

LMG 19-01: 30 Dec. 2019 – 12 February 2019, PAL LTER Cruise 27
Weekly Science Report 2

**LTER: Land-Shelf-Ocean Connectivity, Ecosystem Resilience and Transformation in a
Sea-Ice Influenced Pelagic Ecosystem on the Western Antarctic Peninsula
&
Physiological Ecology of “Herbivorous” Antarctic Copepods
&
Biological and physical drivers of O₂ saturation and net community production variability
at the Western Antarctic Peninsula**

Week 2 overview (Deborah Steinberg, Chief Scientist):

In Week 2, our first full week of the LTER cruise (6-12 Jan.), and after completing operations at Hugo Island, we completed Process Study I in the vicinity of Palmer Station in the Palmer deep submarine canyon (Fig. 1). This included three full stations located: 1) inshore at the edge of the canyon head (LTER grid 616.040), 2) in the Palmer deep (600.040), and 3) at the canyon mouth (595.043). We also conducted an extensive acoustic survey of the Palmer deep region to map prey in the region of penguin and whale foraging, which included CTD casts to map physical parameters such as mixed layer depth, and zooplankton net tows in two dense krill schools to calibrate acoustics. We then sampled the 600, 500, 400, and 300 grid lines. Regular, standard station operations occurred at representative coastal, shelf, and slope stations along the lines.

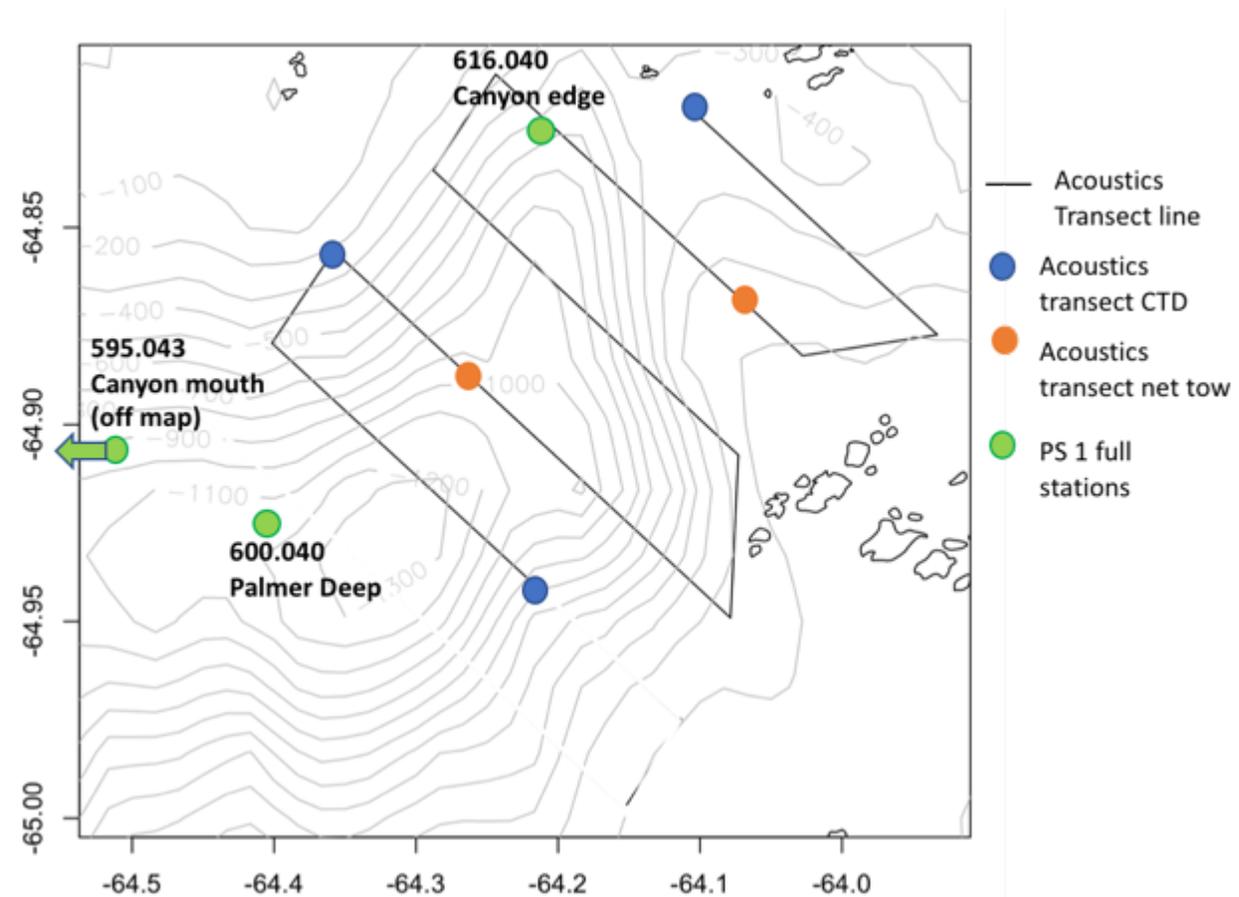


Figure 1. Map of Process Study (PS) I acoustic transect and stations.

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Individual component reports:

C- 021: Physical Oceanography Component-LTER (Doug Martinson, Lamont Doherty Earth Observatory; PI; Elizabeth Shadwick O-270, Virginia Institute of Marine Science; PI)

Field Team Member: Naomi Manahan

The physical oceanography component currently has one mooring deployed at the long-term study site 300.100. The mooring was successfully recovered on January 12, 2019 and the field team is currently in the process of downloading one year's worth of data from a vertical water column, including temperature, current, pressure, CO₂, pH, and oxygen (Figure 1). This allows us to track movement of water masses throughout the year. We will be redeploying the mooring located at 300.100 later during this cruise.



Figure 2. Recovery of the 300.100 mooring, with the top float sitting on the back deck. MT Josh Mitchell and MLT Diane Hutt were instrumental in a smooth and successful recovery.

C-045: Microbial Biogeochemistry Component-LTER (Hugh Ducklow, Lamont Doherty Earth Observatory; PI)

Field Team Members: Naomi Manahan, Rebecca Trinh, Shawnee Traylor, Johanna Ruff, Srishti Dasarathy

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). 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 measuring the ²³⁸U:²³⁴Th disequilibrium. ²³⁴Th measurements allow us to determine the export rate of ²³⁴Th on particles that have sunk out of the water column during the roughly 1-month period of time prior to our occupation of a station.

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Our first port call at Palmer Station was very productive and the support staff at Palmer Station provided assistance with equipment needs and ensuring all supplies were on board. During the first week of operations, we conducted all of the aforementioned measurements at LTER grid stations on the 600, 500, 400, and 300 lines and at three Process Study 1 Stations in the Palmer Deep canyon. Bacterial production rates were generally higher at the coastal stations compared to the offshore sites. We were able to train all team members during the first week and ensure protocols are being followed and all samples were collected correctly. This season we have Rebecca Trinh, who is a PhD student with Hugh Ducklow studying the interactions between krill fecal pellets and associated bacterial activity alongside carbon and nitrogen flux rates measured by the LTER sediment trap. Rebecca Trinh and Shawnee Traylor moved onboard the ship from Palmer Station to assist with the annual cruise operations for the Ducklow team.

Figure 3. MT Holly Martin deploys the CTD at the first Process Study in the Palmer Canyon.

B-461: Biological and physical drivers of O₂ saturation and net community production variability at the Western Antarctic Peninsula (Nicolas Cassar, Duke U., PI)

Field Team Member: Alexandria (Alex) Neibergall

By using equilibrator inlet mass spectrometry (EIMS) to measure net community production (NCP) with high resolution, our group is able to continuously measure gases dissolved in seawater from the ship's underway system. Measurements of O₂/Ar supersaturation of surface waters are 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 first week on the LTER cruise provided many opportunities on the 600, 500, 400, and 300 lines to collect additional samples for depth profiles of dissolved N₂O. Using this data, we will be able to estimate vertical mixing and account for the effect that upwelling has on the surface O₂/Ar measurements.

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C-019: Phytoplankton Component-LTER (Oscar Schofield, Rutgers, P.I.)

Field Team Members: Nicole Waite (lead), Emily Slesinger, Samantha Schofield, Hailey Conrad, Kim Thamatrakoln

The phytoplankton component of the Palmer LTER focuses on understanding the spatial and temporal distributions and physiological ecology of phytoplankton along the WAP. Our field work on this LTER research cruise focuses on maintaining the core phytoplankton time series measurements, including Chlorophyll a and High Performance Liquid Chromatography (HPLC) phytoplankton accessory pigment measurements, ¹⁴C daily primary productivities, and photosynthetic quantum yields through the use of a FIRE fluorometer. We also compliment these measurements with a full array of multispectral optical measurements through use of an AC-9 profiler. Bio-optical property sampling will occur prior to every CTD on the cruise. Back for its second year aboard the LTER Cruise is our Imaging Flow Cytobot (IFCB), which we use to take pictures of individual phytoplankton cells from water collected during CTD casts and during underway sampling. The IFCB allows us to identify WAP phytoplankton to genus, and sometimes to species-level. Finally, we will conduct incubation experiments at process study stations to observe diatom-virus interactions, comparing the north/south and coastal/slope waters of the WAP.

This season, both on LTER cruise and at Palmer Station, we are excited to have an all-female field team (Fig. 4). Thus far, it has been a productive week for the C-019 group. We conducted 14 CTD casts and complimentary AC-9 optical casts during the first process study, the northern section (lines 600 – 400), and into the southern section (line 300) of the LTER grid. We also collected 23 underway samples during the transits between CTD stations. Two incubation experiments were also started at Palmer Canyon station and the 400.040 station.



Fig 4. C-019 field team: From L-R: Kim Thamatrakoln, Samantha Schofield, Emily Slesinger, Marie Zahn (Palmer Station team), Schuyler Nardelli (Palmer Station team), Hailey Conrad, Nicole Waite. Not pictured: Anna Bashkirova (Palmer Station team).

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Preliminary analysis of IFCB data suggest a cryptophyte-dominated phytoplankton community in the Palmer deep region, and cryptophyte and dinoflagellate (e.g. *Gymnodinium* and *Gyrodinium*) dominated communities elsewhere along the WAP, with dinoflagellates increasing in offshore waters (Figs. 5 and 6).

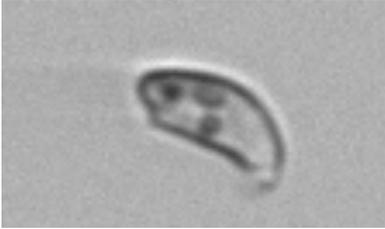


Fig 5. Photo of a Cryptophyte collected at Grid Station 600.040 (Palmer Deep) with the IFCB.

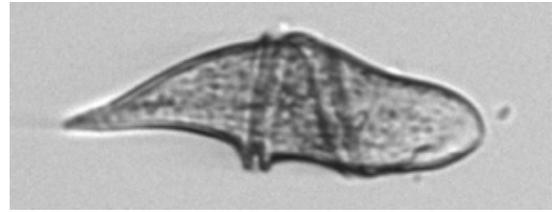


Fig 6. Photo of *Gyrodinium* spp. collected at Grid Station 600.200 with the IFCB.

Chlorophyll *a* remained low ($< 2 \text{ mg/m}^3$) in Palmer Canyon and the majority of the northern WAP, although we did see increased chlorophyll along the 400 grid line. CTD profiles showed shallow summer upper mixed layers (MLD) around 15-20m. Chlorophyll maximums were observed in or at the base of the upper summer MLD (e.g., Fig. 7).

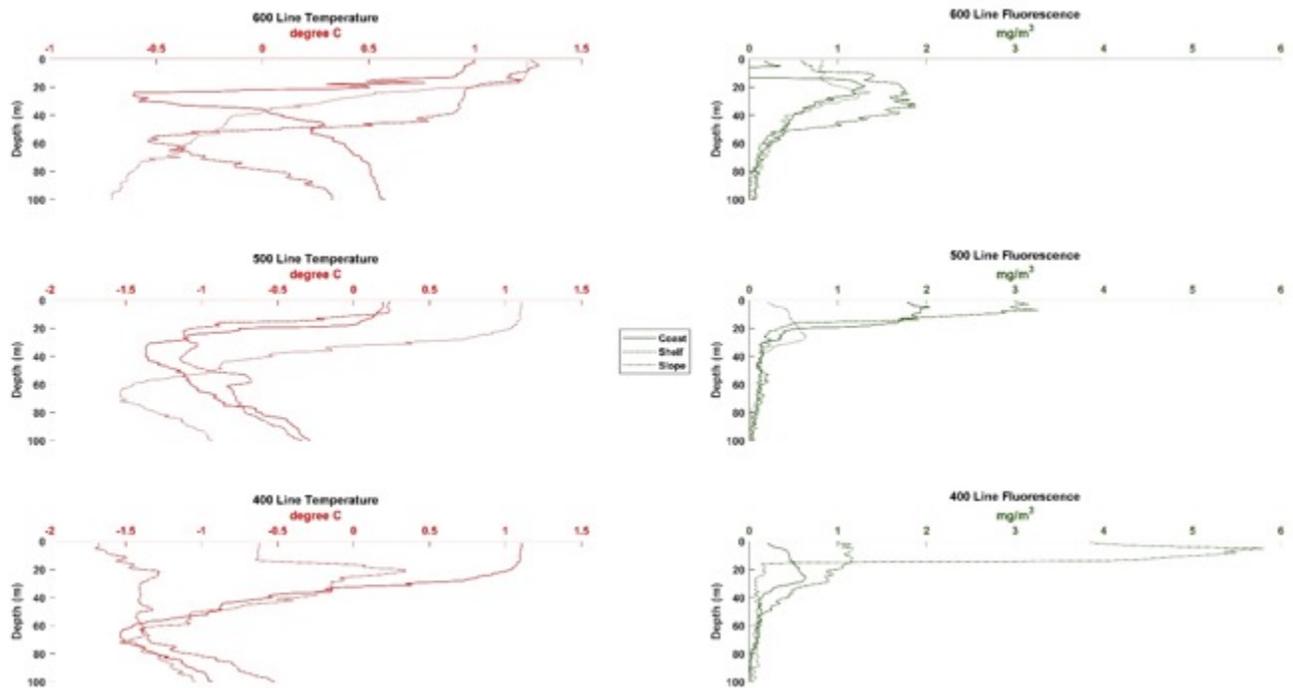


Fig 7. Temperature and Fluorescence profiles for the 600 (top), 500 (middle), and 400 (bottom) Grid Lines. The inshore coastal station (solid line), the shelf station (dotted line), and the slope station (dashed line) are shown.

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C-020: Zooplankton Component-LTER (Debbie Steinberg, VIMS; PI)

Field Team Members: Deborah Steinberg, Joe Cope, Patricia Thibodeau, Joshua Sacks, and Samuel Malmquist

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 coastal and three slope process study stations, we are examining the role that zooplankton play in the biological pump and in nutrient cycling (grazing, fecal pellet production, and diel vertical migration). PhD student Patricia Thibodeau, now in her fifth year, is wrapping up her field study of WAP pteropod biogeography and physiology.

In the first week, we concentrated our operations at the 3-day process study situated in the Palmer Deep canyon area and LTER grid point 600.040, as well as along the 600, 500, 400, and 300 grid lines. 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 (and will be quantified at our home institution). We also take samples at selected stations for zooplankton gut fluorescence (a measure of grazing). Thus far in the tows we are mostly seeing euphausiids (*Euphausia superba*, *Thysanoessa macrura*, and *E. crystallorophias*) and fish larvae, with pteropods occurring in some of the slope and shelf stations. We think we are seeing a summer zooplankton community structure indicative of one which follows a higher than average ice cover winter/year such as we've had: Almost entirely absent so far in the northern sub-region of our grid are salps—we have only caught a few *Salpa thompsoni* at one station (salps usually occur in warmer, more ice-free, open-water years). Also unusual is that we are catching the ice-associated *E. crystallorophias* at northern stations both along the coast and over the shelf; usually we only see this further south where there is more ice.

As in several past years, during the first Process Study we also conducted a bio-acoustic survey. The purpose was to map out aggregations of krill in the Palmer Deep canyon in order to explore relationships with whale distribution and penguin foraging locations. This year we added CTD casts at several places along the survey track to compare physical parameters such as mixed layer depth with krill school distribution. Krill schools distributed along the ~60 m acoustic survey grid were all very shallow; always in the top 0-50 m and usually within the surface 0-25 m (Fig. 8).

We also conducted two experiments measuring rates of fecal pellet production by *Euphausia superba* to continue our time series of the role that different zooplankton taxa play in particle export in the WAP.

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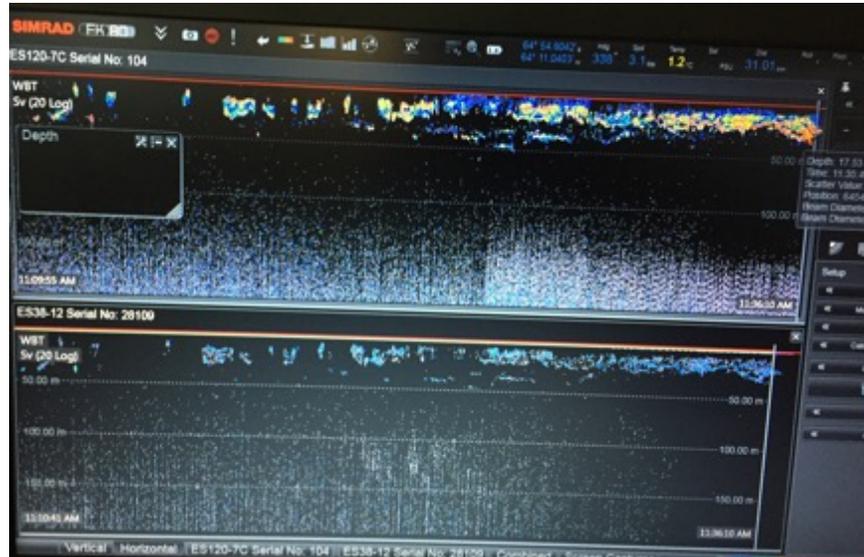


Figure 8. Acoustics trace of large, shallow (top 25m) krill school detected during acoustics survey in Process Study 1. Data from the EK80 echosounder mounted on acoustics towfish; upper panel is 120 KHz, lower is 38 KHz frequency.

The crew/ASC support on the ship has been excellent. The deployment of our net tows has been going smoothly with the expertise of the vessel pilots, marine technicians, and winch operators. We appreciate the work that the ETs and MTs put into ensuring a smooth set up and deployment of the relatively new EK-80 and tow fish system.

B-258: Physiological ecology of ‘herbivorous’ Antarctic copepods (Ann Tarrant, Woods Hole Oceanographic Institution; PI and field team member)

This project focuses on the adaptations of copepods – small animals that live in the water column and are an important food source to predators. Antarctic copepods have developed particular feeding and behavioral strategies to survive in their very seasonal environment; it is not known how each of these species will respond to environmental change. The overall goal of this project is to examine and compare these adaptations across species and to understand how each species responds to natural environmental variation and experimental changes in food availability. Copepods are collected using the standard LTER survey tows (2 m net with 700 micron mesh, 0-120 m tow depth) as well as dedicated ‘live tows’ using the same net with a non-filtering cod end (0-200 m depth). Collectively, these samples will be used to understand the gene content (transcriptome) of these Antarctic species, to characterize the roles of specific metabolic genes, and to understand how energetic condition of the copepods varies across the environment.

In the first week, I was able to sample all three target copepod species, *Calanus propinquus*, *Calanoides acutus*, and *Rhincalanus gigas*. We were also able to opportunistically sample the predatory copepod *Paraeuchaeta antarctica*. Copepods were sampled from 5 stations (600.040, 600.100, 500.200, 400.200, 300.100) with a total of 96 copepods reserved in RNA later for transcriptomic analysis and 16 pooled frozen samples for enzymatic or lipid analysis. In addition, experiments are in progress in which copepods are either incubated in unfiltered chlorophyll-rich

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water (fed) or in filtered seawater (starved). Presently 11 bottles are incubating from three stations (collected 1, 4 and 7 days ago).



Figure 9. A richly pigmented *Calanus propinquus*. The orange pigment is derived from carotenoids in their algal prey.

C-013: Seabird Component-LTER (William Fraser, PI)

Field Team Members: Megan Roberts and Anne Schaefer

The objective of this year's cruise is to continue the long-term data set of at-sea bird surveys to assess abundance and distribution across the LTER regional study grid as well as during the acoustic surveys conducted near Palmer Station. In addition, we plan to continue studies of Adélie penguin breeding and foraging ecology at Avian Island, which is located approximately 600 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. Mainly focusing on Adélie Penguins (but also Southern Giant Petrels, Blue Eyed Shags, South Polar and Brown Skuas) we will assess how and if annual environmental variability (e.g., sea ice and snow conditions) affects population trends, foraging success and diet, growth rates, survival and recruitment, as well as seasonal dispersal. If ice conditions and time allows we also plan to conduct similar fieldwork at Charcot Island and additional historical penguin colony sites along the WAP.

During Process Study 1, seabird and marine mammal surveys were conducted along the entirety of the acoustic transect grid crossing the Palmer Canyon and at process study stations. Species recorded included: Humpback whales, Wilson's Storm-Petrels, Southern Giant Petrels, Gentoo Penguins, skua species, and Kelp Gulls. After the process study and acoustic transect surveys were completed, transect and stationary surveys were conducted along the 600, 500, 400, and 300 LTER grid lines. No high-density bird groups have been observed, but relatively low densities of Cape Petrels, Southern Fulmars, Black Browed Albatross, Southern Giant Petrels, and Kelp Gulls have been recorded. Additionally, we have recorded one Wandering Albatross offshore along the 300 line and a few Snow Petrels, while in ice encountered at the near shore site along the 400 line.

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C-024: Cetacean Biology & Ecology-LTER (Ari Friedlaender, University of California, Santa Cruz, PI).

Field Team Members: Michelle Modest, Ross Nichols

Our main objectives for the 2019 LTER cruise are to conduct visual surveys of cetaceans along the LTER grid lines that involve recording location, group size, and species. In locations where whales are present, our team deploys into a small boat to conduct Photo ID, biopsy and tagging operations. Photo ID consists of taking photos of an individual's dorsal fin and fluke to identify signifying scars, colorations, and other marks that can be later used to identify the individual. Biopsies are collected with modified crossbow bolts that take a small plug of blubber and skin from a whale which will be used in genetic, hormone, and contaminant analysis to measure the sex of the animal and the pregnancy status of females. We also deploy digital suction cup tags that remain on the whale for up to 24 hours. The tags are equipped with a multitude of sensors that measure the time and depth of each dive, as well as the foraging behaviors of the whale while at depth using a 3-axis accelerometer, gyroscope and magnetometer.

Sightings Operations

Since departing Punta Arenas, the whale team has been conducting a visual survey of cetaceans while aboard the LMG. So far, 257 whales have been sighted including 3 mother-calf humpback whale pairs. We will continue to monitor the presence of whales as we continue our journey. Below is a chart describing our total numbers sighted as of 1.12.2019.

	Total Whales Sighted	Total Calves	Total Adults
Humpback	200	3	197
Minke	4	0	4
Orca	6	0	6
Fin Whale	6	0	6
Unknown	41	0	41
Totals	257	3	254

Biopsy and tagging operations

Since the beginning of LMG-01, the whale team has collected 7 biopsy samples from adult humpback whales (Fig. 10). These samples will be later analyzed for hormone concentrations including progesterone, estrogen, testosterone, and cortisol. The genetic analyses of the biopsies are also used to identify individuals that can be tracked from year to year.

On 1.6.2019, the whale team deployed a suction cup tag on an adult humpback whale (Fig. 11) that was participating in shallow foraging dives for the entire duration of the tag's attachment. We were able to record 19 hours of foraging behavior, including the dive profile of the whale's foraging bouts as seen in Fig. 12.

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Figure 10. Michelle fires a prepared biopsy dart at an adult humpback in the Palmer Deep area. The dart takes a small plug of skin and blubber using a specialized bolt tip. The bolt bounces off the whale upon impact and is collected as it floats on the surface. The biopsy is later frozen and stored for future analysis.



Figure 11. A “CATS” digital tag suctioned onto an adult humpback whale. This whale was tagged on 1.6.2019, and foraged while being recorded in the Palmer Deep area over the next 19 hours.

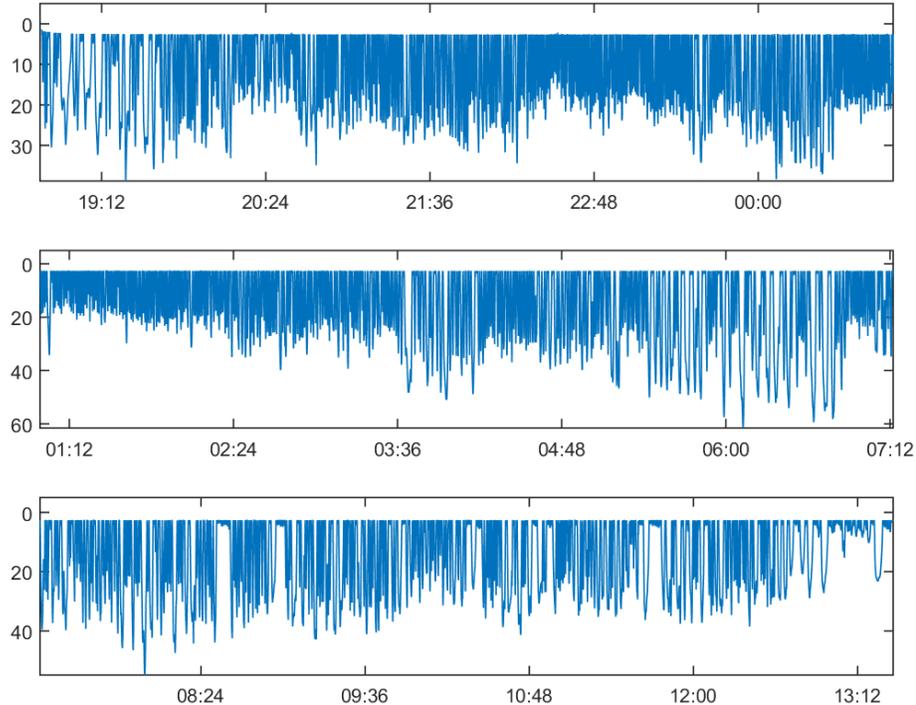


Figure 12. An 18-hour dive profile of an adult humpback whale foraging in the Palmer Deep region. Depth below the surface on the y-axis and local time of day (+3 GMT) on the x-axis. This data was recorded with a CATS digital suction cup on 1.6.2019 – 1.7.2019.