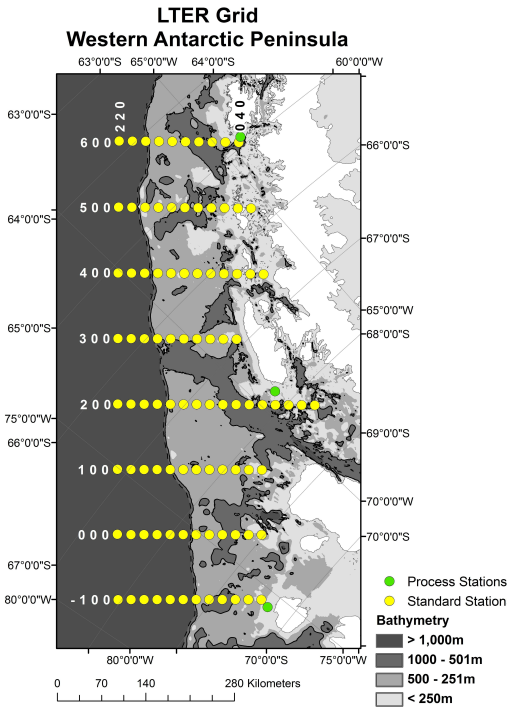
LMG 13-01: 30 Dec. 2012 – 07 February 2013 LTER Cruise 21
Weekly Science Report I

Palmer Long Term Ecological Research Project: Looking Back in Time Through Ecological Space.

Cruise Overview (H. Ducklow, Chief Scientist):

The overall long term objective of Palmer LTER is to understand the mechanistic linkages by which climate, physical oceanographic forcings 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 21st 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.



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, 3-4 day mechanistic process studies along the Peninsula. This year's process studies are focused on the relationships among bathymetry (submarine canyons), physical oceanographic forcing, krill abundance and penguin foraging. During the first few days of the cruise, we completed Process Study I in the vicinity of Palmer Station (**Figure 2**)

Figure 1. Map of LTER Study region along the Western Antarctic Peninsula, showing grid stations occupied on annual cruises.

As always, we received outstanding help from the ASC, Edison Chouest and Damco staff in Punta Arenas, at Palmer Station and aboard the ship. The annual LTER cruise is a large and complex operation and we benefit greatly from the accumulated expertise and corporate memory of many dedicated colleagues and friends.

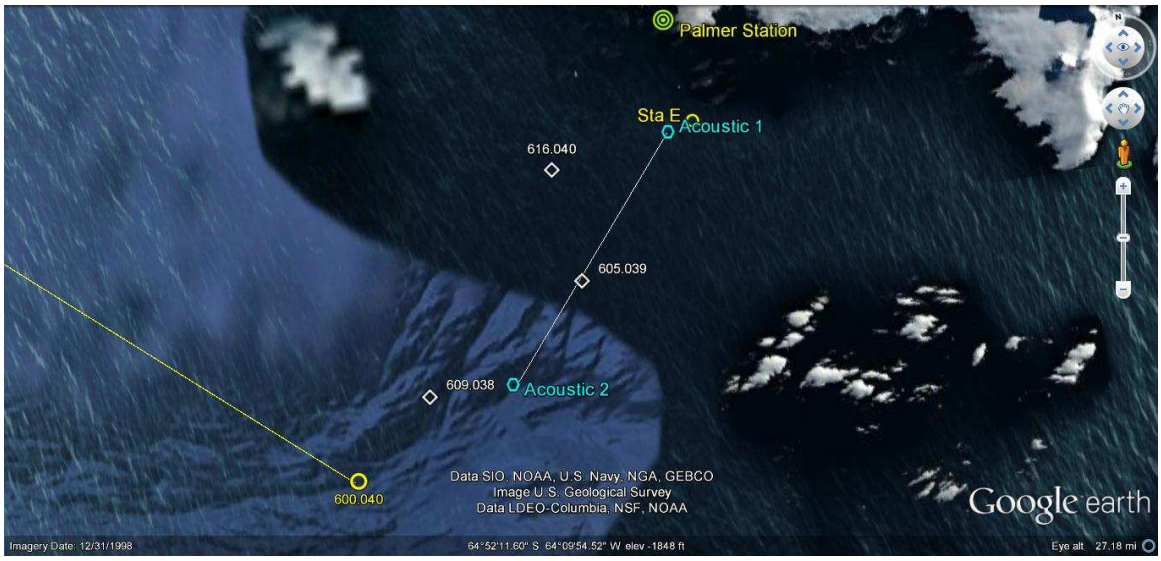


Figure 2. Map of stations occupied during LTER cruise Process Study 1. Shaded bathymetry in the lower left shows the Palmer Deep submarine canyon. LTER grid station 600.040 (bottom left) is in the deepest part of the Palmer Deep (1200 m). Diamonds show CTD stations occupied on the sides of the canyon during Jan. 5-8. Palmer Station is near top of the diagram.

Individual component reports:

B-013: Seabird Component (W.R. Fraser, PI)

Field Team Members: Jen Mannas and Cameron Rutt

The objective B-013's component of this year's LTER cruise (LMG 1301) is to continue the long-term data set of at-sea bird surveys to assess abundance and distribution across the LTER regional study grid. In addition, we plan to continue studies of Adélie penguin breeding and foraging ecology at Avian Island, a southern study area located in Marguerite Bay that provides a higher latitude comparison with similar studies conducted at Palmer Station. We also plan to conduct similar fieldwork at Charcot Island.

The port call at Palmer Station in prep for LTER 1301 was efficient and productive. Both Palmer Logistics and LMG Marine helped us to load our gear for the Avian Island field camp in the LMG hold and organize space in the lab for our work over the next month. During the first week of the cruise, we surveyed seabirds from the bridge of the LMG during the process study at 600.040 and within the Palmer Deep Canyon area. We continued to survey along the 600, 500, 400, and 300 lines, in addition to assisting with whale operations and mooring retrieval. We had a pre-Avian meeting on Friday and prepared for camp put in.

We would like to thank both ASC and ECO personnel who have helped us get started on what we expect will be a very productive cruise.

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

Field Team Members: O. Schofield, Grace Saba, Johanna Blasi, Zachary Swaim, Dena Seidel, Chris Linder

The phytoplankton component continues its time series measurements as part of the Palmer LTER. The productivity measurements show moderate activity this year. The highest

productivities have been found in the near shore waters associated with the highest chlorophyll concentrations. Surface chlorophylls have ranged from 0.1 mg chl a m^{-3} in the offshore waters to values of 5 in the coastal stations. Fluorescence induction relaxation measurements are consistently high yielding values $\geq$0.5 indicating the phytoplankton are healthy and nutrient replete.

The traditional LTER sampling is being complemented with a series of deck board mesocosm experiments. We have initiated mesocosm experiments at both Palmer Station as well as onboard the RV Gould. A long-standing hypothesis of the LTER is that there is high phytoplankton productivity at the edges of the deep sea floor canyons, which ultimately influences the foraging behavior of penguins at near shore rookeries. A fundamental question is the mechanism that drives the enhanced productivity at the canyon edge. One hypothesis is that light availability drives the enhanced phytoplankton productivity through the shoaling of the upper mixed layer. A second alternative hypothesis is that the deep water provides nutrients that drive the overall increase in productivity. To clarify our understanding, deep water was collected from the Palmer Deep canyon adjacent to Palmer Station and mixed with filtered surface seawater. The mesocosms are then being incubated at two different light levels and sampled over time (Figure 3). We are currently halfway through the first mesocosm experiment and both the light and dark treatments are showing responses. This mesocosm experiment will be repeated using water collected offshore Avian Island.

Figure 3. Heroic team members Oscar and Grace removing sample carboys from deck incubator for mesocosm experiment.

Finally, the team is conducting a full shelf survey with two 1000-m class Webb gliders. One glider is running the traditional LTER lines to provide high-resolution data to assess what the historical and more recent decimated ship survey grid is missing. This glider, launched from Palmer has run the LTER 600 and 500 lines. It is currently in transit to the 300 line. A second deep-water glider was directed to assess the variability in deep ocean eddies propagating across

the shelf originating from Upper Circumpolar Deep Water. Rutgers and Columbia university scientists back in the USA are adaptively flying the glider in collaboration. Both gliders will continue their surveys until the mooring deployments at the end of January. The RV Gould will recover the gliders.

B-020. Zooplankton Component (Debbie Steinberg, VIMS; PI)

Field Team Members: D. Steinberg, Joe Cope, Kate Ruck, Miram Gleiber, Joshua Stone, Brandon Conroy.

The overall objective of our component in Palmer LTER is to understand the role that zooplankton community structure plays in biogeochemical cycling of carbon and nutrients, and the effects of climate change on zooplankton communities in the continental shelf sea of the west Antarctic Peninsula. This year, with three process study stations, we emphasize the role that zooplankton play in the biological pump and in nutrient cycling (grazing, dissolved organic matter excretion, particle or fecal pellet production, and diel vertical migration).

In the first week, we completed full stations along the LTER 600, 500, and 400 lines and concentrated our operations at a special 3-day process study station situated near the Palmer Deep canyon area and LTER grid point 600.040. At each station we performed a pair of net tows for larger macrozooplankton (e.g., krill, salps) and smaller mesozooplankton (e.g., copepods). Animals from the macrozooplankton tows were identified and counted on board, while the presence/absence of taxonomic groups was noted in the mesozooplankton samples. We also took samples at selected stations for zooplankton gut fluorescence analyses. At the process study station, Dr. Kim Bernard and Domi Paxton from Steinberg's group at Palmer Station joined us for 24 hours to conduct a bio-acoustic survey (**Figure 2**). The purpose was to map out aggregations of krill in the Palmer Deep canyon over a diel cycle in order to explore relationships with whale distribution and penguin foraging locations. We also conducted two experiments measuring rates of dissolved organic carbon (DOC) by zooplankton (one on krill, *Euphausia superba*, and one on the polycheate worm *Tomopteris* sp.). Hugh Ducklow's group is working with us on these experiments measuring bacterial abundance, and on uptake of DOC excreted by different zooplankton taxa. Graduate student Miram Gleiber completed three gut evacuation rate experiments and 2 fecal pellet production rate experiments on copepods. These experiments, coupled with gut fluorescence measurements, will allow her to quantify removal of primary producers by copepods and the role that copepods play in particle export. We also completed two additional fecal pellet production experiments on *Euphausia superba*.

The crew/RPSC support on the ship has been excellent. The marine science technician built a rack to accommodate some of our smaller bottles in the incubator (to prevent them from being flooded). The deployment of our net tows has been going smoothly with the expertise of the vessel pilots, marine technicians, and winch operators. We had planned to use the MOCNESS (Multiple Opening-Closing Net Environmental Sensing System) to investigate depth distribution of zooplankton over a diel cycle at this first Process Study Station. Unfortunately the MOCNESS flow meter did not work, despite the considerable efforts of the electronic technicians (who replaced almost every part that could be associated with this problem) to fix the problem. We soon lost our time window for sampling, but will try again at the second process study station. (The MOCNESS has always been a tricky piece of equipment.)

Finally, the film crew has been filming many aspects of our work (e.g., performing the net tows, sorting samples) and has conducted extensive interviews with Steinberg and also with several other members of the zooplankton team.

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

Field Team Members: H. Ducklow, Emelia DeForce, Natasja van Gestel, Cat Luria, Mike Stukel, Kathleen Woods.

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 glacial 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.

Postdoc Mike Stukel is studying particle export from the upper 200 meters. As part of our project to measure the balance of new and export production, we have been simultaneously measuring 15NO3 uptake and 238U:234Th disequilibrium. 15NO3 uptake profiles (incubated for 24 hours in screened shipboard incubators) allow us to assess the proportion of phytoplankton production stimulated by allochthonous nutrients. 234Th measurements allow us to determine the export rate of 234Th on particles that have sunk out of the water column during the roughly one month period of time prior to our occupation of a station. When combined with contemporaneous measurements of the C:N:234Th ratio of large (sinking) particles, this measurement allows to estimate carbon and nitrogen export. So far we have measured 15NO3 uptake and 238U:234Th disequilibrium profiles at a total of 12 LTER stations. Additionally, in support of a project by Polar Postdoc Shellie Bench (B-018), we have collected quadruplicate size-fractionated (0.2-3 um and >3 um) samples for RNA and DNA analyses at 6 LTER stations.

Brown University PhD student Cat Luria is pursuing her dissertation research on determinants of bacterial community structure during the winter-to-summer transition, when the upper ocean plankton community shifts from one dominated by prokaryotic chemoautotrophs to a foodweb based on photoautotrophic metabolism, with large numbers of heterotrophic bacteria. As part of her project Cat collected community DNA and RNA samples at the 600.200 and 200.040 stations to characterize the vertical zonation of the bacterial community composition using next-generation sequencing technology.

During the first week of operations, we conducted most of the aforementioned measurements at LTER grid stations on the 600, 500, 400 and 300 lines (**Figure 1**) and at all five Process Study 1 Stations. Preliminary results from flow cytometry and leucine incorporation experiments at 11 stations suggest bacterial abundance and activity are low to moderate, consistent with observations by B-019.

LTER Guest Component: Distribution, abundance, and movement patterns of baleen whales within the Palmer LTER study area. PI: David W. Johnston (Duke Univ.).

Field Team members: David Johnston, Zachary Swaim.

Through a combination of visual surveys, biopsy sampling and opportunistic acoustic recordings, the aim of this project is to 1.) better characterize the density, distribution and stock structure of marine predators within the LTER study area and 2.) Develop protocols for efficiently incorporating visual, photographic, biopsy and acoustic sampling into the LTER cruise. Assessing the density and distribution of a larger suite of krill predators in relation to physical oceanographic conditions and other components of the local marine food web will help determine how ecological relationships within this system are altered by warming conditions in the Western Antarctic Peninsula region.

To date, 49 sightings of marine mammals have been made, the majority (52%) of which have been humpback whales. Details on the species sighted are presented in **Figure 4** below. When group size for each encounter is accounted for, these sightings represent a total of 93 individuals. Group sizes for humpback whales ranged from 1 to 6 with a mean of 2.08, similar to previous studies of humpbacks in the region.

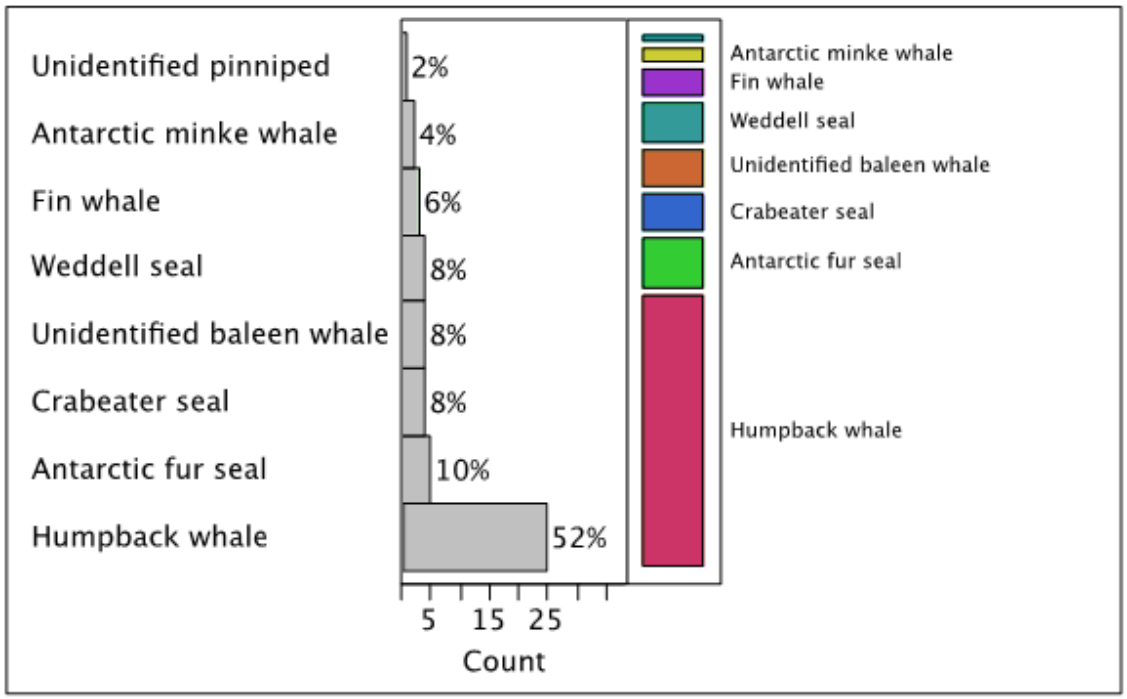


Figure 4. Summary of marine mammals sighting during 02/01/2013 to 10/01/2013 on Palmer LTER cruise.

Sightings have been made in all regions visited by the LTER cruise so far. Fluke photos for photo-identification have been obtained from 5 individual humpback whales, as well as numerous dorsal fin photos of whales for future identification projects. We have obtained photos of two leopard seals to be employed in an assessment of photo-identification methods for this

species. Biopsy samples of 9 humpback whales have been collected for molecular and diet analyses. Figure 5 provides a view of a biopsy sampling being taken by crossbow bolt. Finally, we have made 4 acoustic recordings in the Palmer Deep region of the LTER study area.

Figure 5. An example illustrating how biopsy samples are obtained from whales. The sterile dart has just hit the whale and is rebounding from the impact.

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

Field Team Operator: Rachel Eveleth

We are using equilibrator inlet mass spectrometry (EIMS) to measure net community production (NCP) with high resolution. The quadrupole mass spectrometer and associated plumbing were installed in port by Bruce Barnett. 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, and I am working out some software kinks in this first week of operation.