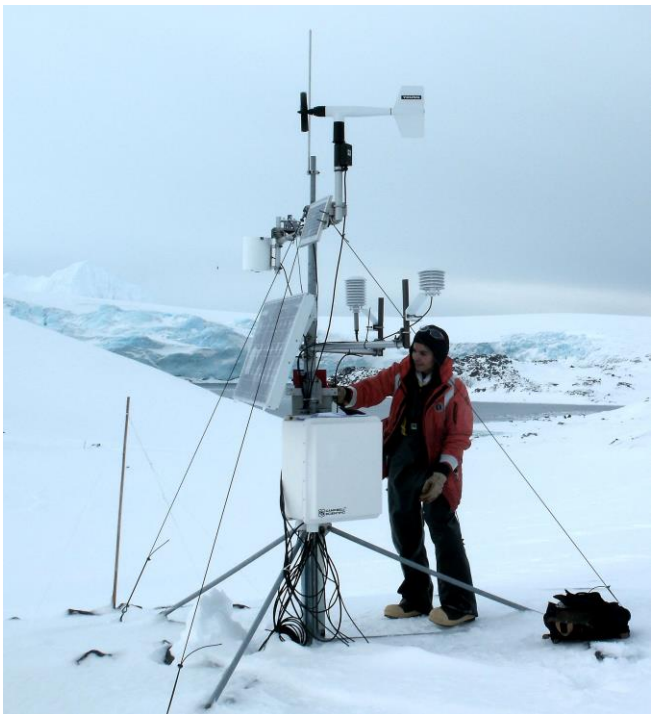
PALMER STATION MONTHLY SCIENCE REPORT
JULY 2014



A. Scott (ASC) downloads weather data from the Amsler Island Automatic Weather Station
(Image Credits: Graham Tilbury)

NEWS FROM THE LAB

Linnah Neidel, Winter Laboratory Supervisor

July opened with the arrival of the *ARSV Laurence M. Gould* (LMG) and fishing groups B-010 (Cheng) and B-266 (Bilyk). Including the trawls performed on the trip down from South America, the groups went fishing on four different occasions during the month, usually for four to five days at a time. Numerous species of icefish and invertebrates were caught and brought back for further study in the Palmer labs and aquaria.

On station, there were flurries of activity surrounding the fish including elevated temperature studies, dissections for sampling, photo-documentation of various species, and both land-based and zodiac-based fishing. B-037 (Detrich) continued their study of fish embryogenesis in the incubators and had success with cryopreservation of sperm.

Wintry conditions descended on the station with the incoming groups. During the first half of the month only those with urgent need headed outside, braving the consistent strong winds and wet (snowy and rainy) conditions. The latter half of the month cleared, bringing much calmer conditions that allowed the sea ice to start forming again. By the end of the month, large numbers of giant petrels were back in the area, taking over the ridgelines of the nearby land masses. The elephant seals and the fur seals have not been seen nearby, due to the growing extent of the sea ice.

JULY 2014 WEATHER
Graham Tilbury, Research Associate

This month, the increasing hours of daylight brought a noticeable change to the Palmer season. The month started with relatively high temperatures, caused mainly by the predominately northerly winds that blew for the first half of the month.

In contrast, the last week of the month was predominated by consistently low speed winds, but from a southerly direction, resulting in much lower minimum temperatures. The maximum temperature for the month occurred on the 12th and was a warm +3.6C.

Barely three days later the temperature dropped to its lowest for the month, -14.6C, much colder than the low for June and considerably colder than the lowest temperature of -9.3C recorded for July last winter.

Relatively low wind speeds for the month averaged out at 12 knots. A short period of strong northerly winds gusted briefly to a maximum of 72 knots on the 14th.

Three days of easterly to northerly winds during the third week of the month brought with them the largest snowfall of 36cm. By month's end Palmer Station had accumulated 171cm of snowfall, slightly less than the 190cm measured last July. The snow stake measurement on the 31st stood at 43cm.

The sea temperature remained well below zero for the entire month. On several occasions, new ice formations covered the waters immediately surrounding the station, only to be blown clear by winds from the N to NE. Calving from the glacier on Arthur Harbor slowed considerably with the overall colder temperature.

B-010-P: ANTARCTIC NOTOTHENIOID FISH FREEZE AVOIDANCE AND GENOME WIDE EVOLUTION FOR LIFE IN THE COLD
Christina Cheng-DeVries and Arthur DeVries, Principal Investigators, University of Illinois at Urbana-Champaign

Personnel on Station: Christina Cheng-DeVries, Arthur DeVries, Elliot DeVries, Lauren Fields, Katherine Murphy, Xuan Zhuang

The Antarctic marine fish fauna is dominated by members (~100 species) of a single taxon, the teleost suborder Notothenioidei. The ecological success of these fishes, the Antarctic notothenioids, resulted from two intertwined adaptive phenotypes that evolved in response to strong selection from freezing cold - the ability to avoid death from freezing by means of antifreeze proteins (AFP), and system-wide ability to perform daily cellular and physiological functions in extreme cold temperatures. Our overall project goal aims at gaining an integrated understanding of these two crucial phenotypes through investigations that span ecological, organismal, physiological, molecular and genomic levels.

Our project involves field research at McMurdo Station and Palmer Station. Our specific objectives at Palmer Station this season are the following:

1. Coastal waters of WAP are considerable milder than the high latitude McMurdo Sound. By surveying as many fish species as we can obtain in the WAP for their antifreeze protein levels, we will determine the relationship of freeze avoidance capability and habitat thermal environment, and contrast this with the species living in perennially freezing (-1.9°C) and icy conditions in McMurdo Sound. The data we obtained thus far show that antifreeze levels of WAP species (notothenioids and non-notothenioids) vary over a wide range, from none or almost none (eelpouts), to low levels (some icefishes), to levels (other icefishes and various red-blooded notothenioids) comparable to McMurdo Sound species. Curiously, species representing the two ends of the AFPs concentration range appear to live in the same habitats (caught in the same trawls), regardless of water depth. Temperatures of bottom at three catch sites obtained by XBT cast show they are non-freezing, from about 0°C to +0.5°C, where antifreeze protection in principle will not be needed, but many species are substantially fortified. An alternate interpretation is that species permanent to the "warmer" bottom water layer experience reduced selection pressure for maintenance of high levels of AFPs (costly to produce), and exhibit reduction of these proteins to various degree depending on the extent of evolutionary residence time in the non-freezing water layer.

2. One notothenioid species, *Lepidonotothen squamifrons*, strikingly has no antifreeze protein activity in its body fluids, unlike its AFP-endowed congeners *L. nudifrons* and *L. larsoni*. We aim to understand how the universal AFP trait in Antarctic notothenioids became absent/lost in *L. squamifrons* through analyzing the antifreeze gene sequences (or what remains of them), and have obtained the necessary specimens and material a year ago for this work. However, knowing how the genes and therefore the trait degenerate do not answer the question of how *L. squamifrons* escapes freezing should it encounters ice and freezing water. To test whether it seeks out non-freezing water layers in the wild to avoid freezing, we have built a long temperature gradient box to assess its locomotive behavior and preferred temperature. The fish wears a tiny temperature logger so its movement with time in the thermal gradient can be tracked with precision. A second and improved version of the thermal gradient has just been built and an undergraduate will be collecting data with the supervision of a postdoc researcher. Anecdotally, when the antifreeze-fortified *N. coriiceps* is manually put at the warm end, it consistently and quickly moves to the cold end.

3. One of our overarching hypothesis regarding adaptive system-wide cold-able functioning and apparent maladaptive functional loss in Antarctic notothenioids is that they resulted from a uniquely polar genome character, shaped by millennia of natural selection from chronic cold. We address this hypothesis by studying three notothenioid species - the S. American robalo (E. maclovinus) as ancestral proxy, a red-blooded Antarctic notothenioid (toothfish Dissostichus mawsoni), and a white blooded icefish, constituting an evolutionary progression of genotypes and phenotypes, from ancestral non-Antarctic to highly derived polar, from which evolutionary genomic and transcriptomic changes in response to environmental change can be gleaned.

Our target during our Palmer/LMG season is to obtain specimens representing the highly derived polar character, i.e. icefishes, for extensive sampling of tissues to be used for generating comprehensive reference transcriptomes (all expressed genes) by deep coverage Next Gen sequencing. We have already sequenced transcriptomes of the cold-adapted, red-blooded Antarctic toothfish, as well as the crypelagic *Pagothenia borchgrevinki*, and will be sampling the ancestral proxy (robalo in Chile) and sequencing its transcriptomes after the Palmer field season.

To evaluate evolutionary change in functional response, specifically modifications of tissue-wide response to heat challenge including the dissaptive loss of inducible HSP70 response in Antarctic notothenioids, at Palmer Station we have conducted a heat stress experiment on the polar, derived representative, the icefish *C. rastrospinosus*. Tissues collected from heated fish and unheated controls will be used for whole transcriptome shotgun sequencing (RNAseq) and mapped to the reference transcriptome to assess differential gene expression. The pattern will be compared to that of a red-blood polar representative, *Pagothenia borchgrevinki* from McMurdo Sound subjected to the same heat stress test (experiment already performed) and the ancestral proxy, the S. American *E. maclovinus*.

B-037-P: PROTEIN FOLDING AND EMBRYOGENESIS IN ANTARCTIC FISHES: A COMPARATIVE APPROACH TO ENVIRONMENTAL STRESS

H. William Detrich, Principal Investigator, Marine Science Center, Northeastern University

Personnel on Station: Nathalie R. Le François and Eileen Sheehan

Antarctic notothenioid fishes have evolved a remarkable suite of characters, including the acquisition of macromolecular antifreezes by most species and the loss of red blood cells and hemoglobin by the icefish family, as the Southern Ocean (SO) cooled to the freezing point of seawater (–1.9°C) over the past 25-40 million years. Today, these cold-adapted stenotherms are threatened by rapid warming of the SO, the temperature of which is likely to increase by 2-5°C over the next two centuries. All levels of biological organization, from the molecular through the organismal to the ecological, are likely to be impacted. During the current winter season, Le François and Sheehan are carrying out long-term incubations of embryos from the Bullhead notothen, *Notothenia coriiceps*, at control (–1°C) and experimental (+4°C) temperatures. Embryos sampled at specific developmental stages will be analyzed for potential perturbation of gene expression by high-throughput RNA sequencing (RNAseq) and by *in situ* hybridization to important developmental genes at my home institution.

Using *N. coriiceps* broodstock captured during the LMG14-04 fishing cruises, Le François and Sheehan have obtained nine biparental crosses by *in vitro* fertilization for the thermal perturbation experiment. These crosses are being maintained in our purpose-built embryo incubation system (Aquamerik, Quebec, Canada) located in Environmental Room 1 of the Palmer Station Aquarium. To keep the culture healthy, embryos are periodically treated with anti-fungal agents.

The oldest of the clutches have now obtained 60 days postfertilization. Embryos at –1°C and +4°C are being monitored daily by microscopy to ensure that we sample embryos at comparable stages for the two temperature treatments, and image banks of key developmental stages are being generated.

We also seek to compare the development and thermal sensitivity of embryos from the icefish *Chaenocephalus aceratus* to those of *N. coriiceps*, but we've been frustrated by the lack of reproductive synchrony of icefish males and females captured in mid-April to mid-May. Le François and Sheehan have taken a major step toward mitigating this problem by developing a method for the cryopreservation of sperm from C. aceratus. Thus, in the future we should be able to bank sperm from the icefish for use in *in vitro* fertilizations when gravid females become available.

We thank the ASC Palmer Station personnel and the Captain, crew, and ASC personnel of the *ARSV Laurence M. Gould* for their exceptional help in making our ongoing field season a great success.

B-266-P: EVOLUTIONARY FATE OF HAPTOGLOBIN AND HEME SCAVENGERS IN THE ANTARCTIC ICEFISHES

Kevin Bylik, Principal Investigator, University of Illinois at Urbana-Champaign

Personnel on Station: Kevin Bylik, Mateusz Grobelny, Konrad Meister

The Antarctic icefishes are remarkable for being the only vertebrate animal where the oxygen binding protein hemoglobin has been lost, a loss that even extends to myoglobin in six of the sixteen icefish species. A number of proteins normally function in support of the role of hemoglobin and we would expect that the evolutionary loss of hemoglobin in these fishes would have relaxed the selective pressure for these supporting functions. This project is an investigation of the evolutionary fate of two such proteins, haptoglobin and the heme scavenger hemopexin.

Experimental work by our group on the station has focused on looking for evidence of haptoglobin presence in the blood plasma of the Antarctic Icefishes. Much of our work has been on using the plasma of the readily available red blooded notothenioid, *Notothenia corriceps*, to work on techniques to isolate and visualize hemoglobin binding proteins. Initial work was verified using samples from additional red-blooded species including *Dissostichus mawsoni* and others. Applying similar affinity binding techniques to blood plasma from various icefishes including *Champsocephalus gunnari, Chionodraco rastrospinosus, Pseudochaenichthys georgianus,* and *Chaenocephalus aceratus* appear to show that a number of hemoglobin binding proteins remain present. Subsequent work at the University of Illinois will have to be carried out to confirm the identity of these proteins and whether they are similar to those seen in the red-blooded fishes. Currently we are working towards further testing of plasma from the collected icefish species with our remaining time on station.

The remainder of our work at Palmer station has been oriented towards collecting the samples needed to continue our analysis back at our home institution. Tissue and blood plasma samples are being collected from icefishes and several of the red blooded notothenioids that can serve as controls. Isolation of hemoglobin from locally caught *N. corriceps* has also been underway so that we will have the raw material we need to continue performing assays of hemoglobin binding activity.

PALMER STATION RESEARCH ASSOCIATE MONTHLY REPORT
JULY 2014
Graham Tilbury

G-090-P: GLOBAL SEISMOGRAPH NETWORK (GSN) SITE AT PALMER STATION.

Kent Anderson, Principal Investigator, Incorporated Research Institutions for Seismology (IRIS)

Station PMSA is one of more than 150+ sites in the GSN, monitoring seismic waves produced by events worldwide. Real-time telemetry data is sent to the U.S. Geological Survey (USGS). The Research Associate operates and maintains on-site equipment for the project.

The system operated normally throughout the month.

A-109-P: ANTARCTIC EXTREMELY LOW FREQUENCY/VERY LOW FREQUENCY (ELF/VLF) OBSERVATIONS OF LIGHTNING AND LIGHTNING-INDUCED ELECTRON PRECIPITATION (LEP).

Robert Moore, Principal Investigator, University of Florida

ELF/VLF radio wave observations at Palmer Station are used to provide a deeper understanding of lightning and its effects on the Earth's inner radiation belt. The Research Associate operates and maintains on-site equipment for the project.

The VLF tower was regularly inspected and looks secure. Three of the four lower antenna feed lines are now covered by snow drifts, but this does not affect the antenna's performance. The receiver system operated normally throughout the month.

O-202-P: ANTARCTIC METEOROLOGICAL RESEARCH CENTER (AMRC) SATELLITE DATA INGESTOR.

Mathew Lazzara, Principal Investigator, University of Wisconsin

The AMRC 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 Research Associate operates and maintains on-site equipment for the project.

The data ingestor operated normally through 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 help to determine rates of marine biological productivity and ocean mixing as well as 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. The Research Associate collects samples fortnightly from both TerraLab and the VLF Building.

A new shipment of air sample flasks arrived on station and were moved to the lab for storage. Air samples were collected as scheduled.

O-264-P: COLLECTION OF ATMOSPHERIC AIR FOR THE NOAA/GMD WORLDWIDE FLASK SAMPLING NETWORK
James Butler, Principal 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. The Research Associate collects weekly air samples for the CCGG group and fortnightly samples for the HATS group.

Carbon Cycle and Halocarbon air samples were collected as scheduled.

O-264-P: ULTRAVIOLET (UV) SPECTRAL IRRADIANCE MONITORING NETWORK
James Butler, Principal Investigator, National Oceanic and Atmospheric Administration / Global Monitoring Division; Boulder, CO

A Biospherical Instruments (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. A BSI GUV-511 filter radiometer, an Eppley PSP Pyranometer, and an Eppley TUVR radiometer also continuously measure hemispheric solar flux within various spectral ranges. The Research Associate operates and maintains on-site equipment for the project.

The system operated normally throughout the month.
The bi-weekly absolute calibration scans were completed as scheduled.

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

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

Quality checks of the downloaded data were performed daily.
The system operated normally throughout the month.

T-295-P: GPS CONTINUOUSLY OPERATING REFERENCE STATION.
Joe Pettit, Principal Investigator, UNAVCO

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

The primary GPS station collected data normally throughout the month.

T-312-P: TERASCAN SATELLITE IMAGING SYSTEM
The TeraScan system collects, processes, and archives DMSP and NOAA satellite telemetry, capturing approximately 25-30 passes per day. The Research Associate operates and maintains on-site equipment for the project. The TeraScan weather and ice imagery is used for both research and station operations.

The replaced satellite antenna tracker unit was monitored for correct operation throughout the month. All scheduled passes were successfully downloaded and the system continues to perform adequately.

B-466-P: FLUORESCENCE INDUCTION AND RELAXATION (FIRe) FAST REPETITION RATE FLUOROMETRY (FRRF)
Deneb Karentz, Joe Grzymski, Co-Principal Investigators, University of San Francisco

The focus of this project is to identify and evaluate changes that occur in genomic expression and physiology of phytoplankton during the transition from winter to spring, i.e., cellular responses to increasing light and temperature. A Fast Repetition Rate Fluorometer (FRRF) with a FIRe (Fluorescence Induction and Relaxation) sensor is installed in the Palmer Aquarium. The Research Associate downloads data and cleans the instrument on a weekly basis.

Daily instrument checks, weekly cleaning and data downloads were performed as scheduled.

T-998-P: INTERNATIONAL MONITORING STATION (IMS) FOR THE COMPREHENSIVE NUCLEAR TEST BAN TREATY ORG. (CTBTO)
Managed by General Dynamics

The IMS Radionuclide Aerosol Sampler and Analyzer (RASA) is part of the CTBTO verification regime. The automated RASA continually filters ambient air and tests for particulates with radioisotope signatures indicative of a nuclear weapons test. The Research Associate operates and maintains the instrument.

Daily filter samples were processed and packaged for shipping.
The system continued operating normally throughout the month.

OCEANOGRAPHY

Daily observations of sea ice extent and growth stage are also recorded, along with continuous tidal height, ocean temperature, and conductivity at Palmer's pier.

The tide level, conductivity and sea water temperature monitoring system performed correctly the entire month. A prototype of the new display screen, incorporating Tidegauge data plots was tested.

METEOROLOGY

The Research Associate acts as chief weather observer, and compiles and distributes meteorological data. 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 National Weather Service for entry into the Global Telecommunications System.

The system operated normally during the month. The development of the new display screen, incorporating images from six individual screens, continues.