PALMER STATION MONTHLY SCIENCE REPORT
May 2009

Jeff Grim from Ohio University is running TBARS assays to measure lipid peroxidation in heart ventricles of red- and white-blooded notothenioid fishes exposed to heat stress.

Photo courtesy of Jeff Grim and Lisa Crockett.

NEWS FROM THE LAB
Pat McMillan, Winter Assistant Supervisor of Laboratory Operations

The month began with the departure of *ARSV Laurence M. Gould (LMG)* with the Doug Nowacek group on board looking for krill patches and humpback whales. We continued alternating between Kristin O'Brien and Doug Nowacek science groups going out on the *LMG* for their research or remaining on station. As a result, we had several *LMG* port calls this month.

The science groups had a busy and successful season. Experiments were done on assessing the upper temperature thermal tolerance limits of Antarctic fishes, including both red-blooded and hemoglobinless species. The whaling group calibrated equipment that was used on zodiacs in addition to data analysis. On a visit to Torgersen Island, a member of the Nowacek science

group sighted and identified a sub-Antarctic fur seal (*Arctocephalus tropicalis*). This is a rare sighting for this species in the Palmer area. We concluded the monitoring work on the giant petrel chicks for Bill Fraser with the last petrel chick having left by May 26.

The month came to a close as we are again awaiting the return of the *LMG* with the Nowacek science party to hear about their encounters. While for others it is a sign that "their ship has come in" and time for them to leave.

MAY WEATHER
Neal Scheibe, Research Associate

The weather this month was marked by several days of gentle breezes around Palmer Station, with one exceptionally powerful storm coming in the middle of the month. Average temperatures in May remained consistent with April, with mild temperatures throughout the month. The coldest day was the 21st at -4.9ºC. The warmest temperature was on the 16th at 2.2ºC. The average temperature for the month was -1.0ºC.

Sea surface temperatures hovered near -1ºC throughout the month. Very little sea ice has been seen at this point. Brash ice and bergy bits continue to calve off of the glaciers, mostly well into the dark hours of the day.

Palmer received only 17 cm of snowfall throughout the month, with the biggest accumulation on the 27th being wiped out by rains a day later. A total of 49.8 mm melted precipitation fell during the month, but half of that came during a storm on the 15th that saw wind gusts over 70 knots.

THE FOLLOWING PROJECTS CONDUCTED RESEARCH AT PALMER STATION:

B-036-P: COLLABORATIVE RESEARCH: LINKAGES AMONG MITOCHONDRIAL FORM, FUNCTION AND THERMAL TOLERANCE IN ANTARCTIC NOTOTHENIOID FISHES
Dr. Kristin O'Brien, University of Alaska Fairbanks and Dr. Bruce Sidell, University of Maine, Principal Investigators

Personnel on station: Kristin O'Brien, Bruce Sidell, Elizabeth Crockett, Jody Beers, Jeffrey Grim, Irina Mueller, Megan O'Neill

One component of our project this year was designed to assess the upper temperature thermal tolerance limits of Antarctic fishes, including both red-blooded and hemoglobinless species. This work is being executed by *University of Maine* field team members, Jody Beers and Bruce Sidell. The first order of business was to construct four thermal tolerance tanks in the aquarium room at Palmer Station. It was this exercise that brought our first challenge of the season for the innovative support personnel at Palmer Station.

Despite assurances of their presence at Palmer Station in our project's RSP, magnetic drive pumps that are essential for recirculation of seawater through flow-through heaters in these systems had not been ordered. This became apparent only after our southbound transit in the LMG was underway. An heroic effort put out by FEMC personnel, Tom Lippert and Craig Bell, under the leadership of Station Manger, Ken Keenan, saved the day. These folks were able both to locate and refurbish a handful of very old pumps from stores at the station and we were able to modify the plumbing fittings of the systems to accommodate them. This is an object lesson on the importance of maintaining reasonable stores of small equipment and supplies on site at Palmer, rather than succumbing to the pressure to store all materials at the warehouse in Punta Arenas. Availability of these old pumps saved the entire thermal tolerance component of our project this year.

The modified thermal tolerance tanks performed almost flawlessly and we were able to complete two series of experiments during the month of May. First, we successfully completed a series of Critical Thermal Maximum (CT_{MAX}) experiments using two icefish species, *Chionodraco rastrospinosus* and *Chaenocephalus aceratus*, and three red-blooded notothenioid species, *Notothenia coriiceps, Lepidonotothen kempi* and *Gobionotothen gibberifrons*. In these experiments, temperature is increased in a continuous fashion until the animal displays a loss of ability to right itself (*i.e.* a disequilibrium) at some critical temperature. Our hypothesis was that the hemoglobinless icefishes would succumb at temperatures below those of the red-blooded species. Although not completely analyzed yet, our data support this hypothesis. The rank-order of CT_{MAX} in these fishes was *Notothenia coriiceps* > *Gobionotothen gibberifrons* > *Lepidonotothen kempi* > *Chaenocephalus aceratus* > *Chionodraco rastrospinosus.* In addition, we were able to demonstrate that *Notothenia coriiceps* held at an elevated temperature of 4°C for one week prior to CT_{MAX} experiments, were able to survive a small but statistically significant higher temperature than wild-type animals, indicating a limited capacity to adaptively modify their physiology to elevated temperatures. We have harvested a number of tissues from these animals, which will be subject to biochemical and gene expression studies in our CONUS laboratories to better define the physiological responses of the species to temperature elevation. This section of our planned field studies was highly successful and sets the stage for similar experiments in 2011 that will determine whether conditions of hyperbaric oxygen will enable the animals to survive to higher temperatures, implicating a mismatch in oxygen supply and demand as part of the underlying cause of physiological failure.

In the second phase of these experiments, we acclimated groups of both red-blooded *Notothenia coriiceps* and hemoglobinless *Chionodraco rastrospinosus* to an elevated temperature of 4°C for a period of one-week. At that point, animals were killed and tissues were harvested for subsequent analyses in our CONUS laboratories. All three participating laboratories will contribute to this effort, which will result in a comprehensive examination of biochemical and molecular responses to elevated temperature exposure. We hypothesize that the hemoglobinless species will show greater evidence of both hypoxic insult and free radical-induced damage to both proteins and membrane lipids.

We also were able successfully to prepare fixed tissue samples from several species of notothenioid fishes for subsequent structural analyses at our CONUS laboratory.

A second component of our project this season was to determine if properties of mitochondria contribute to thermal tolerance of Antarctic notothenioid fishes. The experiments described above confirmed our hypothesis that icefishes are more sensitive to elevations in temperature compared to red-blooded fishes. We hypothesized that characteristics of mitochondria associated with the loss of expression of oxygen-binding proteins may contribute to the differences in thermal tolerance between red- and white blooded fishes. Specifically, we hypothesized that mitochondria from icefishes may be less efficient at synthesizing ATP due to a greater rate of proton leak compared to red-blooded species and that proton leak would increase as temperature increases. We also hypothesized that the high lipid density associated with high mitochondrial densities in heart ventricular tissue of icefishes would make them more susceptible to oxidative damage as temperature increases, compared to red-blooded species.

Measurements of mitochondrial proton leak were completed in isolated mitochondria from heart ventricles of two icefishes, *Chaenocephalus aceratus*, and *Chionodraco rastrospinosus*; and two red-blooded species, *Gobionotothen gibberifrons* and *Notothenia coriiceps* at 2°C and 10°C by Irina Mueller from UAF. Preliminary data analysis indicates that proton leak in isolated mitochondria is similar between red- and white-blooded species at 2°. Proton leak increases as temperature increases in both red-and white-blooded species and is higher in mitochondria from *N. coriiceps* compared to icefishes. Although the lower rate of proton leak in mitochondria of icefishes may increase the efficiency of ATP synthesis, the higher mitochondrial membrane potential may promote the formation of reactive oxygen species and increase oxidative damage at high temperature.

Measurements of the production of reactive oxygen species were carried out in mitochondria isolated from heart ventricular tissue of the red-blooded species, *N. coriiceps* and the icefish, *C. aceratus* at 2°C and 10°C by Irina Mueller and Kristin O'Brien. We had planned to also measure ROS formation in mitochondria from *C. rastrospinosus*, but were unsuccessful in capturing a sufficient number of animals for these experiments. Initial data analysis indicates that ROS formation is similar in mitochondria from *N. coriiceps* and *C. aceratus* at 2°C and increases in mitochondria from *C. aceratus* at 10°C.

Together, measurements of proton leak and ROS formation suggest that mitochondria from icefishes maintain a higher mitochondrial membrane potential as temperature increases, which may promote the formation of ROS and increase oxidative damage to a greater extent compared to red-blooded species. Tissues collected from animals used for measurements of CT_{MAX} will be used to measure protein and lipid oxidation to test this hypothesis.

Mitochondria were isolated from heart ventricles of *C. aceratus* and *N. coriiceps* and flash frozen for measurements of superoxide dismutase by Bruce Sidell at the University of Maine. This will allow us to determine if the defenses against oxidative stress are similar between *C. aceratus* and *N. coriiceps*. We had also planned to isolate mitochondria from *C. rastrospinosus* for these measurements, but were unsuccessful in capturing a sufficient number of animals.

Lisa Crockett and Jeffrey Grim from Ohio University addressed the hypothesis that high mitochondrial densities in icefish hearts of icefishes may make them more susceptible to oxidative damage as temperature increases, compared to red-blooded species. Tissues (including

ventricle, pectoral muscle, and brain) were processed for FOX and TBARS assays in order to determine whether products of lipid peroxidation are elevated during short-term exposure (CT_{MAX} - species including *C. rastrospinosus*, *C. aceratus*, *N. coriiceps*, *G. gibberifrons*, *L. kempi*) and longer periods (one week acclimation - *C. rastrospinosus*, *N. coriiceps*) to elevated temperatures. In addition, tissues were collected and processed from ambient animals (species above plus *C. gunnari*). Preliminary data indicate that TBARS levels rise with temperature during CT_{MAX} trials in heart ventricle. Additionally, interspecific comparisions indicate higher endogenous levels of TBARS in pectoral muscles of red-blooded species than hemoglobinless animals.

Jody Beers and Lisa Crockett took advantage of the availability of Skype™ to carry out videoconferences with elementary schools in the U.S. This opportunity became available during station preparations for the *Oprah Winfrey Show*. Jody Beers held a videoconference with Old Town Elementary school in Old Town, ME, which was highlighted on the local evening news on channel WLBZ, the local NBC affiliate. Lisa Crockett held a videoconference with 4th graders from East Elementary School in Athens, Ohio, as well as a second videoconference using the PolyCom™ system, linking Palmer Station with Ohio University. These outreach activities were featured in an article written in the Athens newspaper, *The Messenger*. The Skype™ sessions were a tremendous success in part, because they allowed us to interact with students in the lab and around the station, showing them live animals and the impressive scenery surrounding Palmer Station. Even more importantly, Skype™ allowed us to interact with schools that do not have access to the more expensive, PolyCom™ system. We hope that NSF will support videochat software for outreach activities in the future.

Megan O'Neill is a high school teacher in Fairhope Alabama and a participant in the ARMADA Project at the University of Rhode Island, who has contributed significantly to our outreach activities and enabled us to interact with students beyond our local communities. She has maintained daily journal entries with photos on the ARMADA Project website, www.armadaproject.org, as well as on the Fairhope High School website, www.fairhopehs.com. The science classes at Fairhope High School followed along on Megan's journey to the Antarctic and participated in two "Live from Antarctica" video conferences through the Polycom™ system. During the conferences, video clips were shown of fishing activities on the *Laurence M. Gould*, as well as laboratory studies and life at Palmer Station. Megan has been collecting photographs and video clips on a daily basis to share with classrooms and community groups upon her return home. In addition to participating in fishing and laboratory work with our field team, she also spent 10 days on a whaling trip with Doug Nowacek's field team, helping to spot and tag whales.

Megan will be featured as a "teacher in the field" on the new *National Geographic* educational website which will be launched in August or September of this year. In preparation, Megan has developed teaching materials that incorporate aspects of the biology of Antarctic fishes and whales for this website, as well as for her own classroom.

B-249-P: COLLABORATIVE RESEARCH: THE ECOLOGICAL ROLE OF A POORLY STUDIED ANTARCTIC KRILL PREDATOR: THE HUMPBACK WHALE, *MEGAPTERA NOVAEANGLIAE*

Douglas Nowacek, Ari Friedlaender and Patrick Halpin, Duke University and Meng Zhou, University of Massachusetts, Principal Investigators

Personnel on station: Douglas Nowacek Ari Friedlaender, Patrick Halpin, Meng Zhou, Yiwu Zhu, Colin Ware, Roland Arsenault, Boris Espinasse, David Johnson, Andrew Read, Reny Tyson, Eletta Revelli, Linsdey Peavey, Alison Stimpert

During the fishing expeditions led by O'Brien and Sidell in May at Palmer Station, members of B-249 used the time for three primary tasks: i) calibrating one of our Simrad EK-60 systems from the small boats at Palmer; ii) data analyses; and iii) preparation of reports and manuscripts. Additionally, while doing some exploring on the islands surrounding Palmer, members of B-249 documented a sighting of a sub-Antarctic fur seal (*Arctocephalus tropicalis*). This is an extremely rare sighting for this species in this area; the nearest breeding colony/aggregation is on South Georgia Island. We are preparing a note for publication.

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT
May 2009
Neal Scheibe

G-295-P GPS CONTINUOUSLY OPERATING REFERENCE STATION.
Bjorn Johns, Principal Investigator, UNAVCO

The Research Associate operates and maintains on-site equipment for the project. Throughout the month, 15-second epoch interval GPS data files were collected continually at station PALM, compressed, and transmitted to the NASA-JPL in Pasadena, CA.

They system operated normally during the month.

G-090-P GLOBAL SEISMOGRAPH NETWORK (GSN) SITE AT PALMER STATION.
Rhett Butler, Principal Investigator, Incorporated Research Institutions for Seismology (IRIS)

The Research Associate operates and maintains on-site equipment for the project. Station PMSA is one of more than 143 sites in the GSN monitoring seismic waves produced by events worldwide. Data files are recorded to tape and also sent real-time to the U.S. Geological Survey (USGS).

The station operated normally throughout most of the month.

O-202-P ANTARCTIC METEOROLOGICAL RESEARCH CENTER (AMRC) SATELLITE DATA INGESTOR.
Mathew Lazzara, Principal Investigator, University of Wisconsin

The Research Associate operates and maintains on-site equipment for the project. The AMRC SDI computer processes satellite telemetry received by the Palmer Station TeraScan system, extracting Automated Weather Station information and low-resolution infrared imagery and sending the results to AMRC headquarters in Madison, WI.

The ingestor operated normally throughout the month.

O-204-P A STUDY OF ATMOSPHERIC OXYGEN VARIABILITY IN RELATION TO ANNUAL TO DECADAL VARIATIONS IN TERRESTRIAL AND MARINE ECOSYSTEMS.
Ralph Keeling, Principal Investigator, Scripps Institution of Oceanography

The goal of this project is to resolve seasonal and interannual variations in atmospheric O_2 (detected through changes in O_2/N_2 ratio), which can aid in determining rates of marine biological productivity and ocean mixing. The results are also used to help determine the terrestrial and oceanic distribution of the global anthropogenic CO_2 sink. The program involves air sampling at a network of sites in both the Northern and Southern Hemispheres. Palmer Station is especially well situated for resolving signals of carbon cycling in the Southern Ocean.

The Research Associate collects samples fortnightly from both TerraLab and the VLF Building. A goal is that all sampling will eventually be moved to TerraLab. Samples taken from the station are sent to Scripps where the analysis of O_2 and CO_2 content takes place.

Sampling equipment and operations were per plan throughout the month.

O-264-P: COLLECTION OF ATMOSPHERIC AIR FOR THE NOAA/GMD WORLDWIDE FLASK SAMPLING NETWORK
James Butler (Principle Investigator), National Oceanic and Atmospheric Administration / Global Monitoring Division; Boulder, CO

The NOAA ESRL Carbon Cycle Greenhouse Gases (CCGG) group makes ongoing discrete measurements to document the spatial and temporal distributions of carbon-cycle gases and provide essential constraints to our understanding of the global carbon cycle.

The Halocarbons and other Atmospheric Trace Species (HATS) group quantifies the distributions and magnitudes of the sources and sinks for atmospheric nitrous oxide (N2O) and halogen containing compounds.

Palmer Station is one of many sites around the world providing data to support these projects. The Research Associate collects weekly air samples for Carbon Cycle Greenhouse Gases Group and fortnightly samples for Halocarbons & other Atmospheric Trace Species Group.

Sampling occurred normally during the month.

O-283-P ANTARCTIC AUTOMATIC WEATHER STATIONS (AWS).
Mathew Lazzara, Principal Investigator, University of Wisconsin

The Research Associate monitors data transmissions for the project and performs quarterly maintenance on the station at Bonaparte Point. AWS transmissions from Bonaparte Point are monitored using the TeraScan system and the Data Ingestor system. Data collected from this station is freely available from the University of Wisconsin's AMRC website.

The system collected data normally throughout the month.

A-306-P GLOBAL THUNDERSTORM ACTIVITY AND ITS EFFECTS ON THE RADIATION BELTS AND THE LOWER IONOSPHERE.
Umran Inan, Principal Investigator, Stanford University

Stanford University has been operating a Very Low Frequency (VLF) receiver antenna at Palmer Station since the 1970's. By receiving naturally and manmade signals between 1 and 40 kHz, the Stanford VLF group is able to study a wide variety of electromagnetic phenomenon in the ionosphere (uppermost layer of the atmosphere ionized by solar radiation) and magnetosphere (the area surrounding the earth dominated by the Earth's magnetic field and particles trapped by it. Many of these studies relate to the energetic releases associated with lightning. For example, Palmer Station's unique location enables it to pick up small bits of radiation from lightning strikes as far away as Africa, the USA, or the Pacific Ocean.

The system collected data normally during the month. Due to the collection of near 24-hour continuous data, there was no need for local synoptic data creation anymore. Synoptic data files are no longer made at Palmer Station. This led to upgrades being made to the summaries created locally for the Stanford website. Previously, the summaries were generated daily from synoptic files, but the summary files are now created directly from the continuous files and automatically placed on the Stanford website for viewing.

T-312-P TERASCAN SATELLITE IMAGING SYSTEM.
Dan Lubin, Principal Investigator, Scripps Institution of Oceanography

The Research Associate operates and maintains on-site equipment for the project. Throughout the month, the TeraScan system collected, archived, and processed DMSP and NOAA satellite telemetry, capturing approximately 25-30 passes per day. A weekly 85GHz SSM/I ice concentration image was produced and transferred to UCSB for B-032-P (Smith).

The data archiving to the tape drive stalled on several occasions during the month, requiring restarting of the writing processes, but no data was lost. Images were sent to the R/V Laurence M. Gould to aid in determining ice locations and concentrations in support of two science groups that are on the vessel: B-036 (O'Brien) and B-249 (Nowacek).

A-357-P EXTENDING THE SOUTH AMERICAN MERIDIONAL B-FIELD ARRAY (SAMBA) TO AURORAL LATITUDES IN ANTARCTICA
Eftyhia Zesta, Principal Investigator, University of California Los Angeles

The three-axis fluxgate magnetometer is one in a chain of longitudinal, ground-based magnetometers extending down though South America and into Antarctica. The primary scientific goals are the study of ULF (Ultra Low Frequency) waves and the remote sensing of mass density in the inner magnetosphere during geomagnetically active periods. Palmer's magnetometer is also a conjugate to the Canadian Poste de la Baleine station, allowing the study of conjugate differences in geomagnetic substorms and general auroral activity. The station Research Associate maintains the on-site system.

The magnetometer operated well during the month.

B-390-P: THERMO-SALINOGRAPH
Vernon Asper, Principal Investigator, University of Southern Mississippi

Sea water is pumped continuously through a thermosalinograph (TSG) sampling system, recording the temperature, conductivity, salinity, and fluorescence. The real-time data, including graphs and web camera images of the ocean in the vicinity of Palmer Station, are compiled by a local server into web page format and relayed to a mirror site at Woods Hole Oceanographic Institute, which is a collaborator in the project. The URL for the WHOI mirror site is http://4dgeo.whoi.edu/tsg/.

The webcam and salinograph performed well during the month.

T-513-P: ULTRAVIOLET (UV) SPECTRAL IRRADIANCE MONITORING NETWORK (UVSIMN)
Charles Booth, Principal Investigator, Biospherical Instruments, Inc

A BSI SUV-100 UV spectroradiometer produces full sky irradiance spectra ranging from the atmospheric UV cutoff near 290nm up to 605nm, four times per hour, while the sun is above the horizon. A BSI GUV-511 filter radiometer, which has four channels in the UV and one channel in the visible for measuring Photosynthetically Active Radiation (PAR), is located next to the SUV-100.

The UV monitor had a change in funding status during the month. This change led to the stoppage of Research Associate support. The instruments are still on-site and ready for normal data collection.

T-998-P: IMS RADIONUCLIDE MONITORING
Michael Pickering, Principal Investigator, General Dynamics

The International Monitoring System (IMS) radionuclide sampler is part of the Comprehensive Test Ban Treaty (CTBT) verification regime. The automated Radionuclide Aerosol Sampler and Analyzer (RASA) unit pumps air continuously through a filter for 24 hour periods, collecting particulates in the .2-10 micron range. The filter is then tested for particulates with radioisotope signatures indicative of a nuclear weapons test. The station Research Associate operates and maintains the instrument.

The system operated normally throughout the month. All on-hand calibration sources were collected for shipment back to General Dynamics, the contractor responsible for CTBT operations. The sources will ship out with the next northbound boat.

TIDE GAGE

The Research Associate operates and maintains on-site equipment for the project. Tide height and seawater temperature are monitored on a continual basis by a gauge mounted at the Palmer Station pier. Although salinity (conductivity) is also recorded by the tide gauge, the measurements are incorrect and should not be used. Correct salinity data can be found on the TSG system.

The tide gauge operated normally during the month.

METEOROLOGY

The Research Associate acts as chief weather observer, and compiles and distributes meteorological data. At the end of the month a summary report is prepared and sent to interested parties. Weather data collected using the automated electronic system is archived locally and forwarded twice each month to the University of Wisconsin for archiving and further distribution. Synoptic reports are automatically generated every three hours by the Palmer Meteorological Observing System (PalMOS) and emailed to the NOAA for entry into the Global Telecommunications System (GTS).

The weather station operated normally throughout the month. Scheduled inspections were carried out of the Gamage Point tower. During the last week of May, changes were made to the local weather display in the BIO building. The Excel macro that creates the charts was changed to startup once a minute, perform processing, then close down. Prior to the change, the macro ran continuously, which slowed the PALMOS weather computer.