

Annual Report for Period:10/2005 - 10/2006**Submitted on:** 07/04/2006**Principal Investigator:** Ducklow, Hugh W.**Award ID:** 0217282**Organization:** William & Mary Marine Inst**Title:**

LTER: PALMER, ANTARCTICA LTER: Climate Change, Ecosystem Migration and Teleconnections in an Ice-Dominated Environment

Project Participants**Senior Personnel****Name:** Ducklow, Hugh**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Burreson, Eugene**Worked for more than 160 Hours:** Yes**Contribution to Project:**

participated on research cruise aboard LM GOULD

Name: Martin, Daniel**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Mr. Martin was a Staff Research Associate and the field team leader for the secondary production component at Palmer Station in the austral spring. He was in charge of the core sampling, including diving operations, acoustic transects from the zodiac once the ice cleared, and conducting growth experiments with larval krill sampled either with divers or with a net from the zodiac. Support was provided with cost-share funds from University of California at Santa Barbara.

Name: Patterson, Donna**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Curchitser, Enrique**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Name:** McCallister, Shannon**Worked for more than 160 Hours:** Yes**Contribution to Project:**

participated on research cruise aboard LM GOULD

Name: Carrillo, Christopher**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Millerand, Florence**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Montes-Hugo, Martin**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Graduate Student**Name:** Oakes, Stephanie**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Ms. Oakes conducted experiments with larval krill at Palmer Station during the austral spring of 2002 as part of her Ph. D. thesis. She also assisted with the core program of sampling for the secondary production component during the Oct-Dec time frame. During the remainder of the year she continued the analysis of samples from previous winter cruises and drafting the chapters for her thesis.

Name: Garibotti, Irene**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Stammerjohn, Sharon**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Daniels, Robert**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Jackson, Steve**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Waterson, Elizabeth**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** France, Kristin**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Ribes, David**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Schwager, Katherine**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Luo, Yawei**Worked for more than 160 Hours:** Yes**Contribution to Project:****Undergraduate Student****Name:** Fuller, Michelle**Worked for more than 160 Hours:** Yes

Contribution to Project:

Ms Fuller was a senior at University of California at Santa Cruz when she was part of the research team for the secondary production component on board the LM Gould in January 2003. She was a volunteer. She participated in all aspects of the core sampling and conduction of experiments during the cruise.

Name: Wright, Matthew

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr Wright was a sophomore at University of California at Santa Barbara when he was part of the research team for the secondary production component on board the LM Gould in January 2003. He was a volunteer. He participated in all aspects of the core sampling and conduction of experiments during the cruise.

Name: Valicenti, Lyndon

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms Valicenti was a junior at University of California at Santa Barbara when she was part of the research team for the secondary production component on board the LM Gould in January 2003. She was a volunteer. She participated in all aspects of the core sampling and conduction of experiments during the cruise.

Name: Holmes, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Holmes was a junior at California Polytechnical Institute in San Luis Obispo when he was a member of the secondary production research team on board the LM Gould in January 2003. He assisted in all aspects of sampling and conducting experiments during the cruise.

Name: Ducklow, William

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Quetin, Gregory

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Lum, Kimberly

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Powers, Meghan

Worked for more than 160 Hours: Yes

Contribution to Project:**Technician, Programmer**

Name: Boch, Charles

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Boch was a field assistant during both the austral spring sampling from Palmer Station and on board the LM Gould during the annual cruise. He did both SCUBA diving and zodiac sampling at Palmer Station, and supervised the midnight to noon shift on board the LM Gould. Partial support was provided with Palmer LTER funds.

Name: Johnson, Charleen

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Ireson, Kirk
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kozlowski, Wendy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Sines, Karie
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Denker, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Anderson, Cynthia
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Geisz, Heidi
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Jerrett, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Pickering, Brett
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Chapman, Erik
Worked for more than 160 Hours: No
Contribution to Project:

Name: Iannuzzi, Richard
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Salerno, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:
 Worked in lab and Participated on annual research cruise.

Name: Mills, Brendon
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wanetick, Jerry

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

Name: Evans, Daniel

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

Name: Watson, Jordan

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

Name: Acheson, Leana

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

Name: Cochran, Michele

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

Name: Haber, Shaun

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

Name: Erickson, Matthew

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

Name: Blum, Jennifer

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

Name: Gorman, Kristen

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

Name: Montaigne, Fen

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

Other Participant

Name: Turnipseed, Mary

Worked for more than 160 Hours: Yes

Contribution to Project:

participated on research cruise aboard LM GOULD

Name: Ross, Robin

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Ross was a co-PI for the secondary production component of the Palmer LTER. The general tasks include (1) planning and preparing for the field season, both at Palmer Station and for the annual cruise, (2) participation in the field season, (3) data entry and analysis, and (4) manuscript preparation and submittal. She was Chief Scientist for the January 2003 cruise aboard the LM Gould. Partial support was provided.

Name: Quetin, Langdon

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Quetin was a co-PI for the secondary production component of the Palmer LTER. The general tasks include (1) planning and preparing for the field season, both at Palmer Station and for the annual cruise, (2) participation in the field season, (3) data entry and analysis, and (4) manuscript preparation and submittal. He conducts the dry suit training class for the divers participating in the austral spring field season for the Palmer LTER. Partial support was provided.

Name: Lindsey, Emily

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms Lindsey graduated from Brown University in May 2002, and joined the secondary production research team both at Palmer Station in December and on board the LM Gould in January 2003. She participated as an assistant in all aspects of the core sampling from zodiacs and from the ship, and in conducting experiments with Antarctic krill.

Name: Rawls, Dawn

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Baker, Karen

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: McCoy, Kim

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Smith, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Vernet, Maria

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Ferrara, Michelle

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Tillbury, Graham

Worked for more than 160 Hours: Yes

Contribution to Project:**Name:** Bechtel, Jefferey**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Bostrom, Erin**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Horne, Peter**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Veloza, Adriana**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:** Rapoport, Shana**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Participated on annual research cruise.

Name: White, Bryan**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Participated on annual research cruise and at Palmer Station.

Name: Pelletreau, Karen**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Participated on annual research cruise.

Name: Loomis, Eli**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Participated on annual research cruise and at Palmer Station.

Name: Cheng, Brian**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Green, Kristen**Worked for more than 160 Hours:** Yes

Contribution to Project:**Name:** Kaiser, Amy**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Watts, Jason**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Haupt, Alison**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Talley, Shannon**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Cadiz, Robin**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Lefens, Mark**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Thomas, Austen**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Spence, Jessica**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Sprague, Josh**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Davis, Katie**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Holloway, Stephen**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Chakos, Diane**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Name: Duplantier, Adrian
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Lemein, Todd
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Sabo, Kathleen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Huang, David
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: van Dover, Cindy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Eam, Boreth
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Husby, Jenny
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wohlford, Tristan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Schram, Julie
Worked for more than 160 Hours: Yes
Contribution to Project:

Research Experience for Undergraduates

Name: Raulfs, Estella
Worked for more than 160 Hours: Yes
Contribution to Project:

participated on research cruise aboard LM GOULD

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: College of William and Mary

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2003

REU Funding: REU supplement

Name: Rogers, Lauren

Worked for more than 160 Hours: Yes

Contribution to Project:

participated in research at Palmer Station

Years of schooling completed: Other

Home Institution: Other than Research Site

Home Institution if Other: Stanford University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2003

REU Funding: REU supplement

Name: Tutrow, Jonathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Loyola Marymount University

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2002

REU Funding: REU supplement

Name: Middaugh, Nicole

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated on annual research cruise with LTER-REU support.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Name: Mills, Anne

Worked for more than 160 Hours: Yes

Contribution to Project:

Participated on annual research cruise with LTER-REU support.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Name: Tsui, Tracee

Worked for more than 160 Hours: Yes

Contribution to Project:

Analyzed data and developed outreach website.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Name: Haber, Shaun

Worked for more than 160 Hours: Yes

Contribution to Project:

Years of schooling completed: Freshman

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Associate's Degree

Fiscal year(s) REU Participant supported:

REU Funding: REU supplement

Name: Kelly, Joann

Worked for more than 160 Hours: Yes

Contribution to Project:

Joann worked in Ducklow's lab at VIMS, processing and analyzing sediment trap samples, and helping out with other routine lab duties.

Years of schooling completed: Freshman

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2004

REU Funding: REU supplement

Name: Moore, Kelly

Worked for more than 160 Hours: Yes

Contribution to Project:

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU supplement

Name: Hoffman, Cliff

Worked for more than 160 Hours: Yes

Contribution to Project:

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2005

REU Funding: REU supplement

Organizational Partners

Digital Library for Env and Sci Edu

NSF Artists and Writers Program

California Center for Ocean Sci Edu

Scripps Committee for Outreach Programs

San Diego Supercomputer Center

University of Wisconsin, Madison

Old Dominion University

University of La Plata

University of Nevada Desert Research Institute

DRI Post-doc Joseph Grzymski participated on our annual cruise

Instituto Argentino de Nivologia

Dr. Irene Garibotti from the Instituto Argentino de Nivologia, Glaciologia y Ciencias Ambientales; Mendoza, Argentina collaborated with coPI Maria Vernet on several manuscripts reporting on LTER findings.

UCSD Teacher Education Program

Teacher's Experiencing Antarctica

LTER Network Office

UCSD Preuss Middle/High School

Rawls Byrd Elementary School

University of Florida

Dr. T K Frazer of University of Florida: worked at Juan Carlos I base (Spanish) on Livingston Island; with a group transported by the Spanish Navy visited Palmer Station and received live krill and phytoplankton cultures. Members of the visiting party consulted with various people on station to learn about different ways to conduct science at stations in the Antarctic.

Spanish Antarctic Program, Juan Carlos B

Dr. T K Frazer of University of Florida: worked at Juan Carlos I base (Spanish) on Livingston Island; with a group transported by the Spanish Navy visited Palmer Station and received live krill and phytoplankton cultures. Members of the visiting party consulted with various people on station to learn about different ways to conduct science at stations in the Antarctic.

UCSD Science Studies Program

UCSD Laboratory for Comparative Human Co

Satellite Educational Resources Consortium

TenXSys

Boise, ID

Aquarium of the Pacific, Long Beach C

Ocean Literacy Network**Other Collaborators or Contacts**

Helena Karasti, Oulu University, Finland
 Geoffrey Bowker, UCSD Communication Department
 Cheryl Peach, UCSD Birch Aquarium
 Lucy Bledsoe, NSF Artists and Writers Program
 Cindy Baker, College of William and Mary Public Relations
 Pete Barnes, K12 teacher
 Lara Kessler, K12 schools
 Daniel Grossman, NSF Media Program
 Martha Ferrario, University of La Plata
 Rebecca Dickhut, VIMS
 Elizabeth Canuel, VIMS
 Michael Bender, Princeton
 Matthew Reuer, Princeton
 David Kirchman, U Delaware
 Craig Carlson, UCSB
 Mary Cerrullo, Children's book writer
 Cyndy Chandler, Data Manager of the JGOFS Data Office, WHOI
 Paula Levin, Graduate Coordinator Teacher Education Program
 Indalecio Manzano, Science Chair UCSD Preuss Elementary/Middle School
 Thomas K Frazer, University of Florida
 Christine Ribic, Univ of Wisconsin
 William Walker, M.S., Collaborator, NMFS., Seattle, WA.
 Eileen Hofmann, Ph.D., Collaborator, Old Dominion U., Norfolk, VA.
 UCSD SIO California Current Ecosystem LTER
 UCSB Santa Barbara Coastal LTER
 UCSD SIO/CalCOFI Program
 Alison Murray, Desert Research Institute
 Chris Fritsen, Desert Research Institute
 William Large, NCAR
 Erik Chapman, Old Dominion Univ
 Steve Emslie, U. of North Carolina, Wilmington
 Jose Torres, U. of South Florida
 Dan Lubin, SCRIPPS
 Alec Barron The Preuss School
 Susan Musante TIEE
 Tamara Ledley DLESE/SERC/NSDL
 Daniel Edelson/David Smith Northwestern University
 Jay Hendricks (high school teacher) Rancho Bernardo High School
 Harry Helling/Rick Baker Ocean Institute, Dana Point
 Renne Carleton San Diego State University (second year student)
 Debi Kilb SIO Visualization Center Director/Scientist

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

Please see attached PDF file.

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

Please see attached PDF file.

Training and Development:

We provide a rich experience in field research -- both at Palmer Station and aboard LM GOULD for numerous undergrad and graduate students listed in our participants section.

Outreach Activities:

The Palmer LTER partnered with Scripps Committee for Outreach Programs in Education (SCOPE) taking science into the classroom through the efforts of SIO graduate student participants. PAL LTER partners with other San Diego based programs such as Partnerships Involving the Scientific Community in Elementary Schools (PISCES) as well as with the Birch Aquarium's efforts with the California Center for Ocean Science Education Excellence (COSEE) support and purchase of toolkit materials.

Twelve volunteers were taken into the field as part of the Palmer LTER field program for the 2002-2003 season. In addition, a Research Experience for Undergraduates student participated in the January cruise. NSF Artist and Writer participant Dan Grossman was hosted by Palmer LTER participants while in the field at Palmer Stations. Contributions to his online website for both teacher guides and for photo galleries. An Antarctic Storytelling Workshop in conjunction with NSF Writer and Artists Program participant Lucy Bledsoe took place in San Diego in March 2003 in coordination with the Palmer LTER Information Management component.

Communication with the public occurred through Antarctic Sun article (http://pal.lternet.edu/lter/biblio/2002/mccoy_apv_pg6_antsun2002_29dec.pdf) as well as an LTER Network News article on outreach with schools (http://pal.lternet.edu/lter/biblio/2003/LTER_newsletters/Spring2003/pg05_spring03_vol16no1.pdf). In addition, William and Mary initiated a new website 'William and Mary in Antarctica' (<http://www.wm.edu/Antarctica/index.php>) and held a variety of outreach activities in collaboration with teachers who participated in a variety of ways with the field experience. In addition, a Picture-of-the-Day ship activity resulted in public outreach for the Palmer LTER January 2003 cruise. It was followed up by coordination of the photos into the Palmer LTER online photo gallery.

Discussions with the LTER Schoolyard cross-site efforts developed over plans for an All Scientists Meeting Workshop to be held jointly by the Information Managers and the LTER Education Representatives. Discussions with the Digital Library activities continued with participation at the Joint Conference for Digital Libraries in May 2003. A mini workshop was held with previous TEA participant Besse Dawson as well as with the NSDL group Science Education Resource Education (SERC) led by director Cathy Manduca.

Beth Simmons, a high school oceanography teacher with training in curriculum development, initiated design of a Palmer LTER framework for case-based module development. Training through the 'Understanding by Design' program continued with a PalLTER prototype module 'Penguin Bones' used as a presentation module.

Journal Publications

Hollibaugh, J. T., N. Bano and H. W. Ducklow., "Widespread Distribution in Polar Oceans of a 16S rRNA Gene Sequence with Affinity to Nitrospira-like Ammonia- Oxidizing Bacteria.", *Applied and Environmental Microbiology*, p. 1478, vol. 68, (2002). Published

Garibotti, I. A., M. Vernet, M. E. Ferrario, R. C. Smith, R. M. Ross and L. B. Quetin, "Phytoplankton spatial distribution in the Western Antarctic Peninsula (Southern Ocean)", *Marine Ecology Progress Series*, p. 21, vol. 261, (2003). Published

Garibotti, I. A., M. Vernet, W. A. Kozlowski and M. E. Ferrario., "Composition and biomass of phytoplankton assemblages in coastal Antarctic waters: a comparison of chemotaxonomic and microscopic analyses", *Marine Ecology Progress Series*, p. 27, vol. 247, (2003). Published

Thomas K. Frazer, Langdon B. Quetin, Robin M. Ross, "Abundance, sizes and developmental stages of larval krill, *Euphausia superba*, during winter in ice-covered seas west of the Antarctic Peninsula", *J. Plankton Res*, p. 1067, vol. 24, (2002). Published

- Karen L. Haberman, Robin M. Ross, Langdon B. Quetin, Maria Vernet, Gabriella A. Nevitt, Wendy Kozlowski, "Grazing by Antarctic krill *Euphausia superba* on *Phaeocystis antarctica*: an immunochemical approach", *Mar. Ecol. Prog. Ser.*, p. 139, vol. 241, (2002). Published
- Karen L. Haberman, L. B. Quetin and R. M. Ross, "Diet of the Antarctic krill (*Euphausia superba* Dana) I. Comparisons of grazing on *Phaeocystis antarctica* (Karsten) and *Thalassiosira antarctica* (Comber).", *J. Expt. Mar. Biol. Ecol.*, p. 79, vol. 283, (2003). Published
- Karen L. Haberman, Robin M. Ross, Langdon B. Quetin, "Diet of the Antarctic krill (*Euphausia superba* Dana) II. Selective grazing in mixed phytoplankton assemblages", *J. Expt. Mar. Biol. Ecol.*, p. 97, vol. 283, (2003). Published
- Langdon B. Quetin, Robin M. Ross, Thomas K. Grazer, Margaret O. Amsler, Carol Wyatt-Evens, Stephanie A. Oakes, "Growth of larval krill, *Euphausia superba*, in fall and winter west of the Antarctic Peninsula", *Mar. Biol.*, p. 833, vol. 143, (2003). Published
- Greenland, D., B. P. Hayden, J.J. Magnuson, S. V Ollinger, R.A. Pielke, Sr., and R. C. Smith
R. C. Smith, "Long-term research on biosphere-atmosphere interactions", *BioScience*, p. 33, vol. 53, (2003). Published
- Hader, D.P., H.D. Kumar, R.C. Smith and R.C. Worrest, "Aquatic ecosystems: effects of solar ultraviolet radiation and interactions with other climatic change factors", *Photochemical and Photobiological Sciences*, p. 39, vol. 2, (2003). Published
- Stammerjohn, S.E., M. R. Drinkwater, R.C. Smith and X. Liu, "Ice-atmosphere interactions during sea-ice advance and retreat in the western Antarctic Peninsula region (accepted)", *Journal of Geophysical Research*, p. 3329, vol. 108C, (2003). Published
- EH Hofmann, DP Costa, KL Daly, JM Klinck, WR Fraser, JJ Torres, "U.S. Southern Ocean Ecosystems Dynamics Program", *Oceanography*, p. 64, vol. 15, (2002). Published
- Carrillo, C.J., R.C. Smith, and D.M. Karl, "Processes regulating oxygen and carbon dioxide in surface waters west of the Antarctic Peninsula (accepted)", *Marine Chemistry*, p. 161, vol. 84, (2004). Published
- Patterson, D. L., E. J. Woehler, J. P. Croxall, J. Cooper, S. Poncet and W. R. Fraser., "Breeding distribution and population status of the Northern Giant Petrel *Macronectes halli* and the Southern Giant Petrel *M. giganteus*.", *Marine Ornithology.*, p. , vol. , (). Accepted
- Karasti, H. and K. S. Baker., "Infrastructuring for the long-term: ecological information management.", *Proceedings of the Hawai'i International Conference on System Sciences (HICSS) 2004*, 5-8 January, Big Island, Hawaii IEEE. New Brunswick, NJ., p. 1, vol. , (2002). Published
- Gales, J. N., W. R. Fraser, D. P. Costa and C. Southwell., "Do crabeater seals forage cooperatively?", *Deep Sea Research II.*, p. 2305, vol. 51, (2004). Published
- Chiuchiolo, A. L., R. M. Dickhut, M. A. Cochran and H. W. Ducklow., "Persistent organic pollutants at the base of the Antarctic marine food web.", *Environmental Science and Technology*, p. 3551, vol. 38, (2004). Published
- Chapman, E. W., C. A. Ribic and W. R. Fraser., "The distribution of seabirds and pinnipeds in Marguerite Bay and their relationship to physical features during austral winter 2001", *Deep Sea Research II.*, p. 2261, vol. 51, (2004). Published
- Baker, K. S., "Ecological design: an interdisciplinary, interactive participation process in an information environment.", *Proceedings of the workshop on Requirements Capture for Collaboration in e-Science*, 14-15 January, Edinburgh., p. 5, vol. , (2004). Published
- Smith, R. C., W. R. Fraser, S. E. Stammerjohn and M. Vernet., "Palmer Long-Term Ecological Research on the Antarctic Marine Ecosystem.", *Antarctic Peninsula Climate Variability: Historical and Paleoenvironmental Perspective*. E. Domack, A. Leventer, A. Burnett, R. Bindschadler, P. Convey and M. Kirby. eds. American Geophysical Union. Washington, DC, p. 131, vol. , (2003). Published
- Siegel, V., R. M. Ross and L. B. Quetin., "Krill (*Euphausia superba*) recruitment indices from the western Antarctic Peninsula: are they representative of larger regions?", *Polar Biology*, p. 672, vol. 26, (2003). Published

- Quetin, L. B. and R. M. Ross., "Episodic recruitment in Antarctic krill, *Euphausia superba*, in the Palmer LTER study region.", *Marine Ecology Progress Series*, p. 185, vol. 259, (2003). Published
- Liu, J., G. A. Schmidt, D. G. Martinson, D. Rind, G. Russell and X. Yuan., "Sensitivity to sea ice to physical parameterizations in the GISS global climate model.", *Journal of Geophysical Research*, p. 35-1, vol. 108, (2003). Published
- Fraser, W. R. and E. E. Hofmann., "A predator's perspective on causal links between climate change, physical forcing and ecosystem response.", *Marine Ecology Progress Series*, p. 1, vol. 265, (2003). Published
- Church, M. J., E. F. DeLong, H. W. Ducklow, M. B. Karner, C. M. Preston and D. M. Karl., "Abundance and distribution of planktonic Archaea and Bacteria in the waters west of the Antarctic Peninsula.", *Limnology and Oceanography*, p. 1893, vol. 48, (2003). Published
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Bibliography: none available

URL(s):

<http://pal.lternet.edu>

Description:

Palmer LTER Home Page

Other Specific Products

Product Type:**Teaching aids****Product Description:**

Palmer LTER Education Outreach Trunks

Sharing Information:

Collection of books, videos, maps, posters, manuscripts and artifacts relevant to polar research. Shared with formal and informal educators and researchers in our laboratory, during workshops or classroom visits.

Product Type:**Physical collection (samples, etc.)****Product Description:**

Palmer LTER Photo Gallery

Sharing Information:

Collections of photos of Antarctic field work or environment shared via web.

Product Type:**Physical collection (samples, etc.)****Product Description:**

Continue archive of preserved samples of zooplankton (in formalin) and fish larvae (in ethanol) from every station occupied during the annual summer cruise.

Continue collection of frozen samples of young Antarctic krill in the spring for condition factor analysis, and of frozen samples of all sizes of Antarctic krill for wet weight analysis.

Sharing Information:

After the planned analysis of the preserved samples is completed, all samples are shipped to the Smithsonian Institution for long-term archival, and are available to any researcher making the request.

Product Type:**Audio or video products****Product Description:**

A video of Antarctic krill under the ice has been edited from underwater footage taken by SCUBA divers.

Sharing Information:

The video clip can be viewed through the Palmer LTER web site.

Contributions

Contributions within Discipline:

Palmer LTER has maintained a regional-scale time series of key ecological and biogeochemical properties and processes over the past 13 years in one of the most remote and hostile regions on the planet. In doing so, we have also maintained a creative and vital program and made important fundamental observations on the response of the Antarctic marine ecosystem to climate change. We thus demonstrate how a long-term approach to science transcends monitoring and contributes to the disciplines of physical, biological and chemical oceanography, Antarctic and climate science.

Contributions to Other Disciplines:

We contribute uniquely to the work of long-term environmental science by continuing development of the Ocean Informatics conceptual framework for information management and informatics work enmeshed with an ongoing project science team. Participatory Design is an approach that in partnership with Science & Technology Studies participants is jointly explored as a working field method. This partnership allows us to consider 'how we do our science' while we are doing our science in order to address the changing expectations with respect to community science today. This interdisciplinary effort aims to create mechanisms addressing informatics literacy, information system sustainability, data interoperability, and cross-project collaboration. Some cross-project informatics topics include dictionaries and metadata templates developed by working closely with co located programs: the LTER California Coastal Ecosystem (LTER CCE), the California Cooperative Ocean Fisheries Investigations (CalCOFI), and the Southern California Ocean Observing System (SCOOS).

Ongoing collaborative efforts (Baker/Bowker/Karasti) of PAL LTER serve as a unique bridge for information science, digital library science, and organizational informatics, taking into account sociotechnical issues while remaining grounded within a practicing environmental field research project. The NSF/CISE/BDEI grant 'Designing an Infrastructure for Heterogeneity of Ecosystem Data, Collaborators and Organizations' continues to investigate a conceptual framework sensitive to infrastructure development, as explored in the fields of CSCW, social informatics and scientific collaboratory assessment. A particular focus on collections of documents contributes to ongoing digital library work on federated repositories and information flow.

We are contributing to the disciplines of social science and information science. The Ocean Informatics environment augments and creates alternatives to traditional computer science, information system, and technology approaches to data and information management. Further, the synergistic Comparative Interoperability Study (NSF/HSD) co led by Bowker and Baker represents an interdisciplinary effort linking environmental science, information management, and social science (science and technology studies) and continues to work closely with LTER in its second of three years. This project involves joint research on interrelated organizational, social and technical aspects of information, technology, and science collaboration providing social scientists unique access for innovative fieldwork on the topic of how science is done. Goals in this work include developing the notion of bidirectional communication and opening up discursive practices and perspectives highlighting design and articulation as important elements for ongoing environmental research programs.

Contributions to Human Resource Development:

Palmer LTER continues to train graduate students in oceanography and climate science and affords them valuable experiences for fieldwork in the Antarctic. Through our ongoing REU program, we also take undergraduate volunteers on our annual cruise and we have hosted teachers at Palmer Station. Finally through our Outreach Programs we expose K-12 students to Antarctic Science and demonstrate the attractions and rewards of careers in science. Finally, there is an ongoing mentoring of environmental scientists with respect to information management which is an integral part of the LTER vision, contributing to the development of data sharing and archival practices.

Contributions to Resources for Research and Education:

(please see also human resources)

A major strength of our outreach focus is the coordinated activity that creates a bidirectional flow of information between between field science, information management, education, and informal outreach through synergistic site education activities such as coordination of the Palmer LTER education workshops, participation in the LTER Network Education Committee and interaction with other LTER site schoolyard programs.

The roles of education/outreach coordinator and information manager in being developed synergistically within the PAL LTER environment contribute to development of a shared conceptual framework of information flow and information exchange. In addition, through enactment of an 'ocean informatics environment', a contemporary approach to training with a focus on 'science-in-making' is being explored through engagement in design activities.

The role of education/outreach coordinator was led by the PAL local information manager for a number of years while developing partnerships that informed the LTER PAL team about education and outreach opportunities and configurations. The last two years, a transitional phase has transpired. The role of education/outreach coordinator was defined to fit within local community and organizational configurations; the role was enacted as a liaison position, effectively creating a new type of interface between local formal and informal organizations and an ongoing research program (Baker and Simmons, submitted). A general education framework with inquiry-based and local signature elements was developed together with an inquiry-based Instruction Module as a deployment mechanism. Through our education-informatics components partnership joint focus on information and learning, a framework and instruction module were prototyped. This work creates an approach to addressing information science literacy through traditional education venues.

Contributions Beyond Science and Engineering:

The Palmer LTER outreach and education, as coordinated by our information manager, is integral to our science program and provides an important contribution to the flow of information to the public in general and to the community over time. An increased understanding of ecosystem response to disturbance on decadal scales (ie, climate change; see Synthesis volume discussed elsewhere) is an important issue for both public education and for national policy.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

RESEARCH ACTIVITIES: Palmer LTER 2005-2006.**Overview.**

In April, 2006 we completed the fourth field season of the current award, and the 15th in the Palmer LTER program that commenced in 1991-92. The annual summer cruise (LMG 06-01) and summer season at Palmer Station were both successful. Zodiac operations at Palmer Station were delayed by brash ice, with the first full sampling at Stations B,E on 17-18 November (the same dates as in 2005). After that the season progressed with few interruptions. The summer LMG cruise was successful with few missed stations or interruptions. During the cruise we visited Rothera Station, to carry out joint scientific operations with our BAS colleagues. This past season we again hosted Tim Hollibaugh from Univ. Georgia aboard LMG 05-01. Hollibaugh is studying the nitrification process along the WAP.

During the field season we cooperated very closely with the research team led by P Matrai (Bigelow Lab), to facilitate their sampling while working to eliminate redundancy and minimize impacts of 2 large science groups on station. Our group undertook several kinds of sampling and sample analyses originally proposed by the Matrai group throughout the season. We will be supplying data to their PIs this summer.

Our annual meeting was held at Scripps in August. It was attended by all PIs, local personnel at SIO and by our oversight group including John Hobbie, Warwick Vincent, Bob Beardsley and David Ainley. The meeting was mainly devoted to preparation and planning for the LTER/NSF Site Review in November (but see below). We also had guest presentations by Mark Ohman (PI, CCE LTER) and talks and tours by local SIO personnel engaged in the Information management and Education/Outreach components of PAL.

Doug Martinson and Bill Fraser were invited speakers at the Antarctic Peninsula Climate Variability Workshop sponsored by the NSIDC in Boulder CO in May. Sharon Stammerjohn attended the meeting as well and gave a talk. All PIs but one will attend the LTER All-Scientists Meeting in September. Following the ASM we plan a one-day workshop with MCM-LTER to review each program's research and educational efforts and explore opportunities for cross-site cooperation.

PAL Postdoc Martin Montes-Hugo started his research in Maria Vernet's lab at SIO last October. He will be in the field in 2006-07. Martin attended the 9th Bi-Annual Circumpolar Remote Sensing Symposium in Seward, Alaska and gave a presentation.

The other highlight of the past year was the LTER-NSF Site Review. It was scheduled to be convened at Palmer Station in November, with an outside review group, NSF Program Managers and PAL participants. Unfortunately the LMG couldn't reach Palmer Station in heavy sea ice (and one blown engine) so the review was postponed until May. Fortunately the review team agreed unanimously to reconvene and complete the review. "The longest site review in LTER history" was finally held in May at VIMS.

Specific project activities are presented below. Two PAL-wide multiauthored manuscripts are submitted, in review or in the final stages of preparation. Preprints are available.

Ducklow, H.W., K.S. Baker, D.G. Martinson, L.B. Quetin, R.M. Ross, R.C. Smith, S.E. Stammerjohn, M. Vernet, and W. Fraser, 2006 (in press). Marine ecosystems: The West Antarctic Peninsula. *Philosophical Transactions of the Royal Society of London, Special Theme Issue, "Antarctic Ecology: From Genes to Ecosystems."*

Massom, R.A., S.E. Stammerjohn, R.C. Smith, M.J. Pook, R.A. Iannuzzi, N. Adams, D.G. Martinson, C. Folwer, and Y. Massom, 2006 (in press). Major impact of anomalous atmospheric circulation on sea ice in the Palmer LTER region, Antarctica, late austral winter-early Spring 2001, *J. Clim.*

Seabirds (Fraser BP-013).

The seabird research group worked in the Palmer Station region from mid-October 2004 to mid-March 2005, sampling daily as weather permitted, and focusing its activities on the demography, foraging ecology and breeding biology of Adélie penguins. Early sampling this season was severely impacted by heavy sea ice, and personnel were only able to go into the field three times prior to mid-December. As in past seasons, we opportunistically obtained basic ecological data on other seabirds and marine mammals in the Palmer area to ensure the continuity of species-specific databases that originated in the early 1970s. In January, two group members participated in the annual LTER cruise (LMG 06-01), continuing surveys of seabirds and marine mammals to investigate their abundance and distribution relative to annual variability in the regional oceanography. This cruise included a 5-day field camp on Avian Island, Marguerite Bay, and a landing on Renaud Island, giving us a first opportunity to compare the foraging ecology of Adélie penguins (diets and at-sea foraging locations/dive-depth profiles based on ARGOS-linked transmitters) with data from Palmer Station. This season we also concluded experiments to examine the effects of snow deposition on Adélie penguin demography.

See elsewhere in report for articles published in 2005-06.

Physical Oceanography (Martinson BP-021)

This component of the PAL-LTER program deals with the physical oceanography, with the requirement of supplying core physical data (at the foundation of the underlying hypothesis that the ecology is being driven directly by the physical system). We have satisfied this requirement through the consistent collection of the grid CTD data set, its overall qa/qc, distribution to all participants (and upload to public data base), and general analysis. In this report, the focus is on important findings related to the physical system. One Ph.D. dissertation was completed under Martinson's supervision (with additional financial support from NASA): Stammerjohn, S.E., (2005), Seasonal sea-ice advance and retreat in the Southern Ocean, sensitivity and response to climate variability, 258 pp.

Publications. The following are submitted (see also above):

Martinson, D.G., S.E. Stammerjohn, R.A. Iannuzzi and R.C. Smith (2006: submitted – preprint online at: <http://pal.lternet.edu/bibliography/>). Palmer, Antarctica, Long-Term Ecological Research program, first twelve years: physical oceanography, spatio-temporal variability, *Deep Sea Res. Special LTER issue*.

Stammerjohn, S.E., D.G. Martinson, R.C. Smith and X. Yuan, 2006a (submitted). Trends in Sea Ice Retreat and Subsequent Advance in Response to ENSO and SAM Variability at High Southern Latitudes, *J. Climate*.

Stammerjohn, S.E., D.G. Martinson, R.C. Smith, R.A. Iannuzzi, 2006b (submitted). Sea Ice in the Palmer LTER Region: Spatio-Temporal Variability from Ecological and Climate Change Perspectives.

Stammerjohn, S.E., D.G. Martinson and R.C. Smith, 2006c (submitted) Profound regional changes in the timing of sea-ice advance and retreat in the Southern Ocean, *Geophys Res. Lt.*

Phytoplankton (Vernet BP-016) and Bio-optics (Smith/Vernet BP-032)

The phytoplankton (B-016) and bio-optics (B-032) groups carried out bi-weekly sampling via Zodiac Mark V within the 2-mile boating limit (Stations B & E) from November 2005 to the third of April 2006, and participated in the January 2006 cruise on the continental shelf. Sampling in October and November was limited by the presence of brash ice that prevented boating operations, but for the first time, one B-016 team member stayed on station during the month of January to maintain the seasonal B and E sampling routine. Throughout the entire field season, the phytoplankton group (B-016) sampled core variables, including daily primary production, particulate carbon and nitrogen, dissolved inorganic nutrients, and photosynthetic pigments. Core parameters for BP-032 included discrete chlorophyll and *in situ* conductivity, temperature, salinity and fluorescence measurements. For the collection of in-water optical data, a Biospherical Instruments Profiling Reflectance Radiometer was deployed throughout the season at all stations sampled. Bi-monthly experiments were carried out on the influence of microzooplankton grazing on primary production.

Educational activity: Vernet is serving as co-advisor for MSc Wendy Kozlowski at San Diego State Univ. Kozlowski's thesis work will use LTER phytoplankton pigment and optical data to develop quantitative linkages between phytoplankton taxonomy and remotely sensed ocean color data along the Western Antarctic Peninsula (WAP). Major phytoplankton groups will be determined using HPLC pigments, and the relationship between composition and measured, in-water optics will be determined for verification of the remotely sensed data. This information will provide a solid platform on which to develop the link between ocean color data and major taxonomic groups in this important oceanic region.

Vernet is also advising PAL Postdoctoral Fellow martin Montes-Hugo. Montes-Hugo has finished the following scientific activities: 1) organization and quality control of chlorophyll *a* (total and chlorophyll fractions) datasets for the whole Pal-LTER time-series (1991-2006). Datasets are ready to be browsed through SQL queries applied to access files, 2) writing of scientific project (Phytoplankton size-structure bio-optical algorithms based on light backscattering) and manuscript to be submitted to International Journal of Remote Sensing, 3) writing software to analyze, visualize and integrate in databases optical measurements of profiling reflectance radiometer.

Publications submitted or in press (see elsewhere for published articles):

Vernet, M. and R.C. Smith Measuring and Modeling Primary Production in Marine Pelagic Ecosystems, in "LTER Net Primary Production Methods", J. T. Fahey and A. Knapp (eds.), Oxford University Press, *in press*

Zooplankton and micronekton (Ross/Quetin BP-028).

The zooplankton and micronekton (BP-028) group participated in the seasonal sampling from Palmer Station from mid-October 2005 until late March 2006, and participated in the January 2006 annual cruise. Seasonal sampling included collection of Antarctic krill for 1) length and stage or mature female frequency and *in situ* growth rate experiments from October through December, and 2) collection of krill from schools for length frequency, digestive gland size, and pigment content from December through March, and 3) twice-weekly bioacoustic runs of two transects (B to E and F to J) within the 3.7 km boating limits of Palmer Station with a

BioSonics DT-X echosounder once the waters were ice free (Dec through Mar). Pigment content is used as an index of ingestion rate throughout an austral summer. Water was also sampled from within the krill school. These data will be utilized to help estimate the role of grazing in the DMS cycle in a collaboration with Matrai and Dacey who studied the dynamics of DMS throughout the season.

On the cruise, two net tows conducted simultaneously with an acoustic transect (BioSonics DT-X echosounder) were done at each station. At each station, the catch was analyzed for zooplankton community composition, including fish larvae. If Antarctic krill or salps were in the catch, length frequency and either occurrence of mature females (krill) or phase (solitary/aggregate for salps) determinations were done on all or a subsample of the total. In situ growth and egg production experiments on Antarctic krill at selected stations allow estimations of secondary production of this dominant member of the zooplankton/micronekton community.

Scientific meetings attended – R M Ross and L B Quetin attended the 11th SCAR International Biology Symposium (July 2005) in Curitiba, Brazil to give an invited keynote presentation titled “Ecological responses of Antarctic krill to environmental variability: Can we predict the future?”

Community activities- Langdon Quetin continued his participation in two USAP committees, the Polar Dive Control Board and the Palmer Area Users’ Committee. Robin Ross completed her term on NISAC, the Network Information System Advisory Committee for the LTER Network with a meeting May 2006.

Education activities- 1) S A Oakes, a Ph. D. student partially supported by the Palmer LTER, continued her study of the energetic consequences of larval krill feeding on surfaces or in 3-dimensional space. 2) Undergraduates (2) and recent undergraduates (3) from UCSB experienced the operation of a multi- and interdisciplinary research program, and valuable hands-on experience in zooplankton ecology during the research cruise. The students also participated in the ‘Picture of the Day’, an informal outreach to a list of interested colleagues and friends that includes a picture and a paragraph of informative text on the range of activities going on during the cruise. 3) The Canadian Broadcasting group on the Sedona IV joined us on the LM Gould for a day of filming and interviews for use in a documentary on global warming. 4) Video segments from the filming efforts of one of our volunteers (David Huang) will be used as part of the education and outreach activities of the LTER. 5) ongoing information interactions with the tourists aboard the cruise shifts that visit Palmer Station.

Publications: the following mss are submitted or in press (see also above):

Martin, D. L., R. M. Ross, L. B. Quetin and A. E. Murray. Molecular approach (PCR-DGGE) to diet analysis in young Antarctic krill (*Euphausia superba* Dana). Mar. Ecol. Prog. Ser. (accepted Jan 2006) (in press)

Quetin, L. B. and R. M. Ross. Order Euphausiacea, in “The Light and Smith Manual: The Intertidal Invertebrates of Central California and Oregon” (Fourth Edition). (J. T. Carleton, ed.) (in press)

Ross, R. M., L. B. Quetin, C. Fritsen and M. Vernet. Ecological responses of Antarctic krill to environmental variability: Can we predict the future? Antarctic Science (to be submitted by June 7) Invited keynote presentation at the 11th SCAR International Biology Symposium (July 2005), Curitiba, Brazil

Ross, R.M., L.B. Quetin, D.G. Martinson, R.A. Iannuzzi, S.E. Stammerjohn, and R.C. Smith, 2006 (submitted). Palmer LTER: patterns of distribution of major zooplankton species west of the Antarctic Peninsula over a twelve-year span. Deep Sea Res., LTER special issue.

Microbes and Biogeochemistry (Ducklow BP-045) 2004-2005.

Fieldwork: 2005-2006 was our fourth full season since joining PAL LTER. We conducted semi-weekly sampling in Arthur Harbor (LTER Stations B,E) via Zodiac continuously from November, 2004 until 01 April, 2005. The work is coordinated closely with other PAL activities. Our objective is to gain a new understanding of the variability in bacterial dynamics and carbon cycling in the immediate nearshore ecosystem, as well as attaining insights into the controlling factors and linkages to processes occurring offshore as sampled on the annual summer cruise. We collected data on bacterial abundance and production rates, dissolved organic carbon concentrations and lipid biomarkers. We completed a third consecutive full set of observations on the seasonal cycle of microbial biomass and activity (we didn't sample in January 2003, but otherwise covered the 02-03 season). We are now analyzing 4 years of data and preparing a manuscript on this comprehensive data set, believed to be the only detailed, multiyear seasonal investigation of bacterial dynamics in the Antarctic.

We also participated on LMG 06-01. The specific objectives of our project are to understanding the role of bacteria in the Antarctic marine foodweb and document spatial and interannual variability in selected carbon system properties (Sedimenting organic matter, DOC, DIC and Oxygen). The deep ocean sediment trap array was recovered and redeployed successfully once again. The sediment trap failed to collect material in 2001-02 but we have complete annual coverage for 12 of 13 years since the program began in late 1992 – an extraordinary record for the Antarctic. We again coordinated release of current drifters for R Beardsley (WHOI; see Findings).

Labwork: Analysis of DOC samples is finally making progress. The new RPSC Shimadzu TOC-V Total Organic Carbon Analyzer was shipped to VIMS and set up in our lab after we encountered very frustrating mechanical/electronic/software problems and were not able to commence sample analyses during the 04-05 season at Palmer Station. Diagnosis and repair was understandably complicated by the remote location. We now have the instrument working reliably and will have worked down the sample backlog by midsummer, so the TOC-V can be returned to Palmer Station.

Publications: Several mss were completed and submitted in 2005-06. Published articles are listed elsewhere in this report.

Ducklow, H. W. and others. Marine ecosystems: The West Antarctic Peninsula. *Philosophical Transactions of the Royal Society of London, Special Theme Issue, "Antarctic Ecology: From Genes to Ecosystems."* (A. Rogers, E. Murphy and A. C. Clarke, Eds.) (accepted).

Ducklow, H. W. and P. L. Yager. Pelagic bacterial processes in polynyas. In *Polynyas: Windows into Polar Oceans*. W. O. Smith and D. Barber. eds. Elsevier/CRC. New York. pp. (*in press*)

Ducklow, H. W. W. Fraser, D. M. Karl, L. B. Quetin, R.M. Ross, R C. Smith, S.E. Stammerjohn, M. Vernet and R. M. Daniels. Water column processes in the West Antarctic Peninsula and the Ross Sea: foodweb structure and interannual variability. *Deep-Sea Research II*, (*in press*).

Education activities- Joann Kelly, an REU student (UVA) participated on LMG0601. Current grad student Heidi Geisz completed her second year at the WM-SMS and is working on her thesis on pollutants in seabirds. A new Ph.D. student, Kristen Myers completed her first year of classes and will be at Palmer Station in the upcoming season. Another grad student, Yawei (Wayne) Luo, working on a non-PAL-related project also participated on LMG 0601.

Information Management (Baker)

Transition of the Palmer LTER computational infrastructure was completed this year after a decade of hardware use at UCSB/Institute for Computational Earth System Science. PAL is contributing to the conceptual as well as the physical development of infrastructure within the SIO Integrative Oceanography Department (IOD). We have presented informal seminars on both ‘Ocean Informatics’ as well as ‘Infrastructure Studies’. After leading two reading groups in the last years as community building efforts, we have focused this year on targeted working groups, strategic design teams and focus groups addressing joint tasks as they emerge. These tasks have included design schema, dictionaries, and plotting alternatives. As a field-information system bridging project, the PAL data manager leads a cross-project team developing a digital event logger that holds potential both to replace typical handwritten logs and also add structure to cruise activities aimed at facilitating post-cruise data ingestion into a data system.

Having developed last year the capacity to deliver metadata into the Ecological Metadata Language format (EML, a standard endorsed by the LTER community), we addressed this year the need to develop more sophisticated mappings and relations among the various datasets in order to incorporate them into a fully functional relational database system. In addition to an ongoing intensive data modeling effort, two dictionary modules have been incorporated and are actively used. The first is a multi-project unit registry, part of a cross-LTER site federating working group. In addition, an attribute dictionary with attendant administrative module capabilities is in place. This module was designed and developed in order to be appropriate for cross-project use. In addressing cross-project design needs in general, a third generation data system was launched early this year. It provides a single portal to multiple projects and runs in parallel with the project-specific second generation systems.

We continue to use the suite of open source tools: Apache, MySQL, and PHP. LTER PAL website launch this year solidified our strategy of delivery to include a two site architecture, ie a development and public arenas, that facilitates development of more complex web elements over time. In addition, the bibliographic and photo/media modules have been updated as part of our cross-projects work in addition to prototyping web delivered dynamic plotting.

LTER PAL information management network activities include co leading a Dictionary Process Design Team (Baker et al, 2005) that culminated in demonstration of a prototype at the Information Manager meeting. Members of the PAL information management team contributed a variety of articles and article types to Databits, the LTER Community Newsletter (Baker et al, 2006a,b; Millerand et al, 2006; Yarmey, 2006; Haber, 2006; Kortz, 2006; see Databits Spring 2006 <http://lternet.edu>). The PAL Information Manager participated in the LTER Planning Process as a member of three committees (Governance, Human Dimensions, and Cyberinfrastructure). Work with the governance team culminated in some major LTER by-laws changes approved by the coordinating committee in May 2006. Three members of the PAL data management team attended the annual LTER Information Manager meeting.

Collaboration with science and technology studies continues with G.Bowker (director of SCU Science, Technology and Society Institute), PostDoc Florence Millerand, and graduate student David Ribes. This work has been presented to the LTER community via talks and written communications. Papers were presented at the American Society of Information Science and Technology (ASIST 2005) as well as the International Digital Government Conference (DGO 2006) on social science engagement and infrastructure building.

Publications (submitted or in press; published articles elsewhere in report):

- Karasti, H., K.S. Baker, and E. Halkola, accepted. Enriching the Notion of Data Curation in e-Science: Data Managing and Information Infrastructuring in the Long Term Ecological Research (LTER) Network. In M. Jirotko, R. Procter, T. Rodden, and G. Bowker (eds). Computer Supported Cooperative Work: An International Journal. Special Issue: Collaboration in e-Research
- Millerand, F., and Bowker, G.C., accepted. Metadata Standards. Trajectories and Enactment in the Life of an Ontology. In S.L. Star and M. Lampland (Eds), Formalizing Practices: Reckoning with Standards, Numbers and Models in Science and Everyday Life
- Millerand, F. and Bowker, G.C., accepted. Metadata Trajectories et <<enactment >>. In C. Rosental (Ed.), Sciences sociales et cognition. Paris: Editions de l'EHESS, Coll. Enquete.

Outreach and Education (Baker/Simmons)

Considerable time and effort has been given to laying the groundwork for Palmer Outreach through the development of the sites educational framework and instructional model. Having this established creates a context for our outreach efforts, aligning the research and education, facilitating coordinated experiences and guiding our interactions over the long term.

We have captured the essence of outreach, the concepts of ecological studies, federated network collaboration and the use of authentic inquiry science through the following specific involvements:

- Ocean Literacy Workshop at the Aquarium of the Pacific in Long Beach California. (June)
- Participation in the Online Ocean Literacy Network Workshop, (May 2006)
- Renee Carleton, research experience for undergrads REU, (June)
- Redefining the role of education outreach coordinator
- Reshaping the learning environment between education and science
- Completion of the DLESE Earth Exploration Toolbook Chapter on 'Penguin Shuffle' (July) <http://serc.carleton.edu/eet/index.html>
- Collaboration on the 'Tale of Two Krill' with CCE LTER. (ongoing)
- Awarded funding for Research Experience for Teachers (RET) supporting collaboration with two local high school teachers on curriculum design (August 2006)
- Creation of the iMovie "Portal to Remote Science" integrating the 'pictures-of-the-day' used at both the steering committee meeting in (August 2005) and revised for the Site Review (May 2006)
- Improved communication with site scientists through participation in site events such as the PAL steering committee meeting (2005) and the PAL site review (May 2006)
- Exploration of integration of the podcasts/interaction with College of William and Mary
- Investigation into the LTER Children's Book Series (Sept)
- Submission of collaborative proposal with Maria Vernet on Antarctic phytoplankton as an IPY contribution (June 7)
- Redesign of exhibit for UCSD/SIO Open House (October 21st, 2006)
- LTER Network participation through attendance at All Scientists Meeting Estes Park Colorado, (September, 2006) and continued participation on the Schoolyard Executive Education Committee

RESEARCH FINDINGS: Palmer LTER 2005-2006.

Overall:

We are about to submit (finally) a comprehensive set of manuscripts for publication in a dedicated volume of Deep-Sea Research II (H Ducklow, Guest Editor). These mss will document, describe and analyze the results of the first decade of observations on the LTER sampling grid. This collection of papers represents a detailed and comprehensive analysis of regional-scale variability in physical oceanography, sea ice, climate, ecological and biogeochemical properties in the PAL LTER study region. We believe it serves as a model for analysis of oceanographic data well beyond the PAL and pan-Antarctic realm however. Some of the specific findings from these analyses are outlined below. Next year's report will have a detailed summary.

Specific findings:

Seabirds (Fraser B-013).

Preliminary analyses of our snow enhancement experiments suggest there is a significant, negative correlation between Adélie penguin fledging weights and snow depth. Colonies in which snow deposition was enhanced fledged chicks up to 550 g lighter than in control sites where wind was permitted to scour snow off breeding locations. This implies that landscape processes, acting independently of marine influences, may be driving key aspects of the demography of this species. Although these dynamics were previously suspected, experimental confirmation has far-reaching implications to a broad suite of ecological issues, including the effects of landscape geomorphology on biological populations, the mechanics of source-sink population dynamics, and, now, the possibility of establishing basic conceptual and empirical links between marine and terrestrial ecology.

Phytoplankton and optics (Vernet B-016 and Vernet/Smith B-032).

This component of the Palmer LTER is studying the spatial and temporal variability of primary production in the Western Antarctic Peninsula, physiochemical parameters that control production and the community structure related to the variability observed. The main findings during the study period are: (1) As originally hypothesized, interannual variability in primary production correlates with ice edge dynamics during the spring and summer and, to a lesser extent, with the ice during the previous winter. The rate of primary production at Palmer Station in this season was average, with an estimated annual production of $142.6 \text{ g C m}^{-2} \text{ year}^{-1}$ (integrated over 6 months) compared to a maximum of $354 \text{ g C m}^{-2} \text{ year}^{-1}$ measured in 1995-1996 and a minimum of $54.3 \text{ g C m}^{-2} \text{ year}^{-1}$ in 1998-1999. Regional daily production on the shelf, sampled in January of 2006, was over two times higher than previously measured, with $1953.5 \text{ mg C m}^{-2} \text{ d}^{-1}$, compared to the 12-year running mean of $722.6 \text{ mg C m}^{-2} \text{ d}^{-1}$. Chlorophyll levels mirrored the main production pulses (late December, and late January into early February) throughout the season.

Physical Oceanography (Martinson B-021)

The Antarctic Peninsula (AP) is undergoing some of, if not *the*, most dramatic climate change on Earth (Figure 1). The AP shows: (1) the most rapid recent regional (winter) warming (5.35 times the global average), (2) **our work shows it has lost nearly all of its perennial sea ice cover on its western margin (dramatically changing surface boundary conditions, and**

ocean-atmosphere interaction), and (3) 87% of the glaciers in retreat, contributing to global sea level rise.

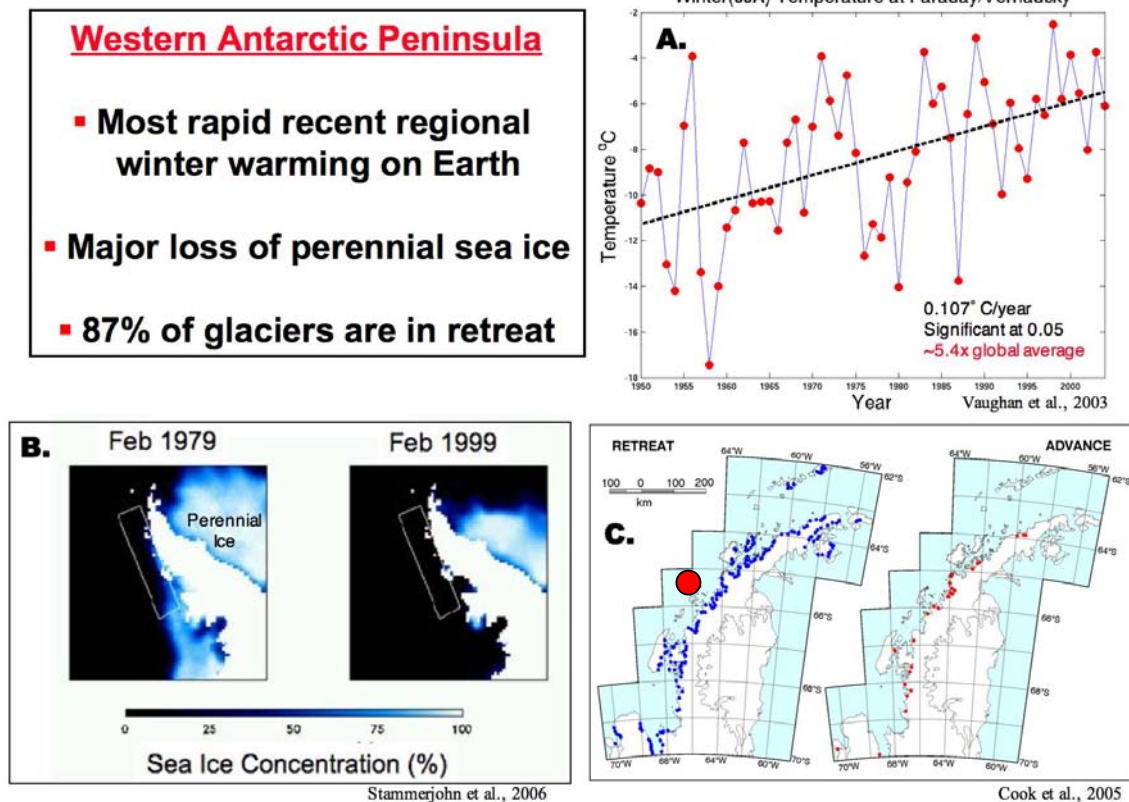


Figure 1: Summary of dramatic climate change over the Antarctic peninsula. Proposed mooring location shown in panel C by red dot (in heart of PAL–LTER sampling grid).

Recent studies have clearly shown that the problem of AP climate change is one involving global scale climate patterns (ENSO and Southern Annular Mode; SAM), their AP signatures and the regional feedbacks involving the ocean-ice interactions. The fundamental problem of interest is the source of heat responsible, its proximity, delivery and ventilation distribution, history and dependencies. *Thompson and Solomon (2002)* have shown that ~50% of the warming is likely to be a direct response to changes in atmospheric circulation associated with the bias toward increased positive SAM (strengthening of the polar vortex); **our work** (*Stammerjohn et al., 2006*, and *Martinson et al., 2006*) show that the remaining 50% is unknown, though the ocean is the likely culprit being the only source of heat in winter in the region. *Stammerjohn et al. (2006)* show that the atmospheric changes likely induce surface boundary responses that drive increased leads in the sea ice cover (venting more ocean heat) and increased ocean upwelling on the continental shelf providing more heat, as shown by *Martinson et al. (2006)*. We show that the changes conducive to surface divergence and upwelling are most common during La Niña and/or +SAM event years (note that the AP region shows the largest extratropical ENSO surface air temperature response on Earth).

We (*Martinson et al., 2006*) also find:

(1) WAP water masses are well separated according to bathymetrically-controlled features (i.e., continental slope, shelf and coastal sub-regions) that show consistent relationships.

(2) The most notable missing water masses in the WAP region are high- and low-salinity shelf water, fundamental ingredients of Antarctic bottom water. This is not surprising given the strong presence of the ACC that bathes the shelf in warm Upper Circumpolar Deep Water (UCDW). Heat fluxes and Modified-UCDW (M-UCDW) heat content on the shelf imply that the shelf is renewed (flooded) with fresh UCDW at least yearly on average.

(3) The poleward limit of the ACC, defined by the poleward limit of the UCDW (and here, apparent as the Southern ACC Front (SACCF)), lies regularly at the continental shelf break, making this region more susceptible to ACC influence than other regions around the Antarctic where the ACC is well removed from the shelf, typically by a polar gyre.

(4) The UCDW provides considerable ocean sensible heat to the waters below the mixed layer on the continental shelf, delivered to the shelf from the slope in response to geostrophic forcing, predominantly in the southern half of the grid, where this forcing is most consistent through time. The ocean heat dictates the nature of the ocean-ice interaction, lying at the foundation of PAL LTER hypotheses concerning the role of this interaction in dominating the ecosystem.

(5) Average winter ocean sensible heat flux from the ocean to the atmosphere is approximately 28 Wm^{-2} , a value estimated by the bulk parameter method of Martinson and Iannuzzi, 1998 and linearly related to the M-UCDW heat content on the shelf.

(6) The heat content supplied to the shelf (i.e., of the UCDW transported to the region by the ACC) increased dramatically in the 1990s relative to preceding decades (back until 1930), consistent with a 0.7° C warming of a 300 m thick slab of water on the shelf or an increase in ocean sensible heat flux of $\sim 4 \text{ Wm}^{-2}$, likely contributing to the recent anomalously high WAP atmospheric warming (this is not the coastal heat flux, which includes the glacial melt flux, not dealt with in this paper).

(7) 1998 was an anomalous year on the continental shelf, showing a dramatic regime shift in a number of properties, though most notably the heat content on the shelf which initiated a trend equivalent to $\sim 3 \text{ Wm}^{-2}$ annual increase in the ocean sensible heat flux and a jump in the salt content of the deep water comparable to the extraction of nearly 80 cm of sea ice (a 60% shift relative to climatology). Spring-to-autumn 1998-1999 displayed a large La Niña, amplified by a strong positive SAM, and preceded by the largest observed El Niño event in the instrumented record; numerous studies (e.g. Smith et al., 1996; Yuan and Martinson, 2001) have documented the large influence ENSO events have on the WAP area.

(8) 2002 was also an anomalous year on the continental shelf, showing an unusually large UCDW incursion across the shelf over the entire length of the grid, resulting in a remarkable 4.5σ excursion in shelf heat content and an unusually large salinity anomaly. Unlike the 1998 response that shifted the entire grid, the 2002 event was limited primarily to that particular year (influenced by a weak La Niña, but amplified by a strong positive SAM).

(9) The distribution of ACC-core UCDW on the shelf in individual years (Figure 8A) is consistently limited to the canyons, suggesting that the mixing involved with encountering the canyon walls to enter the shelf floor appears to mix the pure signal out. However, the rise to the floor at the northern end of Marguerite Trough appears to allow pure UCDW to intrude on the mid-shelf regions during some years, delivering more heat and nutrients to shallower depths, near Lavoisier Island and the southern end of Renaud Island.

(10) The geostrophic flow field for each of the 12 years shows a rather consistent, but complex, circulation field on the shelf: there are circulation cells in the southern and northern thirds of the sampling domain, with either a circulation cell or cross-shelf flow in the middle of the domain at Renaud and Lavoisier islands.

(11) Climatological patterns of the various physical properties seem to consistently fall into 1 of 3 primary patterns, with southern and northern ends of the grid showing different behavior from the rest of the grid due to the strong influence of Marguerite Bay in the south, and the shallow water region around Anvers island in the north (which may also be influenced by southerly flowing northern waters).

(12) Surface ocean anomalies (water above the WW to the surface relative to climatology) in T and S show similar lateral property gradients when moving from the slope toward the coast; the property gradients are comparable for each year (suggesting the mixing of two end-member water masses) resulting in a constant T:S of ~2:1. The lateral gradients are consistent with linear mixing that is proportional to the distance from the slope (i.e., incursions of UCDW toward the coast), such that the closer the incursion is to the coast, the stronger the anomaly.

The results of our study suggest that the relationship between the ACC and the WAP shelf is critical to the physical characteristics of the water column and ocean-ice interaction of the grid domain. Anomalies seem to clearly follow large scale forcings (e.g., ENSO events and SAM strength; La Niña and +SAM events leading to more upwelling of UCDW on the shelf). Grid-wide meteorological and continuous monitoring measurements are required to determine the details of the UCDW delivery to the shelf (nature of delivery, episodic or continuous, frequency and paths of intrusions). Finally, we need to better understand the relationship between Marguerite Bay and the remainder of the domain, as its influence in the south and near the coastal Islands is undeniable; sensitivities and feedbacks between the domain proper and Marguerite Bay have not been considered.

Zooplankton and micronekton (Ross/Quetin B-028).

In collaboration with Alison Murray of the Desert Research Institute, Reno NV, and using DNA as a marker molecule, we evaluated the efficacy of a PCR-DGGE (denaturing gradient gel electrophoresis) approach targeting the 18S rDNA gene to discriminate among diet constituents in gut and fecal pellet samples from young Antarctic krill relative to its feeding environment – the seawater and sea ice microbial community. We have conducted two laboratory-based feeding experiments with known food items, and three field samplings of both the krill and its feeding environment. Sequenced PCR-DGGE phylotypes from laboratory trials clearly distinguished diatom and copepod prey, while *in situ* feeding analyses revealed that a broad diversity of taxa were ingested, including: diatoms (Bacillariophyta, the most prevalent group detected), dinoflagellates, cryptomonads, prasinophytes, ciliates, cercozoans, choanoflagellates, turbellarians, and possibly sponge larvae. Band image analyses allowed environmental and diet phylotypes to be matched, where on average 32% of those from the environment were present in the diet. Conversely, of the phylotypes detected in the diet, an average of 59% were in common with the environment. Changes in environmental phylotypes among sampling dates were reflected by similar changes in the krill diet as potential prey diversity (richness) decreased during a phytoplankton bloom.

Analysis of the 12-year time series of zooplankton distribution and abundance within the summer study region yielded evidence of both cycles and trends:

- several zooplankton species, including Antarctic krill, showed both on/offshore and north/south gradients in abundance – with lower abundance in the south
- the pelagic tunicate, *Salpa thompsoni*, showed a distinct change in the patterns of the anomalies (differences from the long-term mean) after the rapid change from El Nino to a strong La Nina in 1998, with positive anomalies subsequent to that switch
- the range of the shelled pteropod, *Limacina helicina*, appeared to be increasing, spreading north, south and toward the continent from its area of climatological peak abundance on the outer shelf in mid-study region
- the anomaly patterns and the first mode in the Principal Components Analysis for both *Euphausia superba* and *E. crystallorophias*, two long-lived euphausiids, showed multi-year cycles in abundance (recruitment success)

Microbes and Biogeochemistry (Ducklow B-045).

We have now observed bacterial production rates for parts or all of 5 field seasons at Palmer Station (Jan-Mar 2002; Nov-Dec, 2002; Feb-March, 2003; Oct, 2003 – April 2004; Oct, 2004 – April 2005; Nov 2005 – April, 2006). There is substantial short-term (~10 day), seasonal and interannual variability in the BP signal. In general rates are low ($\leq 5\%$ of NPP) but not inconsistent with observations elsewhere in the Antarctic. BP appears to be limited by the supply of dissolved organic matter from phytoplankton, which appears to average less than 10% of the NPP. Labile DOC accumulation is transient and low (40-50 μM , background 40). Bacterial numbers as well as cell size and physiological state (DNA content) begin to increase in December, about a month after the phytoplankton. This initial rise is followed by a series of miniblooms lasting into March. The bacterial signal roughly parallels a midsummer rise in semilabile DOC concentrations.

Sampling the LTER Grid each January gives a view of the broader, regional scale. In 2005-06 BP ($\text{mgC m}^{-2} \text{d}^{-1}$) was greater than in previous years, but still amounted to a small fraction of the grid-averaged PP ($\text{mgC m}^{-2} \text{d}^{-1}$):

| Year | BP | PP | % | n |
|-------------|-----------|-----------|----------|----------|
| 2003 | 7 | 504 | 1.4 | 52 |
| 2004 | 23 | 456 | 5.0 | 54 |
| 2005 | 26 | 864 | 3.0 | 50 |
| 2006 | 33 | 1954 | 1.6 | 51 |

By comparing the detailed inshore data and summer grid data, we can start to explore the connections between inshore and offshore, shelf-wide processes.

With 12 years of sediment trap data, we can begin to relate flux estimates to other ecosystem components. The apparent export ratio (trap flux divided by primary production) seems to be related to zooplankton anomalies according to the equation, E-ratio anomaly = $-0.59 \times \text{krill anomaly} + 0.67 \times \text{Salps} + 0.11$ ($r^2=0.68$, $p=0.01$).

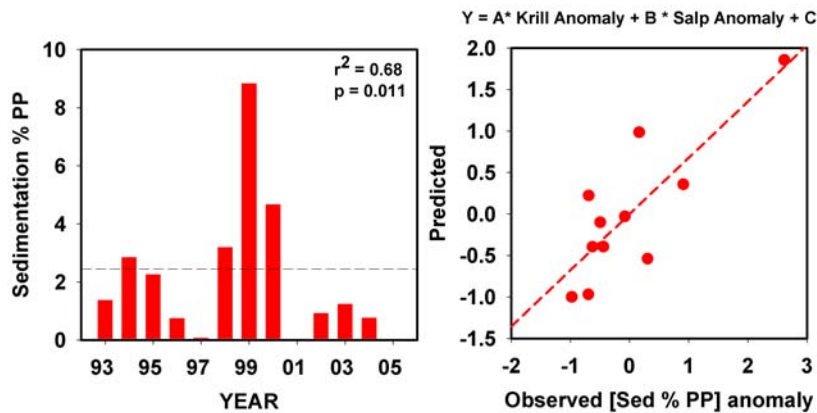


Figure 2. Sedimentation Export (E-) ratio related to zooplankton stocks in the PAL LTER Grid. The zooplankton stocks are averaged over the northern shelf region in the trap vicinity.

Circulation and Current Drifters: In January 2005 we initiated Lagrangian studies of the currents in the LTER region, in collaboration with Bob Beardsley and Dick Limeburner at WHOI. About 15 surface drifters were released throughout the grid in each of the past 2 seasons and tracked by satellite. The drifter tracks show a range of behaviors at several space and time scales. Over the period of LTER cruise operations (ca 7 Jan – 5 Feb), drifters and water parcels remain in the same location, suggesting the temporal and spatial coherence of our ship-based samples (i.e., quasi-synoptic sampling of LTER Grid over ~4 weeks). Over longer periods, drifters move well north and south of the study area and become entrained in sea ice. 5 of the drifters are now in the Bellingshausen Sea (http://www.whoi.edu/science/PO/LTER_Drifter/)

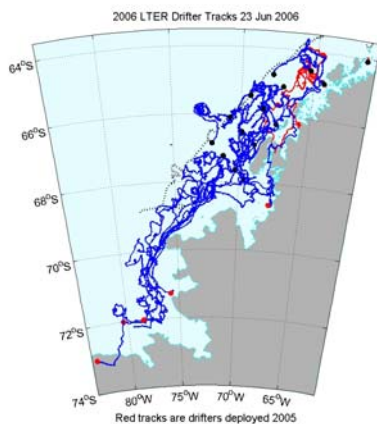


Figure 3. Drifter tracks for January to June 2005 (red) and 2006 (blue).

Information Management (Baker)

We have identified three distinct aspects of our local informatics environment: participatory design methodology, cross-project comparative strategy, and interdisciplinary collaboration. Our design studio long-term approach to design, infrastructure building, and participant engagement has created an environment where there are opportunities for innovative data modeling and bridging between informatics and science-in-practice. In addition, we have found that close cross-project collaboration on shared tasks has been a significant factor in informing development of our information system. This approach contrasts with more traditional short-term, technologically driven data approaches that make data accessible but not necessarily leading to queriability or automated interoperability. The environment created in partnership with social scientists functions as a venue for developing and articulating sustainable data practices as well as for addressing the underappreciated task of data scoping in today's contemporary era of expectations with respect to data curation and archive.

Education and Outreach (Baker/Simmons)

We have explored the value of collaboration among students, educators and scientists to enhance our existing, vibrant learning environment. In doing so, we actively continue to research inquiry learning, literacy and current pedagogical teachings. Our framework and instructional learning model are refined to reflect this research and provides coherent guidance for the interchange between the research and education communities over the long-term.