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Palmer LTER: Stable interannual successional patterns of phytoplankton communities in the coastal waters off Palmer Station, Antarctica

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Over the austral spring/summer periods from November 1991 through January 1994, water column profiles were obtained at the Long-Term Ecological Research (LTER) program station B (Sta B in figure 1) for concurrent determinations of physical and biological parameters related to phytoplankton dynamics. A Seabird® CTD (SEACAT SBE 19-03) was profiled free-fall from surface to near bottom from a Mark V Zodiac®. The instrument samples at a rate of 2 hertz. At a lowering rate of approximately 5 meters per second, approximately four samples per meter were retrieved. Along with the physical measurements, 615 discrete water column samples were collected for pigment determination in 5-liter GoFlo bottles within a few hours of solar noon. Samples were transported in dark bottles within 30 minutes of collection to Palmer Station (figure 1) for analyses. A more detailed description of the sampling strategy is given by Moline and Prézelin (1996, 1997).

Aliquots of all whole-water samples were analyzed for the algal pigments using reverse-phase high-performance liquid chromatography procedures of Wright et al. (1991). Specific details of the sample processing and pigment identification are described elsewhere (Moline and Prézelin 1996; Claustre, Moline, and Prézelin 1997). Pigment data were used to estimate phytoplankton standing crop (chlorophyll-*a*) and as chemotaxonomic markers to differentiate between algal groups. The four taxonomic groups that dominated the phytoplankton communities in the study area over the 3 years were diatoms, prymnesiophytes, cryptophytes, and chlorophytes. From the class-specific accessory pigments and the total chlorophyll-*a*, the percentage contribution of each taxonomic group to the overall biomass was calculated using multiple regression techniques (Everitt et al. 1990; Claustre et al.

1997). This approach indicated that the dominant accessory pigments (fucoxanthin, alloxanthin, 19'-hexanoyloxyfucoxanthin (HF) + 19'-butanoyloxyfucoxanthin (BF) and chlorophyll-

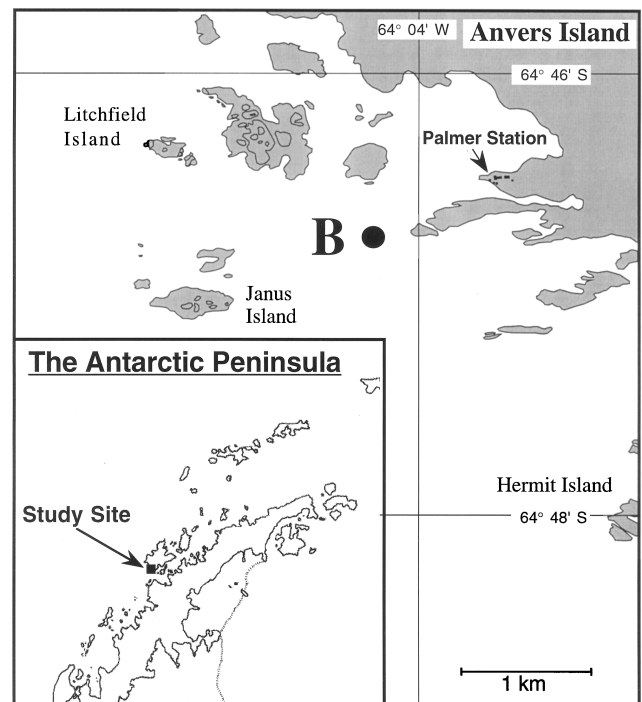


Figure 1. Location of LTER sampling station B (64°46.45'S 64°03.27'W) with respect to Palmer Station and the Antarctic Peninsula (inset). (km denotes kilometer.)

b) explained 99 percent of the variability in the measured chlorophyll-*a* (figure 2A).

High interannual variability in peak phytoplankton standing stock [2.3–29.2 milligrams of chlorophyll-*a* per cubic meter ($\text{mg chl } a \text{ m}^{-3}$)] and integrated chlorophyll-*a* was evident during the 3-year sampling period from 1991 to 1994 (figure 2B). Seasonal and annual patterns were primarily driven by water column stability influenced by local wind stress, which varied dramatically between years (Moline and Prézelin 1996). In 1991–1992, during an extended period of low-velocity winds, the depth of the mixed layer shallowed and a large bloom developed (figure 2B, Moline and Prézelin 1996, 1997; Moline et al. 1997). In contrast, during the 1992–1993 season, continual daily average wind speeds greater than 12 meters per second resulted in low biomass accumulation (figure 2B). Low biomass was measured after the ice broke out during the 1993–1994 season as a result of high wind speeds. As with the first year, however, the surface bloom in December 1993 was associated with periods of low wind stress (Moline and Prézelin 1996).

Despite high interannual variability in chlorophyll-*a* at station B from 1991 to 1994, a constant and repeated pattern in the succession of the phytoplankton groups was observed. Prymnesiophytes (as indicated by HF+BF) accounted for up to 50 percent of the biomass in the early spring (1993–1994), during periods of substantial ice cover (figure 3). By November in all 3 years, the majority of the phytoplankton biomass was composed of primarily (up to 90 percent) diatoms (fucoxanthin). These populations dramatically declined in December all 3 years. Diatoms were replaced by significant surface populations (>75 percent) of cryptophytes during the summers (figure 3). Chlorophytes were ubiquitous throughout the study period; however, they never accounted for more than 20 percent of the total phytoplankton biomass.

The sequence of dominance (and decline) of diatoms, prymnesiophytes, and chlorophytes could not be explained by hydrographic, nutrient

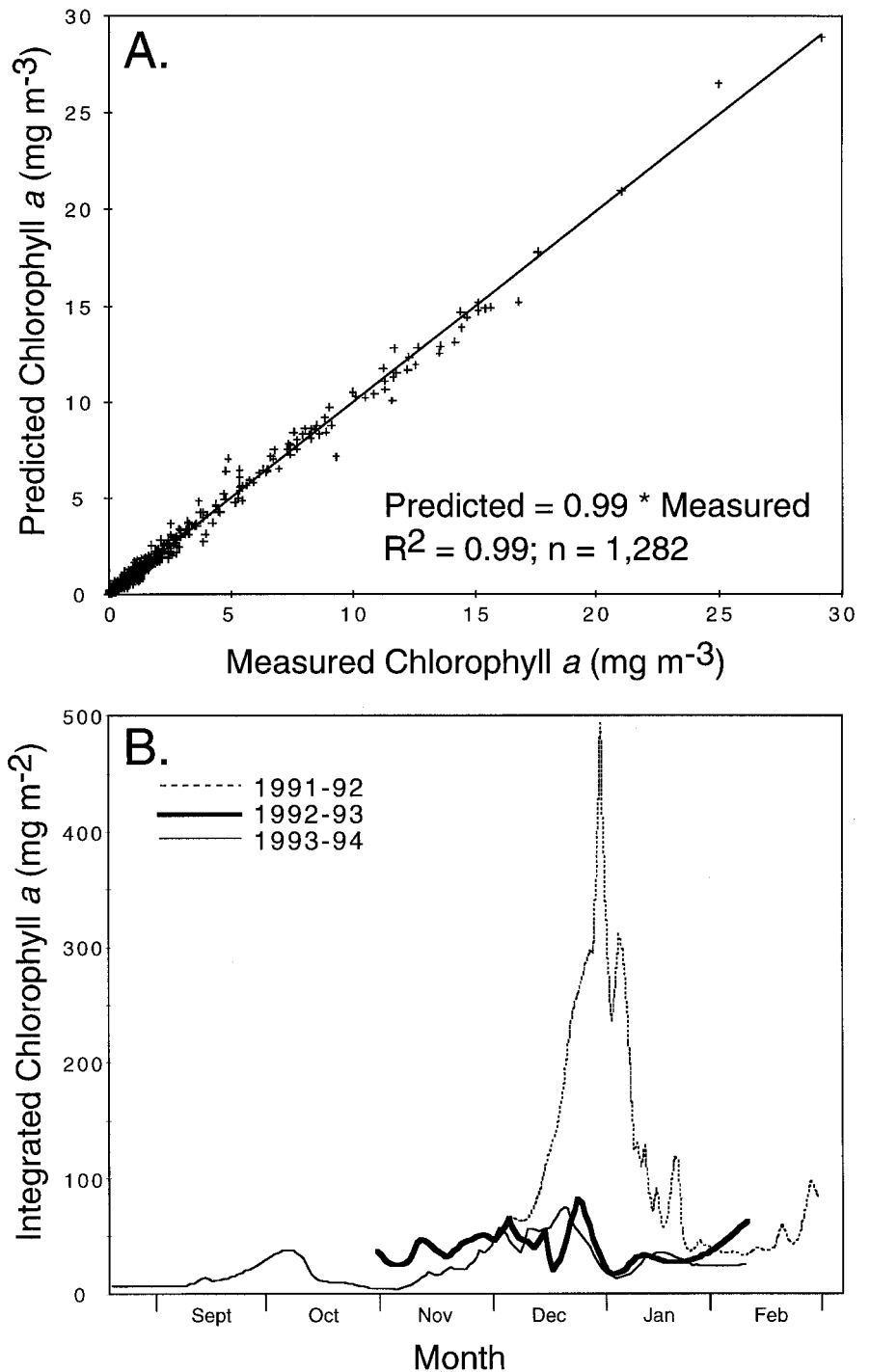


Figure 2. A. Measured chlorophyll-*a* versus predicted chlorophyll-*a* from multiple regression analyses (see text) on all samples collected from LTER nearshore stations B and E from 1991 to 1994 (see Moline and Prézelin 1996). B. Interannual variation in the depth-integrated chlorophyll-*a* at station B from 1991 to 1994.

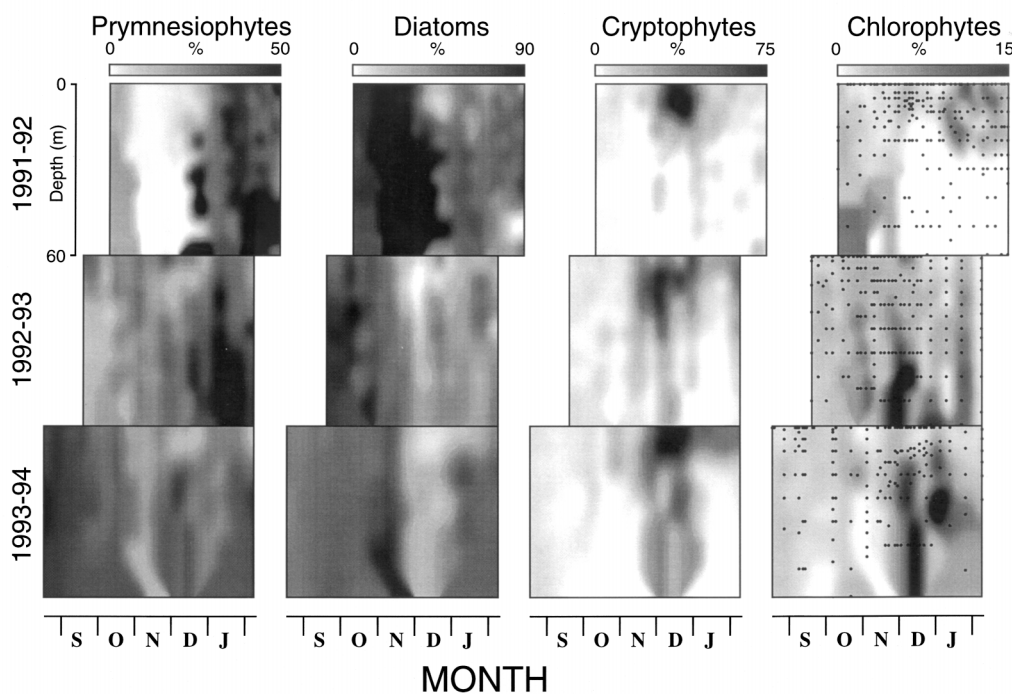


Figure 3. The seasonal variation in depth distribution of the percentage of total chlorophyll-a concentration by four phytoplankton groups at LTER station B from 1991 to 1994. Note the differences in the percentage scale for each taxonomic group. Overlaid on the contours for chlorophytes is the depth/time distribution of discrete samples (filled circles).

fields and light fields. The transition to cryptophytes, however, coincided with the initiation of glacial meltwater input to the coastal waters and was significantly dependent (MANOVA, $p < 0.001$) on the relatively high-temperature/low-salinity water characteristic of the meltwater lens (Moline unpublished data).

The occurrence of cryptophytes also correlated with the daily mean air temperature measured during the 3-year study period (figure 3B). When mean air temperatures exceeded the freezing point, the percentage of cryptophytes to the total biomass increased significantly from approximately 5 percent to approximately 15 percent (ANOVA; $P < 0.05$). As the mean temperature increased to 1–2°C, a highly significant increase was noted in the percentage cryptophytes to approximately 30 percent (ANOVA; $P < 0.001$). Overall, the difference was highly significant between samples greater than 0°C and those less than 0°C (ANOVA; $P < 0.001$), and this finding supported the contention that changes in phytoplankton community structure were in response to the formation of glacial meltwater.

Mean air temperatures along the Antarctic Peninsula have increased significantly (2–3°C) over the past 50 years (King 1994). The increased temperature will likely alter the spatial extent and timing of glacial meltwater runoff, which is already a significant geographic feature of the Antarctic Peninsula during summer months, extending 80–100 kilometers offshore.

We hypothesize that, over large timescales, the consistency in seasonal phytoplankton succession may prove a more robust predictor for “creeping” environmental change in antarctic coastal waters than will highly variable biomass and primary production indices.

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