Long-Term Ecological Research (LTER) program—Antarctic Peninsula and the McMurdo Dry Valleys sites

Palmer LTER: Patterns of distribution of inorganic macronutrients, phytoplankton pigmentation, and photosynthetic activity in an ice-dominated ecosystem in austral winter 1993

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In August and September 1993, we resolved the mesoscale variability in phytoplankton pigmentation, nutrition, and photosynthetic activity in waters west of the Palmer Peninsula. Procedures have been previously described (Prézelin et al. 1992). Samples were collected at geographically defined stations within a 400- × 200-kilometer (km) portion of the Long-Term Ecological Research (LTER) grid, which is characterized by diverse bottom topography and water-mass movement (Hofmann et al. 1993; Klinck and Smith 1994) and where spring ice coverage varies widely from year to year (Stammerjohn 1994). The grid was largely ice free in early August; soon after, a cold snap resulted in ice coverage over the entire grid area for the duration of the cruise. Figure 1 provides contour plots of the vertical distribution of total plant biomass for each transect line (spaced 100 km apart), as well as chemotaxonomic carotenoid markers for diatoms, prymnesiophytes (largely *Phaeocystsis* spp.), and chrysophytes. Figure 2 displays the distribution of macronutrients within the same area, and figure 3 presents the results of a simple linear correlation between most of the parameters thus far analyzed.

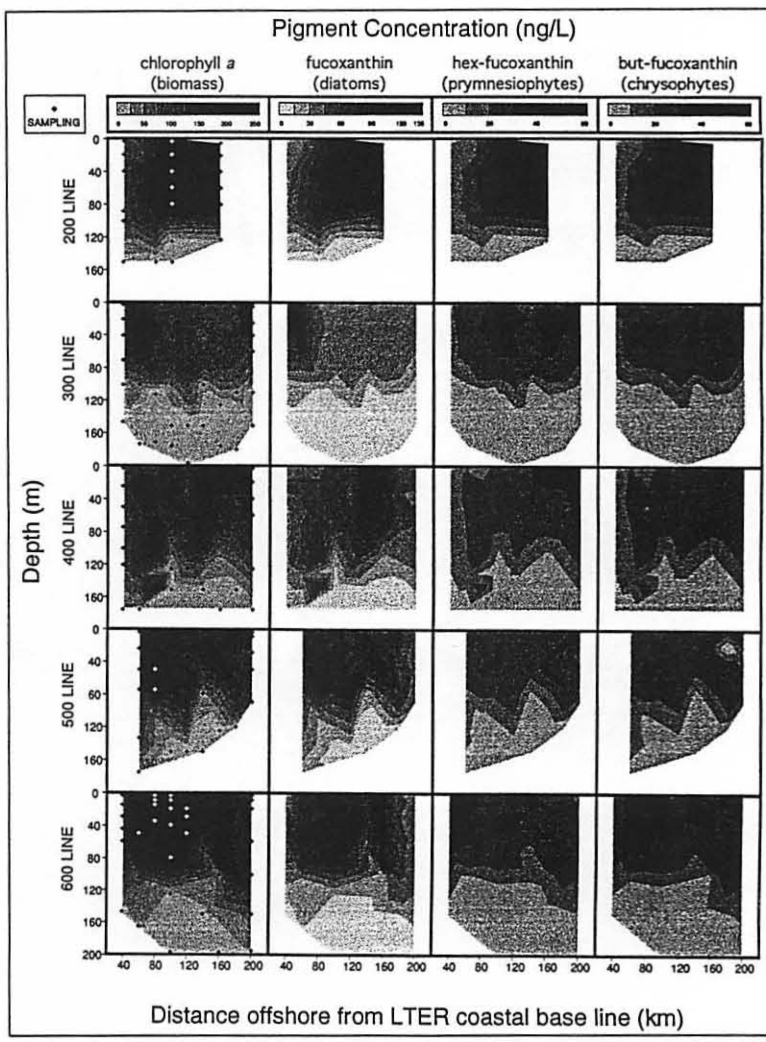

Figure 1. Contour plots for phytoplankton pigment concentrations (ng/L) for each LTER grid line sampled during the late austral winter 1993. Sampling shown for chlorophyll-*a* is identical for all pigments. Note different scales.

Pigmentation was very dilute in the late winter period. Maximum chlorophyll-*a* biomass was approximately 250 nanograms per liter (ng/L), or about one-fourth that measured for the same region the previous austral fall (March and April 1993, Prézelin unpublished data) and about one-half that measured in the austral spring (November) of 1991 when the region was also heavily ice-covered (Prézelin et al. 1992). Chlorophyll was most abundant at either ends of the transect, with highest concentrations and co-occurrence of all chemotaxonomic pigments occurring at the southernmost end of the grid (200 line). Here, offshore waters

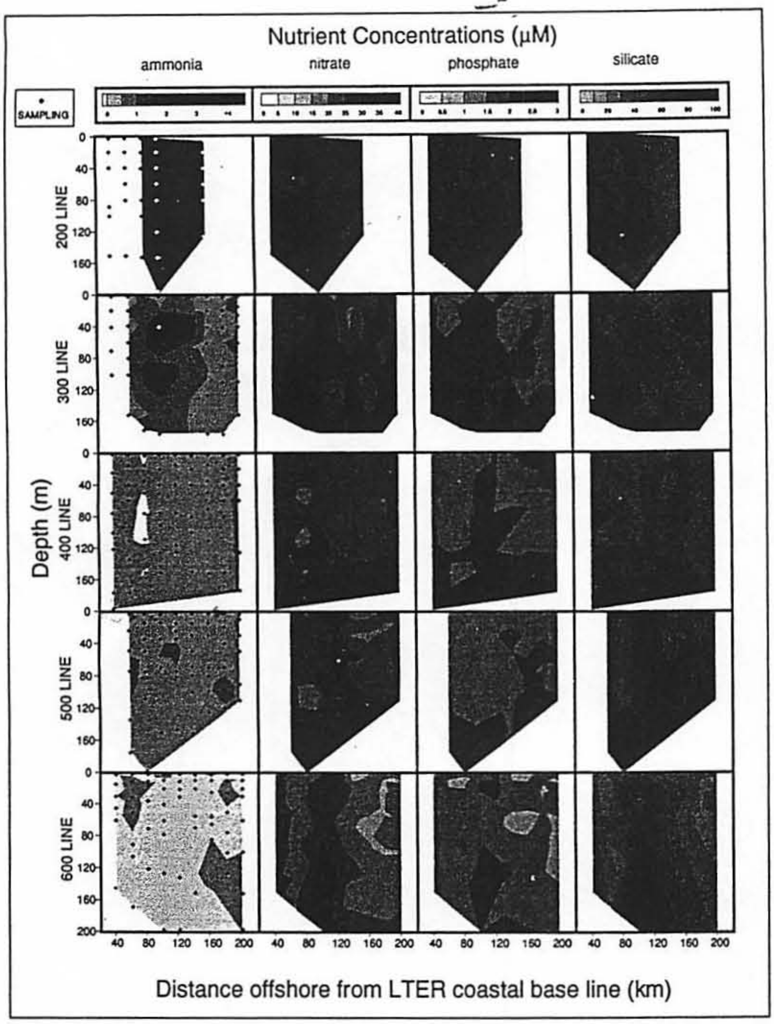

Figure 2. Contour plots for inorganic nutrient concentrations (μM) for each LTER grid line. Ammonia samples for stations 200.040, 200.060, and 300.040 were lost. Sampling shown for ammonia is consistent for all nutrients.

were diatom dominated, and ammonia levels were generally greater than 4 micromolar (μM). Nitrate and phosphate levels were also uniformly high along the 200 line, whereas levels of silicate were significantly enriched in nearshore waters.

Further north along the 300 line, the general pattern of volumetric productivity (Pmax) in the upper 60 meters (not shown) resembled that of chlorophyll distribution. Diatoms dominated surface waters of the shallower inshore waters, but a fairly even mixture of diatoms, prymnesiophytes, and chrysophytes constituted offshore communities with no clear relationship to nutrient distribution. Ammonia was elevated in the middle of the transect; nitrate and phosphate patterns tended to covary but without a discernable pattern; and silicate distribution was concentrated in nearshore deep waters and significantly less in offshore waters.

Data from the 400, 500, and 600 lines showed significant coherence with regards to phytoplankton but not inorganic nutrient distribution. Two diatom patches (approximately 20–50 km wide) were apparent in the middle of each transect. The flagellated prymnesiophytes and chrysophytes tend to covary and were more prevalent in offshore waters. Highest photosynthetic activity appeared associated with the diatoms. The availability of surface nutrients was lowest on the 600 line, though a "chimney" of nitrate, phosphate, and silicate seems to occur over a topographical rise in the middle of the transect, a characteristic repeatedly observed on various LTER cruises (Prézelin unpublished data).

For the combined database, correlations between pigments (chlorophyll-*a*, fucoxanthin, but-fucoxanthin, and hex-fucoxanthin) and nutrient concentra-

	ammonia	nitrate	phosphate	silicate	NO_3/PO_4	$Si(OH)_4/NO_3$	$NO_3/(NO_3+NH_3)$	chlorophyll a	but-fucoxanthin	fucoxanthin	hex-fucoxanthin	chlorophyll c	peridinin	prasinoxanthin	diadinoxanthin	diatoxanthin	lutein	chlorophyll b	Pmax
nitrate	0.008																		
phosphate	0.004	**0.587**																	
silicate	0.000	0.451	0.240																
NO_3/PO_4	0.000	0.042	0.204	0.033															
$Si(OH)_4/NO_3$	0.004	0.037	0.015	**0.719**	0.009														
$NO_3/(NO_3+NH_3)$	**0.948**	0.000	0.001	0.006	0.000	0.010													
chlorophyll a	0.004	0.110	0.093	0.074	0.001	0.012	0.000												
but-fucoxanthin	0.000	0.093	0.087	0.117	0.002	0.049	0.004	**0.878**											
fucoxanthin	0.006	0.061	0.049	0.012	0.001	0.003	0.001	**0.877**	**0.663**										
hex-fucoxanthin	0.000	0.041	0.044	0.099	0.003	0.064	0.005	**0.801**	**0.916**	**0.554**									
chlorophyll c	0.006	0.130	0.078	0.030	0.005	0.003	0.001	0.294	0.201	0.299	0.139								
peridinin	0.003	0.095	0.058	0.016	0.002	0.004	0.000	0.431	0.351	0.411	0.287	0.354							
prasinoxanthin	0.001	0.042	0.024	0.019	0.003	0.001	0.000	0.310	0.235	0.246	0.235	0.214	0.224						
diadinoxanthin	0.005	0.078	0.067	0.068	0.002	0.016	0.000	**0.911**	**0.798**	**0.768**	**0.785**	0.289	0.389	0.309					
diatoxanthin	0.000	0.041	0.035	0.070	0.000	0.039	0.004	0.463	**0.512**	0.313	**0.535**	0.151	0.221	0.240	**0.504**				
lutein	0.003	0.002	0.001	0.040	0.017	0.051	0.010	0.232	0.285	0.168	0.293	0.044	0.150	0.099	0.220	0.172			
chlorophyll b	0.000	0.070	0.038	0.050	0.006	0.012	0.004	0.351	0.346	0.258	0.350	0.231	0.243	0.182	0.370	0.250	0.185		
Pmax	0.019	0.049	0.025	0.013	0.000	0.098	0.001	0.217	0.084	0.202	0.017	0.228	0.229	0.124	0.157	0.002	0.008	0.163	
Ik	0.011	0.021	0.007	0.014	0.004	0.002	0.023	0.028	0.019	0.012	0.007	0.002	0.026	0.002	0.046	0.009	0.012	0.015	0.038

Figure 3. Linear regression values (r^2) between macronutrients (n>200), phytoplankton pigments (n>200), and photosynthetic parameters (n>67) measured within a 400- × 200-kilometer portion of the Palmer LTER offshore grid during late austral winter 1993. Regressions with $r^2>0.5$ are in bold.

tions (nitrate, phosphate, and silicate) were not significant. Although some significance might be resolved within defined water masses within the database, preliminary findings of high nutrients, low biomass, high assimilation rates, and low carbon-to-nitrogen ratios (Prézelin unpublished data) suggest overall phytoplankton growth was not nutrient-limited but light-limited. One is left asking, however, why distinct phytoplankton communities are evident late in the winter, when successional events would not yet have come into play; whether these early seasonal patterns reflect those left at the end of the last growing season; and whether they will be the prevalent signatures in the upcoming spring/summer season. Our Marine Primary Productivity Group plans to combine the measurements presented here with other LTER datasets to

- assess temporal and spatial scales for significant changes in the abundance and diversity of phytoplankton communities within the sampling area,
- advance physical-based and optical-based models of primary productivity, and
- contribute to ecosystem-based models of trophic interactions within the antarctic food web.

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