LMG 15-01: 29 Dec. 2014 – 09 February 2015, PAL LTER Cruise 23
Weekly Science Report III (week of 19-25 Jan)

LTER: Land-Shelf-Ocean Connectivity, Ecosystem Resilience and Transformation in a Sea-Ice Influenced Pelagic Ecosystem on the Western Antarctic Peninsula
&
Natural iron fertilization and bioactive metal dynamics on the Western Antarctic Peninsula shelf

Week 3 overview (Deborah Steinberg, Chief Scientist):

In Week 3 of the annual LTER cruise (19-25 Jan.) we occupied regular grid stations on the 200 line and completed Process Study 2, conducted in Marguerite Bay. The purpose of this process study was 2-fold. First, we aimed to sample in the penguin foraging region between the Avian Island penguin rookery and the head of Marguerite Trough (**Fig. 1**). This process study tests the hypothesis that ocean circulation and mixing associated with the canyon head support high productivity in the region. Second, we sampled ice-edge, shallower waters vs. ice-free, deep canyon waters in Marguerite Bay, to examine plankton community structure changes, and how this may affect biogeochemical cycling in these two environments. A version of this will be repeated in our 3rd process study near Charcot Island.

We also recovered the birder team from Avian Island, and regular station operations occurred at representative coastal, shelf, and slope stations along the 100 and 000 lines as we made our way further south. We successfully deployed 2 British Antarctic Survey (BAS) Slocum gliders as we were making our way along the 100 line.

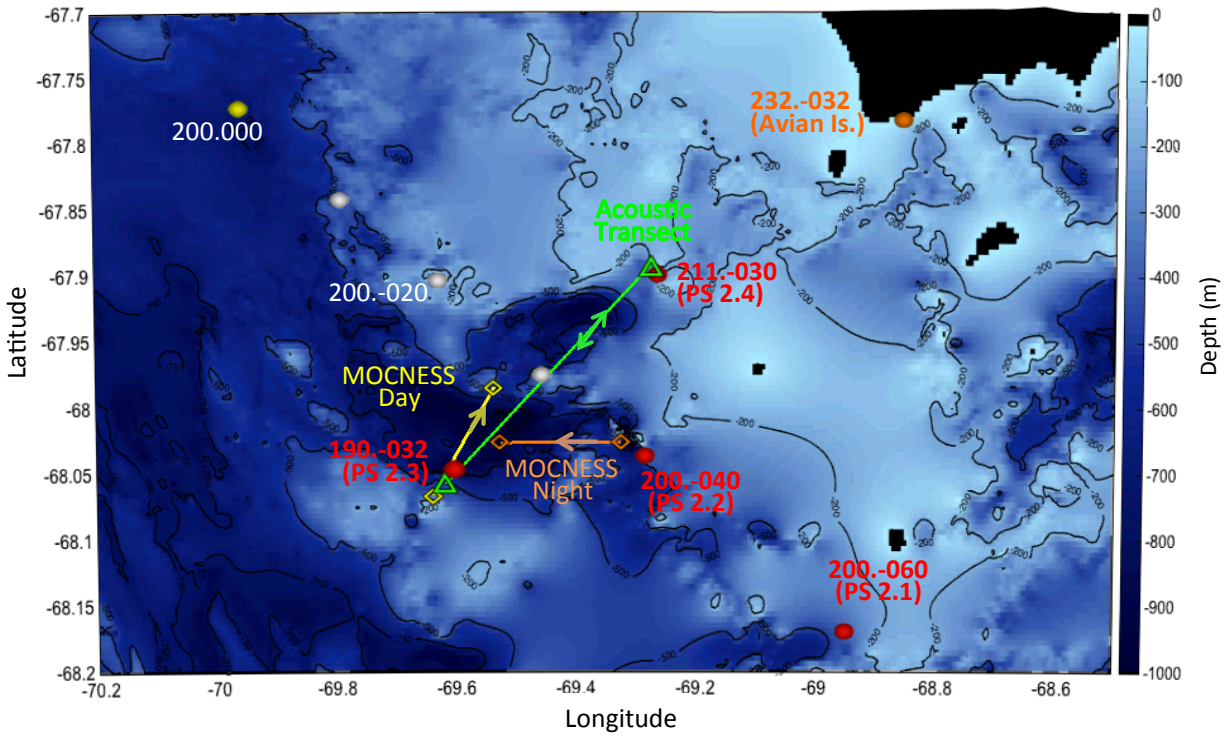

Figure 1. Map of stations occupied during LTER cruise Process Study 2 in Marguerite Bay, with Avian Island to the north. Process Study stations occupied are in red, other grid stations we sampled are in yellow, and 200 line grid stations not sampled, in white. The acoustic transect (green) was crosses the canyon head, shoaling from 900 to 200 meters south to north. MOCNESS surveys were run along the deep canyon axis. PS 2.1 was near the ice edge.

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Individual component reports:

C- 021: Physical Oceanography Component (Doug Martinson, Lamont Doherty Earth Observatory; PI)

Field Team Member: Naomi Shelton

This past week the physical oceanography component geared up for the deployment of all 4 moorings. Thanks to the ETs Mike Coons and Alec Chin for their significant effort downloading all the data from 2014 and programming every sensor and current meter in preparation for these 2015 deployments. Fortunately, we were able to make rearrangements to account for lost sensors, so all moorings will be properly equipped with the appropriate number of sensors in order to track water masses throughout the vertical water column. Our next step will be to prepare all the line for the moorings and attach the sensors, which will be no easy feat with over 1,500 meters of line for the mooring located in the deepest part of Palmer Canyon. MTs Hannah Grey and Meredith Helfrich are quick to assist and answer questions regarding mooring operations, and we cannot thank them enough for their help. We plan to deploy the first and the LTER 'legacy' mooring, at 300.100 on Thursday, January 29, to continue our long-term measurements at that site.

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

Field Team Members: Naomi Shelton, Hyewon Kim, Kimberley Miner, Chelsea Petrenko, Leigh West.

The microbial biogeochemistry group completed sampling for all core measurements along the LTER 200, 100, and 000 survey lines during the past week, including a process study in Marguerite Bay. The bacterial productivity rates in Marguerite Bay at the surface were almost double those at Palmer Canyon, with a maximum rate of 99.12 pM/hr (**Fig. 2**). We encountered significant ice in Marguerite Bay, and the station near the ice edge had the highest bacterial productivity rate measured for the cruise thus far (where we also encountered a *Phaeocystis* bloom). We look forward to investigating bacterial community dynamics at our third process study.

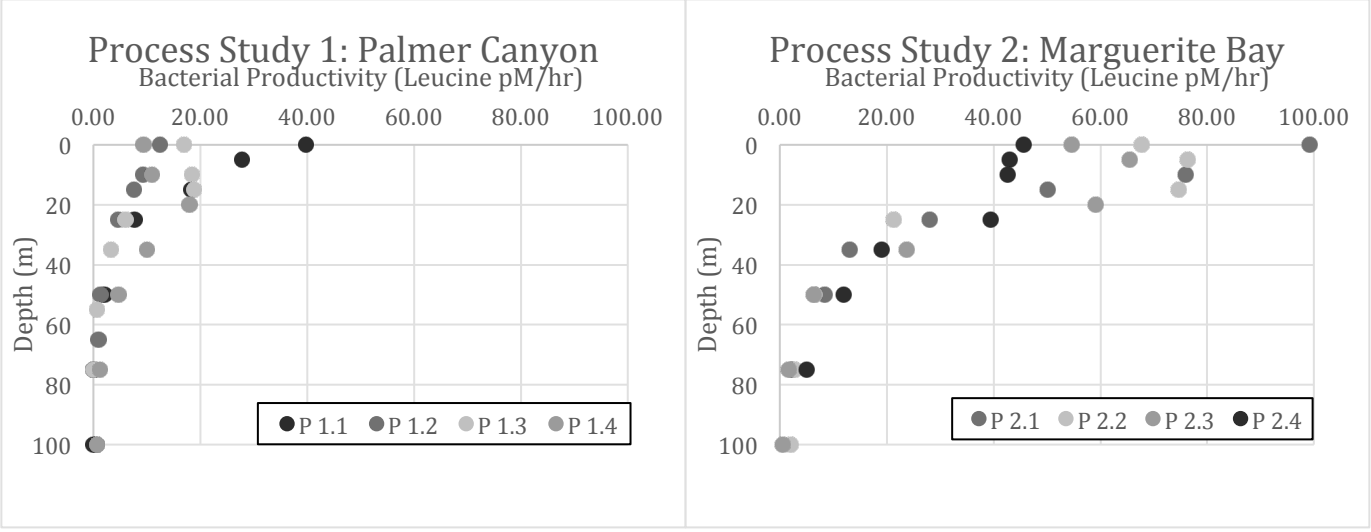

Figure 3. Bacterial production in Palmer Canyon and Marguerite Bay.

C-019: Phytoplankton Component (Oscar Schofield, Rutgers; PI)

Field Team Members: Ana Filipa Carvalho, Mansha Seth-Pasricha, Philip Sontag, Cheryl Zurbrik

The third week of sampling focused on making the core measurements inshore near Avian Island in Marguerite Bay. Daily productivity rates showed significant variability between the inshore and offshore stations. Productivity rates in the Bay were almost 10-fold higher then the shelf stations sampled so far (**Fig. 3**). Highest productivity rates were associated with a Phaeocystis bloom that was coincident with the ice edge (station PS 2.1 in **Fig. 1**). As the sea ice declined the population transitioned to a diatom community. Even productivity rates measured in the deeper regions of the Bay had productivity rates significantly higher than outer shelf waters of the WAP. Photosynthetic quantum yields indicated the populations were still healthy and appeared nutrient replete despite the exceedingly high biomass concentrations (>20 mg Chlorophyll *a* m^{-3}).

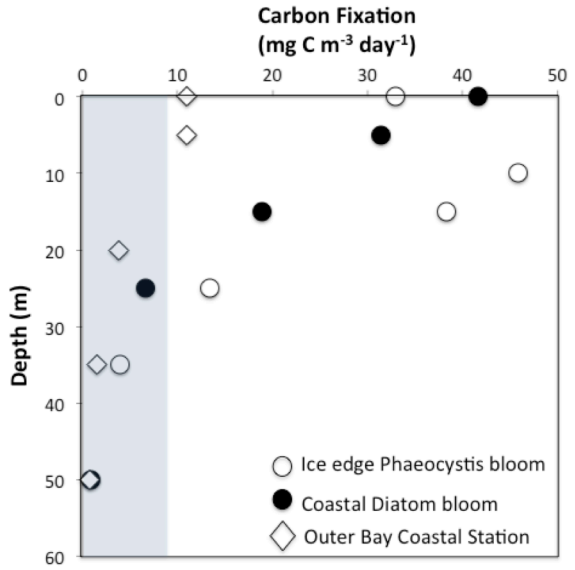

Figure 3. ^{14}C-derived productivity profiles collected offshore Avian Island during Process study 2. The grey shaded shows the range of productivities measured at the shelf LTER sampling stations earlier in the cruise. The *Phaeocystis* bloom was associated with ice edge and had the high productivity peaks measured during the 15-01 cruise to date.

During the process station we collected water for our first incubation experiment. One of the long-standing questions for the Palmer LTER is to what degree the overall ecosystem productivity is shaped by deep seafloor canyons that potentially funnel warm circumpolar water towards the coast. To study this we have initiated a second 5-day experiment to assess the factors leading to enhanced phytoplankton biomass by comparing the relative importance of A) light, B) enhanced iron delivered by the modified circumpolar deep water (mCDW), and C) micrograzer grazing. This experiment was designed to complement the experiment conducted at Palmer Deep during Process Study 1. This experiment was sampled as the ship surveys the LTER grid this coming week. Results of the experiment will not be analyzed until the end of the cruise.

Finally, the intrusions of the mCDW represent the source of heat associated with the observed warming and associated changes in this ecosystem. These intrusions are ephemeral and short-lived making sampling difficult using ship-based sampling strategies. We have thus initiated a glider effort to better understand these intrusions. On Christmas Day 2014, a deep-water glider was deployed and sent to survey the shelf and offshore canyon linked to Palmer Deep. The glider has encountered many intrusions of mCDW and continues to fly well. Working with collaboratively with scientists from Rothera we

launched two British Antarctic Survey gliders in the outer shelf waters (**Fig. 4**). The two gliders will work inshore along the Marguerite canyon, providing complementary data capturing the inshore transport of mCDW. The gliders have already provided the first data back to Rothera.

Figure 4. The deployment of a British Antarctic Survey glider. The inset shows the glider team from the Gould (from left to right, Lindsey Loughry, Alec Chin, and Ana Filipa Carvalho. The picture below shows a glider in the foreground with the LM Gould in the distance.

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

Field Team Members: Deborah Steinberg, Joe Cope, Joshua Stone, Patricia Thibodeau, and Jack Conroy.

In the third week, we conducted sampling and experiments as part of Process study 2, and performed our normal zooplankton sampling operations along the 200, 100, and 000 grid lines. We began the Process Study comparing shallow, ice-edge communities in Marguerite Bay with those further from the ice and also over the deep Marguerite Bay canyon. At the ice edge, where noted above there was a *Phaeocystis* bloom and high Chl a and bacterial procustion, we found high numbers of the Antarctic Silverfish (*Pleurogramma*), consistent with some of our other southern, nearshore stations, and juvenile *Euphausia superba* and copepods were also very abundant. As we moved away from the ice edge where diatoms were dominant, we found fewer fish larvae but still high catches of juvenile *E. superba.* Also as part of Process Study 2, we conducted MOCNESS tows over the deep Marguerite Trough and acoustic surveys in the same

region (see **Fig. 1**). We saw few krill aggregations in the trough, but rather high abundance of copepods. We also conducted three fecal pellet production experiments (**Fig. 5, 6**) to compare particle export by juvenile and adult krill in these more highly productive nearshore stations vs. offshore. As we have made our way south we are seeing more and more krill, especially juvenile *E. superba*, and the ice krill *E. crystallorophias*. At a few of our shelf stations on the 100 grid line, 50% of the adult krill were females with eggs, suggesting a spawning event over the shelf.

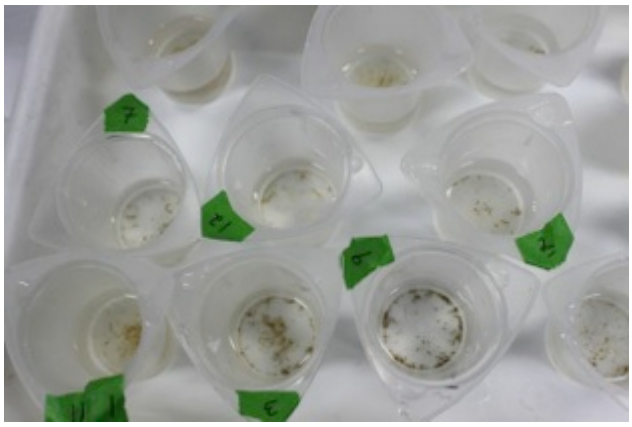

Figure 5. Krill fecal pellets collected from an incubation experiment to measure fecal pellet production rates.

Figure 6. Krill fecal pellets magnified under microscope.

C-013: Seabird Component (William Fraser, PI)

Field Team Members: Carrie McAtee and Ben Cook

Our work during the second and third week of LTER 15-01 included research at Avian Island, where we occupied a field camp for 5 days (January 14-19) (**Fig. 7**). With help from a crew of ASC folks and grantees, our camp set-up was very successful and quick. During our stay on Avian Island we focused primarily on the breeding success and foraging ecology of Adélie penguins. While there, we conducted breeding colony censuses, weighed and measured chicks (**Fig. 8**), as well as diet sampled adult Adélie penguins. In addition, we completed full island surveys for nesting Southern Giant Petrels, Blue Eyed Shag and marine mammals. We collected skua fecal samples, Adélie chick feet for stable isotope analysis, Blue Eyed Shag boli, as well as excrement material from our sediment traps to extract fish otoliths and further examine Adélie penguin diets.

Since our stay on Avian, back aboard the Gould we finished sorting and processing our diet samples. Also, we have continued bird and marine mammal surveys along the 100, 000, and -100 long-term grid lines and just begun our surveys during the third process study station near Charcot at the ice edge. We are interested to see if our observations show a contrast between the open ocean and ice-dominated areas and their associated avian fauna.

We'd like to thank the MPC, Lindsey Loughry, for all of the logistics planning and check-ins while we were camping. Also, thanks to those who carried our heavy, awkward gear during and

after camp deployment, helped with communications support, and braved the drenching seas during our pick-up.

Figure 7. Avian Island, showing camp (at far left).

Figure 8. Adélie penguin chick 'creche' (grouping) on Avian Island.

C-024: Cetacean Biology & Ecology (Ari Friedlaender, Oregon State University, PI).

Field Team Members: David Johnston (Co-PI). At Palmer Station: Andrew Read (Co-PI) & Zach Swaim.

During the third week of science operations we were largely hindered by poor weather and visibility as well as a general lack of whales in the southern portion of the study area. As part of a new project seeking to assess regional/ seasonal variability in the diet of crabeater seals, we collected (4) scats from ice flows in the process station area. These scat samples will be assessed for hard parts to identify diet components, in particular the species of krill consumed. Dietary components will also be assessed through molecular assays to identify which species of krill are being consumed in this location. These diet assessments will be compared to the krill species composition of net tows in the area.

Figure 9. Dr. Dave Johnston demonstrates the proper technique for collecting a crabeater seal fecal sample from an ice floe.

B-023: Trace Metals (Rob Sherrell, Rutgers U., PI).

Field Team Members: Rob Sherrell & Jessica Fitsimmons

The trace metals group continues to enjoy successful sampling and safe deployments. We have completed all planned stations on the 100 and 000 lines, and have collected numerous underway samples of surface water using the trace metal towfish, which has functioned well for hours-long tows, after some minor repairs. In addition to our continued sampling for dissolved and particulate bioactive metals, we have now completed our sampling for dissolved Neodymium (Nd) isotopes, which focused on detailed 2-D inshore-offshore sections on lines 600 and 100/200. Results from these samples will tell us about continental sources of Fe and other trace metals, using the source-specific Nd isotope ratios as a quasi-conservative tracer.

Postdoc Jess Fitzsimmons has also initiated a second mixing/incubation experiment during our second process study using deep water from the Marguerite Trough (where metal-clean water was also collected for Filipa Carvalho's second incubation experiment) and off-shelf phytoplankton inoculate from a location between 100.160 and 000.140. This will be harvested in about a week and will complement the earlier large incubation experiment in revealing the relative bioavailability of dissolved, particulate and colloidal forms of Fe.

We continue to carry out our +/- Fe addition experiments at each full profile station, using surface water collected on arrival to the station using the towfish. Based on experience earlier in the cruise, we are now incubating these experiments for 1-3 additional days, depending on initial biomass. Experiments initiated earlier in the cruise have now been harvested and processed for future HPLC pigment analysis. Visual examination of these filters is showing clear evidence for Fe limitation at some stations and not at others, sometimes in geographical patterns that we did not expect (**Fig. 10**, next page).

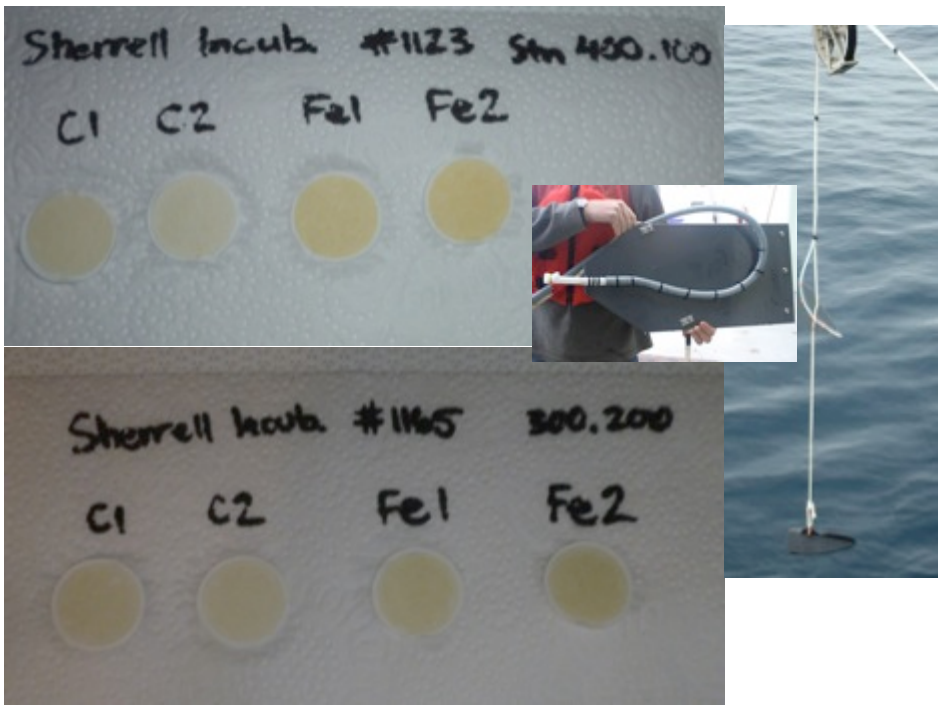

Figure 10. Fe-addition incubation results for stations 400.100 and 300.200. Water was collected using the trace metal towfish (inset) and incubated in duplicate control (C) and +Fe (Fe) for 5-6 days. The more intensely pigmented +Fe filters suggest that Fe-stress or limitation was structuring the phytoplankton assemblage at these stations. Full pigment analyses using HPLC, and macronutrient concentrations at time of harvest, will tell a more complete story.