

Annual Report for Period:09/2008 - 08/2009

Submitted on: 06/22/2009

Principal Investigator: Ducklow, Hugh W.

Award ID: 0823101

Organization: Marine Biological Lab

Submitted By:

Ducklow, Hugh - Principal Investigator

Title:

Palmer, Antarctica Long Term Ecological Research Project

Project Participants

Senior Personnel

Name: Ducklow, Hugh

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Fraser, William

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Martinson, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Baker, Karen

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Simmons, Beth

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Schofield, Oscar

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Steinberg, Debbie

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Stammerjohn, Sharon

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Doney, Scott

Worked for more than 160 Hours: Yes

Contribution to Project:

Post-doc

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Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kahl, Alex

Worked for more than 160 Hours: Yes
Contribution to Project:

Graduate Student

Name: Fragoso, Glauca

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Gorman, Kristen

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Guo, Jige

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Moeller, Heidi

Worked for more than 160 Hours: Yes
Contribution to Project:

Undergraduate Student

Name: Gleiber, Miriam

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Garzio, Michael

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cermino, Meghan

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Savard, Steven

Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wiley, Sean

Worked for more than 160 Hours: No
Contribution to Project:

Name: Peterson, Robert

Worked for more than 160 Hours: No

Contribution to Project:**Name:** Gates, Lara**Worked for more than 160 Hours:** Yes**Contribution to Project:****Technician, Programmer****Name:** Erickson, Matthew**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Waldron, Maggie**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Iannuzzi, Richard**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Cope, Joseph**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Patterson, Donna**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Blum, Jennifer**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Yeager, Kirstie**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Kerfoot, John**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Leonardis, Elizabeth**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Connors, James**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Wanetick, Jerome**Worked for more than 160 Hours:** No

Contribution to Project:**Name:** Yarmey, Lynn**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Kortz, Mason**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Lima, Ivan**Worked for more than 160 Hours:** Yes**Contribution to Project:****Other Participant****Name:** Rukke, Kate**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Price, Lori**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Morgan, Tawna**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Smaniotto, Rick**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Rasmussen, Mark**Worked for more than 160 Hours:** Yes**Contribution to Project:****Research Experience for Undergraduates****Name:** Cardman, Zena**Worked for more than 160 Hours:** Yes**Contribution to Project:****Years of schooling completed:** Junior**Home Institution:** Other than Research Site**Home Institution if Other:** University of North Carolina**Home Institution Highest Degree Granted(in fields supported by NSF):** Doctoral Degree**Fiscal year(s) REU Participant supported:** 2009**REU Funding:** REU supplement

Organizational Partners

Old Dominion University

Woods Hole Oceanographic Institution

Simon Fraser University

University of South Florida

University of Wisconsin-Madison

COSEE

University of California-San Diego Scripps Inst of Oceanography

Fredericksburg Christian School

Point Reyes Bird Observatory

Smithsonian Institution

Santa Clara University

University of Quebec

University of Michigan

Other Collaborators or Contacts

Steve Ackley, UTSA

Chris Fritsen, DRI

Stan Jacobs, LDEO

Rob Massom, Australian ACE CRC

Ted Maksym, BAS

Langdon Quetin, UCSB

Robin Ross, UCSB

David Rind, NASA GISS

Colm Sweeney, NOAA/UC

Maria Vernet, UCSD

Dr. Eileen Hofmann, Old Dominion University, Norfolk, Virginia, USA

Dr. Jose Torres, University of South Florida,

Dr. Tony Williams, Simon Fraser University, BC, Canada

Dr. David Bailey, University of Glasgow, Glasgow, UK

Dr. Ken Buesseler, WHOI

Cheryl Peach Birch Aquarium at Scripps (BAS)

Catherine Fyfe Birch Aquarium at Scripps (BAS)

Laurie Guest Mare Island Technology Academy (MARE)

Ann Artz The Preuss School University California San Diego

Kristin Evans Southwest Marine Educators Association/ National Marine Educators Association

James Connors Technician/Programmer

Bill Sydemann Farallon Institute Advanced Ecosystem Research
 Melissa Pitkin Point Reyes Bird Observatory
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 Jill Johnson SANT Ocean Hall Exhibitor developer
 Florence Millerand, University of Michigan
 Helena Karasti, Oulu University, Finland
 Naomi Oreskes, Dept of History, UCSD
 David Ribes, Information School, UMichigan
 Geoffrey Bowker, Santa Clara University
 Cyndy Chandler, WHOI
 Alison Murray, Desert Research Institute
 David Kirchman, Univ of Delaware
 James T Hollibaugh, Univ of Georgia
 Xelu Moran, Spanish Institute of Oceanography, Xixon
 Andrew Fountain, Portland State University

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

Palmer LTER provides access for undergraduate, graduate and postdoctoral students to Antarctica and the research infrastructure provided by the US Antarctic Program. PAL-LTER also provides mentoring opportunities for our students. We rely significantly on undergraduate volunteers and REUs to conduct our research; thus college undergrads are exposed to, and participate in real scientific research in the field as well as in the lab.

Outreach Activities:

All LTER Sites are mandated to maintain a high level of outreach in their programs. We employ a half-time Education & Outreach Coordinator (Beth Simmons). From our website:

Our Education and Outreach program teams scientists with local scientific and educational facilities engaging the 'K through gray' community in both the process and the understanding gained from this research. We train undergraduates, graduate students, and postdoctoral scholars across disciplinary boundaries. Through collaborations with formal and informal science education organizations, we reach many schoolchildren each year, including local low-income and minority students.

Journal Publications

Baker, Karen S.; Chandler, Cynthia L.; "Enabling long-term oceanographic research: Changing data practices, information management strategies and informatics", Deep Sea Research Part II: Topical Studies in Oceanography, p. 2132-2142, vol. 55, (2008). Published,

Ducklow, H.; "Microbial services: challenges for microbial ecologists in a changing world", Aquatic Microbial Ecology, p. 13-19, vol. 53, (2008). Published,

Ducklow, Hugh W.; "Long-term studies of the marine ecosystem along the west Antarctic Peninsula", Deep Sea Research II, p. 1945-1948, vol. 55, (2008). Published,

- Ducklow, Hugh W.;Doney, Scott C.;Steinberg, Deborah K.;, "Contributions of Long-Term Research and Time-Series Observations to Marine Ecology and Biogeochemistry", *Annual Review of Marine Science*, p. 279-302, vol. 1, (2009). Published,
- Ducklow, Hugh W.;Erickson, Matthew;Kelly, Joann;Montes-Hugo, Martin;Ribic, Christine A.;Smith, Raymond C.;Stammerjohn, Sharon E.;Karl, David M.;, "Particle export from the upper ocean over the continental shelf of the west Antarctic Peninsula: A long-term record, 1992-2007", *Deep Sea Research II*, p. 2118-2131, vol. 55, (2008). Published,
- F. Millerand, GC Bowker, "Metadata Standard: Trajectories and Enactment in the Life of an Ontology", *Formalizing Practices: Reckoning with Standards, Numbers and Models in Science and Everyday Life*, p. , vol. , (2009). Published,
- Friedlaender, A. S.;Fraser, W. R.;Patterson-Fraser, D. L.;Qian, S. S.;Halpin, P. N.;, "The effects of prey demography on humpback whale (*Megaptera novaeangliae*) abundance around Anvers Island, Antarctica", *Polar Biology*, p. 1217-1224, vol. 31, (2008). Published,
- Gasol, JM;Pinhassi, J;Alonso-S??ez, L;Ducklow, H;Herndl, GJ;Kobl??zek, M;Labrenz, M;Luo, Y;Mor??n, XAG;Reinthal, T;Simon, M;;, "Towards a better understanding of microbial carbon flux in the sea", *Aquatic Microbial Ecology*, p. 21-38, vol. 53, (2008). Published,
- Geisz, Heidi N.;Dickhut, Rebecca M.;Cochran, Michele A.;Fraser, William R.;Ducklow, Hugh W.;, "Melting Glaciers: A Probable Source of DDT to the Antarctic Marine Ecosystem", *Environ. Sci. Technol.*, p. , vol. , (2008). Published,
- Kirchman, David L.;Moran, Xose Anxelu G.;Ducklow, Hugh;;, "Role of temperature and potential impact of climate change", *Nature Reviews - Microbiology*, p. 451-459, vol. 7, (2009). Published,
- Mark A. Moline;Nina J. Karnovsky;Zachary Brown;George J. Divoky;Thomas R. Frazer;Charles A. Jacoby;Joseph J. Torres;William R. Fraser;;, "High Latitude Changes in Ice Dynamics and Their Impact on Polar Marine Ecosystems", *Annals of the New York Academy of Sciences*, p. 267-319, vol. 1134, (2008). Published,
- Montes-Hugo, MA;Ducklow, H;Schofield, OM;;, "Contribution by different marine bacterial communities to particulate beam attenuation", *Aquatic Microbial Ecology*, p. 13-22, vol. 379, (2009). Published,
- Montes-Hugo, Martin;Doney, Scott C.;Ducklow, Hugh W.;Fraser, William;Martinson, Douglas;Stammerjohn, Sharon E.;Schofield, Oscar;;, "Recent Changes in Phytoplankton Communities Associated with Rapid Regional Climate Change Along the Western Antarctic Peninsula", *Science*, p. 1470-1473, vol. 323, (2009). Published,
- Patterson, D. L.;Woehler, E. J.;Croxall, J. P.;Cooper, J.;Poncet, S.;Peter, H. -U.;Hunter, S.;Fraser, W. R.;, "Giant Petrel *Macronectes halli* and the Southern Giant Petrel *M. giganteus*", *Marine Ornithology*, p. 115-124, vol. 36, (2008). Published,
- Ribic, C. A.;E. W. Chapman;W. R. Fraser;G. L. Lawson;P. H. Wiebe;;, "Top predators in relation to bathymetry, ice, and krill during austral winter in Marguerite Bay, Antarctica", *Deep Sea Research II*, p. 485-99, vol. 55, (2008). Published,
- Rind, D.;J. Jonas;S. Stammerjohn;P. Lonergan;;, "The Antarctic ozone hole and the Northern Annular Mode: a stratospheric interhemispheric connection", *Geophysical Research Letters*, p. doi: 10.1, vol. 36, (2009). Published,
- Shearn-Bochsler, V. D.;Green, E.;Converse, K. A.;Docherty, D. E.;Thiel, T.;Geisz, H. N.;Fraser, W. R.;Patterson-Fraser, D. L.;, "Cutaneous and diphtheritic avian poxvirus infection in a nestling Southern Giant Petrel (*Macronectes giganteus*) from Antarctica", *Polar Biology*, p. 569-73, vol. 31, (2008). Published,
- Siniff, D. B.;Garrott, R. A.;Rotella, J. J.;Fraser, W. R.;Ainley, D. G.;, "Projecting the Effects of Environmental Change on Antarctic Seals", *Antarctic Science*, p. 425-35, vol. 20, (2008). Published,
- Stammerjohn, S. E.;D. G. Martinson;R. C. Smith;X. Yuan;D. Rind;;, "Trends in Antarctic Annual Sea Ice Retreat and Advance and their Relation to ENSO and Southern Annular Mode Variability", *Journal of Geophysical Research*, p. doi: 10.1, vol. 113, (2008). Published,
- Stammerjohn, Sharon E.; Douglas G.;Smith, Raymond C.;Iannuzzi, Richard A.;, "Sea ice in the western Antarctic Peninsula region: Spatio-temporal variability from ecological and climate change perspectives", *Deep Sea Research II*, p. 2041-2058, vol. 55, (2008). Published,

Straza, Tiffany R. A.;Cottrell, Matthew T.;Ducklow, Hugh W.;Kirchman, David L.;, "Geographic and phylogenetic variation in bacterial biovolume using protein and nucleic acid staining", *Appl. Environ. Microbiol.*, p. AEM.00183, vol. , (2009). Published,

Baker, Karen S.;Chandler, Cynthia L.;, "Enabling long-term oceanographic research: Changing data practices, information management strategies and informatics", *Deep Sea Research Part II: Topical Studies in Oceanography*, p. 2132-2142, vol. 55, (2008). Published,

Clarke, Andrew;Meredith, Michael P.;Wallace, Margaret I.;Brandon, Mark A.;Thomas, David N.;, "Seasonal and interannual variability in temperature, chlorophyll and macronutrients in northern Marguerite Bay, Antarctica", *Deep Sea Research Part II: Topical Studies in Oceanography*, p. 1988-2006, vol. 55, (2008). Published,

Martinson, Douglas G.;Stammerjohn, Sharon E.;Iannuzzi, Richard A.;Smith, Raymond C.;Vernet, Maria;, "Western Antarctic Peninsula physical oceanography and spatio-temporal variability", *Deep Sea Research II*, p. 1964-1987, vol. 55, (2008). Published,

McClintock, J.;H. W. Ducklow;W. Fraser;, "Ecological responses to climate change on the Antarctic Peninsula", *American Scientist*, p. 414-422, vol. 96, (2008). Published,

Meredith, Michael P.;Murphy, Eugene J.;Hawker, Elizabeth J.;King, John C.;Wallace, Margaret I., "On the interannual variability of ocean temperatures around South Georgia, Southern Ocean: Forcing byEl Nino-Southern Oscillation and the Southern Annular Mode", *Deep Sea Research Part II: Topical Studies in Oceanography*, p. 2007-2022, vol. 55, (2008). Published,

Montes-Hugo, M. A.;Vernet, M.;Martinson, D.;Smith, R.;Iannuzzi, R.;, "Variability on phytoplankton size structure in the western Antarctic Peninsula (1997-2006)", *Deep Sea Research Part II: Topical Studies in Oceanography*, p. 2106-2117, vol. 55, (2008). Published,

Ross, Robin M.;Quetin, Langdon B.;Martinson, Douglas G.;Iannuzzi, Rich A.;Stammerjohn, Sharon E.;Smith, Raymond C.;, "Palmer LTER: Patterns of distribution of five dominant zooplankton species in the epipelagic zone west of the Antarctic Peninsula, 1993-2004", *Deep Sea Research Part II: Topical Studies in Oceanography*, p. 2086-2105, vol. 55, (2008). Published,

Smith, Raymond C.;Martinson, Douglas G.;Stammerjohn, Sharon E.;Iannuzzi, Richard A.;Ireson, Kirk;, "Bellingshausen and western Antarctic Peninsula region: Pigment biomass and sea-ice spatial/temporal distributions and interannual variability", *Deep Sea Research II*, p. 1949-1963, vol. 55, (2008). Published,

Vernet, Maria;Martinson, Douglas;Iannuzzi, Richard;Stammerjohn, Sharon;Kozlowski, Wendy;Sines, Karie;Smith, Ray;Garibotti, Irene;, "Primary production within the sea-ice zone west of the Antarctic Peninsula: I--Sea ice, summer mixed layer, and irradiance.", *Deep Sea Research II*, p. 2068-2085, vol. 55, (2008). Published,

Wallace, Margaret I.;Meredith, Michael P.;Brandon, Mark A.;Sherwin, Toby J.;Dale, Andrew;Clarke, Andrew;, "On the characteristics of internal tides and coastal upwelling behaviour in Marguerite Bay, west Antarctic Peninsula", *Deep Sea Research Part II: Topical Studies in Oceanography*, p. 2023-2040, vol. 55, (2008). Published,

Books or Other One-time Publications

Simmons B, Cerullo MM, "Sea Secrets: Tiny Clues to a Big Mystery", (2008). Book, Published
Collection: LTER Children's Book Series
Bibliography: ISBN 10:0-9779603-9-0

Simmons, Beth, "Sea Secrets Website", (2008). Internet site, Published
Bibliography: <http://cce.lternet.edu/outreach/seasecrets/>

Simmons, Beth, "Polar Books Website", (2009). Internet site, Published
Bibliography: <http://www.unep.org/Publications/polarbooks/books/1015.aspx>

Karasti H, Baker KS, "Community Design: Growing One's Own Information Infrastructure", (2008). Book, Published
Bibliography: Participatory Design Conference, Bloomington, IN

Web/Internet Site**URL(s):**

<http://pal.lternet.edu/>

Description:

Project Website, contains Palmer LTER data archives at:

<http://oceaninformatics.ucsd.edu/datazoo/data/pallter/datasets>

Other Specific Products**Product Type:****Data or databases****Product Description:**

All oceanographic data collected in Palmer LTER since 1990:

<http://oceaninformatics.ucsd.edu/datazoo/data/pallter/datasets>

Sharing Information:

Open-access via Internet. Data fully documented with associated metadata

Contributions**Contributions within Discipline:**

Oceanography: Palmer LTER is an oceanographic research program, contributing inter- and multidisciplinary research and data on the marginal sea ice zone of the West Antarctic Peninsula, on rapid climate change and ecosystem responses.

Information Management: Three sessions on informatics were co-chaired at the American Geophysical Union meeting in December as a cross-institutional effort involving Scripps Institution of Oceanography (Karen Baker), Woods Hole Oceanographic Institution (Cyndy Chandler), and Monterey Bay Aquarium Research Institute (John Greybeale, Marine Metadata Interoperability/Initiative). The sessions brought together informatics projects across oceanography, highlighting infrastructural aspects of this work by envisioning future and past data networks in talks by Susan Avery, director of Woods Hole, Steve Jackson, science studies researcher at the Information School of University of Michigan, and Peter Wiebe, zooplankton researcher at WHOI. LTER community efforts have included contribution of datasets to a network information system effort called Ecotrends, cochair of an information management governance working group, cochair of a unit dictionary working group, and editorship of the information management newsletter Databits.

Contributions to Other Disciplines:

Information Management: We are contributing to the social sciences fields of science and technology studies, communication studies, and infrastructure studies as well as information sciences and history of science through partnerships that continue a unique longitudinal ethnography for LTER and Ocean Informatics (<http://interoperability.ucsd.edu>). A presentation at the annual meeting of the Society for Social Studies of Science in Rotterdam resulted in an invitation to contribute to a book on Collaboration in the Life Sciences. Visits were hosted for Florence Millerand (Dept of Communication; UQuebec) to work on an ethnographic monograph on Ocean Informatics and for Helena Karasti (Dept of Information Systems, UOulu) to join in a working group on infrastructure held at the Computer Supported Cooperative Work Conference in San Diego.

Contributions to Human Resource Development:

We train undergraduate, graduate and postdoctoral students in oceanography and marine ecology in the field (Antarctica) and laboratory at a number of Universities and Non-profit research institutions.

Contributions to Resources for Research and Education:

PAL-LTER participates in the LTER Schoolyard LTER Program to provide introductions to scientific research and opportunities to contribute to our research effort by K-12 students. See: <http://schoolyard.lternet.edu/>

Contributions Beyond Science and Engineering:Conference Proceedings

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Contributions: To Any Beyond Science and Engineering

Any Conference

RESEARCH ACTIVITIES: Palmer LTER 2008-2009.

Overview. This is the first annual report for the fourth grant period of Palmer LTER (2008-2014, OPP 0823101). This report focuses on the activities undertaken by PAL since the start date 01 October, 2009. PAL has been significantly restructured for the new award period with new personnel, an extended study region and new emphasis on process-level investigations.

Personnel. We have several new co-investigators:

- Oscar Schofield (Rutgers Univ., primary production and optics; replacing Maria Vernet)
- Debbie Steinberg (VIMS, zooplankton, replacing Robin Ross and Langdon Question)
- Sharon Stammerjohn (UCSC, sea ice and climate; succeeding Ray Smith)
- Scott Doney (WHOI, ocean modeling, new component)

Martin Montes-Hugo (Rutgers), a postdoc, recently left to take a new job at NASA-Stennis, MS. He will remain loosely associated with our program.

Field Season. In April, 2009 we completed the first field season of the current award, and the 18th in the Palmer LTER program that commenced in 1991-92. The annual summer cruise (LMG 09-01, D. Martinson, Chief Scientist) and summer season at Palmer Station were both successful. Field operations commenced at Palmer Station in mid-October and continued until the end of March with few interruptions. In this first grant year, there were fewer PAL personnel at Palmer Station than usual. Fraser's and Schofield's (with postdoc Alex Kahl) groups anchored the PAL presence at Palmer Station. Fuller participation is anticipated in the coming years. The summer LMG cruise was successful with no missed stations. During the cruise we visited Rothera Station to carry out joint scientific operations and visit with our BAS colleagues. We recovered and redeployed five SASSI physical oceanography moorings with conductivity and temperature sensors and current meters. The goal of these moorings is to detect intrusions of warm, nutrient-rich Upper Circumpolar Deep Water (UCDW). They will be recovered and turned around in January 2010.



PAL-LTER undergraduate volunteers (from left) Maggie Waldron, Meghan Cermino, Lara Gates and Zena Cardman at Prospect Point during LMG 0901. LMG visible in background. PAL relies on volunteers for field and lab assistance and provides REU opportunities for several students each season. Photo by Andrew McDonnell, WHOI.

We hosted WHOI geochemist Ken Buesseler and grad student Andrew McDonnell on this cruise. They conducted multiple diverse studies of sinking particles. Other cruise activities were reported in a report submitted earlier and appended here.

Publications are listed in the Findings document.

Meetings. Our annual meeting was held in Denver in September, 2008. The main focus of the annual meeting was cruise planning and logistics, especially for the new co-investigators. Ducklow and Stammerjohn gave invited presentations at the Polar Oceans Gordon Conference, Lucca, Italy in March 2009. Ducklow, Doney, Martinson and Schofield attended the NSF-OCB Southern Ocean Scoping Workshop in Princeton in June. Ducklow and Doney gave invited plenary talks. Fraser and Stammerjohn were invited but unable to attend. Ducklow co-organized an LTER Cross-Site workshop on the disappearing cryosphere with Andrew Fountain (MCM). It was held in April in Woods Hole. A separate report on this meeting is available. Steinberg gave an invited presentation at the GLOBEC Open Science conference in Victoria, British Columbia in June.

Information Management (Karen Baker, SIO-UCSD). Over the last year, the Ocean Informatics LTER architecture was reconceptualized as a three-component system for highly structured tabular data, highly complex data, and very large, homogeneous datasets. Datazoo, an information system for LTER tabular data, currently contains approximately 50 publically-accessible datasets including a subset that extends across decades in time. The system, built upon a relational database with an object-oriented API layer that supports Web-based data query, continues to undergo redesign in order to ensure functionality remains relevant. Added features include posting of associated materials with datasets, reporting options for dataset summaries, improved search capabilities and some initial web service arrangements. Interdependent sets of controlled vocabularies— including unit, attribute, and qualifier dictionaries – are under development to describe datasets to the column level. Dataset titles, categories, and keywords have been re-examined, harmonized, and explained in best practices posted online. A set of major system upgrades brought technical infrastructure up-to-date enabling use and development of new plot capabilities. The work of two REU students focuses on software development of an interface for viewing dataset access logs and upon a set of modules for geopositioning.

Education and Outreach (Beth Simmons, VIMS). The children's book project *Sea Secrets: Tiny Clues to a Big Mystery* (**Figure 1**)



has been our most comprehensive investment for Palmer LTER Education & Outreach. Through its promotion and marketing we have targeted classrooms, aquariums and summer field camps to test its usability and frame our products for the supplemental activity guide that is currently underway. We will be working with teacher Christy Millsap this summer preparing materials for submission to the SANT Ocean hall's Ocean Today kiosk. This proposal will

Figure 1. Beth Simmons sharing *Sea Secrets* with third graders in local private school. (photo: B.Simmons).

help frame the fieldwork completed by the Education and Outreach coordinator. All of these efforts are supporting our effort to bring better resources into the classrooms, and use science and literature to promote ocean literacy.

Seabirds (Bill Fraser BP-013). The seabird research group operated in the Palmer Station region from October 2008 to April 2009, sampling daily as weather permitted, and focusing its core activities on the demography, foraging ecology and breeding biology of Adélie penguins. As in past seasons, basic ecological data on other seabirds and marine mammals in the Palmer area were opportunistically obtained to ensure the continuity of species-specific databases that originated in the early 1970s. During this season we also observed the development of an important new direction in our program, namely, an effort to identify and understand the physiological mechanisms that may underpin the contrasting demographic responses of the three penguin species (Adélie, Gentoo and Chinstrap) now present at Palmer Station. This effort will be represented in the research of a new Ph.D. student, Kristen Gorman, through collaborations with Simon Fraser University and the University of South Florida-St. Petersburg. Also, in January, two group members participated in the annual LTER cruise (LMG 09-01), continuing surveys of seabirds and marine mammals to investigate their abundance and distribution relative to bathymetry and annual variability in regional oceanography. This cruise included a 5-day field camp on Avian Island, Marguerite Bay, and an unprecedented (for our program) landing and brief exploration of Charcot Island south of Marguerite Bay. This effort continues a unique time series that compares the foraging ecology of Adélie penguins (diets and at-sea foraging locations/dive-depth profiles based on ARGOS-linked transmitters) with similar data from Palmer Station. The Charcot exploration added to this effort by providing the first data on WAP-nesting Adélie penguins at their most southerly known colonies.

Physical Oceanography (Doug Martinson BP-021). This component deals with the physical oceanography, wit. It carries the requirement of supplying core physical data. We have satisfied this requirement through the consistent collection of the grid CTD data set, its overall qa/qc, distribution to all participants (directly) and others through upload to LTER-public & NODC data bases, and general analysis. Martinson served as Chief Scientist on LMG 0901 and supervised the successful recovery and redeployment of 5 physical oceanography moorings.

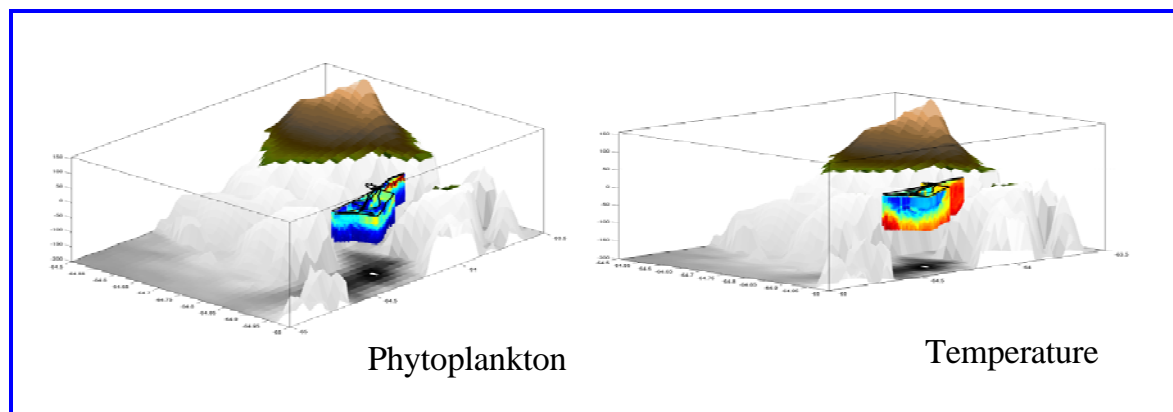


Figure 2. 3-D reconstructions from Webb-Slocum glider transects of chlorophyll (left) and temperature (right) near the apex of the Palmer Deep canyon, the center of Adélie penguin foraging activity off Palmer Station. The glider and penguin satellite transmitter data show that there is upwelling supporting enhanced production at the canyon head, and penguins concentrate their foraging in this region.

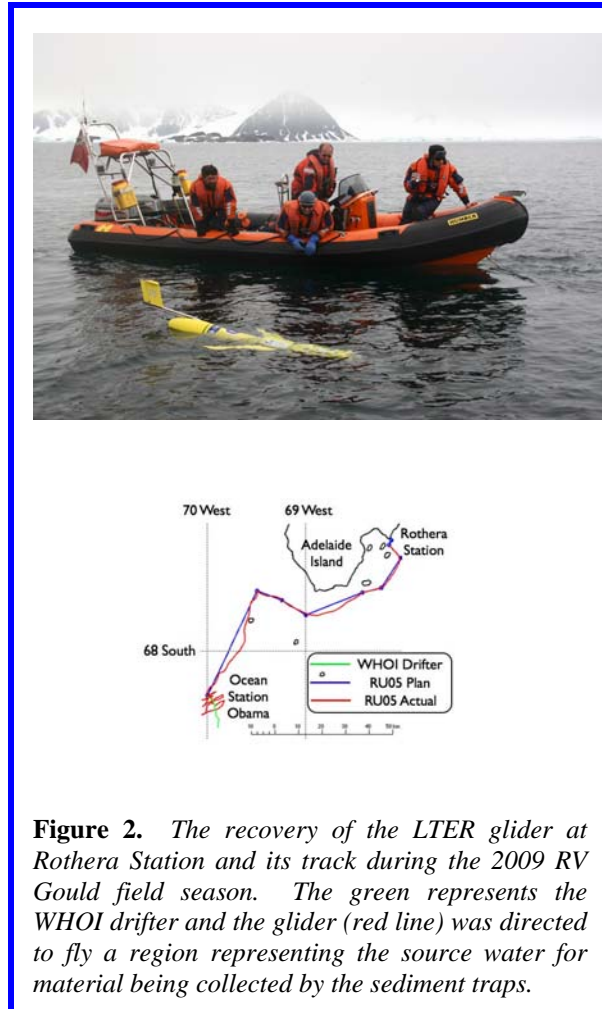


Figure 2. *The recovery of the LTER glider at Rothera Station and its track during the 2009 RV Gould field season. The green represents the WHOI drifter and the glider (red line) was directed to fly a region representing the source water for material being collected by the sediment traps.*

Phytoplankton (Oscar Schofield, B-019). The seasonal Palmer efforts continued successfully in 2009. Zodiac operations maintained the time series collecting phytoplankton pigmentation, ^{14}C productivity, bio-optical information, as well as deploying a Slocum glider to survey the canyon offshore, which is a hot spot for penguin foraging. The bio-optical measurements were a significant addition. The new additions included hyperspectral downwelling irradiance as well as upwelling radiance and spectral inherent optical properties (absorption, attenuation and backscatter). These optical parameters will be used to conduct a series of optical closure analyses.

The glider survey was successful, demonstrating that glider operations could be effectively supported by Palmer Station and that the glider despite strong currents could sample the biological “hot-spot” outside Palmer Station. Data suggested there was upwelling with the enhanced phytoplankton biomass in the canyon (**Figure 1**).

The 2009 LTER cruise was very successful. A significant number of new technologies were added to the program and they have collected a large set of data, which will take months to fully

analyze. The technologies that were added to the LTER this year included the addition of a full bio-optics program. This builds on the bio-optics data that was collected in the initial 3-year cycle of the LTER. The bio-optical components that were added to the program include measurements of the spectral absorption, attenuation, and backscatter. Hyperspectral radiometry was also added to the program. This data will greatly assist in the interpretation of the discrete depth phytoplankton data as well as accelerate improvement of a new suite of satellite algorithms for these waters. Additionally the addition of kinetic fluorometry will also assist the interpretation of the variability in the phytoplankton radio-labeled productivity measurements. These fluorometry measurements were made both on discrete depth as well as in surface mapping mode using the seawater intake line provided by the ship. The ship-based measurements were complemented by data collected with a Slocum Webb glider. The glider was deployed at Ocean Station Obama to support Lagrangian tracking of a deployed sediment trap drifter, a hydrographic survey of a region frequented by radio-tagged penguins, and in a proof-of-concept was directed to within 1000 m of Rothera base allowing British Antarctic Survey personnel to recover the glider (**Figure 2**). This sets up the stage for embarking on Palmer and Rothera Station glider operations in the coming year. This effort will expand in the coming year with funding provided by the Gordon & Betty Moore Foundation and a recently awarded NASA Biodiversity proposal. In all this greatly expands the range of measurements collected by the

phytoplankton component of the LTER and by utilizing proven technologies ushers in a new era of mapping capabilities to complement the traditional phytoplankton measurements.

Data analysis and synthesis. Several publications were produced this year. Using three decades of satellite and field data, we document that ocean biological productivity, inferred from chlorophyll a concentration (Chl a), has significantly changed along the WAP shelf. Summertime surface Chl a (summer integrated Chl a ~63% of annually integrated Chl a) declined by 12% along the WAP over the past 30 years, with the largest decreases equatorward of 63°S and with substantial increases in Chl a occurring farther south. The latitudinal variation in Chl a trends reflects shifting patterns of ice cover, cloud formation, and windiness affecting water-column mixing. This work was published in science. Other publications are listed below.

Zooplankton and micronekton (Debbie Steinberg B-020). The zooplankton group spent much of the first year gearing up and preparing for the January 2009 annual cruise. This included conferring with the former zooplankton LTER PIs (Quetin and Ross) about their LTER zooplankton sampling and identification methods to allow a smooth transition. A visit to UC Santa Barbara by Steinberg's technician Joe Cope was helpful in this regard. Steinberg also recruited two new M.S. students for the project (Kate Ruck and Lori Price) who went on the annual cruise and who will begin their program at VIMS this fall; and is hiring and hired a post-doc, Dr. Kim Bernard, for a related project using acoustics. Cope also set up the Microsoft access data base that will be used for our project, and with the assistance of Karen Baker we are setting up templates in the Pal LTER database to deposit the zooplankton data from this first cruise. We also provided research experience for a W&M undergrad, Miram Gleiber, and a VIMS graduate student, Glauca Fragoso, who participated on the cruise.

On the cruise this year, with three process study stations, we emphasized the role that zooplankton play in the biological pump (grazing, particle or fecal pellet production, and diel vertical migration). At each station we performed a pair of net tows for larger macrozooplankton (e.g., krill, salps) and mesozooplankton (e.g. copepods). Macrozooplankton tows were sorted on board. We also took samples at selected stations for zooplankton lipid and gut fluorescence analyses. At the process study stations we performed depth-stratified zooplankton sampling using the MOCNESS (Multiple Opening-Closing Net Environmental Sensing System) to investigate depth distribution of the abundant taxa over a diel cycle. We also performed dilution experiments to measure microzooplankton grazing; this coupled with gut fluorescence measurements of the larger zooplankton mentioned above will allow us to quantify removal of primary producers by the zooplankton community. We also performed additional fecal pellet production experiments with krill and with salps to determine their role in flux of organic carbon to the deep ocean.

Post-cruise analysis of samples is ongoing in the laboratory this spring. We have also begun to set up the lipid analysis laboratory, and should be ready to start running samples this fall.

Microbes and Biogeochemistry (Hugh Ducklow BP-045). The microbial biogeochemistry group participated in the annual cruise and also had personnel at Palmer Station for an abbreviated period (February-March). Cruise operations were generally similar to previous years (bacterial abundance and production rates, dissolved oxygen, dissolved organic and inorganic



carbon, moored sediment trap). In addition our group will take over responsibility for inorganic nutrients. We hosted WHOI geochemist Ken Buesseler and grad student Andrew McDonnell on LMG 0901 (**Figure 3**). They conducted a variety of studies on sedimentation rates and carbon fluxes, using drifting sediment traps, gel columns to trap particles, a video profiling system and Thorium-234. We successfully recovered and redeployed the moored trap and split samples from it for Th-234 analysis.

At Palmer Station, we completed two mesocosm experiments for our IPY Project. Sample analyses for the IPY and all other samples are underway. Most PAL data through March-2008 have been submitted to the PAL data system.

Education activities: We provided research opportunities for 3 undergraduate students (Maggie Waldron, Lawrence Univ graduated 2008; Zena Cardman, Univ NC, graduating 2010 and Lara Gates (Wm&Mary, graduated May 2009). Ohio State freshman Kathleen

Figure 3. WHOI scientists Andrew McDonnell (left) and Ken Buesseler aboard LM GOULD with drifting sediment trap cylinders.

Woods is working in our lab in Woods Hole this summer. Current VIMS PhD student Heidi Geisz completed her fifth year at the WM-SMS and is working on her thesis on pollutants in seabirds. Current Brown Univ MSc. student Kristen Myers finished her research is working on her thesis.

Sea Ice and Climate (Sharon Stammerjohn). This year's research activities involved (a) a polar ice-climate data synthesis, (b) GISS GCM modeling, and (c) field research in the Amundsen Sea (NBP0901) - collaborative activities aimed at placing PAL LTER research within the context of global cryospheric climate change – and are described as follows. (a) The polar ice-climate data synthesis involved an assessment of how seasonal sea ice changes and sensitivities in the greater PAL LTER region compared to those observed in the rapidly declining sea ice areas in the Arctic. (b) Modeling activities through collaboration with David Rind (NASA GISS) involved (ongoing) assessments of various ozone depletion and SAM/ENSO forced scenarios, within the context of climate variability and observed ice-atmosphere anomaly patterns and trends. (c) Collaborative studies in the Amundsen Sea (on NBP0901) focused on regional processes controlling sea ice mass balance, including snow-ice formation. The processes that control snow and sea ice thickness distributions have implications for how summer sea ice responds to climate change and plays a vital role in the structuring of sea ice ecosystems in porous gap layers in the ice. Within this context, sea ice studies on NBP0901 focused on assessing the properties of summer sea ice in the Amundsen Sea (extent, thickness, growth/melt

history, snow fraction, deformation and drift), while also deploying 3 sea ice mass balance buoys (IMB). Combined with previous IMB deployments in the PAL LTER area (collaborations with Don Perovich on SO-GLOBEC 2001-02 and 2002-03), as well as in the Bellingshausen Sea (collaborations with Steve Ackley on SIMBA 2007), these IMB data, together with process modeling, will help us understand the role these processes play in evolution of the sea ice cover and how these processes might modulate the response of sea ice to climate variability.

Modeling (Scott Doney). *Ocean Physical-Ecological-Biogeochemical Historical Simulations:*

One of our main modeling tools is the ocean component of the Community Climate System Model (CCSM). In previous work, we had created hindcast simulations for the global ocean for the period 1958-2004, the end date controlled by the availability of standard processed atmospheric forcing data. We wanted to extend the reanalysis in time to the present in order to analyze more recent Palmer LTER results and climate trends in the Southern Ocean more generally. This required the construction of new forcing data sets from the NCEP atmospheric reanalysis with the help of a programmer, I. Lima. We now have a procedure in place and can extend the hindcast to about 1 month lagging the present (current full hindcast complete through Dec. 2008).

End-to-end Foodweb Modeling: H. Moeller, a MIT/WHOI graduate student, is beginning this summer a model development project to create a simplified end-to-end foodweb model for the PAL-LTER site. Her work will involve adding higher trophic level compartments (differentiated zooplankton; fish; seabirds) to the existing lower trophic level ecosystem-biogeochemistry model (several phytoplankton functional groups; single zooplankton pool) in the CCSM ocean component.

RESEARCH FINDINGS: Palmer LTER 2008-2009.

NB: not all groups reported findings in this first grant year.

Overview: PAL is building on a 17-year record of observations, process studies and experiments documenting the relationships among meteorological and climate forcing, ocean circulation and mixing, sea ice advance, duration, extent and retreat, ecological and biogeochemical processes in the continental shelf ecosystem west of the Antarctic Peninsula. During the previous grant period (2002-08), we solidified our conclusions that the WAP is one of most rapidly warming regions on the planet, and one, moreover, where the ecosystem is responding in significant, conspicuous and important ways. These findings were reported in numerous publications including the special volume of Deep-Sea Research (2008). With the new award our attention is shifting toward better understanding of the physiological, ecological and biogeochemical mechanisms linking ecosystem response to climate change. Our strategy includes greater reliance on oceanographic process studies, experiments conducted at Palmer Station, autonomous observing systems (sediment trap, gliders and physical oceanography moorings), modeling and a new relational data archive system facilitating data exchange and synthesis. We also try to broaden our research by inviting guest investigators on our cruises and encourage colleagues to submit proposals to work with us. This report notes some initial products of these efforts.

Information Management (Karen Baker, SIO-UCSD). While continuing to maintain and develop a project website, a multi-project information system, and a local Ocean Informatics team supporting PAL, we investigated the concepts of standards as central to data integration and information infrastructure (Millerand and Bowker, 2009). We broadened our understanding of information management strategies for the marine sciences using a comparative approach (Baker and Chandler, 2008), and investigation continues on the diverse temporal orientations involved in LTER work. We studied information issues for digital data curation in association with the digital library community, developing the concept of a sociotechnical ‘distance-from-origin’ to highlight the situatedness of data work (Baker and Yarmey, in press) and the complexities of dataset description that come into play as data travel from the field site and the hands of data collectors. In addition to considering a web of data repositories (site-based, center-based, and archive-based) and a Community Design approach (Karasti and Baker, 2008), a web of users and codesigners was described in a paper providing an augmented approach to Participatory Design (Millerand and Baker, in press).

IM Publications.

Baker, K. S., and C. Chandler, 2008. Enabling long-term oceanographic research: Changing data practices, information management strategies and informatics. Deep-Sea Research II: Special Series Palmer Long-Term Ecological Research, 55 (18-19), 2132-2142, 2008. DOI 10.1016/j.dsr2.2008.05.009. PAL LTER Contribution #0314.

KBaker and LYarmey, in press. Data Stewardship: Environmental Data Curation and a Web-of-Repositories. International Journal of Digital Curation.

Millerand, F., and K. S. Baker, in press. Who are the users? From a single user to a web of users in the design of a working standard. Information Systems Journal (ISJ); Special Issue: User - the Great Unknown of Systems Development: Reasons, forms, challenges, experiences and intellectual contributions of user involvement, in press 2009. PAL LTER Contribution #0329.

H Karasti and K S Baker, 2008. Community Design – Growing One’s Own Information Infrastructure. Proceedings of the Participatory Design Conference. 30Sep-04Oct, 2008, Bloomington, IN. PAL LTER Contribution #0326.

F Millerand and G C Bowker, 2009. Metadata Standard: Trajectories and Enactment in the Life of an Ontology. In Formalizing Practices: Reckoning with Standards, Numbers and Models in Science and Everyday Life. M.Lampland and S.L.Star (eds). Cornell University Press. PAL LTER Contribution #0327

Education and Outreach (Beth Simmons): No results to report (yet!).

E&O Publications:

BSimmons and MMCerullo (2008) Sea Secrets: Tiny Clues to a Big Mystery, Moonlight Publishing, Lafayette, Colorado. ISBN 10:0-9779603-9-0 pp.32.

BSimmons (2009) LTER Network News: <http://www.lternet.edu/news/Article219.html>

BSimmons (2009) MBL webpage: http://ecosystems.mbl.edu/news/sea_secrets_news.html

BSimmons (2009) SIO E-magazine: http://explorations.ucsd.edu/Around_the_Pier/2008/Nov/Simmons/

BSimmons (2009) SWMEA Connection Newsletter:
<http://www.swmea.org/newsletter/printed/summer08.newsletter.pdf>

BSimmons (2009) Databits Article (January 2nd 2009)

Simmons, B., Connors (2009) Telling the Story behind the Photo’s, LTER Databits article, December. <http://databits.lternet.edu/node/36>

Internet/Web sites

BSimmons (2008) Sea Secrets Website <http://cce.lternet.edu/outreach/seasecrets/>

BSimmons(2009) Polar Books Website: <http://www.unep.org/Publications/polarbooks/books/1015.aspx>

BSimmons (2009) CCE Process cruise blog site <http://cce.lternet.edu/outreach/blogs/cruise/>

Other Specific Products

Simmons B & Carlson, K. (2009) Sea Secrets Field Journal

Simmons B. & Carlson, K. (2009) Sea Secrets Sticky Note products

Simmons B & Carlson, K. (2009) Sea Secrets Postcards

Seabirds (Bill Fraser BP-013). There were two principal findings, both related to the long-held PAL-LTER hypothesis that the breeding distribution of Adélie penguins (and other top predators) is mechanistically linked to regional deep bathymetry and associated oceanographic processes because they provide a predictable prey base over ecological time. Using gliders provided by co-PI Oscar Schofield whose range of operation was programmed to cover penguin foraging areas; we demonstrated that, indeed, foraging by these predators is focused over regions of bathymetry-induced upwelling with elevated water temperatures and higher primary production. The programmed glider tracks used waypoints based on satellite transmitters attached to the penguins, thus demonstrating the value of exploring our hypotheses within the scope of a multidisciplinary, dual platform framework. The exploration of Charcot Island

resulted in the first Adélie penguin censuses of this remote colony in more than four decades. Equally important, satellite tags attached to penguins provided the first observations of their foraging areas. In further confirmation of our hypotheses, foraging tracks also identified the presence of previously unknown deep bathymetry and associated upwelling by Upper Circumpolar Deep Water.

Seabird Publications.

- Ainley, D., Russell, J., Jenouvrier, S., Woehler, E.J., Lyver, P.O'B., Fraser, W.R., Kooyman, G.L. **2009**. Antarctic penguin response to habitat change as earth's troposphere nears 2°C above pre-industrial levels. *Ecological Monographs* (in press).
- Ainley, D., Russell, J., Jenouvrier, S., Woehler, E.J., Lyver, P.O'B., Fraser, W.R., Kooyman, G.L. **2009**. The derivation of a model ensemble useful to predict changes in penguin habitat. *Ecological Archives* (in press).
- Chapman, E.W., Hofmann, E.E., Fraser, W.R. **2009**. Modeling the influence of variability in Antarctic krill (*Euphausia superba*) spawning behavior and sex/maturity stage distribution on Adélie penguin (*Pygoscelis adeliae*) prey quality and chick growth. *Deep Sea Research II* (in press).
- Erdmann, E.S., Ribic, C.A., Patterson-Fraser, D.L., Fraser, W.R. **2009**. Characterization of winter foraging locations of Adélie penguins along the western Antarctic Peninsula. *Deep Sea Research II* (in press).
- Ribic, C.A., Ainley, D.G., Ford, R.G., Fraser, W.R., Tynan, C.T., Woehler, E.J. **2009**. Ocean fronts and the structure of seabird communities off the western Antarctic Peninsula. *Deep Sea Research II* (in press).
- Geisz, H.N., Dickhut, R.M., Cochran, M.A., Fraser, W.R., Ducklow, H.W. **2009**. Response to comments on "Melting glaciers: A probable source of DDT to the Antarctic marine ecosystem". *Environmental Science & Technology* 43: 3974-3975.
- Montes-Hugo, M., Doney, S.C., Ducklow, H.W., Fraser, W.R., Martinson, D., Stammerjohn, S.E., Schofield, O. **2009**. Recent changes in phytoplankton communities associated with rapid regional climate change along the western Antarctic Peninsula. *Science* 323: 1470-1473.
- Friedlaender, A.S., Fraser, W.R., Patterson-Fraser, D.L., Qian, S.S., Halpin, P.N. **2008**. The effects of prey demography on humpback whale (*Megaptera novaeangliae*) abundance around Anvers Island, Antarctica. *Polar Biology* 31: 1217-1224.
- Geisz, H.N., Dickhut, R.M., Cochran, M.A., Fraser, W.R., Ducklow, H.W. **2008**. Melting glaciers: A probable source of DDT to the Antarctic marine ecosystem. *Environmental Science & Technology* 42: 3958-3962.
- McClintock, J., Ducklow, H., Fraser, W. **2008**. Ecological responses to climate change on the Antarctic Peninsula. *American Scientist* 96: 302-310.
- Moline, M.A., Karnovsky, N.J., Brown, Z., Divoky, G.J., Frazer, T.R., Jacoby, C.A., Torres, J.J., Fraser, W.R. **2008**. High Latitude Changes in Ice Dynamics and Their Impact on Polar Marine Ecosystems. *Annals of the New York Academy of Sciences* 1134: 267-319.

- Patterson, D. L., Woehler, E. J., Croxall, J. P., Cooper, J., Poncet, S., Peter, H.-U., Hunter, S., Fraser, W.R. **2008**. Breeding distribution and population status of the Northern Giant Petrel *Macronectes halli* and the Southern Giant Petrel *M. giganteus*. *Marine Ornithology* 36: 115-124.
- Shearn-Bochsler, V. D., Green, E., Converse, K.A., Docherty, D.E., Thiel, T., Geisz, H.N., Fraser, W.R. and Patterson-Fraser, D.L. **2008**. Cutaneous and diphtheritic avian poxvirus infection in a nestling Southern Giant Petrel (*Macronectes giganteus*) from Antarctica. *Polar Biology* 31: 569-573.
- Siniff, D.B., Garrott, R.A., Rotella, J. J., Fraser, W.R., Ainley, D.G. **2008**. Projecting the Effects of Environmental Change on Antarctic Seals. *Antarctic Science* 20: 425-435.
- Ribic, C.A., Chapman, E. Fraser, W.R., Lawson, G.L., Wiebe, P.H. **2008**. Top predators in relation to bathymetry, ice, and krill during austral winter in Marguerite Bay, Antarctica. *Deep Sea Research II* 55: 485-499.

Physical Oceanography (Doug Martinson BP-021). The single LTER mooring and 4 IPY moorings deployed in the center of our grid, are situated to document the frequency of UCDW flooding events into the gird, and its ability to spread beyond the canyons through which they enter. We have only had the first full year of data for a few months, but from that, it is clear that the warm UCDW water does not fill the shelf water column from below (as expected if the frequent flooding into the troughs led to trough overflow onto the nominal shelf floor). Also, full water profile shifts in the water column did not spread across the mooring array (as expected from an ACC flooding event). Rather the water column shift typically lasted less than a week long, always showed a consistent temporal slope in rate of ocean heat content (OHC) change suggesting a physical process (i.e., not noise), which we interpret to be eddies (number, frequency, size, etc. now being estimated). The IPY array will be transferred to LTER for future deployments.

Major finding presented in *Martinson et al.*, 2008 (special LTER DSR II issue) shows that the OHC appears to have been increasing thorough the middle of the preceding century, with the LTER years showing considerably more ocean heat than pre-1990 decades. Two mechanisms are most obvious to explain this: (1) global warming has been absorbed at the ocean surface in more tropical oceans, that heat diffusing to depths where the currents transport the warmed waters to the ACC and eventually to our sample grid; (2) increase in the circumpolar westerlies, as a consequence of global warming (positive SAM), leads to a stronger ACC flow with a dynamic response of increased isopycnal tilt bringing the warmest water (UCDW core) to shallower depths, making that warmer water flowing onto the shelf in the eddies. If the former mechanism its correct, this has major implications for society, as it suggests that there is warmer water available for accelerated glacial melt already locked into the system regardless of the future trajectory of global warming; the second mechanism offers hope in that recovery of the Antarctic ozone layer, or recovery of global warming may decrease the westerlies, and relax the tilt, bringing cooler water onto the shelf with the eddies.

Physical Oceanography Publications.

- Montes-Hugo, M., S. C. Doney, H. W. Ducklow, W. Fraser, D. Martinson, S. E. Stammerjohn, and O. Schofield, 2009. Recent Changes in Phytoplankton Communities Associated with Rapid Regional Climate Change Along the Western Antarctic Peninsula. *Science*, 323, 1470-1473.

Montes-Hugo, M., C. Sweeney, S. C. Doney, H. W. Ducklow, R. Frouin, D.G. Martinson, S. E. Stammerjohn, and O. Schofield, accepted. Spring wind patterns and transient changes on summer dissolved inorganic carbon and chlorophyll a concentration in surface waters of the Western Shelf of the Antarctic Peninsula. *J. Geophys. Res.* In review.

Stammerjohn, S. E., D. G. Martinson, R. C. Smith, X. Yuan, and D. Rind. 2008. Trends in Antarctic annual sea ice retreat and advance and their relation to ENSO and Southern Annular Mode Variability. *Journal of Geophysical Research*, 113, C03S90, doi: 10.1029/2007JC004269.

Phytoplankton (Oscar Schofield, B-019). Scientifically the cruise collected an interesting range of data and for what has been analyzed there is a strong inshore to offshore gradient of decreasing primary production. Productivity values were of similar magnitude to past years providing confidence in the continuity in the time series given the personnel changes in the program. The stations with high productivity rates were mirrored with high values of Fv/Fm indicating healthy phytoplankton populations. The population structure will be assessed using the HPLC data which is currently being analyzed at Palmer Station. There is coherence between the optical fields and the phytoplankton productivity suggesting these waters are largely Case I waters. This is consistent with radio-isotope measurements made during the cruise that dissolved organic matter production was only 3-5% of phytoplankton carbon fixation. Size fractionated productivity measurements suggest that over 95% of the phytoplankton were in the less than 20 micron size fraction.

Data Analysis and Synthesis of Historical PAL-LTER Observations: In a published paper in *Science* magazine (Montes-Hugo et al., 2009), we show that there has been a significant poleward shift in phytoplankton blooms (elevated surface chlorophyll and primary productivity) along the western coast of the West Antarctic Peninsula associated with the reduced seasonal sea-ice and earlier seasonal spring retreat. The analysis involved a combination of in situ data and satellite observations. In a second manuscript (Montes-Hugo et al., submitted), we examine the relationship between physical climate driving factors (winds, ice, currents) and interannual variability in biological productivity and surface dissolved inorganic carbon concentrations. Particularly, we demonstrate that strong northerly winds during spring are associated with enhanced summer biological productivity and inorganic carbon drawdown.

Phytoplankton Publications (papers by graduate student or postdoc underlined)

Montes-Hugo, M., Ducklow, H., Schofield, O. 2009. Contribution by different marine bacterial communities to particulate beam attenuation. *Marine Ecology Progress Series*.
Doi:10.3354/meps07883.

Montes-Hugo, M., H. Ducklow, S. Doney, W. Fraser, D. Martinson, S. Stammerjohn, and O. Schofield, 2009: Recent changes in phytoplankton communities associated with rapid regional climate change along the western Antarctic Peninsula, *Science*, 323, 1470-1473.

Montes-Hugo, M., H. Ducklow, O. Schofield, S. Stammerjohn, C. Sweeney, S. Doney, and D. Martinson, Anomalous strong and persistent spring winds affect carbonate system in the Western Shelf of the Antarctic Peninsula during summer, *J. Geophys. Res. Oceans*, submitted.

Zooplankton and micronekton (Debbie Steinberg B-020). No findings to report (yet!)

Zooplankton publications:

Ducklow, H.W., S.C. Doney and D. K. Steinberg. 2009. Contributions of Long Term Research and Time Series Observations. *Annual Reviews of Marine Science*. 1:279- 302

Microbes and Biogeochemistry (Hugh Ducklow BP-045). The microbial biogeochemistry group participated in the annual cruise and also had personnel at Palmer Station for an abbreviated period (February-March). Cruise operations were generally similar to previous years (bacterial abundance and production rates, dissolved oxygen, dissolved organic and inorganic carbon, moored sediment trap). In addition our group will take over responsibility for inorganic nutrients. We hosted WHOI geochemist Ken Buesseler and grad student Andrew McDonnell on LMG 0901. They conducted a variety of studies on sedimentation rates and carbon fluxes, using drifting sediment traps, gel columns to collect particles, a video profiling system to quantify standing stocks and distributions of different particle types in the water column; and Thorium-234 to estimate particle removal rates. We successfully recovered and redeployed the moored trap and split samples from it for Th-234 analysis. Preliminary results from these investigations all suggest that the moored trap collection efficiency is likely under 10%, that is, sedimentation fluxes derived from the moored trap are underestimates of the flux as reflected in short-term drifting traps and Th-234 deficits. This real-time comparison is uncertain because at this point we can only compare the shipboard (January-February, 2009) flux estimates from drifting traps and Th-234 with the moored trap results from Nov-Dec. 2008. Buesseler's group will be on next year's cruise, at which time we will recover the moored samples from 2009 to make more detailed comparisons. This analysis is ongoing.

At Palmer Station, we completed two mesocosm experiments in connection with our IPY Project. The objective was to perturb large-volume (50-liters) seawater samples with changes in nutrients, temperature, irradiance or organic matter and determine the changes in bacterial community structure (species composition) over ten-day intervals. We have a manuscript in preparation comparing three community fingerprinting techniques (DGGE, TRFLP and LH-PCR) for probing these changes. Similar experiments have been conducted in November – March in LTER and July-September in IPY. Sample analyses for the IPY and all other samples are underway. Most PAL data through March-2008 have been submitted to the PAL data system.

Microbial biogeochemistry Publications (grad students and postdocs underlined):

Straza, T. R. A., M. T. Cottrell, H. W. Ducklow, and D. L. Kirchman. 2009. Geographic and phylogenetic variation in bacterial biovolume using protein and nucleic acid staining. *Appl. Environ. Microbiol.:*AEM.00183-00109.

Kirchman, D.L., X.A.G. Moran, and H. Ducklow, Microbial growth in the polar oceans role of temperature and potential impact of climate change. *Nature Rev Micro*, 2009. 7(6): p. 451-459.

Montes-Hugo M, Ducklow H, Schofield O. 2009. Contribution by different marine bacterial communities to particulate beam attenuation. *Aquatic Microbial Ecology* 379:13-22

Montes-Hugo M, Doney SC, Ducklow HW, Fraser W, Martinson D, Stammerjohn SE, Schofield O (2009) Recent Changes in Phytoplankton Communities Associated with Rapid Regional Climate Change Along the Western Antarctic Peninsula. *Science* 323:1470-1473

Ducklow, H.W., S.C. Doney and D. K. Steinberg. 2009. Contributions of Long Term Research and Time Series Observations. *Annual Reviews of Marine Science*. 1:279-302

Ducklow, H. W. Microbial services: challenges for microbial ecologists in a changing world. 2008. *Aquatic Microbial Ecology* 53:13-19.

Gasol, J.M., Pinhassi, J., Alonso-Sáez, L., Ducklow, H.W., Herndl, G.J., Koblížek, M., Labrenz, M., Luo, Y., Morán, X.A.G., Reinthaler, T., Simon, M., 2008. Towards a better understanding of microbial carbon flux in the sea. *Aquatic Microbial Ecology* 53:21-38.

Geisz, H.N., Dickhut, R.M., Cochran, M.A., Fraser, W.R., Ducklow, H.W., 2008. Melting Glaciers: A Probable Source of DDT to the Antarctic Marine Ecosystem. *Environ. Sci. Technol.* 42: 3958–3962.

McClintock, J., H.W. Ducklow and W. Fraser. 2008. Ecological responses to climate change on the Antarctic Peninsula. *American Scientist* 96:414-422.

Education activities: We provided research opportunities for 3 undergraduate students (Maggie Waldron, Lawrence Univ graduated 2008; Zena Cardman, Univ NC, graduating 2010 and Lara Gates (Wm&Mary, graduated May 2009). Ohio State freshman Kathleen Woods is working in our lab in Woods Hole this summer. Current VIMS PhD student Heidi Geisz completed her fifth year at the WM-SMS and is working on her thesis on pollutants in seabirds. Current Brown Univ MSc. student Kristen Myers finished her research is working on her thesis.

Sea Ice and Climate (Sharon Stammerjohn). (a) The large-scale ice-climate data synthesis revealed that sea ice changes in the Antarctic Peninsula-Bellinghausen-Amundsen Sea region (~67-71°S, ~60W-120°W, ~0.5 x 10⁶ km²) are occurring 29% faster than the fastest sea ice changes in the Arctic as observed in the East Siberian-Chukchi-Beaufort Sea region (~70-76°N, ~138°W-155°E, ~1 x 10⁶ km²), e.g. an 83- versus 59-day shorter sea ice duration (over 1979-2006), respectively (Stammerjohn et al, submitted). The largest seasonal sea ice changes are occurring during the austral autumn in the Antarctic Peninsula-Bellinghausen-Amundsen Sea region versus in the boreal spring in the East Siberian-Chukchi-Beaufort Sea region. In the paper submitted, we also review and discuss mechanisms contributing to the asymmetric polar seasonal sea ice changes and implications for increased ocean heat content and inter-seasonal feedbacks.

(b) Results from the GISS GCM ozone runs showed a few surprises (Rind et al, 2009), primarily a possible mechanistic connection between a Southern Hemisphere (S.H.) spring ozone hole and a more positive Northern Annular Mode (NAM). Observations show that the S.H. spring ozone hole deepened in the mid-1990s while the NAM became more positive. This relationship was reproduced in the model simulations, and a possible mechanism for the inter-hemispheric connection is given. As noted in previous analyses of sea ice trends in the Southern Ocean (Stammerjohn et al, 2008a; 2008b), the more positive Southern Annular Mode (SAM), believed to be induced by a combination of ozone depletion, increasing greenhouse gases and natural variability, imposes atmospheric circulation anomalies that are consistent with the observed wind-driven regional sea ice trends. This possible inter-hemispheric atmospheric connection poses the question of how the polar sea ice trends (described above) might be implicated in this connection as well.

(c) During NBP0901 we made 197 underway hourly observations during approximately 13 full days in sea ice, held 20 sea ice stations and collected 92 meters of sea ice cores. Our stations and samples were distributed along north-south and east-west transects in the region of the summer pack ice. Our initial findings suggest that there are two features which appear to play an important role in the persistence of summer sea ice in the Amundsen Sea: (1) the confinement of drift ice by the Thwaites iceberg tongue, and (2) the import of thick multiyear ice from north of Thurston Island. The Thurston Island region is particularly interesting as it is a highly persistent region of perennial ice that appears to be maintained by a combination of high snowfall and an unusually stable water column. Recent changes in ice extent and duration there may also have implications for the ice cover downstream in the Amundsen Sea. In general, summer sea ice thinning and retreat appears to be controlled by ice drift variability and disposition of solar energy in the ocean. A key question is how change or variability in snow accumulation or summer surface melt processes might affect ice thickness and modulate sea ice response to climate variability. Time series data collected by the ice mass balance buoys (from the PAL LTER, Bellingshausen and Amundsen Seas), together with process modeling, will help answer this question as described above.

(d) As noted by other PAL LTER PIs, a pair of papers by Montes-Hugo et al (2009, *Science*; submitted, JGR) shows how changes in sea ice, cloudiness and winds have been associated with a poleward shift in primary productivity along the WAP region over 1998-2006 as compared to 1978-86, where a seasonal drawdown in inorganic carbon has also been observed during the later period in the more southern region.

Climate/sea ice Publications

Montes-Hugo, M, S. C. Doney, H. W. Ducklow, W. Fraser, D. G. Martinson, S. E. Stammerjohn, and O. Schofield. 2009. Recent Changes in Phytoplankton Communities Associated with Rapid Regional Climate Change along the Western Antarctic Peninsula. *Science*, 13 March, 323 (5920).

Montes-Hugo, M., H. Ducklow, O. Schofield, S. Stammerjohn, C. Sweeney, S. Doney, and D. Martinson, Anomalous strong and persistent spring winds affect carbonate system in the Western Shelf of the Antarctic Peninsula during summer, *J. Geophys. Res. Oceans*, submitted.

Rind, D., J. Jonas, S. Stammerjohn and P. Lonergan. 2009. The Antarctic ozone hole and the Northern Annular Mode: a stratospheric interhemispheric connection. *Geophysical Research Letters*, 36, L09818, doi: 10.1029/2009GL037866.

Stammerjohn, S., R. Massom, and D. Rind. Polar spatio-temporal changes in the timing of sea ice advance and retreat, *Journal of Climate*, submitted.

Published Abstracts, Invited Talks

Stammerjohn, S., C. Sweeney, M. Vernet, R. Ross, L. Quetin, and C. Fristen, Improving current assessments and future predictions of carbon fluxes in the Southern Ocean as mediated by the dynamical response of ice-ocean-ecosystem interactions to climate change, 2008 NASA Carbon Cycle and Ecosystems Joint Science Workshop, April 28-May 1 2008, Adelphi Maryland, Poster.

Stammerjohn, S., R. Massom, E. Maksym, R. Cullather, S. Jacobs, and D. Martinson, Wind-Driven Changes in Sea Ice Advance and Retreat and Ocean Freshening Near Antarctica, AGU Fall 2008 Meeting in San Francisco, Dec 15-19 2008, Invited.

Stammerjohn, S., Seasonal Ice-Ocean-Atmosphere Interactions: A Polar Comparison, Gordon Research Conference on Polar Marine Science, Lucca, Italy, March 15-20 2009, Invited.

Stammerjohn, S., Large Scale Ice-Atmosphere Anomalies during SIPEX/SIMBA 2007, NSF IPY Sea Ice Workshop, Lucca, Italy, March 22-24 2009, Invited.

Stammerjohn, S. Disappearance of Sea Ice, NSF LTER Workshop on the Ecosystem Response to Diminished Snow and Ice in a Warming Climate, MBL, Woods Hole, March 31-April 1 2009, Invited.

Modeling (Scott Doney). *Data Analysis and Synthesis of Historical PAL-LTER Observations:* S. Doney contributed to a pair of analysis papers on historical PAL-LTER data in collaboration with the bulk of the project team. In a published paper in *Science* (Montes-Hugo et al., 2009), we show that there has been a significant poleward shift in phytoplankton blooms (elevated surface chlorophyll and primary productivity) along the western coast of the West Antarctic Peninsula associated with the reduced seasonal sea-ice and earlier seasonal spring retreat. The analysis involved a combination of in situ data and satellite observations. In a second manuscript (Montes-Hugo et al., submitted), we examine the relationship between physical climate driving factors (winds, ice, currents) and interannual variability in biological productivity and surface dissolved inorganic carbon concentrations. Particularly, we demonstrate that strong northerly winds during spring are associated with enhanced summer biological productivity and inorganic carbon drawdown.

Modeling Publications

Ducklow, H., S.C. Doney, and D.K. Steinberg, 2009: Contributions of long-term research and time-series observations to marine ecology and biogeochemistry, *Ann. Rev. Mar. Sci.*, 1, 279-302, 10.1146/annurev.marine.010908.163801.

Montes-Hugo, M., H. Ducklow, S. Doney, W. Fraser, D. Martinson, S. Stammerjohn, and O. Schofield, 2009: Recent changes in phytoplankton communities associated with rapid regional climate change along the western Antarctic Peninsula, *Science*, 323, 1470-1473.

Montes-Hugo, M., H. Ducklow, O. Schofield, S. Stammerjohn, C. Sweeney, S. Doney, and D. Martinson, Anomalous strong and persistent spring winds affect carbonate system in the Western Shelf of the Antarctic Peninsula during summer, *J. Geophys. Res. Oceans*, submitted.