PALMER STATION MONTHLY SCIENCE REPORT

MARCH 2020

Mass Antarctic krill beaching event on Gamage Point. *Image Credit: Randy Jones*

NEWS FROM THE LAB

Randy Jones, Summer Laboratory Supervisor

On 5 March, we noted the presence of Antarctic krill beached by the tide upon the upper reaches of the intertidal zone along Gamage Point near Palmer Station. Many grantees and ASC staff came out to inspect, and it was determined that this mass beaching event extended along several hundred meters of the Gamage Point coastline and likely involved tens to hundreds of thousands of krill. Not much is known about these beaching events, but colloquial knowledge among the Palmer community noted that these beaching events occur occasionally, typically during the latter part of the season in February, March, or April.

In the second half of the month, the entire grantee community departed Palmer Station and successfully traveled back to their homes, as the coronavirus pandemic affected research and operations and created uncertainty. The ARSV *Laurence M. Gould* arrived to Palmer on 15 March and departed 17 March with B-005-NP (Kohut) and C-045-P (Ducklow), and members of other science groups. Within several days after the port call, the NSF decision to remove remaining grantees from Palmer Station via the RVIB *Nathaniel B. Palmer* resulted in the early departure of B-027-P (McClintock), C-013-P (Fraser), C-019-P (Schofield), and C-024-P (Friedlaender). Many grantees and ASC staff worked tirelessly to assist the grantees with their abbreviated close-out windows – many thanks!

My appreciation and kudos go out to the support staff for their efforts to enable and support high-quality science. I would like to extend special thanks to Research Associate Marissa

Goerke, Instrument Technician Carolyn Lipke, and Peninsula S&TPS Implementation Manager Jamee Johnson for their efforts.

MARCH 2020 WEATHER
Marissa Goerke, Research Associate

Temperature
Average: 0.9 °C / 33.6 °F
Maximum: 7.2 °C / 45.0 °F on 5 Mar 07:16
Minimum: -8.1 °C / 17.4 °F on 27 Mar 17:52
Air Pressure
Average: 982.3 mb
Maximum: 1008.4 mb on 11 Mar 21:27
Minimum: 959.2 mb on 26 Mar 01:24
Wind
Average: 11.6 knots / 13.3 mph
Peak (5 Sec Gust): 57.0 knots / 65.0 mph on 25 Mar 17:14 from NE (45 deg)
Prevailing Direction for Month: NNE
Surface
Total Rainfall: 70.4 mm / 2.77 in
Total Snowfall: 8.0 cm / 3.1 in
Greatest Depth at Snow Stake: 5.4 cm / 2.1 in
WMO Sea Ice Observation: 6-10 Bergs, bergy bits, growlers, brash
Average Sea Surface Temperature: 1.21 °C / 34.2 °F

The high temperature in March was 45.0° F and averaged 33.6° F. Winds were calm and variable for most of the beginning on the month. The end of the month brought more stormy weather and colder temperatures. Snow accumulated on several occasions but was followed by rain which diminished snow levels quickly.

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

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

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

Our March 2020 activities focused on ensuring we completed our field season tasking, preparing cargo for shipment north, and working with Logistics to get ourselves back home. We balanced weather windows, sampling requirements, and equipment recoveries to ensure we met all logistics deadlines for cargo and personnel movement. March was the third month in which we had the full polar ocean observatory up and running. As summarized in previous reports, this network includes autonomous underwater gliders (AUV), moorings, High Frequency Radar (HFR) stations, RHIB surveys and a profiling LISST holographic imaging sensor. With this ocean observatory, we were able to track the distribution of phytoplankton, zooplankton, and predators relative to the physical oceanographic features captured by the integrated network of platforms. With each platform resolving scales necessary to test our hypotheses.

On 7 March, we recovered our second mooring. Once again through an awesome collaborative effort between our local scientists, ASC, and NSF, we were able to easily and smoothly recover the second mooring with RHIB *Rigil* deployed out of Palmer Station. We have stated in each

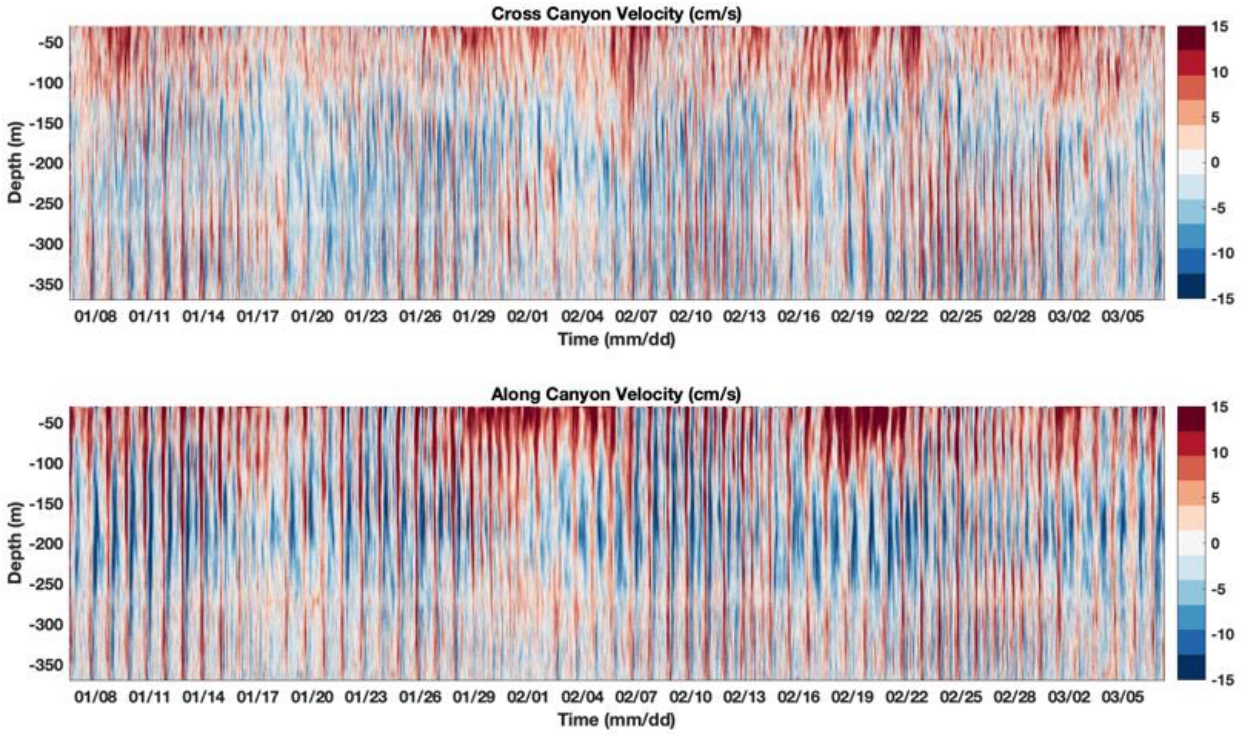


Fig. 1 – Acoustic Doppler Current Profiler full water column velocities (cm s^{-1}) for the cross-canyon direction (top panel) and along-canyon direction (bottom panel) for 5 January through 7 March 2020 from the retrieved second mooring.

report this season how critical the RHIB capabilities have been to the success of our project, highlighted by the mooring recovery. Once recovered we were very excited to see the well resolved dataset collected over the two month deployment, including full water column velocities (Fig. 1), full water column multi-frequency zooplankton acoustics (Fig. 2), as well as bottom time series of temperature, salinity, pressure, and oxygen. The mooring equipment was provided by the NOAA/AMLR team who have deployed six identical moorings further north on the Peninsula. We look forward to working with them to integrate these two moored data streams.

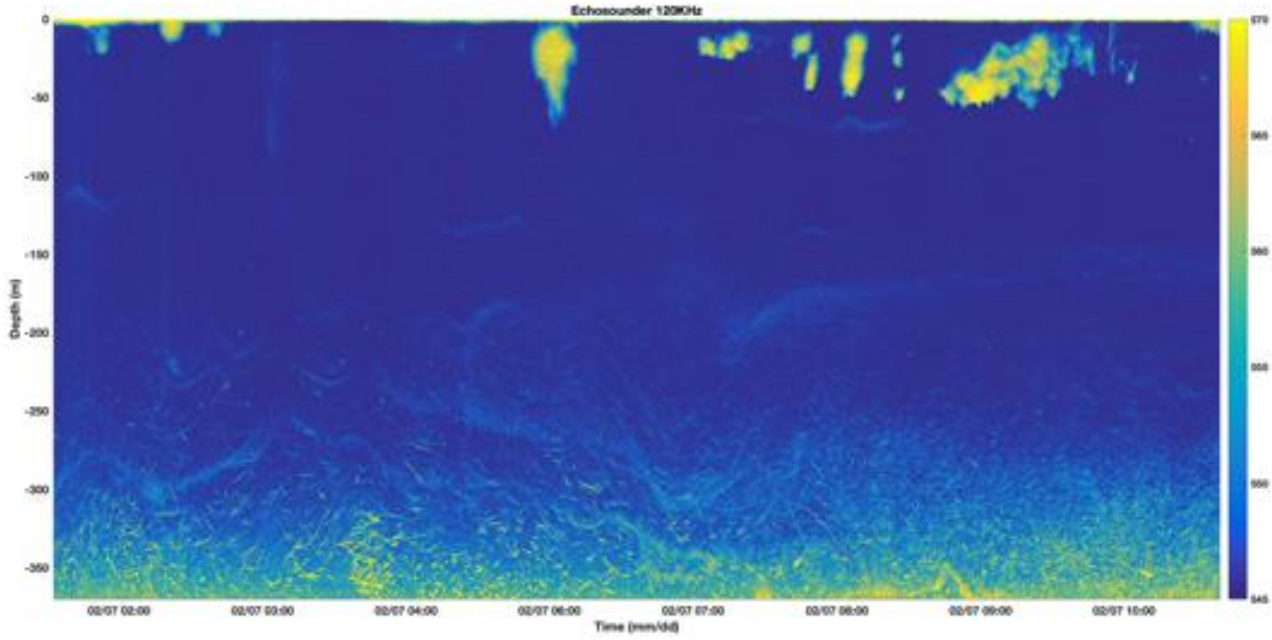


Fig. 2 – Multi-frequency echosounder full water column zooplankton acoustic returns (at 120 kHz) over an approximately 8-hour section from the second mooring.

HF Radar: The three site HF radar network has operated continuously throughout the month. Data was delivered in real time through the Palmer Station network to our central processing machine in Terra Lab. As March marks the end of our intensive field season, we visited each site to recover the large raw level dataset (which is not possible to transmit in real-time), and inspect the equipment to ensure it is ready for the winter weather to come. On 3 March, we visited the Joubin Island site to recover all raw level data and inspected and readied the site for the winter. On 9 March, we visited the Wauwermans Islands site to do the same, and we noticed immediately that there was significant melting that had occurred between January and March. That melting impacted the stability of the Wauwermans HF radar antenna installation, leaving it very unstable (Fig. 3, left panel). Fortunately, the melt also exposed a nearby rock (not previously visible since we first visited the site in November and again in January). In order to secure this site for winter, we moved the antenna from its original location to the new location on the rock. Through great support from ASC (equipment and personnel), we were able to mount the antenna to the rock over the next two days (Fig. 3, right panel). Given all the melt and the dramatic change in surface conditions on this island, we were very relieved to have the antenna secured to a much more stable base. These data have been critical to understand some of the variability we have seen in the glider and ACROBAT data.

Fig. 3 – The Kohut team (along with ASC assistance) prepares to move the Wauwermans Island HFR antenna to newly exposed bare rock (left panel), and the mounted antenna two days later (right panel). *Image Credit: Kohut group*

Glider AUVs: On 11 March, we recovered the last two gliders in our network. These coordinated glider missions have collectively provided an unprecedented sampling over Palmer Deep the last two months with continuous water column measures of hydrography, optics, and acoustics. These data allowed us to simultaneous map spatial and temporal changes in the physical structure of the oceanography and the distribution on the phytoplankton and zooplankton communities. As of the draft of this report, the three gliders have been deployed for a total of 154 glider days, sampling over 2,400 km throughout the Palmer Canyon and Deep regions.

RHiB surveys: Coordinating with the LTER grantees and Palmer Station MTs, we conducted 18 surveys with the towed ACROBAT and EK-80 echosounder totaling over 1,200 km of sampling! This is a result of a great team effort. 15 of the 18 surveys have been over the complete grids covering much of our Palmer Canyon and Bismarck Strait study site. The others are modified surveys covering portions of these grids and one new survey line that included two cross shore transects east and west of the Palmer boating area. The combination of the acoustics and towed system allow us to simultaneously map the hydrography, phytoplankton, and zooplankton structure along these transects. Over these 18 surveys, we have captured remarkable variability in both time and space. We also conducted zooplankton net surveys to document the density of krill aggregations targeted by the net and to get a better understanding of how effectively different species avoid the net. They will provide critical synoptic detail when integrated with the glider surveys, mooring time series, and the HF radar surface current maps.

Penguin Telemetry: In collaboration with the LTER project, a total of 66 penguins were tagged in the Palmer Canyon and Deep regions this season. These tagged animals include GPS positioned tags (52 Adélie and gentoo penguins) and presence/absence radio tags (14 Adélie penguins). As of the draft of this report, there will be no additional penguin tagging as most of the chicks have fledged. An initial review of the penguin foraging tracks indicates great overlap with the CODAR coverage area and other platform sampling within our coastal observatory.

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

At the conclusion of our intensive field program, we would like to thank all station staff for their support of our project. We recognize the significant logistical support required for our project, including Boathouse, Cargo, and Information Technology & Communications. We would also like to thank the LTER science team for their partnership and collaboration. Our work pushed hard to take full advantage of the amazing opportunity to conduct the observatory based sampling our project required from a place so remote as Palmer Canyon and Deep. It utilizes the significant resources available to us from station including the small boats and especially the RHIBs. This success would not have been possible without the dedication of all involved in the planning and implementation. We used effective communication to respond to conditions and situations presented to us. Without the awesome team on station, we would not have been able to pull it off. We are very happy to work in this collaborative environment and are seeing the direct benefits in what we have collectively accomplished. Through all the planning, the communication has been so critical to this success. Thank you Palmer Station for an amazing season!

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

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

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

Personnel movements: Jim McClintock sailed north with LMG20-02 on 16 March. The others (unexpectedly) sailed north with NBP20-02 on 24 March.

March came in like a routine lamb and went out like a frantic lion. Up until mid-morning on 19 March, when we learned that we might be redeploying on NBP20-02, we continued with the daily water chemistry monitoring of our ocean acidification experiment that was described in our February situation report. (The experimental setup is described in the January report.) We immediately started making preliminary preparations to leave and by early afternoon our early redeployment was confirmed.

Over the next four-and-a-half days we prepared for and took down the experiment, cleaned and dried all the components, packed the lab (including our titrator which is being shipped north for annual service), packed the dive locker, inventoried and packed samples for shipment and everything else for storage over winter at Palmer or the PA warehouse, and cleaned the aquarium, dive locker, and lab. Thanks to help from many of the ASC staff, particularly the

Laboratory and Logistics staffs, we were (physically) ready to leave when the NBP arrived on the morning of 24 March.

Once on the NBP we were given laboratory space. Palmer allowed us to borrow a dissecting microscope and in combination with one from the NBP we were able to start analysis of the samples from our experiment. Hannah Oswalt was to have remained on station through the originally planned LMG20-04 cruise to complete this because the data (counts of which amphipods and other crustaceans remained in the experiment across the different treatments) are needed to be able to plan our next field season. Fortunately, the slow and most tedious part of the analysis is enumerating individuals from the smaller crustacean groups, while pulling out, identifying, and counting the larger amphipods is easier and less time consuming. It is the amphipod counts that are needed for next season, and during the relatively calm parts of the crossing and while at the dock in Punta Arenas we have been able to complete the amphipod counts. The remaining crustacean groups will be enumerated whenever the preserved samples arrive back at University of Alabama at Birmingham (UAB) through the cargo system.

In support of our activities, we made eight scientific scuba dives in March. All dives were within the standard Palmer boating limits.

We are grateful for the generous and professional assistance of numerous ASC staff in meeting our goals. Laboratory Supervisor Randy Jones and Instrument Technician Carolyn Lipke have provided outstanding support in the Aquarium and Lab. Randy's assistance in cleaning components of our experiment during our last days at Palmer was essential in allowing us to get them drying in time to be able to be packed. NBP Marine Lab Technician Linnah Neidel provided invaluable support for our sample analyses on the ship. Expeditious efforts of Cargoperson Senior Lindsey Clark and Cargoperson Colleen Lawler enabled us to get our cargo and samples ready during our final, frantic days on station. The Palmer Marine Technicians, Mike Burns, Otto Neumuth, and Ken Block facilitated our diving activities.

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

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

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

Adélie penguin work concluded this month with the fledgling of all chicks ending our presence/absence radio transmitter study on Humble Island. Gentoo penguin breeding was slightly behind Adélie penguins this year with work during March focused on obtaining adult diet samples and chick fledging weights on Biscoe Point and in the Joubin Islands.

A gentoo penguin fledgling in the Joubin Islands. *Image Credit: Fraser group*

Brown skua work also 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 also continued into, and concluded in March.

Giant petrel chick banding on all local islands was completed in March. Thanks to volunteers from station, our intensive giant petrel chick growth study on Humble Island will continue through April. We deployed our last GPS loggers on giant petrels this month concluding all bird tagging for the season. In addition to GPS loggers, we deployed 13 GLS (Global Location Sensor) loggers that will track giant petrel location data throughout the winter. These tags use light sensors to determine day length, and using an internal clock, determine position.

Marine mammal monitoring continued with observations of large numbers of fur seals, rapidly declining elephant seal numbers, sporadic leopard seal and crab-eater seal sightings, and a return of a few Weddell seals to the area. Whale observations in the Palmer area decreased during March with sporadic sightings of humpback and minke whales.

Sediment trap contents were collected from Adélie colonies on Torgersen Island, gentoo colonies on Biscoe Point 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.

Giant petrel banding on Cormorant Island. *Image Credit: Fraser group*

GLS tags prior to deployment on Giant Petrels. *Image Credit: Fraser group*

As March progressed it became apparent that things would change for the end of the season. Megan Roberts and Leigh West departed on the ARSV *Laurence M. Gould.* Donna Patterson-Fraser, and Darren Roberts departed on the NBP. In spite of the early departure, our team was able to have a very successful and productive season.

We would like to thank the entire crew at Palmer this year for making it a very successful and enjoyable season. Our most sincere thanks goes to ASC Travel for moving mountains to get our crew home in this challenging time. Additionally, Bob Farrell has been a unifying, and calming leader through all of this. We wish all the best for all of our Palmer family.

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

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

Personnel on station: Quintin Diou-Cass, Katie Hudson, and Rachael Young

For the month of March, we waved farewell to Katie Hudson and the rest of the SWARM team, leaving behind just under half of the science population to continue work until the end of the season. Quintin Diou-Cass wrapped up his final incubation experiment, and the team switched to a Tuesday/Wednesday schedule for the Adélie and Gentoo transect surveys. Unfortunately, due to the spreading travel closures from the COVID-19 pandemic, the decision was made to extract all non-essential personnel (primarily science staff) from Palmer Station in an attempt to secure commercial travel back to the United States. As a result, all C-019-P (Schofield) lab and field operations ceased on Friday, 20 March. All samples, lab supplies, field supplies, and other C-019-P-related items were returned or inventoried/packed within four days, at which point the NBP arrived at station to transport samples and scientists to Punta Arenas, Chile for departure back to the US.

March resulted in another productive month for bi-weekly sampling despite the early end of the season. Chlorophyll concentrations remained low during the month, averaging around 1.5-2.0 mg m^{-3} for both stations and maxing out just under 5.0 mg m^{-3} for both stations in the surface waters (Figs. 4 and 5). Photosynthetic efficiency (as approximated by Fv/Fm values) of phytoplankton at both stations remained closely coupled to each other in averaged values, following a marked increase/decrease pattern that dropped in peak value over the month, both in depth-specific and averaged values (Figs. 4 and 5).

Collaborative surveys proved to be a success for March, as well. With the aid of project SWARM's ACROBAT collecting real-time data simultaneously with the acoustic surveys, both the Adélie and Gentoo transects were surveyed in one day up until 10 March. Beginning on 13 March, surveys were performed by deploying a CTD at five different stations along a fixed grid followed by the acoustic survey. During the acoustic surveys, predator observations were completed to investigate the potential connections between the presence of phytoplankton (estimated by the CTD fluorescence), zooplankton (estimated by the EK80 acoustic sensor), and higher trophic level species calculated through observation. Figure 6 shows the presence of various sea-birds, penguins, seals, and whales throughout the season which will be analyzed with the EK80 data.

Although we had a unique and unexpected end, our incredibly accomplished season with a combined total of 119 sampling events between C-019-P, C-045-P (Ducklow), C-020-P (Steinberg), and B-005-NP (Kohut, SWARM) marked another amazing year added to the LTER project. A final thank you goes out to ASC staff who continue to support station. In addition, our Marine Technicians, Ken Block, Mike Burns, and Otto Neumuth, and our Laboratory staff, Lab Supervisor Randy Jones and Instrument Technician Carolyn Lipke, are massively appreciated for all of their help throughout the season – without them along with the rest of Palmer Station, our science would not be possible!

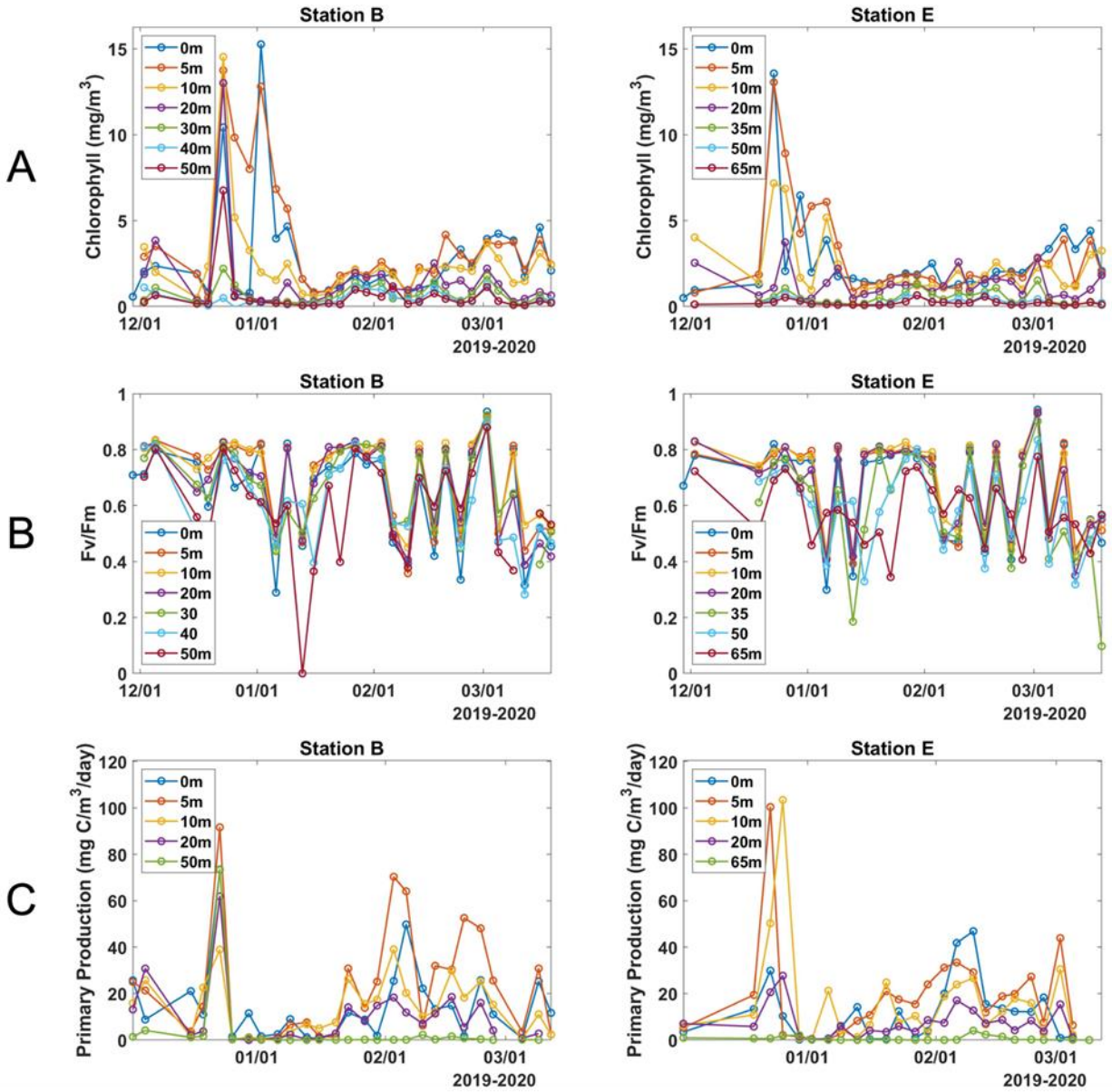


Fig. 4 – Depth-specific values for A) chlorophyll concentration (mg m^{-3}), B) Fv/Fm (decimal percent; approximating photosynthetic efficiency), and C) primary production (mg C m^{-3} day^{-1}) at Stations B and E between December 2019 and March 2020.

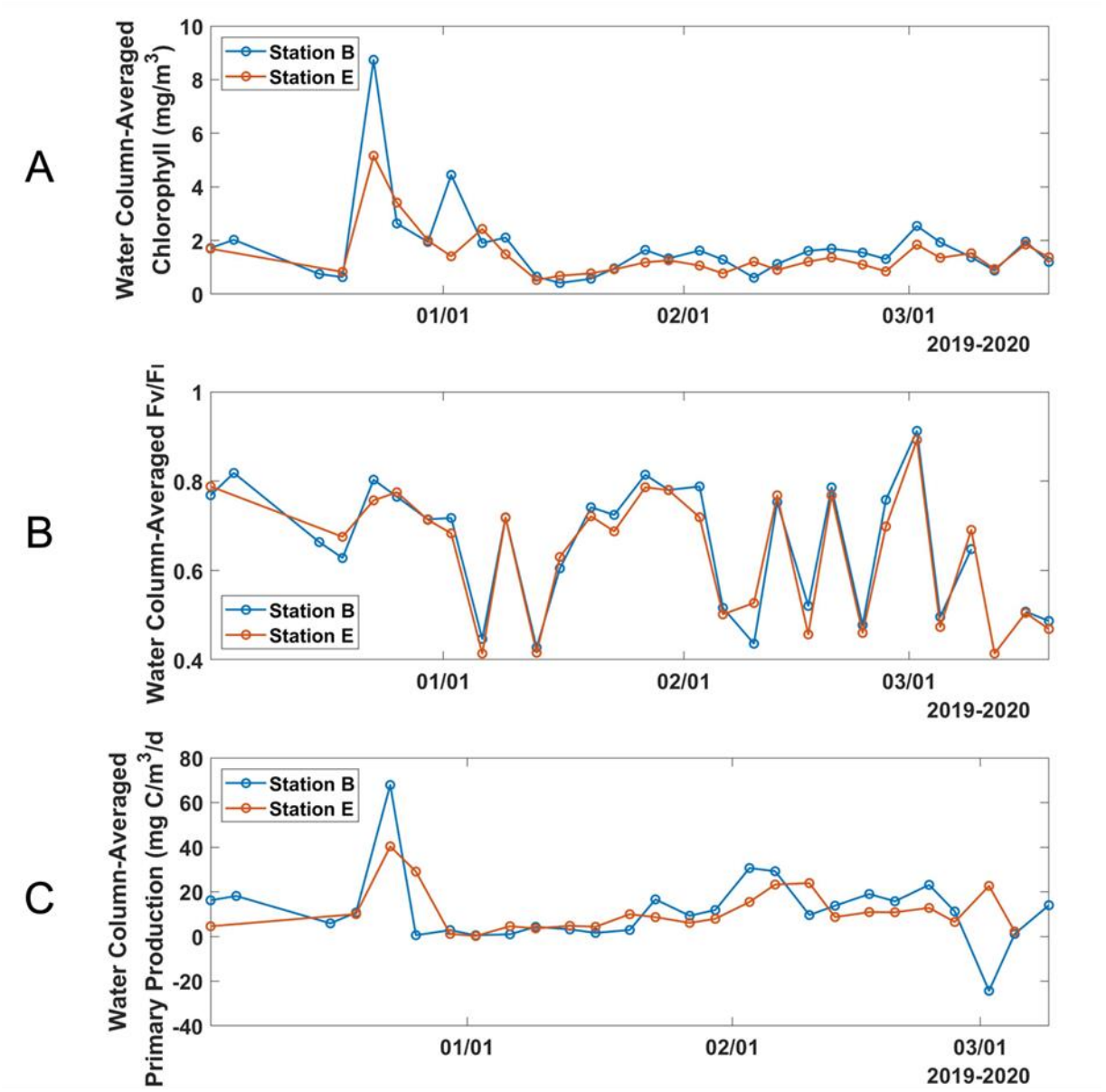
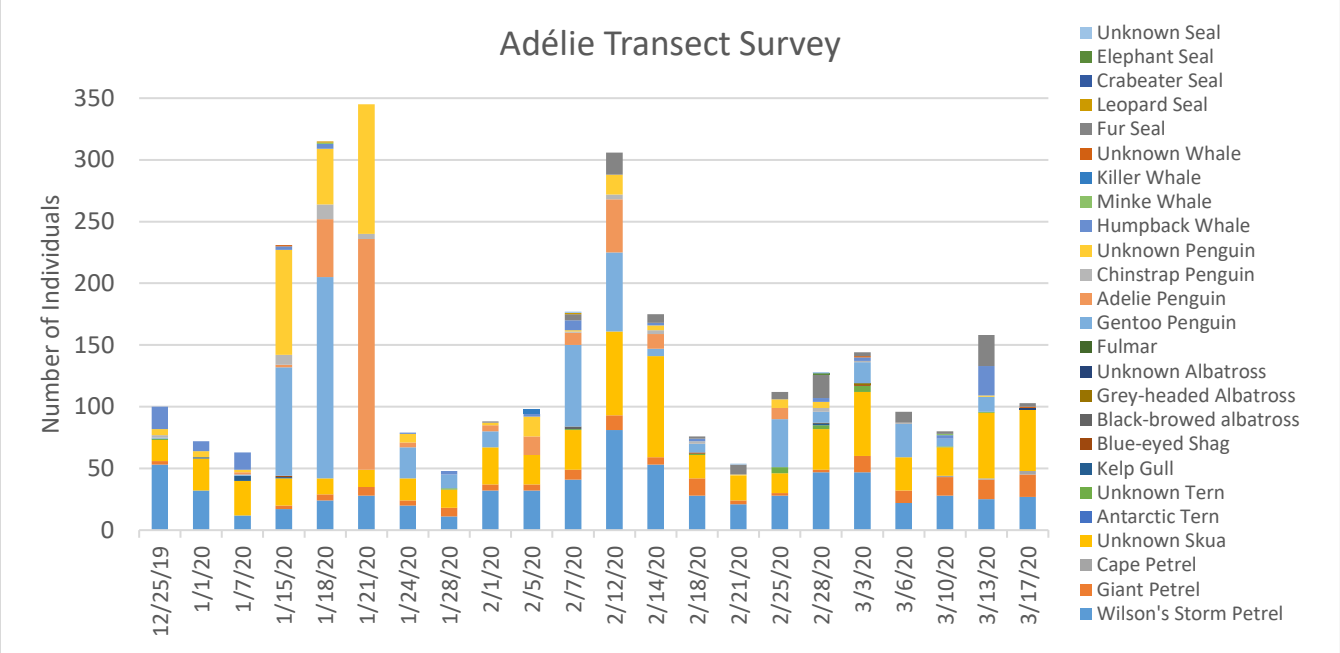


Fig. 5 – Values averaged over the water column for A) chlorophyll concentration (mg m^{-3}), B) Fv/Fm (decimal percent; approximating photosynthetic efficiency), and C) primary production (mg C m^{-3} day^{-1}) at Stations B and E between December 2019 and March 2020.



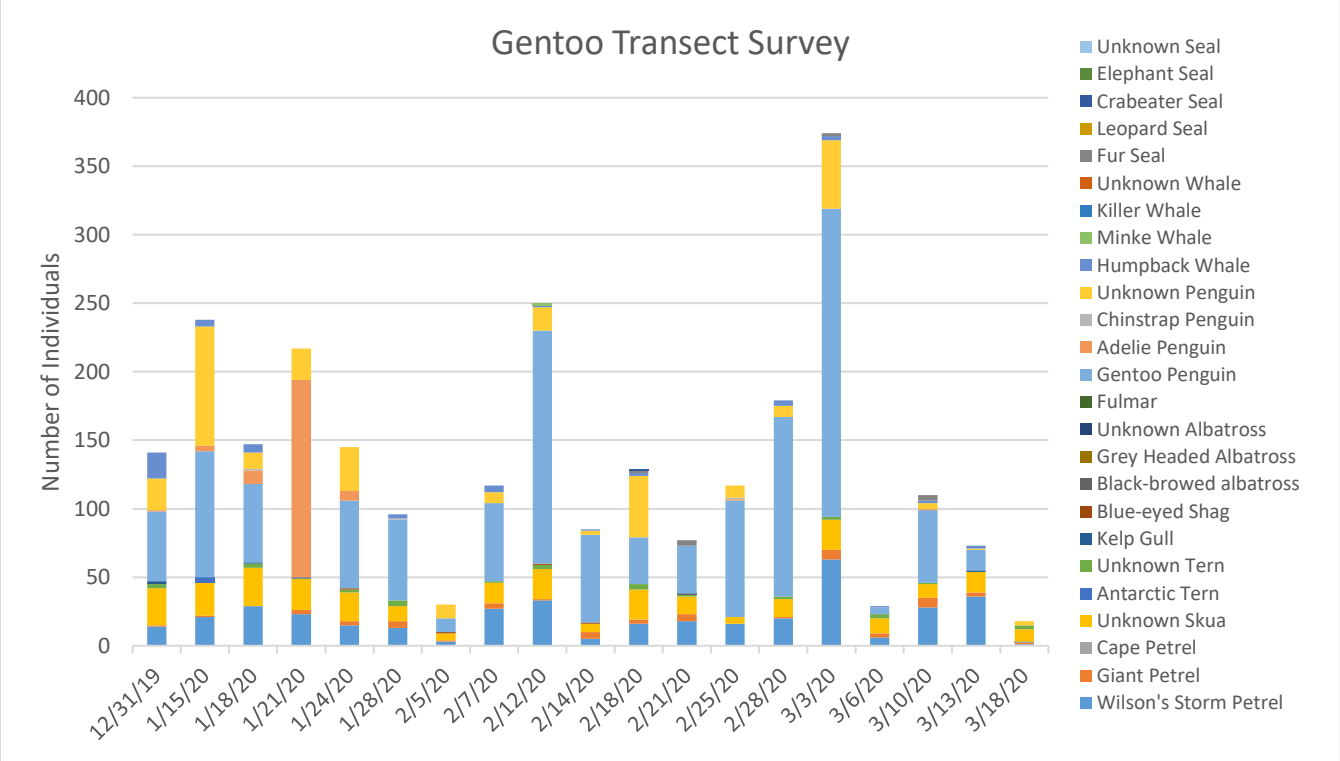


Fig. 6 – Predator observations for the Adélie (top panel) and Gentoo (bottom panel) transects for the season from 25 December 2019 through 18 March 2020. Observations from 25 December 2019 through 7 January 2020 were performed with a 360º visual search field of view, and observations from 15 January through 18 March 2020 were performed with an 180º visual search field of view. Surveys include the entire grid, except for an abbreviated survey on 5 February 2020 for legs 1, 3, and 5 of the Adélie transect, and legs 2 and 3 of the Gentoo transect.

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

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

Personnel on station: Greg Larsen and Ross Nichols

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

We conduct daily visual surveys in the regular boating area around Palmer Station and utilize the "extended" and "beyond-extended" boating areas whenever possible to expand our spatial range of observation. During these trips, photo-ID, biopsies, and drone-derived measurements are collected opportunistically whenever whales are encountered. Whales have shown an inconsistently low but persistent presence near Palmer Station, yielding valuable but intermittent opportunities to collect data.

As of 29 March, we at station have conducted over 192 hours of surveys, during which time we have observed 275 humpback whales and 17 minke whales, collected 196 biopsy samples (171 humpback adults, 20 humpback calves, and 5 minke whales), 152 individual animal flukes for individual ID (in addition to 37 volunteered photo sets collected by on-station personnel before we arrived), and aerial photo-sets of up to 76 humpback whales for later morphometric measurement and analysis (potentially fewer whales if we encountered unidentified repeats or if some flights failed to obtain adequate photo-sets).

The biopsy samples will be used for a suite of analyses regarding the health, demography, and reproductive rates of baleen whales as they recover from commercial whaling (humpback whales) and respond to the ecological and environmental changes taking place along the Antarctic Peninsula (humpback and minke whales). Demographic parameters such as pregnancy rates will be contextualized relative to interannual variability of regional environmental conditions including sea ice and krill availability to better understand how changes affect the ecology and population dynamics of humpback whales. A subset of these samples will be used to test for persistent organo-pollutants and the presence of endocrine disruptors that may indicate exposure to microplastic pollution. These samples will also be evaluated to determine the breeding stock of the population of whales feeding around Palmer Station. This is done by 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, which winters on the west coast of Central and South America.

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

Survey Analysis: In the month of March, we encountered the fewest number of whales of the field season, in part due to the impacts of poor weather on our survey efforts as the month progressed (Fig. 7). Despite this long-term downward trending, 8 March saw the largest abundance of whales sighted all season. On this particular date, our survey was conducted in the "extended" and "beyond-extended" boating areas with C-013-P (Fraser) in a collaborative field effort to access the Joubin Islands. We observed multiple feeding groups performing bubble net feeding and surface vertical- and lateral-lunge feeding near the waters west of Dream Island. This large presence of humpback whales was ephemeral and did not persist more than a day.

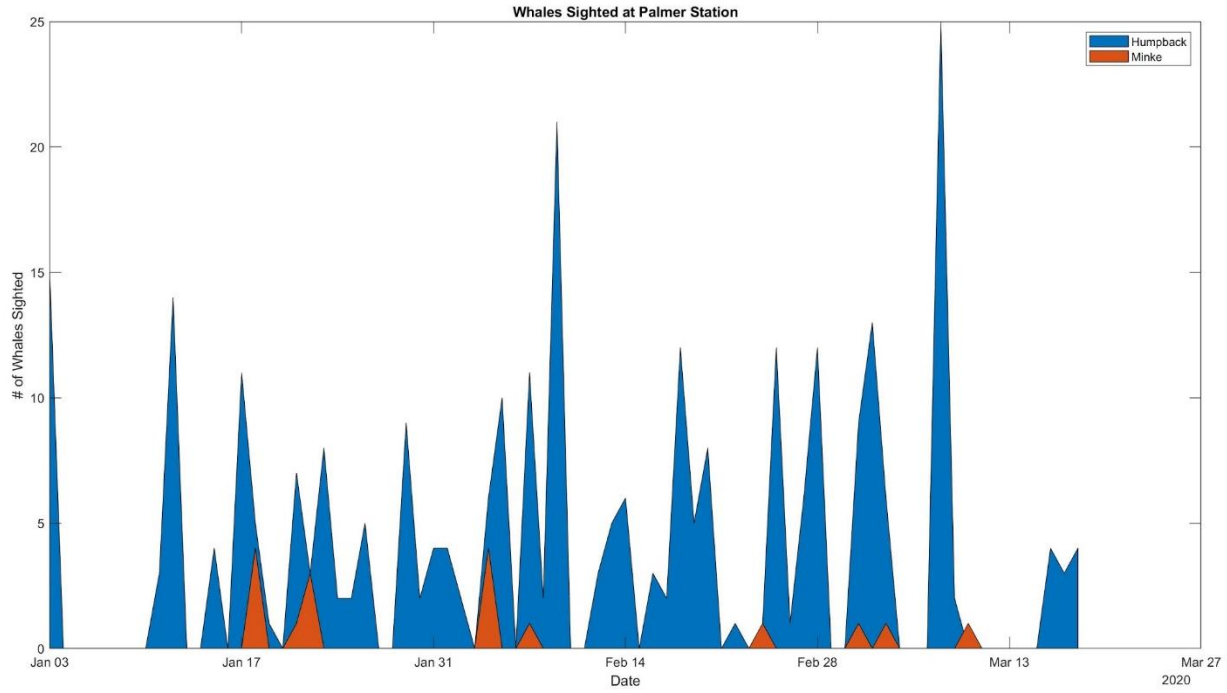


Fig. 7 – Time series of cetacean sightings (number of whales sighted; blue are humpback whales and orange are minke whales) over the course of the season at Palmer Station, between 3 January and 27 March 2020. Each day was summed by the number of individuals sighted, yielding the daily totals of sightings throughout the season (not reflecting effort) by species.

The spatial distribution of our cetacean sightings largely reflects the area covered by our survey efforts (Fig. 8), but also can reveal areas of relatively high and low habitat use within that survey region (Fig. 9). When studied across seasons and between seasons, these data will describe variability in local cetacean occupancy over time, which can be studied in relation to physical and biological processes described by other components of the Palmer LTER and related projects.

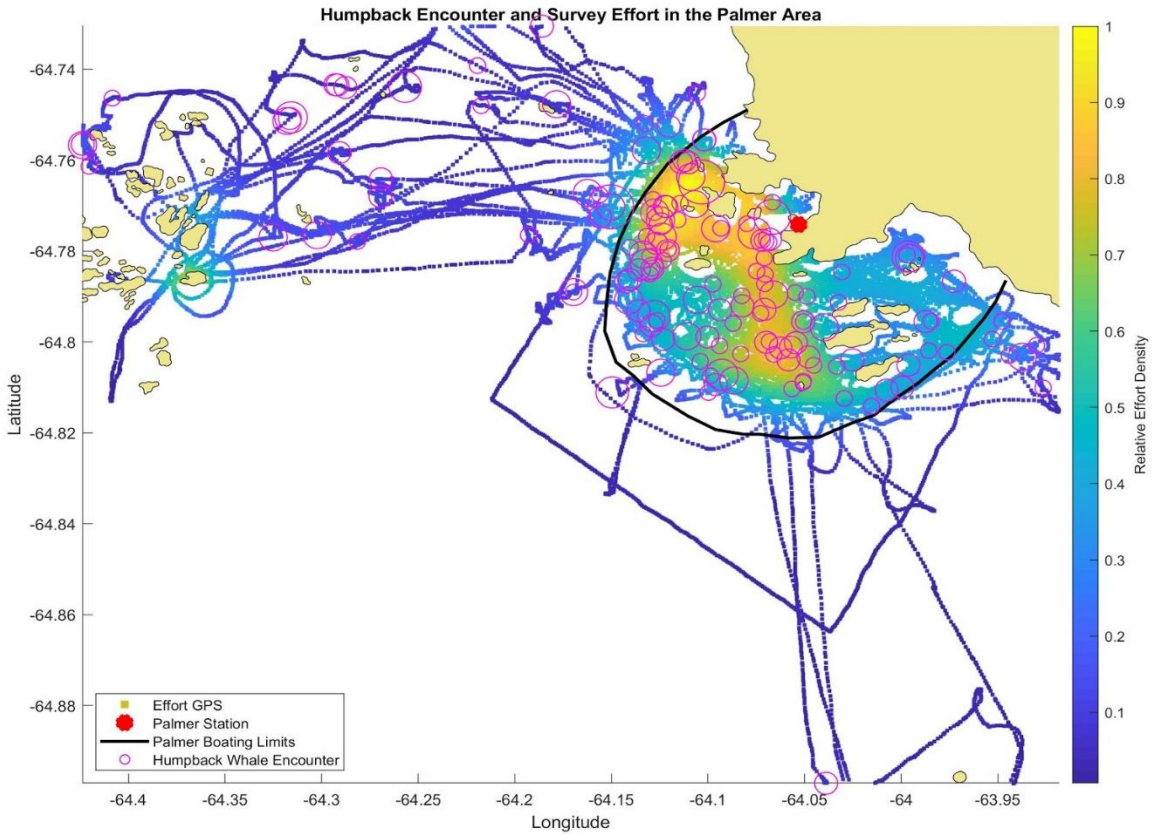


Fig. 8 – Survey relative effort density (multicolored points) and humpback whale encounters (varying sized pink circles) from the 2019-20 field season at Palmer. Green to yellow colors of survey effort indicate a higher density of points and effort from our surveys in that area; blue to aquamarine colors indicate a relatively low effort density. Pink circles indicate individual sighting events of humpback whales. The size of each circle is proportional to the size of the group encountered (ranging from 1 to 6+).

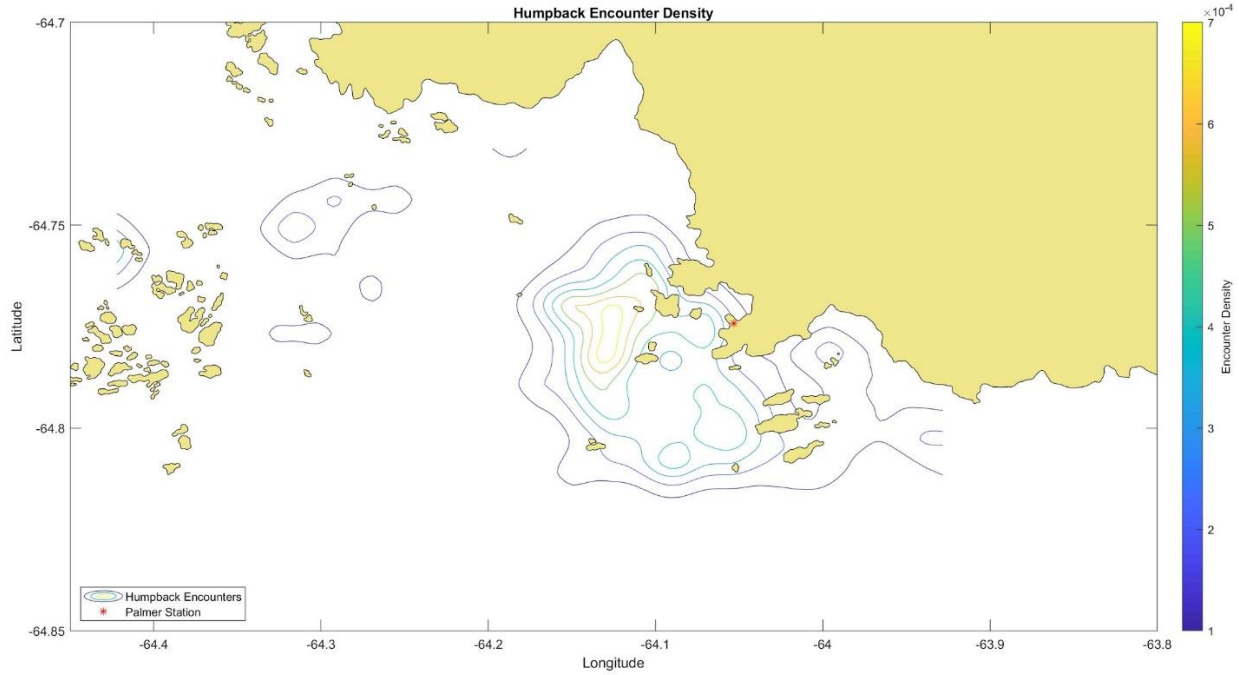


Fig. 9 – Contour plot of density estimates from humpback whales encountered in our survey area over the 2019-20 field season. Such information reveals areas of relatively high (yellow end of colorbar) and low habitat use (blue end of colorbar) by cetaceans within the Palmer survey area, and can be compared between years as well as within the season to explore plasticity in the foraging ecology of our local cetaceans.

Unique Sightings: During our surveys, we occasionally encounter animals with unique markings, coloration, or scarring that helps us identify the animal in the future. Animals with very unique markings are more likely to be identified in the field, while others with more subtle markings are often not recognized until their data are methodically compared within our photo catalogue. This season we sighted two calves with a uniquely visible (but heretofore undescribed) skin condition. Close examination of our photosets revealed that the two animals had similar but not identical patterns of scarring (Figs. 10 and 11). Biopsy samples were collected from both animals, and we hope to investigate this skin condition in more detail. If either calf is sighted in future years, we hope to track the progression of the skin condition to determine whether it bears any lasting consequences for the health and survival of the afflicted animals.

Fig. 10 – Photos of a humpback whale calf Mn20_038G_P, sighted on 7 February with an adult. The skin on this calf showed a high density of scarring, which consisted of circles and arching scars in the middle-dorsal region and continuing laterally around the calf. The posterior-dorsal region of the animal had large nodules and bumps along the dorsal ridge.

Fig. 11 – Photos of a humpback whale calf Mn20_078A_P, sighted on 18 March with an adult. This calf was confirmed to be different from individual Mn20_038G_P based on close examination of scarring along the calf's fluke and dorsal side. Additionally, each calf was sighted with a different adult, which are presumed to be the calves' respective mothers. This calf's dataset includes photographs from the survey vessel and from a drone platform overhead. Scarring patterns similar to those described for Mn20_038G_P are present on Mn20_078A_P: circular and arching scars are visible along the middle dorsal and lateral regions of the animal with large bumps in the posterior regions.

Suction Cup Tag - Video Data: Suction cup tags were deployed on 11 humpback whales this season, representing the greatest number of tags deployed during an LTER field season so far. The raw data collected from each tag will take much time to process, but some immediately available data can be examined from video cameras on the tags, which can reveal behaviors that are of scientific interest to our project, with timestamps that allow these video records to be synchronized to the other sensors onboard the suction cup tags (Figs. 12-14).

Fig. 12 – A tagged adult humpback whale was recorded performing a bubble net feeding behavior. The tag is located on the left side of the whale, facing towards its head. The left pectoral fin can be seen on the top left portion of the photo. The bubbles being blown from its nares are seen on the top right. Using this video footage paired with other sensor data, we plan to construct an algorithm to automatically detect bubble net feeding events based on characteristic movements measured in the tag's sensor records. Analysis of these events and the conditions in which they occur will help us investigate the strategic trade-offs that whales make among the wide variety of foraging behaviors that they exhibit.

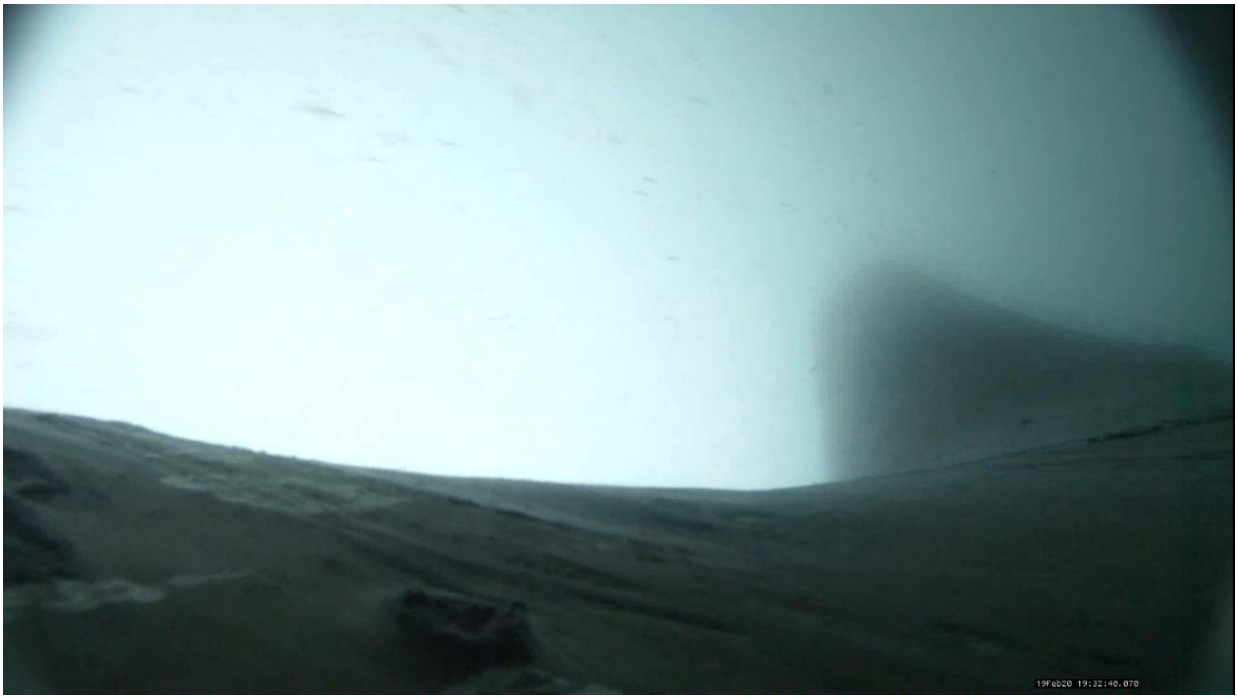


Fig. 13 – A tagged adult humpback whale performing a vertical lunge foraging event. The tag is attached to the right side of the animal's dorsal. The opening mouth can be seen in the top right of the photo. Krill that escaped the maw can be seen in the upper and upper left portion of the photo.

Fig. 14 – Two tagged adult humpback whales are featured in this video frame. The tag that captured the frame is deployed on the dorsal side of its humpback whale, with its camera facing the left side of the animal. A proximally associating humpback whale, with its own suction cup tag attached to its dorsal side, is visible swimming adjacent to the first whale. Data collected with both whales will inform us about social aspects of foraging and the possible roles that whales enact and might maintain during foraging behaviors.

UAS Operations: Unoccupied aircraft systems (UASs or drones) are a critical new tool in cetacean research at Palmer Station (and now in all areas where cetaceans are studied). Aerial photography, when paired with precise altitude measurements, enables analysts to measure dimensions of a whale's body with high precision and accuracy. These measurements contribute to analyses of whale anatomy and physiology, and comparisons across time and space can address broader questions of foraging ecology and prey consumption in different regions and periods of the feeding season (Fig. 15). Though a secondary priority for our field team, occasional aerial photography and video can also capture cetacean behaviors that are difficult to discern and describe from observations at sea-level.

Fig. 15 – Aerial photograph of a mother-calf pair on 16 March 2020. There are very few photosets of mother-calf pairs in Antarctica this late in the season, and data from images such as this will critically inform our understanding of how calves grow and mothers recover body-mass throughout their first feeding season after birth.

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

On 23 March, UAS operations concluded after a successful season at Palmer Station. In total we carried out 234 successful UAS flights near Palmer Station: 14 flights for testing, maintenance and calibration; 60 flights for whale photogrammetry; and 160 flights for pinniped habitat mapping. The whale photogrammetry flights have captured 94 potential morphometric datasets, including repeat-flyovers of multiple individuals that have visited the Palmer area at different times in the season. The habitat mapping flights constitute 95 site surveys over 12 regions of terrestrial pinniped habitat in the Palmer area, including 7 sites that have been surveyed on a near-weekly basis (Table 1).

Table 1 – Summary table of all pinniped surveys and terrestrial mapping efforts achieved between 6 January and 23 March 2020. Pinniped surveys include any series of flights over a site that was sufficient to count and locate all pinnipeds in the site; terrestrial mapping efforts include any series of flights over a site that was sufficient to construct high resolution orthomosaic and digital surface model mapping products (generally entailing aerial photographs with greater overlap and at multiple altitudes).

Site	Pinniped surveys	Terrestrial mapping
Bonaparte Point	13	4
Kristie Cove	13	4
Torgersen Island	11	3
Elephant Rocks	13	8
Humble Island	11	4
Amsler Island SE quadrant	10	3
Pi Island	9	3
Point 8	4	1
Shortcut Island	3	1
Joubins Island 1	3	1
Dream Island	3	2
Joubins Island 96	1	1

These flights captured some of the major shifts in abundance and distribution that took place during the months of January-March 2020 as local pinnipeds and seabirds underwent their annual cycles of breeding and molting on land and then departed back to their pelagic distributions. Some of these changes were conspicuous – such as the departure of breeding Adélie penguins and fledglings, or the sudden arrival of Antarctic fur seals, both of which occurred in the first half of February; whereas more subtle shifts – such as the demographically staggered molting periods of southern elephant seals, will be explored in our later analysis of our datasets. Additionally, less-frequent, intensive drone-mapping efforts are yielding precise maps that will allow us to quantify both groundcover and topography at these habitat sites (Fig. 16).

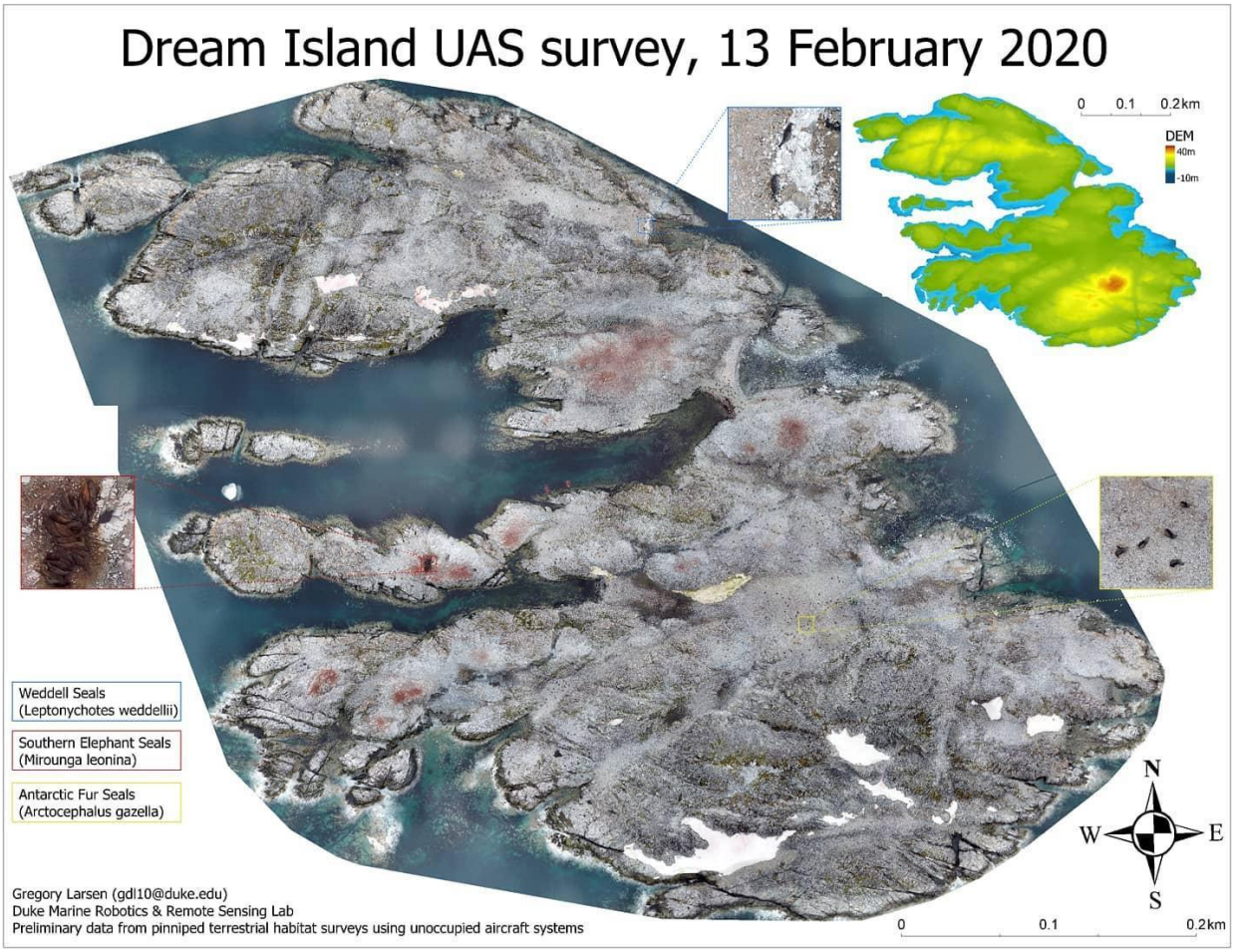


Fig. 16 – Example orthomosaic and digital surface model products from a UAS mapping survey of Dream Island collected on 13 February 2020. High-resolution orthomosaic products can be used to classify land cover and identify the presence of animals in the landscape, whereas digital surface models can be processed to describe topographic characteristics such as elevation, slope, aspect, and more derived indices (e.g., wind exposure, solar irradiance) that might be ecologically relevant.

During the months of February and March, we completed an effort to ground-truth some of our UAS-derived maps, collecting high-accuracy GPS points of natural features that are visible in UAS imagery using Palmer Station's survey-grade GPS unit with the gracious assistance of Palmer Station's Research Associate, Marissa Goerke (Fig. 17). These datasets will enable analysts to evaluate the accuracy of remote-sensing imagery at a range of scales, from the aforementioned UAS-derived orthomosaics to high-resolution satellite imagery products. This will critically inform subsequent spatial analyses for this project's habitat mapping and, potentially, any future projects that incorporate remote sensing at the same near-station sites. By the time of our departure, we were able to survey Torgersen Island, Elephant Rocks, and Humble Island, locating 12–14 features per site with precise GPS measurements that will soon be corrected using post-processing kinematic data.

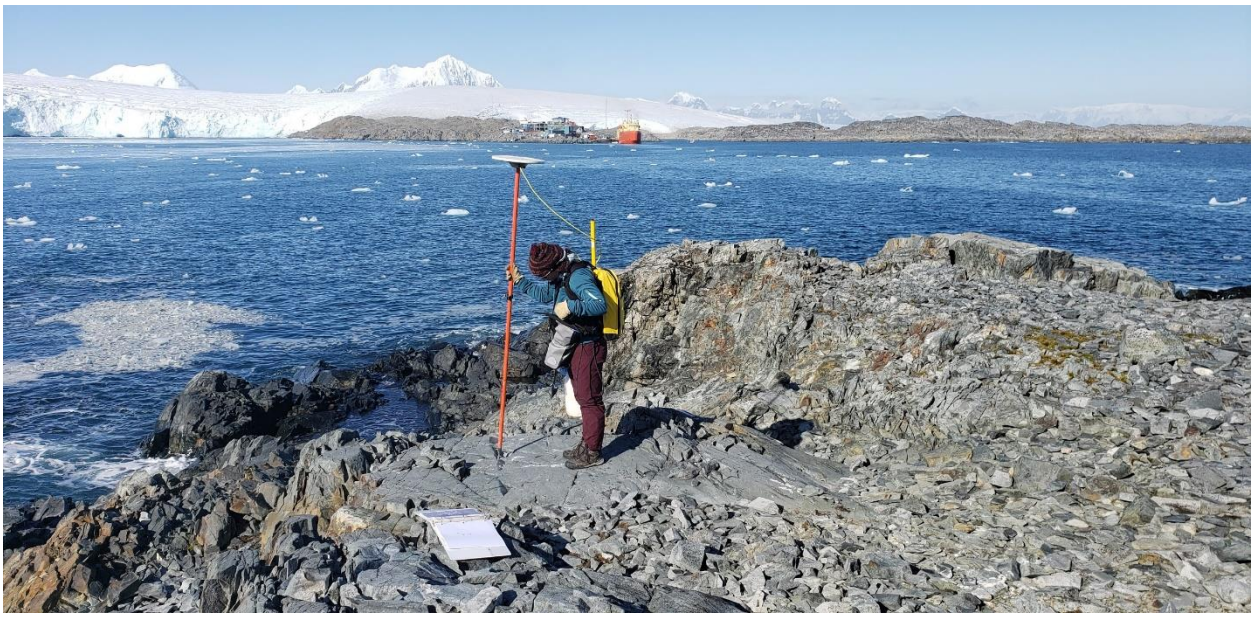


Fig. 17 – Palmer Research Associate Marissa Goerke holds a monopod with a survey-grade GPS antenna at a rock feature on Torgersen Island that has just been surveyed-in to ground-truth remote sensing imagery; photo taken on 25 February 2020. *Image Credit: Greg Larsen*

Finally, in the course of drone surveys this month we were able to capture photo series at multiple flight altitudes of all five pinniped species that we encountered in the Palmer area, and imaged them at proportionally variable ground sampling distances (Figs. 18 and 19). Comparisons among these species in imagery with various ground sampling distances will allow us to determine how the altitude of a drone's flight affects the ability of analysts to discriminate between morphologically similar pinniped species.

Fig. 18 – Aerial photograph of a low-lying beach haul-out site at Dream Island on 21 March 2020. Four species of pinniped were present in this single site: (A) a single crabeater seal (*Lobodon carcinophagus*), (B) two Weddell seals (*Leptonychotes weddellii*), (C) five southern elephant seals (*Mirounga leonina*), and (remainder) 18 Antarctic fur seals (*Arctocephalus gazella*). Proximal comparisons like this are especially helpful for improving our ability to distinguish morphologically similar phocid species from one another in drone imagery.

Fig. 19 – Clips from a series of aerial photographs capturing a leopard seal (*Hydrurga leptonyx*) hauled out on a bergy bit near Amsler Island on 20 March 2020. Photographs were taken at 5-meter intervals between from ~100 meters to ~35 meters altitude. Photo series such as this one illustrate how morphological characteristics resolve in photographs from different altitudes, with proportionally different ground sampling distance in their imagery. Such data can inform future surveys of this species, indicating what ground sampling distance is necessary to discriminate this species from other pinnipeds.

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

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

Personnel on station: Beth Connors

This month the remaining lab member of C-045-P, Beth Connors, finished sampling and left Palmer Station on 17 March 2020. For the first two weeks of March, Stations B and E sampling continued as scheduled, with no delays due to weather or ice. In her final week at Palmer, Beth was busy packing the lab, preparing various samples to ship home, and inventoring all of the lab supplies. This is the final season for Hugh Ducklow, our PI of the biogeochemical component of the LTER science crew, who is retiring. Therefore, we want to thank him for his expertise and immense contribution to Palmer Station and the science of the LTER in his sixteen years of leadership. Thank you, Hugh!

Lab member Beth Connors (far right), along with C-019-P lab members Quintin Diou-Cass and Katie Hudson, getting ready to collect water with the CTD from RHIB *Hadar.* *Image credit: Ducklow group.*

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT

March 2020
Marissa Goerke

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

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

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

Both the ELF/VLF operated normally throughout the month. The hard drives filled up and were swapped out for empty ones to continue archiving daily data.

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

Dr. Michael Taylor, Principal Investigator, Utah State University

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

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

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

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

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

The system operated normally throughout the month.

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

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

Air samples were successfully taken twice this month. Condenser tube disassembled and cleaned in accordance with PI instructions.

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

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

CCGG samples were taken once a week during favorable winds and HATS Air samples were successfully taken within one week of their target sampling dates due to boating operations and high winds.

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

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

The system operated normally this month. Bi-weekly absolute scans and the quarterly three-lamp absolute scans were completed as scheduled without complications.

R-938-P: TERASCAN SATELLITE IMAGING SYSTEM

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

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

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

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

The system operated normally throughout the month. The survey equipment was used to confirm a survey control point for the pier replacement engineers in preparation for a virtual visit of the pier site.

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

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

The system operated normally throughout the month. The firewall tunnel was accidently unplugged during network maintenance and resulted in a half-day data flow delay. No data were lost in this delay. Prepared and sent a command request filter samples. Processed filters and sent logs as needed.

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

Observations of sea ice around station were made daily. First grease ice of the winter season was sighted.

METEOROLOGY

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

The local weather station (PAWS) operated normally throughout the month. All three remote sites went down on 17 March due to what seems to be a combined battery and communications lag issue. An attempt to visit the Gossler Island remote weather station was successfully and was able to get that site sending data again. Trips to the other two sites were not yet possible due to weather and those sites remain uncommunicative.
Observations are archived on the AMRC website: ftp://amrc.ssec.wisc.edu/pub/palmer/.