LMG 15-01: 29 Dec. 2014 – 09 February 2015, PAL LTER Cruise 23
Weekly Science Report II

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 2 overview (Deborah Steinberg, Chief Scientist):

In Week 2 of the annual LTER cruise (12-18 Jan.) we sampled the 400, 300, and 200 grid lines. Regular station operations occurred at representative coastal, shelf, and slope stations along the lines. We deployed the birder team on Avian Island for the annual census and sampling of the Adelie penguin colony there (**Fig. 1**). We also made our annual visit on January 17 to the British Antarctic Survey (BAS) Rothera Base, and hosted British and Dutch scientists on a day cruise to carry out joint water sampling with the CTD at three regular stations in Ryder Bay (**Fig. 2**).

During recovery of our fourth and final physical oceanographic mooring at 300.100, part of the mooring line became entangled in the propeller, cutting the mooring line and resulting in the loss of 4 temperature/depth sensors, 1 set of floatation, and 1 acoustic release. We were able to recover the rest of the sensors and floatation, but part of the mooring line still remains wound around one of the propeller blades. SCUBA divers at Rothera were able to remove much, but not all, of the line. Due to concerns about damage to the propeller seal (or other components), we will continue science operations without the use of the starboard engine for the rest of the cruise, which will reduce our transit speeds from an average of 10 nm/ hr. to ~7.5-8 nm/ hr. We are adjusting our schedule accordingly.

Figure 1. Birders heading out with ASC support staff to set up 5-day field camp on Avian Island.

Figure 2. CTD cast in Ryder Bay near the British Antarctic Survey (BAS) Rothera Base.

Individual component reports:

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

Field Team Member: Naomi Shelton

As mentioned above, while recovering the legacy mooring at 300.100, the line became tangled in the prop and sensors located at the deepest section of the mooring, as well as the release, were not recovered. Fortunately, the majority of the sensors were recovered, and we can continue to track the water masses occurring at that location. We are grateful for the efforts by the ASC and ECO helping us to move forward with the cruise, and we are still able to deploy all of the 4 new moorings for 2015.

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.

This past week we sampled regular grid stations on the 400, 200, and part of the 300 line. We also began the second process study in Marguerite Bay, encountering the coastal ice edge near 200.-080 grid station. Bacterial production rates along the 600 line from last week's sampling indicate a decrease as we move offshore (**Fig. 3**). Along the 500 line bacterial production rates increased with distance from the coast, but the overall rates at the 500 line were lower in the surface waters midshelf and inshore compared to those of the 600 line. The offshore profiles look similar for both lines, with higher rates on the 500 line versus the 600 line.

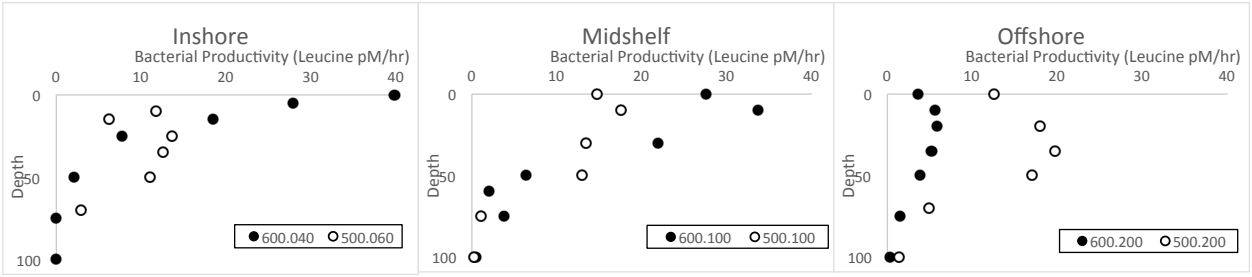

Figure 3. Bacterial production along the northern (600 and 500) grid lines from the coast to offshore.

In addition to our core measurements, we are collecting samples for several collaborators: Dr S. Henley (Univ of Edinburgh and BAS, carbon and nitrogen isotopic composition of nitrate and particulate organic matter), Dr. M. Meredith (BAS, oxygen-18 isotopic composition of seawater). Our visit to the British Antarctic Survey base at Rothera enabled us to drop off the oxygen-18 samples. Our collaboration with BAS has been an enjoyable one and we always look forward to our port call at Rothera while aboard the R/V Laurence M. Gould.

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

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

The second week of sampling focused on making core measurements along the LTER transect lines. Daily productivity rates showed significant variability between the inshore and offshore stations. On the northern transect line phytoplankton productivity declined by almost an order of

magnitude between the inshore and offshore stations (**Fig. 4**). On the northern 600-line, high coastal productivity was observed halfway across the continental shelf (600.100) before substantially decreasing offshore. Production in offshore waters on the 500-line were similarly low as the offshore 600-line. Production mid-shelf and nearshore along the 500-line was lower than the more northern 600-line (**Fig. 4**). Primary production this year appears lower than previous years, which is mirrored by the low chlorophyll a observed in the flow through and filtered chlorophyll samples. The fluorescence quantum yields indicate communities of moderate health. Nearshore stations further to south (400 and 200-lines) show higher production values comparable to the stations near Palmer Deep.

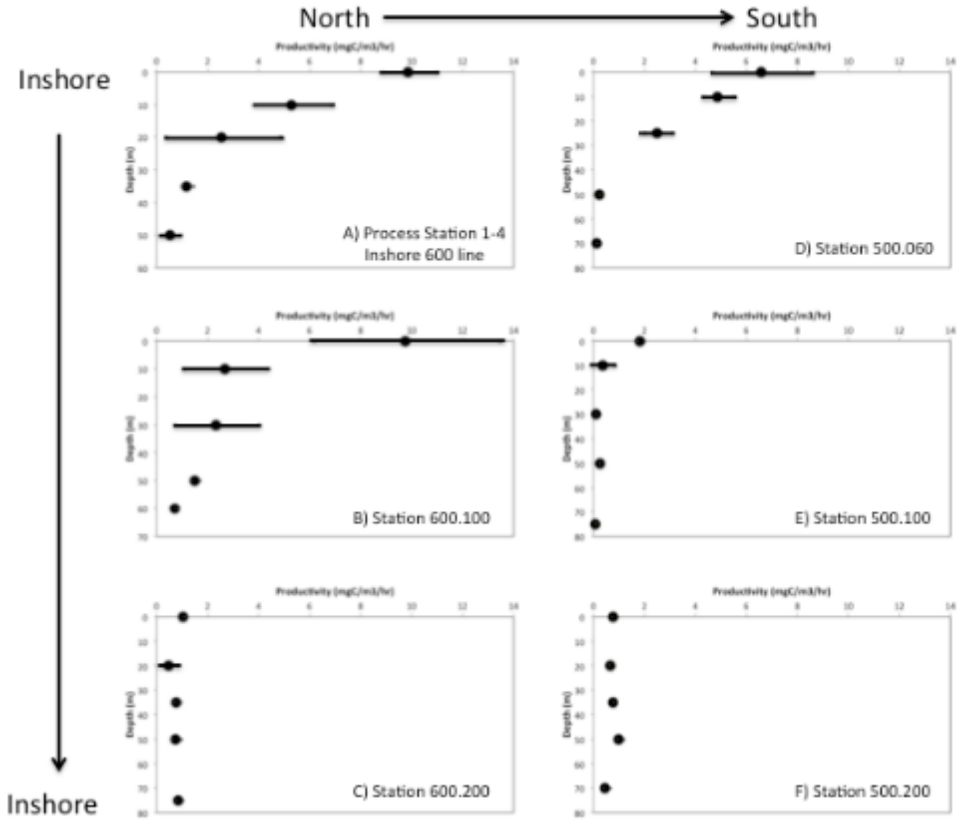

Figure 4. Primary production results for the northern 600 and 500 lines.

During the first 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 initiated a 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. Samples from the experiment won't be analyzed until the end of the cruise, but initial qualitative observations suggest populations grew well within the incubators, which is promising for the experiments (**Fig. 5**). The experiments will be repeated at Process Study 2 using water collected from the subsurface canyon stations at Avian island.

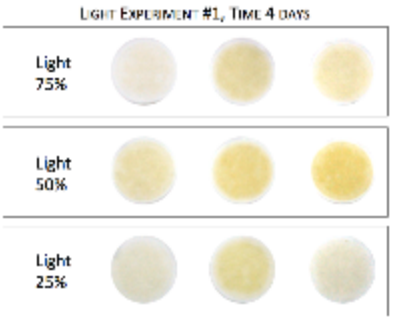

Figure 5. Final filters collected during the deck-board light gradient experiment showing difference between treatments.

Finally, the intrusions of the mCDW represent the source of heat associated with the observed warming and associated changes in the WAP ecosystem. These intrusions are ephemeral and short-lived, making sampling difficult using ship-based sampling strategies. To that end we 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 (**Fig. 6**). We will attempt to apply thermal wind equations to estimate the transport of water identified as mCDW. We thus conducted two ship-based ADCP surveys at the head of the nearshore and offshore entrance and the data will be combined with glider data to provide more robust estimates of the heat inputs onto the WAP. Discussions are underway how to use the remainder of the battery power on this deployment. Current thoughts are to conduct a mid-shelf of survey of the canyon (thin pink line) or canyon slope surveys inshore close to the Converge gliders (bold zig-zag blue and pink lines at Palmer deep).

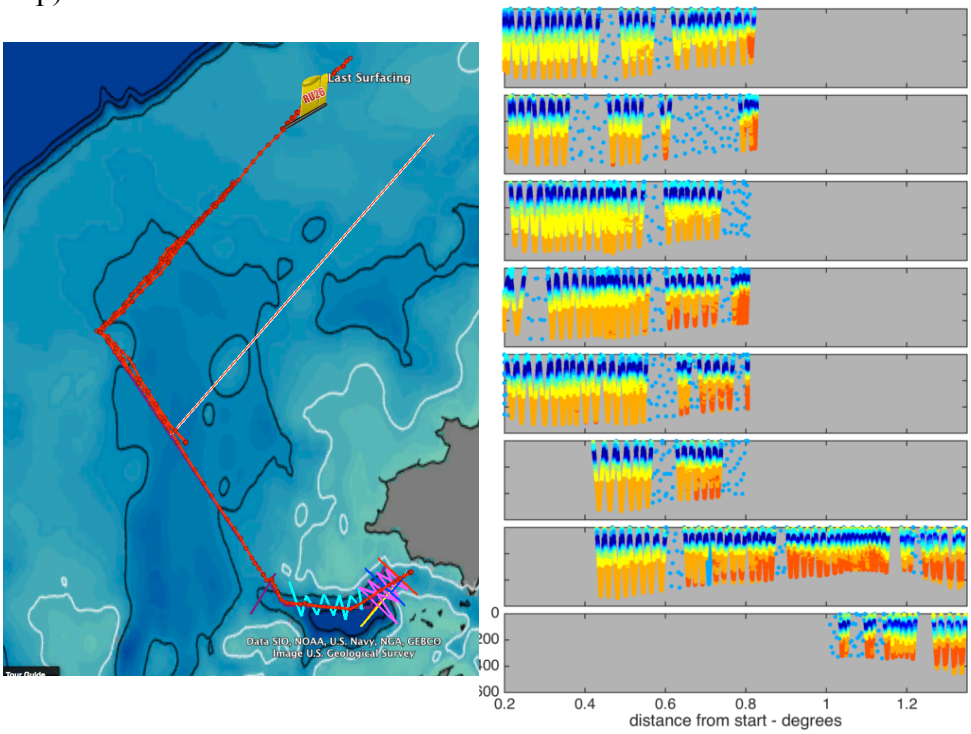

Figure 6. Deep water temperature surveys at the offshore mouth of the canyon that presumably feeds mCDW into the Palmer Deep. Glider transects (right) show intrusions of warm mCDW water at depth indicating a consistent inflow of heat at the canyon mouth.

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

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

In the second week, we concentrated our normal zooplankton sampling operations along the 400, 300, and 200 grid lines. In 400 and 200 line coastal waters (400.040 and 200.040) we found juvenile euphausiids (both *Euphausia superba* and *E. crystallorophias*) and fish larvae, with adult *E. superba* over the shelf. We conducted both a DOM excretion experiment and a fecal pellet production using adult *E. superba* from the shelf station (400.100). At all slope stations (400.200, 300.200, and 200.180) we encountered salp blooms again. The 400.200 salp bloom was particularly large and the weather was calm with salps clearly visible in surface waters, so we were able to to hand-collect them. We were thus able able to sample individual chains of salps and the large solitary stage, and quantify hyperiid amphipod (crustacean) parasites associated with them, to compare with those we sampled further north at 600.200. We were interested to find that a further inshore station on the 200 line (200.000) was nearly exclusively copepods (*Calanus propinquus*) in high abundance (**Fig. 7**), with very few euphausiids. This station is over a deep region of the Marguerite Bay canyon (~735 m), which may be the reason for the different assemblage there compared to 200.040.

We have also sampled high numbers of fish larvae, mostly those of the Antarctic Silverfish (*Pleurogramma*) in the nearshore, southern stations. This is consistent with previous years, and of interest as *Pleurogramma* is an important component of the Adelie penguin diet, especially in the southern (Avian Island) colony. We have not found *Pleurogramma* larvae in the northern stations, consistent with Adelie penguin diet data from there, and W. Fraser's hypothesis that *Pleurogramma* may be functionally extinct in the northern WAP due to warming.

Zooplankton tows have been going smoothly (**Fig. 8**), and all incubators and other equipment working well.

Figure 7. *Calanus propinquus* copepod.

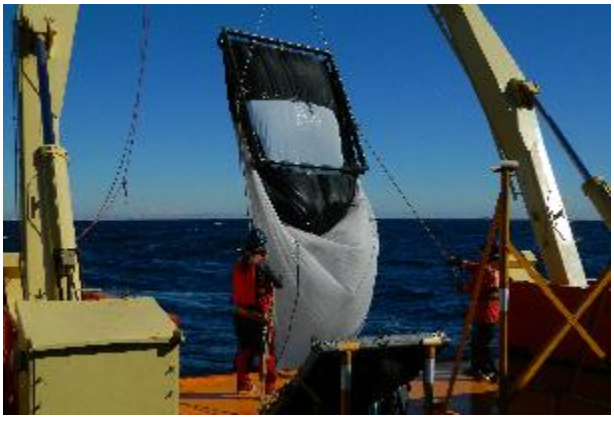

Figure 8. Deploying the large, 2-m square Metro net used for sampling krill and other macrozooplankton on an unusually sunny day this week.

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

Field Team Members: Carrie McAtee and Ben Cook

The seabird component has been at Avian I. most of this week and will report on the next sit rep.

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 second week of the LTER we continued visual surveys for whales as we moved south along the sampling grid. Conditions were generally not favorable for observations or deploying the Zodiac for biopsy and satellite tag deployment. As we have moved south, we have noticed a considerable decrease in the number of humpback whales. Generally speaking, we believe that this reflects the magnitude of winter sea ice and the timing of its retreat. This has likely led to a significant phytoplankton bloom well to the north, near the Bransfield Strait and whales returning from their migrations (from North to South) would likely encounter suitable feeding areas without having to venture very far south. Over time, this is likely to shift and whales will fill in the LTER study region. Reports from Palmer Station are that whales continue to be seen in increasing numbers, which supports our hypothesis.

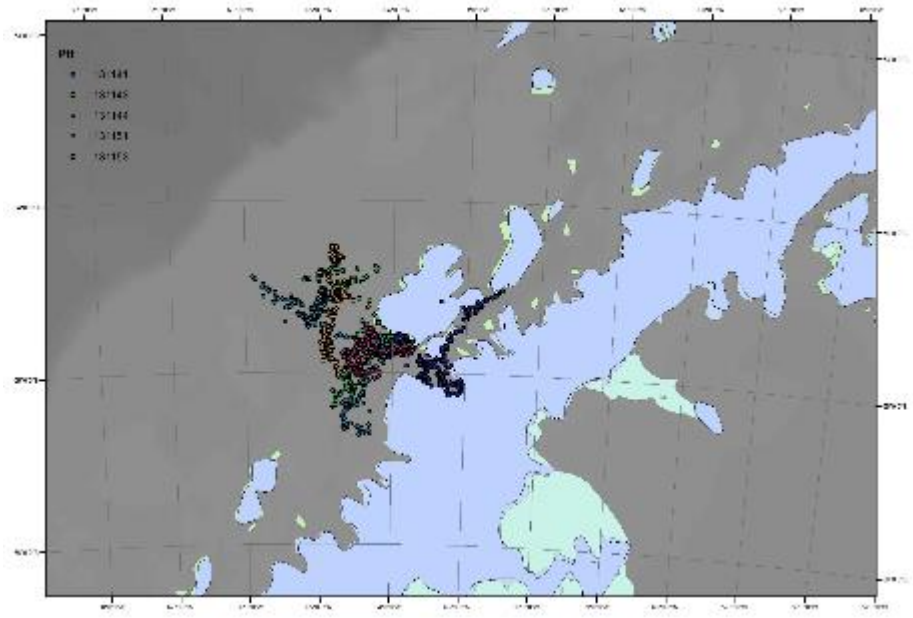

Figure 9. Satellite tag positions from 5 Humpback whales. All tags were deployed last week.

All of the satellite tags that were deployed earlier in the cruise are still working. The duty cycle of these tags was set to transmit positional information whenever possible, rather than a more typical duty cycle of transmitting for four hours every 8 hours. The duration of the tags will likely be ~ 2 months and during that time we will be able to collect enough positional information (at a fine enough resolution) to create state-space models that characterize different behavioral states based on swim speeds, turning angles, and other space-use metrics. This

information will be critical for us to determine where feeding areas occur, how long whales feed, during which times of the day they are more likely to be feeding, and how large the areas are over which whales forage. These questions are central to testing our LTER hypotheses and understanding the concurrent and sympatric foraging ecology of krill predators within the LTER study area. The map above shows the five satellite tags and all of their positional information (**Fig. 9**). Four of the whales have remained south of Anvers Island and continue to feed in the continental shelf waters to the south and west of the Island. One whale moved to the east, spending time in Flandres Bay before moving north along the western side of the Gerlache Strait.

On 17 January we had the unique opportunity to conduct an aerial survey around the Peninsula using resources made available by BAS at Rothera Station. We believe this to be the first fixed-wing survey for whales conducted in this region. Over the course of 4.25 hours we covered over 720 km flying south to north along the bays and nearshore waters around the western side of the Antarctic Peninsula up to Anvers Island, and then back south to Rothera. We had perfect conditions and we sighted over 65 whales (all humpback whales except for 2 sightings of minke whales along the fast ice edge), the largest aggregations of which are highlighted on the map of our survey below (**Fig. 10**).

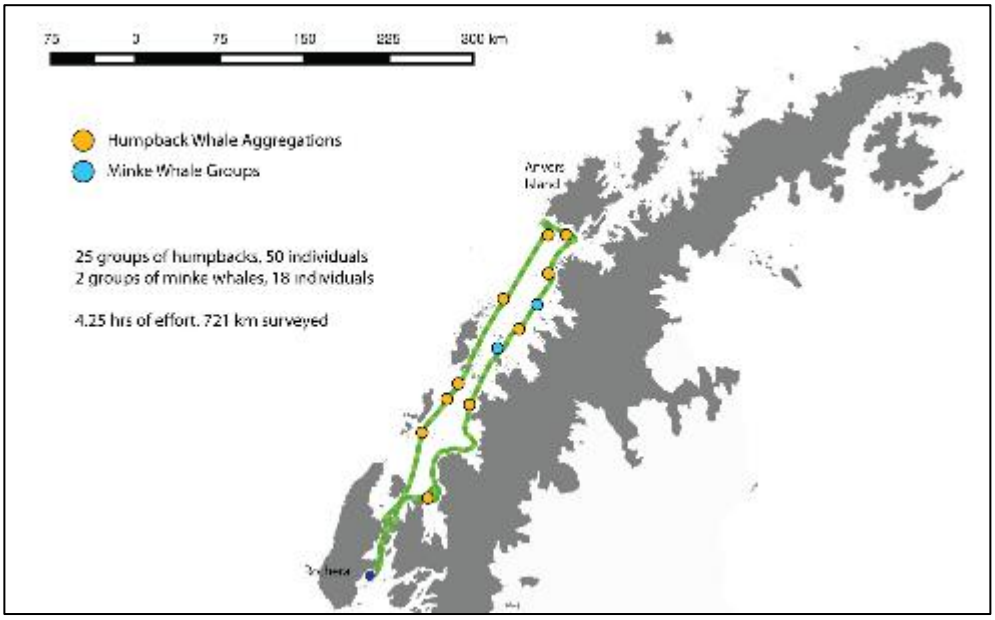

Figure 10. Whales sighted from aerial survey around the Peninsula.

Below are two images from the aerial survey. The first shows a fast ice edge in Crystal Sound with winter sea ice still intact but beginning to fracture into pack ice (**Fig. 11**). The second image was taken on our final approach to Rothera Station and the LM Gould can be seen at the south end of the runway tied up to the pier (**Fig. 12**). Rothera Station is on the left.

Figure 11. Fast ice edge in Crystal Sound as seen by aerial survey.

Figure 12. Rothera station and runway, with L.M. Gould in the background.

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

Field Team Members: Rob Sherrell & Jessica Fitsimmons

The trace metals program has been a great success so far, thanks to full incorporation into the LTER sampling plan, and continued support from the captain, crew, and ASC staff. We have collected vertical profiles of all of our dissolved, particulate and colloidal sample types at every planned station on the 600, 500, 400, 300 and 200 lines, except for the inner shelf station on the 300 line and the off-shelf station 200.180. The former was skipped overall as a station due to logistical issues, and will be sampled later in the cruise. The latter occurred during our first spate of rough weather, with winds sustained in the 30 knot range. Given observed loads on the main CTD wire, we decided not to deploy the trace metal rosette, given the rolling loads likely to be sustained by the much more fragile non-metallic cable. It was a bit of a shame to lose this station, as we had been sampling especially intensively on the 200 line for variables like Nd isotopes. But we are focused on maintaining the excellent performance of the trace metal CTD/rosette (**Fig. 13**) that we have enjoyed to date. Fortunately, we hope to get a relatively deep 1750m deployment at 100.160 which we expect will be relatively comparable to the missed offshelf 200 line station.

In addition to station work, we have been taking surface samples using the trace metal towfish, every 20km along all the LTER grid lines. These will provide the kind of high-resolution trace metal concentration maps that we can compare with our results from 2010, 2011 and 2012. A few wear and tear issues with the towfish, related to being towed for hours at full speed, have been repaired quickly.

Incubation experiments have been keeping us busy as well. A number of incubation experiments initiated earlier in the cruise have been harvested and processed in the last few days, after 5-6 days of growth. These include the Fe addition experiments at each normal station, which have demonstrated Fe stress or limitation even at inshore and mid-shelf stations of the northern grid. Postdoc Jess Fitzsimmons' large mixing experiment intended to explore the relative

bioavailability of various phsico-chemical Fe fractions in waters taken from the Palmer deep, has also been terminated. Seawater from these incubation bottles is being processed for HPLC pigments, metagenomic RNA analysis, macrionutrients and residual dissolved Fe. The very preliminary findings based on visual inspection of HPLC filters suggest that the biomass dilution inherent to the experiment design may require longer incubations than the planned 5 days – filters showed low biomass on all treatments, challenging conclusions based on visual comparisons. A modified version of this experiment will be conducted in the coming days using deep water from Marguerite Bay and offshelf biomass from 100.160.

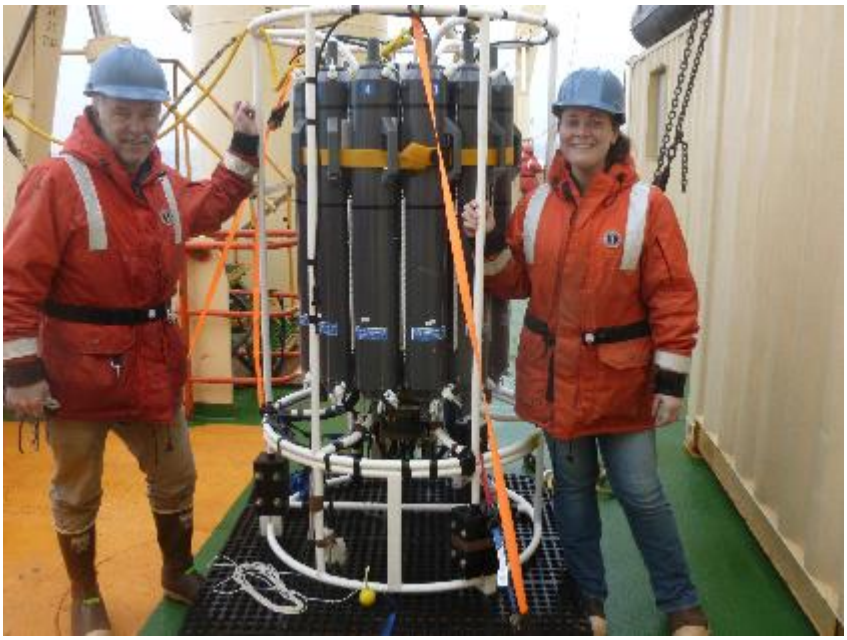

Figure 13. PI Rob Sherrell and postdoc Jess Fitzsimmons celebrate another successful recovery of the trace metal clean CTD/rosette.