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[Awards & Reporting](#)
[Notifications & Requests](#)
[Project Reports](#)
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[Award Functions](#)
[Manage Financials](#)
[Program Income Reporting](#)
[Grantee Cash Management Section Contacts](#)
[Administration](#)
[Lookup NSF ID](#)

Preview of Award 1440435 - Annual Project Report

[Cover](#) |
[Accomplishments](#) |
[Products](#) |
[Participants/Organizations](#) |
[Impacts](#) |
[Changes/Problems](#)

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1440435
Project Title:	LTERR Palmer, Antarctica (PAL): Land-Shelf-Ocean Connectivity, Ecosystem Resilience and Transformation in a Sea-Ice Influenced Pelagic Ecosystem
PD/PI Name:	Hugh W Ducklow, Principal Investigator Douglas G Martinson, Co-Principal Investigator
Recipient Organization:	Columbia University
Project/Grant Period:	09/01/2014 - 08/31/2020
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Submitting Official (if other than PD\PI):	Hugh W Ducklow Principal Investigator
Submission Date:	06/30/2017
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Hugh W Ducklow

Accomplishments

* What are the major goals of the project?

The Palmer Long Term Ecological Research (PAL) program seeks to obtain a comprehensive understanding of the Antarctic

seasonal sea ice-influenced ecosystem – the climate, plants, microbes, animals, biogeochemical processes, ocean, and sea ice south of the Antarctic Polar Front (northernmost extent of ice-influenced water). Since its inception in 1990, the central hypothesis of PAL has been that the seasonal and interannual variability of sea ice affects all levels of the Antarctic marine ecosystem, from the timing and magnitude of primary production to the breeding success and survival of penguins and whales. Our site on the western side of the Antarctic Peninsula (WAP) addresses multiple spatial and temporal scales from hemispheric, decadal, climate-relevant scales to regional and local, daily to seasonal, process-relevant scales.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

Climate and sea ice

We analyzed the 2016-2017 air-sea-ice interactions that led to seasonally contrasting sea ice extent anomalies, both along the WAP and over Antarctica as a whole (Stammerjohn and Scambos, 2017). We completed several WAP (Fountain et al., 2016; Obryk et al., 2016), Antarctic-wide (Heil et al., 2016; Stammerjohn and Maksym, 2017; Stammerjohn and Scambos, 2017) and polar-wide (Stroeve et al., 2016) ice-climate analyses investigating mechanisms and drivers of sea ice change. We also contributed to several investigations on ice-ecosystem interactions (Yager et al., 2016) relevant to PAL. Work continued on data-model investigations of the role of ocean heat on sea ice dynamics in the PAL area (Saenz et al., in prep) and neighboring Amundsen Sea (St-Laurent et al., submitted).

Physical Oceanography

We continued to collect, process and distribute shipboard CTD and ADCP data at every station visited, including a high resolution transect across the slope which for the first time resolves the shelf-break front and bottom frictional layers. The single mooring deployed in 2016 was unable to be recovered on the 2017 cruise and was likely dragged off by an iceberg. Three moorings were deployed along a latitudinal gradient on the 2017 cruise, each equipped with current meters to sample coastally-propagating signals and thermistors and a salinity sensor to quantify variability of the mixed layer. Overall, these data are collected to provide the physical setting of the ecosystem and in the long term to allow us to determine the manner in which the physical system is changing.

Phytoplankton

The phytoplankton team is focused on measuring phytoplankton, bio-optics and physical oceanographic measurements for the LTER project. Routine measurements include discrete measurements of chlorophyll *a*, pigments via high performance liquid chromatography, fluorescence kinetics and whole water carbon fixation rates. These discrete measurements are complemented with bio-optical profiles and autonomous glider data. Discrete sampling was augmented with 2 glider missions. The team conducted experiments to assess how meltwater contributions influence the phytoplankton. The team made trace metal clean measurements of glacial meltwater chemistry and collected a large number of samples for DNA sequencing. We made range of prototype chlorophyll fluorescence measurements to assess physiological status. Schofield gave 9 invited lectures.

Zooplankton

This year the zooplankton group again emphasized the role that zooplankton play in

carbon and nutrient cycling, and long-term changes in zooplankton community structure. On the annual cruise we focused some of our sampling efforts and experiments on pteropod (pelagic snail) biogeography, physiology, and feeding ecology as related to the effects of ocean warming and food changes (see Findings) as part of PhD student Patricia Thibodeau's dissertation. At VIMS we also performed detailed analysis of the PAL LTER time-series sediment trap samples, to detect changes in timing of pteropod (*Limacina helicina antarctica*) life history events through seasonal and interannual changes in shell size and abundance, and to determine their contribution to WAP inorganic carbon flux. We continued our analysis of the long-term MOCNESS (depth-stratified zooplankton sampling) data set to examine diel vertical migration in WAP zooplankton, led by MS student John Conroy.

Seabirds

During the 2016-2017 season, we continued to expand our gentoo penguin sampling program to match the sampling regime that has been in effect longer-term with Adélie penguins to test hypotheses regarding competition between the two penguin species and between penguins and whales. The specific metrics of interest include diets, foraging locations, dive-depths and fledging weights. Including both species, we obtained 55 diet samples, 428 fledging weights and deployed 26 satellite tags that returned data on the foraging distributions and dive-depth profiles of 44 individual birds. Our focal study areas included Biscoe Point, the Joubin Islands, and Torgersen, Humble and Dream islands. In January two field team members participated in the annual LTER cruise, continuing surveys of seabirds and marine mammals within the LTER grid, and including a 5-day field camp on Avian Island to extend the time series on aspects of Adélie penguin ecology to compare with Palmer Station populations.

Cetaceans

We utilize a multi-disciplinary approach to study the ecology and demography of baleen whales, and how inter-annual changes in pregnancy rates are affected by the timing and extent of sea ice cover, the location of phytoplankton blooms, and the relative abundance and size-frequency distribution of krill. To understand seasonal body condition changes in whales, we utilize UAS (unoccupied aerial systems) to measure animal length and girth throughout the feeding season. By relating body condition changes to the distribution and behavior of whales from satellite tags, we can evaluate the critical needs of whales in the region. This information is synthesized with data from the Seabird group to test for competition between these sympatric krill predators. We use both Palmer Station and the LMG, collecting biopsy samples and photo-ID at both, running prey mapping surveys with fisheries echosounders to quantify prey availability at Palmer, and flying UAS missions with both fixed wing and multicopters to assess the body condition and behavior of humpback whales, and to assess penguin colonies at Torgerson Island and Avian Island.

Microbial ecology and biogeochemistry

We continued nearshore research on microbial ecology and biogeochemistry at Palmer Station, now in its 15th season (excluding 2006-07-08), and participated on LMG 1701, the 25th LTER Cruise. The start of our Palmer Station season was delayed until mid-November due to late ice retreat. We also lost 5 days on the January cruise because of heavy sea ice in the south of our study area. Otherwise all our sampling and

measurements proceeded normally. Cross site synthesis by postdoc Jeff Bowman was a major emphasis this past year.

Synthesis and modeling

Data analysis studies were conducted on historical biogeochemical data from the Palmer LTER annual regional survey cruise and seasonal small boat sampling at Palmer Station. Numerical modeling studies were conducted across a hierarchy of model resolution scales exploring ocean-atmosphere-sea ice physical dynamics and ocean biogeochemistry (1-D water column model), regional physical circulation-biogeochemistry (MIT Ocean General Circulation Model), and the impact of climate change on Southern Ocean biogeochemistry (Community Earth System Model).

Information Management

During the 16/17 reporting period, PAL LTER Information Management continued to make improvements to the information management infrastructure supporting data and information services for the PAL LTER research project. DataZoo was migrated from legacy architecture to the modern Laravel PHP framework. The new framework supports modern web development practices and ensures more productive and stable updates and maintenance of PAL LTER's primary application supporting the local data management workflow. During the redevelopment, upgrades to EML publishing were made that allow single-command publishing of dataset data and metadata to the LTER Network Information System. Additional metadata fields were added to generate EML to improve data use and a fully functional administrative interface for managing dataset metadata, personnel and documenting data management tasks was added to the application in order to support productivity and task sharing. Much progress has been made and efforts continue to complete a comprehensive set of documentation outlining the duties of information management as a primary reference for PAL LTER IM.

Specific Objectives:

The specific objectives for this award are to answer the following questions with a strategically designed program of oceanographic and ecological observations and experiments conducted at Palmer Station and along the western Antarctic Peninsula.

1. Long-term change and ecosystem transitions. What is the sensitivity or resilience of the ecosystem to external perturbations as a function of the ecosystem state?
2. Lateral connectivity and vertical stratification. What are the effects of lateral transports of freshwater, heat and nutrients on local stratification and productivity and how do they drive changes in the ecosystem?
3. Top-down controls and shifting baselines. How is the ecosystem responding to the cessation of whaling and subsequent long-term recovery of whale stocks?
4. Foodweb structure and biogeochemical processes. How do temporal and spatial variations in foodweb structure influence carbon and nutrient cycling, export, and storage?
5. Education and outreach activities. In what ways do we communicate our results to the public and how are they incorporated in new education initiatives? What are the Broader Impacts of PAL research on the WAP?

Significant Results:**Climate and sea ice**

Circumpolar Antarctic sea ice extent (SIE) saw swings from moderately negative to positive anomalies from January to mid-Sept 2016, followed by record-low sea ice extent anomalies from mid-Sept onward (**Fig 1, top**). This abrupt shift in circumpolar sea ice extent anomalies coincided with a shift from strong positive to negative SAM index values later in the year (**Fig 1, bottom**). Sea ice extent along the WAP was well above-average in summer-autumn (Jan-May) but swung to well below average in spring-early summer (Sept-Dec) (**Fig 2**). In contrast to record highs observed over 2012-15, there has been much attention on the record lows in 2016-17. The consensus: due to extremely high Antarctic sea ice variability and its strong global connectivity, a concerted effort to extend time series observations and efforts at the process-level is critically needed. Antarctic sea ice variability remains a puzzle, despite other clear signs of warming (e.g., increases in air temperature, ocean heat content, continental ice mass loss).

Physical Oceanography

Continuing our examination of ocean stratification to determine the northernmost limit at which sea ice can form [Antarctic Sea Ice Wall, **Fig 3**], we have switched to using ARGO data—now the SIW does an good job of capturing the sea ice extent; its expansion is slightly faster than that of the SIE. It is possible that the SIE expansion is do to stratification changes. At periods longer than ~20 days the current response is consistent with a circumpolar-coherent wind forcing. At shorter periods, our moorings detect propagating first and second mode coastally trapped waves. The second mode wave is important along the WAP owing to the very steep continental slope. It projects onto the shelf-break current and manifests as a propagating upwelling signature. A consequence is that winds very remote from the WAP can have a major impact on the local dynamics and stratification. Interleaving provides a major means of water mass transformation, particularly in frontal regions where lateral gradients are largest.

Phytoplankton

Inconsistent definitions of mixed layer depth (MLD) make comparisons around Antarctica difficult. We defined an ecologically relevant MLD based buoyancy frequency confirmed through phytoplankton distributions. We characterized the Upper Circumpolar Deep Water (UCDW) on the WAP shelf. The UCDW was associated with bathymetric depressions and transport intruded as subsurface eddies. Variability in WAP net community production (NCP) peaked offshore and followed sea-ice retreat influenced by the SAM and El Nino. The relationship between MLD and phytoplankton was linked to ice melt. Spatial variability reflected local circulation. Long-term patterns in the phytoplankton communities were analyzed. There was a significant increase in the seasonally integrated of chl-a (**Fig. 4**). Dominant phytoplankton were diatoms, with cryptophytes next. A shallower seasonal mixed layer resulted in larger diatom blooms. Summers with lower phytoplankton biomass had more chl-a associated with cryptophytes (Fig. 5).

Zooplankton

The pteropod *L. helicina* is one of the most abundant zooplankton taxa in the WAP. Our aim is to identify environmental and physiologic mechanisms controlling

pteropod biogeography as well as its influence on carbon cycling in the WAP food web, to better predict effects of environmental change in the region. PhD student Tricia Thibodeau conducted shipboard multi-stressor experiments to measure the potential future effects of limited food availability and higher seawater temperature on pteropod metabolism (respiration and excretion). She conducted shipboard experiments exposing pteropods to predicted elevated temperature and decreased phytoplankton, along with a present-day temperature and natural (higher) chlorophyll concentration controls (**Fig. 6**). Low food concentrations and to some extent higher temperatures enhanced respiration. Possibly low food concentrations caused animals stress and increased metabolism. There was not as strong a relationship between temperature and respiration as we hypothesized. Excretion of ammonia, phosphate, and dissolved organic C and N was also measured.

Seabirds

In contrast to the 2015-16 season when heavy sea ice prevailed throughout the summer, the 2016-17 summer was marked by anomalously light sea ice conditions, allowing us to directly compare the effects of sea ice on gentoo penguin chick fledging weights. Gentoos are ice-intolerant, and during the previous season we noted that sea ice presence significantly depressed this demographic metric (**Fig. 7**), a major determinant of chick overwinter survival and future recruitment and population change. The absence of sea ice in 2016-17 had a direct, positive effect on gentoo chick fledging weights on Biscoe Point and the Joubin Islands compared to the previous season. The Joubin Islands produced heavier chicks during both seasons compared to Biscoe Point, suggesting that Gentoo penguin foraging areas may not only be colony-specific over relatively small spatial scales, but also that the chicks from these colonies may be asymmetrically vulnerable to growth disruptions due to sea ice-imposed costs on parental foraging efficiencies associated with these areas. These findings provide a mechanistic explanation for understanding the role of sea ice as a determinant of gentoo penguin population dynamics.

Cetaceans

From Jan to the end of May, we collected 205 humpback and 10 minke whale biopsy samples and nearly 100 individual fluke images for photo-ID. Seven satellite-linked dive-recording tags were deployed on humpback whales in late April. We conducted 18 multicopter and fixed wing missions (7500 images, 244 gb 4K video, 1.3 gb thermal video and 5 gb of mapping data). **Fig 8** illustrates a drone-based image of a humpback whale being measured for body condition. Student Projects included: ‘Foraging niche separation of Adélie and gentoo penguins during the breeding season at Palmer Station, Antarctica’ that utilized 6 years of satellite tag data to ‘Temporal Variation in Humpback Whale Demographics Along the Western Antarctic Peninsula (WAP)’ which used over 500 biopsy samples collected during the LTER.

Microbial ecology and biogeochemistry

We highlight a paper published in *BioScience* as part of a cross-site study we conducted with the MCM-LTER. Microbes dominate energy and materials flows in MCM & PAL. Of special relevance is Bowman’s finding of a significant trend in euphotic zone dissolved organic carbon in the Palmer region, and substantial interannual variations in the share of primary production utilized by bacteria (BP:PP ratio) (**Fig 9**). The contrasts

in this property between MCM and PAL are notable. Lake Bonney and the PAL region are similar (0.05 – 0.3), reflecting their dependence on *in situ* sources of organic matter, whereas the values are all in excess of 0.5 in Fryxell, suggesting inputs of organic matter from outside the system.

Synthesis and modeling

Rohr et al. (2017) conducted a numerical simulation with the Community Earth System Model using remote sensing data to examine the role of top-down (grazing pressure) and bottom-up (light, nutrients) controls on marine phytoplankton bloom dynamics in the Southern Ocean. Phytoplankton seasonal phenology is evaluated in the context of the recently proposed “disturbance-recovery” hypothesis relative to more traditional, exclusively “bottom-up” frameworks. Regional case studies illustrate how unique pathways allow blooms to emerge despite very poor division rates or very strong grazing rates. In the Subantarctic, southeast Pacific small spring blooms initiate early co-occurring with deep mixing and low division rates, consistent with the disturbance-recovery hypothesis. In the simulated Antarctic zone (70°S–65°S) seasonal sea ice acts as a dominant phytoplankton-zooplankton decoupling agent, triggering a delayed but substantial bloom as ice recedes (Fig 10).

Key outcomes or Other achievements:

* What opportunities for training and professional development has the project provided?

Palmer LTER affords numerous opportunities for training in field research for undergraduate and graduate students. We engage upper level PhD students and postdocs in teaching our undergraduate classes and graduate seminars at Columbia, Wm & Mary, WHOI-MIT and Rutgers.

Professional development opportunities have been pursued by Research Associate Naomi Shelton at Columbia (MSc in Sustainability Management) and by PAL Informatio Manager James Connors at UCSD, who has attends numerous professional IM Workshops.

* How have the results been disseminated to communities of interest?

The Rutgers education and outreach team has designed a variety of education programs focused on communicating the research of the Palmer LTER to predominantly a K-12 educator and student audience. We match these efforts with a companion NSF award from the Polar Science Division (grant#1525635) called Polar Interdisciplinary Coordinated Education or Polar ICE (polar-ice.org).

Schoolyard LTER: Video Teleconferences with Palmer Station

The Education and Outreach team worked with Palmer LTER scientists to offer video teleconference calls to virtually connect students and their teachers to Palmer. Teachers completed an application process and agreed to teach 2-3 lessons prior to their call, with hands-on activities that would help prepare the students for the experiences. Students submitted their science questions 24 hours in advance. We engaged 23 educators and approximately 1,725 students from 5 states spanning 5-12th grade (**Table 1**).

Evaluation of VTCs

Educators filled out a short on-line survey post the VTC broadcast. Our goal was to capture some formative data to help us fine tune the VTCs for future field seasons (**Table 2**). Overall the educators ranked the broadcast very good for engaging their students in Antarctic science.

We asked the educators to please explain why they chose this rating for the effect of the VTC/Live Video Broadcast on their students' engagement in and identity with science. We saw the following trends:

1) **Ability to practice asking scientific questions:** Educators noted the importance of getting students to develop and ask scientific questions. Students were generally interested in questions posed by their peers from their schools and from other schools.

"As a class, we spent time examining types of questions and quality of questions. We read previously submitted questions and evaluated where on Blooms Taxonomy did that question fall- comprehension to an analysis. This seemed to be the first encounter my students had with the idea of question types. They were engaged and extremely thoughtful about the quality of their questions".

"Students don't see themselves as 'scientists'. Coming up with questions gave them a feeling of self-consciousness. They wondered if their question would be dumb or if someone else would ask the same thing. Having the opportunity to see their questions and the questions of others in action helped them better identify with science".

2) **Increase understanding and awareness of Polar Regions:** Educators noted that students were interested to learn more about Antarctica. Students were able to learn more about the Antarctic food web from the smallest microbes to the largest whales.

"All in all the students were happy to have the opportunity. I believe this experience will stay with them and raised their awareness about Antarctica and research opportunities".

3) **Ability to meet a practicing scientist:** Many educators noted that it was important for students to have the opportunity to meet and talk to a real scientist.

"It was helpful to see a female scientist and allow female students to see themselves with her and both scientists were engaging but it was also hard to actually see them to allow students to see themselves in the scientists".

4) **Technology concerns:** Many educators noted that the Blackboard system with a small window for the video interaction was not optimal. Many noted that it was hard to hear other students ask their questions and sometimes (depending on the weather) difficult to hear the scientist's response. A few educators asked for tours of the laboratory space or live video of scientists sampling.

Schoolyard LTER: Engage educators in professional development related to Palmer LTER research.

The Sci-I Project is a year-long project that consists of a Summer Educator Workshop and a follow up Student Polar Research Symposium. 24 educators from CA and NJ explored polar science and data through interactions with 6 Palmer LTER scientists and participated in polar data-focused activities. A large portion of the workshops was devoted to using exemplar student science investigations as case studies to highlight how to effectively lead students in designing, developing, and conducting polar science investigations. Educators taught 2 [polar-related science classroom lessons](#) that used polar data from the Palmer LTER DataZoo and assisted students to conduct their own investigations related to the topics and data for LTER research explored through this project. The students worked on these investigations throughout the winter and spring and then presented their results and findings to polar scientists and to one another at the [Student Polar Research Symposium](#) (Feb 2016 – CA, and June 2017 – NJ). Approximately 2,200 students participated in the project, with about 120 coming to Univ of California Monterey Bay and about 130 to Rutgers in person to interact with 12-15 polar scientists at each Symposium.

Our intended impact for this work is to: contribute to the engagement of middle school youth in science and increase student identity as a scientist through increased enthusiasm and personal engagement with scientists. Our objective is to make science personally relevant to students and influence their long-term interest in science through authentic science data experiences. A second workshop is scheduled for June 25-30, 2017 at the Byrd Center, Ohio State Univ. 2 other LTER

programs are sending educators to help expand the model. States included in this program are NJ, KS, MO, OH, UT, CA, and CO.

We also hosted the Education and Research Testing Hypothesis (EARTH) workshop (July 25-29, 2016 at Rutgers University and a second program is planned for July 17-21, 2017 at MBARI). Developed by MBARI, EARTH providing teachers with a means for integrating real-time data with existing educational standards and a tested curriculum in an interactive and engaging way. Polar-ICE and Palmer LTER collaborated with MBARI to host 25 K-12 educators at Rutgers and Columbia Universities. Educators have created lessons that focus on Palmer LTER data. The lessons have been shared broadly through the Polar-ICE, LTER, and EARTH/MBARI websites.

The Rutgers outreach team also conducted an evening workshop October 13, 2016 focused on the LTER children's' book focused on Palmer Station. Rutgers has maintained a network of approximately fifty K-8 schools in NY-NJ that are integrating marine science themes and concepts in their school curriculum. Twenty-four K-5 educators were introduced to the LTER book series (we purchased the books for each participant and provided them with classroom activities to take back to their schools).

Schoolyard LTER: Support the Research Experience for Teachers (RET) program: We worked with two educators from the Polar ICE Science Investigation workshop (Alexis Custer and Mathew Fitcher) to work on development of Data Nuggets and other Palmer related lessons that can be shared with the our education network. In addition, these educators facilitated one-day workshops for their peers at the NJ Science Convention (October 24-25, 2016). They collected student data on the effectiveness of the newly developed lesson plans and will be publishing the lessons on the data nuggets website and are working on a manuscript for the National Science Teachers Association publication *Science Teacher*.

Outreach and Engagement of the Science-Interested Public

We also collaborated with Public Radio (You're the Expert) on November 9, 2016 at the George Street Playhouse in New Brunswick, NJ to share Palmer LTER research stories and information. Dr. Oscar Schofield participated in a broadcast with three comedians and host Chris Duffy. Approximately 300 Rutgers students attended the recording of the show. The show is available as a podcast at <https://itunes.apple.com/us/podcast/youre-the-expert/id624677543>. NPR reports close to 250,000 downloads of the podcast to date. Oscar was the funniest.

* What do you plan to do during the next reporting period to accomplish the goals?

Continue field and lab research and collaborative data analysis as outlined in proposal.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
Figures 2017.pdf	PDF documents with plots cited in Findings Section and 2 tables cited in Dissemination (Education) section.	Hugh Ducklow	06/27/2017
Figure 6.pdf	Fig 6 is listed separately due to loading issues.	Hugh Ducklow	06/27/2017
E&O Tables 2017.pdf	Tables for Education and Outreach	Hugh Ducklow	06/27/2017

Products

Books

Book Chapters

Steinberg, D.K. (2017). Chapter 6: Marine zooplankton biogeochemical cycles. *Marine Plankton* Castellani, C. and Edwards, M.. Oxford Univ. Press. Oxford, UK. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Inventions

Journals or Juried Conference Papers

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Albertson, G.R. and Friedlaender, A.S. and Steel, D.J. and Aguayo-Lobo, A. and Bonatto, S.L. and Caballero, S. and Constantine, R. and Cypriano-Souza, A.L. and Engel, M.H. and Garrigue, C. and Flórez-González, L. and Johnston, D.W. and Nowacek, D.P. and Olavarría, C. and Poole, M.M. and Read, A.J. and Robbins, J. and Sremba, A.L. and Baker, C.S. (2017). Temporal stability and mixed-stock analyses of humpback whales (*Megaptera novaeangliae*) in the nearshore waters of the Western Antarctic Peninsula. *Polar Biology*. *Polar Biology*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes

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Bernard, K.S. and Cimino, M. and Fraser, W. and Kohut, J. and Oliver, M.J. and Patterson-Fraser, D. and Schofield, O. and Statscewich, H. and Steinberg, D.K. and Winsor, P. (2017). Factors that affect the nearshore aggregations of Antarctic krill in a biological hotspot. *Deep-Sea Research Part I*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; DOI: 10.1016/j.dsr.2017.05.008

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Eveleth, R. and Cassar, N. and Doney, S. C. and Munro, D. R. and Sweeney, C. (2017). Biological and physical controls on O₂/Ar, Ar and pCO₂ variability at the Western Antarctic Peninsula and in the Drake Passage. *Deep Sea Research Part II: Topical Studies in Oceanography*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <http://dx.doi.org/10.1016/j.dsr2.2016.05.002>

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Licenses

Other Conference Presentations / Papers

Other Products

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

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Websites

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Ducklow, Hugh	PD/PI	2
Martinson, Douglas	Co PD/PI	10
Conners, James	Co-Investigator	6
Doney, Scott	Co-Investigator	1

Fraser, William	Co-Investigator	3
Friedlaender, Ari	Co-Investigator	4
McDonnell, Janice	Co-Investigator	2
Schofield, Oscar	Co-Investigator	4
Stammerjohn, Sharon	Co-Investigator	2
Steinberg, Deborah	Co-Investigator	5
Bowman, Jeff	Postdoctoral (scholar, fellow or other postdoctoral position)	3
Feehan, Colette	Postdoctoral (scholar, fellow or other postdoctoral position)	4
Kavanaugh, Maria	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Weinstein, Ben	Postdoctoral (scholar, fellow or other postdoctoral position)	4
Falkowski, Paul	Other Professional	2
Ferraro, Carrie	Other Professional	12
Fraser, Donna	Other Professional	3
Henley, Sian	Other Professional	2
Hunter-Thompson, Kristin	Other Professional	1
Lichtenwalner, Sage	Other Professional	1
Aragon, David	Technician	2
Cook, Ben	Technician	5
Cope, Joseph	Technician	6
Fahlbusch, James	Technician	5

Farry, Shawn	Technician	5
Iannuzzi, Richard	Technician	12
Jaycox, Adrian	Technician	2
Lima, Ivan	Technician	1
McAtee, Carrie	Technician	5
McElroy, Mary	Technician	2
Musan, Israela	Technician	2
Rheuban, Jennie	Technician	2
Roberts, Darren	Technician	2
Roberts, Megan	Technician	2
Rushworth, Kelvin	Technician	2
Shelton, Naomi	Technician	12
Waite, Nicole	Technician	12
Zahn, Marie	Technician	2
Johnston, David	Staff Scientist (doctoral level)	3
Nowacek, Doug	Staff Scientist (doctoral level)	1
Brown, Michael	Graduate Student (research assistant)	12
Carvalho, Ana Filipa	Graduate Student (research assistant)	12
Couto, Nicole	Graduate Student (research assistant)	12
Kim, Hyewon	Graduate Student (research assistant)	12
McKee, Darren	Graduate Student (research assistant)	12
Nardelli, Schuyler	Graduate Student (research assistant)	12

Pallin, Logan	Graduate Student (research assistant)	12
Pickett, Erin	Graduate Student (research assistant)	3
Rohr, Tyler	Graduate Student (research assistant)	10
Schultz, Cristina	Graduate Student (research assistant)	8
Sherman, Jonathan	Graduate Student (research assistant)	2
Thibodeau, Patricia	Graduate Student (research assistant)	12
West, Leigh	Non-Student Research Assistant	6
Conroy, John	Undergraduate Student	12
Leshko, Shana	Undergraduate Student	3
McBride, Colleen	Undergraduate Student	7
Schrage, Kharis	Undergraduate Student	2
Suman, Anjali	Undergraduate Student	2
Westmoreland, Katie	Undergraduate Student	2

Full details of individuals who have worked on the project:

Hugh W Ducklow

Email: hducklow@ldeo.columbia.edu

Most Senior Project Role: PD/PI

Nearest Person Month Worked: 2

Contribution to the Project: Lead PI and supervisor of microbial ecology component

Funding Support: Columbia University

International Collaboration: Yes, United Kingdom

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Douglas G Martinson

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Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 10

Contribution to the Project: Leader of Physical Oceanography component

Funding Support: Institution - Columbia Univ

International Collaboration: No

International Travel: No

James Conners

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Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 6

Contribution to the Project: Information Manager

Funding Support: Scripps Inst of Oceanography

International Collaboration: No

International Travel: No

Scott Doney

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Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: data synthesis and numerical modeling

Funding Support: Woods Hole Oceanographic Institution

International Collaboration: Yes, United Kingdom

International Travel: No

William Fraser

Email: bfraser@3rivers.net

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 3

Contribution to the Project: Leads all work related to seabird investigations

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Ari Friedlaender

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Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 4

Contribution to the Project: Leads all work related to marine mammal investigations

Funding Support: Oregon State University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Janice McDonnell

Email: mcdonnel@marine.rutgers.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: Education & Outreach Coordinator

Funding Support: Rutgers University

International Collaboration: No

International Travel: No

Oscar Schofield

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Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 4

Contribution to the Project: Leads all work related to phytoplankton investigations

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 2 months, 0 days

Sharon Stammerjohn

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Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: research on sea ice and climate

Funding Support: University of Colorado

International Collaboration: No

International Travel: No

Deborah Steinberg

Email: debbies@vims.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 5

Contribution to the Project: Leads all work related to zooplankton investigations

Funding Support: Virginia Institute of Marine Science

International Collaboration: No

International Travel: No

Jeff Bowman

Email: bowmanjs@ideo.columbia.edu

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 3

Contribution to the Project: research on microbial diversity

Funding Support: Columbia University

International Collaboration: No

International Travel: No

Colette Feehan

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Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 4

Contribution to the Project: field technician at Palmer Station

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 4 months, 0 days

Maria Kavanaugh

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Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 2

Contribution to the Project: data synthesis and numerical modeling

Funding Support: Woods Hole Oceanographic Institution

International Collaboration: No

International Travel: No

Ben Weinstein

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Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 4

Contribution to the Project: data analysis and manuscript writing using LTER whale data

Funding Support: Antarctic Wildlife Research Foundation

International Collaboration: No

International Travel: No

Paul Falkowski

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Most Senior Project Role: Other Professional

Nearest Person Month Worked: 2

Contribution to the Project: Field work aboard the LMG

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 2 months, 0 days

Carrie Ferraro

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Most Senior Project Role: Other Professional

Nearest Person Month Worked: 12

Contribution to the Project: education specialist

Funding Support: Rutgers University

International Collaboration: No

International Travel: No

Donna Fraser

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Most Senior Project Role: Other Professional

Nearest Person Month Worked: 3

Contribution to the Project: Data Management

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Sian Henley

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Most Senior Project Role: Other Professional

Nearest Person Month Worked: 2

Contribution to the Project: scientific collaborator

Funding Support: Univ Edinburgh, NERC

International Collaboration: Yes, United Kingdom

International Travel: No

Kristin Hunter-Thompson

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Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: education specialist

Funding Support: Rutgers University

International Collaboration: No

International Travel: No

Sage Lichtenwalner

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Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: education specialist

Funding Support: Rutgers University

International Collaboration: No

International Travel: No

David Aragon

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: glider pilot

Funding Support: Rutgers/NASA

International Collaboration: No

International Travel: No

Ben Cook

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Most Senior Project Role: Technician

Nearest Person Month Worked: 5

Contribution to the Project: Field Technician

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Joseph Cope

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Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Field and laboratory Technician

Funding Support: Virginia Institute of Marine Science

International Collaboration: No

International Travel: No

James Fahlbusch

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Most Senior Project Role: Technician

Nearest Person Month Worked: 5

Contribution to the Project: Palmer Station and LMG marine mammal research and data management

Funding Support: OSU Foundation

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Shawn Farry

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Most Senior Project Role: Technician

Nearest Person Month Worked: 5

Contribution to the Project: Field Team Leader

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Richard Iannuzzi

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Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: programmer

Funding Support: Columbia University

International Collaboration: No

International Travel: No

Adrian Jaycox

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: field technician on cruise

Funding Support: Columbia Univ and this award

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Ivan Lima

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Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: data synthesis and numerical modeling

Funding Support: Woods Hole Oceanographic Institution

International Collaboration: No

International Travel: No

Carrie McAtee

Email: mcateecarrie@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 5

Contribution to the Project: Technician at Palmer Station

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Mary McElroy

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: field technician on cruise

Funding Support: Columbia Univ and this award

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Israela Musan

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: field technician on cruise

Funding Support: Columbia Univ and this award

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Jennie Rheuban

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: data analysis and modeling

Funding Support: Woods Hole Oceanographic Institution

International Collaboration: Yes, United Kingdom

International Travel: No

Darren Roberts

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Assisted with field work aboard LMG

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Megan Roberts

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Field work aboard the LMG

Funding Support: Polar Oceans Research Group

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 5 days; Antarctica - 0 years, 0 months, 5 days

Kelvin Rushworth

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: LMG marine mammal tagging and biopsy sampling

Funding Support: OSU Foundation

International Collaboration: Yes, Australia

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Naomi Shelton

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Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: Field and laboratory Technician

Funding Support: Columbia University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Nicole Waite

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Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: Field and Laboratory Technician

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 7 days; Antarctica - 0 years, 5 months, 0 days

Marie Zahn

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Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: field technician on cruise

Funding Support: Columbia Univ and this award

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

David Johnston

Email: dwj2@duke.edu

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 3

Contribution to the Project: field team participant and data management

Funding Support: Duke University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Doug Nowacek

Email: dpn3@duke.edu

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 1

Contribution to the Project: Data analysis

Funding Support: Duke University

International Collaboration: No

International Travel: No

Michael Brown

Email: mbrown@marine.rutgers.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Works on data and does Field Work at Palmer Station for PhD

Funding Support: Rutgers

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 5 months, 0 days

Ana Filipa Carvalho

Email: filipa@marine.rutgers.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Works on data and gliders for PhD

Funding Support: Rutgers University

International Collaboration: Yes, Portugal

International Travel: No

Nicole Couto

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Works on data and gliders for PhD

Funding Support: Teledyne Webb Research

International Collaboration: No

International Travel: No

Hyewon Kim

Email: hk2768@columbia.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: research on biogeochemistry

Funding Support: Columbia University

International Collaboration: No

International Travel: No

Darren McKee

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: research on physical oceanography

Funding Support: Columbia University

International Collaboration: No

International Travel: No

Schuyler Nardelli

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: works on data and does field work at Palmer Station and aboard the LMG for PhD

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 3 months, 0 days

Logan Pallin

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Assisted with field work at Palmer Station, data analysis and management

Funding Support: Oregon State University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Erin Pickett

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: Using project data for MSc.

Funding Support: Polar Oceans Research Group, OSU

International Collaboration: No

International Travel: No

Tyler Rohr

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 10

Contribution to the Project: data analysis and modeling

Funding Support: NDSEG Fellowship

International Collaboration: No

International Travel: No

Cristina Schultz

Email: cschultz@whoi.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 8

Contribution to the Project: data synthesis and numerical modeling

Funding Support: Woods Hole Oceanographic Institution

International Collaboration: Yes, United Kingdom

International Travel: Yes, Chile - 0 years, 0 months, 4 days

Jonathan Sherman

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Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 2

Contribution to the Project: field work aboard the LMG

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 2 months, 0 days

Patricia Thibodeau

Email: psthibodeau@vims.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Field and laboratory work for PhD

Funding Support: Virginia Institute of Marine Science

International Collaboration: No

International Travel: No

Leigh West

Email: ltw2110@columbia.edu

Most Senior Project Role: Non-Student Research Assistant

Nearest Person Month Worked: 6

Contribution to the Project: Field and laboratory Technician

Funding Support: Columbia Univ and this award

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days

John Conroy

Email: jaconroy@vims.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 12

Contribution to the Project: Field and laboratory Technician

Funding Support: Virginia Institute of Marine Science

International Collaboration: No

International Travel: No

Shana Leshko

Email: sbl2137@barnard.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: lab analyses for dissolved inorganic carbon samples from cruise

Funding Support: Barnard College

International Collaboration: No

International Travel: No

Colleen McBride

Email: cemcbride@email.wm.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 7

Contribution to the Project: laboratory volunteer

Funding Support: Wm & Mary

International Collaboration: No

International Travel: No

Kharis Schrage

Email: krschrage@email.wm.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: cruise volunteer

Funding Support: Wm & Mary

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 2 months, 0 days

Anjali Suman

Email: anjalisuman@gmail.com

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: field technician on cruise

Funding Support: Rutgers University

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 2 months, 0 days

Katie Westmoreland

Email: ktmwestmoreland@yahoo.com

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: cruise volunteer

Funding Support: Texas A&M and this award

International Collaboration: No

International Travel: Yes, Chile - 0 years, 0 months, 4 days; Antarctica - 0 years, 2 months, 0 days

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Alfred-Wegener Institute for Polar and Marine Research	Other Organizations (foreign or domestic)	Bremerhaven Grmany
British Antarctic Survey	Other Organizations (foreign or domestic)	Cambridge, UK
Cornell University	Academic Institution	Ithaca, NY
Detroit Zoological Society	Other Nonprofits	Detroit, MI
Duke University	Academic Institution	Durham, NC
Hebrew University of Jerusalem	Academic Institution	Jerusalem, Israel

Full details of organizations that have been involved as partners:

Alfred-Wegener Institute for Polar and Marine Research

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Bremerhaven Grmany

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

British Antarctic Survey

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Cambridge, UK

Partner's Contribution to the Project:

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution:

Cornell University

Organization Type: Academic Institution

Organization Location: Ithaca, NY

Partner's Contribution to the Project:

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution:

Detroit Zoological Society

Organization Type: Other Nonprofits

Organization Location: Detroit, MI

Partner's Contribution to the Project:

Financial support

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution:

Duke University

Organization Type: Academic Institution

Organization Location: Durham, NC

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

Hebrew University of Jerusalem

Organization Type: Academic Institution

Organization Location: Jerusalem, Israel

Partner's Contribution to the Project:

Collaborative Research
Personnel Exchanges

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?

Matt Long, National Center for Atmospheric Research

Ben Halpern, University of California, Santa Barbara

Impacts**What is the impact on the development of the principal discipline(s) of the project?**

The principal discipline(s) of our project are polar Antarctic oceanography, ecology and biogeochemistry. Our research focused on polar ecosystem responses to climate change is frequently included in scientific syntheses and climate change reports as key examples of the status of the Antarctic environment under rapid climate change.

Our pioneering application of autonomous glider and unattended aerial vehicle technology in polar, ice-covered areas has set precedents now followed in most other major Antarctic seas.

What is the impact on other disciplines?

Nothing to report.

What is the impact on the development of human resources?

In collaboration with the POLAR Partnership (Polar Learning & Responding Climate Change) at The Earth Institute, Columbia University, we have developed a new educational card game, EcoChains Antarctica, age groups 10-adult, designed to teach concepts of food chains and polar ecology. We are in discussion with NSF about marketing the game at the Palmer Station store. This outlet has access to several 100 cruise passengers visiting Palmer Station each year. This allows us to access several different groups from our other education and outreach efforts.

What is the impact on physical resources that form infrastructure?

We are pioneering application of unattended vehicles including ocean gliders and both fixed wing and helicopter aerial drones in our research. CoPI Oscar Schofield (Rutgers) is a leader of the Southern Ocean Observing System. CoPI David Johnston (Duke) has established the Duke Marine Robotics and Remote Sensing Lab (<http://superpod.ml.duke.edu/uas/>) to further ecological applications of drone technology.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

Nothing to report.

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

We hope it is high. Communicating the science of climate change and ecosystem transformation to the informed, interested and concerned public via presentations to alumni, municipal and other groups has never been more important. Even more importantly, we need to reach out to the uninformed, disinterested and unconcerned public who seem to make up about half the electorate. Antarctica is an invaluable tool for engaging the public about these issues. Everybody loves penguins! Especially in today's society, we try to use our research to remind people that truth and science are real, but they come with uncertainty. This is not a reason to condemn our work, but rather is necessary to properly interpret our results and translate them into policy and education.

Changes/Problems

Changes in approach and reason for change

Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

Nothing to report.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.