LMG 18-01: 05 Jan -- 7 Feb. 2018 LTER Cruise 26
Weekly Science Report I

"Palmer Antarctica LTER (PAL): Land-Shelf-Ocean Connectivity, Ecosystem Resilience and Transformation in a Sea-Ice-Influenced Pelagic Ecosystem"

Cruise Introduction and Overview. This is the twenty-sixth consecutive January cruise of the Palmer LTER, starting in 1993. The first cruise utilizing the Palmer LTER Grid was aboard the RVIB Polar Duke in November 2001, but it is not included in this accounting. This is our third cruise under the current award. We are on the fifth six-year NSF-LTER award since PAL started in 1990 (NSF-PLR 1440435 to Columbia University). The overall long term objective of Palmer LTER is to understand the mechanistic linkages by which climate, physical oceanographic forcings and sea ice extent and duration control ocean productivity, food web processes, krill, penguin and cetacean recruitment and carbon biogeochemistry in the marginal sea ice zone of the western Antarctic Peninsula (WAP) region. The WAP is one of the most rapidly-warming regions on the planet, and we have documented responses throughout the foodweb from phytoplankton to penguins. The annual oceanographic cruise provides a large scale regional view of physical-trophic-biogeochemical processes in the region, and contributes to a time series of ecosystem transformation in response to regional warming and sea ice loss.

Our cruises are currently divided between 1) standard LTER stations along the regional grid extending from Palmer Station to Charcot Island and from the inshore coastal region to deep (>3000 m) water off the continental shelf break in the Antarctic Circumpolar Current, and 2) conducting three, 3-4 day mechanistic process studies along the Peninsula. This year's process studies are focused on canyons as mechanisms of continental shelf-ocean-land connectivity; and how bathymetry (submarine canyons and troughs) and physical oceanographic forcing combine to link together the coastal and shelf subsystems of the Antarctic marine ecosystem. During the first few days of the cruise, we completed Process Study 1 in the vicinity of Palmer Deep Canyon (**Figure 1**). Stations were selected on the basis of previous current measurements and penguin tag locations, and to highlight characteristic regions of the canyon geography: canyon mouth, head and deepest central locations. Cross-canyon transects were also conducted to sample across as well as along the axis of the canyon. Aspects of the process study are discussed in additional detail below.

As always, we received outstanding help from ASC, Edison Chouest and Damco staff in Punta Arenas, at Palmer Station and aboard the ship. The annual LTER cruise is a large and complex operation and we benefit greatly from the hard work, accumulated expertise and corporate memory of many dedicated colleagues and friends. Our cruise stages over the winter holidays, placing extra burden everyone involved.

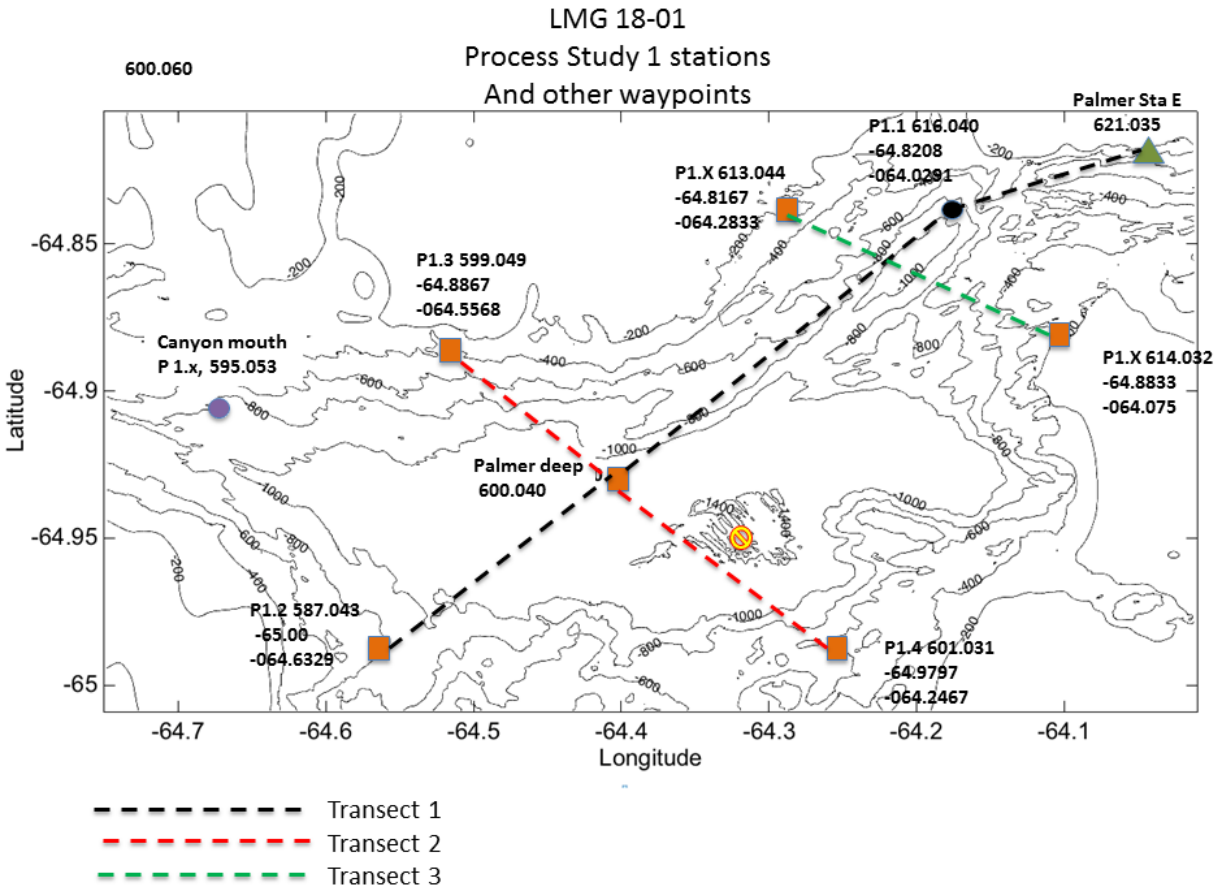

Figure 1. *Map of the Palmer Deep region 10 nm from Palmer Station, showing bathymetry and hydrographic sampling station locations. Some of the transects were run with the new EK-80 Simrad echosounder system actively collecting data.*

Individual component reports:

C-013: Seabird Component (W.R. Fraser, PI)

Field Team Members: Darren Roberts and Megan Roberts

The objective of C-013's component of this year's cruise is to continue the long-term data set of at-sea bird surveys to assess abundance and distribution across the LTER regional study grid. In addition, we plan to continue studies of Adélie penguin breeding and foraging ecology at Avian Island, which is located approximately 600 km south of Palmer Station. This southern study area located in Marguerite Bay provides a higher latitude comparison with seabird studies conducted at Palmer Station. Mainly focusing on Adélie Penguins (but also Southern Giant Petrels, Blue Eyed Shags, South Polar and Brown Skuas) we will assess how and if annual environmental variability (e.g. sea ice and snow conditions) affects population trends, foraging success and diet, growth rates, survival and recruitment, as well as seasonal dispersal. If time and ice conditions allow we also hope to conduct similar fieldwork at Charcot Island, Hugo Island, Armstrong Reef, and the Fish Islands.

During the first week of bridge surveys we completed intensive stationary, and underway surveys in the Palmer Deep region as part of Process Study 1. Following Process Study 1, transect and stationary surveys were conducted along the 600, 500, 400, and 300 lines of the LTER grid. We have observed relatively low densities of all bird species. Wilsons Storm Petrels have been the most common bird observed, followed closely by Southern Fulmars and Cape Petrels (**Figure 2**). We have had a few relatively uncommon LTER sightings including White Chinned Petrels, Black-Bellied Storm Petrels, a worn immature Light-Mantled Sooty Albatross, Wandering Albatross, and a Grey-Headed Albatross.

Figure 2. *A group of Cape Petrels.*

C-019: Phytoplankton Component (O. Schofield, Rutgers; PI)
Field Team Members: Nicole Waite, Carly Moreno, Taylor Dodge, Steve Weber, Oscar Schofield

The objective of this component of the Palmer LTER is to understand the physiological ecology and the spatial/temporal distribution of phytoplankton along the WAP. Field efforts are focused on three areas. The first is to maintain the core time series of the Palmer LTER. Core time series of the phytoplankton time series are chlorophyll a, HPLC to provide phytoplankton accessory pigments, chlorophyll *a* fluorescence induction measurements of photosynthetic quantum yields, and daily 14C-radioisotope uptake experiments. This year we are adding species identification to the time series through selected the addition of an automated imaging flow cytobot. We additionally characterize the bio-optical properties of the water column to provide optical baseline measurements for remote sensing approaches through the deployment of the profiling Biospherical C-OPS spectral radiometer.

Additionally, during the cruise, we are also conducting manipulation experiments to assess factor driving the overall community composition within the LTER grid during process stations. This we are conducting deckboard incubations we are assessing the physiological signatures of iron

limitation using fluorescence and RNA-based approaches in partnership with the laboratory of Professor Adrian Machetti at the University of North Carolina at Chapel Hill. We are also conducting experiments on selective grazing by phytoplankton species by Antarctic peninsula in partnership with the Steinberg laboratory at the Virginia Institute of Marine Sciences and the laboratory of Professor Grace Saba at Rutgers University. The deckboard manipulations are being conducted on the 01 deck of the *Gould* representing discrete short term incubations (12-24 hours). The water at the end of the incubations is being analyzed for fluorescence-based estimates of phytoplankton photophysiology, HPLC pigments, chlorophyll, RNA-profiling and phytoplankton species composition.

We are also coordinating with the team at Palmer Station, the operation of two Slocum gliders. One deep-class glider (2000m) was sent to survey the area on the northern peninsula region. The flight design was developed in collaboration with the NOAA AMLR efforts at Cape Sheriff. At the request from NOAA we redirected our northern survey to sample the waters near Astoblade island, which will help them developed their nascent glider program. The second glider (2000 m class) was launched from Palmer station and has surveyed the shelf south of Palmer Station and it is currently loitering offshore Avian Island conducting local missions tracking the input of modified circumpolar water. Discussions are currently in motion to have the glider flight into Margueritte Bay towards Rothera and have it cross-calibrate against a UK mooring before heading in to boating limits for the station where recovery will be by either the Rothera station personnel or by the *Gould* when it arrives at station.

The first week of sampling during the first Process experiments was successful. Measurements (chlorophyll fluorescence) and 14C measurements indicated a relatively low biomass signal over the Palmer Deep canyon (**Figure 3**). Daily watercolumn integrated carbon fixation rates ranged 3-fold over the Palmer deep and canyon flanks from 105 to 497 mgC fixed m^{-2} day^{-1}. This places this year's measurements in the lower tier of productivity rates measured in the canyon during the LTER process studies over the last 9 years.

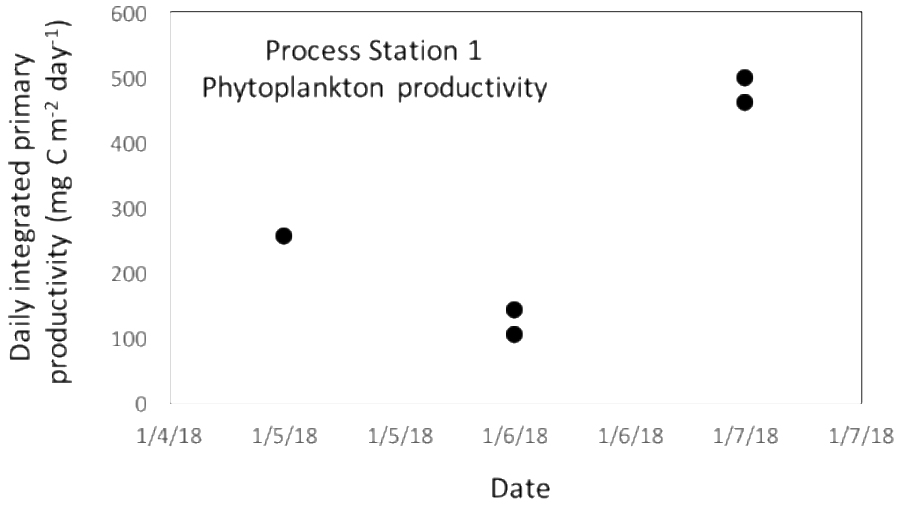

Figure 3. ^{14}C-derived productivity daily integrated rates of carbon fixation collected during Process Station 1.

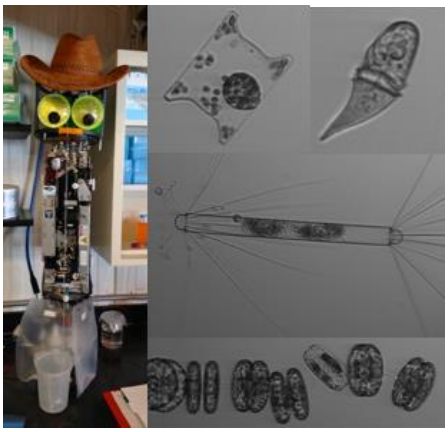

Figure 4. The imaging cytobot and some images collected this season.

The big technical addition to the project this year was the addition of the automated imaging flow cytometer. The cytobot, christened "Floyd" by the graduate students (**Figure 4**) provides every 20 minutes measurements for each particle analyzed by the cytometer along with a digital image of the particle. As of the first week of sampling we have collected on the order of 3 million digital images of the plankton. The images will be used to train an artificial intelligence algorithm back at Rutgers University this summer given this field season is providing the training data set for this exciting new tool. Some images of particles observed so far are shown in Figure 4B.

C-020. Zooplankton Component (Debbie Steinberg, VIMS; PI)

Field Team Members: Joe Cope, Patricia Thibodeau, Andrew Corso, Kharis Schrage, and Colleen McBride.

The objective of our Palmer LTER component is to analyze the effect that zooplankton community structure has on biogeochemical cycling of carbon and nutrients, and the effects of climate change on zooplankton communities on the continental shelf sea of the western Antarctic Peninsula (WAP). This year, with three process study stations, we are examining the role that zooplankton play in the biological pump and in nutrient cycling (grazing, particle or fecal pellet production, and diel vertical migration).

During the first week, we concentrated our operations at a 3-day process study situated in the Palmer Deep canyon, near LTER grid point 600.040, as well as along the 600, 500, 400, and 300 grid lines. At each station (15 stations total) we performed a pair of net tows, one for larger macrozooplankton (e.g., krill, salps) and one for smaller mesozooplankton (e.g., copepods). Animals from the macrozooplankton tows were identified and counted on board, while the presence/absence of taxonomic groups was noted in the mesozooplankton samples (and will be quantified at our home institution).

To investigate depth distribution and diel vertical migration of zooplankton, we collected day/night samples with the Multiple Opening-Closing Net Environmental Sensing System (MOCNESS). The MOCNESS has eight nets which we can open at discrete depth intervals. This year the MOCNESS was equipped with a new software and instrument package. This updated the antiquated hardware to instrumentation compatible with modern CTDs.
We completed several fecal pellet production rate experiments on *Euphausia superba* and *Salpa thompsoni* to continue our time series of the role that different zooplankton taxa play in particle export in the WAP. We collected specimens at selected stations for zooplankton gut fluorescence (a measure of grazing) and for future physiological studies. Krill were also

collected for grazing and fecal pellet production experiments conducted by scientists of other Palmer LTER components.

We have been catching abnormally high numbers of larval icefishes (family Channichthyidae) this year (**Figure 5**). Apart from looking cool, they have some unique adaptations that make them popular research subjects. They are the only vertebrate that lacks red blood cells (they are also known as white blooded icefishes), so, instead of binding to hemoglobin, oxygen is transported in solution. To compensate for an inefficient oxygen transport system, icefish have large hearts. Mitochondria demand more oxygen in warmer water, so icefishes are expected to be susceptible to climatic change. While icefish do not produce red blood cells, they contain the genetic information to produce them. Thus, scientists can identify the genes that regulate red blood cell formation. This information is important in the study of human blood diseases, such as sickle cell anemia or leukemia.

Figure 5. Icefish. Photo credit: Peter Konstantinidis

C-024: Cetacean Biology & Ecology (A. Friedlaender, University of California, Santa Cruz, PI).
Field Team Members: Doug Nowacek (Co-PI) and Julian Dale, Duke University.
At Palmer Station: Greg Larsen and Ross Nichols.

The objective of this component of the Palmer LTER is to collect information on the distribution, movement patterns, behavior, and life history of whales around the Antarctic Peninsula to test ecological hypotheses regarding these top predators. We are interested in the most basic sense in understanding the demography, population structure, and ecology of the whales that utilize this area as a feeding ground. To this end, we will be collecting skin and blubber biopsy samples, photographs of individual whale flukes, and aerial photogrammetry images throughout the cruise, and then attaching short-term (hours to days), multi-sensor (accelerometer, compass, temperature, depth) tags (CATS) to whales during some of the process studies. The biopsy and imagery data will be used to determine the sex ratio, pregnancy rates, breeding population identity, diet composition and demography of humpback whales. We are also interested in the foraging behavior and movement ecology of these whales in relation to both physical and biological features of the seascape. In order to determine this, we will be deploying a number the tags. The data from these instruments will allow us to determine the diving behavior and feeding rates and locations. By then linking the data on foraging to oceanographic data collected at process studies we can begin to understand what features of the environment promote the

necessary conditions for whales to feed. With these data we will also compare the amount of spatio-temporal overlap in foraging areas with other krill predators (e.g. Adelie penguins) to try and understand the interspecific interactions between these sympatric and krill-dependent animals.

During the first week of operations in the Process Study Site around the Palmer Deep Canyon we had great success in locating whales, collecting samples, and deploying tags. We collected 6 biopsy samples from humpback whales, collected photogrammetry images for two whales, and deployed and retrieved 6 CATS multi-sensor tags. Of note, nearly all of the whales that we encountered feeding were actively using bubble-nets to corral prey, a behavior unique to humpback whales. This is a dramatic and cooperative behavior seen in other feeding grounds and observed in Antarctica. Below is an image of a humpback whale with a CATS tag attached in one of the photogrammetry images (**Figure 6**), and in **Figure 7** Dale and Nowacek are holding a tag recovered 6 days after deployment. This tag recovery was an impressive team effort using both satellite and VHF tracking methods, expert vessel maneuvering by the ECO personnel and tag recovery with ASC staff.

Figure 6. Humpback whale photographed from one of our UAS platforms. The pink CATS tag attached to its back with suction cups is recording kinematic and depth data, and it serves as an excellent scale for photogrammetry measurements.

Figure 7. Nowacek and Dale on the deck of the LMG with recently recovered tag.

C-045: Microbial Biogeochemistry Component (H. Ducklow, Lamont Doherty Earth Observatory; PI).

Field Team Members: Hugh Ducklow, Naomi Shelton, Rebecca Trihn, Hugo Berthelot, Mar Arroyo and Shana Lesko (Figure 8)

Introducing this year's Ducklings (Figure 8):

Figure 8. The Duklow team. Ducklings 2018: Clockwise from upper left: Hugh and PhD student Rebecca Trinh (front left) with 2017-18 Palmer Station team members. Naomi and Hugo (postdoc at Univ de Brest, on loan from Nicolas Cassar) inspecting the Equilibration Inlet Mass Spec. Mar Arroyo, PhD student with Elizabeth Shadwick (VIMS) posing with Shadwick's pCO2 and pH sensor array; and Shana (Barnard College '16) with Accuri Flow Cytometer.

Our group investigates the carbon cycle of the upper ocean, including the role of heterotrophic bacteria in carbon cycling, net community production (NCP) and particle export. We'll explore these themes in upcoming reports. So far on this cruise we've sampled our full array of properties and processes (bacterial production, NCP, export) at grid stations on the 600, 500 and 400 grid lines and at the first Process Station in the Palmer Deep region. Columbia PhD student Rebecca Trinh is commencing her thesis research on microbial associations with krill fecal pellets (Figure 9). After the cruise, she'll continue her research at Palmer Station until the end of the summer season in late March. Our work is going well, unusually rough seas notwithstanding.

Figure 9. Antarctic krill fecal pellets in a bucket modified to separate the krill producing pellets from the egested pellets and prevent re-consumption. Larger string-like pellets are ca 1 mm long. Photo by H. Ducklow

B114: Chemoautotrophy in Antarctic Waters (J. Hollibaugh, University of Georgia; PI).

Field Team Members: James T. Hollibaugh and Brian N. Popp

Sampling collection for nitrification rate measurement is proceeding smoothly. Measurements have been initiated for a total of 35 samples using ^{15}N-labeled nitrite, ammonium and urea, with a subset (22 samples) analyzed for oxidation of ^{15}N from putrescine. Nineteen measurements have been completed to date, with the remainder (from the LTER 500 and 400 lines) currently in the incubator. We have also measured nitrite and ammonium concentrations in the same samples (these are consistently <100 nM). Samples for determining nitrification rate have been frozen at -80 ^{0}C awaiting del^{15}N determination in Popp's lab at the University of Hawaii. Chemoautotrophy measurements (incorporation of $NaH^{14}CO_3$) have been attempted on 7 samples, but I am not happy with the protocol and am working to refine it so that the measurements can be done more reliably.

We have collected particulate DNA from this same set of samples. These samples, which are in Sterivex filter capsules, have been fixed with lysis buffer and frozen at -80 ^{o}C pending analysis in my lab at UGA after the cruise ends. We have not encountered any insurmountable issues with our program, other than occasionally running out of water in the sampling rosette.