supervisor

As daylight faded quickly throughout the month of March, it was clear that the 2023-24 summer season was winding down and transitioning into wintertime. Penguins fledged, winds picked up, and boating hours continue to grow shorter and shorter as the sun sets earlier in the evening. As discussed in the previous monthly report, R/V HADAR was decommissioned for the season at the beginning of March due to the remaining engine failing. It will return to Punta Arenas, Chile on the R/V LAURENCE M. GOULD on the closing cruise of the season. The lack of a RHIB didn't stop the water and zooplankton teams completely though! As detailed below, the B-285-P (Bowman) and C-045-P (Van Mooy) grantees returned to sampling with the Go-Flo daisy chain and monsoon pump protocols they established earlier this season, as well as successfully launched the CTD Rosette off of the Marine Landing Craft. The C-020-P (Steinberg) zooplankton group worked with the Boat House to set up net tows off of the Marine Landing Craft, but due to the lack of an A-Frame and winch, was unable to visit Station E to do any tows at depth with the quantifiable measurements needed for these sampling procedures.

The C-013-P (Cimino) and C-024-P (Friedlaender) teams wrapped up their field work in local and distant boating areas. The C-024-P (Friedlaender) whaling team was able to turn around their acoustic moorings both locally at Station H. and further afield in the Wauwermans. The C-013-P (Cimino) birding team finished up work at Biscoe Point, Joubins Islands, and Dream Island and are currently wrapping up local boating work before the ship heads north at the end of the week.

B-046-P (Teets) grantee Cleverson Lima wrapped up his midge field work around the local boating area, and was busy crunching data to outline in this report- be sure to check it out below.

I would like to extend a congratulations and thank you to all the grantees and PIs for all the work accomplished this summer at Palmer Station. There were many things that went differently than we may have expected, but the resilience, communication, and collaboration of people on and off the ice allowed field work to be completed. I would also like to thank the entire Palmer Station Antarctic Support Contract summer team for all the support they directly and indirectly provided our science groups throughout the season. Finally, I would like to thank Lance Roth, Marissa Goerke, and our offsite supervisor Jamee Johnson for all the work and support they provided throughout the season. Winterovers have arrived, and we welcome Sallie Anderson (Lab Supervisor), Harpoon Seabring (Instrument Tech), and Evan Quinter (Research Associate) to the Palmer Lab team!

B-046-P: MECHANISMS OF ADAPTATION TO TERRESTRIAL ANTARCTICA THROUGH COMPARATIVE PHYSIOLOGY AND GENOMICS OF ANTARCTIC AND SUB-ANTARCTIC INSECTS
Dr. Nicholas Teets Principal Investigator, Department of Entomology, University of Kentucky.
Personnel on station: Cleverson Lima

Our main goal for this season was to understand the importance of environmental conditions in shaping physiological and genetic variation in *Belgica antarctica*. During our stay at Palmer Station, we investigated how tolerance to environmental stress change in populations from three distinct islands (Fig. 1) early in the summer and early in the winter to measure this stress tolerance variation across a broad range of space. We also investigated tolerance to stress over the course of the season in populations from different parts of one single island (Fig. 6) to measure changes in the stress tolerance of this species as the summer progressively transitioned to winter.

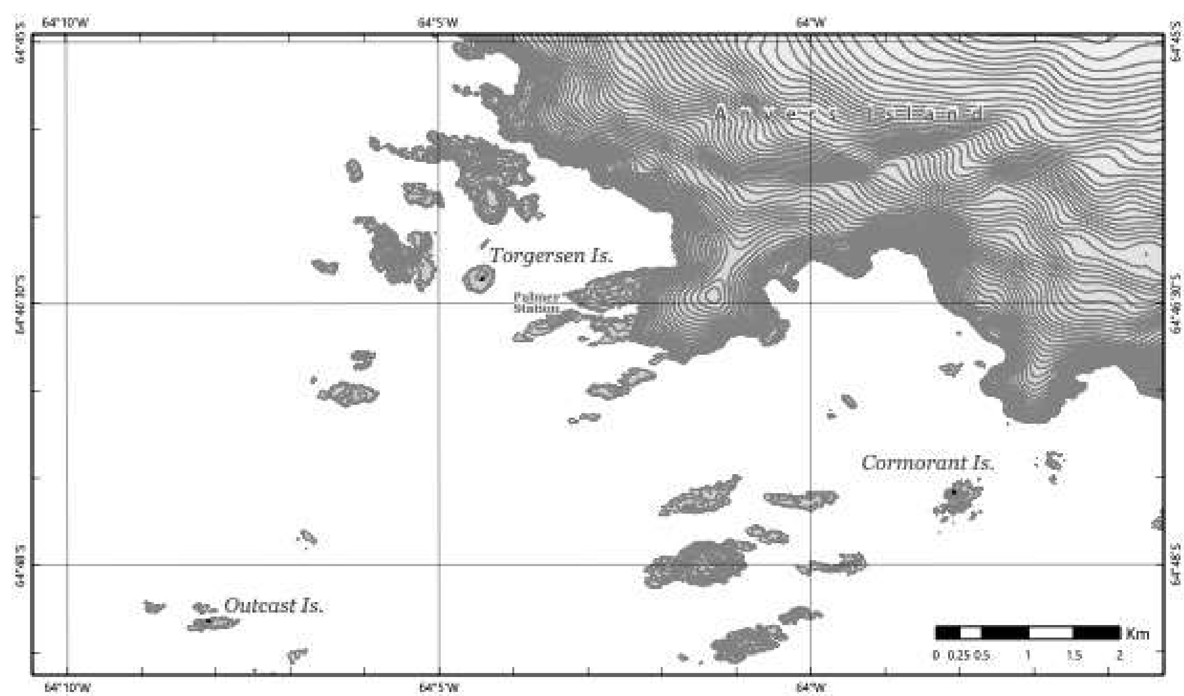

Figure 1- Map of the vicinity of Palmer Station highlighting islands used in these studies. *Map by Rachel de Sobrino, Polar Geospatial Center.*

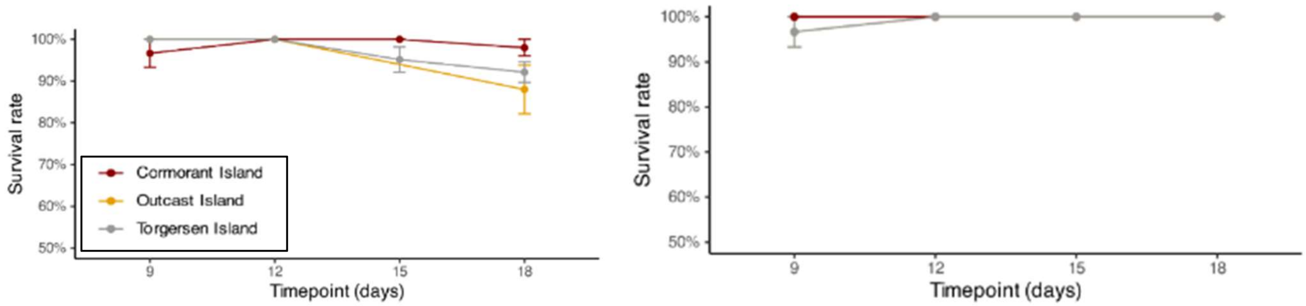

Figure 2- Survival responses to -5C over the course of 18 days. Figure on the left shows summer larvae, figure on the right shows winter larvae. Duration of stress as well as population from different islands did not seem to have any significant effect on survival of both summer and winter larvae.

To look at stress tolerance variation across multiple islands, we used *B. antarctica* larvae from Torgersen, Cormorant, and Outcast islands. The animals were collected late-December, when *B. antarctica*'s austral summer started and early-March, as the winter started for this species. For each of these timepoints, we measured tolerance to a range of high (24C, 27C, 30C, 33C) and low temperatures (-9C, -12C, -15C, -18C). Additionally, we measured tolerance to ecologically relevant high (15C) and low temperatures (-5C) for a number of days (6, 9, 12, 15, 18 days at 15C; 9, 12, 15, 18 days at -5C). Midges collected in late-December will be referred as "summer larvae", and midges collected in early-March will be referred as "winter larvae". Our hypothesis was that winter larvae would show an improvement in stress tolerance to all conditions compared to summer larvae as they prepared to overwinter.

Summer larvae from Outcast Island showed significantly higher tolerance to extreme cold temperatures (specifically -12C) than summer larvae from Torgersen Island, but this effect disappeared in winter larvae from both islands. All populations showed similar tolerance to extreme cold temperatures (Fig. 3).

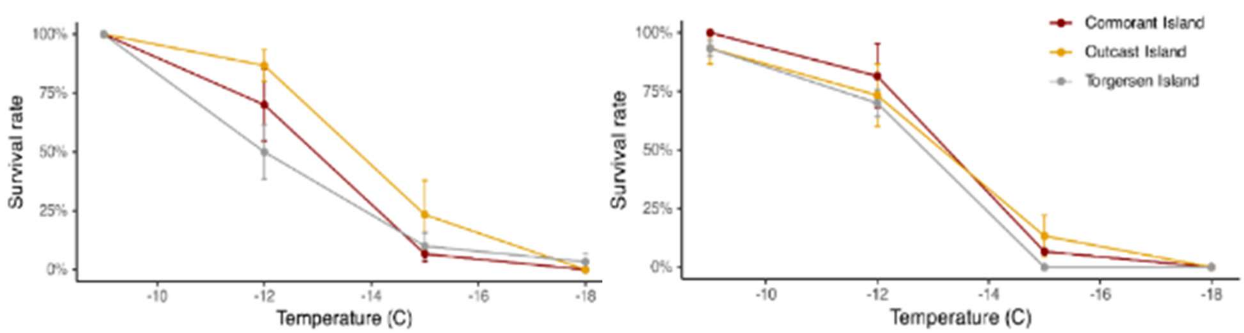

Figure 3- Survival responses to multiple degrees of freezing (-9C to -18C) for 24h. Figure on the left shows summer larvae, figure on the right shows winter larvae. There were no significant differences in freezing tolerance of winter larvae from any islands. Temperature significantly affected both summer and winter larvae survival, showing that lower temperatures have a negative effect in survival.

Summer larvae from Outcast showed significantly higher tolerance to longer periods of exposure to heat than larvae from other islands, demonstrating over a 50% survival rate than summer larvae from Torgersen and Cormorant Islands. This significant effect disappeared in winter larvae, with midges from Torgersen and Cormorant showing a significant improvement in tolerance to heat compared to summer larvae. Here, heat tolerance in winter larvae from Torgersen was significantly higher than in larvae from Cormorant (Fig. 4).

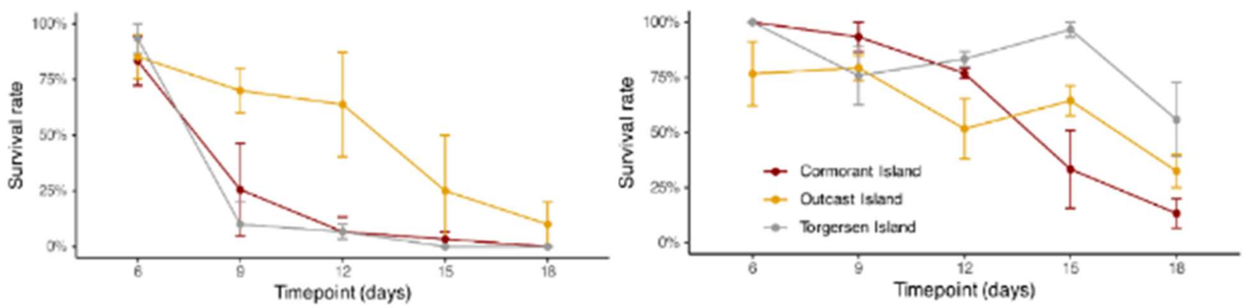

Figure 4- Survival responses to 15C over the course of 18 days. Figure on the left shows summer larvae, figure on the right shows winter larvae. Summer larvae from Outcast Island had a significant higher survival rate compared to summer larvae from the other two islands. Winter larvae from Torgersen showed a significantly higher survival rate than larvae from Cormorant Island. Exposure time had a significant effect on larvae from both periods, showing that long periods at 15C had negative effects in their survival rates.

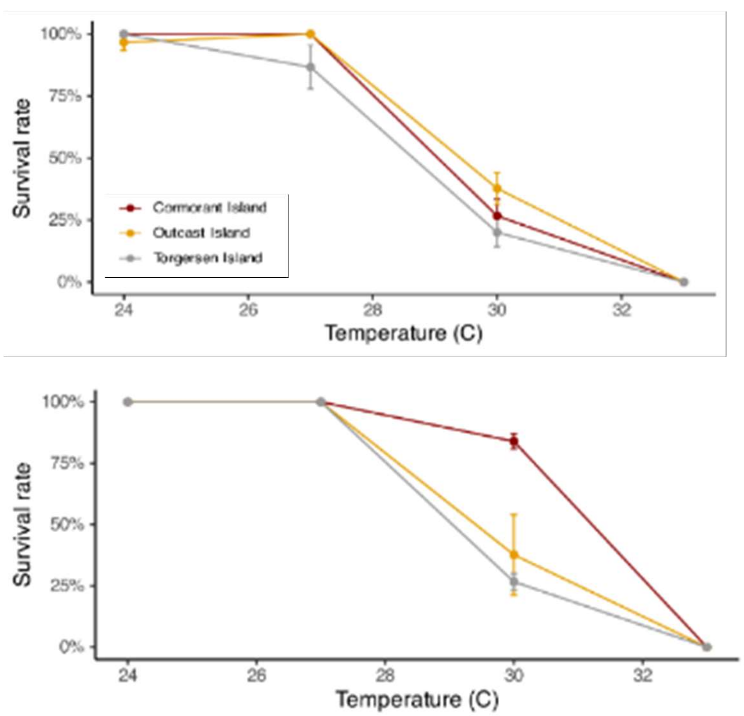

Figure 5- Survival responses to multiple degrees of heat (24C to 33C) for 24h. Figure on the left shows summer larvae, figure on the right shows winter larvae. Only temperature had a significant effect on survival in summer larvae, showing that the higher the temperature, the lower the survival. This effect is similar in winter larvae, but larvae from Cormorant Island had a significant improvement in their survival rates in comparison to larvae from other islands. They achieved almost 100% survival in 30C, whereas larvae from Torgersen and Outcast had 50% survival or less at the same level of stress.

Winter larvae from Cormorant Island showed significantly higher tolerance to extremely high temperatures than winter larvae from other islands and summer larvae from all the islands (Fig. 5). Cormorant Island was an important collection site for multiple objectives of our project. *B. antarctica* were collected in distinct microhabitats of the island from December to March in a biweekly basis to monitor changes in freeze tolerance as the summer climate transitioned to the winter. In addition, we deployed data loggers in the beginning of the experiment that recorded soil temperature data. This data can help us understanding whether specific patterns of soil temperature are associated to specific patterns of change in stress tolerance of each of the collection sites throughout the summer.

The first collection site was on the south site of a cliff and the animals were living under soil and moss. The second collection site was on a flat, open space; midges were living in soil and bird guano. The third collection site was open, rocky (less protected than site 1 and more protected than site 2) and the animals were living in soil and moss. We also collected larvae from random parts of the island and maintained in laboratory at constant 4C to evaluate if living in constant environmental conditions would affect their physiology throughout the season (which we called control).

Post exposure to freezing (-12C), larvae were returned to a temperature of 4C for 24h (i.e., to recover) before survival was checked. We classified the larvae in three groups: 1. alive and active, where larvae spontaneously moved around when we checked survival; 2. alive and inactive, where larvae moved only if stimulated (i.e., forceps were used to poke the animals and check whether they were alive or not); 3. dead, which were the animals that did not show any sign of movement, even when stimulated. We separated in categories because we were also interested in individual responses to stress in larvae from these distinct microhabitats (i.e., larvae that are active post exposure to freezing respond better to stress than larvae that are inactive).

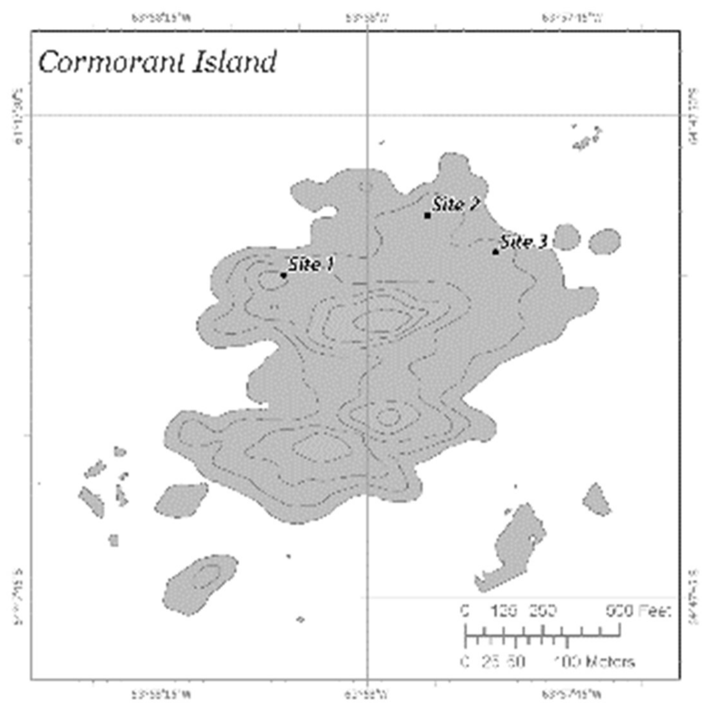

Figure 6- Map of Cormorant Island showing locations where *B. antarctica* were collected. Map by Rachel de Sobrino, Polar Geospatial Center.

Our hypotheses were that larvae in the control group would show a linear relationship between physiological responses and time since they were maintained in laboratory at the same temperature throughout the experiment (i.e., their survival rates would not change over the course of the season). Sites 1-3 would show a decrease followed by an increase in freezing tolerance over time assuming that they would experience the peak of warm temperatures as the summer progressed and return to experience lower levels of temperature as the winter approached. These changes would occur in different timeframes for each collection site (i.e., larvae from site 3 would become more freeze tolerant faster than larvae from site 1). Below, we show changes in survival rate over time for both active and inactive larvae (Fig. 7), and survival rates of the larvae that were alive and active post exposure to freezing (Fig. 8)

When we consider the results of all alive larvae (both active and inactive), the survival rate overall increased over time (i.e., animals tended to respond better as the winter got progressively closer). However, this improvement in survival rate was not linear across different experimental groups. For instance, larvae from site 3 started showing lower survival rate than larvae from site 1 (10 Jan) but had considerably higher survival than larvae from site 1 in the next two sampling points (25 Jan and 7 Feb). Control showed a relatively linear increase in survival rate over time, which is interesting given that they spent this time at the stable temperature of 4C. As an alternative parameter to measure *B. antarctica* responses to freezing throughout the season, we assessed survival rates of larvae that do not seemed to be negatively impacted by the exposure to stress (i.e., larvae that showed spontaneous movement after going through this harsh level of stress).

When we consider survival rates of only the larvae that were active post exposure to stress, we can observe a depression in responses to freezing in larvae from site 1 as the season progressed. Then, the number of active larvae from site 1 picked up and almost reached the number of the active larvae from site 3. We can also observe a decrease in the number of active larvae from site 2, 3, and control but this decrease is not as steep as the decrease of active larvae from site 1. Moreover, this decrease occur in different timepoints (Feb 7 for site 2 and control, and Feb 21 for site 3), and although the number of active larvae from sites 2 and 3 almost achieve 100% at the end of the season, numbers in the control group are maintained relatively similar over the course of the season.

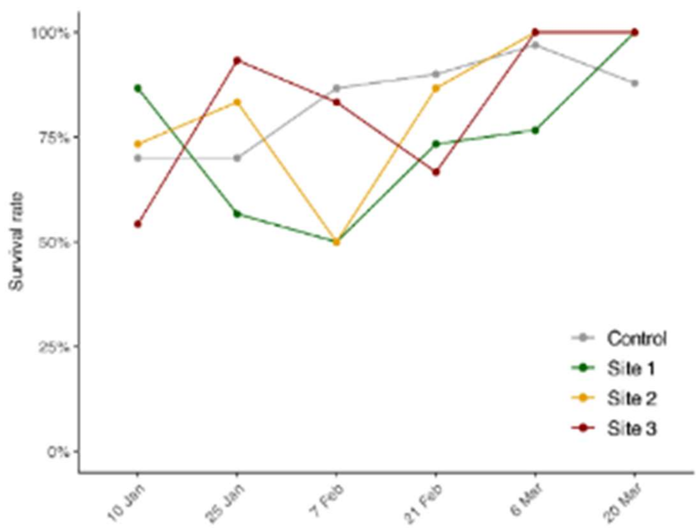

Figure 7- Changes in survival rate of active and inactive larvae to -12C over the course of the summer at Cormorant Island. Larvae from site 3 showed significantly higher survival rates over time than larvae from sites 1 and 2**.**

Our hypotheses seem to be relatively supported by our data. Considering the numbers that we obtained from the control group, the different survival rate patterns of sites 1-3 might be associated with the variation of soil temperature of each of the collection sites. For instance, larvae from site 1, which is in a cliff, are covered from the northeast. They might have experienced freezing temperatures later in the season (i.e., given that they are possibly not as exposed to events of wind and snow) than larvae from the more exposed collection sites, which would confer larvae from site 1 a slower improvement in tolerance to freezing in comparison to larvae from sites 2 and 3. The temperature data that will be collected at the end of this season will help us to analyze these results even further, and allow us to have more detailed interpretation of these interesting patterns of variation in stress tolerance of populations that inhabit distinct microhabitats.

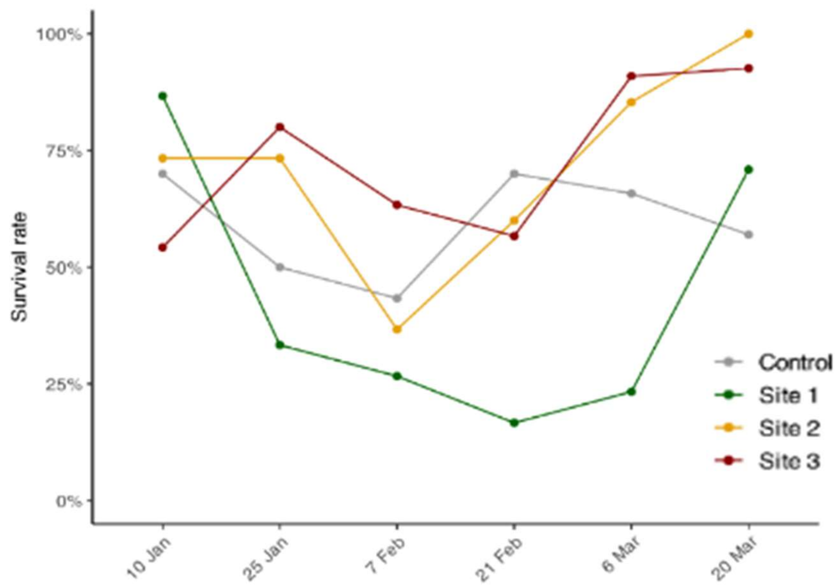

Figure 8- Changes in survival rate of only active larvae to -12C over the course of the summer at Cormorant Island. Larvae from site one showed significant lower survival rates over time than larvae from the other collection sites.

Moreover, we collected extra samples of larvae and adults from each collection site as well as from Torgersen and Outcast Islands to investigate changes in gene flow and transcript variation (transcriptomics) over the course of the season. These follow-up studies will have the objective to uncover the mechanisms that are potentially behind the patterns of stress tolerance variation throughout the summer that were discussed in this report.

Many animals rely on acclimation to enhance their stress tolerance to face unfavorable conditions. Some animals can also rely on their phenotypic plasticity to respond to these unfavorable conditions without the need to slowly experience increasing levels of stress to enhance their stress tolerance (i.e., acclimate). *Belgica antarctica* can rely on both types of strategies, but since they evolved to live in a habitat with such dramatic environmental changes as Antarctica, they are very sensitive to any type of stress (e.g., a sudden drop in temperature, or a bout of high-speed wind). Studying the extent to which *B. antarctica* rely on each of these strategies to survive and how environmental variation can shape this species' biology across distinct populations is important to help us understand better how polyextremophiles adapt and evolve while inhabiting extreme environments.

On a final note, I want to acknowledge all the ASC personnel that assisted our project throughout this field season. We planned big goals knowing that they would be difficult to achieve with such short staff on station, which made ASC's help of the utmost importance in completing all the objectives that our team proposed. We could not be more grateful. Thank you!

Figure 9- Photo of *B. antarctica* larvae feeding in the field taken with a portable microscope. Each larva size can reach up to 5 mm in length. Credit: Dr. John Michael Watson.

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 currently on station: none (work performed by ASC staff)

The specific goal of this project is to study how warming affects the carbon cycle in Antarctica; specifically, how warming affects carbon entering (i.e., via photosynthesis) and leaving (i.e., via respiration) the land ecosystem. The major players in the carbon cycle of the western Antarctic Peninsula are plants and microbes. A major strength of the Palmer Station environs is that the receding Marr Ice Piedmont glacier conveniently provides for a successional gradient, such that we can examine warming-induced changes to the carbon balance as we shift from a solely microbial dominated system (close to the glacier edge) to a fully vegetated system: the moss peatbanks of Litchfield Island.

Figure 10- - B-086-P (van Gestel) site locations. Google Earth satellite imagery taken in 2014 and 2017. *Figure credit Hannah James*.

This year, because of logistical challenges, our field experiment was continued thanks to ASC staff who deployed the open-top chambers along the successional gradient. Chambers were deployed as soon as the areas became snow-free, in January 2024. Open Topped Chambers on Litchfield Island are accessed with permit ACA 2023-007. All 40 field plots contain TEROS12 sensors inserted perpendicular into the soil (0-5 cm) that are linked to a ZL6 data logger (METER Group, Inc., Pullman, WA). There were no moss samples collected this year at any of the sites (including Litchfield). We did not take carbon flux measurements to examine whether warming stresses out the moss.

The chambers were removed from all sites on March 26. Batteries were also swapped to power the dataloggers. These overwintering sensors are logging soil temperature and moisture. There are also the four light sensors measuring light levels through the snowpack. Data was downloaded and sent to the PI for further analysis.

Figure 11-A side-by-side view of the start of the experiment (January 12, left) and the end after the chambers had been returned to the lab (March 26, right). ACA permit 2023-007. *Image credit: Hannah James*.

B-285-P: Understanding Microbial Heterotrophic Processes in Coastal Antarctic Waters

Dr. Jeff Bowman, Principal Investigator, Scripps Institution of Oceanography, University of California San Diego
Personnel on station: Beth Connors

B-285-P (Bowman) had a productive final month of environmental sampling and experiments. This past month, we were successful at retrieving seawater from Station E on six occasions: March 1, 4, 6, 12, 18 and 22. After a failure of Hadar's second engine (which brought use of the boat to a complete stop), we went back to collecting water by hand with Go-Flos from a Zodiac after March 1. We were able to successfully perform experiments on these days with water from the mixed layer (10 m), near the subsurface chlorophyll max (30 m), and below the mixed layer (50 m). At each depth we took initial measurements for bacterial abundance and community structure, then we used the remaining water to perform live experiments to monitor microbial dynamics to infer carbon flow through microbial food webs. The most important of these experiments for our group is a dilution series, where water from 10 m is first filtered either by only a 0.2um filter to remove large grazers or filtered by a tangential flow filter (TFF, pore size 30kDa) to remove viruses. These two types of filtered water are then combined with unfiltered seawater at different concentrations in two (30kDa or 0.2um filtered) series (0% whole water, 30% whole water with either 70% 0.2 or TFF filtered water etc).The dilution series is incubated at 2C for 24 hours, and we use our measurements to determine the influence of both protists and viruses on bacterial growth rate. Obtaining a better

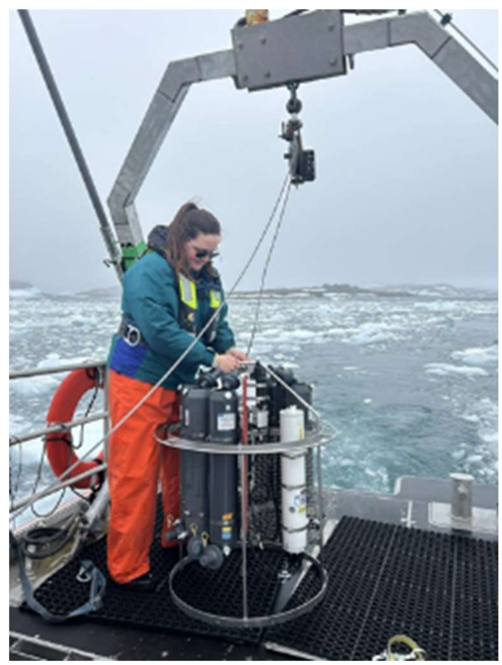

Figure 12- PhD student Beth Connors onboard RHIB HADAR setting up the CTD (which measures conductivity, temperature and depth and collects water for our group). When RHIB HADAR's engine second engine failed, we switched to collecting water from a Zodiac and even used the Marine Landing Craft successfully this month. *Image credit Beth Connors.*

understanding of the influence of predation on bacterial growth is critical to understand microbial carbon flow along the Western Antarctic Peninsula (WAP) as it is currently very poorly understood.

In addition to undertaking the sampling for our lab, PhD student Beth Connors successfully continued sampling for the phytoplankton group C-019-P (Schofield) with the help of C-045-P (Van Mooy) grantee Shavonna Bent. We also, in collaboration with the Marine Technicians on station, successfully deployed the CTD rosette from the Marine Landing Craft at Station E on March 20th. We are currently creating new protocols so that future grantees have detailed information for all three platforms (from RHIB HADAR*,* a Zodiac, or the Marine Landing Craft) to collect water from Station E. Our group would like to thank all of the Antarctic Support Staff, especially the Marine Technicians on station, for a successful season.

C-013-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

Dr. Megan Cimino, Principal Investigator, University of California at Santa Cruz.
Personnel on Station: Megan Cimino and Allison Northey.

Favorable weather allowed us to conduct boating field work on 21 days in March. Gentoo penguin chick fledging masses were obtained at Biscoe Point and in the Joubin Islands.

Brown skua work concluded this month with nest monitoring and growth measurements of breeding pairs from Dream Island to Biscoe Point. Our south polar skua study on Shortcut Island continued throughout March.

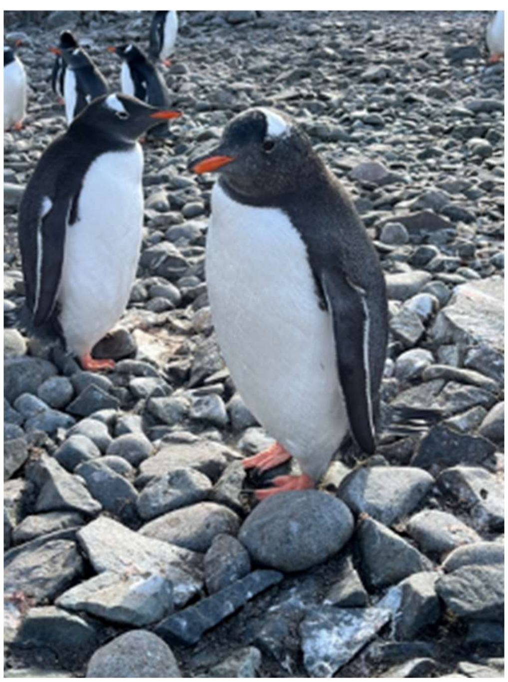

Figure 13- Curious gentoo penguin chicks ready for their first swim. *Image Credit: Megan Cimino*

Giant petrel chick banding on all local islands was completed in March and we continued our chick growth study.

Marine mammal monitoring continued with observations of fur seals, elephant seals, sporadic leopard seal and a few Weddell seals. Whale observations in the Palmer area decreased during March but humpback whales were still regularly seen.

Sediment trap contents were collected from Adélie colonies on Torgersen, gentoo colonies on Biscoe and chinstrap colonies on Dream Island. These Palmer area sediment trap samples as well as Avian Island samples will be processed for otoliths. Limpet trap contents were also collected and processed from kelp gull colonies on four local islands.

Special thanks to everyone who help with field efforts, especially fledge weights.

C-019-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

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

Personnel on station for month of January: none

C-045-P (Van Mooy) and B-285-P (Bowman) grantees have continued baseline Station E and pump house sampling for the C-019-P (Schofield) lab. This is detailed in each of their reports.

C-020-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

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

Personnel currently on station: Maya Thomas

The Steinberg lab completed their last month of sampling at Palmer Station for the 2023-2024 season. Unfortunately, this month began with a mechanical failure on our main sampling vessel, RHIB HADAR. Since it was deemed out of commission for the rest of the season we had to retire our regular Station E sampling. Luckily, the Boat House had been working on getting the Marine Landing Craft (MLC) online and the zooplankton lab was able to transition from regular sampling to methodology testing onboard the contingency boat.

Figure 14- Maya Thomas, zooplankton lab lead, deploying the ring net off of the marine landing craft. *Image credit: Beth Connors.*

From the knowledge we gathered on previous seasons, it seems like there have been only a few previous attempts to try zooplankton sampling from the MLC, but there were major problems with counterbalancing the weight of the net to ensure that the boat does not move in a circular track when the net is in the water. After initial trials in Arthur Harbor, the Boat House was able to test a couple of different line configurations and rig the net up in a way where the boat could still move forward in a straight line. This was a huge hurdle to overcome and is important knowledge to pass down to future net towers, but there were still many disadvantages to using the MLC. Although the MLC may be a capable vessel to do surface net tows to collect animals for experiments, it is not able to be used for our regular Station E sampling with either the ring or metro net. For that, we must have a vessel with an A-frame and winch- especially for the heavy metro net frame.

Meanwhile, during MLC testing, the zooplankton lab was able to SOLAS Bellatrix for surface net tows to collect animals for experiments. Within the month we conducted three zooplankton dissolved organic matter production experiments that will be used in Maya's dissertation.

As the season is wrapping up, I think it's important to mention once again that the work completed this year would not have been possible without the continued help of all personnel on station. Although this has been a difficult year, it has been amazing to see everyone work collaboratively through each problem that has arisen. Particularly, it has been a joy to work with so many amazing women throughout the season!

Figure 15- The annual International Women's Day photo! *Photo by Hector Plaza*

C-024-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

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

Personnel currently on station: Ross Nichols and Helena Dodge

March marked the second month of the 2024 season for the C-024-P (Friedlaender) group, led by PI Dr. Ari Friedlaender with field team members Ross Nichols (lead) and Helena Dodge based at Palmer station. The group's main research hypotheses are focused on understanding the behavior, ecology, life history and demography of baleen whales in the waters around Palmer Station, and the potential for ecosystem competition and partitioning between baleen whales and other krill predators. The research objectives are addressed through a multi-platform approach, which combines both observational and direct sampling methods. These include visual boat-based surveys, photo-identification, tissue biopsy sampling, drone-derived measurements, passive acoustic recording devices, and animal-borne motion-sensing tags. These data are also integrated with seasonal and oceanographic parameters (*e.g.* krill abundance measured from echosounders). The field team based at Palmer Station conduct research in the station's local and extended boating areas, while the team members on the LMG collect similar data across the LTER oceanographic sampling grid.

The station team conducted daily visual surveys aboard the SOLAS vessel 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 we collected photo-ID, biopsies, and drone-derived measurements are collected opportunistically whenever whales are encountered. As of April 1st, we at station have conducted over 97 hours of surveying, during which time we have observed 176 humpback whales (73 non-mother adults, 12 juveniles, 41 mothers calf pairs and 9 of unknown age class). We have collected 84 biopsy samples (36 non-mother adults, 8 juveniles, 27 mothers, and 15 calves). We have 105 individual animal flukes for individual ID and drone-derived morphometrics for 65 humpback whales. See summary statistics for sampling in Table 1. See Figures 16-19 for maps related to the sightings data.

	Adults	**Juveniles**	**Mothers**	**Calves**	**Total**
Observations	73	12	41	41	176
Photo-IDs	50	8	30	17	105
Biopsies	36	8	27	15	84
UAS	23	5	18	19	65

Table 1- Summary of Humpback Whale sighting observations, photo-identification (fluke only), UAS morphometrics and biopsy sampling. Samplings have been broken down by age class (note that 'Adults' does not include mothers).

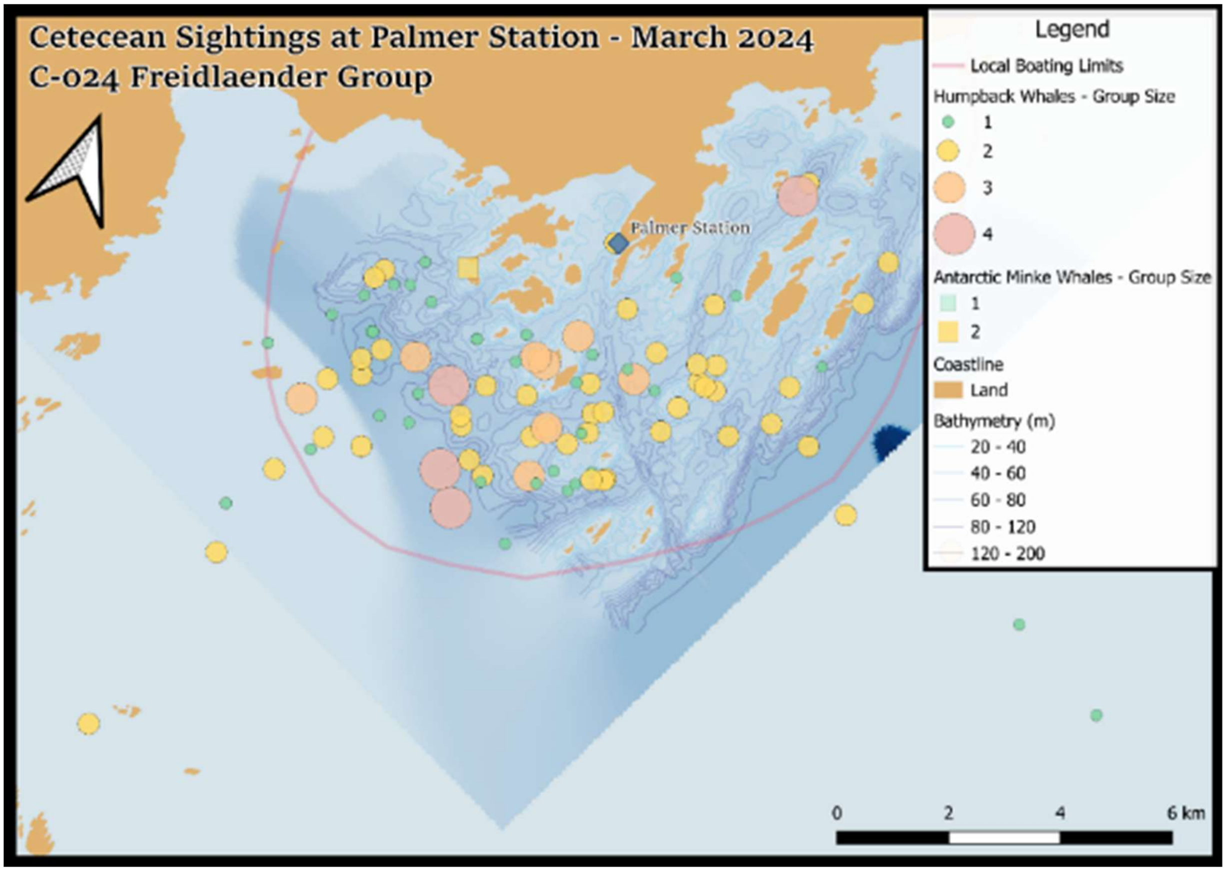

Figure 16- A map of all humpback whale sightings between January 29th and April 1st by C-024. Shape indicates species. Color and size indicates group size, with green representing solo individuals, yellow is groups of 2, orange groups of 3, and red is 4+ individuals.

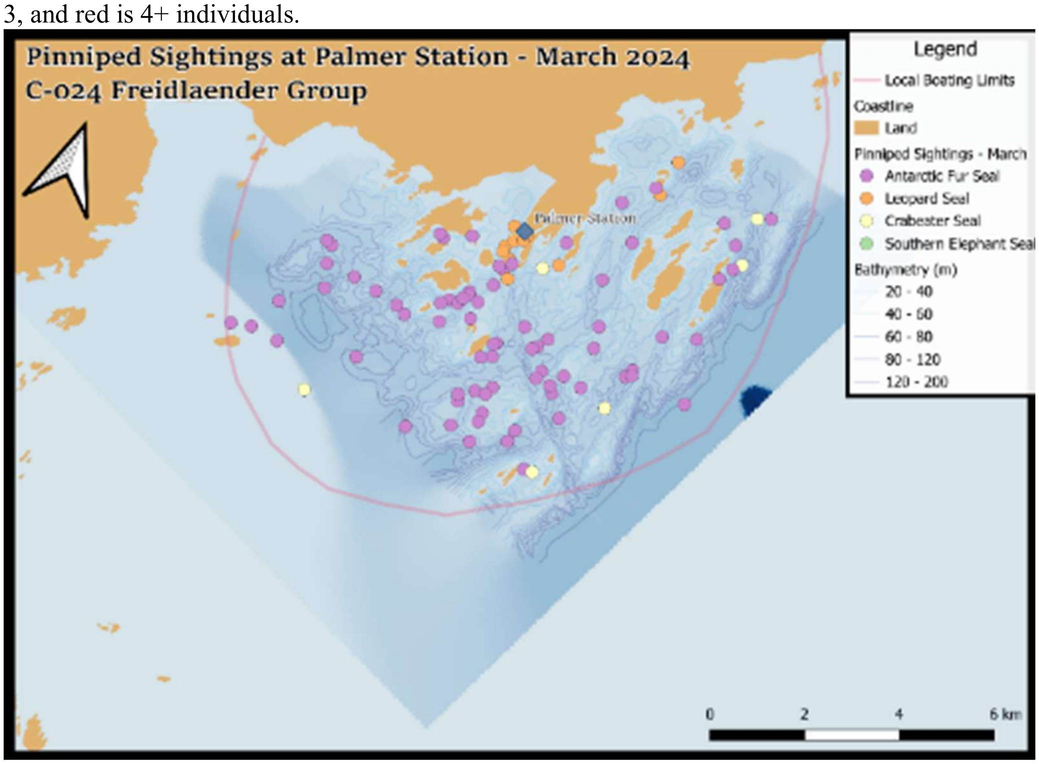

Figure 17- A map of all pinniped sightings between January 29th and April 1st by C-024. Color indicates species.

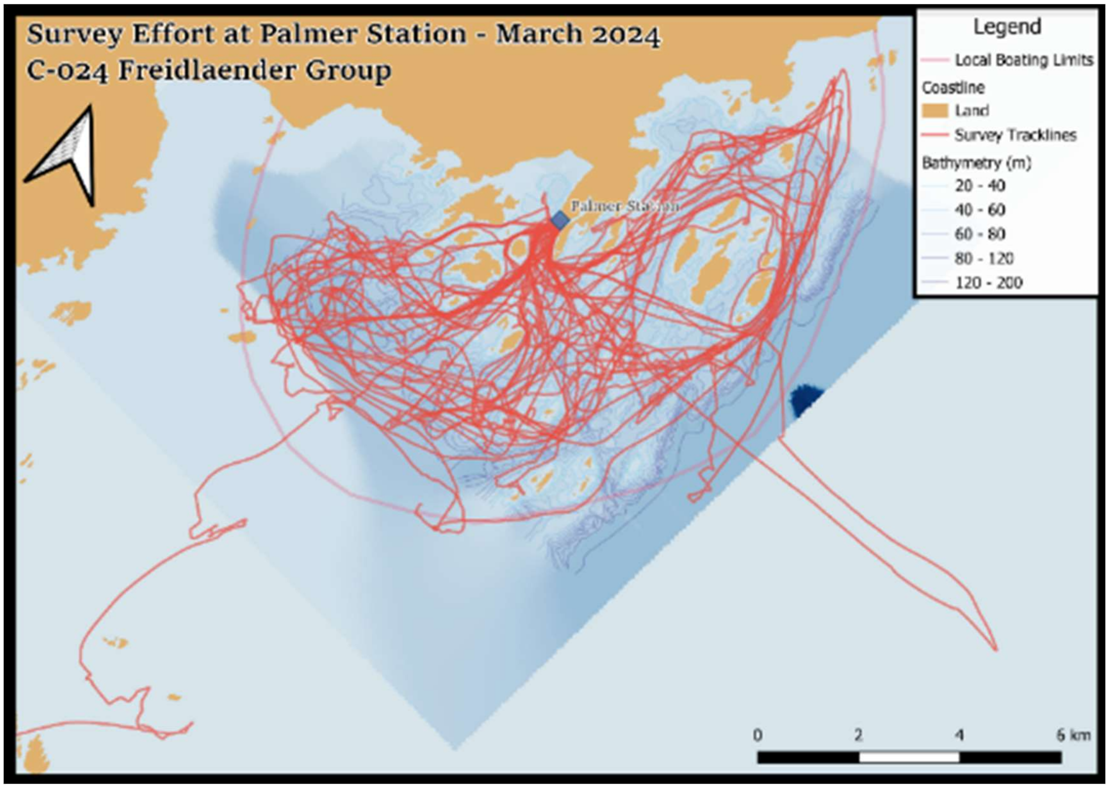

Figure 18- A map of our survey effort track-lines between Jan 29th 2024 – April 1st 2024.

Photo-Identification

Photo-identification is done using the markings, scarring, and coloration on the fluke of the animal (Fig. 20). As with previous seasons, there is relatively little site fidelity and low residence times for humpbacks in the Palmer Station survey area, though this is potentially an artifact of the limited size of the survey area. Only 17 individuals were observed in multiple sightings and the vast majority were re-sighted within 1-2 days. This matches our general understanding from previous seasons that most humpback whales do not reside within the Palmer Station survey area for extended periods of time. This low residency time is also corroborated by our historic tag data that shows whales using extended spatial areas for feeding during summer months before moving inshore and decreasing their home range sizes towards the end of the feeding season. When individuals were re-sighted, it was often in association with different individuals than the initial sighting. This is consistent with the fission-fusion social structure typical of baleen whales, which consists of short-term associations that switch frequently.

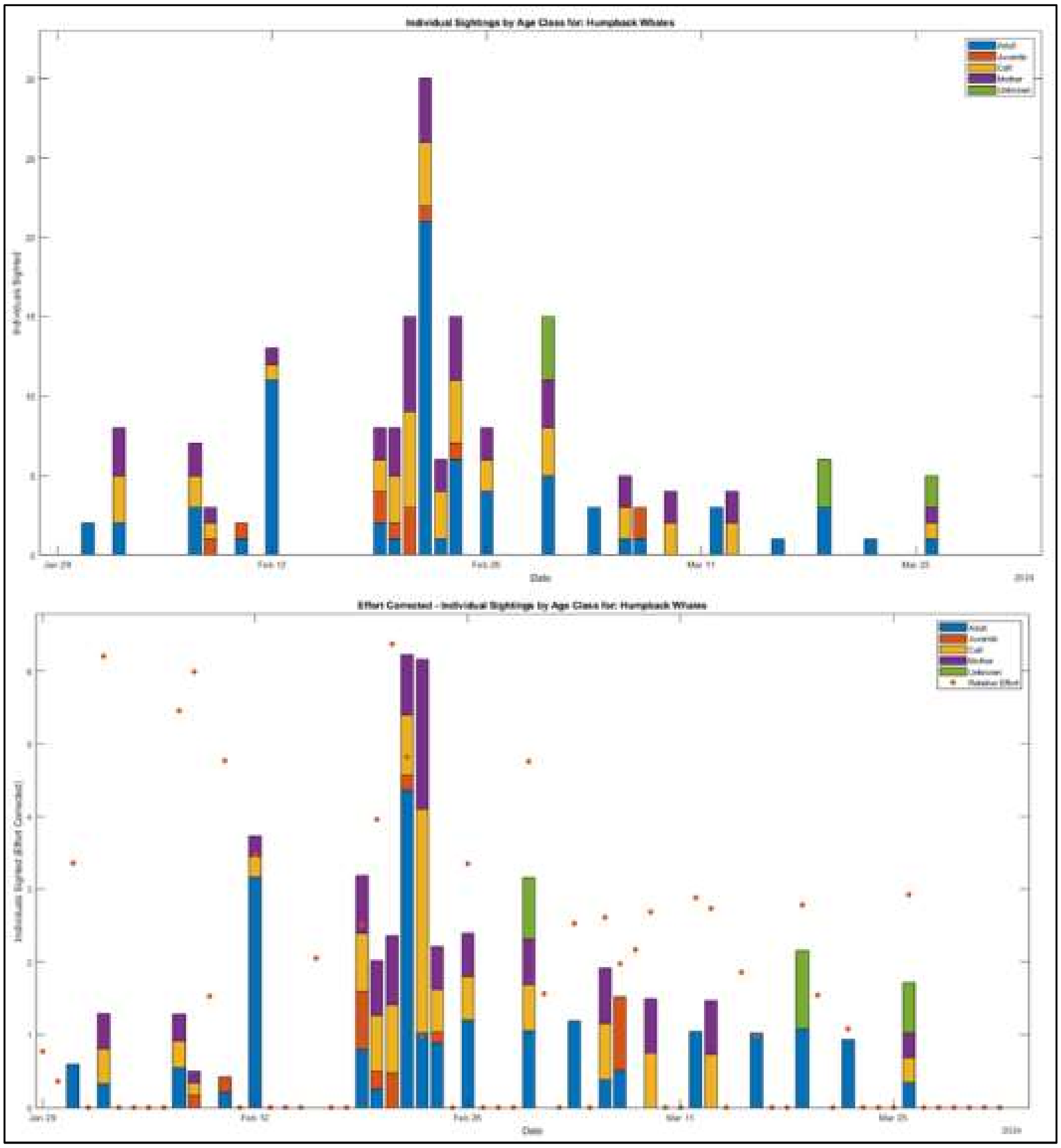

Figure 19- (TOP) - Number of humpback whales sighted by date. Colored sections of each bar plot indicate the proportion of age classes for each day. (BOTTOM) – Number of individual humpbacks sighted relative to the amount of survey effort each day. The red points indicate the relative amount of effort for each day.

Figure 20- A humpback whale fluke photo-ID shot taken during our 2024 surveys, showing clear black and white identifying marks, the yellow color is produced by diatom growth. *Image credit: Ross Nichols.*

Biopsy Tissue Sampling

The biopsy samples (Fig. 21) are collected via crossbows with a specialized bolt. Photo-ID of flukes and dorsal fins are used to ensure that individuals are not double-sampled. These samples typically contain both skin and blubber, are used for a suite of analyses regarding the health, demography, and reproductive rates of baleen whales and respond to the ecological and environmental changes taking place along the Antarctic Peninsula. Skin samples are used for genetic identification and sexing of animals, and to determine the breeding stock of whales sighted around Palmer Station. This is done by comparison of 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 that winters off the west coast of Central and South America. Blubber samples are used for hormone and pollutant detection and analyses. Stress levels are determined using cortisol levels, while pregnancy is determined using progesterone and estrogen levels. Demographic parameters like 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. Blubber is also used to assess the presence of pollutants, specifically persistent organo-pollutants and the presence of endocrine disruptors that may indicate exposure to microplastic pollution.

Figure 21- Helena Dodge performing a biopsy on the side an adult Humpback whale. Collected under permits: NMFS 23095, ACA 2020-016, and IACUC Frie2305dn. *Image credit: Ross Nichols.*

UAS Operations

Unoccupied aircraft systems (UAS 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 (Fig. 22). These measurements contribute to analyses of whale anatomy and physiology, and comparisons across time and space can address broader questions of foraging ecology, phenology and prey consumption in different regions and periods of the feeding season.

UAS operations have been greatly successful this year, with a DJI Inspire 2 being deployed for whale photogrammetry and behavioral observation. Since beginning work on Jan 29th our team conducted 45 successful UAS flights near Palmer Station and within the Palmer Boating Area: 4 test flights from station and 44 flights for photogrammetry and behavioral observation. The whale photogrammetry flights have taken place throughout the local and extended boating area. Photogrammetry flights were also performed on Bonaparte Point (Fig 24), producing an Orthomosaic map. These photogrammetry flights were performed as test flights and method testing for eventual data collection in April, where the C-024-P (Friedlaender) group will be performing similar operations over Litchfield Island in a collaborative project with the C-013-P (Cimino) group in relating topographic characteristics to avian presence on Litchfield Island. (*Post note- this permit amendment adding ground-based flights over ASPA 113 Litchfield Island was granted April 1, 2024.*)

Figure 22- A screenshot from a video collected by a drone of a mom and calf pair that will be used for photogrammetry and measurement. Collected under permits: NMFS 23095, ACA 2020-016, and IACUC Frie2305dn. *Image credit: Ross Nichols.*

Figure 23- An adult humpback whale traveling through brash ice in Wiley Bay. Collected under permits: NMFS 23095, ACA 2020-016, and IACUC Frie2305dn. *Image credit: Ross Nichols.*

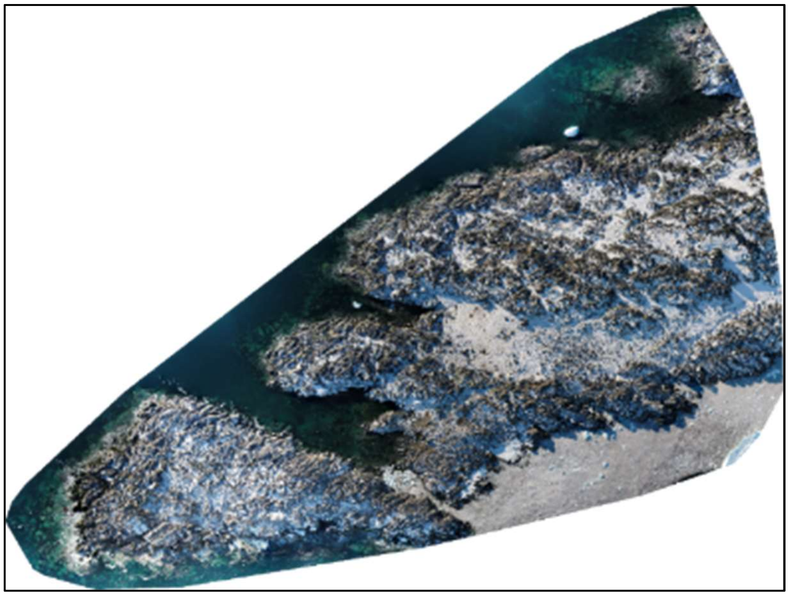

Figure 24- An orthomosaic photo of Bonaparte Point. Collected using UAS photogrammetry under permits: NMFS 23095, ACA 2020-016, and IACUC Frie2305dn. *Image credit Ross Nichols.*

C-045-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

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

Sampling for the C-045-P (Van Mooy) group wound down in March, with only six trips to Station E, four via Zodiac after the second engine on Hadar went down in the beginning of the month. The standard parameters for water collection were obtained, including lipids, carbohydrates, particulate organic carbon (POC), flow cytometry, nutrients, and $\delta^{18}O$. Samples for flow cytometry were fixed and will be shipped home to run after repairs can be made to the Accuri C6 flow cytometer. In addition to sampling at Station E via Zodiac, grantees in the water collection groups (C-045-P (Van Mooy) grantee Shavonna Bent and B-285-P (Bowman) grantee Beth Connors) worked with the Boat House to test the Marine Landing Craft, with the aim of developing protocols for future seasons when a RHIB may not be available. This testing would not have been possible without the diligent efforts of the Boat House to get the MLC online and provide training on safe operations. The results of the MLC testing included a successful deployment and recovery of the full CTD rosette at Station E. Importantly, the day which testing was conducted, we experienced exceptionally calm seas; this sampling effort would be made challenging by typical Station E sea-states. A protocol for deployment from RHIB Hadar, the MLC, and Zodiac sampling is drafted and will be circulated within the water collection groups as well as to ASC.

Sampling efforts for the C-019-P (Schofield) group continued in conjunction with water collection by C-045-P (Van Mooy) and B-285-P (Bowman). Samples were filtered or fixed for high performance liquid chromatography (HPLC) analysis of pigments, chlorophyll α, and the imaging flow cytobot (IFCB).

Finally, at the end of March and into the first few days of April, grantee Shavonna Bent is conducting a fourth and final diel experiment from the pumphouse, collecting water every six hours for lipid, carbohydrate, POC, flow cytometry, and IFCB analysis. This final timepoint at the end of the season when there is more darkness than light will give important context for the previous experiments when days were longer than nights.

The C-045-P (Van Mooy) group thanks all of the ASC staff that assisted with our science this season – we would not have been able to successfully carry out the continuation of the time-series to the degree that was achieved without the combined efforts of all the personnel here on station!

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT
March 2024
Marissa Goerke

Figure 25- UNAVCO GPS with the moon, March 28, 2024. *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.

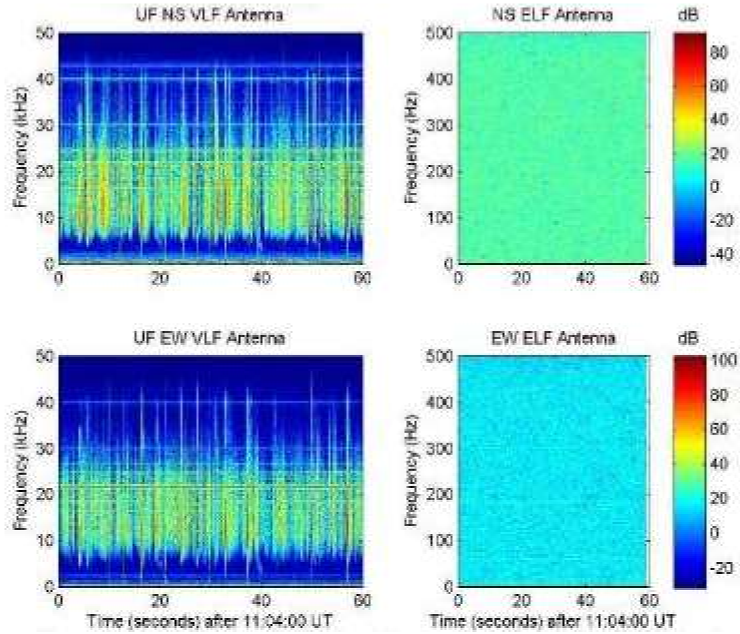

Figure 26. Real-Time broadband VLF and ELF Spectrogram from Palmer Station, Antarctica.

The GPS receiver did not weather the October power outage and remains unlocked. A replacement GPS receiver is being prepared for shipment. Both systems continue to run without the GPS lock through April. 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. A new Raspberry Pi system was installed in 2023. The system operated normally this month. More information can be found at: http://magnetometers.bc.edu/index.php/palmer.

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-P) 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.

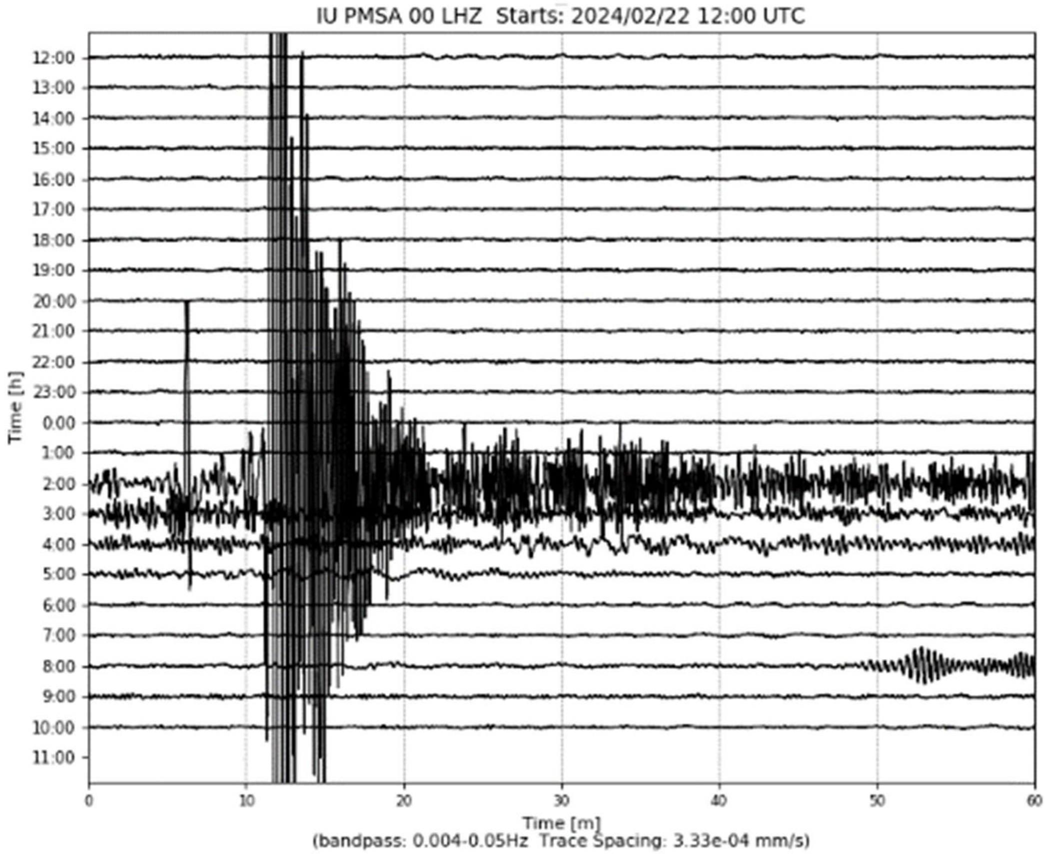

Figure 27- The February 22, 2024 6.3 earthquake near the southern East Pacific Rise, as recorded from the Palmer seismic station.

The system suffered network related outages throughout March. The underlying network problem has not yet been resolved. The time stamp and seismic activity found on the Heliplot was checked daily. 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.

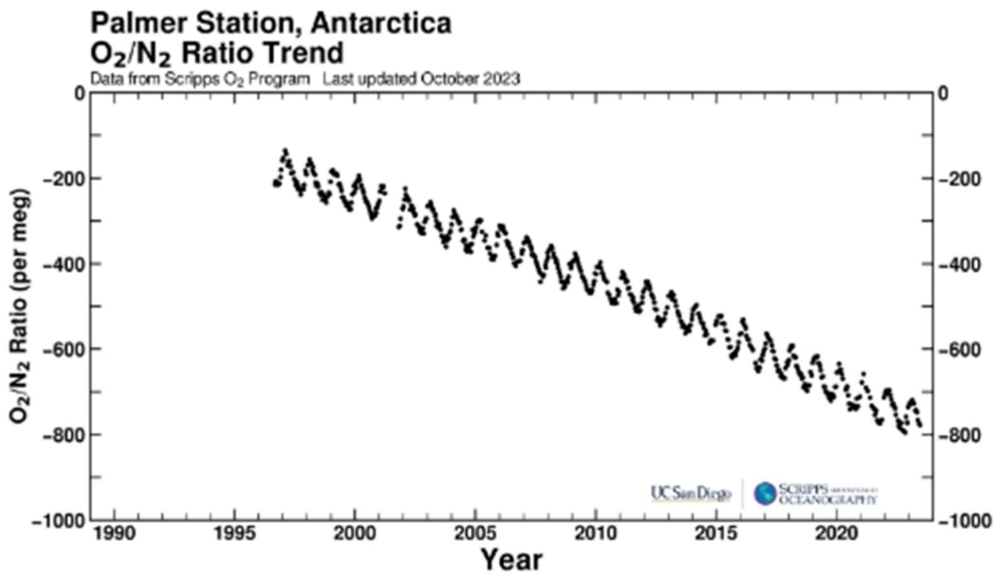

Figure 28- Historical plot of O_2/N_2 ratio per meg and CO_2 ppm updated October 2023.

Air samples were collected on March 4 and March 22. 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 are shipped to the 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 Laboratory; 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 March 4, March 11, March 21, and March 28 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: https://gml.noaa.gov/ccgg/.

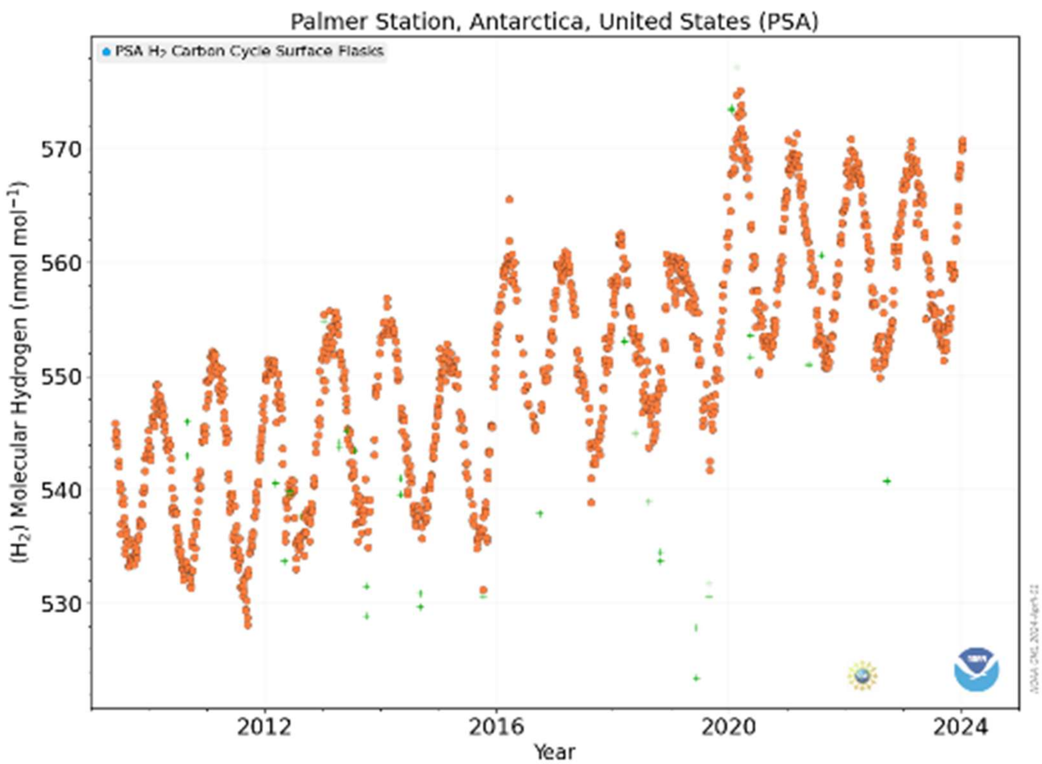

Figure 29-Molecular Hydrogen (H_2) levels at Palmer Station dating back to 2009. Orange dots are preliminary data.

HATS samples were collected on March 11 and March 29 during favorable wind conditions. More information and data for the Halocarbons and other Atmospheric Trace Species group can be found at: https://gml.noaa.gov/hats/

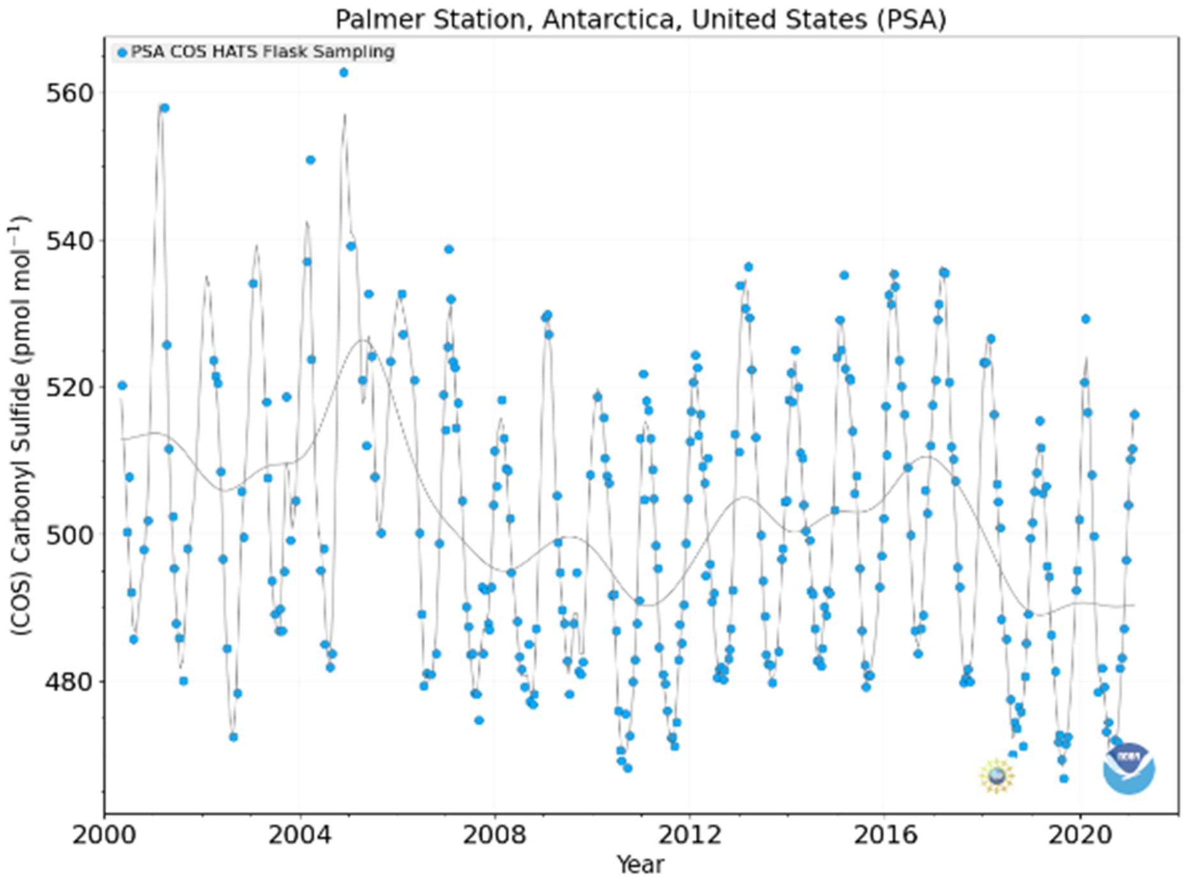

Figure 30- Carbonyl Sulfide (COS) levels at Palmer Station dating back to 2000, one of the Halocarbon and Trace Gases measured at Palmer Station. Orange dots are preliminary data.

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 Laboratory; 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.

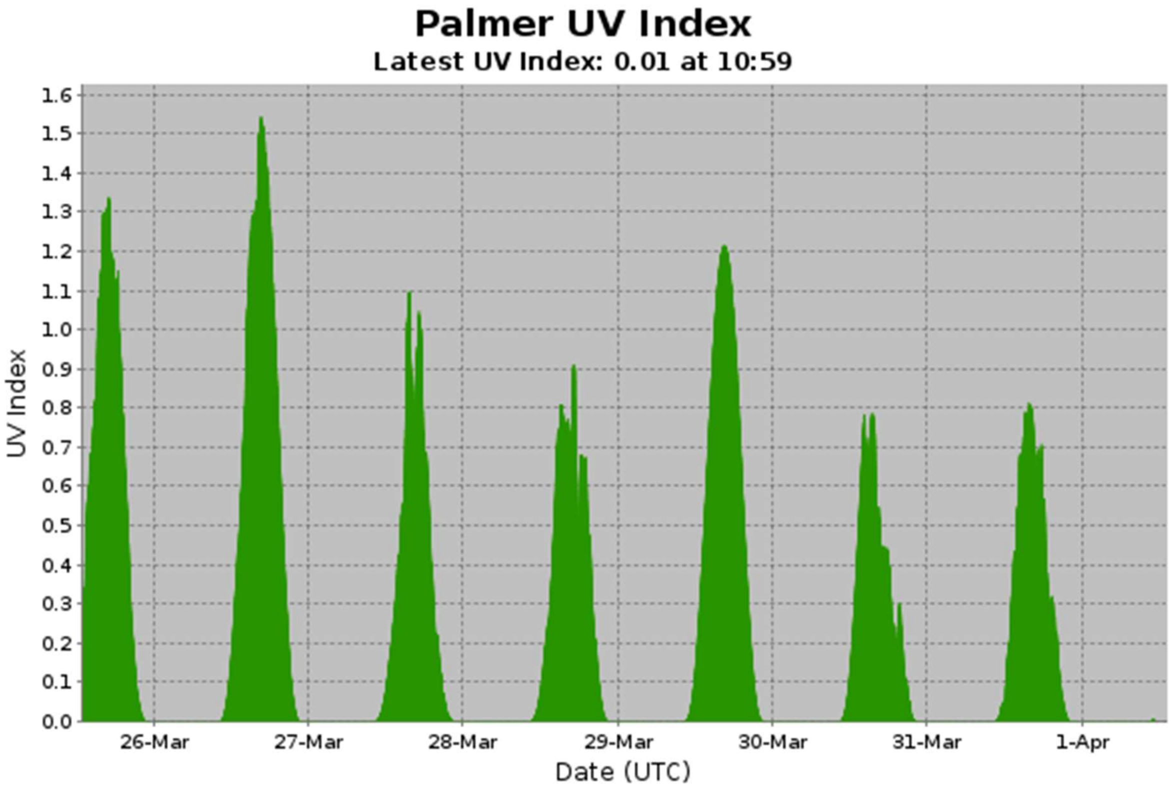

Figure 31- UV index generated from the GUV-511 radiometer in real time.

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 an SUV-100 Absolute Scan was performed on March 11 and the quarterly triple lamp SUV-100 Absolute Scan was performed on March 26 without issues. 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.

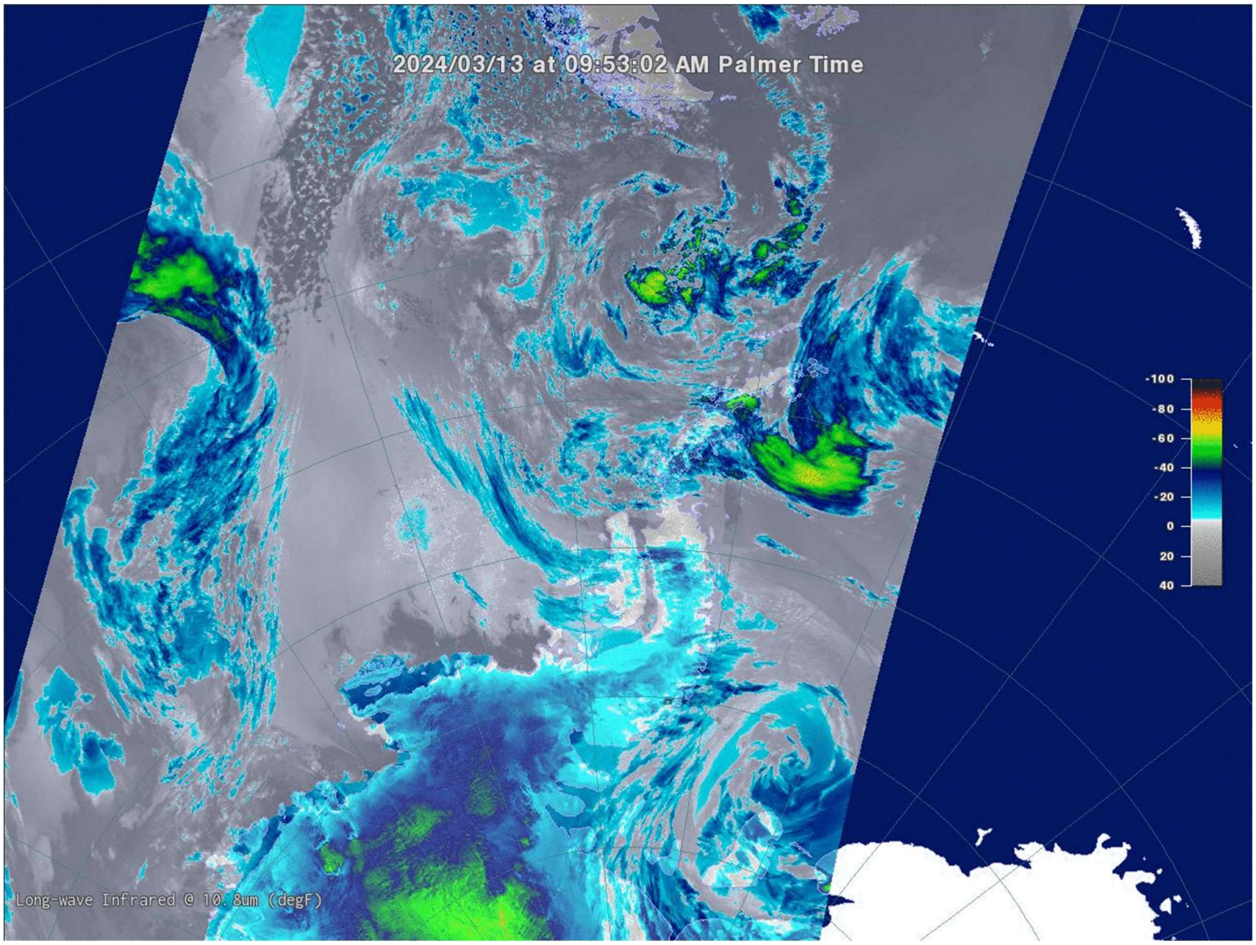

Figure 32- NOAA-19 March 13, 2024 satellite pass

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

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's splitter failed in December 2023 and the system is operating on only one GPS receiver instead of the normal two. The glacier backyard terminus, profile and Point 8 terminus was survey data was processed.

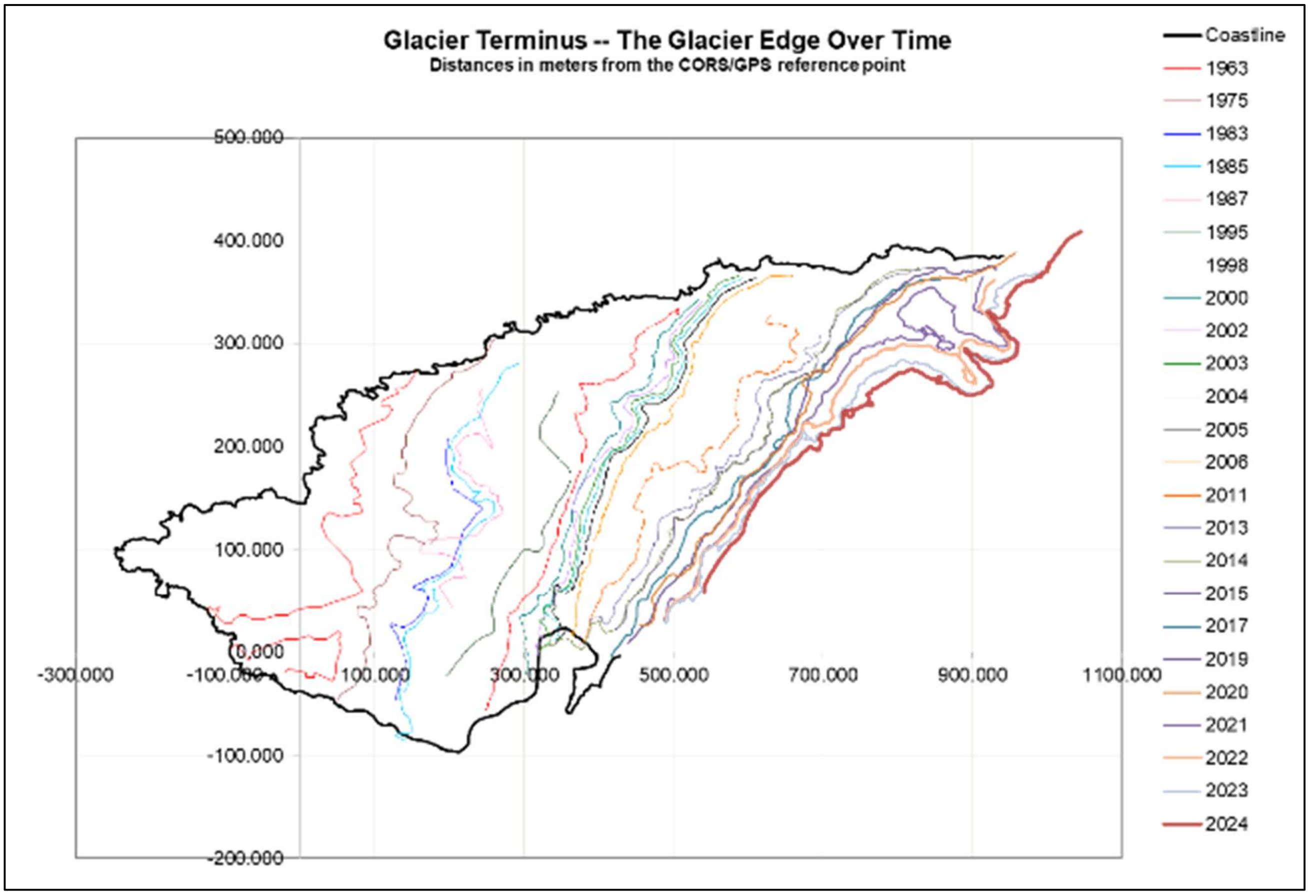

Figure 33: Palmer Backyard glacial retreat data from the last 61 years. *Image credit: Palmer Station Research Associates.*

For more information, visit: 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 anomalies were heard coming from the blower. The flow meter was swapped out due to erratic flow rates. 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 website, 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 depth 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. The system operated normally this month.

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 to the University of Wisconsin on the first day of each month for archiving and further distribution. The system operated normally this month.

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

Palmer Monthly Met summary for March, 2024

Temperature
Average: 0.5 °C / 32.8 °F
Maximum: 7.8 °C / 46.04 °F on 5 Mar 03:45
Minimum: -3.8 °C / 25.16 °F on 29 Mar 00:36
Air Pressure
Average: 985 mb
Maximum: 1015.6 mb on 4 Mar 04:01
Minimum: 964.1 mb on 29 Mar 12:08
Wind
Average: 7 knots / 8.1 mph
Peak (5 Sec Gust): 59 knots / 67 mph on 5 Mar 04:54 from N (10 deg)
Prevailing Direction for Month: NNE
Surface
Total Rainfall: 54.9 mm / 2.16 in
Total Snowfall: 17 cm / 6.6 in
Greatest Depth at Snow Stake: 13.8 cm / 5.4 in
WMO Sea Ice Observation: More than 20 bergs, bergy bits, growlers, brash ice, shuga, grease
Average Sea Surface Temperature: 0.67 °C / 33.2 °F