LMG 14-01: 31 Dec. 2013 – 05 February 2013 LTER Cruise 22
Weekly Science Report III
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 transformation in response to regional warming and sea ice loss.

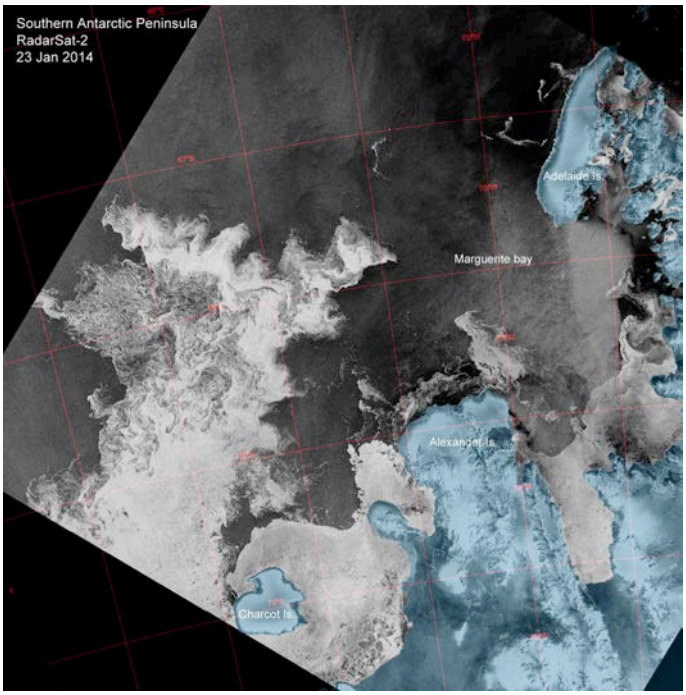

Figure 1. The ice south of Margueritte Bay. The heavy sea ice and chunks of the Wilkes ice sheet severely limited sampling in the south portion of the LTER survey grid.

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 (submarine canyons), physical oceanographic forcing of the phytoplankton populations, krill abundance and penguin and whale foraging.

After successful recovery of the Birders from Avian island we conducted a survey to the south. Heavy bands of ice bisected through the historical LTER survey lines and made any attempt at Charcot not possible. In order to collect data to the south, we surveyed the 100-line. Slow cruising speeds, because of the ice, almost tripled the survey times, however we did complete the offshore, mid-shelf and coastal stations for the 100-line. The chlorophyll values in the open water adjacent to the inshore side of the ice edge was

characterized by exceptionally high phytoplankton concentrations with values exceeding 40 mg Chl a m^{-3}. Given the historical focus of Process station 3 on penguins, we decide to not waste shiptime for a futile attempt to Charcot and instead decided to survey the penguin colonies in and around Renaud Island. These colonies used to be part of the LTER sampling, however because of the recent focus on Charcot it had been years since a survey had been conducted. In the transit to north the group deployed two moorings, which will be recovered during next year's cruise. The ASC staff were invaluable in preparing and then deploying the moorings. We are very lucky to have such an experienced crew and it is luxury that makes the work so much easier here. We also thank the ECO bridge crew who actively saved the cruise time by proactively avoiding ice areas as much as possible during the stream to the north. Upon arrival to Renaud, we repeated the 500:060 with a full sampling station to assess to what degree the system had changed compared to our sampling we conducted during Week 1. We found that the phytoplankton/bacteria productivity and biomass had declined compared to the earlier measurements during the cruise.

Over the next three days we surveyed three penguin colonies (near Armstrong reef, near Prospect Point and on the Fish Islands). At each station we conducted a full sampling for physics, optics, and biology (bacteria, phytoplankton and animals) in the adjacent seafloor canyon. Two of the stations were facing the ocean while the third colony near Prospect Point was in the bay in-between the continent and Renaud Island. To assess to what degree there was communication between the inland and offsore waters we condcted a detailed survey grid from within the bay, over the sill at the mouth of the bay and in the nearshore oceanic canyon. Despite heavy ice in these inland waters we were able to deploy the Birder team. At all three colonies they were able to collect census and diet samples of the birds, allowing an analysis of the foraging contrasts between the ocean facing and inland penguin colonies.

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.

The objective of this component is to obtain a mechanistic understanding of the carbon cycle along the Western Antarctic Peninsula, and the roles of heterotrophic bacterioplankton in these geochemical transformations. We are also concerned with possible responses of the microbial foodweb and biogeochemical transformations to climate warming. Our routine measurements include heterotrophic and autotrophic microbial abundance by flow cytometry conducted on-site, bacterial production by leucine incorporation, as well as water column inventories of dissolved inorganic and organic carbon, particulate organic carbon and nitrogen and inorganic macronutrients. We are collecting samples for oxygen-18 analyses to determine sea ice and meteoric inputs to seawater, in collaboration with LTER colleague Dr Mike Meredith (BAS-UK) Finally, we deploy a time-series sediment trap to collect settling particles and determine the export flux from the upper ocean.

The microbial biogeochemistry group completed sampling for all core measurements along the LTER 200 and 100 survey lines during the past week. Extensive late season sea ice prevented proceeding to the two southernmost lines on our grid, so we turned back north to perform a process study of the penguin foraging region surrounding Renaud Island and any potential deepwater zones associated with troughs in the area. Our observations suggest the continued presence of high phytoplankton biomass and elevated bacterial activity in the inshore region of the 400 line surveyed earlier in the cruise. Regardless of the declines, the bacterial production has been remarkably high (Fig. **XX**).

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) and Dr. T. Hollibaugh (Univ of GA, urea distribution in LTER region).

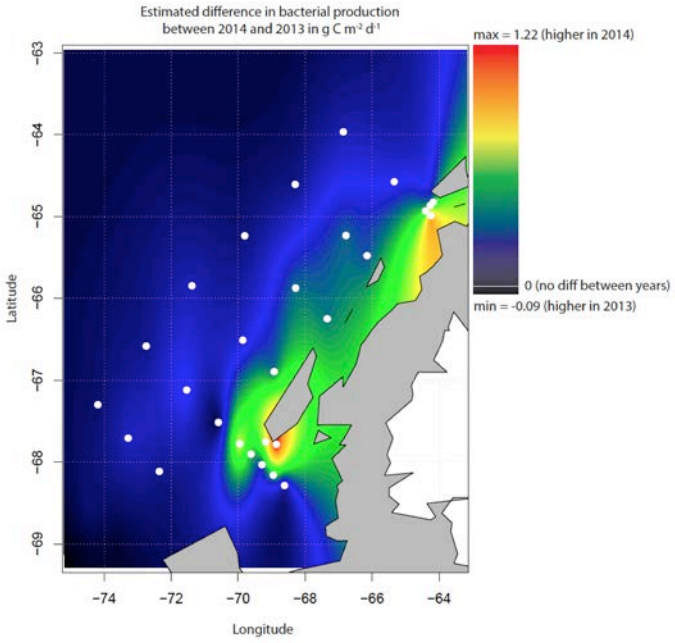

Fig XX. Results showing the enhanced bacterial productivity along the WAP grid. The comparison is between the 2014 and 2013.

We are also hosting two PhD students who are conducting research related to their own interests where they overlap the purview of the B-045 project: Jamie Collins (WHOI) and Jeff Bowman (Univ Washington). As part of an ongoing project, Jamie is investigating the effect of ultraviolet radiation on surface-layer dissolved and particulate organic matter. He has been collecting water samples during the cruise as time allows for analysis of dissolved and particulate lipids. In addition to their function as structural and energy storage compounds, lipids are the parent molecules of oxylipins, a class of highly oxidized biomolecules that serve as a means of intercellular communication in phytoplankton and other microorganisms.

Jeff is using flow cytometry to evaluate the relationship between bacterial abundance and primary production, and to identify the dominant phytoplankton groups associated with the summer bloom. Thus far we've observed strong coupling between bacterial abundance and fluorescence among both high and low nucleic acid bacteria throughout the study region. The taxonomy and physiology of phytoplankton throughout the study region are largely unconstrained (Fig.). To facilitate the interpretation of flow cytometry data Jeff is also testing methods to fix phytoplankton samples for cell sorting. The

positive identification of sorted populations will enable us to connect physiology to the observed bloom dynamics.

We thank all ECO and ASC personnel for their outstanding support.

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.

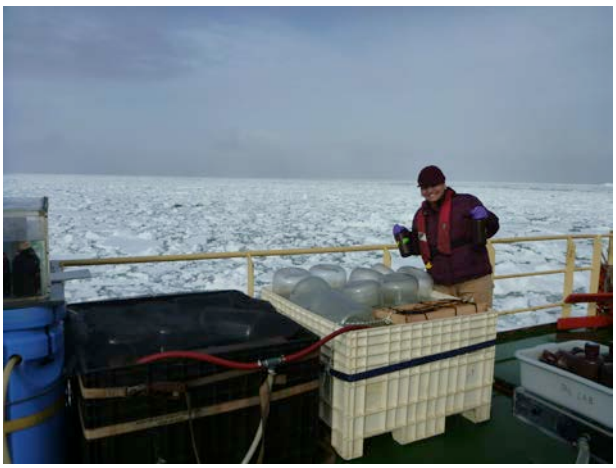

Figure 3. PhD candidate Filipa Carvalho sampling her deckboard experiment. The heavy sea ice that has challenged the cruise can be seen in the background. The second 7 day experiment was completed this last week.

We continued our traditional phytoplankton measurements as part of the LTER grid. Notable was the exceptionally high biomass and productivity in the coastal waters of the 100-line. These were the highest chlorophyll values that the PI had encountered in his over 20 years of going to sea. The second deckboard phytoplankton experiment was completed which will be central the PhD thesis of Filipa Carvalho (Figure 3). The initial findings show similar trends as the incubation experiment conducted at the Palmer Deep earlier in the cruise. The biomass and productivity values were higher in 50% light treatment suggesting cells were susceptible to significant photoinhibition. These does not appear to a large impact of deep-water to surface bottles, suggesting enhanced productivity at the canyon heads are likely associated with light limitation and potentially shoaling of the upper mixed layer depth. We thank all ECO and ASC personnel for their outstanding support.

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

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

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During the third week of the 2014 PalLTER field season, we completed full stations along the 200 and 100 grid lines. During our transit north, we sampled two additional stations along the 500 grid line. Inshore zooplankton tows were also taken to complement observations made by the birders (B-013) and whalers (guest component). These inshore samples were heavily contaminated with phytoplankton and contained high numbers of Antarctic krill, *Euphausia superba*. They contrasted with samples collected further offshore (500 grid line), where phytoplankton and krill were sparse.

Several experiments were completed. A dissolved organic matter (DOM) excretion experiment was conducted on *Limacina*. Another fecal pellet production experiment was conducted on *Euphausia superba*. Gut evacuation rate experiments were performed on the calanoid copepod species *Calanus propinquus*, *Calanoides acutus*, and *Rhincalanus gigas* (Figure 4). Gut fluorescence and biovolume-to-carbon ratio specimens were collected and frozen for laboratory analyses. Specimens included krill (*Euphausia superba*, *Euphausia crystallorophias*, and *Thysanoessa*), salps (*Salpa thompsoni*), pteropods (*Limacina*), and copepods (*Calanus propinquus*, *Calanoides acutus*, *Rhincalanus gigas*, and *Metridia gerlachei*).

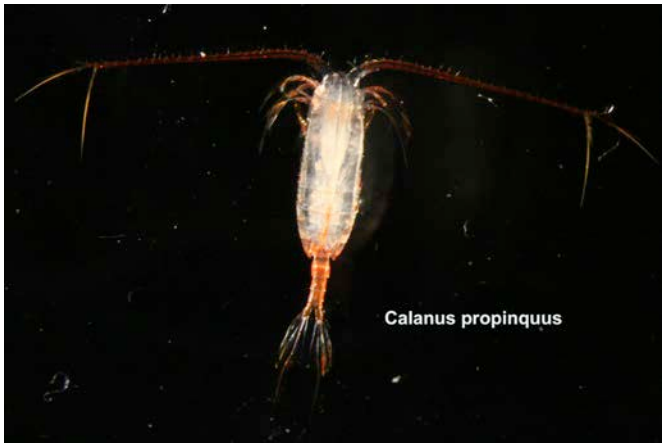

Fig. 4. A Calanus picture conducted during live animal experiments conducted this last week.

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

The objective of the physical oceanography group is 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. After successful recovery, the mooring were refurbished and two of the moorings were redeployed successfully for another year. A third mooring will be deployed at the LTER station E near Palmer

station in the coming week. We would like to thank the ECO bridge and the Lockheed ETs and MTs for great support during these recoveries.

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

Figure 5. The view down over a hill looking towards the penguin colonies at Avian Island.

Our work during the second and third weeks of LTER 14-01 included research at Avian Island, where we occupied a field camp for 6 days, January 15-20, 2014. The camp deployment went smoothly, weather for the landing and hauling of gear was cooperative except for a bit of brash ice near the landing. The camp set-up was very successful due to the efforts of ASC and science crew. During our time on Avian Island we primarily worked on the breeding and foraging ecology of Adélie penguins. We deployed PTTs on two individuals, conducted breeding colony censuses, weighed and measured chicks, as well as diet sampled adult Adélie penguins. In addition, we surveyed the entire island for marine mammals, giant petrels, and blue eyed shags, collected skua fecal samples, penguin chick feet (the chicks had been previously eaten by skuas) for stable isotope analysis, and material from our sediment traps.

After leaving the field camp we continued shipboard observations and processed samples from Avian Island. Due to heavy ice to the south of Adelaide Island the cruise track turned north and has provide opportunities to sample penguin colonies on the southern side of Renaud Island. Populations near Armstrong Reef and Prospect Point were counted and sampled. We would especially like to thank the ASC marine crew for help with the camp deployment and for communications support. MPC Lindsey Loughrey consistently awaited our twice daily safety call-ins and greatly helped with the camp logistics.

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

We are 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 forcings on NCP and carbon export fluxes. The instrument hardware has been operating well.

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 counted several groups of humpback whales offshore of the pack ice west of Adelaide Island and Marguerite Bay and a very different pagophilic community in the pack ice consisting of hundreds of crabeater seals and low numbers of minke whales.

We were also fortunate enough to begin biopsy sampling for demographic, stock structure, and diet analysis, collecting samples from 39 humpback and 3 minke whales early in the period. Ten samples were collected offshore from a large feeding aggregation of humpback whales, 16 were collected from humpback whales in the coastal waters off of Renaud Island, in the location of several Adelie penguin colonies that were counted, and 13 were collected from Flandres Bay at the southern end of the Gerlache Strait. Three minke whales were sampled in the Penola Strait. On the last day of this period, a visual survey of the Gerlache Strait, Andvord and Flandres Bay was conducted along with biopsy sampling. This area typically represents the highest 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 can and have been successfully integrated into the existing cruise framework.

Species	Samples
Humpback Whale	39
Antarctic Minke Whale	3

Table. Skin and blubber biopsy samples from whales during Week 3.