

Annual Report for Period:10/2004 - 10/2005**Submitted on:** 07/12/2005**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:****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:

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:

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: Mason, Kortz

Worked for more than 160 Hours: No

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:

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 Grzymalski 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****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

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_ant_sun2002_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 Nitrosospira-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

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, "Major impact of anomalous atmospheric circulation on sea ice in the Palmer LTER Region, Antarctica, late austral winter-early Spring 2001", *Journal of Climatology*, p. , vol. , (2003). Submitted

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
- Bowker, G. C. and K. S. Baker., "Information ecology: open system environment for data, memories and knowing.", *Journal of Intelligent Information Systems (BDEI Special Series)*, p. , vol. , (2004). Accepted
- 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
- Ainley, D. G., G. Ballard, S. D. Emslie, W. R. Fraser, P. R. Wilson and E. J. Woehler., "Adelie penguins and Environmental change.", *Science*, p. 429, vol. 300, (2003). Published
- Gauthier-Clerc, M., Gendner, J-P, Ribic, C.A., Fraser, W. R., Woehler, E.J., Descamps, S., Gilly, C., Le Bohec, C. & Le Maho, Y. 2004., "Long-term effects of flipper bands on penguins.", *Proceedings of the Royal Society, London B (suppl)*, *Biology Letters*, published online., p. S243, vol. 271B, (2004). Published
- Ross, R M and L B Quetin., "Working with living krill -- The people and the places.", Ross, R M and L B Quetin. 2003. Working with living krill ? The people and the places. *Marine and Freshwater Behaviour and Physiology* 36(4): 207-228., p. 207, vol. 36, (2003). Published

- Rebecca M. Dickhut, Alessandra Cincinelli, Michele Cochran, and Hugh W. Ducklow., "Atmospheric Concentrations and Air-Water Flux of Organochlorine Pesticides along the Western Antarctic Peninsula", *Environmental Science and Technology*, p. 465, vol. 39, (2004). Published
- Daniels, RM, HW Ducklow and TL Richardson, "Food web structure and biogeochemical processes during oceanic phytoplankton blooms: An inverse model analysis", *Deep-Sea Research II*, p. , vol. , (). Accepted
- H. W. Ducklow and Robert M. Daniels, "Water column processes in the West Antarctic Peninsula and the Ross Sea: interannual variations and foodweb structure.", *Deep-Sea Research II*, p. , vol. , (). Submitted
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Web/Internet Site

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.

In order to facilitate cross-community collaboration, the notion of an Ocean Informatics environment is being developed. Such an approach incorporates concepts of information system sustainability, data interoperability, and participatory or collaborative design.

Contributions to Other Disciplines:

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.

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 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.

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 2004-2005.**Overview.**

In April, 2005 we completed the third field season of the current award, and the 14th in the Palmer LTER program that commenced in 1991-92. The annual summer cruise (LMG 05-01) and summer season at Palmer Station were both successful but we were challenged by heavy, persistent and long-duration sea ice. Preliminary analyses suggests the latest ice retreat and ??? greatest extent ??? in 15 years (the entire length of our program). Zodiac operations at Palmer Station were hampered, with the first full sampling at Stations B,E on 17-18 November, and just 5 such full stations occupations before Christmas! The summer LMG cruise was also complicated by extensive sea ice, extending for example to Station 200.100 in late January. However nearly all regular grid stations were successfully occupied, thanks to dedicated ship operation by Captain Scott Flanagan and his officers and crew, as well as phenomenal support from RPSC MPC Andy Nunn and the MTIs, ETIs and Science Tech. During the cruise we visited Rothera Station, to carry out joint scientific operations with our BAS colleagues. This season we hosted Tim Hollibaugh's group from Univ. Georgia aboard LMG 05-01. Hollibaugh is studying the nitrification process along the WAP. We will host them again in 2006.

Our annual meeting was held at The Novartis Foundation, London in September. This was coordinated with the Antarctic Peninsula Climate Variability Workshop convened in Cambridge, where all PAL PIs presented talks or posters. The organizers and several participants noted the large impact PAL made at this international meeting. Later, Ducklow attended the Final Symposium of the SCAR Program, Ecology of the Antarctic Sea Ice Zone, giving the opening plenary lecture in Korcula, Croatia (see listing below). Fraser represented PAL at the ICCED Workshop, also held in Cambridge in May, 2005. ICCED is slated to be a large international program of Southern Ocean research beginning in 2008.

We had a major research and data synthesis workshop at Lamont-Doherty in May. There we reviewed our progress toward a special volume of Deep-Sea Research, Part II, focusing on the empirical orthogonal function (EOF) analysis of many decade-long PAL datasets. Papers are in preparation for submission later this summer. This will be the major synthesis effort on our program to date.

Ray Smith has retired from active duty at UCSB but is still very much involved in PAL. We have been engaged in a search for a postdoctoral fellow in phytoplankton ecology and biooptical oceanography since May, 2004. Offers have been made to two excellent candidates but unfortunately neither was able to accept. The search was extended and two finalists are now being reviewed.

Specific project activities are presented below.

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 negatively impacted by heavy sea ice. As in past seasons, we also 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 05-01), 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. Other research activities included further deployments of ARGOS-linked instruments on AdÉlie penguins to obtain at-sea foraging locations and dive-depth profiles, and assessing the first year results of experiments to examine the effects of snow deposition on AdÉlie penguin demography.

Major education activities, training, development and findings. Our field program has traditionally attracted both graduate and undergraduate students interested in gaining more experience in a variety of areas, including project planning and logistics, implementing and developing field methods and data management and analysis. Most of these students remain with our program for 2-3 years, and eventually seek positions with state and federal governments, or pursue other degrees. This season two former technicians were admitted (Fall 2005) to Ph.D. programs at the University of Montana (Ms. C. Anderson) and the University of Washington (Mr. D. Evans).

Outreach Activities. Project activities and findings reached the public in a variety of formats. Through national programs such as *Blue Ice*, a class on *The Ecology of Antarctica* was taught to several hundred K-12 students worldwide via Internet from Palmer Station. Blue Ice students were given project data to analyze and asked to interpret their results, which were then discussed via e-mail from Antarctica. There have also been collaborations with reporters representing a wide range of journals, magazines and newspapers, including *The Los Angeles Times* (McFarling 2004) and *National Geographic* (Montaigne 2004). Finally, at the invitation of Senator John McCain, testimony on the interactions between climate warming and ecosystem response in the western Antarctic Peninsula region was provided to the full Senate Committee on Commerce, Science and Transportation in May 2004 (Fraser 2004).

Physical Oceanography (Martinson BP-021)

Our efforts are aimed at providing a complete assessment of the physical oceanography (including air-sea-ice interactions) that are relevant to the complex physical-biogeochemical system on the western Antarctic Peninsula. This includes overseeing the CTD data collection, processing and analysis for each LTER cruise, and helping design a coherent data analysis/modeling strategy for synthesizing our observations.

In January 2005 we collaborated with R Beardsley (WHOI), deploying 16 surface current drifters at inshore, midshelf and coastal stations in our sampling grid. Drifter locations were reported by satellite daily to WHOI and positions calculated. An animation has been produced showing the paths and velocities of the drifters and data are being analyzed.

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

The phytoplankton (BP-016) and bio-optics (BP-032) groups carried out bi-weekly sampling via Zodiac Mark V within the 2-mile boating limit (Stations B & E) from October 2004 to the first of April 2005, and participated in the January 2005 cruise on the continental shelf. Sampling from October to December was limited by the presence of brash ice that prevented boating operations. Throughout the field season, the phytoplankton group (BP-016) sampled core variables, including daily primary production, particulate carbon and nitrogen, nutrients, and photosynthetic pigments. Core parameters for BP-032 included discrete chlorophyll (analyzed by BP-028) 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. Monthly experiments were carried out on the influence of microzooplankton grazing on phytoplankton (Dilution technique). For the first time, we also carried out these experiments on the January cruise (10 standard experiments in addition to 4 grazing experiments with simultaneous measurement of primary production, photosynthetic pigment, and particulate carbon and nitrogen collection). Experiments of macrozooplankton grazing were done in collaboration with BP-028 simultaneous with microzooplankton experiments.

Manuscript preparation during this period included: (1) Interannual variability in spatial distribution of phytoplankton communities on the shelf. (2) Interannual variability of chlorophyll vertical distribution on the shelf. (3) Principal component analysis of primary production variability and ice dynamics. Analysis efforts are done in collaboration with PAL PIs.

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

Research Activities - The zooplankton and micronekton (BP-028) group participated in the seasonal sampling from Palmer Station from mid-October 2004 until mid March 2005, and participated in the January 2005 annual cruise. Seasonal sampling included collection of Antarctic krill for: 1) condition factor of ~ one year old krill in austral spring at the end of their first winter, and 2) length and stage or mature female frequency and in situ growth rate experiments from October through December. Twice-weekly bioacoustic runs of two transects (B to E and F to J) within the 3.7 km boating limits of Palmer Station were conducted with a BioSonics DT-X echosounder after the cruise to document whether the late ice retreat impacted the seasonal pattern of krill abundance. Collection of krill was done by SCUBA divers in the early spring when waters were ice-covered, and with a net from a Mark V zodiac once the waters were ice-free. During January to mid-March, over 40 krill schools within the 3.7 km boating limit were sampled for length frequency, digestive gland size, and pigment content. The sampling scheme was devised to explore the within- and between-school variability in pigment content as an index of ingestion rate throughout an austral summer. Water was also sampled from within the krill school for the last 11 schools sampled. 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. At process stations, the grazing activity (whole body fluorescence for krill and salps and fecal pellet production experiments for krill only) of the two dominant macrozooplankton grazers was evaluated.

We also attended two workshops (Nov 2004, May 2005) run by our colleague D M Martinson at Lamont Doherty Earth Observatory on time-series analysis of LTER data sets. The workshops were to analyze and prepare for publication manuscripts on the spatial/temporal variability in various parameters, and to discuss possible environmental interactions.

Scientific meetings attended ñ Two members attended the SCAR Open Science meeting in Bremen, Germany in late July 2004 to present posters (RM Ross and SA Oakes), and one

attended the 'Antarctic Peninsula Climate Variability' meeting in Cambridge, UK to give a talk on changes in zooplankton abundance over the past 12 years.

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 as chair of ARVOC, the Antarctic Research Vessel Oversight Committee and NISAC, the Network Information System Advisory Committee for the LTER Network. R M Ross and S A Oakes both attended the Meeting of 100 in November 2004 as part of the Planning Proposal activities for synthesis in the LTER Network.

Education activities- 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. S A Oakes also helped write a proposal to the LTER Network Office for a graduate student meeting to acquaint each other with research activities at the various sites and to discuss with several mentors issues such as searching for post-doctoral positions and proposal writing. She was one of the prime organizers for this successful meeting at Andrews LTER in Oregon in April 2005. Two SCUBA divers (Sprague, Schwager) new to the program were trained for dry suit use in polar waters. Undergraduates and recent undergraduates 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.

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

Fieldwork: 2004-2005 was our third 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 Maria Vernet's (BP-016) sampling. 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. Sampling was considerably hampered by extensive sea ice in the immediate Palmer vicinity, or by storms, until after Christmas. Nonetheless we completed a second 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 also have observations from January to March 2002, made during our previous project on persistent organic pollutants.

We also participated on LMG 05-01. Ducklow served as Chief Scientist. 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. 3 more years of sediment trap data have just been added to the PAL data system (2000-2001 from D Karl and 2002-2004 from our lab). The sediment trap failed to collect material in 2001-02 but we have complete annual coverage for 11 of 12 years since the program began in late 1992 - an extraordinary record for the Antarctic.

Labwork: Analysis of DOC samples was delayed again. RPSC purchased a new Shimadzu TOC-V Total Organic Carbon Analyzer but we encountered very frustrating mechanical/electronic/software problems and were not able to commence sample analyses during the season at Palmer Station. Diagnosis and repair was understandably complicated by the remote location. The TOC Analyzer was shipped to VIMS and we hope to get it up and running reliably here (in closer access to service experts). Former LTER Grad Student Chris Carillo (Univ Hawaii) is working in our lab setting up our in-house facility for analyzing DIC and Alkalinity (ALK). Sediment trap samples for 2003 and 2004 were analyzed by an REU student. She is working on the 2005 samples now. Most bacterial samples for 2004-05 have been analyzed. Data are being processed now.

Publications and presentations: Ducklow gave the keynote address at the SCAR-EASIZ Final Symposium last September, in *Water Column Processes: Comparative Plankton Ecology In the Antarctic Sea Ice Zone*. 3 manuscripts have been submitted. A manuscript based on the EASIZ presentation was submitted to DSR-II. A manuscript synthesizing PAL data, in *Food web structure and biogeochemical processes during oceanic phytoplankton blooms: An inverse model analysis*, by Bob Daniels, Tammi Richardson and Ducklow was submitted to Deep-Sea Research II. Finally, an ms comparing microbial ecology of Antarctic vs Arctic polynyas (with P Yager, Univ Georgia) will be published in a new book on polynyas edited by Walker Smith and David Barber.

Education activities- Joann Kelly, an REU student (UVA) is working again in the lab at VIMS processing sediment trap samples. Current grad student Heidi Geisz completed her second year at the WM-SMS and is working on her thesis on pollutants in seabirds. 2 grad students participated in the LMG cruise along with recent MSc graduate from VIMS Bob Daniels. Daniels and another recent WM MSc grad, Taylor Heyl, worked at Palmer Station from February to April. Finally, as always, we worked with K-12 teachers and students in the Williamsburg-James City County, VA schools, making classroom visits and participating in *International Day* at Rawls Byrd Elementary School. The Rawls Byrd school mascot is the AdÉlie penguin.

Information Management (Baker)

Site information management activities included support for annual updates to the Palmer LTER database. In addition, transition of the Palmer LTER computational infrastructure was planned and largely carried out this year after a decade of hardware use. Experience with one of the oceanographic community's standard systems (<http://usjgofs.who.edu/jg/dir/jgofs/>) informed redesign of a relational database system that will be able to serve data into the Ecological Metadata Language, a standard endorsed by the LTER community. Data migration issues that arose during the JGOFS migration revealed the need for an extensive quality control effort and data normalization in addition to the need for development of site unit and attribute dictionaries. A mapping of the site metadata form tags to those of EML is ongoing and the subject of LTER community development as well. Enactment of EML for a federated site data system as detailed in the LTER data management guidelines demands -network interfaces and provides timely design criteria as PAL LTER undergoes a transition to a second generation relational data system.

PAL is contributing to the conceptual as well as the physical development of infrastructure within the SIO Integrative Oceanography Department (IOD) that provides a computational environment for the work of information management (Baker et al, 2005). Two reading groups

(Information Studies and Ocean Informatics), each meeting monthly, provide a forum for discussion of the science and practice of informatics. A new server (iOcean) has been integrated into the local infrastructure, providing web and shared data storage services. A redesigned LTER PAL website is being launched this year that creates an updated and more dynamic modular design common to other websites within IOD through updates to infrastructural elements, scripting, and to design with style sheets. The relational data approach began with a personnel directory in order to exercise a new suite of open source tools: Apache, MySQL, and PHP.

Local cross community work included a series of joint activities including discussion of critical terms such as data types, unit types, metadata, and integrative indexes. Development of and participation in a series of community design teams culminated in a cross-project working group producing a broadly defined data schema. LTER Network information management network activities include coleading a Dictionary Process Design Team (Baker et al, 2005), good reads for DataBits Newsletter (Baker and Wanetick, 2005; Millerand, 2005), participation of the PAL Information Manager in the LTER Planning Process as a member of three committees (Governance, Human Dimensions, and Cyberinfrastructure) and participation by several PAL participants in 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. A paper was presented at the Hawaii International Conference on System Science in addition to presentations at a variety of communities has provided opportunities to consider, together with the international community, how collaboration in the field of science is being addressed.

Outreach and Education (Baker/Simmons)

Project Training and Development (Program support and development). Continued interface with site scientists helps promote the collaborative nature of effective education outreach. One of our most recent collaborations was with the DLESE Data Services Workshop. We created our own team of participants (6), four of whom are connected with Palmer Education and Outreach (education coordinator, information manager, Palmer scientist, local teacher). This collaboration allowed Palmer to establish a network of participants that learned from each other while contributing to a common effort. An educational module is being developed, centered around Palmer's ice time-series data that incorporates the use of a data visualization and analysis tool called My World to support the inquiry learning process.

The concepts of biome research, federated network collaboration, and authentic data have been captured and delivered into educational arenas through the following specific activities:

- Co-Organizer of Artists and Writers program/ Storytelling workshop held at UCSD/SIO in 2004/05.
- Organized 2004/05 author visits to the Preuss School (Phytoplankton Soup Series/Using Your Senses to Learn Science).
- Implementation/assessment of phytoplankton/krill lesson to 6th graders @ University of San Diego's, Preuss School.
- Implementation of Sea Ice/Penguin DLESE Data Services EET Chapter to 6th graders at the UCSD, Preuss School.

- Contributor to the 2005 Marine focused NSF Symposium/LTER Coordinating Committee meeting.
- Continued contributions to our site repository of educational assets
- Participant in Ocean Literacy Workshop @ the Long Beach Aquarium of the Pacific June 15th, 2005.
- Compilation of Education/Outreach portfolio materials and artifacts as resources for program participants and classroom teachers.
- Member of the LTER Schoolyard Education Committee and participant in the LTER Schoolyard annual meeting.
- Contributed a chapter for the LTER Schoolyard Education Handbook and participated in the assessment process (February, 2005).
- Assessing and revising a DLESE Data Services EET chapter after implementing it at a local level through the UCSD's Preuss School.

RESEARCH FINDINGS: Palmer LTER 2004-2005.**Overall:**

We are currently preparing a comprehensive set of manuscripts for publication in a dedicated volume of Deep-Sea Research II. These mss will document, describe and analyze the results of the first decade of observations on the LTER sampling grid. Results will be presented at the PAL Site Visit in November, 2005 and at the Winter Ocean Sciences meeting next February.

Specific findings:**Seabirds (Fraser BP-013).**

Preliminary analyses of our snow enhancement experiments suggest there is a significant, negative correlation between AdÈlie penguin fledging weights and snow depth. 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 BP-016 and Vernet/Smith BP-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 (as indicated by the ice ì end daysî index) and, to a lesser extent, with the ice during the previous winter. (2) This year production was higher than the average; (3) Dilution experiments to estimate the fate of the phytoplankton carbon revealed that microzooplankton grazing in coastal waters near Palmer Station (St. B and the shelf) indicate a large variability in grazing losses by microzooplankton.

The rate of primary production at Palmer Station in this season was intermediate, compared to the maximum of 354 g C m⁻² year⁻¹ measured in 1995-1996 and the minimum of 54.3 g C m⁻² year⁻¹ in 1998-1999. Regional daily production on the shelf, sampled in January of 2005, was above average, compared to the 10-year mean of 630 mg C m⁻² d⁻¹. Chlorophyll levels mirrored the main production pulses (late November, late December and early February) throughout the season.

Physical Oceanography (Martinson BP-021)

The most exciting finding is that the ocean heat flux to the WAP (the primary source of heat to this region showing the most rapid warming on Earth), has undergone a significant jump in the 1990s relative to the previous decades back to 1930.

Other findings include the following:

- (1) WAP water masses are well separated according to bathymetrically-controlled features (i.e., the continental slope, shelf and coastal sub-regions) that show extremely consistent relationship, with the slope waters presenting as more angular shapes in T-S space reflecting frequent renewal by lateral advection from the ACC, while the coastal waters show more

rounded shapes due to vertical mixing, given their isolation from the ACC, the shelf presents in a rather intermediate form;

- (2) the southern limit of the ACC, defined by the southern limit of the UCDW, 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;
- (3) the UCDW provides the heat to the deep waters on the shelf, that dictate the nature of the ocean-ice interaction, at the foundation of our hypothesis concerning the role of this interaction in dominating the ecosystem;
- (4) average winter ocean sensible heat flux from the ocean to the atmosphere is approximately 30 Wm^{-2} , a value derived by the bulk parameter method of Martinson and Iannuzzi, 1998, and with heat conservation assuming that the heat available to the shelf over the slope is indeed the source of heat on the shelf;
- (5) 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 0.6° C warming of a 300 m thick slab of water on the shelf, or an increase in ocean sensible heat flux of $\sim 10 \text{ Wm}^{-2}$;
- (6) the most notable missing water in the WAP region is high- or low-salinity shelf water, one of the fundamental ingredients of Antarctic bottom water, though this is not surprising given the strong presence of the ACC which minimizes the amount of water mass modification that can accumulate on the shelf in this region, and in the protected embayments, the huge inflow of glacial melt water effectively buffers the deeper water from extensive modification;
- (7) computation of the geostrophic flow field for each of the 10 years shows a rather consistent, but complex, circulation field on the shelf, but without absolute current meter measurements, we cannot be sure what fraction of the total flow field obeys geostrophy, there are systematically a circulation cell at the southern and northern thirds of the sampling domain, with either a circulation cell in the middle, or cross-shelf flow tendencies in the middle of the domain;
- (8) the freshwater content of the upper ocean (above the permanent pycnocline stabilizing the upper ocean) showed a dramatic shift in interannual anomalies about the climatology, whereby they were consistently strongly negative ($\sim 30\%$ of climatology) through 1997, after which they changed to be uniformly positive by the same magnitude from 1998 onwards;
- (9) surface ocean anomalies (water above the WW to the surface relative to climatology) in T and S are present in 1995, 1997, 1998, 2001 and 2002 that show the same lateral property gradients when moving from the slope toward the coast; temperature anomalies show a similar gradient (resulting in a 2:1 change in T:S; 1994 and 1996 show the T gradients, but not S). 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 to the coast the incursion went, the stronger the anomaly (coastal regions are least influenced by the UCDW, so when it does approach, it makes a large jump in properties relative to climatology). A 2-variable linear regression suggests that a large fraction of the salinity anomalies ($\sim 96\%$) are described by the relationship of distance of incursion from slope, and 34% of the residuals about that regression are fit by regressing the residual salinity anomaly against surface air temperature (reflecting a sea ice impact in addition to UCDW mixing effect);

(10) a number of upper ocean property distributions show remarkably consistent relationships in their cross-shelf and interannual anomalies which we take as evidence that the anomalies are consistently a mixture of UCDW (controlled by the distance of the ACC incursions onto the shelf) and the amount of glacier melting each year ñ this relationship is particularly strong in the middle of our 500 line, about 100 km south of Palmer Station.

(11) Climatological patterns of the various properties seem to consistently fall into 1 of 3 primary patterns, with the northern and southern ends of the grid showing different behavior from the rest of the grid owing to the strong influence of Marguerite Bay in the south, and the shallow water region around Anvers island in the north 9whih may also be influenced by Bransfield Strait waters flowing in from the north.

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

Analysis of 12 years of catch data for larval Antarctic silverfish, *Pleuragramma antarcticum*, showed that larval silverfish precipitously declined in abundance in the northern section of the PAL grid after large catches in 1993-1996, and have not been collected there since 1999. Larval silverfish are still found in the southern coastal region and in Marguerite Bay. The 0405 season was unusual for the late retreat of sea ice, which had repercussions at multiple levels of the food web. For Antarctic krill, the reproductive cycle was delayed and spawning had not yet occurred over most of the PAL grid by January. Few krill of the age class 1 size were present, suggesting that recruitment for year class 2004 was low. For the first time in 6 years, the shelled pteropod *Limacina helicina*, was not among our most abundant species, leading to speculation on the role of summer ice on its distribution.

Microbes and Biogeochemistry (Ducklow BP-045) 2003-2004

We have now observed bacterial production rates for parts or all of 4 field seasons at Palmer Station (Jan-Mar 2002; Nov-Dec, 2002; Feb-March, 2003; Oct, 2003 ñ April 2004; Oct, 2004 ñ April 2005). Only in the past 2 years do we have complete weekly to semiweekly coverage. There is substantial short-term (~10 day), seasonal and interannual variability in the BP signal. In general rates are low (~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. These observations highlight the importance of obtaining complete seasonal observations of microbial/organic biogeochemical processes in the nearshore ecosystem (Oct to April).

Sampling the LTER Grid each January gives a view of the broader, regional scale. Microbial activity is strongly enhanced in the southern part of our sampling region, inside Marguerite Bay (roughly, stations 200.-060 to 200.020). This enhancement of heterotrophic microbial activity is reflected in lower DIC concentrations. The lowest concentrations of dissolved inorganic carbon (DIC or total CO₂) are routinely found at the inner stations on the 200 line, and underway pCO₂ is strongly depleted in that region. A new time series program recently started at Rothera will provide new insights into stimulation of microbial activity in Marguerite Bay.

With the addition of new inshore data we can start to explore the connections between inshore and offshore, shelf-wide processes.

3 more years of sediment trap data have just been added to the PAL data system (2000-2001 from D Karl and 2002-2004 from our lab). The sediment trap failed to collect material in 2001-02 but we have complete annual coverage for 11 of 12 years since the program began in late 1992 – an extraordinary record for the Antarctic. Although many years have similar total annual carbon flux ($\text{mgC m}^{-2} \text{y}^{-1}$), the range from the minimum to maximum observed annual flux is an order of magnitude. Fluxes during any given year range over about 4 orders of magnitude. We have begun to discern coupling among the ice retreat, primary production and vertical fluxes at our site.

Information Management (Baker)

In concert with the LTER approach of embedding data management within an operational scientific research site, we find that community engagement through development of common language (i.e. core data, metadata, unit registry, attribute dictionary, integrative indexes) during joint activities is a critical element for creating sustainable data practices for a long-term and/or federated data system. Further, successful data management strategies include identifying and designing processes that integrate with site component work practices. Engagement with interdisciplinary social science partnerships provides critical help with language and perspective making in support of long-term information system design.

Education and Outreach (Baker/Simmons)

In our pursuit to bridge long-term scientific research and education, the Palmer Education and Outreach Program continues to research the “science of learning”. In doing so, the social, political and pedagogical context in which learning takes place is examined. As a result, we are in the midst of refining the Palmer Education Framework that addresses the challenges of teaching and learning and anchors our curriculum design. Additionally, an inquiry-based learning model unifies the features of our framework with pedagogical research and combines the characteristics of authentic learning environments with research on inquiry learning. The instructional design of this learning model aids in the development of authentic learning applications that support student inquiries and assist the teachers we interface with in their curricular development. In addition to the benefits of guiding our outreach efficacy, researching the science of learning also helps us define the role scientists’ play in our outreach program and how their contributions strengthen our community of learners.

RESEARCH ACTIVITIES

Overview.

In April, 2004 we completed the second field season of the current award, and the 13th in the Palmer LTER program that commenced in 1991-92. The annual summer cruise (LMG 04-01) and summer season at Palmer Station were both successful with few major problems. We lost 5 days off the cruise due to logistical demands imposed by other cruises. This resulted in our canceling one of 3 24-h process studies but the entire LTER grid was completed. The BioSonics Acoustic Sensor system was lost when a Leopard Seal attacked and sunk a Zodiac tied up at the dock overnight at Palmer Station. The Autonomous Profiling Vehicle from ??? failed to perform reliably during the past season and has been retired. The Fast Repetition Rate Fluorometer failed during the cruise, depriving us of some important data. Otherwise most individual systems worked well and we collected much valuable data.

We held a large annual meeting in Montana in August, 2003. Many students and technicians were invited to meet with the PIs. Several guests (David Ainley, Colm Sweeney and Andrew Clarke) also attended our meeting. We reviewed the past season, presented and discussed results and planned for the year ahead. One major topic was how to replace retiring PI Ray Smith (see below). Ducklow and X. Yuan (Martinson colleague) attended the Southern Ocean meeting at The Royal Society in London in July.

Ray Smith is retiring in September 2004. We are considering alternatives for filling his place in PAL. In the interim we've decided to hire a postdoctoral fellow and started a formal search in January, 2004. We are currently negotiating with a candidate.

Specific project activities are presented below.

Seabirds (Fraser BP-013).

The seabird research group worked in the Palmer Station region from mid-October 2003 to mid-April 2004, sampling daily as weather permitted, and focusing its activities on the demography, foraging ecology and breeding biology of AdÈlie penguins. As in past seasons, we 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 04-01), 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 4-day field camp on Avian Island, Marguerite Bay, and a 1-day sampling effort on Armstrong Reef, Renaud Island, north of Marguerite Bay. AdÈlie penguins were sampled at both locations to compare aspects of their ecology with similar data from Palmer populations. Other research activities included further deployments of ARGOS-linked instruments on AdÈlie penguins to obtain at-sea foraging locations and dive-depth profiles, and the construction of a snow fence on Dream Island north of Palmer Station. The latter marks the beginning of experiments that for the next two years will examine the effects of snow deposition on AdÈlie penguin demography.

Major education activities, training, development and findings. Our field program has traditionally attracted both graduate and undergraduate students interested in gaining more experience in a variety of areas, including project planning and logistics, implementing and developing field methods and data management and analysis. Most of these students remain with our program for 2-3 years, and eventually seek positions with state and federal

governments, or pursue other degrees. This season Cynthia Anderson obtained a position with the Canadian Wildlife Service following her training with our program, Jordan Watson accepted a teaching position (Chemistry and Ecology) with a non-profit organization in Cambodia and Daniel Evans is supervising an endangered species research program of the USFWS. Heidi Geisz was accepted as a Master's student at the Virginia Institute of Marine Science, College of William and Mary.

Outreach Activities. The field team hosted Fen Montaigne, NSF Writers and Artists Program, during his extended stay at Palmer Station. Mr. Montaigne was a freelance writer specializing in environmental topics on assignment for National Geographic to produce a story on climate change. Personnel including Fraser, Patterson, Geisz and Pickering, were also involved in many off-site outreach activities, including talks to fraternal organizations and presentations at colleges, universities and at K -12 schools.

Phytoplankton (Vernet BP-016).

The phytoplankton (BP-016) and bio-optics (BP-032) groups carried out semi-weekly sampling via Zodiac Mark V within the 2-mile boating limit (Stations B & E) from October 2003 to the first of April 2004, and participated in the January 2004 cruise on the continental shelf. Throughout the field season, the phytoplankton group (BP-016) sampled core variables, including daily primary production, particulate carbon and nitrogen, 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. Also, an Ocean Sensors Autonomous Profiling Vehicle (APV) was moored in Arthur Harbor to collect time series CTD and fluorescence data. While working out mechanical difficulties between October and February, the APV was deployed a total of 72 days, with data being collected every four to six hours. On February 25th, the instrument was recovered and found to have irreparable piston damage and was returned to OS for repairs.

In collaboration with Joseph Grzymiski, DRI, time series data (October through December) on Arthur Harbor sub-surface water was collected with a Fast Track Rate Repetition Fluorometer for phytoplankton physiological studies of environmental forcing (i.e. photo-inhibition, nutrient limitation). Additionally, weekly experiments were carried out on the effect of ultraviolet radiation on daily primary production and phytoplankton composition, on the influence of microzooplankton grazing on primary production, and the on the rates of DOC production as compared to primary production.

Data analyses during this period included: (1) An investigation of phytoplankton dynamics during periods of ice formation and ablation. (2) A study of carbon cycling through the coastal Antarctic food chain. (3) A study of the major drivers to inter-annual variability in primary production and its relationship to climate variability. (4) A study of pigment changes in winter sea ice algae after exposure to ultra-violet radiation. During this period we also completed a project looking at the relationship of temporal and spatial variability in primary production to environmental parameters. This work is being done in collaboration with all PAL PI's. In particular, there are 2 synthesis efforts: (1) A statistical analysis of physical, chemical and biological parameters through EOF and CCA analyses, and (2) the estimation of carbon cycling through the food chain.

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 2003 until late January 2004, and participated in the January 2004 annual cruise. Seasonal sampling included collection of Antarctic krill for: 1) condition factor of ~ one year old krill in austral spring at the end of their first winter, and 2) length and stage or mature female frequency and in situ growth rate experiments from October through January. Twice-weekly bioacoustic runs of two transects (B to E and F to J) within the 3.7 km boating limits of Palmer Station were conducted with a BioSonics Model 102 echosounder from mid-November when ice left the area until mid-January when a leopard seal punctured the pontoons on the zodiac holding the echosounder equipment and the system was irreparably damaged by saltwater. Collection of krill was done by SCUBA divers in the early spring when waters were ice-covered, and with a net from a Mark V zodiac once the waters were ice-free. 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. At process stations, the grazing activity (whole body fluorescence for krill and salps and fecal pellet production experiments for krill only) of the two dominant macrozooplankton grazers was evaluated. In February/March 2004 we conducted a series of experiments in a collaborative effort with Dr. T K Frazer at the Spanish base. We investigated the relationship between ingestion rate measured by chlorophyll a disappearance, and estimated by the field ingestion method with plant pigment (whole body fluorescence) in the krill immediately at the end of the experiment and clearance times estimated by the disappearance of pigment in the krill.

Education activities- 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. Two SCUBA divers (Green, Cheng) new to the program were trained for dry suit use in polar waters. Undergraduates and recent undergraduates from UCSB experienced the operation of a multi- and interdisciplinary research program, and valuable hands-on experience in zooplankton ecology during the research cruise.

Bio-optics (Smith/Vernet BP-032)

The bio-optics (BP-032) and phytoplankton (BP-016) groups carried out coordinated semi-weekly sampling via Zodiac Mark V within the 2-mile boating limit (Stations B & E) from October to the first of April 2004, and participated in the January 2004 cruise on the continental shelf. In collaboration with other LTER PIs the BP-032 group focused on Profiling Reflecting Radiometer (PRR) and SeaCAT CTD data and analysis.

Analysis of satellite data included: SeaWiFS ocean color data, to provide an estimate of pigment biomass; passive microwave satellite data, to provide daily estimates of sea ice extent and/or sea ice coverage; scatterometer data, to provide estimates of monthly winds. A space/time analysis of SeaWiFS data, along with observations by Vernet (BP-016), is being used to study the relationship of pigment biomass to other environmental parameters. Microwave and scatterometer analysis were carried out in collaboration with Martinson and Stammerjohn (B-

021-L). These satellite data are being used to investigate the larger regional domain surrounding the Palmer LTER ship sampling grid as well as the space/time climatology and seasonal variability of the western Antarctic Peninsula region. These data are also being used in the collaboration with the PAL PI synthesis effort (see Vernet findings).

Microbes and Biogeochemistry (Ducklow BP-045) 2003-2004

2003-2004 was our second full season since joining PAL LTER. We conducted semi-weekly sampling in Arthur Harbor (LTER Stations B,E) via Zodiac continuously from mid-October, 2003 until 01 April, 2004. The work is coordinated closely with Maria Vernetis (BP-016) sampling. 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 also participated on LMG 04-01. Ducklow served as Chief Scientist. 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 (DOC and DIC). The deep ocean sediment trap array was recovered and redeployed successfully.

In addition to fieldwork we completed sample analyses for some but not all samples collected in 2002-2003. Analysis of DOC samples was delayed because the Palmer Station DOC analyzer proved unreliable for the second straight year. DIC samples were subcontracted to Lamont Doherty for analysis. Sediment trap samples for 2003 and 2004 are being analyzed now. All bacterial samples for 2002-03 and 2003-04 have been analyzed. Data are being processed now. We are analyzing data on DOC release experiments performed by the 016 group. Finally, we completed an inverse model analysis of the marine foodweb (including penguins) in the LTER study area (Robert Danielsí MSc thesis at VIMS). This work continues with a comparison between the LTER and Ross Sea foodwebs. Ducklow is invited to give a keynote address at the SCAR-EASIZ Final Symposium in September, and will synthesize findings from LTER and other Antarctic programs (AESOPS, ROAVERRS, BAS etc).

Education activities- Two REU students (one William & Mary, one Oberlin College) participated on our January cruise, experiencing the Antarctic environment, learning about oceanographic research and participation in our investigations in microbiology and biogeochemistry. A third RU student (W&M) created a website featuring the W&M educational initiative in the Antarctic and its interactions with the Williamsburg K-12 schools. A 4th REU student (UVA) worked in the lab at VIMS processing sediment trap samples. Lauren Rogers, a recent Stanford graduate supervised my field program for the entire season, learning about every facet of our research from logistic setup to field and labwork to data management.

Information Management (Baker)

Site data management activities included support for annual updates to the Palmer LTER database. In addition, transition of the Palmer LTER computational infrastructure was planned and largely carried out this year after a decade of hardware use. In preparing for redesign of the Palmer LTER data system, an earlier workshop on Data Management Exchange provided input for the installation of the Joint Global Ocean Flux Studies (JGOFS) Data Management System. Installation occurred this year. The system is one the oceanographic community's standards

(<http://usjgofs.who.edu/jg/dir/jgofs/>) and Palmer PIs are familiar with the user interface. This application makes use of hierarchical file structure by study (cruise or season) so is compatible with the existing Palmer LTER system; conversion scripts are required to migrate to the expected JGOFS formats. Transfer of the data has been initiated with the goal of porting a full set of files from one cruise and one particular file from all the cruises in order to identify all data migration issues that need to be addressed and put needed computational infrastructure into place. In addition, the JGOFS data requirements are being juxtaposed with the LTER Ecological Metadata Language requirements as data is quality controlled and normalized. Transition work includes a site variable dictionary and establishment of a unit dictionary in XML and compatible with JGOFS and EML. A mapping of the site metadata form tags to those of EML has been initiated; full requirements are a subject of ongoing development throughout the community. Additional analysis packages such as LAS/FERRET and Ocean Data View and community exchange protocol packages such as NVOBS and OPENDaP are being investigated as part of transition efforts.

A focus on science and technology studies continues with collaborators G. Bowker, chair of the Dept of Communication at UCSD and H Karasti at the University of Oulu. This work has been presented to the LTER community via talks and written communications including articles in the LTER Newsletters. A paper was presented at the Hawaii International Conference on System Science and a poster presented at the LTER All Scientists Meeting. Follow-up on the Computer Supported Scientific Collaboration Workshop at the European Computer Supported Cooperative Work Conference in September 2003 included a published proceedings and a paper as well as the opportunity to consider, together with the international community, how collaboration in the field of science is being addressed.

LTER Network activity included participation in the LTER Information Manger Committee, attendance at the LTER IM Committee Meeting, a web services workshop, and an LTER IM Executive Committee Meeting in San Diego. Support was provided for the Spring 2004 LTER IM Databits issue. A new Palmer LTER website is under design that includes integration of a subset of collaborative tools and synergies with ongoing efforts at the LTER Network Office, at other LTER sites, and with an Antarctic NEON.

Outreach and Education (Baker)

Palmer LTER education activities are summarized on the site education web page (<http://www.ices.ucsb.edu/lter/education>). Coordination with the LTER Network Schoolyard activities continues with Palmer LTER participants attending and presenting at the education meetings held at the LTER All Scientists Meeting in Seattle (KS Baker, BE Simmons, and DRowls, 2003. Palmer LTER Outreach: Education-by-Design; R Bohanan, P McCartney, K Baker, A Berkowitz, and S Ortega. Integrating Long-Term Ecological Research and Data into Education Seattle, Washington, 18-21 September 2003).

Contacts with primary and secondary schools continued through partnerships with classrooms and university education office efforts. Coordination is ongoing with partners Scripps Committee for Outreach Programs in Education (SCOPE), an oceanography program taking science into the classroom, and the California Center for Ocean Science Education Excellence (COSEE), an NSF regional ocean science center consortium, a program fostering community awareness of long-term Antarctic science through outreach. Attendance at a national education workshop (B. Simmons, 2003. Looking at Data: Sea Ice. Science Education Resource Center) provided

feedback for the site's ongoing work this year in developing a Palmer LTER education framework. Prototype modules and lessons are under development in addition to a summary of the underlying pedagogy. Work with a subset of researchers helped to identify initial topics and data sets of interest for teaching at various levels of K-12 curricula.

LTER and Palmer LTER were highlighted at the UCSD/SIO annual open house (B Simmons, and K Baker, 2003. Palmer Station Antarctic Marine Biome and the Long-Term Ecological Network) with over a thousand attendees and 100 participants stopping to take a survey about Antarctica and to hear about Palmer LTER work. The survey provided valuable feed-back for next year's outreach efforts and about public perceptions of Antarctic Scientific research. Partnerships continue to develop with UCSD Preuss Middle/High School in La Jolla, California and with Rawls Byrd Elementary School in Williamsburg, Virginia. Other ongoing informal education efforts include contributions to the UCSB Marine Science Education Center-tours of touch tanks for pre-schoolers and VIMS publications (H Ducklow, VIMS leads long-term ecological research program in Antarctica. *The Crest*. 5: 6, 2003). The William & Mary outreach site (<http://www.wm.edu/antarctica>) presents a variety of Palmer activities, lessons, and continues field journaling representing a range of participant views over the years including teachers, volunteers, PhD's, students and technicians (LTER Network News, Baker, 2001).

Collaboration with authors whose work reaches K-12 student classrooms introduces the concepts of long-term and marine ecosystem science through both non-fiction and fiction books. Palmer LTER is cited in Mary Cerullo's recent book 'Under-the-Antarctic-ice'. As author of *Phytoplankton Soup* and *Zooplankton Soup*, collaboration on another school book is under discussion. Coordination continues with author Lucy Bledsoe, a participant in the NSF/OPP program for Artists and Writers for the 2003-2004 season. Palmer LTER contributed to the LTER Newsletter an article on Bledsoe's Antarctic book series (D Rawls, Palmer LTER Site: Publication of New Children's Book, *The Network Newsletter* Fall2003). Having sponsored an Antarctic Storytelling workshop introducing LTER concepts prior to Bledsoe's deployment, a post-deployment workshop is planned.

RESEARCH FINDINGS

Specific findings:

Seabirds (Fraser BP-013).

With the conclusion of the 2003-2004 season, we ended the acquisition of two complementary, overlapping databases on AdÉlie penguin foraging ecology that span the combined efforts of the GLOBEC and LTER programs since autumn 2001, and include continuous seasonal data on diets, foraging locations and dive profiles. Following the development of a statistical filter to validate and merge some database components, analyses are progressing with the objective of presenting results at the upcoming July 2004 SCAR meetings in Germany. Preliminary findings indicate there are significant differences in all aspects of AdÉlie penguin foraging ecology between the Palmer and Marguerite Bay populations. Moreover, and especially significant, is that we have observed gender-specific differences in the winter foraging ecology of this species that may account for some previously unexplained trends in the demography of AdÉlie penguins.

Phytoplankton (Vernet BP-016 and Vernet/Smith BP-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. (2) This year production was slightly higher than last season. (3) Dilution experiments to estimate the fate of the phytoplankton carbon revealed that microzooplankton grazing in coastal waters near Palmer Station (St. B) was negligible throughout the season (average = - 0.0009 d⁻¹, stdev = 0.009 d⁻¹, n = 17). These results continue to be consistent with the 2002-2003 season at Palmer as well as Ross Sea estimates. (5) Experiments of bacterial uptake of phytoplankton carbon excretion show low values (1-2% of primary production ñ see Ducklow results). (6) Experiments suggest that macrozooplankton grazing and cell sedimentation are the main sources of loss of phytoplankton from the upper mixed layer, with advection being an unknown factor. (7) Size fractionation of chlorophyll a through the season show that Palmer Station has a classical bloom development with a high proportion of small cells early in the season (October through December), including through the spring bloom (December), while large cells dominate/become more dominant during the January bloom and then during the fall (March).

The rate of primary production at Palmer Station in this season was average, with an estimated annual production of 220.8 g C m⁻² year⁻¹ (integrated over 6 months) from a maximum of 354 g C m⁻² year⁻¹ measured in 1995-1996 and a minimum of 54 g C m⁻² year⁻¹ in 1998-1999. Regional daily production on the shelf, sampled in January of 2004, was slightly below average, with 428 mg C m⁻² d⁻¹, compared to the 10-year mean of 609 mg C m⁻² d⁻¹. Chlorophyll levels mirrored the main production pulses (late November, late December and early February) throughout the season, with an additional increase in the measured chlorophyll a without a corresponding increase in production in the late fall (late March).

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

During the 0304 season, salps were primarily restricted to the northern transects and the outer shelf stations of the study region. Recruitment success of the 2003 year class of Antarctic krill was low, and reproduction the summer of 2004 delayed, but abundance was at approximately average levels. With grazing experiments performed on station, we found a strong correlation between measured ingestion rate and the pigment content (whole body fluorescence) of Antarctic krill. This information will allow us to better interpret grazing activity data (whole body fluorescence) taken at process stations during the annual cruise. Analysis of samples taken in austral spring 2002 for diet analysis with a molecular fingerprint technique (PCR-DGGE) was completed. The diet of krill feeding under the ice in spring showed evidence of feeding both on the sea ice biota and in the water column.

Bio-optics (Smith/Vernet BP-032)

Using satellite data we have developed a monthly climatology for a larger (~ 10 times) regional domain surrounding our normal 200 km x 1000 km Palmer LTER ship sampling grid along the western Antarctic Peninsula (WAP). This climatology covers the seven seasons from 1997/98 through 2003/04 and permits our regular January cruises to be placed into a larger spatial and a seasonal temporal context. These data are permitting a testing of several of our original, as well as a few new, hypotheses relating sea ice and pigment biomass. We find, in agreement with our initial hypothesis, that pigment biomass in the WAP region usually require relatively shallow mixed layer depths including, especially, those produced by stratification in the marginal sea ice zone. However, we may also be seeing an important influence of glacial melt water and investigating this influence is a current research focus. In addition, the climatology for the larger regional domain often shows increased biomass beginning in early spring beyond the shelf break before moving on shore in late spring, early summer. There is also evidence that a strong (weak) spring bloom follows a strong (weak) fall bloom, in agreement with the Ackley/Sullivan phytoplankton entrainment in sea ice hypothesis. This larger climatology should also permit an evaluation of the influence of the Antarctic Circumpolar Current (and associated Circumpolar Deep Water) as compared to local forcing within the Palmer LTER grid.

Microbes and Biogeochemistry (Ducklow BP-045) 2003-2004

We have now observed bacterial production rates for parts of all of 3 field seasons at Palmer Station (Jan-Mar 2002; Nov, 2002 ñ March, 2003 and Oct, 2003 ñ April 2004). There is substantial short-term (~10 day), seasonal and interannual variability in the BP signal. In general rates are low (~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. 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 appears to be reflected in the temporal sequence of semilabile DOC concentrations. Semilabile DOC averages about 10-20 µMol above the deepwater background value, without a clear seasonal pattern.

We completed construction of a detailed, quantitative description of foodwebs for the LTER region in 1996 and 1999 (high and low production years respectively). Our approach was to use as much of the LTER data as possible and then use an inverse method to reconstruct the missing (not observed) flows. The models show that krill dominate the carbon fluxes in both

years, removing substantial portions of the primary production. The microbial loop and DOC fluxes are a relatively small part of the total carbon throughput but still significant. Only a small fraction of CO₂ (< 1%) is released by upper trophic level predators, in contrast to earlier speculations.