The weight specific egestion of carbon can be described from:

$$E_t = E_0 \times e^{-\beta t}$$

where E_0 is the initial weight specific egestion rate (micrograms carbon per milligram dry weight per day), E_t is the egestion rate at time t and β is the rate at which the egestion rate declines with time. The slopes of the regressions of E_t versus time for 8 individual *E. superba* were not significantly different, but the intercepts were significantly different (table). Carbon egestion rates of all individuals are used in the figure. The estimated *in situ* egestion rate, E_0 was predicted to be 18 micrograms carbon per milligram dry weight per day (figure).

We employ an independent method to estimate *in situ* egestion rate, and hence to assess whether our experimental measurements are of expected magnitude. *In situ* egestion rate can be calculated by rearranging the equation for daily growth rate (G):

$$G = \frac{a \times (E_0 - R) \times W}{(1 - a)}$$

where E_0 is the *in situ* weight specific egestion rate, R is losses due to respiration, W is the krill dry weight, and a is the assimilation efficiency.

Individual *E. superba* in their second year increase in dry weight from about 10 milligrams at the beginning of the austral summer to about 150 milligrams at the end of the season, a period of approximately 4 months. The estimated growth rate over this period is 0.022 milligrams dry weight per day. We further assume a 70 percent assimilation efficiency (Conover 1978), a respiration rate of 50 milliliters of oxygen per milligram dry weight per day and a respiratory quotient of 0.8 (Ikeda and Mitchell 1982). By rearranging the growth equation, these assumptions yield a weight-specific carbon egestion rate of 20 micrograms per milligram dry weight per day, which is roughly equal to our measured E_0 of 18 micrograms carbon per milligram dry weight per day.

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Regression statistics for egestion rates (E) versus time (T) for animals of different dry weights. log E = b × log T + log x, where b = slope and log x = intercept.

r^2	log x	b	p[a]	Dry weight[b]
0.99	1.70	0.46	0	57.8
0.87	0.50	0.74	0.020	46.9
0.97	1.56	0.31	0.003	48.2
0.99	1.67	0.53	0	45.3
0.97	2.26	0.29	0.002	69.1
0.70	1.45	0.56	0.077	18.5
0.67	2.01	0.08	0.088	31.1

[a] Probability of b not equal 0.
[b] Dry weight in milligrams.

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RACER: Phaeopigment photooxidation during the spring bloom in northern Gerlache Strait

MARIA VERNET *and* B. GREGORY MITCHELL

Marine Research Division
Scripps Institution of Oceanography
La Jolla, California 92093

Photooxidation rates of phaeopigments in polar waters are of particular importance due to the high phaeopigment concentrations often found in surface waters of these regions (Rey, Sjkoldal, and Slagstad 1987; Holm-Hansen and Mitchell in press). Weight ratios of chlorophyll *a*:phaeopigments ranging from 2:1 to 1:1 are not unusual in the euphotic zone suggesting either a high production rate or lower loss rates of phaeopigments than in temperate and tropical waters. If phaeopigments in seston originate from zooplankton grazing (Currie 1962; Shuman and Lorenzen 1975) and light is their main source of degradation (SooHoo and Kiefer 1982; Welschmeyer and Lorenzen 1985), it follows that either grazing is higher than previously expected and/or photooxidation rates are lower in polar regions.

Rates of pigment photooxidation are dependent on light intensity and quality, oxygen, temperature (SooHoo and Kiefer 1982), and probably factors such as type of material attached to or surrounding the phaeopigments. Other factors, such as the type of sensor used to measure radiation fluxes (Laws et al. 1988), can affect indirectly our estimates of photooxidation rates.

Previous studies on phaeopigment photooxidation rates in Antarctica showed temperature dependence (Letelier et al. 1987)

with lower rates at lower temperatures. The material analyzed consisted of krill fecal pellets finely ground and incubated in a photosynthesis vs. irradiance incubator with controlled temperature. In this study, we present *in situ* rates of photooxidation of material collected in sediment traps. In addition, photooxidation rates of several size fractions were estimated to assess the effect of particle size in this process.

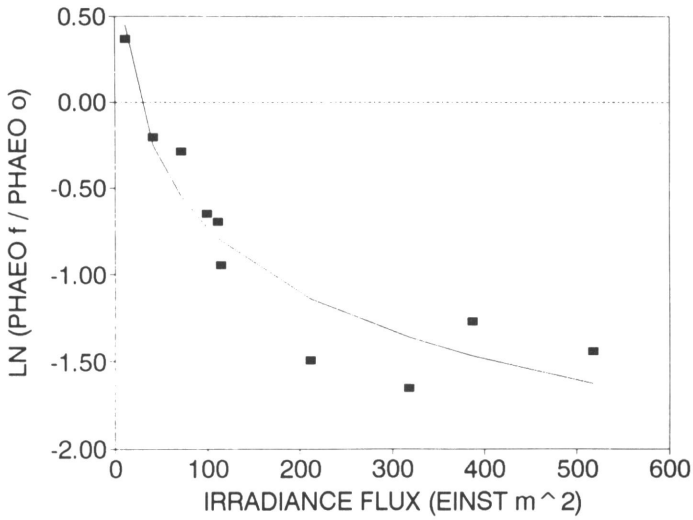
Samples for photooxidation experiments were obtained from material collected by traps deployed in November of 1989 for periods ranging from 1.4 to 2.1 days (Karl and Asper, *Antarctic Journal*, this issue). No preservative were added to the traps. Traps were filled with a brine solution (50 grams of salt (NaCl) per liter of seawater) before deployment. Upon trap retrieval samples were stored in polyvinyl bottles, in the dark, at 2 °C, for a few days. For *in situ* experiments samples from the sediment traps were diluted in filtered seawater and placed in 2-liter polycarbonate bottles. These bottles were incubated in the water for a few hours, attached to a floating array consisting of a spar buoy, floats, and a 50-meter line. photosynthetically available radiation (PAR) fluxes were measured on board ship with a 2-pi collector (Biospherical Instruments Model QSL-40). Light extinction in the water column was measured with an *in situ* PAR sensor (International Light Model SUDO38/PAR/W). A ratio of 0.8 was used for irradiance loss through the water interface (Vernet and Karl, *Antarctic Journal*, this issue). For the size fractionation experiments, the sample was filtered through successive mesh sizes, 200, 20, 10, 3, and 1 micrometer. Each fraction was sampled and incubated in 0.5-liter polycarbonate bottles in a plexiglass incubator fitted with running seawater and placed on the ship's deck away from any shade.

In situ photooxidation rates (table) were lower than previously reported, similar to rates measured for the Arctic (Vernet in press). These rates were estimated using the initial slope of phaeopigment loss. Very long incubations did not follow first-order kinetics (figure). These results suggest the existence of "background" phaeopigments not very sensitive to light or fluorescence by a stable compound different from phaeopigments. These hypotheses will be tested by high-performance liquid chromatography analysis of the samples that will allow for estimations of photooxidation rates of individual phaeopigments.

Apparent first order kinetic constants of phaeopigment photooxidation (k_1, in einsteins per square meter) of the material collected in sediment traps in northern Gerlache Strait in November 1989. The first experiment was conducted on deck and lasted 6 days. The second and third experiments were incubated *in situ* for approximately 10 hours at depths 2, 6, and 21 meters and lasted 10 hours, at depths of 1, 5, 9, 13, and 21 meters, respectively. The fourth experiment was carried out on deck and lasted 4 hours. (Size is in micrometers.)

Date	Size	k_1	r^2	n
7 Nov 89	all	0.0089	0.95	7
8 Nov 89	all	0.0041	0.99	3[a]
15 Nov 89	all	0.0062	0.99	5
20 Nov 89	<200	0.0187	0.98	7
	<20	0.0273	0.94	7
	<10	0.0301	0.94	7
	<3	0.0303	0.99	7
	<1	0.0336	0.99	7

[a] Two bottles were lost in the deployment.



Phaeopigment photooxidation of sedimenting particles collected with sediment traps in Northern Gerlache Strait in November 1989. Experiment was carried on deck, at *in situ* temperature, for a period of 4 days. (EINST m ^ 2 denotes einsteins per square meter.)

The apparent first-order kinetic rates (k_1) determined from the initial slopes, are clearly dependent on particle size with higher rates associated with smaller particles (table). A twofold increase of photooxidation occurs in <1-micrometer particles as opposed to <200-micrometer particles, with a sharp cutoff at <10 micrometers. A large fraction of phaeopigments was associated to >20-micrometer particles in the water column during the spring bloom (Holm-Hansen personal communication) suggesting a $k_1 = 0.0187$ einsteins per square meter should be used for natural waters. The variability in photooxidation rates due to particle size is of the same order as that associated with temperature (SooHoo and Kiefer 1982; Letelier et al. 1987; Vernet in press) and could be part of the reason for discrepancies in the literature (SooHoo and Kiefer 1982; Welschmeyer and Lorenzen 1985; Downs 1989).

The lower photooxidation rates estimated *in situ* as compared to on deck incubations may reflect the difference in experimental procedure. *In situ* rates may reflect a more realistic environment, with screening by the water column of very active wavelengths such as the ultraviolet and red regions of the spectrum. On the other hand, *in situ* rates were estimated with longer incubations and may not consider the initial slope of pigment degradation. A third source of variability is the size of particles exposed to the light presumably due to the fact that large particles can shade some of the pigment included in the matrix.

The complex array of variables that affect photooxidation rates of natural particles makes it difficult to estimate rates for general application in pigment models. The results from this study and others in polar regions all agree that rates at about 0 °C (Vernet in press) are lower than those at 10 to 25 °C (SooHoo and Kiefer 1982; Welschmeyer and Lorenzen 1985). Within the range of photooxidation constants measured in polar waters (0.0041 to 0.0301 einsteins per square meter) factors such as smaller particle size, shorter incubations, and surface irradiance spectrum increase the estimated rate while larger particles, incubated for longer periods and at *in situ* irradiance conditions decrease the estimated rates. More research is needed before establishing photooxidation rates that are representative of *in situ* conditions, in particular the relationship between *in*

situ and simulated conditions, duration of experiments, and particle size.

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RACER: Phytoplankton growth and zooplankton grazing in the northern Gerlache Strait estimated from chlorophyll budgets

MARIA VERNET

Marine Research Division
Scripps Institution of Oceanography
La Jolla, California 92093

DAVID M. KARL

School of Ocean and Earth Sciences and Technology
University of Hawaii
Honolulu, Hawaii 96822

Pigment budgets use chlorophyll *a* and phaeopigment standing stock in combination with their photooxidation and sedimentation rates in the euphotic zone to estimate phytoplankton growth and grazing by micro) and macrozooplankton (Welschmeyer and Lorenzen 1985). Their model assumes that chlorophyll *a* is associated only with phytoplankton while phaeopigments are the product of a stoichiometric degradation of chlorophyll *a* due to grazing (Shuman and Lorenzen 1975). Phaeopigments in seston are attributed to microzooplankton grazing while the rate of phaeopigment in sinking particulate matter sedimentation (i.e., that material collected in sediment traps) is due to macrozooplankton grazing. The model was developed to explain biological processes in the euphotic zone using chlorophyll *a* and its degradation products as tracers of phytoplankton biomass, and it does not consider processes below illuminated waters. Furthermore, the model assumes that vertical processes are dominant over lateral advection, where sinking of particles out of the euphotic zone is related to the body of water immediately above the sediment-trap collector.

The model estimates phytoplankton growth rates with success in temperate (Welschmeyer and Lorenzen 1985) and subarctic (Laws et al. 1988) coastal areas, assuming a 66 percent conversion efficiency in the degradation of chlorophyll *a* to phaeopigments. In this article, we present results from three differing sampling periods during the spring bloom in the Northern Gerlache Strait, from 6 to 21 November 1989 (Karl and Asper, *Antarctic Journal*, this issue). The sediment traps were deployed three times, 1 week apart, for a duration raging from 1.43 to 2.04 days, at station A (64°11.17'S 61°21.8'W) in the RACER study area (Huntley et al., *Antarctic Journal* this issue).

Chlorophyll *a* and phaeopigments were measured in methanolic extracts using a Turner Designs fluorometer calibrated with chlorophyll *a* (Sigma Chemical Co.). All samples were filtered onto Whatman GF/F filters and extracted in methanol for at least 2 hours in the dark at room temperature. Pigments from the water column were sampled using 10-liter Niskin bottles attached to a conductivity-temperature-depth (CTD)-rosette. Samples from the sediment traps were filtered from the saline solution (50 grams of salt (NaCl) per liter of filtered seawater, without preservative), immediately after trap retrieval.

The model is based on Welschmeyer and Lorenzen (1985), assuming chlorophyll *a* sedimentation is not zero and is due to cell sinking. Equations were solved numerically and changes in the depth of euphotic zone and chlorophyll concentrations at those depths were accounted for as in Laws et al. (1988).