Palmer LTER: Annual January cruise for 1997 (*PD*97-1)

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Each year since 1993, the Palmer Long-Term Ecological Research (LTER) program has surveyed a mesoscale study region west of the Antarctic Peninsula with a standard grid that was set up at the initiation of the program (Waters and Smith 1992). During the 1997 cruise aboard the R/V *Polar Duke* (*PD*97-1), sampling occurred between 11 January and 13 February. The cruise plan (table) included standard cardinal transect lines (figure 1), high-density sampling within the foraging range of Adélie penguins nesting near Palmer Station (figure 2), periodic visits to the stations near Palmer, and spatial variance transects. Three of the five major cruise objectives for 1997 are common to all January cruises:

- to document interannual variability in various physical and biological variables along and offshore at the mesoscale in the LTER study area,
- to investigate the linkage between marine resources and Adélie penguins during a time of peak food requirements for the chicks, and
- to maintain seasonal sampling at the stations near Palmer Station.

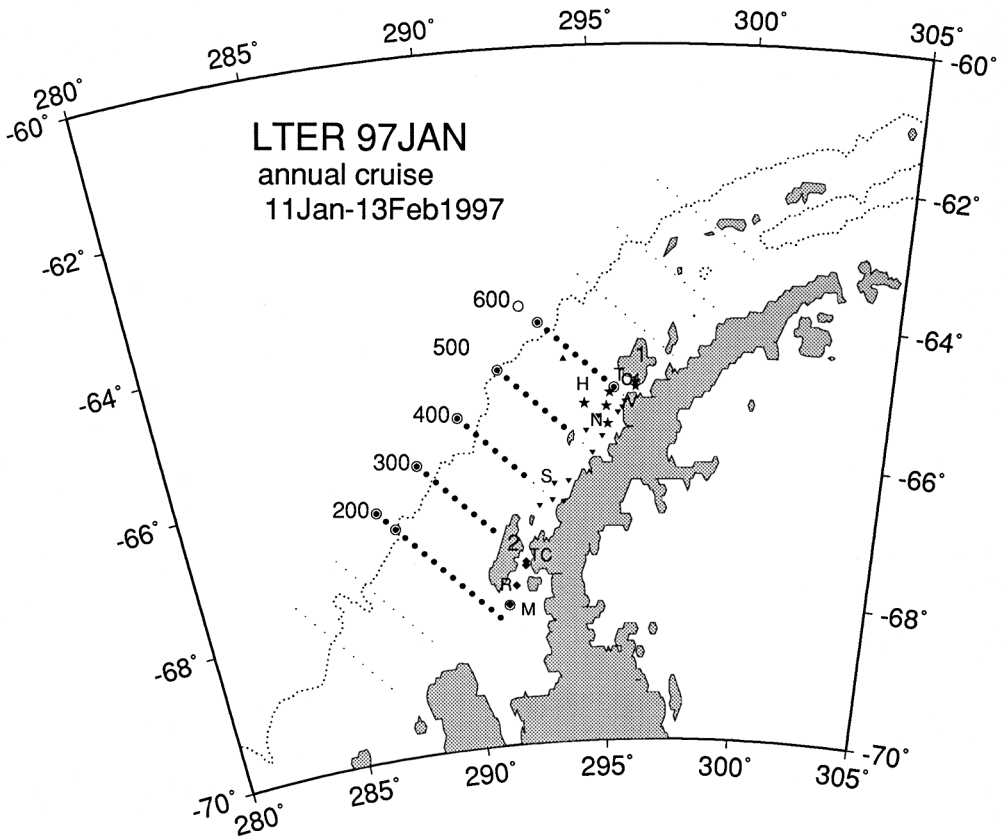

Figure 1. The cardinal stations of the Palmer LTER regional grid (dots) off the Antarctic Peninsula are overlaid to indicate standard station sampling (large dots) and conductivity-temperature-depth (CTD) sampling (circles) during *PD*97-1. Labeled are Anvers Island (1), Adelaide Island (2), Torgersen Island (T), Palmer Station (O), Rothera Station (R), Vernadsky Station (V), Hugo AWS (H; 64°957'S 65°941'W), sediment trap (triangle), northern stations (N; inverted triangle), southern stations (S; inverted triangle), Marguerite Bay (M; diamond), Tickle Channel (TC; diamond), and hydrographic parameters only stations (star). The 1,000-m bathymetry line (dotted) is shown.

Palmer LTER January 1997 (PD97-1) cruise overview

NOTE: Daily events summarized include LTER transect lines (grid line), LTER nearshore stations (grid inshore), high density grid (HD), picket lines (PL), zodiac operations, CTD casts, and automatic weather station (AWS). The proportion of time spent on each activity du ring the cruise is summarized.

Month	Day	Cruise day	Grid	Inshore high-density and picket	Transect, multi, search, zodiac	Other information
Jan	5					Depart Palmer; XBT sampling
Jan	6					
Jan	7					
Jan	8				H	Hugo penguin census; arrive Palmer
Jan	9					
Jan	10					
Jan	11	1		B-J		LFA onboard/film
Jan	12	2	500			500.060; 080; 100; 120
Jan	13	3	500			500.140; 160; 180; 200; weather
Jan	14	4			T(550)	Transect: offshore to Grandidier (550.240–550.010)
Jan	15	5	550			
Jan	16	6	600.040			600.040C; 060; 080; 100
Jan	17	7	600			600.120; 140; 160; 180; 200
Jan	18	8		P (3.7)		600.240C; Hugo Trap
Jan	19	9		B-J	Z*3 (bird)	Torgersen Island beach count; Palmer visitors
Jan	20	10		P*2 (3.7+10)		Salps; krill; whales
Jan	21	11		HD1		Targeted tows
Jan	22	12	600.030		Z*3 (bird)	Humble Island beach count; Palmer DAS repair
Jan	23	13			S1	Search Palmer N-Bismark St; LFA broadcast
Jan	24	14		HD1r		
Jan	25	15	600.040	B; E; H; J	S2	Search Palmer
Jan	26	16	600.040		S3; multi	Targeted tows
Jan	27	17	400			400.040; 060; 080; 100
Jan	28	18	400			400.120; 140; 160; 180; 200C
Jan	29	19	300			300.200C; 180; 160; 140
Jan	30	20	300			300.120; 100; 080; 060; 040
Jan	31	21			T250	Transection to offshore (250.005–250.200)
Feb	1	22	200			200.200C; 180; 160C
Feb	2	23	200			200.140; 120; 100; 080; 060
Feb	3	24	200			200.040; 020; 000; -020
Feb	4	25	200		Z*1 (chk)	200.-040; -060; Ginger Island; Rothera visit
Feb	5	26			Z*1 (diet)	Marguerite Bay; British Antarctic Survey aboard; photosynthetically available radiation; Ginger Island diet sample
Feb	6	27			Z*1 (ice)	Tickle Channel; ice sample; Wyatts Island
Feb	7	28	S		Z*2 (ice)	Zodiac in/out ice; in south Darbel Bay (380.010; 400.000)
Feb	8	29	S			Crossing ceremony; in south Crystal (440.000; 420.015)
Feb	9	30			T (inshore)	Transect; inshore
Feb	10	31	N		Z*1 (ice)	In north Grandidier (520.030; 500.000; 530.005; 550.030)
Feb	11	32	N			575.010; In north Lem (585.010; 595.013); Vernadsky visit
Feb	12	33	600.040	B-J		600.040C
Feb	13	34				Dock Palmer
Feb	14					
Feb	15					Depart Palmer; Gerlache; Dallman Bay
Feb	16		700		S4	XBT 700 line
Feb	17					
Feb	18					
Feb	19					
Feb	20					

These nearshore stations are within 3.7 kilometers (km) of Palmer Station and sampled from zodiacs from November through March to document interannual variability in seasonal patterns (Baker et al., *Antarctic Journal,* in this issue). The fourth objective this year was to document spatial variance of multiple physical and biological parameters on both on/offshore and alongshore transects. The fifth objective was to initiate cooperative studies with the British Antarctic Survey (BAS) making a visit to Rothera Station (figure 1). In addition, the R/V *Polar Duke* participated in a broadcast of *Live from Antarctica 2* from Palmer Station in late January. Questions from middle school students were answered real-time by those onboard through use of satellite communications. Finally, personnel aboard participated in an expendable bathythermograph study directed by Janet Sprintall of Scripps Institution of Oceanography during the southbound crossing.

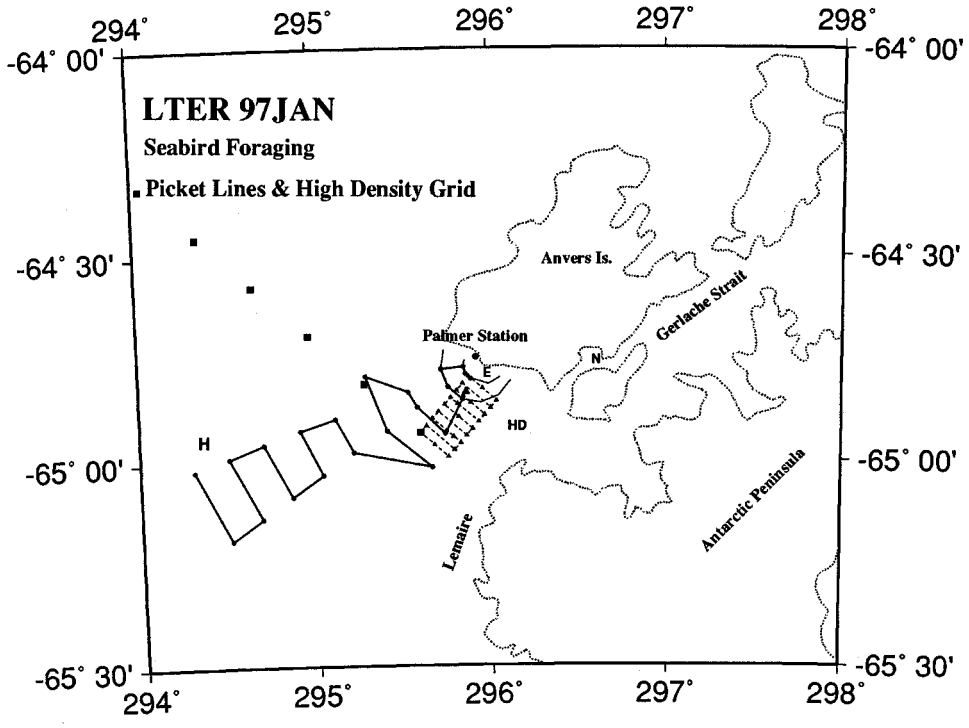

Figure 2. Sampling area near Palmer Station on Anvers Island with the Neumeyer (N) and Gerlache Strait to the East. Locations are shown for inshore station (E) of the Palmer nearshore stations and the Hugo AWS (H). The 3.7-km and 10-km picket lines, the multi-picket line (solid line), and the high-density grid (HD; dashed line) are shown. The LTER regional grid 600 line stations 040, 060, 080, 100, 120 are marked (filled squares).

Standard measurements at stations 20 km apart on cardinal transect lines included seabird community composition as well as the following water column characteristics:

- optics and hydrography,
- gases,
- microbial parameters,
- bacterial production,
- plant pigments,
- primary production, and
- plant physiology.

Bioacoustic surveys and net tows for zooplankton and krill were centered on each station, and physiological condition determined for krill collected. Underway surface measurements between stations included

- temperature,
- salinity,
- fluorescence,
- seabird community composition, and
- carbon dioxide partial pressure (pCO_2), as measured with a carbon dioxide equilibrator system.

Sea ice was encountered only in the southern part of Grandidier Channel (inside north), the inner reaches of Crystal Sound (inside south), and Tickle Channel (TC) in northern Marguerite Bay. Only one bad weather day was logged, preventing sampling at the two outermost stations on the 500 cardinal transect line. Chlorophyll-*a* concentrations were an order of magnitude lower in the northern area of the Peninsula grid in comparison with January 1996. Further, there was less of an onshore-to-offshore biomass gradient and fewer phytoplankton communities dominated by Cryptomonads and Prymnesiophytes. In the southern area of the Peninsula grid, biomass was generally less than 1 milligram per cubic meter (mg m^{-3}), although a large phytoplankton bloom was found within Marguerite Bay having surface chlorophyll values ranging from 10 to 30 mg m^{-3} and water-column-integrated-to-30-m values from 2 to 4 mg m^{-3} that were coincident with low pCO_2 values. Diatoms and the Prymnesiophyte Phaeocystis sp. dominated the phytoplankton community. A mixture of salps and krill was found at many stations, and antarctic krill abundances were at average levels.

In addition to the mesoscale survey, intensive sampling was conducted within the foraging area of Adélie penguins whose reproductive success and foraging ecology were being studied simultaneously by investigators at Palmer Station. Surveys were conducted at Torgersen and Humble Islands in conjunction with zodiac tracking of Adélie penguins. The relative distributions of the predator (Adélie penguins) and prey (antarctic krill) were observed on 3.7- and 10-km picket-line transects (Smith et al. 1995) and on high-density grids (figure 2). Only seabird counts were performed on the picket lines farther than 10 km from Palmer Station. The 10-km × 20-km high-density grid (figure 2), as described for January 1995 (Quetin et al. 1995), was repeated twice. These seabird censuses showed higher numbers of Adélie penguins foraging

within 10 km of Palmer Station than in previous years and showed that most penguins were foraging relatively close (<20 km) to their rookeries where acoustic biomass (primarily antarctic krill) was higher than farther offshore.

Annual servicing of the two Palmer LTER program sediment trap moorings (Hugo Island and Palmer Basin) and replacement of two automatic weather stations (AWS Bonaparte and AWS Hugo) (figure 1) were carried out during cruise *PD*96-12 in December 1996. In early January, however, the R/V *Polar Duke* visited Hugo Island to complete the AWS Hugo service and to survey the island bird population. During the day of exchange with BAS personnel at Rothera, LTER procedures were discussed (Smith et al. 1996) and demonstrated to those involved with the new British nearshore sampling program. In addition, the diets of Adélie penguins on Ginger Island were sampled. The R/V *Polar Duke* also paid the first official visit of the U.S. Antarctic Program to the Ukrainian station, Vernadsky Station.

This research cruise was a result of a productive team composed of Palmer LTER research team members with team leaders: Karen Carney with W.R. Fraser, Wendy Kozlowski with M. Vernet, Dave Menzies with R. Smith, and Luis Tupas with D. Karl. Special thanks go to Charleen Johnson and Janice Jones as well as to Antarctic Support Associates personnel and Captain Karl Sanden and his crew of the R/V *Polar Duke*. Our grateful appreciation is extended to all. This research was supported by National Science Foundation grant OPP 96-32763. This is Palmer LTER contribution number 148.

References

Baker, K.S., W.A. Kozlowski, M. Vernet, J.L. Jones, L.B. Quetin, R.M. Ross, R.C. Smith, and W.R. Fraser. 1997. Palmer LTER: Annual season October 1995 to March 1996. *Antarctic Journal of the U.S.*, 32(5).

Live from Antarctica 2. Passport to Knowledge, P.O. Box 1502, Summitt, NJ 07902-1502 (*http://quest.arc.nasa.gov/antarctica2*).

Quetin, L., K.S. Baker, W.R. Fraser, D. Hardesty, J. Jones, R. Ross, R.C. Smith, L. Somervill, W. Trivelpiece, and M. Vernet. 1995. Palmer LTER: Observations in foraging areas of Adélie penguins during the January 1995 cruise. *Antarctic Journal of the U.S.*, 30(5), 269–271.

Smith, R.C., L.B. Quetin, J.L. Jones, D.W. Menzies, T.A. Newberger. 1996. Palmer LTER: Small boat design for water column sampling. *Antarctic Journal of the U.S.*, 31(2), 167–169.

Smith, R.C., L.B. Quetin, R.M. Ross, J. Jones, W.R. Fraser, W.Z. Trivelpiece, L. Somervill, and D. Hardesty. 1995. Palmer LTER: Seabird picket-line sampling and zodiac tracking during the January 1995 cruise. *Antarctic Journal of the U.S.*, 30(5), 273–274.

Waters, K., and R.C. Smith. 1992. Palmer LTER: A sampling grid for the Palmer LTER program. *Antarctic Journal of the U.S.*, 27(5), 236–239.

Palmer LTER program: Underway semicontinuous measurements of surface ocean carbon dioxide concentrations

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Accurate estimation of carbon dioxide (CO_2) fluxes, coupled with an understanding of the processes that control these fluxes, is necessary to predict future CO_2 concentrations in the southern oceans. The chemical, physical, and biological controls on *in situ* CO_2 concentrations cause habitat variability both temporally and spatially. Open ocean areas presently have high nutrient concentrations but low standing stocks of phytoplankton and low rates of primary production. In sharp contrast to the high-nutrient, low-productivity open ocean areas, coastal regions of Antarctica exposed to the annual advance and retreat of sea ice, sustain seasonal phytoplankton blooms with high rates of primary production (Smith and Nelson 1985; Holm-Hansen et al. 1989). Consequently, coastal and ice-edge regions of Antarctica could potentially remove atmospheric CO_2, but these local sinks may be offset by equally large sources of CO_2 during winter periods of net heterotrophy or as a result of the upwelling of CO_2-enriched waters. The seasonal advance of the ice in the fall and retreat in the spring may also affect the flux of CO_2 in the ice-dominated Arctic Ocean and southern oceans. Quantifying these fluxes will require sampling in the dissimilar ecosystems that make up the southern oceans. The Palmer Long-Term Ecological Research (LTER) Program was established in 1990 to study the physical determinants on the antarctic marine ecosystem. The central tenet of the Palmer LTER program is that the annual advance and retreat of sea ice is a major physical determinant of spatial and temporal changes in the structure and function of the antarctic marine ecosystem, from total annual primary production to breeding successes in seabirds (Smith et al. 1995.

During the 1995–1996 and 1996–1997 austral summer LTER field seasons, an automated underway CO_2 measurement system was deployed on the R/V *Polar Duke*. During each field season, spatial surveys of surface water CO_2 concentrations were conducted in coastal and open ocean ecosystems over a 3-month period from mid-December to mid-February. These surveys included four transects across the Drake Passage, five to eight surveys of Arthur Harbor near the U.S. research base at Palmer Station, and a survey of the LTER grid area located off the Antarctic Peninsula (figure 1). The survey of the LTER grid area included transects into coastal areas of Marguerite Bay and Crystal Sound. Overall, 11,679 surface-