in photosynthetic rates when samples are enclosed within pyrex or plexiglass as compared to quartz remains approximately the same at all light levels.

Ozone-related increased fluences of ultraviolet radiation have recently caused some researchers to predict calamitous results on the southern ocean ecosystem. Because depletion of ozone increases ultraviolet radiation only at wavelengths shorter than 320 nanometers, it is important to recognize that much of any documented deleterious effects of ultraviolet radiation in the Antarctic is partially due to:

- the "normal" fluence of ultraviolet-B radiation, even with high ozone levels, and
- ultraviolet-A radiation, which is not affected by ozone concentrations in the stratosphere.

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Effects of diesel fuel arctic on photosynthesis and pigment levels in antarctic marine algae following the *Bahia Paraiso* fuel spill

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The grounding of the Argentine ship *Bahia Paraiso* near Anvers Island on the Antarctic Peninsula in late January 1989 released more than 150,000 gallons of refined petroleum into the surrounding environment (Kennicutt et al. 1990). The most immediate effect of this petroleum, primarily diesel fuel arctic (DFA), was observed in the intertidal zone which was heavily populated by herbivorous limpets and macroalgae. Early observations indicated significant losses of limpets (as much as 50 percent) in oiled areas (Fraser personal communication). No quantitative data were available on the loss of intertidal macroalgae, although Fraser reported that the thalli turned black or became covered with lesions at heavily oiled sites. Two months following the spill, we attempted to quantify the physiological effect of the oil on intertidal and shallow subtidal macroalgal species. We examined photosynthetic production and pigment content under concentrations of DFA to which the plants were probably exposed within the first several days of the spill.

Laboratory exposure of marine macroalgae to the water-soluble fractions of DFA (up to 20 percent volume/volume for 96-hour periods) addressed changes in photosynthetic rate and pigment concentrations in two intertidal species (*Palmaria de-*

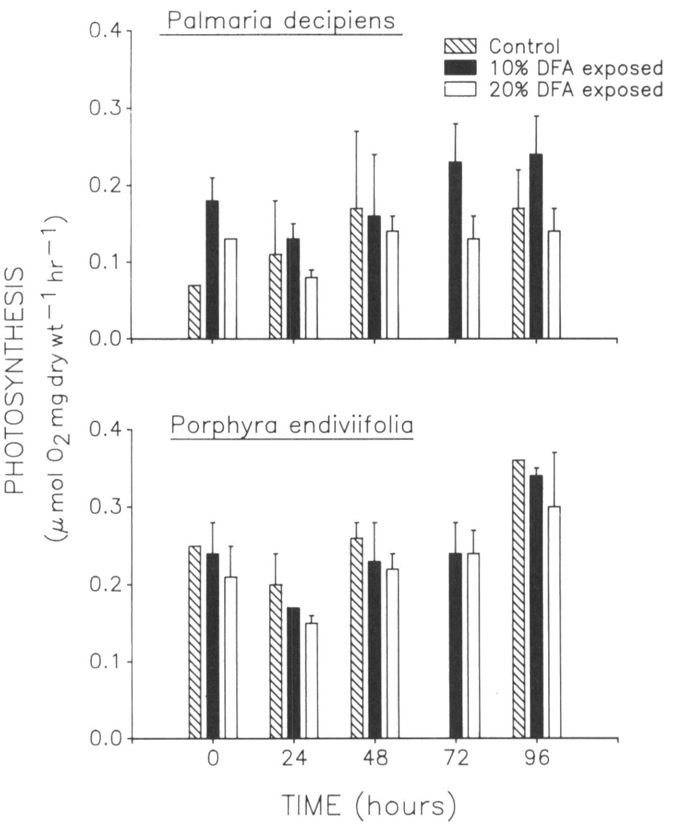

Figure 1. Light saturated photosynthesis in two antarctic red algae exposed to 10 and 20 percent solutions of DFA over a 96-hour period. Values are $\bar{x} \pm SE$ (n = 2). No data are available for controls at 72-hour interval. (μmol O_2 mg dry wt^{-1} hr^{-1} denotes micromoles of oxygen per milligram of dry weight per hour.)

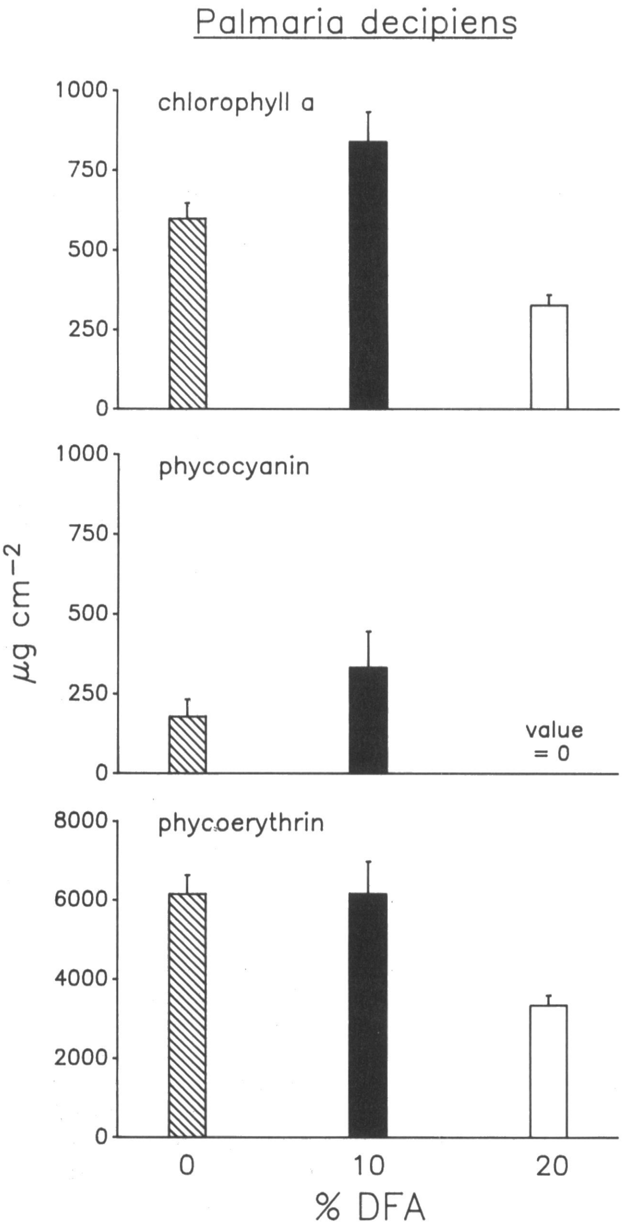

Figure 2. Pigment content in *Palmaria decipiens* following a 96-hr period of exposure to 10 and 20 percent solutions of DFA. Values are $\bar{x} \pm SE$ (n=3). ($\mu g\ cm^{-2}$ denotes micrograms per square centimeter.)

cipiens and *Porphyra endiviifolia*) and one shallow subtidal species (*Desmarestia menziesii*). Photosynthetic production was measured using light-and-dark bottles incubated for 1–2 hours in outdoor aquaria under natural daylight conditions at midday. A modified winkler procedure (Dawes 1981) was used to measure dissolved oxygen. For pigment analysis, chlorophyll *a* was extracted from *D. menziesii* in 95 percent methanol following hyperosmotic treatment (4.5 molar sodium chloride) according to Reed (1988). For *P. decipiens* and *P. endiviifolia*, chlorophyll *a* (solvents dimethyl sulfoxide and 90 percent acetone) and phycobiliproteins (solvent 0.1 molar phosphate buffer) were extracted following Seely, Duncan, and Vivaver (1972) and Beer and Eshell (1985), respectively. Pigment concentrations were determined according to the method of Duncan and Harrison (1982) for chlorophyll *a* and Beer and Eshell (1985) for phycobiliproteins. Extractions were always performed on plants following a treatment exposure period of 96 hours.

The results of the photosynthetic measurements are shown in figure 1 for *Palmaria decipiens* and *Porphyra endiviifolia*. No statistically significant reduction in photosynthesis ($P>0.05$), as measured by oxygen evolution up to concentrations of 20 percent DFA, was documented. *Desmarestia menziesii* also demonstrated no significant reduction in photosynthesis at 10 percent DFA compared to controls (this species was not exposed to 20 percent DFA concentrations). The variation in oxygen evolution in control plants at different times (figure 1) is due entirely to lower incubation light levels. Light levels generally ranged between 75 and 200 micromoles per square meter per second during each incubation.

The results of the pigment analyses for *Palmaria decipiens* and *Porphyra endiviifolia* are shown in figures 2 and 3. No significant differences ($P>0.05$) in chlorophyll *a* were observed in a 10 percent DFA concentration among all three species, including *Desmarestia menziesii* (not shown). Chlorophyll *a* concentrations

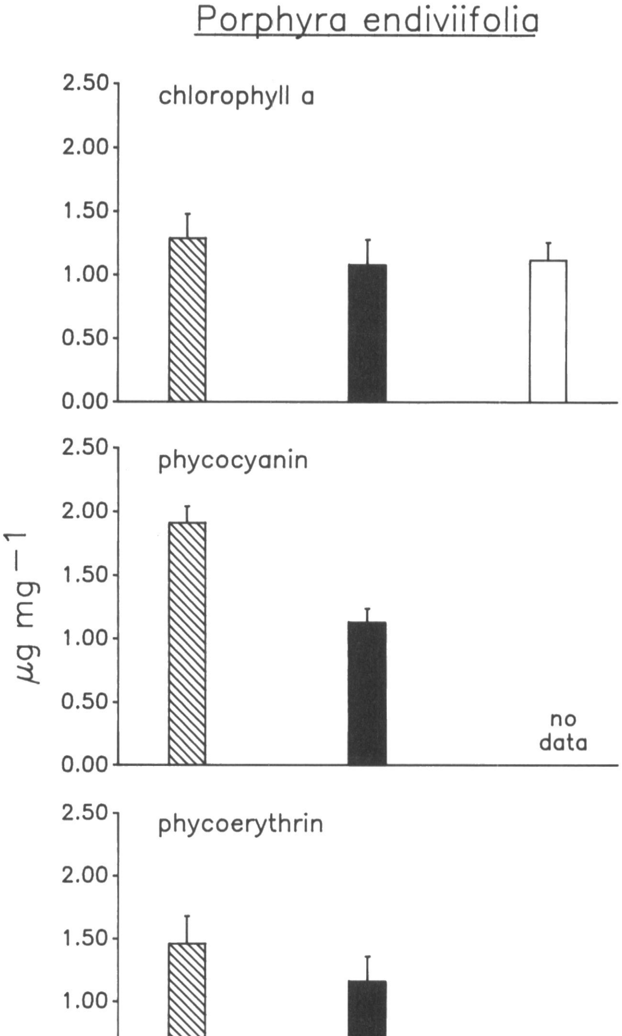

Figure 3. Pigment content in *Porphyra endiviifolia* following a 96-hour period of exposure to 10 and 20 percent solutions of DFA. Values are $\bar{x} \pm SE$ (n=3). ($\mu g\ mg^{-1}$ denotes micrograms per milligram.)

in *P. decipiens* at 20 percent DFA, however, were significantly lower (P>0.05) than plants exposed to a 10 percent DFA concentration. Phycobiliprotein content also dropped significantly among *P. decipiens* and *P. endiviifolia* plants exposed to 10 and 20 percent DFA concentrations. In *P. decipiens* phycocyanin and phycoerythrin content was lowest at 20 percent DFA (phycocyanin content was undetectable at 20 percent DFA, figure 2). No data are available for *P. endiviifolia* at 20 percent DFA, but at 10 percent DFA, phycocyanin content dropped significantly from that of control plants (figure 3).

Previous studies of this nature also revealed that changes in photosynthesis and pigment content are variable, depending on the type of oil, its concentration, the length of exposure, method of preparation of the oil-seawater mixture, the irradiance, and the algal species (Johnson 1977). The significant drop in phycocyanin content in *Porphyra endiviifolia* at 10 percent DFA is noteworthy, since the presence of phycocyanin enables this genus to maintain high rates of photosynthesis throughout the green and into the orange region of the action spectrum (Lüning and Dring 1985) compared to phycoerythrin-rich species (e.g., *Palmaria decipiens*) which occurs lower intertidally than *P. endiviifolia*. The lack of a significant change in photosynthetic rate in these two species is not understood but may be related to the high variability in oxygen measurements that resulted from incubations performed under a wide range of natural irradiance conditions.

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Chlorophyll distribution and primary productivity in the Ross Sea, austral summer 1990

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During January and February 1990, a cruise was conducted in the Ross Sea to measure:

- the silica and carbon production of phytoplankton in the euphotic zone off the Ross Sea of the coast of Victoria Land,
- the vertical flux of particulate material through the water column,
- the regeneration of carbon and silica within the water column, and
- the accumulation of carbon and silica in the sediments.

As part of this experiment, we measured phytoplankton distribution and primary productivity along transects perpendicular to the ice edge. Based on previous results, we expected that a large phytoplankton bloom would develop in the region adjacent to the receding ice edge (Smith and Nelson 1985). Furthermore, we expected that this bloom would be restricted to the region of significant vertical stability imparted by meltwater addition. Other studies of sediment accumulation rates suggested that a large portion of the material produced at the surface within this bloom must reach the sediments (Ledford-Hoffman, DeMaster, and Nittrouer 1986). These results also suggested that a north-south gradient in sediment accumulation rates occurred along the coast of Victoria Land, although a similar gradient in surface productivity has not been observed and, furthermore, would not be expected based on a conceptual model of ice-edge phytoplankton blooms (Smith and Nelson 1986). Our study directly tested whether a latitudinal gradient in surface biomass and productivity exists.

We collected samples from the R/V *Polar Duke* from 12 January to 10 February 1990 (figure 1). Stations were occupied principally along two transects perpendicular to the ice edge (and coastline). One transect was at 76°30'S (the site of the study conducted in 1983 and reported by Smith and Nelson 1985) and one at 72°30'S. Continuous profiles of temperature, conductivity, optical transmission, and fluorescence were made at each station, and samples were collected using Niskin bottles equipped with teflon-coated stainless steel springs and mounted on a rosette frame. Sample depths were based on irradiance penetration. Chlorophyll *a* was analyzed fluorometrically and primary productivity measured by simulated *in situ* techniques (Wilson, Smith, and Nelson 1986).

Chlorophyll concentrations were elevated throughout much of the entire region, particularly along the southern transect. Surface chlorophyll levels ranged from 1.49 to 8.19 micrograms per liter along the southern transect and 0.22 to 2.42 micrograms