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Planktonic Respiration in a Shallow Eutrophic Lake

ABSTRACT

We studied the relationships between planktonic respiration and key physicochemical parameters and total autochthonous biomass for three years in Lake Pamvotis, a shallow and eutrophic Greek lake. Planktonic community respiration was correlated with only one environmental parameter, dissolved inorganic nitrogen concentration, which appeared to be the limiting nutrient. Community respiration was also related to heterotrophic bacterial abundance.

In lakes, respiration tends to increase with primary production, nutrient loading, and increased trophic status (del Giorgio and Peters 1994, Pace and Cole 2000, Cimbleris and Kalff 1998). However, lake ecosystems receive organic matter from multiple autochthonous and allochthonous sources potentially uncoupling ecosystem respiration from planktonic primary production (Wetzel 1992). Although autochthonous carbon can be readily metabolized, allochthonous carbon is not readily bioavailable (Cole et al. 2000). Cross-systems studies showed no correlation between respiration and organic carbon in rivers, estuaries, and lakes (del Giorgio and Peters 1994, Coffin et al. 1993). Nutrient availability is thought to be a major factor determining the utilization of organic carbon by the freshwater planktonic communities (Mazumder and Lean 1994). Respiration was increased in lakes with high concentrations of nutrients; however, respiration differed among lakes with the same nutrient loading (Pace and Cole 2000). Cimberlis and Kalff (1998) demonstrated that phosphorus was the only single element able to predict planktonic respiration across temperate lakes; however, no systematic change was observed between respiration rates and lake trophic status. In addition, planktonic bacteria constitute a fundamental component of the organic carbon cycle in aquatic systems (Schindler and Scheuerell 2002). Like herbivores and carnivores, bacteria convert existing organic molecules into their own biomass (e.g., bacterial production) and oxidize some of these to final metabolic endproducts (e.g., bacterial respiration), thus contributing to the total community respiration (Cole and Pace 1995).

The aim of the present study was to investigate the coupling of planktonic respiration with the key eutrophication parameters and with total autochthonous biomass in a shallow eutrophic lake. The contribution of bacteria to community respiration was also studied.

Lake Pamvotis, in northwestern Greece (39^0 40′ N, 20^0 53′ E,), is a highly eutrophic shallow lake (mean depth, 4.3 m, maximum depth of 7.5 m) that occupies an area of 22.8 km^2. The lake has no naturally occurring surface outflows and is continuously enriched with allochthonous organic and inorganic matter from the watershed.

Integrated epilimnetic water samples were collected monthly at five sampling stations from 1995 to 1998. Soluble reactive phosphorus (SRP), nitrogen (NO_3-N, NO_2-N, NH_4-N), and chlorophyll *a* (chl *a*) were examined. Chemical analyses were by standard methods (APHA 1989). Nitrates were determined spectrophotometrically by reduction to nitrite and following the method of diazotation and condensation with salicylate. Ammonium content was measured spectrophotometrically by the Nessler method. Determination of orthophosphates was made by the molybdenum blue method. Chlorophyll *a* was determined spectrophotometrically, after the extraction of pigments with ethanol (Jespersen and Christoffersen 1987). Total autotrophic biomass was estimated from chl *a* concentrations, using a conversion factor of 1 mg chl *a* equals to 40 mg C (del Giorgio and Gasol 1995). Planktonic respiration rates were estimated by

measuring the dissolved oxygen consumed. Water samples were siphoned into BOD bottles which were incubated in the dark, at 20-21 ^{0}C for a period of 96 hours. Bacterial abundance was estimated by the pour plate method (APHA 1989). Because the values of limnological parameters among sampling stations did not differ, data from the five stations were combined. All data were log-transformed in order to ensure homoscedasticity.

The concentration of the dissolved inorganic N compounds (e.g., NO_3-N, NO_2-N and NH_4-N) fluctuated between 1.43 and 2.07 mg/L. Higher values were observed during the winter months, while late spring and summer showed the lowest concentrations. The most abundant form of DIN was nitrate contributing 89%-94% of the DIN pool. Annual SRP, at the same period showed no clear trend ranging between 0.72 and 2.86 mg/L. Maximum values were recorded during the warm period. Monthly averages of chl *a* ranged between 28 and 193 mg/m^3, with an annual mean concentration of 76.91 mg/m^3.We found a significant positive correlation between planktonic respiration and the nitrogen compounds (Fig.1). Neither the soluble reactive phosphorous nor the pH was related to community respiration.

Autotrophic biomass ranged between 760 and 7,732 mg C/L, and bacterial abundance between 19.10^2 and 102.10^2 cfu/mL. Community respiration was significantly correlated with bacterial abundance ($R= 0.529$; $p<0.001$), while no correlation was found with chl *a*.

Wetzel (1992) suggested that there is an overemphasis on autotrophic production along gradients of increasing eutrophication and that most lakes are likely heterotrophic systems controlled by the overwhelming importance of the allochthonous over autochthonous carbon in lake metabolism. Lake Pamvotis has experienced high amounts of allochthonous organic loads (Kagalou et al. 2003), which presumably support a high part of respiration. In contrast to phytoplankton biomass, bacterial abundance showed a significant positive correlation with respiration ($R= 0.529$; $p<0.001$). We found that bacterial abundance was the only parameter able to predict planktonic community respiration in Lake Pamvotis.

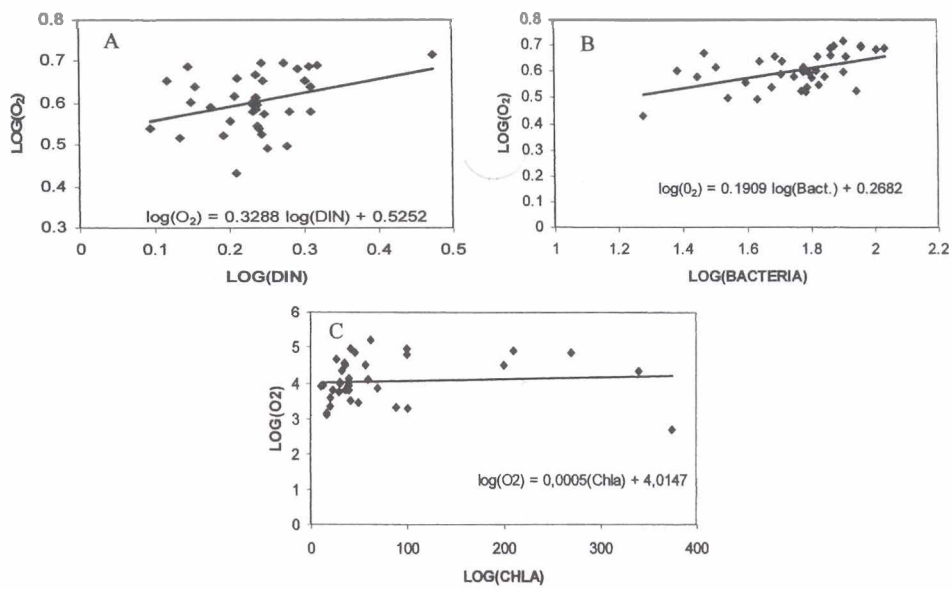

Figure 1. Relationships between planktonic community respiration (as O_2 consumed) and dissolved inorganic nitrogen (A), bacterial abundance (B), and algal biomass (C) in Lake Pamvotis over a 36 month period.

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