

LMG 14-01: 31 Dec. 2013 – 05 February 2013 LTER Cruise 22

Weekly Science Report I

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 22nd 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.

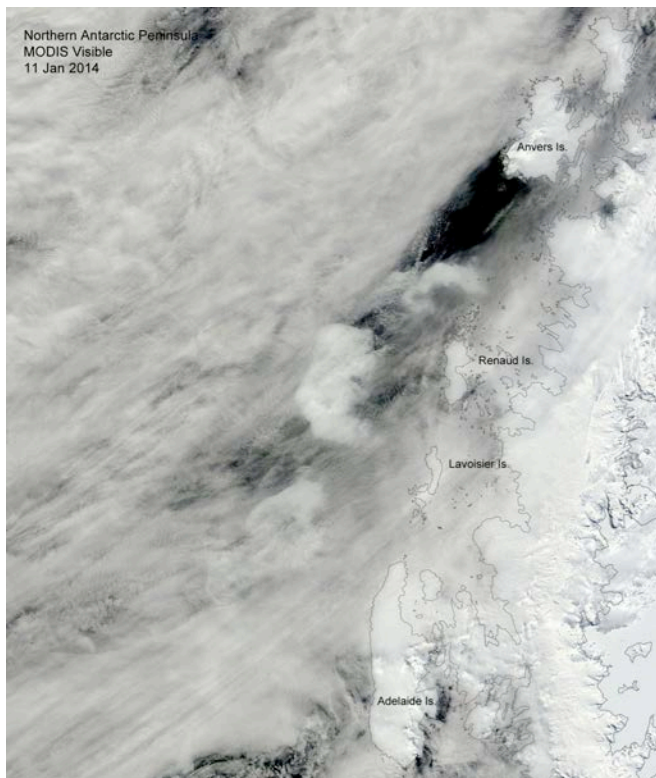


Figure 1. Ice image taken January 11 2014. The image shows significant ice in the mid-shelf and in the southern expanses of our grid.

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.

This year has provided significant challenges with a loss of two days from the schedule and the heaviest sea ice in decades (Figure 1). This ice significantly hampered operations of our Palmer field team throughout the season. Beyond the physical challenges, the loss of Andy Nunn was a big blow, and the entire ship sends him the warmest thoughts and sympathies. Special thanks to Lindsey Loughrery who took over as our MPC after the

tragic loss of Andy Nunn's wife, Sarah Dizick. We extend our heartfelt sympathy and best wishes to Andy and his family. Despite the challenges the ECO and Lockheed staff have been spectacular.

During the first few days of the cruise, we completed Process Study I in the vicinity of

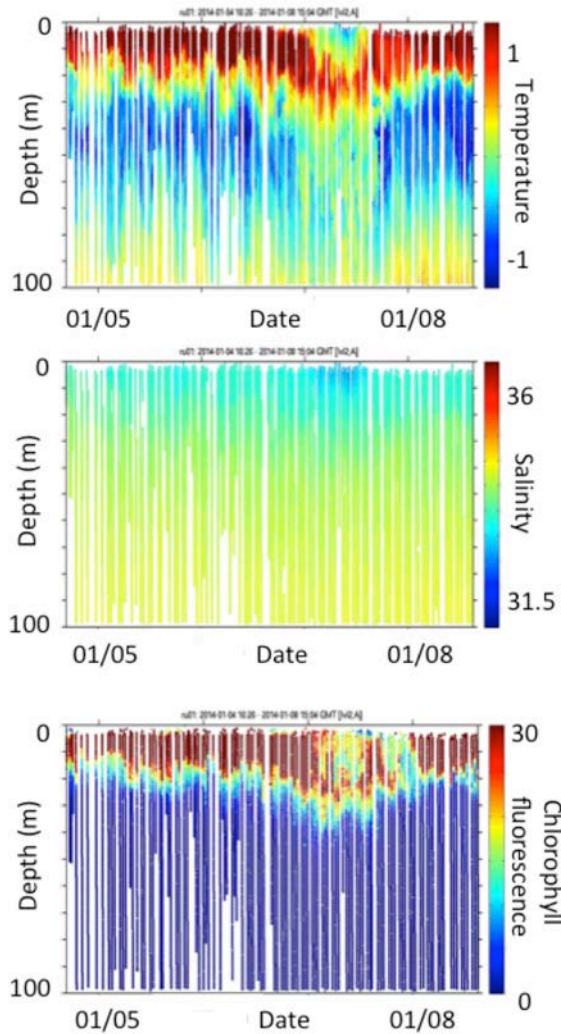


Figure 2. Glider data collected at Palmer Deep with a Webb glider during Process Station 1.

Palmer Station. The goal was to map the biological properties relative the Palmer Deep Canyon, hypothesized to carry warm offshore modified Upper Circumpolar Deep water to shore. The Gould occupied stations spanning the shallow canyon head to the deep waters over the seafloor canyon. The neashore areas around Palmer were iced in which limited small boat operations. To assist B-068 (Saba, PI) at Palmer we collected krill and delivered them back to station for sampling. The ship transect was complemented with a spatial map provided by the Rutgers Webb glider that was surveying the canyon in regions where the ship was not. Both the ship's CTD casts and the glider showed a unique hydrography with a weak winter water layer underlying a low saline buoyant water mass. Associated with the low saline water was a spectacular phytoplankton bloom. Concentrations exceeded 25 mg m⁻³ in the glider and ship

data. Upon completion of the Process Station 1, the team has been occupying the LTER cross shore grid stations. Since leaving Palmer station, we have completed the 600, 500, 400 and 300 line. We have also recovered two of the three the LTER moorings. Over the next week we will deliver the Bird team to Avian Island, recover another mooring, occupy several of the grid stations, and conduct the second process station. We are watching the ice conditions to the south, as currently it looks unlikely for us to reach Charcot. The efforts of the individual teams for the LTER are provided below.

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.

We are also studying new production and particle export by simultaneously measuring $^{15}\text{NO}_3$ uptake and the $^{238}\text{U}:$ ^{234}Th disequilibrium. $^{15}\text{NO}_3$ uptake profiles (incubated for 24 hours in screened shipboard incubators) allow us to assess the proportion of phytoplankton production stimulated by allochthonous nutrients. ^{234}Th measurements allow us to determine the export rate of ^{234}Th 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.

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 and at four Process Study 1 Stations. We encountered a humongous phytoplankton bloom at the coastal stations on the 4,5 and 600 lines with chlorophyll in the surface layer exceeding 25 mg/l. Bacteria were in hot pursuit of the carbon fixed in the bloom, yielding the highest leucine incorporation rates we have ever measured in Antarctica – rates over 800 pmol/l/hr by about 2 million cells per milliliter. These levels are typical of eutrophic temperate estuaries but to the best of our knowledge have not previously been documented in Antarctica. We extend our thanks to all the ASC, ECO, Palmer Station and Damco-Punta Arenas personnel who helped to mount this year's cruise.

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 ^{14}C -

radiolabelled estimates of photosynthetic activity. Like the B-045 we found spectacularly high ^{14}C productivities at the Palmer deep canyon. Overall phytoplankton and biomass declined offshore.

Beyond the standard measurements we are conducting two sets of process studies. The first is an assessment of how small changes in temperature affects microbial community structure and community physiological status. For this experiment, we are using a custom built temperatron, which incubates samples over a 10-degree difference. Samples are then analyzed over a 2-week time frame. The first experiment of water collected at Palmer Deep is ending in three days. The second process study is focused on the role of the deep canyon water in being responsible for the regions of high phytoplankton productivity. Palmer Deep is a biological hotspot providing predictable food resources for penguins; however the physiology and composition of these blooms and the mechanism driving them are not yet known. Two main hypotheses for the driving mechanism are being evaluated. The blooms can be controlled by the upwelling of nutrients or they are driven by the shoaling of the Upper Circumpolar Deep Water (UCDW) below surface waters in the canyon creating a shallow mixed layer alleviating light limitation. In order to test these two hypotheses, we have been deploying gliders, equipped with CTD, fluorescence, backscatter; ADCP and FRe to map the center, along the edges and outside of the canyon, and capturing localized regions of high biological activity “hotspots” using chlorophyll as indicator. This year we have initiated seven-day incubations to determine the response of natural phytoplankton communities to various nutrient (dilutions with deep and nutrient rich water) and different light regimes. We are just completing our first set of incubations early this coming week.

Additionally B-019 team invited Dr. John Reinfelder to assist LTER efforts and make initial assessments of mercury cycling within the food web. Antarctic continent is partially isolated from anthropogenic sources of Hg. However, even though concentrations of dissolved Hg are low in the Southern Ocean water column, higher concentrations occur at the edges of sea ice and Hg accumulates in Antarctic food webs and biomagnifies in consumers, including penguins, to levels comparable with those in marine consumers in the Northern Hemisphere. Ongoing changes to the climate and plankton community of the WAP may affect the accumulation of Hg in the marine food web. For example, decreased productivity and shifts to longer food chains will both favor increased Hg accumulation in upper trophic level consumers due to higher Hg concentrations per unit biomass at the base of the food web in less productive waters and a greater scope for the biomagnification of monomethylmercury (MeHg) in longer food chains which is a developmental neurotoxin in birds and mammals including humans. Despite the central position of zooplankton in the Southern Ocean food webs and its importance to Hg bioaccumulation in higher trophic levels, there are very few studies of Hg in Antarctic zooplankton and none of their MeHg contents.

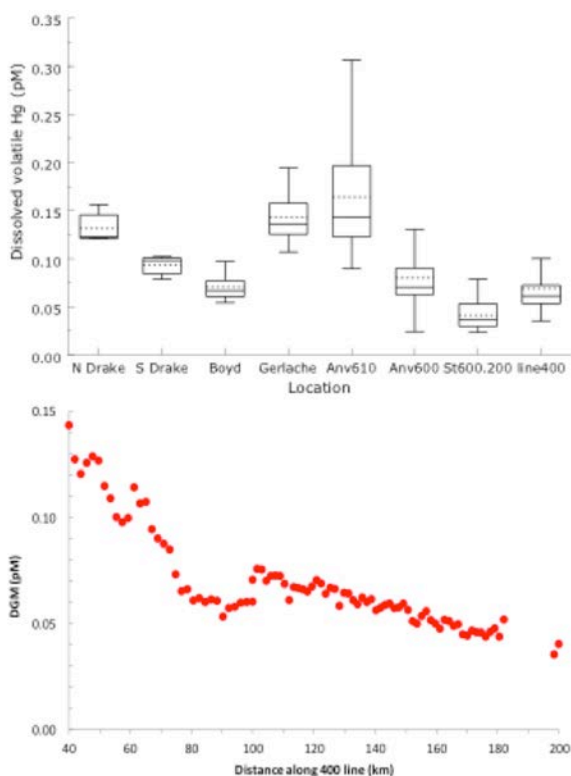


Fig. 3A. Concentrations of dissolved volatile Hg concentrations in the Drake Passage and along the West Antarctic Peninsula. Boxes show mean (dashed line), median, 25th and 75th percentiles, and upper and lower values.

Fig. 3B. Declining offshore trend in dissolved gaseous Hg along LTER line 400.

As part of ongoing efforts to characterize the concentrations, transformations, and bioaccumulation of Hg in the West Antarctic Peninsula ecosystem, we are collecting water, phytoplankton, and krill samples within the LTER sampling grid for the analysis of total Hg and MeHg. In addition, using a real-time, underway system, we are measuring volatile forms of Hg (primarily dissolved elemental Hg) in surface waters of the WAP including the Drake Passage, the Boyd and Gerlache Straits, and throughout the LTER grid stations visited so far. The concentration of dissolved elemental Hg depends on the total concentration (dissolved plus particulate) of Hg in the system and microbial and photochemical processes which drive its production and oxidation. Generally, concentrations of volatile Hg appear to be highest in more productive inshore waters such as the Gerlache Strait and just south of Anvers Island and lower toward the shelf edge (Fig 3A). Indeed, moving offshore along LTER line 400, a steady decline in the concentration of volatile Hg was observed (Fig. 3B). This pattern was

not clearly evident along LTER line 500, perhaps due to major amounts of sea ice encountered.

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

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

The overall objective of our component in the Palmer LTER program 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 along the continental shelf of the western Antarctic Peninsula. This year, with three process study stations, we emphasize the role that zooplankton play in the biological pump (grazing, particle or fecal pellet production, and diel vertical migration).

In the first week, we completed full stations along the LTER 600 and 500 lines and concentrated our operations at a special 3-day process study station located near the



Net tows conducted at a LTER grid station in the ice.

Palmer Deep canyon area at LTER grid point 600.040. At each station, we performed a pair of net tows with 1- and 2-m Metro nets. All animals captured with the 2-m net were identified, counted, and biovolumed on board. These animals are larger macrozooplankton, including ecologically important krill and salps. Krill and salps were also processed from the 1-m net samples; the presence/absence of smaller mesozooplankton taxa (e.g., copepods) was noted. We also took samples at selected stations for

zooplankton gut evacuation and fluorescence analyses from taxonomically diverse groups: krill (*Euphausia superba* and *Thysaneossa*), salps, and copepods (*Calanus acutus*, *C. propinquus*, *Rhincalanus gigas*, *Paraeuchaeta antarctica*, and *Metridia gerlachei*). Gut evacuation and fecal pellet production experiments were completed for copepod species *C. acutus*, *C. propinquus*, and *R. gigas*. The gut evacuation experiments, coupled with gut fluorescence measurements mentioned above, will allow us to quantify the removal of primary producers by the zooplankton community. Dissolved organic matter (DOM) excretion experiments were conducted on the krill *Thysaneossa*. These experiments estimate liable carbon available to the microbial community. We also collected and delivered live Antarctic krill for a NSF-funded, Palmer Station experiment looking at the physiological effects of carbon dioxide concentration.

At the process study station, we attempted to perform depth-stratified zooplankton sampling using the MOCNESS (Multiple Opening-Closing Net Environmental Sensing System) to investigate depth distribution of the abundant taxa over a diel cycle. However, the MOCNESS stopped communicating with the ship at 300m depth. Since it only stops functioning at depth (it works fine at the surface), it has been difficult to trouble shoot the failure. The ETs have been hard at work to correct the problem and hopefully the MOCNESS will be fully functional at the next process study station.

The crew/ASC support on the ship has been excellent. The deployment of our net tows went smoothly with the expertise of the vessel pilots, marine technicians, and winch operators. We are very thankful for everyone's efforts. (photo credits: Miram Gleiber)

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. We have successfully recovered 2 of 3 moorings, and plan on recovering the third mooring early next week. The moorings will be deployed later in the cruise. We would like to thank the ECO bridge and the Lockheed ETs and MTs for great support during these recoveries. The second mooring recovery was quick and efficient despite moderate ice cover and heavy fog.

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

Field Team Members: Carrie McAtee and Brett Pickering

The objective B-013's component of this year's LTER cruise (LMG 1401) 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, which is located approximately 400 km south of Palmer Station. This southern study area located in Marguerite Bay provides a higher latitude comparison with seabird studies conducted at Palmer Station. If ice conditions allow we also plan to conduct similar fieldwork at Charcot Island.

The port call at Palmer Station in prep for LTER 1401 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. 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 bird surveys along the 600, 500 and 400 lines. So far the observations have provided comparisons between open ocean and ice dominated areas and their associated avian fauna. Additionally we assisted the marine mammal group with their observations and Zodiac operations. We would like to thank both ASC and ECO personnel for their assistance.

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

During the first week of the LTER we conducted a significant amount of underway visual survey effort from the LMG and have sighted substantial numbers of marine mammals that will help us generate density estimates and better understand the influence of environmental variability on the distribution of several species. We have conducted 478 nm of visual surveys in inshore, continental shelf, and offshore areas. As well, we have collected a number of photo-IDs for individual humpback whales that will be used to help determine both the residency patterns of individual whales within the LTER study area and also the breeding stock identity by comparison with photographic catalogs maintained for a number of breeding populations (e.g. east and west coast of South America, Oceania). Below is a figure of a representative humpback whale fluke and a sightings table for Week 1.



Figure 4. Humpback whale flukes off Anvers Island, Western Antarctic Peninsula.

Species	Sightings	# of Animals
Crabeater Seal	49	84
Leopard Seal	1	1
Antarctic Minke Whale	1	1
Fin Whale	5	7
Humpback Whale	106	204
Killer Whale	4	21
TOTAL	166	318

Table 1. Marine Mammal Sightings from LTER-14 Week 1.