LMG 14-01: 31 Dec. 2013 – 05 February 2013 LTER Cruise 22
Weekly Science Report IV (Final Report for 1401)
Palmer Long Term Ecological Research Project: Looking Back in Time Through Ecological Space.

Cruise Overview (O. Schofield, Chief Scientist):

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 foodweb from phytoplankton to penguins. The annual oceanographic cruise (now in our 22st year) provides a large scale regional view of physical trophic biogeochemical processes in the region, and contributes to a time series of ecosystem change in response to regional warming and sea ice loss.

This cruise is about equally divided between 1) occupying 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 (Figure 1), and 2) conducting three, 3 day mechanistic process studies along the Peninsula. This year's process studies are focused on the relationships among bathymetry (seafloor canyons), physical oceanographic forcing of the phytoplankton populations, krill abundance and penguin and whale foraging.

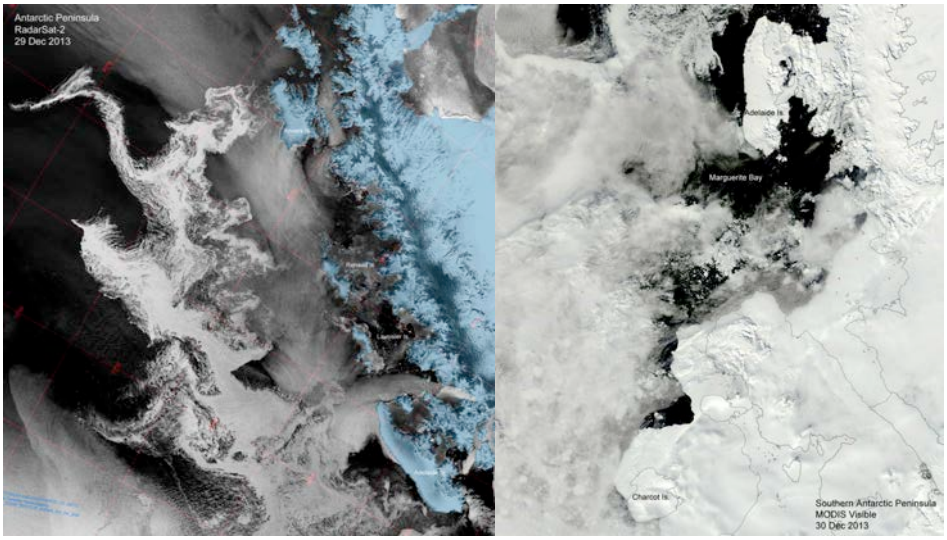

Figure 1. The sea ice imagery collected during the fourth week of the 14-01 LTER cruise. Ice remains extremely heavy. In the northern portion of the grid the ice continues to be advected to the north and offshore. The offshore ice bands did not impact the sediment trap operations or any grid sampling during the last week. In the south, the inshore inner water we had considered sampling in the southern potion of LTER grid has closed up with thick ice. Therefore the team feels our strategy to head north and sample the Renaud area was a prudent decision allowing us to maximize the science conducted during the 14-01 LTER cruise.

After the presence of the historic ice (Figures 1 and 2) forced the team to begin process station 3 at Renaud island, we steamed north this week to complete efforts in the vicinity of Palmer Station. During process study 1, the Mocness system was not functioning and returning to the north, after the equipment repair, allowed us to ensure the depth stratified tow time series was completed. After a full hydrographic and full biological sampling, the Mocness sampled the canyon at local noon and midnight. The following day was followed with a noon and midnight acoustic survey using the towed echosounder. This allowed us to complete the zooplankton data set for B-020 team while also supporting the krill efforts of B-005 (Kohut, PI) that was operating out of Palmer, but has been hampered by the existing boating limits. During whaling surveys and sampling, the team was joined by B-005 to conduct a ship-based survey of the offshore proposed CODAR sites in the Palmer deep areas. The survey involved the MTs-ETs-and lead PIs of B-005 and LTER. The sites are exceptional and are ideal for CODAR set-ups. The resulting data will enhance any science group that works at Palmer by providing a detailed picture of the complicated flow patterns and circulation in this region. The fourth physical oceanography mooring of the LTER was deployed at Station E, which will provide an invaluable time series to help interpret dynamics in the region. Net tows were collected in the Palmer Deep and live krill were captured and returned to Palmer in support of B-068 (Saba, PI). Upon completion of the surveys we retrieved the two sediment moorings, which were then refurbished and deployed. During the sediment trap refurbishment, the ship directed by researchers from Florida State deployed a buoyancy subsurface bottom drifter.

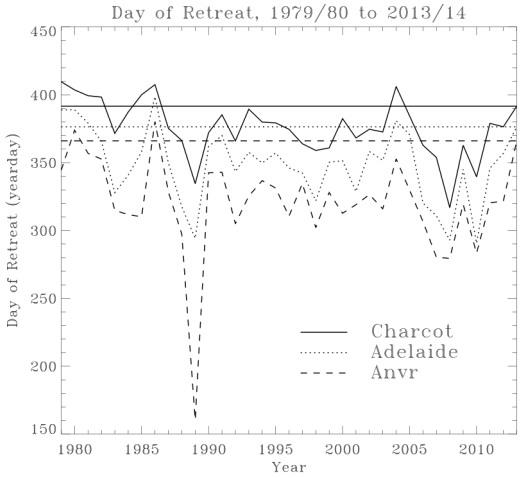

Figure 2. The time series for day of ice retreat for the three major process study locations for the Palmer LTER. The horizontal lines highlight the value obtained for this season. The heavy ice set the record as one of the latest retreats of sea ice at Anvers in the last 30 years.

The cruise was a success but the loss of time from the schedule was problematic. One net outcome was shorter and less complete process stations. Compared to other the other years of the LTER the process studies were a ½ to one day shorter. The net result was a lower number of occupied stations, and forcing us to move on when equipment was not functioning properly. While the ice did not allow us to reach Charcot Island this year, the loss of time would have severely impacted a southern process station in an ice free condition.

The cruise has been remarkably successful and the team is happy with the great group effort. The success of the year could not have been accomplished without the stupendous

support provided by the ASC staff (MPC Lindsey Loughery; ETs Mike Coons and Tony D'Aoust ; MTs: Meredith Helfrich and Sandy Aylesworth). There ability to repair, adjust and accommodate the teams shifting needs was amazing and it was the honor of the LTER to have them work with us. Additionally the ECO crew especially the captain and officers (LMG Captain Joe Abshire, Ernest Stelly III (Chief Mate), Drew Merget (Second) and William Ladd Olsen (Third) provided exceptional support in the deployment of sensitive equipment, navigating in and around heavy sea ice, and assisting in planning effective transits. This ASC and ECO group is an exceptional pleasure and privilege to work with

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

Field Team Members: H. Ducklow, Jeff Bowman, James Collins, Scott Doney, Naomi Shelton.

After completing our water column sampling with process stations in the Renaud Island vicinity, we successfully recovered the tow LTER sediment traps (Figure 3) near Grid location 585.131, about 70 miles west of Palmer Station, mid-shelf in 350 meters 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 (above left) since 1991. On last year's cruise, we also deployed a trap with a different design, the Technicap 24-sample cylindrical trap (above left). 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.

Figure 3. Pictures of both sediment traps before being redeployed again to sample until next years cruise.

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 Sandy Aylesworth successfully recovered the traps, rigged and rebuilt the moorings and deployed the traps. ETs Mike Coons and Tony D'Aoust turned around the dual mooring releases for the moorings after chasing down a nagging malfunction in one release. MPC Lindsey "Miley" Loughery organized and oversaw the successful operation from start to finish. Their support and especially great good humor and friendship are deeply appreciated.

LMG Captain Joe Abshire and his officers Ernest Stelly III (Chief Mate), Drew Merget (Second) and William Ladd Olsen (Third) drove the ship smoothly, guided us flawlessly to all our sample locations and put up with many changes of plan. The LMG crew performed all deck ops 24-7 with their usual skill and efficiency. The entire LTER team – scientists, support and ship crew all contributed once again to a successful and really fun cruise. Thanks everybody!

B-019. Phytoplankton Component (O. Schofield, PI)

Field Team Members: Oscar Schofield, Filipa Carvalho, Nicole Couto, Oliver Ho, John Reinfelder.

The objective of this component is to understand the biophysical forcing of the phytoplankton communities present along the West Antarctic Peninsula. We are also focusing on how climate mediated modifications in the community structure (both size and taxa) will impact the overall food web dynamics as well as altering the biogeochemical cycling. Our routine measurements include bio-optical measurement (spectral radiometry as well as a full suite of inherent optical properties), chlorophyll a, HPLC accessory pigments, fluorescence induction and relaxation kinetics, and 14C-radiolabelled estimates of photosynthetic activity. Like the B-045 we found spectacularly high 14C productivities at the Palmer deep canyon. Overall phytoplankton and biomass declined offshore.

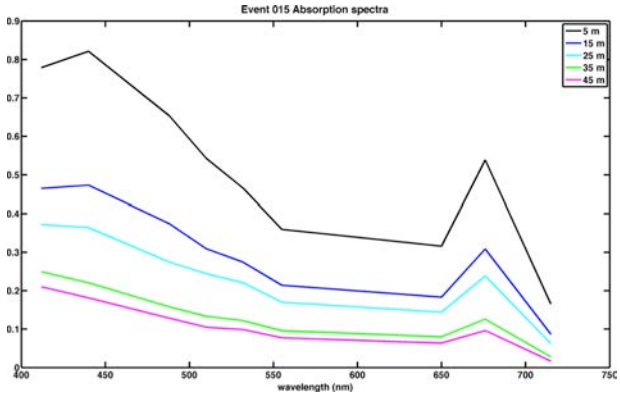

Figure 4. Spectral absorption data collected by the AC-9 instrument. The data clearly shows the strong soret peaks associated with chlorophyll and carotneoids. At depth, the steeper exponential rise relative and relative decline in carotenoid absorption suggest the relative increase in colored dissolved organic matter and detritus.

Sampling for the phytoplankton group was smooth and the team collected the data they hoped for. The group completed two 7-day incubation experiments, two 7-day full temperature characterization for the

resident phytoplankton communities, collected 29 bio-optical profiles using the WetLabs AC-9 and Ecopucks for satellite cal/val efforts (Figure 4), and 33 water column profiles of the LTER long term data. The results showed the early season had stupendously high phytoplankton productivity rates and biomass. The blooms were associated with the low salinity surface layer most likely associated with the retreat of ice from earlier in the season. The total activity declined by a factor 2-3 by the end of the cruise. The unique features of this year are going to be scientifically valuable providing us an ecosystem anomaly to understand the overall processes regulating the regional ecology of the phytoplankton.

B-020. Zooplankton Component (D. Steinberg, PI)

Field Team Members: Joe Cope, Kate Ruck, Miram Gleiber, Jami Ivory, Domi Paxton, and Bruce Pfirrman.

During the fourth and final week of the 2014 Pal-LTER field season, we revisited the Palmer Deep for a second time during the third Process Study (PS). This allowed us to capture our day/night MOCNESS pair in the area, which was missed during PS 1 due to equipment failure. We also had time to complete a full day/night bio-acoustic survey. Several copepod experiments were completed. Fecal pellet production experiments and gut evacuation rate experiments were conducted on the calanoid copepod species *Calanus propinquus*, *Calanoides acutus*, and *Rhincalanus gigas*. Gut fluorescence and biovolume-to-carbon ratio specimens were collected and frozen for laboratory analyses. Specimens included krill (*Euphausia triacantha* and *Thysanoessa*), salps (*Salpa thompsoni* and *Ihlea racovitzai*), pteropods (*Limacina*, *Clione*, and *Spongiobranchaea*), silver fish (*Pleuragramma antarcticum*), hyperiid amphipods, and chaetognaths.

Overall, we deployed a total of 109 nets, including sixty-five 2-m Metro net (700-µm mesh), thirty-seven 1-m Metro net (333-µm mesh), and seven MOCNESS (500-µm mesh) tows. Twenty-three grid stations and 3 Process Studies were occupied. The MOCNESS was fished from 500 m at PS 2 and 3 (8 depth intervals). Sixty-five complete taxonomic workups (taxon counts and biovolumes) and thirty-six partial taxonomic workups (counts and biovolumes for euphausiids/salps only and presence/absence for the remaining taxa) were completed. Thousands of krill and hundreds of salps were measured from these samples. The remaining tows were taken for the collection of experimental animals. Twelve fecal pellet production experiments were conducted on calanoids and *Euphausia superba*. Thirteen

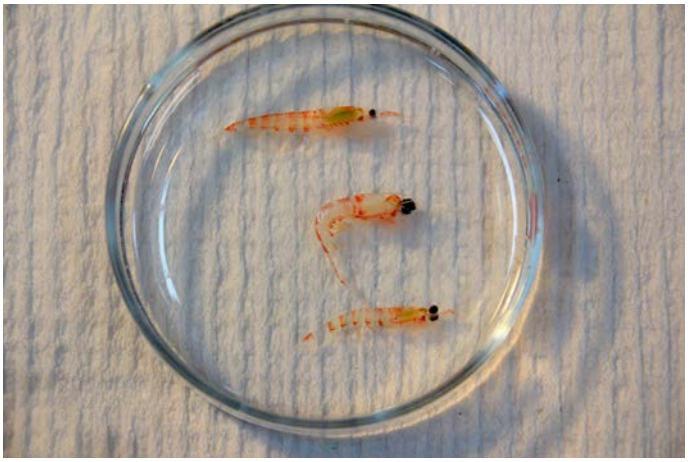

Figure 5. photo credit: Miram Gleiber of (top to bottom) Euphausia superba, Thysaneossa, and E. crystallorophias

gut evacuation rate experiments were completed on calanoids. Three dissolved organic matter (DOM) excretion experiments were conducted on the *Euphausia superba*, *Thysaneossa*, and *Limacina*. Numerous taxa were frozen for laboratory analyses. Two bio-acoustic surveys were taken, one off Avian Island (PS 2) and one in the Palmer Deep (PS 3). Specimens were collected for several other studies. *Euphausia superba* and *E. crystallorophias* were analyzed for mercury content. The effect of CO2 concentration was performed on *E. superba*. Larvae of the caridean shrimp *Nematocarcinus* were collected for genetic analysis.

B-021: Physical Oceanography Component (Doug Martinison, PI)
Field Team: Darren Mckee

The objective of the physical oceanography group is to understand the circulation and major transports of heat and salt in the WAP and how those transport processes affect the overall heat of the system. A major effort for this field season is to recover, refurbish, and then redeploy the mooring before the end of the cruise. This last week the fourth and final physical oceanography mooring was deployed. The fourth mooring was deployed near Station E, which is part of the Palmer Station LTER sampling grid. This data set should be extremely valuable in interpreting the variability being seen in the biological data being collected by the Palmer team. Finally, Kevin Speer's group requested the deployment of an experimental bottom drifter. Despite some initial instrument difficulties, the sensor was successfully deployed during the sediment trap refurbishment.

B-013: Seabird Component (W.R. Fraser, PI)
Field Team Members: Carrie McAtee and Brett Pickering

Figure 6. Penguin colony encountered during the survey to northern half of the LTER grid.

We started the week during the continued process stations located around Renaud Island. We were able to visit the Pitt Island group where there are colonies of Adelie and chinstrap penguins for the first time since 2003 (Fig. 6). Census information was collected in the various small islets where the penguins are present. We were also able to collected penguin diet samples and blue-eyed shag boli.

After leaving the Renaud area we processed our samples by measuring prey items taken by the penguins. We conducted surveys in the area near Palmer Deep. During this week we also assisted the whale research group during their sampling activities. Thanks to all of the ASC support during boating and laboratory activities.

O-405: Physiological and Ecosystem Structure Forcings on Carbon Fluxes in the Southern Ocean Mixed Layer (Nicolas Cassar, Duke Univ., PI)
Field Team Operator: Yajuan Lin

This effort is using equilibrator inlet mass spectrometry (EIMS) to measure net community production (NCP) with high resolution. The instrument has been continuously measuring gases dissolved in seawater from the ship's underway system since December 31st. I am measuring Nitrogen (both masses 28 and 29), Oxygen, Argon, and Carbon Dioxide (masses 44 and 45). Measurements of O2/Ar supersaturation of surface waters will be used to constrain net community production (NCP) in the mixed layer. At steady-state, NCP is equal to new production and carbon export from the mixed-layer. We are interested in assessing the biogeochemical forcing on NCP and carbon export fluxes. The instrument hardware has been operating well.

Throughout the cruise additional environmental samples for the determination of microbial community structures have been taken from surface water via the on board continuous sampling system for every 20km along the LTER grid lines. I have finished the 600, 500 and 400 lines so far. DNA will be extracted from these samples and 16S (prokaryotes) and 18S (eukaryotes) amplicon libraries will be sequenced using Illumina MiSeq at Duke University to map the microbial community structures in sampled region.

The group is particularly interested in O_2/Ar ratio supersaturation (ΔO_2/Ar), which reflects biological O_2 variation in mixed layer and could be used to estimate net community production. In the fourth week we revisited the northern coastal region. While the bloom we saw at the beginning of the cruise is dying out, ΔO_2/Ar has decreased significantly (Figure. 7). This indicates that the pelagic system at this site is shifting towards less autotrophic.

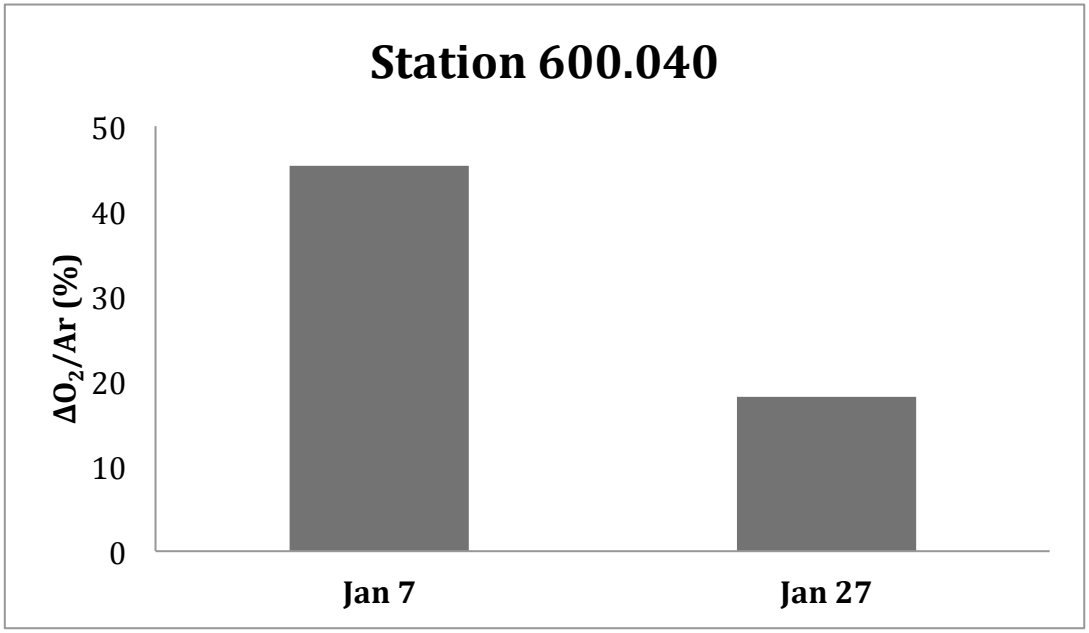

Figure 7. O_2/Ar supersaturation (ΔO_2/Ar) at coastal station 600.040 measured at different phase of the bloom.

LTER Guest Component: Distribution, abundance, and movement patterns of baleen whales within the Palmer LTER study area (David W. Johnston, PI).
Field Team Members: Ari Friedlaender and Heather Foley

Over the course of this week we conducted extensive visual survey effort along the continental shelf within and outside of pack ice remaining from the winter. We were also fortunate enough to have a successful week of biopsy sampling for demographic, stock structure, and diet analysis, collecting samples from 47 humpbacks. Samples were largely collected inshore from a large feeding aggregation of humpback whales that were taking advantage of large krill swarms observed in the area. This areas high densities of whales during the feeding season and samples collected here will make for interesting comparisons with those from animals sampled elsewhere within the LTER grid.

Our survey and biopsy sampling effort represent a significant proportion of the work we propose be part of the upcoming LTER proposal and we are completely satisfied that these activities have been successfully integrated into the existing cruise framework.

Figure 8. A whale feeding and living the dream near the Joubin Islands.