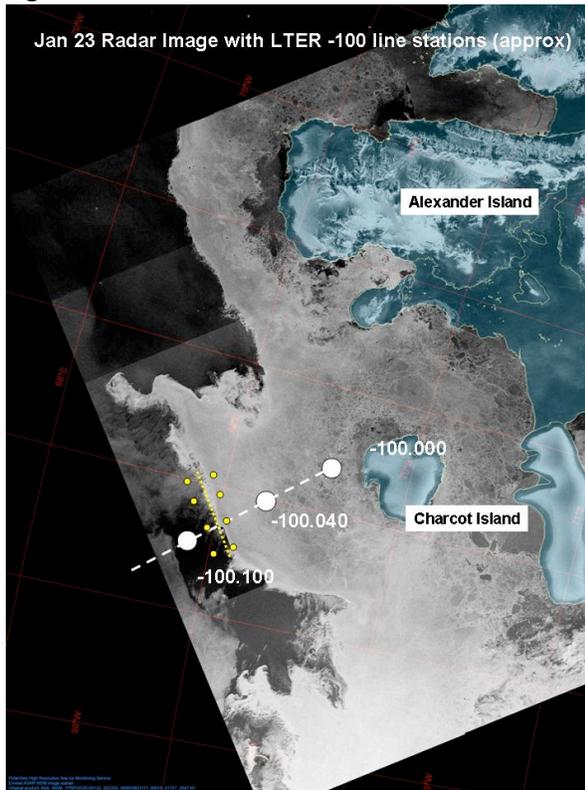


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Palmer Long Term Ecological Research Project: Looking Back in Time Through Ecological Space.

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 20th 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.

With the 4th week of operations we successfully concluded the science portion of LMG 12-01, LTER Cruise 20. Sea ice retreated late from the southern, Marguerite Bay – Charcot Island region of the LTER Study area, and we were confronted by a well-defined ice edge and loosely consolidated summer sea ice along the 000 and -100 survey lines (**Figure 1**). After completing a regular station at -100.100, we entered the ice near -100.070 and initiated Process Study 3 along the ice edge. This study (Jan 24-28) was a comparative study of physical, biogeochemical and ecological processes within and outside the sea ice. We conducted 8 regular stations, 4 on either side of the ice edge (small yellow dots). Following the process study we successfully deployed 3 thermistor moorings at 300.160, 300.100 and 357.080. The purpose of the moorings is to monitor the entry of warm, Upper Circumpolar Deep Water onto the shelf. Finally, we returned to the Palmer Station region and conducted a second acoustic survey to locate krill aggregations, as a followup to the survey described in our first report.



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Figure 1. Radar image of sea ice (white) in the southern region of the Palmer LTER study area, showing the -100 LTER Grid line. Image courtesy of Paul Morin, Polar Geospatial Imagery Center, Univ. Minnesota.

During the week and for the entire cruise we benefitted from excellent support by the Raytheon science support team and the officers and crew of the LMG. We're also grateful for imagery support from Paul Morin, Polar geospatial Imagery center, Univ. Minnesota.

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Individual component reports:

B-013: Seabird Component (W.R. Fraser, PI). Field Team Members: Jen Mannas and Kristen Gorman

The objective B-013's component of this year's LTER cruise (LMG 1201) 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.

The final week of research for B013 during LTER 1201 primarily included at-sea bird observations during Process Study 3 at the southern end of the LTER study outside of Charcot Island. Our surveys throughout Process Study 3 identified a rare sighting of a Ross seal on the pack ice. We also assisted with whale tagging operations lead by A. Friedlaender either on the zodiac or keeping track of whales from the bridge of the LMG. We spent the last days of the current cruise organizing data and packing up our field gear in preparation for the portcall at Palmer Station.

LTER 1201 was a successful cruise overall for B013. We were able to complete an entire LTER grid survey of seabirds and marine mammals, in addition to completing a 6 day field camp at Avian Island despite heavy sea ice conditions. Although we were unable to access our southern study colony of Adélie penguins at Charcot Island this year due to heavy sea ice, we were able to obtain samples of larval silverfish collected during zooplankton tows with the sea ice, courtesy of Dr. Debbie Steinberg's zooplankton group. This species is an important prey item in the diets of southern nesting Adélie penguins and will be extremely important in developing relationships between otolith characteristics and length of individual fish.

We are especially grateful to the Captain and crew of the LMG for a terrific cruise, in addition to RPSC marine personnel that made this an extremely smooth operation.

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

Team Leader: Oscar Schofield (Rutgers Univ). Field Team Members: Kaycee Coleman, Marie Séguret, Christian Laber, Amelia Snow, Andrew Irwin

The 2012 LTER cruise was extremely successful and the expanded sampling was successfully carried out over the entire grid combined with the experimental efforts conducted at the three Process Stations. The objective of this component is to understand how the ocean physics regulates overall phytoplankton productivity and community composition and how these dynamics affect the higher trophic levels of the food web. The team is focused on collecting an extensive set of measurements during the cruise. Bio-optical properties were characterized at 44 stations with measurements of the inherent (absorption, attenuation, backscatter) and apparent (spectral irradiance, radiance) optical properties. The inherent optical properties are measured with WetLabs absorption/attenuation meter (AC-9) and WetLabs EcoPucks. The visible and ultraviolet spectral radiometry is measured with Bio-Spherical Profiling Reflectance Radiometer (PRR) and Profiling UltraViolet sensor (PUV). Optical closure between the inherent and apparent optical properties were checked using the Hydrolight radiative transfer program onboard the ship. These profiling measurements were complemented with 370 measurements of chlorophyll *a*, HPLC, CHN, phytoplankton productivity ascertained via ¹⁴C-radioisotope, and photosystem II quantum yield (Fv/Fm). The measurements are augmented with samples

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collected for dissolved and particulate trace metal concentrations. This year, these micronutrient samples are augmented with measurements of particulate barium and RNA. Additionally 4 incubations carried out for the response to micronutrient additions (manipulations carried out on the 600 line, at 600.040 and 600.160 stations) using natural iron and zinc isotopes and two were carried out on the -100 line at the process study PS-3. Both incubations involved the enriched isotopes, the PS-3.3 (outside the ice edge) was spiked with Fe57 and Zn68, while the PS-3.4 (inside the ice edge) was spiked with Fe57. B-019 also collected 42 samples of particulate iodide that will be given to Dr. Tim Jickell's at the University of East Anglia. Measurements of particle size distribution and microbial community composition were made at each station using Beckman Coulter Multisizer 3 and Fluid Imaging Inc. FlowCAM unit respectively. At the Process Stations the phytoplankton team conducted three dual-labeled stable isotope nitrogen and carbon uptake measurements to determine general cycling of nitrogen, uptake rates of various nitrogen sources (NO₃⁻, NH₄⁺, and urea), and preferential selection of nitrogen types by different phytoplankton communities along the WAP. Finally these ship-based efforts were complemented with a full Slocum glider sampling effort sampling the southern portions of the LTER grid to complement ongoing glider efforts being conducted at Palmer Station.

Results from the cruise showed moderate phytoplankton productivity rates across the WAP grid with the overall productivity near the climatological mean observed over the 20 year LTER database. Generally 14C-uptake rates declined by 3-5 fold in offshore compared to nearshore waters. Overall productivity rates were highest in the coastal zones of Process study 1 and 2 during the cruise. Preliminary analysis indicates abundance and taxonomic gradients both cross-shelf and along the peninsula. Cryptophytes and other small flagellates were most abundant towards the coastal stations and Palmer station while small and medium-sized diatoms became more abundant off shore and south of Adelaide Island. Samples taken from sea ice were particularly diverse in diatoms. *Corethron* was the most commonly observed large diatom and a *Phaeocystis*-like colonial species was observed at both Process stations 1 and 2 (Palmer and Adelaide Island). Representative images of the diverse array of plankton from different regions are shown in **Fig. 2**. The large spatial extent of the small flagellate phytoplankton species was unique compared to the historical LTER HPLC data, which suggests that flagellate species generally only numerically dominate the nearshore waters associated with low salinity water. Our current thought is that the abundance of small flagellate reflects the ice melt associated with the big ice year encountered during the 2011-2012 field season.

Glider operations from the LMG were successful with the navigation of the RU26D glider past Avian Island through an ice field to Rothera Station where it was recovered. Additionally a second glider (RU05) was deployed from the LMG and was left to sample Avian island waters while the ship transected south to finish the sampling grid and conduct Process Station 3 at the ice edge. The glider flight locations at Avian followed historical penguin foraging tracks, determined via radio-tags, and efforts focused on collecting data inside and outside of penguin "hot-spots". The glider, after 4 days of sampling, was directed to fly offshore and rendezvous with the LMG at LTER grid station 200:050 as the ship was transecting north to deploy the physical oceanography moorings. The glider data show two distinct water masses near Avian Island. The upper 200 m were dominated by either a warm (>0.5 degrees C) and low salinity (≥ 33.25 salinity units) water masses consistent with offshore waters of Avian or 2) colder waters with values ranging from -1.4 to -0.7 and even lower salinity values (<33.5) waters. The chlorophyll fluorescence and scattering were 3-4x fold higher in colder water which appeared to associated with the retreating ice edge. Data analysis efforts will next combine the available

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glider, ship and satellite data to provide a coherent picture of the factors driving the variability in the phytoplankton distributions.

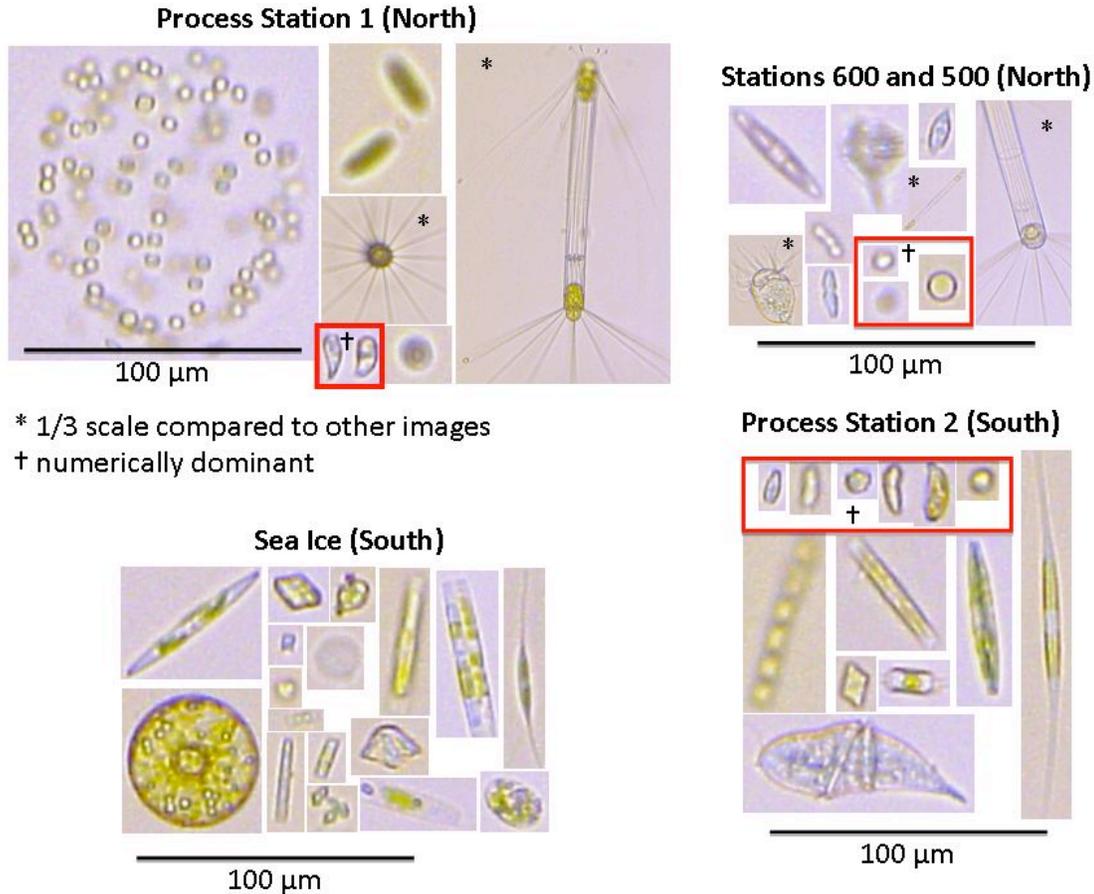


Figure 2. Characteristic phytoplankton species imaged using the Fluid Imaging Inc. FlowCAM (images by Andrew Irwin). All cells are shown to the same scale unless noted by *.

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

Field Team Members: Joe Cope, Kim Bernard, Kate Ruck, Lori Price, Karen Stamieszkin, Frances Armstrong.

We deployed a total of 121 nets, including sixty-five 2-m Metro net (700- μ m mesh), fifty 1-m Metro net (333- μ m mesh), and six MOCNESS (500- μ m mesh) tows. Twenty-four grid stations and 3 process studies (PS) were occupied. The MOCNESS was fished from 500 m at PS 1 (8 depth intervals), from 300 m at PS 2 (6 intervals), and from 350 m at PS 3 (7 intervals). Eighty-seven complete taxonomic workups (taxon counts and biovolumes) and forty-seven 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; indeed, krill were very abundant during this cruise. The remaining tows were taken for the collection of live animals. Throughout the cruise, whole animals, including *Salpa thompsoni*, *Thysanoessa*, *Euphausia superba*, *E. crystallorophias*, *Limacina*,

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Pleuragramma antarcticum, and dominant copepod and hyperiid species, were frozen at -80°C for lipid and gut fluorescence analysis (400 samples). Seven fecal pellet production experiments were conducted, including 2 for *Salpa thompsoni*, 4 for *Euphausia superba*, and 1 for *E. crystallorophias*. Samples resulting from these experiments will be analyzed for CHN and Chl *a*. *Euphausia superba* specimens were collected for collaborators for a variety of purposes: persistent organic pollutants content, genetics, behavior, and outreach. Three microzooplankton dilution experiments were conducted, one at each process study, to measure phytoplankton and bacteria growth and mortality rates.

Four gut evacuation rate experiments were conducted on dominant copepod species, *Rhincalanus gigus*, *Calanus propinquus*, *Calanoides acutus*, and *Paraeuchaeta antarctica*, at process study stations. Three rounds of copepod developmental experiments were conducted with *Paraeuchaeta antarctica* and *Calanus propinquus*. Although the copepods produced eggs, ship board techniques are being developed and refined. Specimens were preserved for training the ZooScan, a digital photography system capable of identifying zooplankton. A field guide was developed for identification live, dominant species.

Three bioacoustic surveys were taken, one at PS 2 and two at PS 1. These surveys targeted krill in major penguin foraging areas and will be overlaid with tracks taken by penguins fitted with satellite transmitters. Net samples taken concurrently with the survey will allow us to estimate biomass from signal strength.

B-045: Microbial Biogeochemistry Component (H. Ducklow, MBL; PI).

Team Leader: Hugh Ducklow. **Field Team Members:** Matthew Erickson, Cat Luria, Pam Moriarty, Sevrine Sailley, Mike Stukel.

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 completed cruise operations with stations on the 100, 000 and -100 lines as well as 8 stations in process study 3 and a final repeat CTD at 600.040. In all, we obtained 42 vertical profiles of leucine incorporation rates and microbial abundance, accompanied by other biogeochemical properties including inorganic nutrients, DIC, DOC, dO₂, 17 and 18O and dissolved Iodine. We also obtained profiles of the Thorium-234 deficiency at 25 stations. Finally we collected sea ice and water for Brown Univ PhD student Cat Luria to conduct a large, controlled incubation experiment to investigate the role of sea ice in structuring pelagic bacterial assemblages. Cat will collect community DNA samples to be analyzed at Brown with Prof. Jeremy Rich using Illumina sequencing.

Our results from measurements of 3H-leucine incorporation rates (an indicator of bacterial secondary production) suggest both the early seasonal succession and regional differences in the factors that govern bacterial activity (**Figure 3**). A plot of leucine rates vs temperature in the upper 50 meters shows no overall relationship between temperature and activity. That is, higher activity is not universally associated with warmer water. The plot also shows that we encountered no water warmer than +1C (in contrast to 2011 with temperatures >3C). Peak incorporation rates were observed in warm water (0-1C) in the north part of the study region, and in cold water (-2 to 0C) in Marguerite Bay. In the south, rates were low at all temperatures, probably reflecting an early stage in the seasonal succession following a late ice retreat.

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Successful operations are due to the help of many people: our LTER colleagues, the Captain, Officers and crew of the LMG and the Raytheon science support team, ably headed by MPC Stian Alesandrini. Our group especially wants to thank MST Lindsay Loughery for unstinting support characterized by a calm, sober and analytical mien. ETs Tony D'Aoust and Mike Coons were always ready to drop what they were doing to solve a problem with the ship's ancient computer system. MTs Mike Lewis and Chance Miller were indefatigable and never slowed for a second. We look forward to next year with the A-Team under new management.

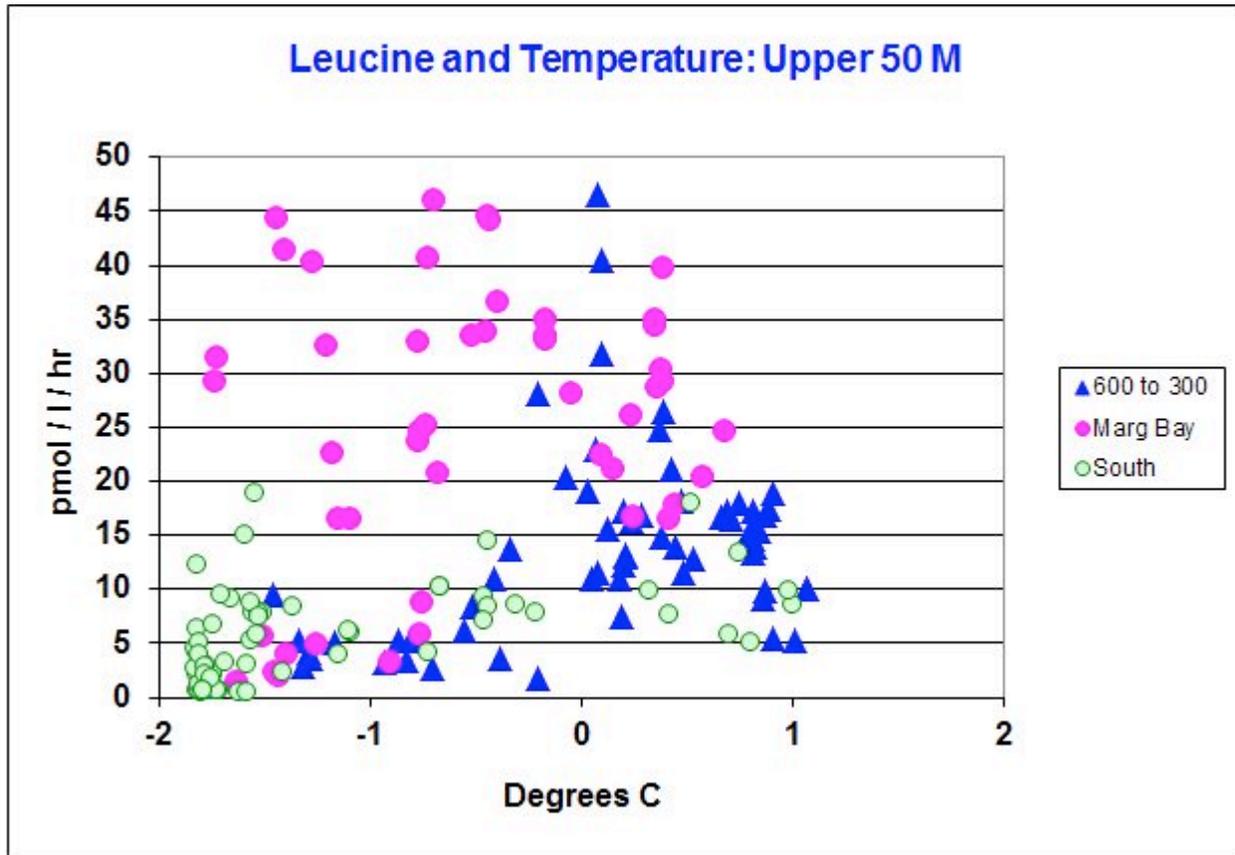


Figure 3. Relationship between rate of leucine incorporation (pmol/l/hour) and ambient temperature in different areas of the LTER study region.

LTER Guest Component: Distribution, abundance, and movement patterns of baleen whales within the Palmer LTER study area. PI: Ari Friedlaender.

Through a combination of visual surveys and satellite telemetry, the aim of this project is to better characterize the distribution and movement patterns of baleen whales within the LTER study area. By linking the movement patterns and distribution of these krill predators to oceanographic conditions and the historic feeding areas for Adelle penguins, we can begin to understand the ecological relationships that are likely to be affected by warming conditions in the Western Antarctic Peninsula region.

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To date, 138 sightings of over 250 humpback whales have been made. As well, six satellite-linked Argos tags have been deployed on humpback whales in the vicinity of Palmer Station, off the southern tip of Adeliade Island, off Charcot Island, and Andvord Bay . Their movement patterns suggest both residency in the krill-rich region around Anvers Island and longer-range movements to find other high-density krill areas in which to feed, but remaining in coastal waters around the islands of the Western Antarctic Peninsula. Six sightings of minke whales have also been made, and three sightings of killer whales. In general, it appears that the relative abundance of humpback whales is much greater in the northern portion of the study area than to the south in Margeurite Bay. Thirty biopsy samples were also collected from humpback whales throughout the cruise.

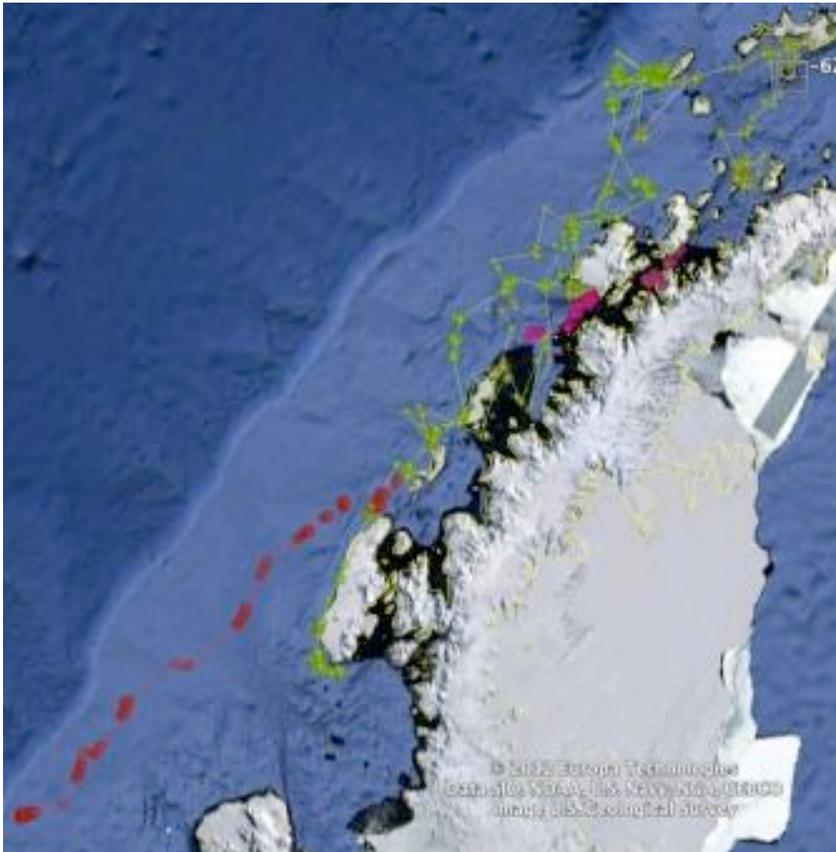


Figure 4. Satellite-linked locations of three humpback whales and their movements in the LTER Study region along the WAP

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

Field Team Leader: Bruce Barnett.

Continued measurements of gases dissolved in seawater measurements. We should have a fairly continuous dataset for the entire cruise with several transitions between the seasonal sea ice and open water. Seawater filtration for RNA extractions will continue through the Drake Passage for comparison of Polar Front water with shelf and off shelf collections.