Science Report for Week 2 of LTER 1701.

The LTER 1701 cruise departed Palmer Station on January 6, 2017. After a process study in week 1, the second week focused on mapping the standard sampling grid along the WAP. The progress to data is illustrated in Figure 1 by the red line. We have completed the 600, 500, 400, 300, 200, and 100 standard survey lines. We have also deployed and recovered the penguin team from Avian island. During the birder survey of Avian, the science team conducted both an inshore and offshore process study and collected a high resolution CTD survey of the 200 line to complement the inshore and offshore surveys. The focus of the process study was to compare contrast the night/day vertical migration differences between the coastal and marine end-members within our sampling region.

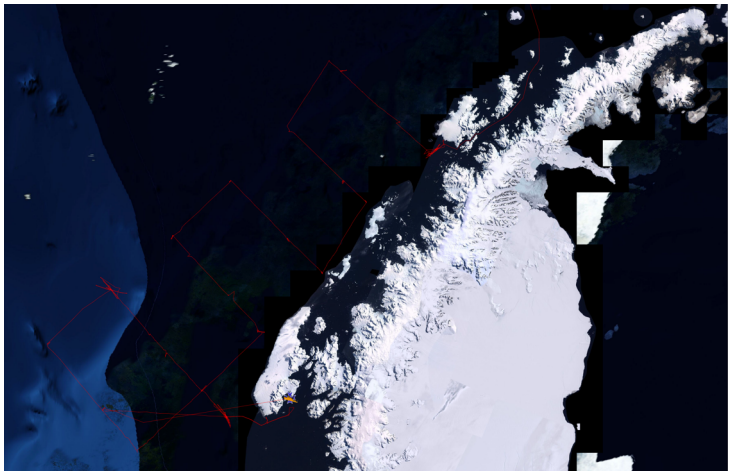

Figure 1. Map of the area covered to date during LTER 1701.

B-021. Physical oceanography of the WAP (Douglas Martinson, Lamont Doherty Earth Observatory, Columbia University.

Field team Members: Darren McKee

One of the things the physical oceanography component is interested in is understanding the processes of shelf-slope exchange: how do water masses and tracers from the continental slope make their way onto the continental shelf? While transiting across the continental slope of the 200 line we were fortunate enough to be able to conduct a transect of closely-spaced CTD casts across the shelf. We hoped to diagnose the structure of the shelf-break front and also to see if any bottom Ekman layer may exist along the slope. A summary of the data is shown in Figure 2. These data reveal that the 1.7 ºC isotherm and the velocity maximum -- two commonly used definitions for the southern ACC front -- are coincident here. These data clearly reveal for the first time the V-shaped nature to the front (a common feature elsewhere in the Antarctic). The absolute currents from the SADCP suggest that the shear in the upper 500 m

roughly matches the geostrophic shear, but there is a significant contribution from an unresolved barotropic component (something we suspected based on other data) or from shear deeper than 500 m. Interestingly, it appears that we caught a UCDW eddy at station 200.145. This location suggests that eddies are indeed shed where our theory suggests they should be (at the base of the permanent pycnocline, at the site of steepest isopycnal slope).

Profiles at 200.140 (Figure 3) and 200.145 reveal what appears to be a bottom Ekman layer containing cooler and saltier (and hence denser) LCDW. Owing to the mean direction of the shelf-break current, flow in this layer should be coastward, and this is a widely-implicated process of shelf-slope exchange elsewhere in the world. The layer does not appear to persist inshore, however. While that may be true, this still indicates a means by which the saltier-endmember LCDW (and whatever tracers are along the base of the slope) can at least be brought up to the edge of the shelf-proper.

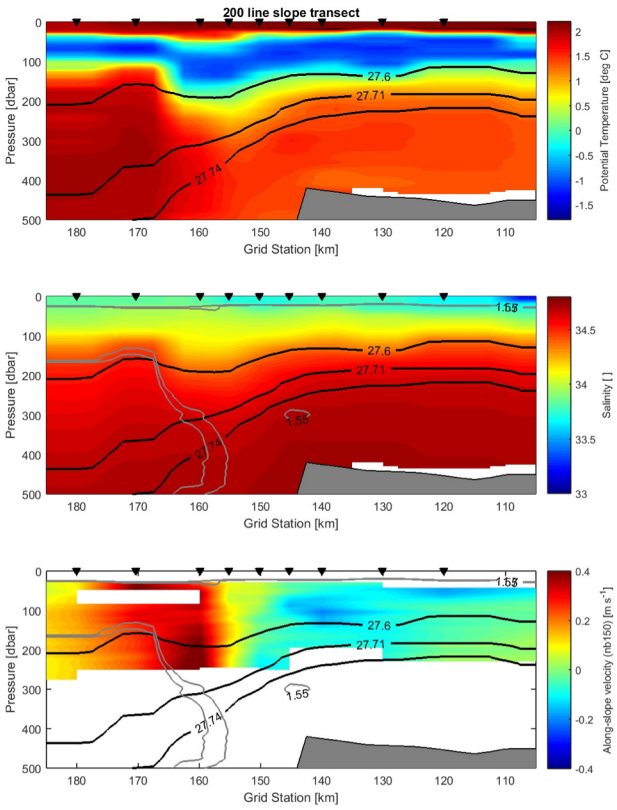

Figure 2. Data gridded (upper 500-m) across section. From top to bottom: potential temperature, salinity, and along-slope current (from the nb150 instrument). Select isopycnals (labeled black contours) and isotherms (labeled grey contours) indicated. Cast locations indicated as black wedges, bathymetry from ETOPO indicated as grey patch.

Later on, when the SADCP and CTD data are fully processed and quality-controlled, we can examine mixing parameterizations over these steep slope stations and compare the values with those on the shelf. One thought is that the shape of the front is maintained, in part, through energetic internal waves.

We are thankful for the efforts (and patience!) of the technicians and crew for conducting these closely-spaced casts and yielding this valuable data set!

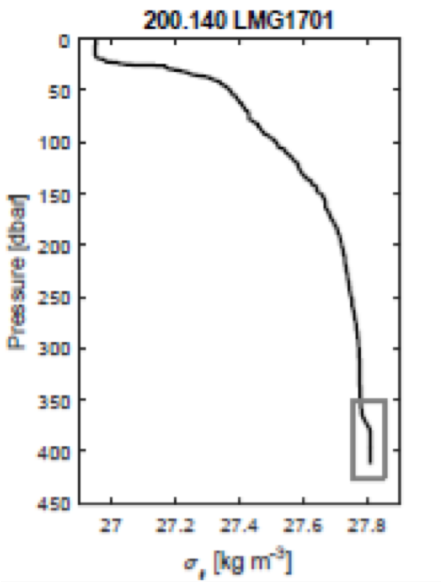

Figure 3. Sigma-theta profile from 200.140. Note the well-mixed bottom layer containing denser water properties.

performance liquid chromatography, fluorescence induction and relaxation kinetics to derive estimates of the optical cross section of photosystem II and the maximum quantum yield of electron transport, whole water carbon fixation rates. These discrete measurements are complemented with watercolumn bio-optical profiles of the absorption and attenuation properties at nine wavelengths, optical backscatter at a single wavelength, and chlorophyll and colored dissolved organic matter fluorescence. For this cruise we are also genomic samples (RNA and DNA) for Professor Adrian Marchetti at the University of North Carolina at Chapel Hill.

B-019: Phytoplankton and Primary Productivity Component (O. Schofield, Rutgers University; PI).

Field Team Members: Oscar Schofield, Paul Falkowski, Darren Mckee, Schuyler Nardelli, Jonathan Sherman, Anjali Suman.

The objective of our component is to obtain a mechanistic understanding of the bio-physical controls that determine the overall primary productivity and phytoplankton community composition along the Western Antarctic Peninsula. Specific focus areas include improved understanding how the interactions between the physics, nutrient availability drive the overall carbon fixation in the upper ocean and how that is related to the structure function of the higher trophic levels. Our routine measurements include discrete measurements of chlorophyll a, chemotaxonomic pigments via high

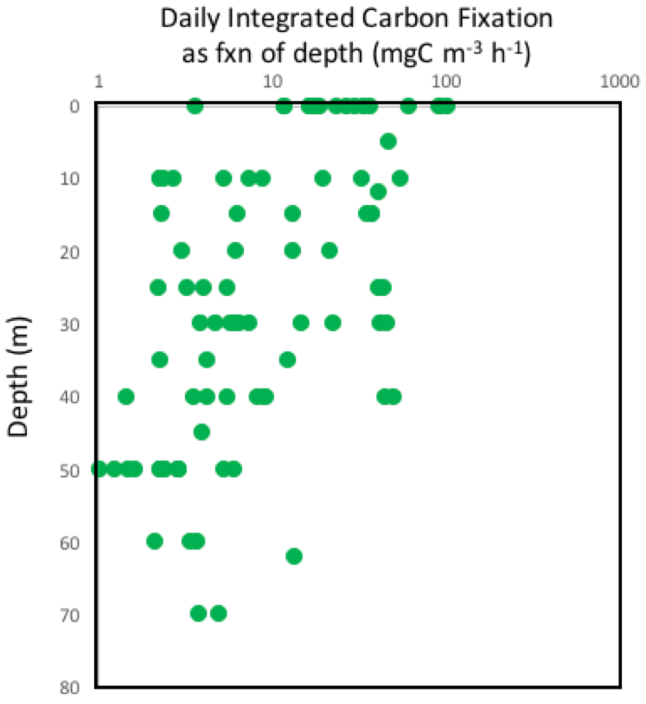

Figure 4. Daily integrated carbon fixation rates as a function of depth across the WAP grid sampled to date.

During the second week of operations we have collected our full suite of water column profiles of discrete measurements at 9 Stations, 2 of which were collected during the the inshore/offshore process studies. These measurements have been complemented with a series deckboard iron addition experiments comparing inshore/offshore. We have found so far during deckboard daily 14C incubations there is significant productivity across the grid, with the daily-integrated rates varying by a factor of 3. Vertical profiles also show a decline with depth with the variability close to 2 orders of magnitude across most depths within the euphotic zone across the sampling grid.

A major focus for the phytoplankton team is better unravel the photochemistry of the phytoplankton photosynthesis and how this variability might be used to better the physiological state of the phytoplankton. This is being achieved using a variety of fluorometers that when combined will allow us to assess different states of the in the initial photosynthetic reactions which include the capture of light energy as electron flow out of photosystem II as well as the energy dissipation sinks (fluorescence and heat). A major factor that dominates the dissipation of light energy via fluorescence is the processes associated with nonphotochemical quenching. These process, are photochemically induced changes within the cell believed to be driven by a transthylakoid pH gradient associated with light induced electron flow. One net effect is that a universal correlation between standard fluorometers and chlorophyll is difficult reflecting the resulting changes in the fluorescence quantum yield. For this cruise we are using a custom-built picosecond lifetime instrument to measure the fluorescence lifetimes in real time, thereby quantifying the energy dissipation pathways. The nonphotochemical processes are extremely prevalent with the WAP phytoplankton

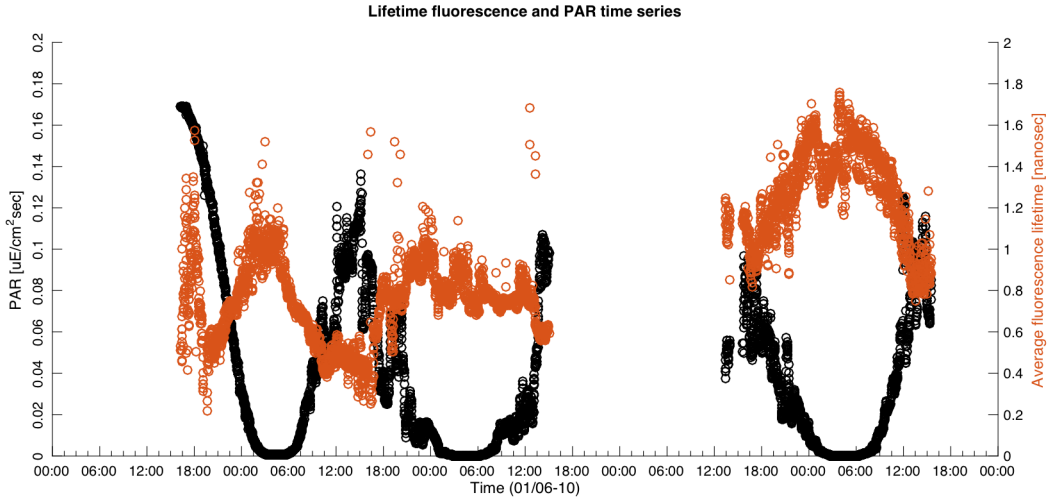

Figure 5. Daily variation in PAR (black) and average fluorescence lifetimes (orange) during the first days of the cruise. Note the opposite trends between the PAR and the lifetime values

communities (Fig. 5).

There is a clear inverse relationship between ambient light and the fluorescence lifetimes. As light increases during the day, fluorescence lifetimes decrease. Conversely, as the sun declines, the fluorescence lifetime increases. This diel cycle is evident throughout all days analyzed thus far on the cruise. The results clearly show dynamic changes in lifetimes in response to irradiance, strongly implying that the cells can adjust the light harvesting efficiency of their antenna. Over the next few days, we will look at shorter time scales and try to resolve the change of the for short term features (clouds) that alter overall light flux to the surface ocean.

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

Field Team Members: Hugh Ducklow, Naomi Shelton, Mary McElroy, Israela Musan, Tyler Rohr, and Marie Zahn.

During Week 2 we completed regular LTER grid stations on the 600,500,400,300 and 200 lines as well as 2 more on the 100 line. A preliminary comparison of bacterial production rates, presented as nanomoles of leucine incorporated per m^2 per day to 100 m, suggests very high rates at the inshore stations, with the rest of the study region being Figure 6**.** Bacterial leucine incorporation rates in 2014-17 at LTER grid stations. Few stations south of the 200 line were occupied in 2016 due to heavy ice. This year's survey

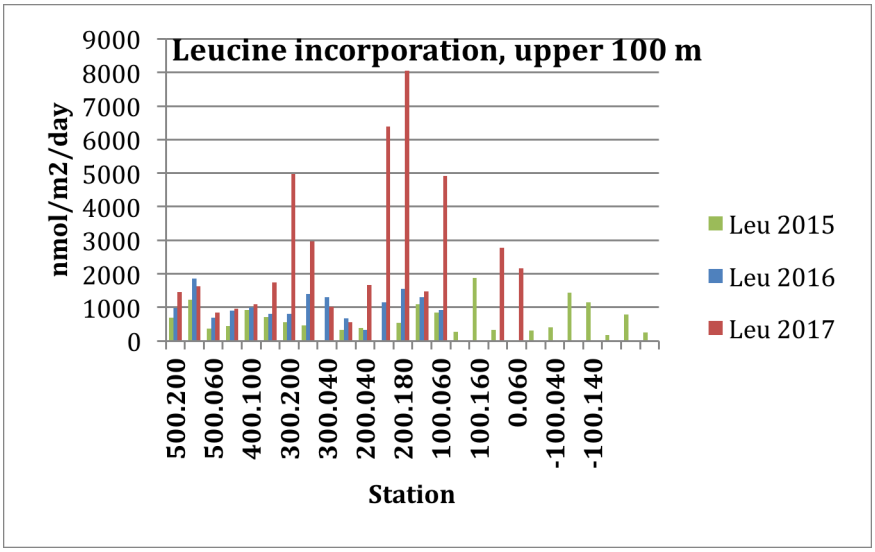

Figure 6. Leucine incorporation by WAP bacteria for standard grid stations during the 2015, 2016 and 2017 field seasons.

has not yet been completed but results so far suggest the bacterial productivity was about the same, or a little higher than normal (Figure 6). We have had unusually sunny, calm, clear weather that likely fostered high primary production, to which the bacterial assemblage is responding, at least in the coastal region.

This week's C045 report is brought to you by team member Tyler Rohr (Figure 7A). Tyler has a Bachelor's degree from Duke and is now a PhD student in the MIT/WHOI Joint program, conducting his thesis work advised by PAL coPI Scott Doney. His research focuses on disentangling the bio-physical interactions that drive phytoplankton phenology in the Southern Ocean. Ecologists contrast two general modes of control over animal and plant populations in the ocean and on land. Bottom up, or resource control concerns nutrients, light and temperature and how they influence different populations and levels in the foodweb. Control by predators from "above" in the foodchain is called top-down control. Physical processes can force phytoplankton accumulation rates from both the bottom-up, by regulating nutrient and light availability as well as the top-down by disrupting tightly-coupled predator-prey relationships. Tyler uses large numerical simulations and remote sensing observations to study the effects of seasonal surface

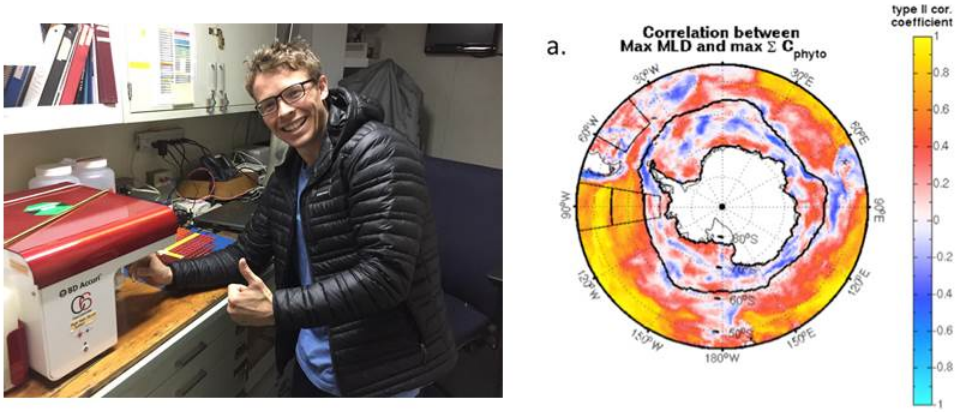

Figure 7 left: WHOI PhD student Tyler Rohr enumerating microbial populations on a flow cytometer. Right: The simulated interannual correlation between maximum surface mixing and peak bloom size reveals that in the model, some regions (i.e. South East Pacific) show a strong correlation between deep mixing and bloom size while others (i.e. South West Atlantic) show almost no correlation at all.

mixing and mesoscale eddy propagation on both top-down and bottom-up controls. The goal is to better understand how these often competing controls convolve to dictate the observed ecosystem response. Further, he considers how variability in the surrounding biogeochemical landscape might dictate variability in the role of mixed layer deepening, shoaling and eddy interactions.

This is Tyler's first venture into the world of data collection. He measures microbial abundance on the flow cytometer for every set of samples taken on his 12-hour watch. Figure 8 shows a cytogram, a kind of signature of the optical properties of individual cells, by which different populations of pigmented phytoplankton and heterotrophic bacteria can be enumerated.

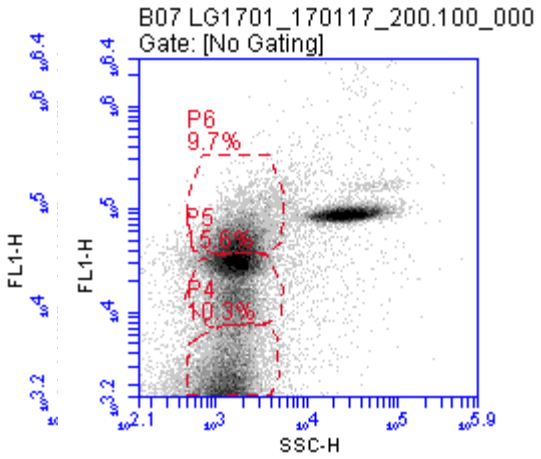

Figure 8. Output from the flow cytometer showing microbial cells stained with a fluorescent nucleic acid dye to visualize the cells after excitation with a blue laser. Each individual point is one cell. The axes are side scatter and fluorescence intensity

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

Field Team Members: Joe Cope, Patricia Thibodeau, Jack Conroy, Kharis Schrage, Katie Westmoreland.

In this second week of the cruise we conducted our standard set of net tows along the 400, 300, and 200 lines and completed a process study station in Marguerite Bay. We also performed two more pteropod (*Limacina helicina*) metabolism experiments. As we moved south along the peninsula, we no longer regularly encountered gelatinous salps as we had in the north (600 line), and instead have been finding a mix of the Antarctic krill *Euphausia superba*, smaller krill species *Thysanoessa macrura*, and *Limacina helicina* pteropods. We conducted fecal pellet production experiments with *E. superba* at several stations to compare krill-mediated export along the north-south and coast-offshore gradients. A day-night pair of MOCNESS tows at the coastal Marguerite Bay station (200.000) will be compared with the same at the offshore/slope (200.200) station.

The abundance of *Limacina* pteropods this cruise has allowed PhD student Tricia Thibodeau to conduct 3 (thus far) full pteropod multi-stressor/ metabolism experiments. Preliminary results of the first experiment are shown in Fig. 9. She is measuring the potential future effects of limited food availability (chlorophyll) and higher seawater temperature on pteropod metabolism (respiration and excretion) by conducting shipboard experiments exposing pteropods to elevated temperature and decreased phytoplankton (food), along with a present-day temperature and natural (higher) chlorophyll concentration control. We are conducting multiple experiments like this along the WAP north-south climate gradient to capture different temperature and food conditions in each WAP subregion. Preliminary results indicate that *L. antarctica* under low food and high temperature have the greatest respiration while *L. antarctica* exposed to high food and low temperatures experience the lowest respiration. Excretion and nutrients were measured at the beginning and end of each experiment and samples will be analyzed at out home institution.

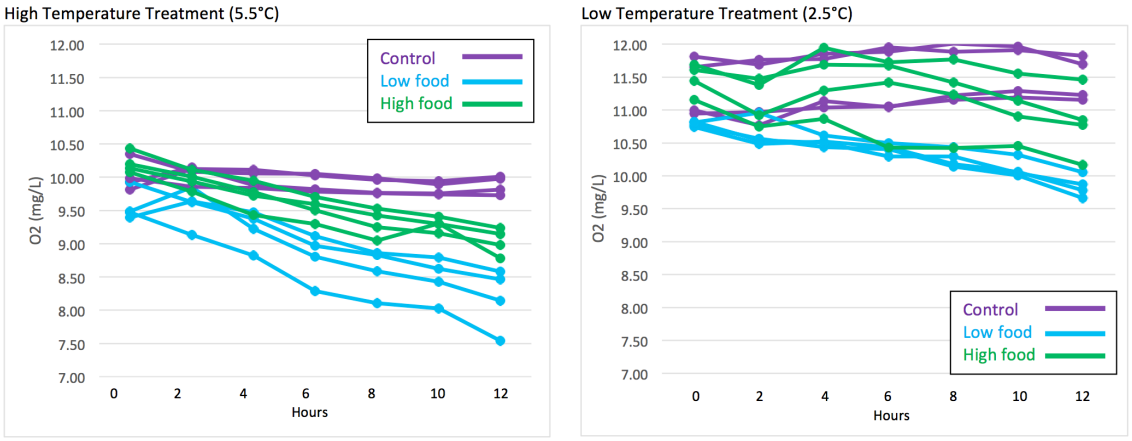

Figure 9. Multi-stressor experiment to measure Limacina helicina antarctica metabolism. Limacina helicina antarctica oxygen uptake (respiration) over 12 hours. Respiration of pteropods was measured in two different food (chlorophyll) concentrations and temperatures to simulate current (high food, low temperature) and future (low food, high temperature) WAP environmental conditions with predicted increasing sea ice melt. Controls were incubated under same conditions but contain no animals.

B-013: Seabird Component (W.R. Fraser Polar Associates, PI)
Field Team Members: Darren Roberts and Megan Roberts

The second week of LTER, the birders were deployed to Avian island to conduct their annual census. After a successful week, they were recovered yesterday evening and the results of the census will be available in the next few days. They successfully conducted population counts, collected diet and scat samples, and in a coordinated fashion weighing penguin chicks simultaneously when penguin chicks were weighted at Palmer allowing for cross comparison across the core focus penguin sites of LTER. It was very successful week collecting data. The Gould will attempt to reach Charcot next to provide a third penguin data point in the coming week.

B-024 Whale Component (A. Friendlander, Oregon State University; PI)
Field Team Members: David Johnson, Julian Dale.

During the second week of the cruise the cetacean team (David Johnston and Julian Dale) conducted a second set of visual surveys, small boat operations and Unoccupied Aircraft System (UAS) flights. Visual surveys for whales have generated an additional 15 sightings of humpback whale groups from the 500 line of the PAL grid down to Avian Island. This included the first sightings of minke whales in the Avian Island region this cruise, and the first biopsy sample of a minke whale for the cruise. During the second

Figure 10. A biopsy dart with biological sample rebounds from the flank of a humpback whale

week of cruise operations the cetacean team collected an additional 5 biopsy samples and 8 individual IDs through photo-identification. An example of a dorsal fin image during the biopsy procedure is presented in figure 10.

The cetacean team as also conducted a series of LTER UAS (aka drones) flights at Avian Island and offshore. Drone operations consisted of both fixed wing flights with a senseFly eBee and multirotor flights with a FreeFly Alta. Fixed wing flights were used to support colony assessments for penguins and to establish efficient approaches for habitat studies. Avian Island operations consisted of six flights employing a standard RGB sensor (figure 11), a thermal sensor (figure 12), and a multispectral sensor (NIR channel, Figure 13). All fixed wing flights were conducted without incident, although several south polar skuas were attracted to the drone initially, after which they paid no attention to it. Fixed wing flights generated ~540 RGB images, 3577 thermal images and 1101 multispectral images. The multirotor aircraft was also flown for one missions at Avian Island, to test 4K video, thermal video and 24 megapixel still imagery of penguin colonies for abundance estimation and photogrammetric habitat assessments. This flight generated 1500 still images and 10 gb of 4K RGB and thermal video. Initial results indicate that fixed wing drones will be useful form habitat mapping, counting penguins and assessing colony size and location using RGB, thermal and multispectral imagery. An image illustrating the launch of the eBee drone is presented in Figure 14.

Figure 11. The eBee is hand-launched for flights over penguin colonies at Avian Island, Western Antarctic Peninsula

The multirotor aircraft was also deployed from the Solas skiff and recovered without incidentv at sea on Station 100.200 to assess body condition and collect

behavioral data on feeding humpback whales. Sampling at this station, approximately 200km offshore, is a notable as few whales are sighted/sampled in deeper, more oligotrophic surface waters. The single Alta flight generated 638 still photos and 4 gbs of video for behavioral assessments. This was a remarkable sampling opportunity as the whales were engaged in coordinated bubble net feeding (figure 15). It should also be noted that these whales were identified through photo ID and biopsy sampled, providing for a full biological profile for each of these animals.

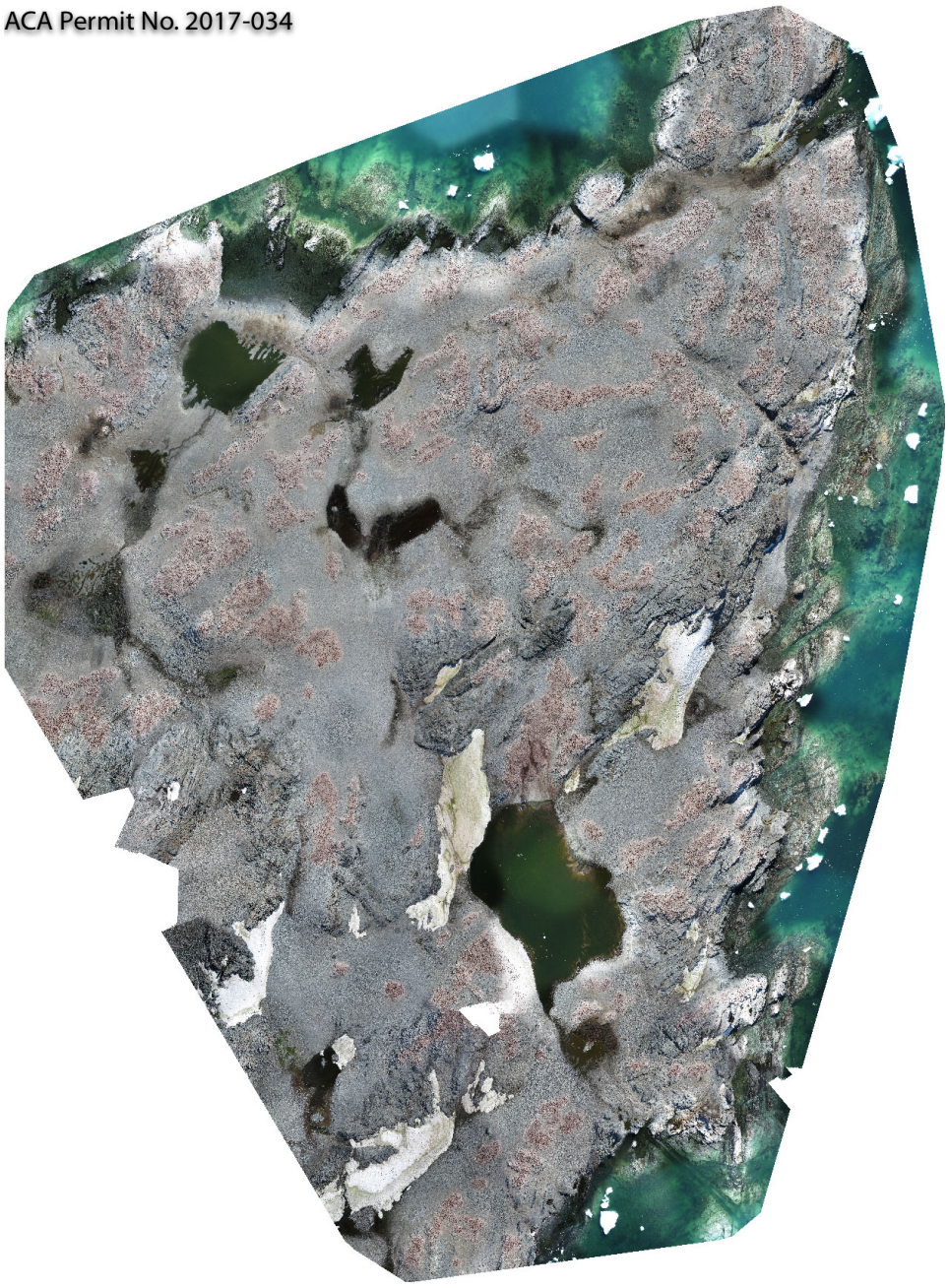

Figure 12. Low resolution RGB orthomosaic of Adelie penguin colonies at Avian Island, Western Antarctic Peninsula

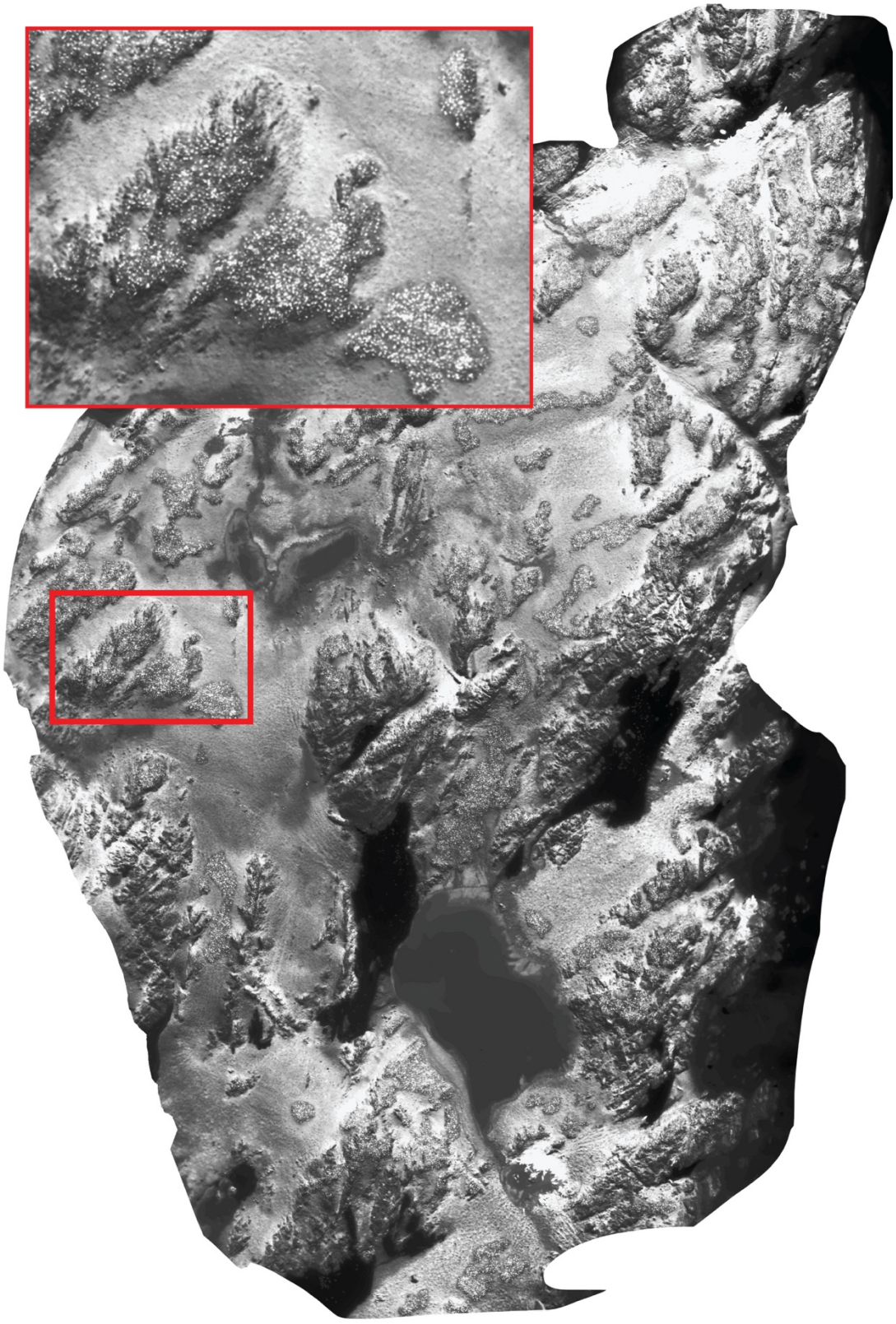

Figure 13. Thermal map of Adelie penguin colonies at Avian Island, Western Antarctic Peninsula. Zoomed region shows thermal signature of individual penguins

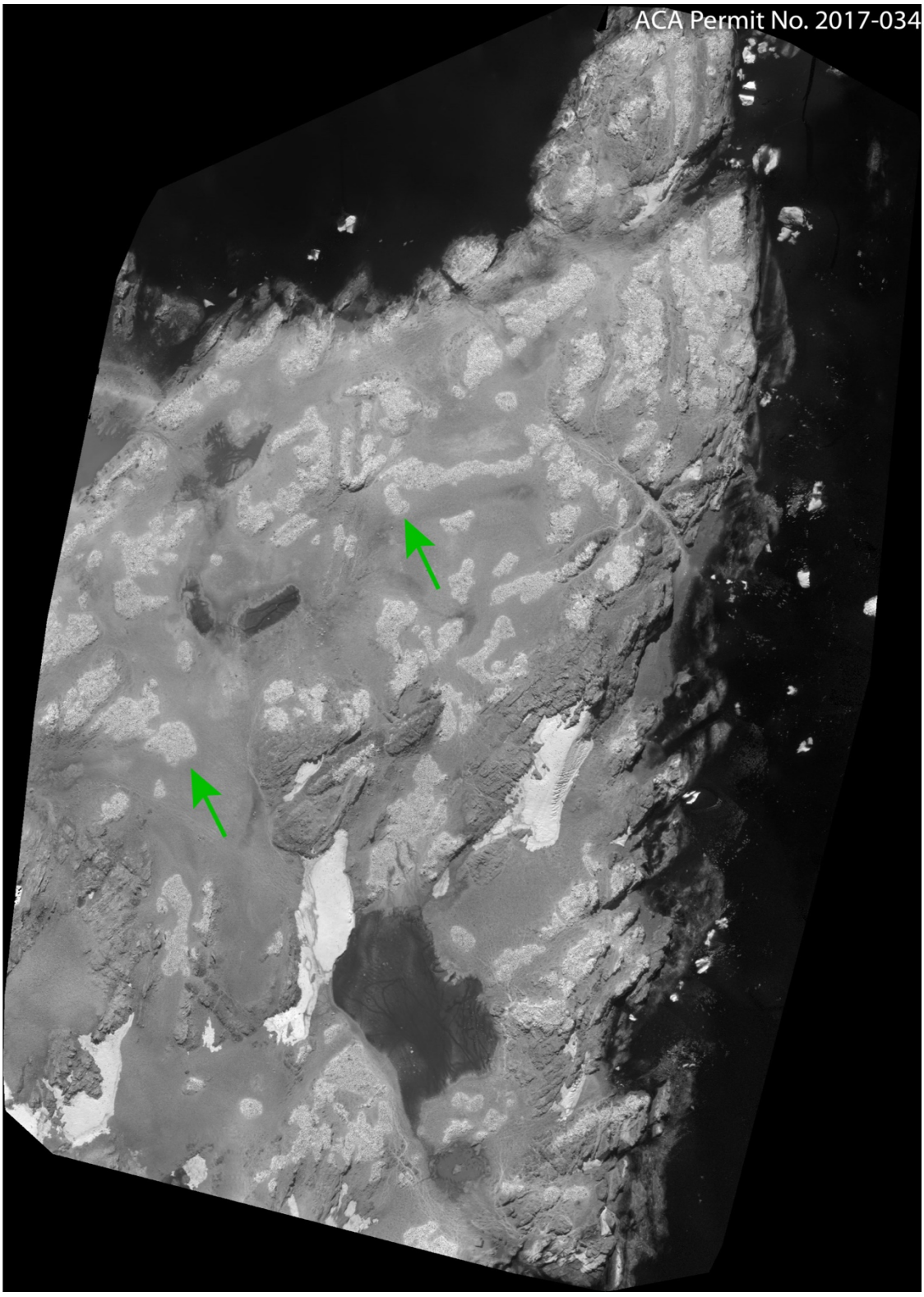

Figure 14. A false color Near Infrared (NIR) map of Adelie penguin colonies at Avian Island, Western Antarctic Peninsula. Green arrows indicate individual colonies that are eaily discerned in NIR reflectance.

Figure 15. An overhead image of two humpback whales in the process of coordianted bubble net feeding at the surface. Not the extended ventral ouch (cavum ventrale) of the central whale.