LMG 19-01: 30 Dec. 2019 – 12 February 2019, PAL LTER Cruise 27
Weekly Science Report 5

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 O_2 saturation and net community production variability at the Western Antarctic Peninsula

Week 5 overview (Deborah Steinberg, Chief Scientist):

In Week 5 (27 Jan.- 2 Feb.), we redeployed the 300.100 mooring, conducted whale and seabird operations in the Renaud Island (Armstrong Reef) and Prospect Point (Fish Islands) region, and recovered and redeployed our long-term sediment trap. We also revisited grid station 500.100 on our way north, to complete operations there that we missed (due to weather) earlier in the cruise. Finally, we conducted a day/night MOCNESS pair at station 600.200 before moving on to the Palmer Deep for our final cruise operations.

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 successfully deployed the legacy mooring at 300.100 on January 27, 2019. The success of deployment was due to the great efforts of the ASC and ECO crew that ensured a smooth operation. **Figure 1** shows the mooring staged on the back deck.

Figure 1. Naomi Manahan, physical oceanography team member, kneeling in front of the mooring prior to deployment. By placing the line and buoys into crates on the back deck, the risk of tangle or trips is reduced.

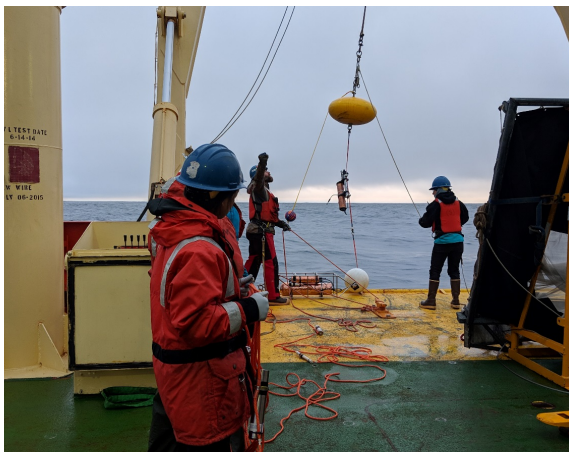

Figure 2. Scientists stay out of the yellow zone while MT Josh Mitchell and MLT Diane Hutt use the stern A-frame to lift the heavy yellow EF-33 top float off the ship. In the air is the SeapHOx, which will monitor pH and oxygen. On the deck is the CO_2Pro, which monitors carbon dioxide throughout the year.

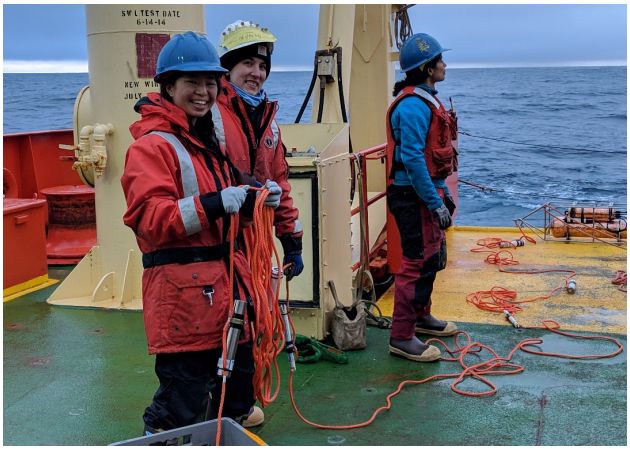

Figure 3. Rebecca Trinh (left), Naomi Manahan (right), and ET Adina Scott prepare to hand line to the people working in the yellow zone. The metal instrument hanging from the line in Rebecca's hand is a temperature/pressure sensor that sits at a specific depth in the water column.

On the morning of deployment, rough seas and high winds pushed back the schedule by several hours. Thankfully, in the evening the seas had calmed down enough to allow operations to proceed safely. After performing a benthic survey to determine the most suitable drop point (with a desired depth of 485m), the mooring was staged on the back deck in crates in preparation for the hand deployment (**Fig.1**). Since there are so many instruments tied directly to the line, spooling the hundreds of meters of mooring line onto the winch could damage the instruments. Consequently, the physical oceanography moorings are always hand deployed (aside from the top buoy, which is too heavy to hand deploy). **Fig. 2** shows crew members handing the line and instruments towards the stern as the MT monitors items going off the deck and into the ocean. It is critical that the instruments are not dragged across the deck, which is why our team was on hand to pass instruments and line to the MT and MLT in the yellow zone (**Fig. 3**).

After all instruments are in the water, it is critical that the mooring "anchors away" location is at the proper depth so that sensors are measuring the desired water masses in the vertical water column. Team member Naomi Manahan was on the bridge with the captain and chief mate to watch as the ship approached the drop point. Upon arrival at the drop point, Naomi called out "anchors away" over the radio and the MT used a quick release mechanism to rapidly drop the anchor into the water at the desired location. Physical oceanography moorings traditionally use railroad wheels as their anchors, weighing upwards of 800 pounds.

The physically oceanography component is incredibly thankful for the input from the ASC and ECO staff, especially while assessing the sea-state and determining the safest way to put the mooring in the water. It wouldn't be a mooring deployment without Captain Ernest!

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

This week was primarily focused on recovery and deployment of our McLane conical sediment trap at 580.130. The instrument sits at a depth of 170 m for one year, collecting sinking particles that are used to measure carbon and nitrogen flux. The trap is programmed to rotate between sample bottles throughout the year, so a total of 21 sediment trap samples are collected after one deployment. The instrument is connected to a dual release, which will let go of the anchor and allow the trap to float to the surface when commanded. We are happy to report that the recovery was successful, with a sediment trap full of particles! A big thanks to MT Holly Martin and MPC Sean Bercaw for their smooth back deck ops. **Fig. 4** shows the trap samples lined up, and **Fig. 5** the Ducklow team members in front of the sediment trap.

Figure 4. Sediment trap bottles lined up in order of sampling. Bottle 1 began collecting sinking particles on February 4, 2018. Cups that show high flux (indicated by high particle volume) are bottles 4 and 5, which collected during the months of March and April 2018, respectively.

Figure 5. From left to right: Shawnee Traylor, Johanna Ruff, Srishti Dasarathy, Naomi Manahan, and Rebecca Trinh.

Figure 6. Rebecca Trinh carefully screws on the new bottles for the redeployment of the trap. The bottles contain a fixative to ensure material that falls into the trap does not decompose.

The trap recovery is the first step in a day-long process of refurbishing the sediment trap and dual-releases. Fresh sample bottles are filled with preservative for the redeployment (**Fig. 6**).

The instrument was re-programmed to ensure the rotation dates are correct for the upcoming year, bottles replaced, and the instrument was redeployed once again at 580.130 (**Fig. 7**). Thanks to ASC ETs Adina Scott and Gabby Inglis for refurbishing the releases, MT Josh Mitchell and MLT Diane Hutt working in the yellow zone, and ECO crew on the bridge maintaing the ship at a perfect speed. We look forward to another successful recovery on LMG20-01.

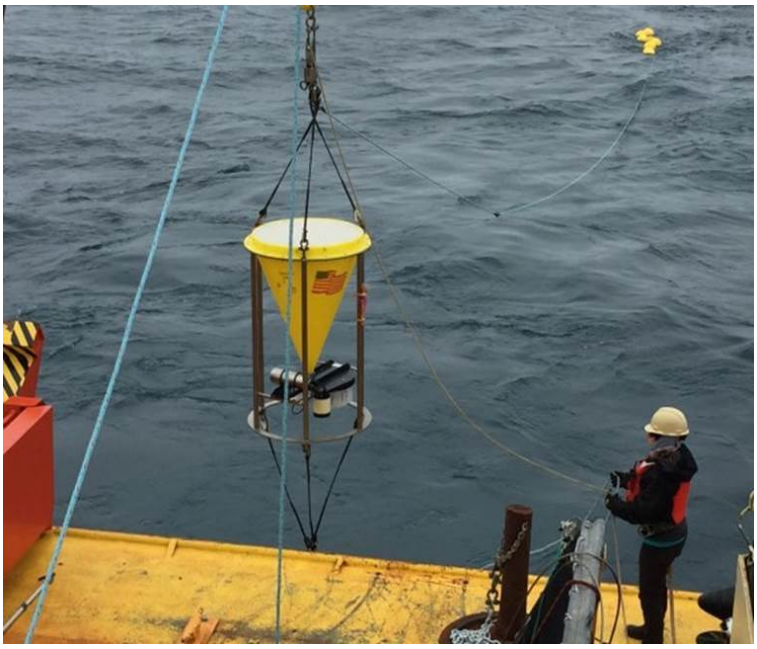

Figure 7. MLT Diane Hutt assists with the re deployment of the sediment trap off the stern A-frame. The trap is lowered off the back deck, and the "hard hat" floats, which are glass spheres, are trailed behind the ship.

B-461: Biological and physical drivers of O_2 saturation and net community production variability at the Western Antarctic Peninsula (Nicolas Cassar, Duke U., PI)

Field Team Member: Alexandria (Alex) Niebergall

The Equilibrator Inlet Mass Spectrometer (EIMS) has run continuously for the entire week. These data will be used to estimate net community production (NCP) in the mixed layer along the cruise track. I opportunistically collected duplicate 4L water samples from the ship's underway system and at CTD stations. These samples were filtered through 0.2µm Sterivex filters and will be used for 16S/18S amplicon sequencing. These opportunistic samples will allow us to further explore the microbial community composition at the ice edge and examine temporal variation at sites that were sampled at the beginning and end of the cruise. By coupling these data with the EIMS data, we will further elucidate the relationship between the microbial community composition and net community production in the mixed layer.

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

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

Coastal birding and whaling operations this week afforded us time to focus on data entry, data processing of FIRe and AC-9 data, and continued sampling of incubation experiments. We also completed a CTD cast after the successful redeployment of the sediment trap, collecting our usual suite of samples to support the Ducklow group with water column profiling and sampling to compare with the sediment trap data.

Additionally, our Imaging Flow Cytobot (IFCB) began having technical and computer issues this week, and a portion of the week was spent troubleshooting. Unfortunately, we did not have success in fixing the IFCB – which needs to be sent back to the manufacturer for repairs. We were able to remove the hard drive from the IFCB and backup all of the data collected thus far this cruise. We are happy to have IFCB data from the entire grid survey (underway sampling and CTDs) and the first 3 process studies.

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

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

In addition to sampling the 500.100 gird line (for which we missed tows earlier in cruise), we conducted day and night sampling of zooplankton distribution at discrete depth intervals using the MOCNESS (Multiple Opening-Closing Net Environmental Sensing System) (**Fig. 8**) to investigate depth distribution and diel vertical migration of zooplankton at the slope process study station on our furthest north grid line (600.200). We also picked "swimmers" (zooplankton that swim into the sediment trap and die, and are not part of the flux) from the two most recent sediment trap samples so that they can be processed for Thorium-234.

With three day/night MOCNESS pairs in deep (>3,000m) slope waters we now have a nice diel and latitudinal comparison of zooplankton vertical distribution in the north (600.200), south (200.180), and far south regions of the LTER grid. While much of the analysis of these samples will be done at our home institution we did note some qualitative similarities and differences already. For example, at all three stations we found deep layers (in our 750-1000 m, and 500-750 m nets) of large scyphomedusae that did not seem to vertically migrate (i.e., they were found at the same depths during both day and night sampling) (**Fig. 9**).

The MOCNESS is a big operation, and we appreciate the excellent support from ASC techs and ECO that made it go very smoothly.

Figure 8. Nighttime MOCNESS deployment.

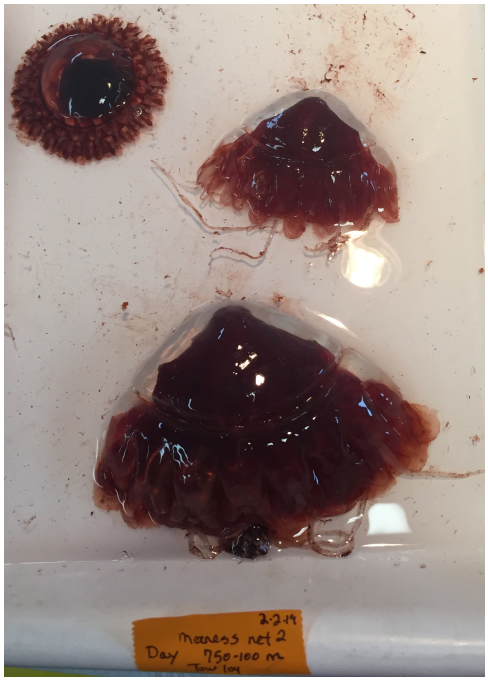

Figure 9. Deep-Sea jellies collected in MOCNESS samples. Upper left is *Atolla* sp. Two on the lower right are *Periphylla periphylla*.

This week PhD student Tricia Thibodeau continued her metabolic experiments on the dominant pteropod taxa located along the Western Antarctic Peninsula (**Fig. 10A-C**). Only one other study has recorded respiration rates for the gymnosome (non-shelled) *Clione antarctica* (**Fig. 10B**) along the WAP and no previous study has published respiration rates for *Clio pyramidata* (**Fig. 10C**), a shelled pteropod. Tricia also conducted a multifactorial experiment to determine how increasing temperatures and shifting food availability due to climate change affects *Limacina helicina antarctica* (**Fig. 10A**) respiration and excretion (metrics for measuring metabolism). Results from are in line with her previous experiments that high temperatures (~4°C) significantly increase *L. antarctica* respiration rate while changing food concentrations (e.g., chlorophyll) have variable or insignificant effects (**Fig. 11**).

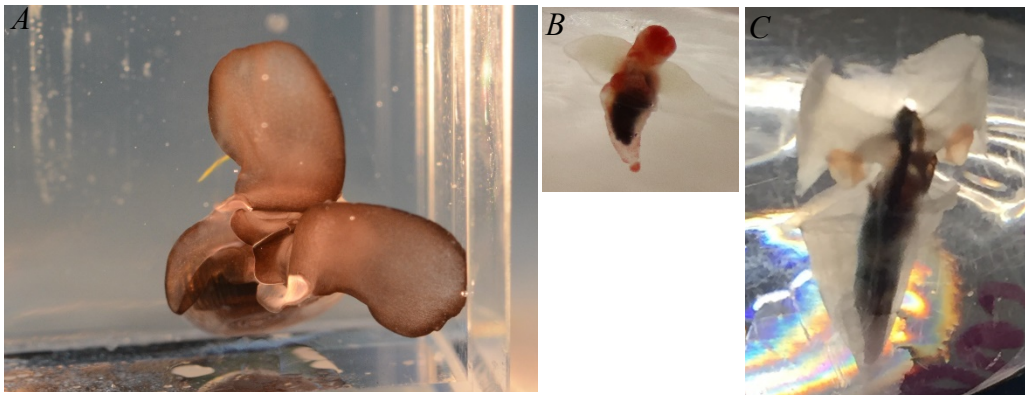

Figure 10. Three of the four major pteropod taxa located along the Western Antarctic Peninsula; *Limacina helicina antarctica* (A), *Clione antarctica* (B), and *Clio Pyramidata* (C).

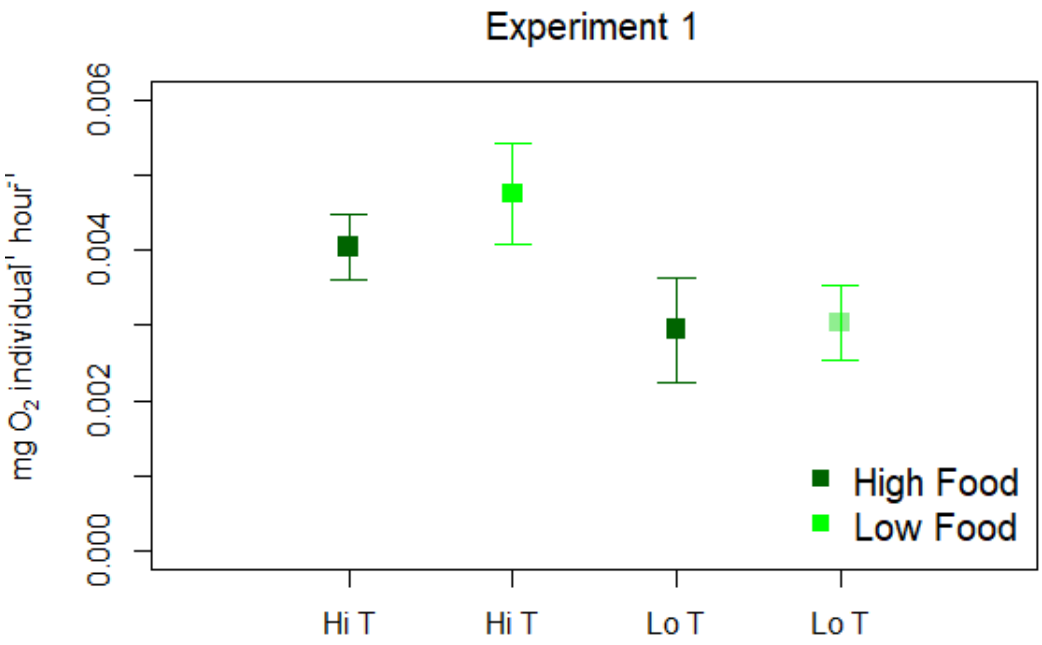

Figure 11. Respiration rate (mg O_2 individual^{-1} hour^{-1}) of pteropods as a function of two temperature treatments (Hi T and Lo T) and two food treatments. Respiration was significantly higher (ANOVA, $F = 5.88$; $p = 0.03$) in the high temperature (4°C) treatments than the low temperature treatments (-1°C). There was no significant effect ($p > 0.05$) of food concentration on respiration rate (high food ~ 4 µg/L chl, low food ~ 0.4 µg/L chl).

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

This week, sampling was completed of the *Calanus propinquus* feeding experiment. Groups of copepods were either fed a natural assemblage of plankton or starved in filtered seawater. As with the earlier *Calanoides acutus* experiment, animals were sampled after 5 and 9 days of shipboard incubation. The following samples are in hand:

Experiment 1: *Calanoides acutus.* Collected January 14, 2019, Station 200.040

Date	Treatment	RNA samples	Cryo Samples	Observations
1/19/19	5 days Fed	6 pools of 2-3	4 pools of 3-5	1/60 animals dead
1/19/19	5 days Starved	6 pools of 2-3	5 pools of 3-5	3/45 animals dead
1/23/19	9 days Fed	15 individuals	7 pools of 3-5	17/60 animals dead

1/23/19	9 days Starved	12 individuals	5 pools of 2-5	16/45 animals dead
1/23/19	5 days Starved then 4 days fed	11 individuals	3 pools of 3-4	7/30 dead

Experiment 2: *Calanus propinquus.* Collected January 22, 2019, Station 000.100. All animals live until time of sampling.

Date	Treatment	RNA samples	Cryo Samples	Observations
1/27/19	5 days Fed	11 individuals	4 pools of 3-4	19/25 high food in gut (4 low, 2 no)
1/27/19	5 days Starved	8 individuals	4 pools of 3	20/20 no food in gut
1/31/19	9 days Fed	12 individuals	4 pools of 2-4	24/26 high food in gut (2 low)
1/31/19	9 days Starved	11 individuals	4 pools of 2-3	16/22 no food in gut (6 low)

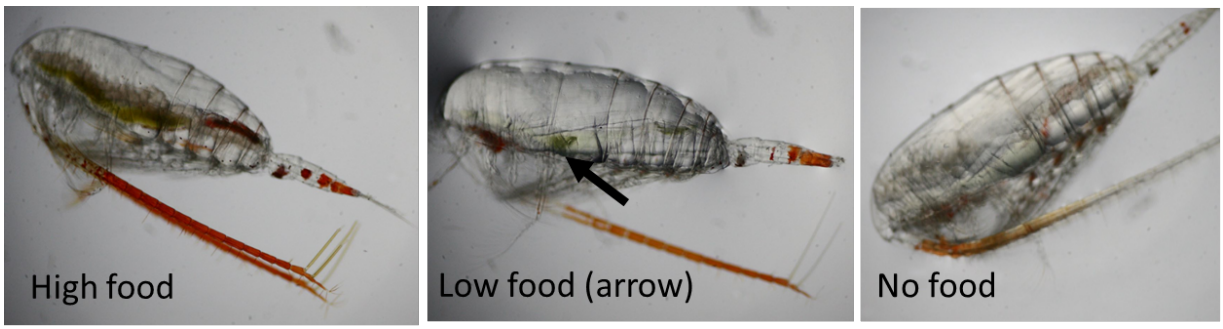

Figure 12. Examples of *Calanus propinquus* with high, low and no food in their gut after 9 days of laboratory incubation.

Overall the experimental samples will enable analysis of metabolic and transcriptomic responses to starvation under laboratory conditions. The *C. acutus* experiment is complicated by significant mortality at the later time point, indicating that these animals did not thrive under laboratory conditions, even when food was present. *C. propinquus* were robust to laboratory conditions and appeared to readily feed on available algae (**Fig. 12**). During the second sampling point, small amounts of algal material were visible in the guts of some specimens. The source of this material is not entirely clear (e.g., leakage into buckets, incomplete filtration).

Field-based sampling

During this week, copepods were sampled from two stations (500.100 and 600.200). *Calanus acutus* was relatively abundant at 500.100, but few copepods were recovered at 600.200.

Below: Schematic of *C. acutus* and *C. propinquus* samples collected to date (RNA samples in RNAlater or frozen samples in cryo vials). Numbers along vertical axis indicate latitudinal line on the LTER grid. Numbers along the horizontal axis indicate position relative to shore (inshore 0-40, mid 100, offshore 180-200), with green shading indicating larger sample numbers. Asterisks indicate stations sampled on multiple dates.

RNA - *C. acutus*

	0-40	100	180-200
600	17	(9 + 6)*	0
500	12		3
400	16		1
300		6	
200	61*		
100			
0		11	
-100	16		

RNA - *C. propinquus*

	0-40	100	180-200
600	3	2	0
500			4
400	2		2
300		5	
200*	18		
100			15
0		9	
-100	8		

Cryo - *C. acutus* (pools)

	0-40	100	180-200
600	1	2	
500	6		
400			
300		1	
200	20*		
100			
0		6	
-100	5		

Cryo - *C. propinquus* (pools)

	0-40	100	180-200
600			
500			
400			
300			
200*			
100			2
0		4	
-100	5		

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

Field Team Members: Megan Roberts and Anne Schaefer

This week was used to wrap up data entry, conduct bridge based surveys at grid stations, and conduct censuses of Adélie colonies at the Fish Islands near Prospect Point and at Armstrong Reef, just south of Renaud Island (**Fig. 13**). Additionally, the team was able to collect and process five diet samples from Adélies at Armstrong Reef.

Unfortunately, due to heavy ice within the bay near the Fish Islands, the team was unable to access the Fish Island colonies in small boats and could not collect diet samples or complete full island censuses. However, due to the hard work of the captain and mates of the LMG Gould, we

were able to get quality photos of multiple colonies from the bridge that can be used for adult and chick counts.

The team was able to access most of the islands with Adélie colonies within Armstrong Reef. We were able to conduct full island censuses of Adélies and Blue Eyed Shags, and collect five diet samples. Diet samples from this region were composed of mostly fresh adult and juvenile *Euphausia superba* and contained pieces of fish as well as fish otoliths. The team observed more snow on the islands than the previous season.

Figure 13. Fish Island Adélie colonies as seen from the bridge (left), colonies on Island 3 at Armstrong Reef (right).

Bridge-based surveys were conducted at grid stations and at the mooring deployment site. No high-density bird groups were observed during surveys. Off survey, during transit to the 600.200 station, we observed large groups of Black Browed Albatross on the water with a mix of Light-Mantled Sooty Albatross and a few Grey-Headed Albatross. We also had our first sighting of the season of a Black-Bellied Storm Petrel and two Blue Petrels within the area.

We would like to thank Captain Ernest Stelly and all the mates for their hard work and for safely getting us to our research sites this week. We also would like to thank the ASC team, especially the MTs, Josh and Holly, and the ETs, Gabby and Adina, for their hard work in scouting sites and for helping get us safely to and from the ship to our research sights. Also, a big thank you to Debbie and Diane for your assistance at Armstrong Reef.

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

Field Team Members: Michelle Modest, Ross Nichols

Sightings Operations
Over the last week, Humpbacks were the sole species observed and have increased in sighting frequency as we have gone more North (**Figs. 14, 15**). The whales observed this week were seen foraging at the surface using surface lunge feeding, bubble net feeding, transiting, and dive foraging. Photo ID was taken on all animals that were present during zodiac deployments. During breaks in birder operations at Armstrong reef, the whale team was able to deploy on large groups of foraging whales. Over 12 biopsies were collected within 36 hours at this time, and signaled a hotspot for humpback foraging.

Biopsy operations

Over the last week, our team has collected 14 biopsies on humpback whales. All 14 of these whales showed signs of foraging during or after biopsy operations. A group of four whales was seen foraging at Armstrong reef. This group consisted of 3 adults and 1 calf (**Fig. 16**) and biopsies were collected on all three adults. This is vital information, as it will enable us to learn more about the demography of foraging groups of adult whales with a calf accompanying. We will determine the mother of the calf using hormone analysis, and will determine the pregnancy status of the currently nursing mother. Knowing what types of adults that accompany mother-calf pairs gives us clues as to how social and foraging groups are formed throughout the summer season on the Western Antarctic Peninsula.

	Weekly Whales Sighted	Total Calves	Total Adults
Humpback	24	2	22
Minke	0	0	0
Orca	0	0	4
Fin Whale	0	0	0
Unknown	0	0	0
Totals	**24**	**2**	**22**

Biopsies	Total Samples
Humpback	14
Minke	0

Figure 14. Weekly statistics of our sightings from the LMG 1901 from 1.28.2019 – 2.2.2019.

	Total Whales Sighted	Total Calves	Total Adults
Humpback	276	6	274
Minke	4	0	4
Orca	10	0	10
Fin Whale	6	0	6
Unknown	41	0	41
Totals	**342**	**6**	**336**

Biopsies	Total Samples
Humpback	32
Minke	0

Figure 15. Total statistics of our sightings from the LMG 1901 from 12.28.2018 – 2.2.2019.

Figure 16. Two adult humpback whales (REAR) accompany a humpback calf (FRONT). The calf was likely born over the Antarctic winter off the west coast of South America. It migrated to the Western Antarctic Peninsula with its mother who was seen foraging with 2 other adults. The biopsies collected from the adults in this group will lead to important demographic information of mother-calf whale groups during this critical time of year.

Figure 17. Two adult humpbacks perform vertical surface lunge feeding, and these photos illustrate the baleen present on the upper jaw of humpback whales. The color of the baleen can differ from individual to individual as seen in this photo. The whale on the left has a homogenous grey baleen color, as where the whale on the right shows a mixed color pattern of grey and white.