LMG 15-01: 29 Dec. 2014 – 09 February 2015, PAL LTER Cruise 23
Weekly Science Report IV (week of 26 Jan - 1 Feb)

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 4 overview (Deborah Steinberg, Chief Scientist):

In the fourth and final week of the annual LTER cruise (26 Jan – 1 Feb), we finished regular grid stations on the -100 line, completed Process Study 3 in the coastal ice-covered region west of Charcot Island (**Fig. 1**), deployed four physical oceanography moorings, recovered two LTER time series sediment traps, and deployed one trap. The purpose of our third process study was to conduct a comparative ice edge study, sampling plankton communities in ice-edge waters vs. outside the ice (**Fig. 2**). Our aim was to examine plankton community structure changes, and how this may affect biogeochemical cycling in these two environments. We also use it as a comparison to the ice edge work we did in Process Study 2, and on an earlier PAL LTER cruise (LMG 12-01).

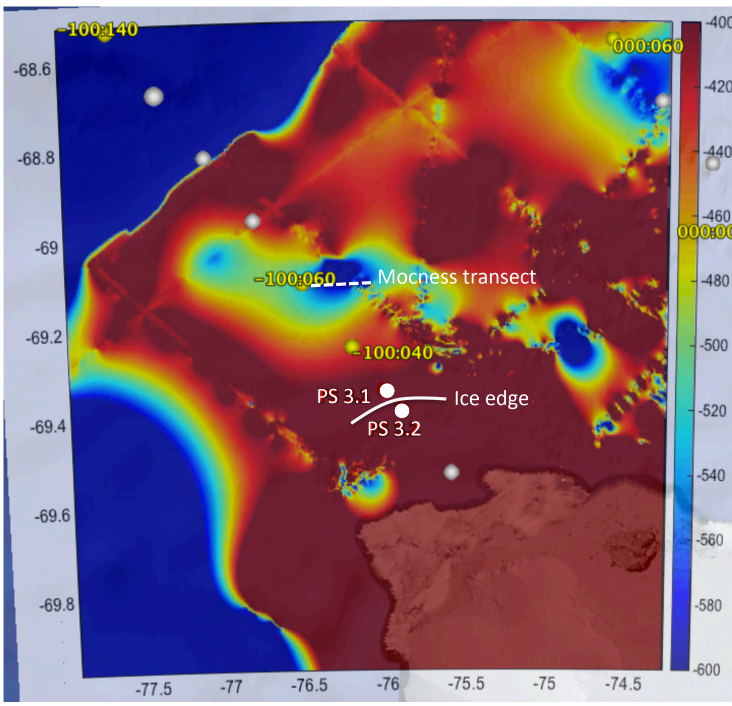

Figure 1. Map of stations occupied during LTER cruise Process Study 3 along -100 line and northwest of Charcot Island. Contours are depth (m). Process Study stations occupied include PS 3.1 outside the ice edge, PS 3.2 inside the ice edge, and several grid stations shown in yellow were also sampled. A MOCNESS survey was run across a deep canyon axis east of -100.060 (dashed white line).

Figure 2. The ice edge at Process Study 3.

Overall, we had a very successful cruise. We were able to complete sampling at all of the regular grid stations in our cruise plan, and recover and deploy all our moorings and traps. While the complications from the mooring line being caught in the propeller did slow our transit times, and made it harder to maneuver in the ice, we were able to successfully adjust our schedule and sampling plan to accommodate. We express our thanks to all members of the ECO officers and crew, Lockheed/ASC contractor support team, Palmer Station and Punta Arenas science support personnel for indispensible and professional help, without which our work could never be accomplished (see full personnel lists of the science support team and ship's officers and crew appended).

Final weekly reports from each of the science groups are given below. We also append group photos of each science team.

Individual component reports:

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

Field Team Member: Naomi Shelton

Over the past week, we successfully deployed all 4 moorings at the following locations: 300.100, Palmer Canyon (Head), Palmer Canyon (Mouth), Palmer Canyon (Deep). The 300.100 mooring is a legacy mooring that has been an important part of LTER data collection. The Palmer Canyon moorings are located with the aim to better understand upwelling dynamics there, which we believe is contributing to higher productivity. Thanks to the ECO and ASC staff for their effort assembling the moorings and ensuring their proper deployment. Despite losing part of the 300.100 mooring in recovery, we consider the physical oceanography component a success, with 3 full moorings recovered all 4 moorings redeployed. We look forward to their recovery when we return next year.

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.

We completed sampling for all core measurements along the LTER -100 survey line during the past week, including a process study along the ice edge at the -100 line. The bacterial productivity rates at the southern ice edge near the -100 line were similar to those at the first process study near Palmer canyon (**Fig. 3**). This is an interesting area, due to the presence of a freshwater layer in the upper water column.

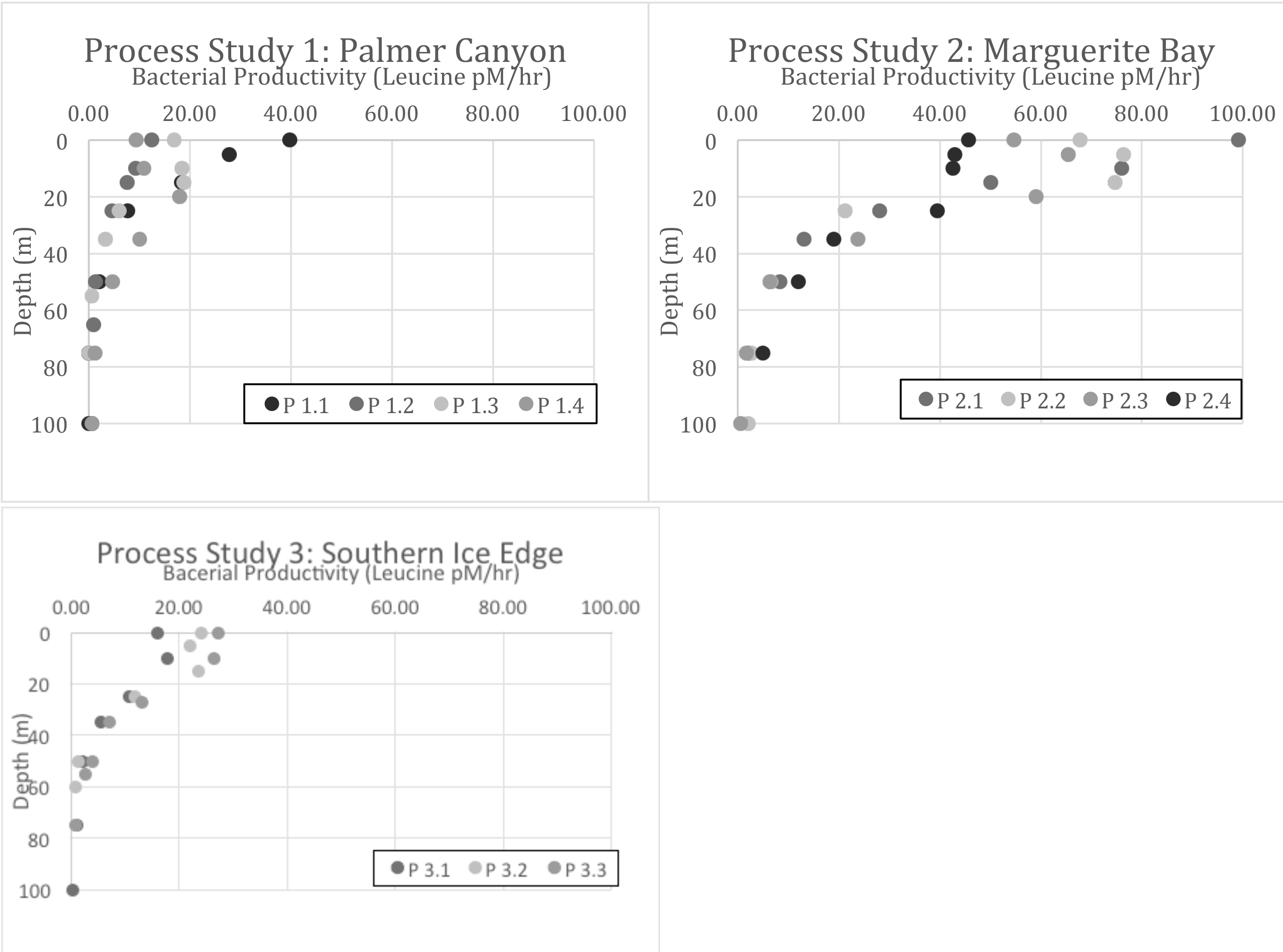

Figure 3. Bacterial production in Palmer Canyon and Marguerite Bay compared to the Southern Ice edge.

This week also included the recovery and deployment of our sediment traps (**Fig. 4**). We successfully recovered the two LTER sediment traps near Grid location 585.131, about 70 miles west of Palmer Station, mid-shelf in 350 m water depth. The principal objective of the sediment trap component of our project is to provide a long-term record of year-long particle sedimentation, or export from the ocean surface layer. Carbon export is a mechanism for supplying the deep ocean and benthos with organic matter produced in the surface layer, and for storage of carbon away from exchange with the atmosphere. The LTER has deployed a time series, 21-sample McLane PARFLUX conical trap (see photo) since 1991. The two previous years, we have also deployed a trap with a different design, the Technicap 24-sample cylindrical trap. The two traps are located 1 mile apart and are synchronized to open and close each sample cup simultaneously. By deploying the two trap designs side by side over several years we hope obtain a better estimate of their particle collection efficiency, and possible sampling biases. Due to time constraints this year, we were only able to deploy the McLane conical trap, but both trap recoveries were successful and we plan to redeploy the Technicap cylindrical trap next year.

To better understand the sedimentation process and trap collection efficiency we also measure the amount of Thorium-234 carried into each trap on settling particles. Comparison with the Th-234 deficit in the overlying water column provides a direct estimate of capture efficiency.

The ASC science team provided outstanding support with sediment trap operations and all during our cruise. MTs Meredith Helfrich and Hannah Grey successfully recovered the traps, rigged and rebuilt the moorings and deployed the traps. ETs Mike Coons and Alec Chin turned around the dual mooring releases for the mooring and reconfigured a release to allow for our physical oceanography component to deploy a mooring in the deepest part of Palmer Canyon. MPC Lindsey Loughery organized and oversaw the successful operation from start to finish.

Figure 4. Sediment trap deployment.

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

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

The fourth week of sampling was highly successful. We completed our annual survey of the WAP for the LTER cruise. During the effort we collected 34 vertical casts for *in situ* absorption and attenuation using the ac-9 WetLabs instrument (**Fig. 5**). From the community CTD cast we collected 239 samples for both extracted chlorophyll *a* and high performance liquid chromatography pigment measurements. This was complemented with 239 discrete measurements of phytoplankton using the FIRE sensor. We additionally collected 30

Figure 5. The ac-9 deck team celebrating a successful and stressful deployment in the ice.

slides for SEM and 30 preserved samples for phytoplankton identification back at Rutgers. The samples were collected during the traditional sampling cross-shelf transect lines and the 3 process stations. Early results suggest that the 2015 was a productive year for phytoplankton (**Fig. 6**).

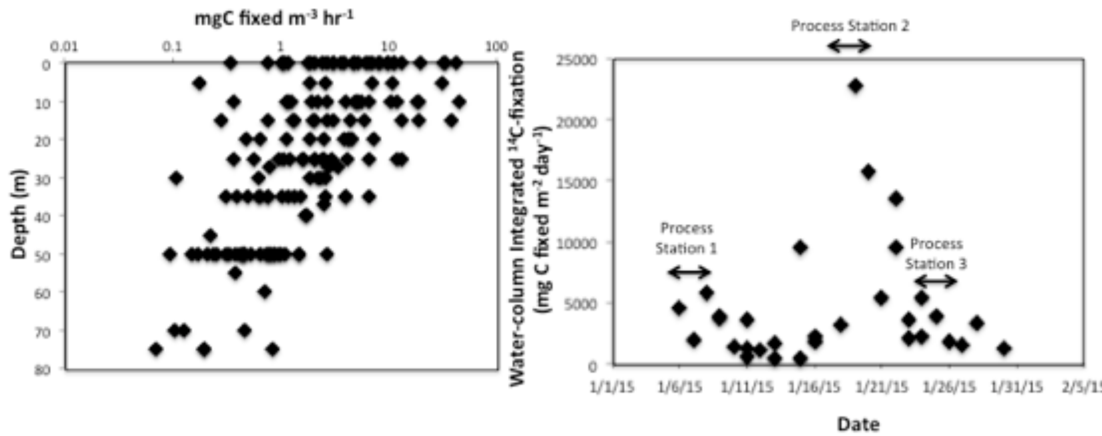

Figure 6. Preliminary 14C-data from the 15-01 LTER cruise. The productivities generally show a decline with depth, which tracks the exponential decay of light. The 3-order range of productivity is typical compared to prior years of LTER data. Note the anomalously high productivity at Process Study/ Station 2.

During the 15-01 cruise, we conducted incubation experiments at all three Process stations. The process studies were designed to assess the importance of light, trace metals, and micro-grazing in regulating the productivity in the sea floor canyons associated with sustained penguin colony populations. This effort addresses one of the long-standing questions for the Palmer LTER: to what degree is the overall ecosystem productivity shaped by deep seafloor canyons that potentially funnel warm circumpolar water towards the coast? This experiment was designed to complement the experiment conducted at Palmer Deep during Process Station 1. This experiment was sampled as the ship surveys the LTER grid this coming week. Results of the experiment won't 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 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 collaboratively with scientists from Rothera, we launched two British Antarctic Survey gliders in the outer shelf waters. The British glider has been making good progress towards the coast, and during the transit the presence of warm bottom water eddies were clearly identified. The Rutgers glider completed it mission and was recovered by our science team onboard the LM Gould on January 31st. Data from the British glider are shown in **Fig. 7**.

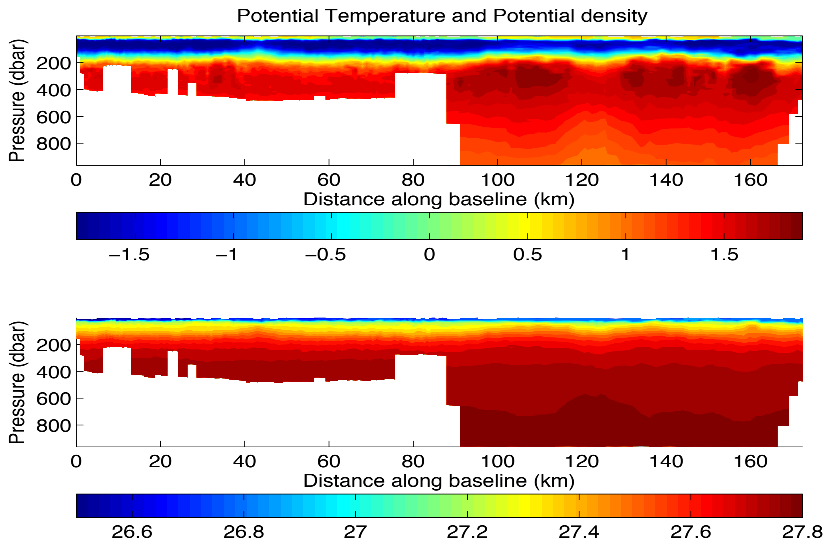

Figure 7. Data collected by the British glider, which complements an offshore LTER glider. In the potential temperature the eddies of modified circumpolar deep water is visible as warm water present between 200 and 400 meter water depth.

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

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

In the fourth week, we concentrated our efforts on Process study 3. We began the Process Study comparing ice-edge zooplankton communities (**Fig. 8**) with those further from the ice and also further away over the a deeper canyon on the shelf and away for the ice (analogous to some of the sampling we did further north in our other process studies). One notable difference was higher abundance of the ice krill (*E. crystallorophias*) inside the ice edge, but for the most part we found similar communities at our inside vs. just outside the ice edge stations (PS 3.2 and 3.1, respectively, in Fig. 1 above), which were both largely comprised of adult and juvenile *Euphausia superba* (the latter in very high abundance, **Fig. 9**). We did not find high numbers of the Antarctic Silverfish (*Pleurogramma*) as we did further north, but copepods were also very abundant near the ice. The ice edge was clearly a feeding area for krill predators, with crabeater seals on floes inside the ice edge, and in the water outside the edge (during one of our tows a group of ~25 crabeaters followed the net for a while). As we moved away from the ice edge to stations further out on the shelf abundance of krill decreased.

Also as part of Process Study 3, we conducted day and night MOCNESS tows over the deep canyon (~700m) east of grid station -100.060 (see **Fig. 1**). For the first time we caught *E. superba* in some of our deeper nets (depth interval 250-300m, and deeper) at night. It was evident from the CTD cast here that there was a large nepheloid layer above the bottom, and we wonder if krill were feeding there. We also conducted fecal pellet production experiments at different stations along the ice gradient to compare particle export by juvenile and adult krill in and out of the ice, and as compared to those conducted further north at our other Process study stations.

Figure 8. Towing in the ice.

Figure 9. Juvenile krill (*E. superba*) subsample lined up to be measured.

Overall, we have an excellent set of samples and experiments from this cruise. We are particularly excited about our ability to sample the far southern grid lines and to perform a far south Process Study station. This will allow us to compare MOCNESS tows in 3 deep canyons along the north to south gradient (and with those of previous years). We also completed a thorough ice edge study in both Process Studies 2 and 3 for comparison. Finally, we found salps in the north for the first time in several years, which allowed us to complete a set of DOM excretion experiments, and to perform some new sampling of amphipods associated with salps.

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

Field Team Members: Carrie McAtee and Ben Cook

During the fourth week of LTER 15-01 we were unable to reach Charcot Island for our planned day trip to census the Adelie penguin population and weigh chicks due to heavy ice. Instead, we continued bird and marine mammal surveys along -100 grid line as well as during the third process study at -100.020. We were able to get off on an ice floe that recently had Adelie Penguins on it and collected the minefield of guano they left behind. We were successful in processing the samples collected and found many otoliths– fish ear bones used for species identification. On January 30, we arrived at Prospect Point/Fish Islands and while we were unable to reach any small islands to census the penguin colonies due to ice, we were able to successfully diet sample Adelie penguins (**Fig. 10**) off of nearby ice floes and the shoreline of Prospect Point. Special thanks to MT, Hannah Gray, for maneuvering for hours through the thick ice and to our honorary birder, Lindsey Loughry.

It's been a productive cruise for us; beginning with our continued long-term grid surveys from the bridge, to 5 days camping at Avian, then collecting samples at the ice edge, and ending with Adelie penguin diet sampling at Prospect Point. Thanks to Chief Scientist, Debbie Steinberg and MPC, Lindsey Loughry for their daily logistics and scheduling. We'd also like to acknowledge the folks who shared the hydro lab for staying civil despite our very smelly sample processing and all of the crew of the Gould, including the mates and captain who kept track of us during our outings from the ship.

Figure 10. Adelie penguin stomach contents containing mostly Antarctic krill, *Euphausia superba*.

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.

We continued to collect biopsy samples from humpback whales throughout the LTER study area during week 4. The number of whales encountered seems to increase substantially the farther north and inshore we sail. In the Grandidier Channel and around the Prospect Point area we encountered over 25 humpback whales. Combined with our work from this week, we have collected 36 skin and blubber biopsy samples and have deployed 7 satellite-linked tags. The figure below (**Fig. 11**) indicates the movement tracks of the whales tagged throughout the LTER cruise.

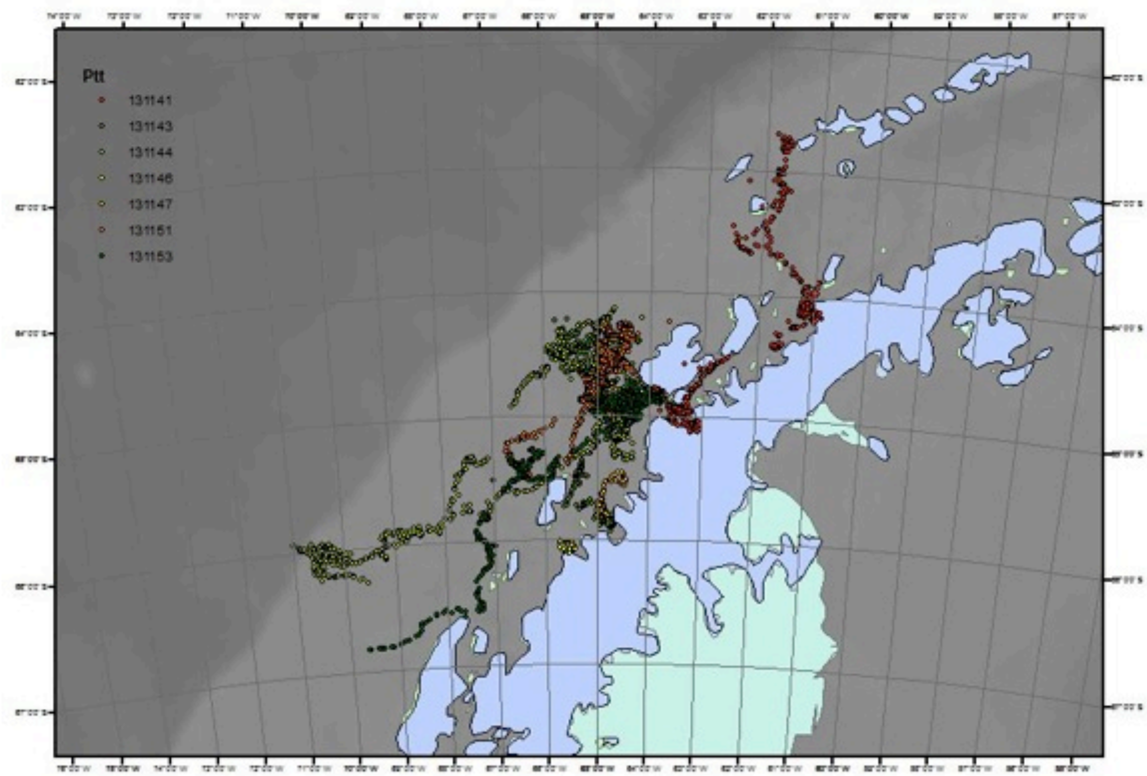

Figure 11. Satellite track of seven tagged humpback whales over 4 weeks.

During week 4 we also processed recordings of the soundscape of Avian Island. Measurements of ambient noise between 100Hz and 20kHz were made using a UMIK-1 calibrated microphone connected to an Apple iPad running the Sound Meter Pro app. Measurements of broad spectrum sound levels were made over 5 minute windows, and 1 minute integrations of standard 1/3 octave band levels were also made. Recordings of sounds were made using the PCM recorder app using the same microphone. Broad-spectrum equivalent sound levels were mapped across bird and seal colonies (**Fig. 12**). A spectrogram of penguin and seal calls from Avian Island is shown in **Fig. 13**. These data will be used to assess potential for noise disturbance for future fixed-wing drone missions aiming to map colony habitats and enumerate seals and penguins. Thanks to Ben and Carrie for making the recordings during their standard operations.

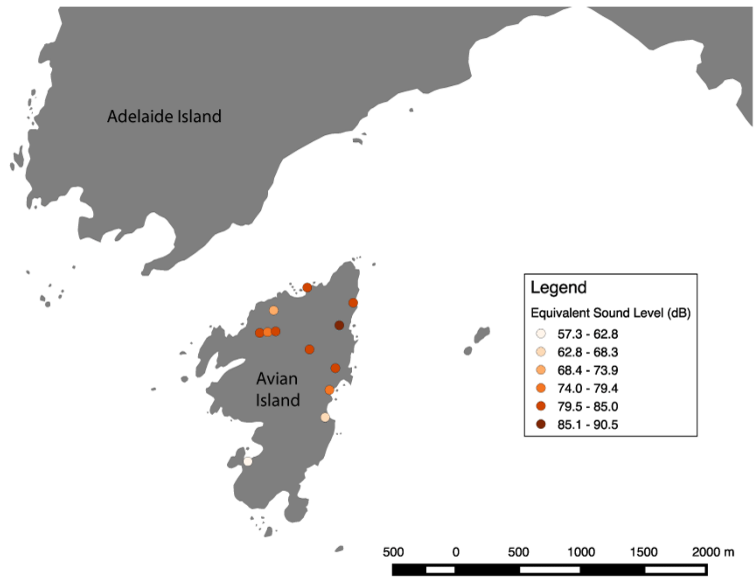

Figure 12. Location of bird and seal colonies on Avian Island where measurements of broad spectrum sound levels were made.

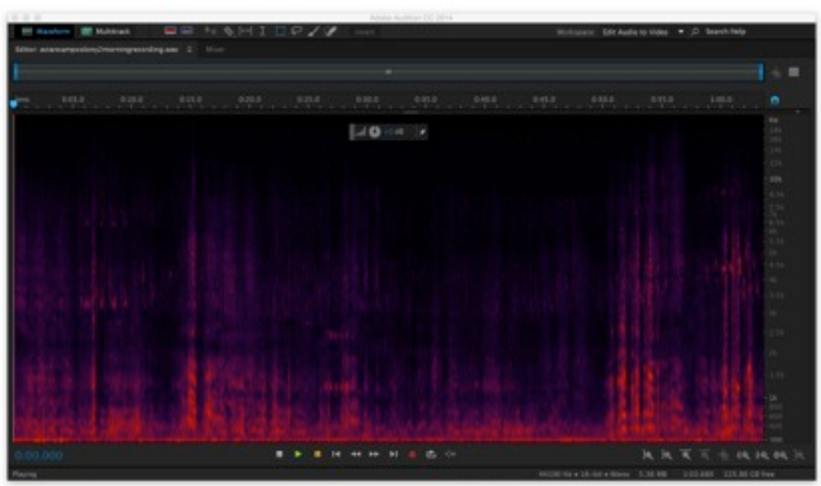

Figure 13. Spectrogram of penguin and seal calls from Avian Island.

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

Field Team Members: Rob Sherrell & Jessica Fitsimmons

The trace metals group finished all sampling this week, covering the entire LTER grid as planned, from the 600 to the -100 lines, except for two stations, where we didn't sample due to rough weather and the tenuous and uncertain strength of the non-metallic trace metal cable.   The trace metal towfish continued to work well, allowing us to complete our sampling of surface water between the stations, in coordination with the Ducklow and Schofield groups.

Postdoc Jess Fitzsimmons completed a second mixing/incubation experiment using deep water from Marguerite Trough and off-shelf phytoplankton inoculate from a location between 100.160

and 000.140 (**Fig. 14**). Results await analysis of samples for pigments, genomics, macronutrients, and residual dissolved Fe.

We also completed the set-up of our +/- Fe addition experiments, carried out at each full profile station, using surface water collected on arrival to the station using the towfish. All but one of these incubations has been harvested. Most of the results for the southern region of the WAP show Fe replete conditions (based provisionally on visual observation of filter colors) but the off-shelf station 000.140 showed strong evidence of an Fe addition response after slightly more than a week of incubation.

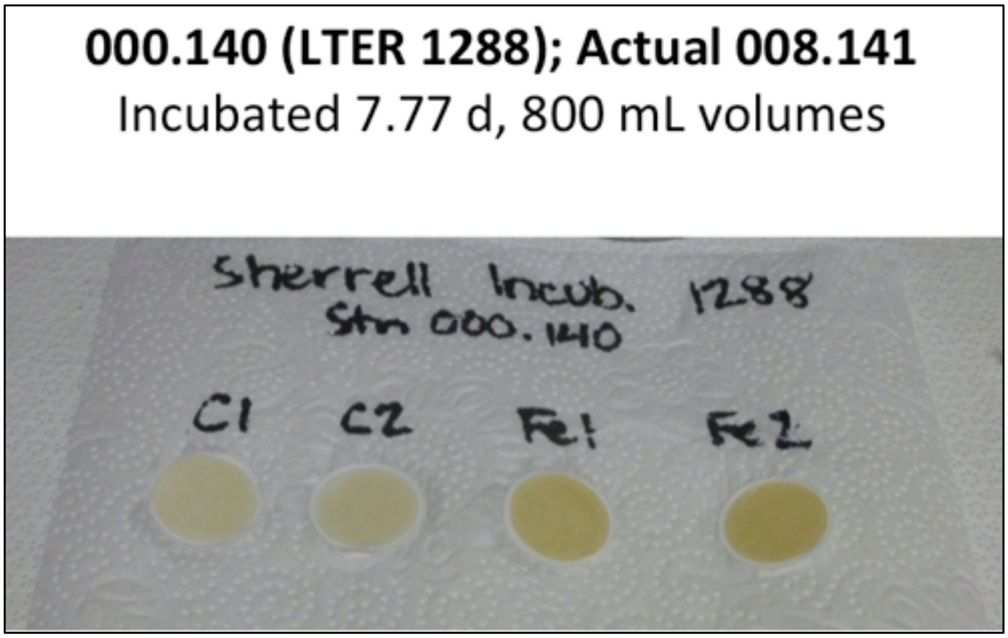

Figure 14. Fe-addition incubation results for offshore station 000.140. Water was collected using the trace metal towfish and incubated in duplicate control (C) and +Fe (Fe) for 5-6 days, in duplicate for each condition. The more intensely pigmented filters from the +Fe addition suggest that Fe-stress or limitation was structuring the phytoplankton assemblage at this station.

Overall, despite concerns with broken and lost equipment shortly before the cruise, the trace metal group had an extremely successful expedition. The majority of results await further work in our shore lab at Rutgers University, but all indications suggest that this will be a high-quality data set, and the first comprehensive investigation of trace metal distributions throughout the WAP. We are extremely excited to see the results, not only for dissolved distributions of bioactive metals, but for particulate and colloidal distributions as well, and for the Fe source information that will result from our analysis of Fe and Nd stable isotopes. The cruise has been quite an effort for our team, but thanks to the wonderful cooperative work of Chief Scientist Debbie Steinberg and the entire LTER group, and the ASC and ECO personnel, we have accomplished everything we set out to, proving that incorporation of a trace metal sampling program is compatible with the normal operation of the LTER sampling effort.

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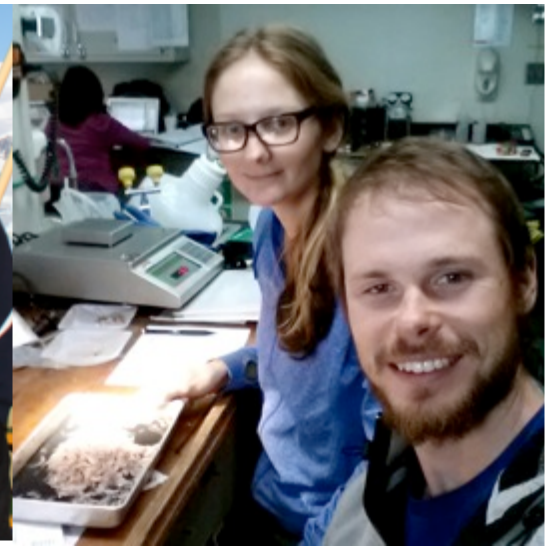
Weekly Science Report IV (week of 26 Jan - 1 Feb)

Appendix 1. This year's PAL LTER cruise was brought to you by the following scientists, students, and volunteers:

C-020 Zooplankton ecology team (L to R): Joe Cope, Patricia Thibodeau, Debbie Steinberg, Joshua Stone, and Jack Conroy

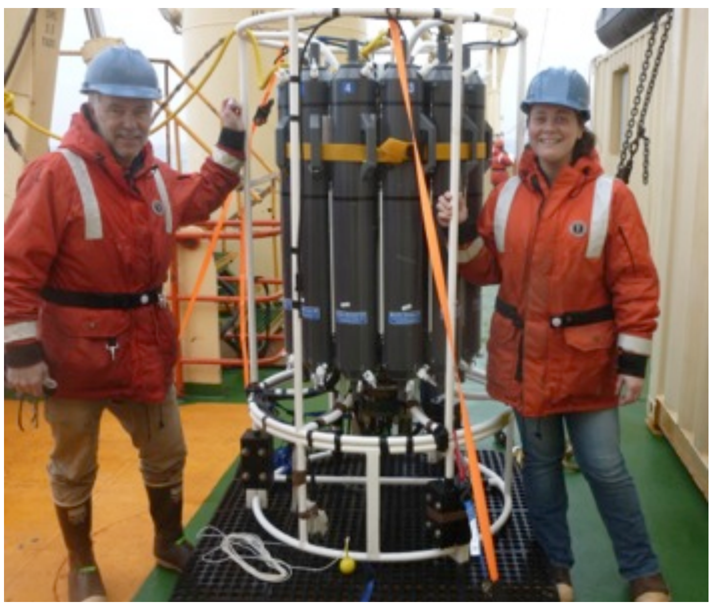


C-013 Birder team: Carrie McAtee (L) and Ben Cook (R).

C-045 Microbial Biogeochemistry team (L to R): Chelsea Petrenko, Naomi Shelton, Hyewon Kim, Kimberley Miner, and Leigh West

C-024 Whaler team: Ari Friedlaender (top) and David Johnston (bottom)

C-019 Phytoplankton team (L to R): Oscar Schofield, Mansha Pasricha, Ana Filipa Carvalho, Philip Sontag, and Cheryl Zurbrick



B-203 Trace Metals team: Rob Sherrell (R) and Jessica Fitzsimmons (L)

Appendix 2. Science support team and ship's officers and crew.

Lockheed/ASC:
Lindsey Loughry, MPC
Mike Coons, ET
Alec Chin, ET
Hannah Gray, MT
Meredith Helfrich, MT
Jen Lennon, MLT

Edison Chouset Offshore:
Ernest Stelly, Captain
Mike Brett, Chief Engineer
Brandon Bell, Chief Mate
Gregory Goodwin, 2nd Mate
Michael Kilrain, 3rd Mate
Terry Jackson, Asst Engineer
Owen Hnat-Dembitz, Asst Engineer
Elfren Prado, Oiler
Efren Prado, AB
Michael Belloli, Head Chef
Arnulfo Aaron, Bosun
John Ambrosio, AB
Lloyd Aguirre, Oiler
Roberto Cortez, Asst Engineer
Ryan Liquicia, Chief Steward
Samuel Guillermo, AB
Dionesio Adlaon, AB