LMG 23-01: 22 Dec. 2022 – 06 Feb. 2023, PAL LTER Cruise #30
Weekly Science Report I
(Dec. 31st to Jan 8th)

LTER: Ecological Response and Resilience to "Press-Pulse" Disturbances and a Recent Decadal Reversal in Sea Ice Trends Along the West Antarctic Peninsula.

Other projects: CAREER: Understanding Microbial Heterotrophic Processes in Coastal Antarctic Waters (Jeff Bowman, Scripps, PI) and CAREER: The transformation, cross-shore export, and along-shore transport of freshwater on Antarctic shelves (Carlos Moffat, U. of Delaware, PI).

Cruise Overview (Carlos Moffat, Chief Scientist)

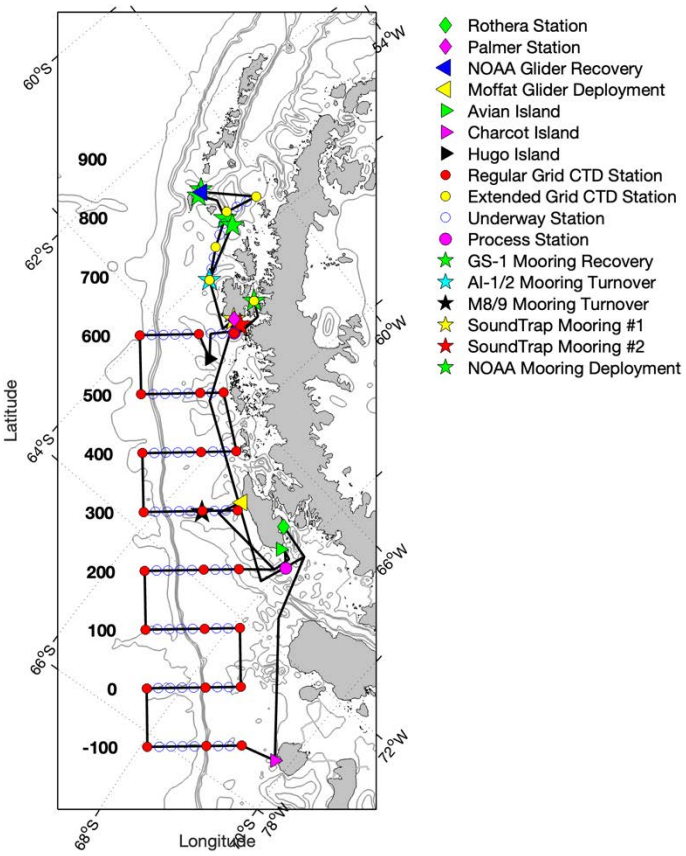

Figure 1: Cruise Plan.

The overall long-term objective of Palmer LTER is to understand the mechanistic linkages by which climate, physical oceanographic forcing and sea ice extent and duration control ocean productivity, food web processes, krill and penguin 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 food web from phytoplankton to penguins and whales. The annual oceanographic cruise (this is the 30th) provides a regional-scale view of the physical, trophic, and biogeochemical processes in the region while also contributing to time series of ecosystem change in response to regional warming and sea ice loss.

The cruise is divided between (1) occupying the extended grid north of Palmer Station, (2) sampling the standard LTER grid between along-shore *grid lines* -100 (off Charcot Island) to 600 (off Anvers Island/Palmer Station) and (3) conducting about three, ~3-day intensive process studies. The extended grid was added last year and is composed of five new grid stations and six underway stations to an *extended grid* north of Palmer Station (Figure 1, north of Palmer Station). These stations are located along the mid-shelf and Gerlache Strait, with the goal of understanding the ecosystem impact of the exchange between

Bransfield Strait, heavily influenced by the cold Weddell Sea, and the relatively warm LTER study region.

This year, the science party is comprised of 21 people. During the preparations for the cruise and this first week, we have received excellent support from the six ASC personnel on board as well as Captain Stelly and the officers and crew of the *L.M.Gould*.

This first report of LTER science starts after we finished the port call at Palmer Station on December 31st.

Cruise Departure and NOAA Activities (Carlos Moffat, Chief Scientist)

The *R/V L.M. Gould* departed Punta Arenas on December 23rd, a day later than planned. The cruise left through the western exit of the strait of Magellan, reaching the South Shetlands in the afternoon of December 27th.

Prior to arriving to Palmer Station our plan was to deploy four NOAA moorings, two across Boyd Strait and two off Low and Hoseason islands, respectively (Figure 1). On December 26th, however, we received an urgent request from our NOAA colleagues to recover a glider (part of the AMLR program efforts) that malfunctioned while sampling off Cape Shirreff. Nicole Waite, group lead of the Schofield group for the LTER cruise, led the recovery efforts with assistance of NOAA personnel. We were able to successfully recover the glider and continued to the mooring deployments, all of which were successfully completed on December 28th. We arrived at Palmer Station for a two--and-half day port call the morning of December 29th.

Among the activities before the port call, I want to highlight a series of science talks organized by Henry Holm and Shavonna Bent, from the Van Mooy group at WHOI, during our transit to Palmer Station. The LTER program spans a broad range of disciplines in marine sciences and these talks have allowed us to learn about the goals of each science group, and how they fit with broader ecosystem studies.

First week of LTER Activities

This first week, we completed the *extended grid* of stations north of Palmer Station, recovered and redeployed the AI mooring off the north-west coast of Anvers Island, and completed an extensive process station at Palmer Deep (Station 600.040) that included two full grid stations (optics cast, CTD profile, net tows) and MOCNESS tows, a 24+ sediment trap deployment, seabird surveys, whale tagging and biopsies, and a successful acoustic survey using an EK-80 dual frequency system. The GS-1 mooring in Gerlache Strait was not recovered.

A significant storm kept us from continuing the grid survey, but we used this time effectively to calibrate the EK-80, an acoustic dual frequency sensor to map plankton and fish distribution, and conduct hydrographic surveys to document the exchange between Gerlache Strait and the Palmer Deep region. We expect to continue the grid sampling starting on Sunday, January 8th.

Group Reports

C-024 Whales-LTER (Logan Pallin, Friedlaender Group, UCSC)

Team Members: Logan Pallin (lead), Arianna Torello

This week, the Whalers continued their efforts to conduct bridge surveys of marine mammals. Sighting have included heavy concentrations of humpback whales in the Gerlache and Bismark Straits as well as around Palmer Canyon, three sightings of Type B2 Killer Whales (Gerlache Ecotype; Figure 2), and a few sightings of Antarctic minke whales. Among humpback whales, feeding activities observed have included both surface lunge and bubble net feeding. As well, surface breaching, peduncle throws, pec slapping and spy hopping has been observed among several animals. The whalers have deployed using small boat operations multiple times thanks to the continued support of the ASC/ECO staff and crew to collect photos, biopsy samples, and deploy tags. Photo identification data using fluke imagery (Figure 3) has been collected on a total of eight humpback whales that will aid in the understanding of the movement and mixing of humpbacks across ocean basins. In fact, the animal shown in Figure 2 was first photographed on the Antarctic peninsula in January of 2017 (Happywhale ID: HW-MN1301198). As well, the whaling group has collected 14 skin-blubber biopsy samples (12 humpback whales, 2 killer whale) that will be used to determine the sex of individuals, hormone markers for health and pregnancy, and will be integrated into our genetic database of over 2,500 samples from the Antarctic Peninsula region since 2010. Lastly, our group was incredibly successful on the evening of the 4th of January, and we successfully deployed two of our non-invasive motion/video/audio suction cup tags (Figure 4) on two humpback whales in a group of four that was feeding. These tags provide critical data on the foraging behavior and acoustics of whales in this region and outline times of the day/year when feeding is most important.

The LMG 23-01 Cruise completed its annual ~35 NM acoustic transect (Figure 5a) in the Palmer Canyon area in the early morning hours on the 6th of January 2023, followed by a successful calibration of the EK-80 acoustic system the following day in the Neumayer Channel. This was accomplished successfully due to the involvement of team members from all labs, as well as the continued support of ASC/ECO. The transect took roughly 14 hours to complete, maintaining a speed of three knots to ensure high data quality. As well, we interrupted the survey with targeted 2-meter net tows led by the Steinberg group when significant krill patches were detected. The EK-80 acoustic system, composed of two transducers (38 kHz and 120 kHz), mounted to a tow fish (yellow frame; Figure 5b/c) was lowered into the water off the starboard A-frame of the research vessel at a depth of 5 meters. Multiple frequencies were used as different target items (i.e., krill vs. fish) have different acoustic signatures. For example, krill will be more visible on the 120 kHz system, while fish would be more visible on the 38 kHz system. While underway, rotating science staff monitored the EK-80 software to detect krill patches (Figure 5d). We detected several small, isolated patches, as well as a few large, dispersed patches (Figure 5d) near the north-west and south-east edges of the transect. These tended be located near canyon walls and closer to islands. All patches were consistently in the upper 20 meters of the water column and targeted net tows (Figure 5e) did in fact confirm that these were krill patches. The following day, we calibrated the EK-80 acoustic system by hanging a 38.1 mm tungsten carbide calibration sphere over the side of the research vessel underneath the

acoustic system. This sphere has a pre-set acoustic target strength, similar to what we might expect for krill in this area. During the calibration process, both transducers received enough acoustic pings from the calibration sphere (Figure 5g) so that the overall calibration coverage was >90%. In the end, this data will be used to understand the spatial and temporal dynamics of krill patches in the region, and increase our understanding of why the Palmer Canyon area is such a critical foraging area for krill predators (i.e. penguins and whales).

Figure 2: Photographs of a group of six of type B2 ecotype killer whales observed north of Trinity Island. The group was composed of one mature male (identified by large dorsal fin), 4 female/subadult male, and one calf. This ecotype feeds on penguins and is frequently observed in the Gerlache Strait.

Figure 3: Photograph of the underside of a humpback whale's fluke (BETBEL Individual: I_LMG_20230103_2_1; Happywhale ID: HW-MN1301198) that will be used for photo-identification. These pigmentation and scarring patterns are unique to the individual whale and act as a fingerprint.

Figure 4: Motion and video suction cup tag deployed on a humpback whale near Palmer Station. Photo provided by TR.

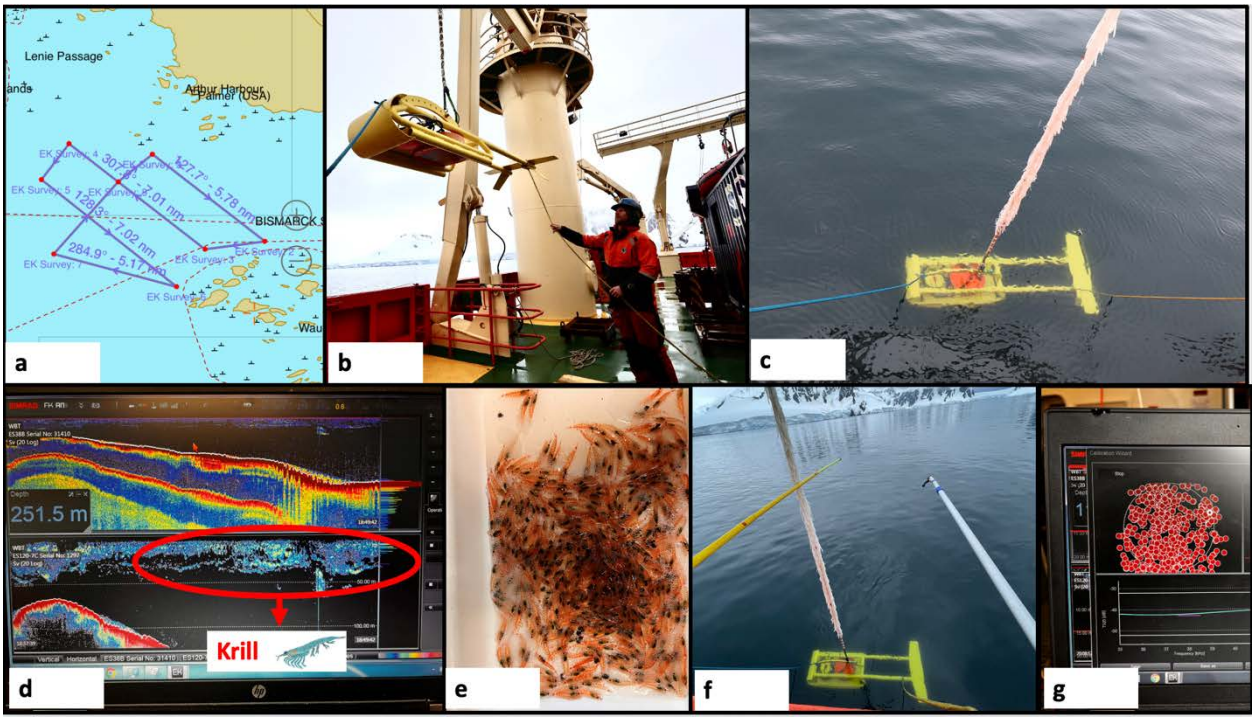

Figure 5: EK-80 Survey and calibration activities.

C-021 & O-263 Physical Oceanography-LTER (Carlos Moffat, LTER PI, U. of Delaware)

Team Members: Carlos Moffat (lead), Rike Benz, Jake Gessay, Michael Cappola, Evan Quinter

The C-021 component of the LTER is focused on physical variability and processes that impact ecosystem structure and function. We continue to focus on long term, core measurements of ocean properties by collecting and processing about 22 CTD profiles so far. We are also collecting water samples for field calibration of the SeaBird dissolved oxygen sensors.

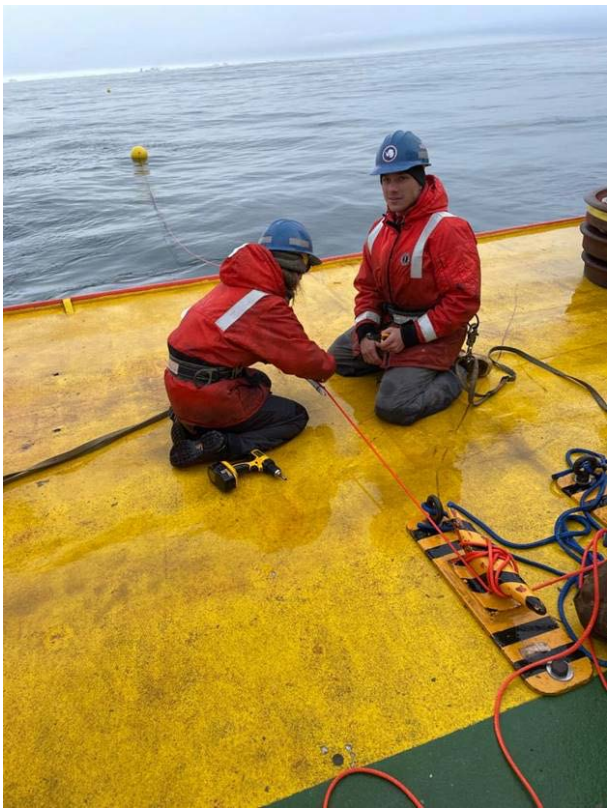

Figure 6: Rike Benz (Ph.D. Student, left) and Michael Cappola (recent graduate, right) from the University of Delaware install instrumentation on the AI-2 mooring being deployed off the coast of Anvers Island, January 2023.

The physical oceanography program deployed three moorings in April 2022 with the assistance of ASC: the GS-1 mooring in southern Gerlache Strait, the AI-1 mooring off the north-west coast of Anvers Island, and the M-8 mooring, a long-term deployment at the 300.100 grid station location. During our first week of LTER science, we focused on recovering GS-1 and turning over the AI mooring. Because of ASC staffing issues, we put mooring ops first on the schedule so as to be able to move to 24-hour operations. The GS-1 mooring's acoustic releases responded to remote release commands, but we were unable to locate the mooring at the surface. This could have been caused by a loss of buoyancy of the mooring, but there were some large icebergs in the area, and it is also possible they prevented the mooring from surfacing. We continued to ping for the releases whenever we were in the area with no success.

The AI-1 mooring recovery and re-deployment was successful (Figure 6). All mooring instrumentation returned data, in what we believe is the first multi-season dataset of continuous records in a critical area of exchange between Bransfield Strait and the Palmer Station/Deep region. The final mooring turnover will occur when we recover and redeploy the mooring at the 300.100 site later in the cruise.

We are also collaborating closely with the NOAA AMLR program to coordinate mooring deployments and hydrographic sampling along the WAP (See our report about NOAA mooring deployments above).

As part of the O-263 work, two glider deployments and a series of high-resolution hydrographic sections (HRS) will be conducted during the cruise. The goal of these observations is to understand the processes controlling the transport and transformation of freshwater along the WAP. The first HRS will be conducted at the 500 LTER grid line, and the glider deployments at the 300 line. During this week, the team has been preparing instrumentation and checking the ship's underway ADCP system, which will be used to inform the glider deployments and HRSs.

C-023 Seabirds-LTER (Megan Roberts, Cimino Group, UCSC)

Team Members: Megan Roberts (lead), Allison Northey

The objective of C-013's component of this year's cruise is to continue the long-term data set of at-sea bird and mammal surveys to assess abundance and distribution across the LTER regional

study grid. In addition, we plan to continue studies of Adélie penguins along the peninsula at Avian Island and if sea ice allows, Charcot Island. Other long term study sites will be visited if time allows.

The first week of bridge-based surveys conducted were along the Extended LTER Grid and the Palmer Deep Process Study area. Along the extended grid, we conducted multiple stationary and transect surveys in which we observed small groups of Southern fulmars, Chinstrap penguins, at least two small pods of killer whales, and multiple humpback whales. During the Palmer Deep Process Study, stationary surveys were conducted during CTD casts and net tows. Most commonly, humpback whales and Wilson's storm petrels were observed. Additionally, the team conducted consecutive transect surveys along the Acoustic Predator-Prey Study Grid crossing the Palmer Canyon. Most notably, we observed multiple feeding groups of Gentoo penguins and humpback whales near a large prey mass observed on the echo sounder. In addition to the species listed above, we had some sightings of species that are relatively rare for the LTER including: White-chinned petrels (Figure 7) and Black-bellied storm petrels.

Figure 7: A White-chinned petrel encountered along the extended grid.

C-019 Phytoplankton-LTER (Nicole Waite, Schofield Group, Rutgers University)

Field Team Members: Nicole Waite (lead), Miah Manning, Ben Fisher, Michael Cappola
(Figure 8)

Our field work on this LTER research cruise focuses on continuing the core phytoplankton time series measurements of Chlorophyll, phytoplankton accessory pigments through High Performance Liquid Chromatography (HPLC), daily primary productivities using Carbon-14 labeled sodium bicarbonate, FIRe fluorometry to characterize the physiology of the phytoplankton community through photosynthetic quantum yields (Fv/Fm) and photosynthetic rate response to light through P-E curves, and the use of our Imaging Flow Cytobot (IFCB) to identify WAP phytoplankton to genus, and sometimes to species-level.

Our phytoplankton measurements are complimented with bio-optical measurements. This year, we will be using a profiling LISST-200X to measure particle size distribution of the water column before every CTD cast. We also have mounted a Hyperspectral Acquisition System (HyperSAS, Figure 9) of three radiometers on the bow of the LMG to measure the color

Figure 8: C-019 Field Team members Michael, Nicole, Miah, and Ben (L-R).

spectrum of light coming from the ocean, sky, and all light coming from above throughout the duration of the cruise. A new addition to our instrumentation suite is the QFT-ICAM, which is used to measure the light absorption spectra and optical density of samples to determine the light absorption coefficients of particles in water.

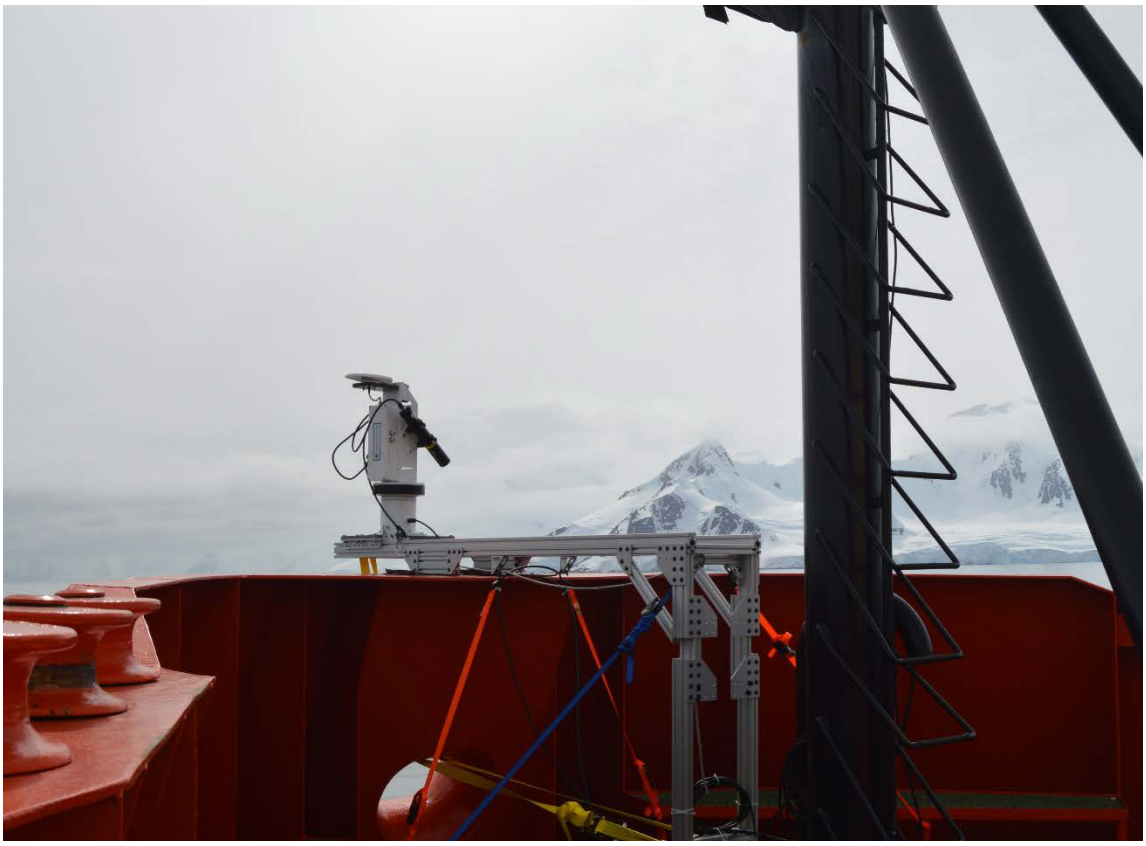

Figure 9: HyperSAS Radiometer on bow of LMG.

Lastly, Ben Fisher, a graduate student from the University of Edinburgh joins the C-019 group on this cruise and will be conducting solid phase extraction of dissolved organic matter across selected grid sites alongside dissolved organic carbon (DOC) sampling. These samples will be later analyzed for molecular composition, elemental stoichiometry (carbon, nitrogen, phosphorous, sulphur) and for the δC13 isotope signature. Phytoplankton are responsible for the vast majority of organic matter input into the Southern Ocean and their community composition varies with differing chemical inputs and physical drivers across the LTER grid. This work aims to understand how phytoplankton community composition variability across the LTER grid influences the inputs and longevity of dissolved organic matter and the net effect on the marine carbon cycle.

After a busy port call in Punta Arenas and at Palmer Station, we began science and sampling this week on New Year's Eve. In the first week of the LMG23-01 cruise, we completed the survey of the northern extended grid and concluded the week with a process study in Palmer Canyon. During the process study, we conducted diurnal CTD sampling, to look at changes in chlorophyll and phytoplankton over the course of a day-night cycle. In total, we completed 12 CTD casts, 10 of which we collected water at. We also completed 7 underway surface stations. We have analyzed 18 samples for optical density with the QFT-ICAM on surface waters and the

deep chlorophyll max waters from CTD casts and underway stations. Ben collected his first set of samples from 600.040 during the process study as well.
The phytoplankton community at the northern extended grid stations was composed of mainly cryptophytes and dinoflagellates – with relatively low chlorophyll overall (fluorescence ~1 mg/m^3). In Palmer Canyon, we saw much higher chlorophyll (fluorescence of 5-7 mg/m^3,Figure 10), though the community was also mainly cryptophytes and dinoflagellates, but a few diatoms were present.

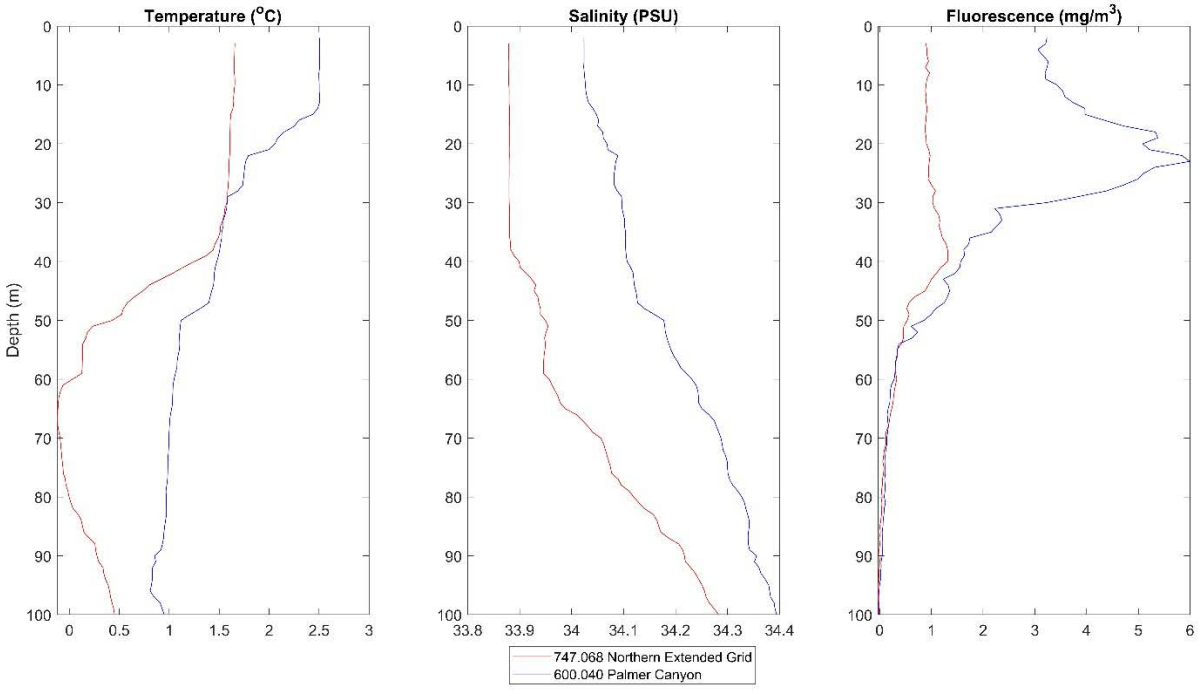

Figure 10: CTD profile of Temperature, Salinity, and Fluorescence at station 747.068 on the northern extended grid (red) and at station 600.040 in Palmer Canyon (blue).

C-020 Zooplankton (Joe Cope, Steinberg Group, VIMS)

Team Members: Joe Cope (lead), Tor Mowatt-Larssen, Maya Thomas, and Meredith Nolan (Figure 11)

The overall objective of our Palmer LTER component is to analyze the role that zooplankton community structure plays in 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 via fecal pellet production and diel vertical migration. PhD student Tor Mowatt-Larssen will be looking at how warming temperatures affect larval fish. PhD student Maya Thomas will be measuring fecal

pellet production of Antarctic krill, *Euphausia superba*, and salps, *Salpa thompsoni* and conducting sediment trap analysis of sinking particulate organic matter (POC). In addition to preserving samples along the LTER grid for taxonomic analysis, we will also freeze dominant animals for gut fluorescence and for future physiological measurements. Frozen Antarctic krill will be examined for parasites by Alison Cleary from the British Antarctic Survey. Krill will also be given to Shavonna Bent (C-045-L) to determine spatial differences in lipid content along the grid.

At each grid station, we perform a pair of net tows, first deploying a 2-m net with 700-µm mesh and then a 1-m net with 335-µm mesh. The larger net captures larger macrozooplankton (e.g., krill, salps), and the smaller net captures smaller mesozooplankton (e.g., copepods). Animals from the macrozooplankton tows are identified and counted on board, while the presence/absence of taxonomic groups is noted in the mesozooplankton samples (these samples will be quantified at our home institution).

We completed all five sampling stations in the northern Extended Grid. These samples were dominated by salps. This was expected because this is a low ice year and salps favor ice-free environments since ice can damage their fragile bodies. Krill *E. superba* and *Thysanoessa* were also common. Many specimens of the krill *E. triacantha* were noted, which are typically uncommon. Two pairs of tows were made at station 600.040, in the Palmer Deep region. These tows were dominated by *E. superba* and *Thysanoessa*; few salps were collected.

To investigate depth distribution and diel vertical migration of zooplankton, we collected paired day/night samples in the Palmer Deep region with the Multiple Opening-Closing Net Environmental Sensing System (MOCNESS). The MOCNESS has eight nets which we open at discrete depth intervals. Krill species at this station were vertically stratified. *E. triacantha* appeared in the deeper depths and was slowly replaced by *Thysanoessa* as depth decreased. *E. crystallorophias* inhabited shallower depths while *E. superba* was found in the surface waters. In addition, a bioacoustic survey was conducted in the Palmer Deep region to compliment research conducted by the whales and seabirds LTER components. Tows deployed in patches revealed by acoustics found that the patches were Antarctic krill.

Figure 11: Steinberg field team (left to right): Maya, Joe, Andrew Corso (at Palmer), Tor, and Meredith.

C-045 Biogeochemistry (Shavonna Bent, Van Mooy Group, WHOI)

Team Members: Shavonna Bent (lead), Henry Holm, Mackenzie Curtice, Aidan Kenny

During the first week of science on LMG2301, the Van Mooy group has undertaken both water column and sediment trap sampling. We completed sampling of the extended grid for our full suite of measurements, including: lipids, carbs, particulate organic carbon (POC), nutrients, DIC/Alkalinity, oxygen isotopes, and flow cytometry. The extended grid sampling included full depth profiles at five stations, with underway stations between them. Additionally, we completed a diel cycle of shallow (100 meter) CTD profiles at station 600.040 (Palmer Deep), consisting of four CTDs over approximately 6-hour intervals, concurrent with MOCNESS and net tow samplings. During the process station we deployed three Particle Interceptor Traps (PITs), which collected sinking material from 50, 100, and 200 meters for ~28 hours (Figure 12). Both the deployment and recovery went smoothly, with issues in ballasting the highflyer and associated satellite resolved from the previous field season – many thanks to the MTs for their help in the successful operations! Samples for lipid, carbohydrate, and POC analysis were collected in triplicate from each PIT depth, as well as gel traps for imaging by the Steinberg group. Initial assessment of the material indicates the primary flux was that of krill fecal pellets (Figure 13).

Figure 12: (Clockwise from top left) Aidan Kenny (Van Mooy Group), Maya Thomas (Steinberg Group), Meredith Nolan (Steinberg Group) and Shavonna Bent (Van Mooy Group) process samples from a sediment trap recovery.

Figure 13: Krill fecal pellets from 50 m PIT trap.

B-285 Bacterial Communities (Beth Connors, Bowman Group, Scripps)

Team Members: Beth Connors

Our primary activity is a series of grazing experiments to determine the mortality rates of marine bacteria as caused by protists and bacteriophage. The experiments require precise conditions, large volumes of water, and considerable time to set up and execute. These same experiments are being conducted at Palmer Station by PI Jeff Bowman at the same time as the cruise, to compare grazing rates across the LTER shelf. This first week, the first of nine planned grazing experiment was successfully completed at the Palmer Deep Station (600.040). In addition to the successful grazing experiment, water was collected at each of the LTER Grid Stations for measurements of bacterial community structure, abundance, activity, and energetics. This week, the first 6 of 30 planned CTD casts were undertaken, most of which were on the extended grid of the LTER to the North of Palmer Station.