

Annual Report for Period:10/2002 - 10/2003**Submitted on:** 07/02/2003**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:**

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:

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.

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:** Rawls, Dawn**Worked for more than 160 Hours:** No**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:****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: 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:

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

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

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

Activities and Findings

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

Please see attached PDF file.

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

Please see attached PDF file.

Training and Development:

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

Outreach Activities:

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

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

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

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

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

Journal Publications

Hollibaugh, J. T., N. Bano and H. W. Ducklow., "Widespread Distribution in Polar Oceans of a 16S rRNA Gene Sequence with Affinity to 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) (accepted)", *Marine Ecology Progress Series*, p. , vol. , (2003). Accepted

Garibotti, I. A., M. Vernet, W. A. Kozlowski and M. E. Ferrario (2003). ô, "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

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. 000, vol. 000, (2003). Accepted

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. , vol. , (2003). Accepted

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. , vol. , (2003). Accepted

Books or Other One-time Publications

Ducklow, H. W., "Biogeochemical Provinces: Towards a JGOFS Synthesis.", (2003). Book, Published
Editor(s): M. J. R. Fasham
Bibliography: *Ocean Biogeochemistry: A New Paradigm*. New York. Springer-Verlag.

Baker, K.S., G.Bowker and H.Karasti, "Designing an Infrastructure for Heterogeneity in Ecosystem Data, Collaborators, and Organizations", (2002). Book, Published
Editor(s): Digital Government Research Center
Collection: *Proceedings of the 2nd National Conference on Digital Government Research*
Bibliography: Los Angeles, CA: 141-144

Baker, K.S., J.Brunst and D. Blankman, "Organizational Informatics: Ste Description Directories for Research Networks", (2002). Book, Published
Editor(s): N. Callaos, J.Porter and N.Rishe
Collection: *Proceedings of the 6th World Multi-Conference on Systematics, Cybernetics and Informatics*
Bibliography: *IIIS 7: 355-360*

Brunst, J.W., P.McCartney, K.S.Baker and S.Stafford, "The Future of Ecoinformatics in Long Term Ecological Research", (2002). Book, Published
Editor(s): N.Callaos, J.Porter and N.Rishe
Collection: *Proceedings of the 6th World Multi-Conference on Systematics, Cybernetics and Informatics*
Bibliography: *IIIS 7:367-372*

Gold, A.K., K.S.Baker, J-Y LeMeur and K.Balkdridge, "Building FLOW: Federating Libraries on the Web", (2002). Book, Published
Editor(s): *International Conference on Digital Libraries*
Collection: *Proceedings of the 2nd ACM/IEEE-CS Joint Conference on Digital Libraries*
Bibliography: New York, ACM Press: 287-288

Melendez-Colom, E.C. and K.S. Baker, "Common Information Management Framework: In Practice", (2002). Book, Published
 Editor(s): N.Callaos, J.Porter and N.Rishe
 Collection: Proceedings of the 6th World Multi-Conference on Systematics, Cybernetics and Informatics
 Bibliography: IIS 7:385-389

Goodin, D. and R.C. Smith, "Century to Millennial Scale -synthesis (accepted)", (2003). Book, Accepted
 Editor(s): D. Greenland, D. Goodin and R. C. Smith
 Collection: Climate variability and ecosystem response at Long-Term Ecological Research (LTER) sites
 Bibliography: New York, Oxford Press

Edited Book,, "Climate Variability and Ecosystem Response at Long-Term Ecological Research (LTER) Sites (accepted)", (2003). Book, Accepted
 Editor(s): Greenland, D. D. Goodin and R. C. Smith
 Bibliography: New York, Oxford Press

Greenland, D., D. Goodin and R. C. Smith, "An introduction to climate variability and ecosystem response (accepted)", (2003). Book, Accepted
 Editor(s): D. Greenland, D. Goodin and R.C. Smith
 Collection: Climate Variability and Ecosystem Response at Long-Term Ecological Research (LTER) Sites (accepted)
 Bibliography: New York, Oxford Press

Smith, R.C., W.R. Fraser and S. E. Stammerjohn, "Climate variability and ecological response of the marine ecosystem in the western Antarctic Peninsula (WAP) region (accepted)", (2003). Book, Accepted
 Editor(s): D. Greenland, D. Goodin and R. C. Smith
 Collection: Climate Variability and Ecosystem Response at Long-Term Ecological Research (LTER) Sites (accepted)
 Bibliography: New York, Oxford Press

Smith, R.C., X. Yuan, J. Liu, D.G. Martinson and S. E. Stammerjohn, "The quasi-quintennial time scale -synthesis (accepted)", (2003). Book, Accepted
 Editor(s): D. Greenland, D. Goodin and R.C. Smith
 Collection: Climate Variability and Ecosystem Response at Long-Term Ecological Research (LTER) Sites (accepted)
 Bibliography: New York, Oxford Press

Smith, R.C., W.R. Fraser, S.E. Stammerjohn, and M. Vernet, "Palmer Long-Term Ecological Research on the Antarctic Marine Ecosystem (accepted)", (2003). Book, Accepted
 Editor(s): E. Domack, A. Burnett, A Leventer, P. Conley, M. Kirby and R. Bindschadler
 Collection: Antarctic Peninsula Climate Variability: A Historical and Paleoenvironmental Perspective
 Bibliography: Washington, DC, American Geophysical Union

Vernet, M. and R. C. Smith, "Estimating NPP in marine pelagic ecosystems", (2003). Book, Submitted
 Editor(s): Timothy J. Fahey and Alan Knapp
 Collection: Principles and standards for measuring net primary production
 Bibliography: LTER synthesis series, Oxford Press

Wendy Kozlowski and Maria Vernet, "Abstract & Poster Session: Response of pigments in sea ice algae to ultraviolet radiation exposure - time series studies", (2003). Abstract & Poster, Accepted
 Collection: 10th Congress of the European Society for Photobiology (ESP), Vienna, Austria, 6-11 September 2003.
 Bibliography: Sesson: Environmental Photobiology

DL Patterson, AL Easter-Pilcher, WR Fraser, "The effects of human activity and environmental variability on long-term changes in Adelie Penguin populations at Palmer Station, Antarctica", (2003). Book, Published
 Editor(s): WWC Gieskes, J Rozema, RML Schorno, SM van der Vies and WJ Wolff
 Collection: Antarctic Biology in a Global Context
 Bibliography: Proceedings VIIIth SCAR International Biology Symposium, Backhuys Publishers, Leiden, p 301-307

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.

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.

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:

General:

With the new award, Ducklow succeeded Smith as PI and administration and oversight were successfully transferred from UCSB to VIMS with no hiatus in research or program support. An executive group (Ducklow, Smith, Vernet and Ross) is responsible for program guidance and the 8 PAL PI's have a monthly hourlong conference call. An external scientific steering committee helps provide expertise and guidance for PAL. The current SSC includes Tom Fisher (Horn Point), David Ainley (Point Reyes), John Hobbie (Ecosystems Center-MBL), Bruce Hayden (VCR and UVA) and Jim Reichmann (NCEAS). Andrew Clarke (BAS-UK) has moved from the SSC to being a full co-PI in PAL. PAL held its annual science meeting in Duck, NC in September, 2002, braving Tropical Storm Gustav, planning the 2002-03 field season, reviewing recent scientific accomplishments and setting the agenda for the next few years.

Annual Palmer LTER Summer cruise Jan03 (LMG03-01, 31 Dec 2002 – 8 Feb 2003):

Robin Ross was the Chief Scientist for the 11th annual summer cruise of the Palmer LTER. We occupied multiple spatial scales within one regional scale 'grid' of about 55 regularly occupied oceanographic stations between Anvers and Adelaide Islands, including several stations behind the Biscoe Islands and in Crystal Sound and Marguerite Bay, i.e. in areas where summer ice can persist. We successfully achieved all planned cruise elements: (1) Core data were collected at all stations, allowing us to assess temporal/spatial variability in all aspects of the ecosystem. (2) Two high-density foraging grids were conducted within the foraging range of the Adélie penguins nesting near Palmer Station to document the linkage between the nesting Adélie penguins and their marine foraging grounds. (3) The sediment trap deployed near Hugo Island was retrieved, and a new sediment trap deployed. (4) Three process stations focused on food web dynamics were conducted in Palmer Basin, in the Grandidier Channel near Trundle Island, and in Marguerite Bay east of the Faure Islands, along an inner shelf latitudinal gradient with high variability in phytoplankton standing stock. (5) Diets of Adélie penguins nesting both near Palmer Station and at Avian Island, at the southern end of the summer study region, and the prey fields within the respective foraging areas were quantified. (6) A visit to Rothera Base in Marguerite Bay furthered LTER collaborations with BAS personnel. We spent a day at sea cross-calibrating instruments and documenting the hydrographic link between the nearshore sampling at Rothera and the annual sampling grid of the Palmer LTER.

Specific reports:

Fraser (BP-013): Seabirds.

PAL-LTER Seabird Component efforts and objectives this season focused on, 1) continuing the Adélie penguin foraging ecology time series in the Palmer Station and Marguerite Bay regions, 2) expanding the sampling effort associated with Adélie penguin breeding biology and, 3) testing instruments we have customized for obtaining at-sea foraging locations and dive-depth profiles. Objectives one and two address hypotheses associated with the effects of variability in marine versus terrestrial habitats on Adélie penguin demography, while objective three reflects our program's efforts to use emerging ARGOS and GPS technologies to better understand the foraging behavior and movements of this species at sea. As last season, personnel changes and activities were closely coordinated with the austral 2002 autumn and winter GLOBEC program regional cruises and the January PAL-LTER cruise (LMG 03-01), which facilitated a May field camp on Avian Island, Marguerite Bay, further sampling on this island during January 2003, and

extensive surveys (seabird and marine mammal abundance and distribution) at sea between Palmer Station and Marguerite Bay.

M. Vernet (BP-016): Phytoplankton.

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 November 2002 to the end of March 2003. At the beginning of the season (October/November) we conducted several days of ice sampling in Arthur Harbor as well. In addition, we participated in the January 2003 cruise to the continental shelf. The phytoplankton group (BP-016) sampled core variables (daily primary production, particulate carbon and nitrogen, nutrients, and photosynthetic pigments), profiles of the upper 100-m water column with a Fast Track Rate Repetition Fluorometer for phytoplankton physiological studies of environmental forcing (i.e. photo-inhibition, nutrient limitation) and three types of experiments: the effect of ultraviolet radiation on daily primary production and phytoplankton composition, microzooplankton grazing (the dilution technique) and phytoplankton-bacteria interactions. Nutrient determinations are done on board, following the auto-analyzer protocols set up by Oregon State University in 2001 (5 nutrients). Data analysis during this period was intense. We are pursuing 3 lines of research: (1) An investigation of phytoplankton dynamics during periods of ice formation and ablation. (2) A study of the major drivers to inter-annual variability in primary production and its relationship to climate variability. (3) A study of krill-phytoplankton interactions. During this period we finished two projects: (1) An evaluation of the use of photosynthetic pigments as taxonomic markers by microscopic analysis and (2) The relationship of spatial variability in the main phytoplankton communities within the study area. This work is being done in collaboration with all PAL PI's. In particular, there are 3 synthesis efforts: (1) A statistical analysis of physical, chemical and biological parameters through EOF and CCA analyses, (2) The estimation of carbon cycling through the food chain, and (3) A contribution to the net primary productivity methods within Palmer LTER for a LTER Network synthesis book, Oxford Press.

D. Martinson (BO-021): Physical oceanography.

Martinson's group has focused on 2 tasks: (1) the collection/processing/release of the CTD and related hydrographic data for the LTER cruises (summer and winter) including XBT and XCTD data; (2) analysis/synthesis and modeling of the PAL LTER data. Task (1) involved a special emphasis on establishing a PAL LTER CTD sampling strategy and standard protocol for this sampling. In addition we provide shipboard personnel for many cruises and shore-based QA/QC control when we are not physically on the ship. The CTD and related upper ocean physics sampling data have been processed and submitted to the LTER public database (data and metadata).

Regarding Task 2, we have focused on performing a comprehensive cross-grid analysis of the LTER physical system (in terms of its spatial and temporal structure, covariability and relevant characteristics). This work is now well advanced, having established a grid structure for the LTER PAL domain, refining the analysis methodology for analyzing the variables within the grid, and writing the first draft of the paper to present the methodology and results. Thousands of graphs have been generated, and the results are now being consolidated to a manageable number of relevant results.

R. Ross & L. Quetin (BP-028): Zooplankton.

Krill component specific efforts during 2002/2003 included: (1) Palmer 0203 season. A 3-person team (2 divers plus a Ph. D. student) had a very successful austral spring. For about 4-weeks in the austral spring (mid-Oct to mid-Nov), divers collected larval and juvenile krill from under the ice for instantaneous growth rate (IGR) experiments and later analysis for condition, and also documented diel differences in behavior (including feeding activity) of krill associated with the ice/water interface. The Ph. D. student conducted grazing experiments to document the functional response of larval and juvenile krill feeding on surfaces compared to feeding in the water column, and changes in hepatopancreas size related to feeding activity. From the time zodiac activity was possible until the start of the annual cruise, two acoustic transects were run twice weekly, one on the outside of the islands surrounding Arthur Harbor, and one from Arthur Harbor to the 200 m bathymetric contour. Antarctic krill were collected with targeted tows for length frequency distributions, IGR experiments, and condition factor. In addition, a pilot project was conducted in conjunction with Dr. A. Murray of the Desert Research Institute to test the use of 18S rDNA analysis of gut and fecal pellet contents using DGGE to analyze the diet of *Euphausia superba*. (2) On the annual summer cruise, the zooplankton team did two net tows with simultaneous acoustic transects at each station along the standard lines. We also did acoustic transects for two fine-scale grids of 10 x 20 km, one in the same location as previous surveys during the time series and one located where GPS satellite packs on the Adélie penguins indicated the birds were foraging. IGR experiments were conducted with krill collected from the inner and outer shelf stations on all 5 lines, and spawning frequency and egg production experiments conducted on the outer shelf stations on all 5 lines. At the three process stations, day/ night feeding activity of the dominant macrozooplankton grazers was monitored via pigment content in both Antarctic krill and salps, and fecal pellet production of Antarctic krill. The three process stations were chosen to represent regions of varying phytoplankton composition and standing stock, and documenting the response of the grazers to these differences was one of the goals.

Quetin and Ross attended the Gordon Research Conference on Polar Marine Science, Mar 16-21, 2003. They presented a poster titled "Patterns of distribution of major zooplankton species west of the Antarctic Peninsula over a 10-year period" by R. M. Ross, L. B. Quetin, D. Martinson, R. Iannuzzi, S. Stammerjohn and R. Smith. Spatial-temporal analysis of the time series of macrozooplankton distribution in the Palmer LTER region is based on Empirical Orthogonal Functions (EOF). Climatologies (long term averages) and standard deviates of the distributions of the most numerous zooplankters (Antarctic krill (*Euphausia superba*), two other euphausiids, a pteropod, and a salp) were shown. Examples of between-species interactions (Antarctic krill and salps) and species-to-environment interactions (ice krill and the last day of 50% ice cover) illustrated the usefulness of the approach.

R. Smith (BP-032): Optics, Remote Sensing and Sea Ice.

Fieldwork was carried out at Palmer Station (Kim McCoy and Graham Tilbury) for the deployment of the Autonomous Profiling Vehicle (APV) in collaboration with Maria Vernet's phytoplankton group. Research activities also included work on determining the interannual variability of phytoplankton distribution with remote sensing images (SeaWiFS, 1998-2002) in the Bellingshausen Sea (with Kirk Ireson). Chris Carrillo, a young investigator recently graduated from the University of Hawaii, was hired as a post-doc. Dr. Carrillo is synthesizing his work with gases in relation to nutrients, physics and phytoplankton. An LTER Network synthesis

volume to be published by Oxford University Press (Greenland, Goodin & Smith) is already in press. This cross-site synthesis volume, 'Climate Variability and Ecological Response at Long-Term Ecological Research (LTER) Sites', began in the Fall 1997 LTER Coordinating Committee meeting, hosted by the Palmer LTER in Santa Barbara, with the science theme 'Climate variability and ecological response'. Subsequently, Greenland, Goodin and Smith held three workshops dealing with this overall theme at the 2000 All Scientists LTER Meeting.

Autonomous Profiling Vehicle (BP-032 and BP-016):

An APV (Autonomous Profiling Vehicle) was purchased and deployed for the first time during the 2002-2003 season at Arthur Harbor, within the 2-mile boat limit. The instrument is an Ocean Sensors Model OS500 APV that measures water column pressure, conductivity, and temperature. The instrument can be programmed to profile the water column at set times in order to provide profiles in the desired time frequency. In addition to the basic CTD, 2 additional channels were used for a Wet-Labs fluorometer and transmissometer in order to add biological and optical data. The instrument is deployed with a fixed mooring, in an area free of large icebergs with flat bottom topography. The instrument is small enough that can be deployed off a Zodiac. The programming on the profiling (sampling depth interval, frequency, etc.) is done previous to the deployment. Data can be downloaded in < 30 minutes when the instrument is programmed to surface during routine profiling. The downloading can be done directly onto a laptop, on board the Zodiac.

The scientific questions addressed by a high-frequency profiling system are those that cannot be addressed by the bi-weekly sampling from the Zodiacs. In particular, we are interested in (1) understanding the dynamics between biology and physics as a function of wind, storm events and tides. The sampling from the Zodiacs is biased towards good weather, in days with wind < 20 knots. The sampling is thus restricted to days before or after and in-between storms. We will combine the detailed Zodiac sampling with the APV profiling in order to obtain a tighter link between phytoplankton distribution, abundance and productivity and mixed layer depths, water exchange and freshwater input. (2) In addition, the warming of the Peninsula during the last 50 years has increased melting of glaciers and their subsequent retreat. The high-frequency sampling from the APV will measure freshwater inputs from the glacier and we will use the meteorological data to understand the relationship between these events and air temperature, winds and tides.

The ultimate goal of moored, high frequency sampling is to complement and supplement part of the water-column sampling done from the Zodiacs. Coastal areas such as the waters around Palmer Station have specific dynamics not always well sampled by common oceanographic approaches. We also expect to complement deep-ocean moorings as deployed by the GLOBEC project. Finally, we expect to contribute to the Antarctic coastal stations sampling (i.e. BAS) and other sampling/monitoring carried out in coastal areas. To this purpose, Ray Smith is now at a "Workshop on real-time coastal observing systems for ecosystem dynamics and harmful algal blooms" on 11-21 June 2003 at the Observatoire Océanologique in Villefranche-sur-Mer, France. Dr. Smith is presenting our results from the first season of APV sampling at Palmer Station.

H. Ducklow (BP-045): Microbial ecology and biogeochemistry.

Ducklow succeeded Dave Karl as leader of the microbial ecology-biogeochemistry component, continuing research on bacterial processes and sampling biogeochemical properties during the PAL summer (January) cruise (LMG 03-01) in January-February 2003. The overall objective of

this effort is to determine the degree to which organisms, biogeochemical properties and heterotrophic processes at the base of the Antarctic marine foodweb respond to the marked climate warming PAL and others have identified along the WAP climate gradient. Do these fundamental ecosystem processes follow trends already established at higher trophic levels, or do they form a less variable foundation underlying changes magnified at increasingly higher levels of the trophic structure? We measured bacterial production and biomass at all stations along the 200 through 600 lines of the LTER grid, and conducted enzyme activity assays at a subset of these stations. Samples were collected for analyses of oxygen, carbon dioxide, alkalinity and dissolved organic carbon concentration throughout the grid. In addition we collected Oxygen-17 samples for Matt Reuer and Mike Bender (NASA Grant NAG5-11301; Princeton University), who will estimate rates of net primary production from the ¹⁷O data. Finally, we successfully recovered the PAL deep ocean sediment trap array deployed in 2002 by D. Karl's colleagues, and redeployed it for another year of sampling during 2003.

In addition to offshore work during LMG 03-01 we initiated a new program, investigating with semiweekly resolution the seasonal evolution of microbial processes in the inshore ecosystem of Arthur Harbor. This work was conducted in close association with Vernet's (BP-016) group, with the intention of testing the hypothesis that heterotrophic and autotrophic processes are at best loosely coupled in this region. Bacterial production was assayed between mid-November and mid-March, and samples were also collected for bacterial biomass, dissolved organic carbon and organic biomarkers.

K. Baker: Information Management.

Data management activities included support for annual updates to the Palmer LTER database. Database access was modified to include a 'data policy' acceptance page designed with input from the Palmer LTER principal investigators. Project summaries were updated including the site bibliographic database posted online periodically. We developed interface with CERN this year to prototype software (CDSware) in collaboration with participants from the UCSD Library and San Diego Supercomputer. Palmer LTER web projects included finalization of the website redesign with a three tier template format. An investigation of existing oceanographic information systems resulted in discussions with the Palmer PI's and Woods Hole Oceanographic Institution about adopting the JGOFS data system for use in PAL.

Socio-technical investigations included research collaboration informed by participatory design and ethnographic field studies. Sharing this work with the LTER community through presentations, written communications remains an ongoing priority (see references). An emphasis on identifying communities with related interests resulted in presentation of our findings at the Computer Supported Cooperative Work Conference in November, the Joint Conference of Digital Libraries in May and the upcoming Hawaii International Conference on System Science. Collaboration with Geof Bowker (UCSD, Communication Dept) and Helena Karasti (University of Oulu, Department of Information Processing) continues with organization of a workshop on 'Computer Supported Scientific Collaboration' at the European Computer Supported Cooperative Work Conference in September 2003.

LTER Network activity includes participation in the LTER Information Manager Executive Committee monthly conference calls, attendance at the LTER IM Executive Committee Meeting at NCEAS, support for the fifth year of the LTER Information Manager DataBits Newsletter, and coordination with the LTER Education Committee. A second LTER Metadata workshop was

attended last year in Phoenix at the CAP site to continue focus on the Ecological Metadata Language. Initial EML/XML prototyping helped define redesign needs for the Palmer LTER metadata forms.

General

We have been working for several years on a comprehensive statistical analysis of the spatiotemporal patterns of variability observed in the first decade of observations made on the regional grid. This effort is nearing maturation and we anticipate submitting several articles in a special volume of Deep-Sea Research II or another journal this year. We have also embarked on a major upgrade of our data system, to stimulate data synthesis activities and closer interaction among PAL investigators, facilitate use by colleagues outside PAL, and make our results available to students at the K-12 and college undergraduate levels.

Fraser (BP-013): Seabirds.

Our activities contributed to a unique, nearly continuous 4-year record of Adélie penguin foraging ecology within and between the Palmer Station and Marguerite Bay regions. Continued analyses of the data show that irrespective of season, diets in the former are dominated by krill and in the latter by fish. These differences, however, appear to be unrelated to penguin foraging behavior at sea, implying that diet variability may be due instead to some fundamental differences in prey abundance and species composition between these two marine regions. The activities also added to a longer-term, large-scale record of Adélie penguin breeding biology. This record is now providing evidence that breeding success and recruitment in this species is regulated in part by habitat-specific differences in the terrestrial nesting environment.

M. Vernet (BP-016): Phytoplankton.

This component of the Palmer LTER is studying the spatial and temporal variability of primary production in the Western Antarctic Peninsula and physicochemical 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, inter-annual variability in primary production correlates with ice edge dynamics during the spring and summer and, to a lesser extent, with the ice during the previous winter. The spring bloom came early this year, associated with the receding ice edge (beginning of November) and in contrast to previous seasons, no summer bloom was observed in January 2003. (2) This year yearly production was somewhat higher than last season. The rate of primary production at Palmer Station in 2002-03 was about average, with an estimated annual production of 212 gC m^{-2} (integrated over 6 months) relative to a maximum of 354 gC m^{-2} measured in 1995-1996 and a minimum of 54 gC m^{-2} in 1998-1999. The grid had an above average daily production, with $817 \text{ mg C m}^{-2} \text{ d}^{-1}$, compared to the 10-year mean of $650 \text{ mg C m}^{-2} \text{ d}^{-1}$. These results suggest the coastal Antarctic system is undergoing a second production cycle that started in 1999-2000. (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 = -0.0005 d^{-1} , standard deviation = 0.01 d^{-1} , $n = 16$ from November to April). These results are consistent with Ross Sea estimates and 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. (4) Phaeopigment production during 48-h incubations suggests microzooplankton grazing to be somewhat higher ($>0.01 \text{ d}^{-1}$) though still very low. This discrepancy will be tested more extensively during the 2003-2004 field season. (5) Experiments of bacterial uptake of recently excreted phytoplankton carbon also show low values (see Ducklow results).

D. Martinson (BO-021): Physical oceanography.

Martinson has recently classified and documented the WAP water mass distributions and their relationships to ACC (Antarctic Circumpolar Current) waters for the 10 years of LTER sampling. The shelf waters are dominated by intrusion of the ACC waters onto the shelf, though we need additional time series data to clearly understand the underlying mechanisms and frequency at which shelf waters are renewed. The work has revealed: (1) the general relationships between shelf and ACC waters, (2) that the waters within the LTER domain are well separated according to bathymetrically-controlled subregions (i.e., slope, mid-shelf and coastal waters), giving some insights regarding the communication between ACC and shelf waters, and (3) what additional sampling is required to improve our understanding of the mechanism by which the ACC waters evade and renew the shelf waters. This work has been presented at several meetings (GLOBEC, LTER), and is currently being written up for publication.

DGM has also determined the spatial/temporal relationships of the physical variables throughout the LTER sample domain. This work has also been presented at the GLOBEC and LTER meetings, and forms the basis of another paper currently in preparation. The foundation for this work was developed and published in a paper recently published in JGR (Martinson and Iannuzzi, 2003).

All of the older LTER data (those data collected prior to our participation in the LTER program) were re-processed to conform to our new standard data QA/QC. This processing has recently been completed (assuring that the two papers in preparation discussed above are using the best and most consistently processed data). The re-processed data (recently uploaded to the LTER data base) have led to cleaner T-S relationships and improved bathymetrically controlled subregion separation.

R. Ross & L. Quetin (BP-028): Zooplankton.

Antarctic krill in the Palmer LTER region showed a pattern of episodic recruitment, with two strong year classes in succession followed by 3 or 4 moderate or poor year classes. The two strong year classes represented 85 - 90% of the krill caught for 5 or 6 years, and as the absolute abundance of the year class declined due to mortality, so did the abundance of Antarctic krill in the region. The recruitment index was positively correlated with the absolute value of a seasonal ENSO index, with strongest recruitment during the neutral or moderate periods of ENSO. The mechanism underlying the strong link between the recruitment index and ENSO is most likely the effects of seasonal sea ice dynamics on both reproduction and winter-over survival of the resulting larvae as previously documented.

R. Smith (BP-032): Optics, Remote Sensing and Sea Ice.

Optics, remote sensing and sea ice (Smith S-032) findings include the following. The annual advance and retreat of sea ice has been considered a major physical determinant of spatial and temporal changes in the structure of the Antarctic coastal marine ecosystem. Stammerjohn and collaborators (2003) have shown that ice dynamics during winter formation and ablation in the Western Peninsula region is related to low-pressure systems in the area. In particular, the warming of the Peninsula is related to increase low-pressure systems bringing moisture and warmth from lower latitudes and to the high-pressure systems in the South Pacific. During spring, wind plays an important role in creating divergence areas. The ecological influence of

these trends has already been demonstrated at all trophic levels (Smith, Fraser and Stammerjohn; Smith, Fraser, Stammerjohn and Vernet). The most recent years have seen an increasing maritime influence in the WAP region, with corresponding effects on the marine ecosystem. These results have stimulated a new PAL hypothesis associated with the concept of ecosystem migration along the western Antarctic Peninsula. Smith and Ireson (in prep) show extreme interannual variability in both phytoplankton biomass in an area around the Western Antarctic Peninsula and including the Bellinghousen Sea and Drake Passage. Persistent spatial patterns have been observed over the many years of study (e.g., an on- to offshore gradient in biomass and a growing season characterized by episodic phytoplankton blooms). This high interannual variability at the base of the food chain influences organisms at all trophic levels. Several chapters for an LTER synthesis volume are in press (see publication list). This volume, edited by David Greenland, Doug Goodin and Raymond Smith, examines the theme of how ecosystems respond to climate variability. A timely subject in light of the recent IPCC report on Climate Change, these authors have examined this theme for most of the LTER sites and across a variety of time scales. With increasing attention to possible ecological consequences of global climate change it is essential that we understand how climate varies and the potential for rapid ecological change in response. This synthesis volume addresses this and related questions.

H. Ducklow (BP-045): Microbial ecology and biogeochemistry.

Preliminary results suggest that seasonal bacterial production in the nearshore ecosystem (Arthur Harbor) was low, $\sim 3 \text{ gC m}^{-2}$, or about 1% of the primary production estimated by Vernet. One mechanism linking primary and bacterial secondary production is utilization of labile dissolved organic matter excreted by healthy phytoplankton during photosynthesis. In collaboration with Vernet's group we are estimating the simultaneous excretion and uptake of such DOC compounds using ^{14}C tracer and nonlinear compartmental analysis tools. Preliminary results indicate that excretion rates are sometimes moderate to high, but utilization is lower. The model analysis needs to be refined before final conclusions can be drawn.

One problem plaguing all ecologists is that we cannot make measurements of many key processes in foodwebs. During the past year graduate student Robert Daniels completed his MSC thesis in which he synthesized observations from the PAL sampling in 1996 (a high primary production, low-sea ice year) and 1999 (low ice and PP). These data were used to constrain inverse solutions to the full WAP foodweb from bacteria to penguins and skuas. Findings suggest that although there are differences in foodweb structure between the high- and low-ice years, there are also strong similarities. The microbial foodweb commands a very small portion of carbon flow within the foodweb in both years, whereas krill process a large fraction of the primary production. Thus the model results confirm traditional views that the Antarctic marine diatom-krill-predator foodchain is predominant under both scenarios of physical forcing. However the results also contradict earlier speculations that high trophic level predators are an important leak in the carbon system (Huntley, M. E., M. D. G. Lopez and D. M. Karl. 1992. Top predators in the Southern Ocean: A major leak in the biological carbon pump. *Science*, **253**, 64-66). Daniels' work has been presented in posters and talks at several meetings and will be also at the upcoming LTER All-Scientists' meeting in Seattle and the Royal Society meeting on the Southern Ocean in London.

Although it was not directly supported by LTER, our work on persistent organic pollutants (OPP-0087872) benefited from PAL logistic and scientific assistance. We have detected the flame-retardants brominated diphenyl ethers in Antarctic sea ice, krill and air samples. These are

current use compounds that are not banned, and our observations are the first report of their presence in the Antarctic.