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Harold G. Marshall
Old Dominion University, hmarshal@odu.edu

Lubomira Burchardt

Elżbieta Wilk-Woźniak

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Research Article

COMPARISON OF PHYTOPLANKTON AND AUTOTROPHIC PICOPLANKTON POPULATIONS FROM A POND'S SURFACE AND SUBSURFACE WATERS OVER A 24-HOUR PERIOD

HAROLD G. MARSHALL[1*], LUBOMIRA BURCHARDT[2], ELŻBIETA WILK-WOŹNIAK[3]

[1]*Department of Biological Sciences, Old Dominion University*
Norfolk, Virginia, U.S.A.
[2]*Department of Hydrobiology, Adam Mickiewicz University*
Poznan, Poland
[3]*Institute of Natural Conservation, Department of Freshwater Biology, PAS*
Krakow, Poland
[*]*e-mail: hmarshal@odu.edu*

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Abstract

Phytoplankton abundance and composition relationships within the surface layer changed over short time periods (4-6 hours) in comparison with more constant associations at 2 cm below the surface. Both strata had a diverse algal flora (>50 taxa), but no distinct neuston assemblage characterized the surface layer algal composition over the 24-hour study. The similarity between the two strata indicated the floral composition of the surface layer came from the water column algae below the surface. Chlorophytes, diatoms, cyanobacteria, and cryptophytes represented the most abundant algal categories for both strata with a total mean phytoplankton abundance of 3,566 cells ml^{-1} at the surface and 40,532 cells ml^{-1} at 2 cm over the 24 hours. The autotrophic picoplankton had generally similar levels of abundance over time. Their mean abundance for the 24-hours was 469 and 599 x 10^3 cells ml^{-1} at the surface and 2 cm respectively.

INTRODUCTION

The surface waters of freshwater and marine habitats represent a dynamic region of the water column. The surface layer and strata directly below the surface are occupied by floral and faunal populations referred to as neuston (Naumann 1917). The fragile nature of this region is under the direct influence of wind action, changing air and water temperatures, variable light intensities, plus water movement occurring within the upper strata of the water column. These and various environmental conditions will influence the composition and abundance of the biota occupying these strata (Marshall, Burchardt 2005). The surface layers of a freshwater pond located in Norfolk, Virginia (U.S.A.) was the habitat under study in this paper. The pond is shallow (ca. 2 m deep), with a surface area of 0.23 ha. In a seasonal study of this pond, Burchardt and Marshall (2003) reported a diverse assemblage of algae within both the surface neuston layer and waters at ca. 40 cm depth, with no unique floral assemblage associated with the neuston. The objectives of this study were to compare phytoplankton composition and abundance, plus autotrophic picoplankton abundance, between the surface layer and waters at 2 cm depth of this pond over a 24-hour period.

MATERIAL AND METHODS

Water samples were taken on June 8-9, 2004 at four randomly designated stations in the pond, with consecutive collections taken at 2:00 pm, 8:00 pm, 1:00 am, 5:00 am, and 2:00 pm. The surface neuston samples were obtained following a glass plate collection protocol (Harvey and Burzell 1972), with separate collections for the phytoplankton and autotrophic picoplankton analysis. Sub-surface samples were collected using a 20 ml pippet that was modified so that the lower end of the pippet was bent at a right angle. The pippet was used to obtain water at 2 cm below the surface with the bent region held horizontal to the water's surface, with separate sample sets collected for phytoplankton and autotrophic picoplankton. During each sampling period a minimum of 10 sub-samples were taken at each station and combined for phytoplankton analysis, this procedure repeated to obtain the water for picoplankton analysis. The phytoplankton samples were preserved with Lugol's solution and analyzed using light microscopy at 300X and 600X magnification. The picoplankton was preserved with glutaraldehyde and cell counts determined using epifluorescence microscopy (Burchardt and Marshall 2003). Results from each of the four stations, for each time period, were analyzed separately and the results recorded. Mean values were then determined from data taken at the four

stations for each time period. Water quality analysis was conducted using standard analytical methods.

RESULTS

During the 24-hour study the surface waters and their phytoplankton assemblages were exposed to changing environmental conditions. These included water temperatures at the pond's surface which ranged from 24.0 to 30.0°C and pH from 8.6 to 9.3. Air temperature was from 21.1 to 33.8 °C and wind velocity 3.2 to 9.7 km h^{-1}. The pond's surface water chemistry (upper 2 cm) indicated values (mg l^{-1}) as: total nitrogen (0.75), total dissolved nitrogen (0.54), total phosphorus (0.05), and total dissolved phosphorus (0.02).

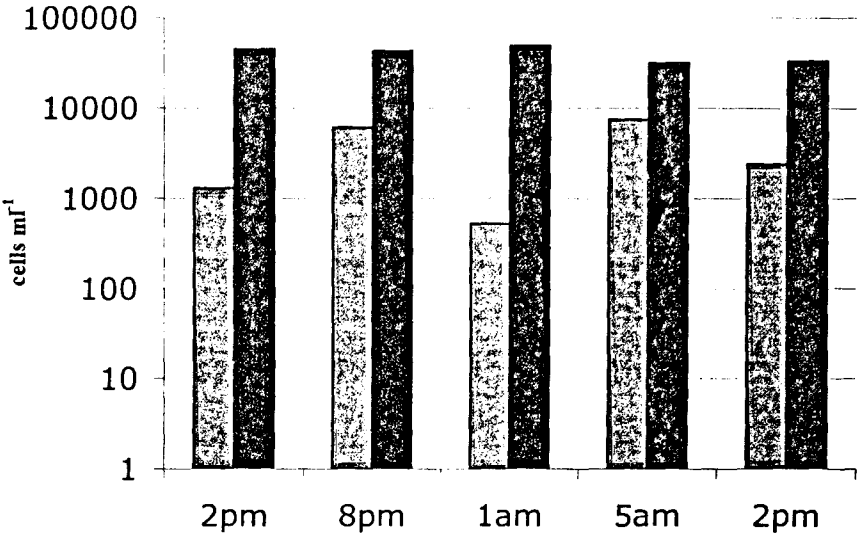

Fig. 1. Total phytoplankton abundance comparison (log scale), June 8-9, 2004, for the surface layer (gray) and at 2cm layer (black).

Phytoplankton

Total phytoplankton abundance in the surface layer fluctuated over the 24-hour period between 527 (1:00 am) and 7,487 (5:00 am) cells per ml^{-1} (Fig. 1). In contrast, at 2 cm the total phytoplankton ranged from 31,872 (5:00 am) to 49,478 (1:00 am) cells ml^{-1}. These concentrations varied over the 24-hours at both the surface and at 2 cm. Mean cell concentrations of total phytoplankton over the 24-hour period were 3,566 cells ml^{-1} at the surface and

40,532 cells ml^{-1} for 2 cm (Table 1). Chlorophytes were abundant in both layers with mean counts of 2,182 and 13,018 cells ml^{-1} for the surface and 2 cm, respectively. The other most common and diverse algae were diatoms. Their mean abundance was 907 and 11,210 cells ml^{-1} for the surface and 2 cm depth. More abundant and common at 2 cm than in the surface layer were cryptophytes and cyanobacteria with mean concentrations of 9,223 and 6,872 cells ml^{-1}, respectively. The mean concentrations of the total phytoplankton community were 3,566 and 40,562 cells ml^{-1} at the surface and 2 cm. In total, there were 57 taxa recorded for the surface layer and 58 taxa at 2 cm. No unique phytoplankton assemblage over the 24-hours was associated with the neuston surface layer. The flora at the surface included taxa present at 2 cm. Representative taxa recorded in the surface layer and at 2 cm are given in Table 2. In addition to these species, small (< 5 microns) unidentified diatoms were common representatives throughout the study in both strata.

Table 1

Mean cell concentrations of phytoplankton and autotrophic picoplankton in the pond over 24 hours, June 8-9, 2004.

Phytoplankton (cells ml^{-1})	Surface	2 cm
Chlorophytes	2,182	13,018
Diatoms	907	11,210
Cryptophytes	282	9,227
Cyanobacteria	180	6,872
Others	14	239
Total	3,566	40,562
Autotrophic picoplankton (cells ml^{-1})	469,000	599,000

The relative abundance relationships among the floral groups are given in Figure 2. At the surface, the chlorophytes represented from 38% to 95% of the flora. Changes in the representation of the major algal categories, and individual taxa, occurred throughout the study. Several of the most common species were *Ankistrodesmus fusiformis* Corda, *Coelastrum cambricum* Archer, *Cosmarium grantum* Bréb. ex Ralfs, and *Scenedesmus armatus* Chodat. The other major surface components were diatoms that included an abundant representation of unidentified centric diatoms and several pennate species. The cyanobacteria, cryptomonads and a category of other algae had decreasing abundance relationships. Many of the most common surface flora were also common taxa at 2 cm. These included the small centric diatoms. The relative abundance

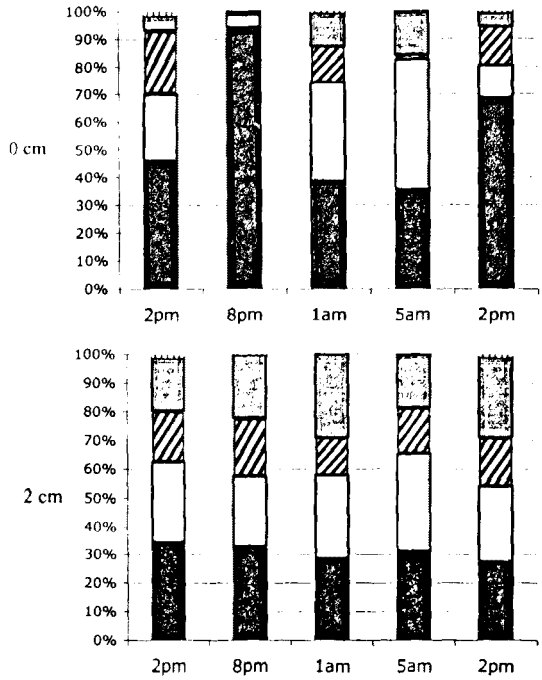

Fig. 2. Relative abundance of major algal categories at 0 cm (surface) and 2 cm depth beginning June 8 into June 9, 2004 for chlorophytes (black), diatoms (white), cyanobacteria (diagonal hatch), cryptophytes (gray), and others (vertical hatch).

Table 2

Representative phytoplankton taxa from the pond at the surface and 2 cm depth, June 8-9, 2004.

Surface	2cm
Ankistrodesmus fusiformis Corda	*Actinastrum hantzschii* Lagreheim
Coelastrum cambricum Archer	*Coelastrum cambricum* Archer
Cosmarium grantum Bréb. ex Ralfs	*Oocystis parva* W. et G.S. West
Oocystis parva W. et G.S. West	*Phacotus lenticularis* (Ehr.) Stein
Phacotus lenticularis (Ehr.) Stein	*Scenedesmus armatus* Chodat
Scenedesmus armatus Chodat	*Scenedesmus subspicatus* Chodat
Gomphonema parvulum (Kütz.) Grunow.	*Tetraedron muticum* (A. Brown) Hansgirg
Navicula spp Bory	*Treubaria schmidlei* (Schroeder) Fott et Kovač
Nitzschia sp Hassal	*Aulacoseira ambigua* (Grun.) O. Müller
Small centric diatoms, < 5 microns	*Aulacoseira granulata* (Ehr.) Ralfs
Romeria okensis (Meyer) Hindák	*Cyclotella meneghiniana* Kützing
Microcystis wesenbergii Komárek	*Gomphonema parvulum* (Kütz.) Grunow.
Merismopedia tenuissima Lemm.	Small centric diatoms, <5 microns
Trachelomonas superba Swirenko emend. Deflandre	*Anabaena sp* Bory
Rhodomonas minuta Skuja	*Merismopedia tenuissima* Lemm.
	Microcystis wesenbergii Komárek
	Romeria okensis (Meyer) Hindák
	Cryptomonas marsonii Skuja
	Rhodomonas minuta Skuja

relationships between the dominant algal categories of chlorophytes, diatoms, cryptophytes, and cyanobacteria at this lower depth had less variability compared to the surface layer.

Autotrophic picoplankton

The autotrophic picoplankton at both depths were similar in their shape, size, and fluorescence, and consisted predominantly of isolated single cell cyanobacteria <2 microns in size. Their mean concentrations during the study at the surface and 2 cm were 469 and 599 x 10^3 cells ml^{-1} respectively. In the surface layer, concentrations ranged from 168 (2:00 pm) to 530 (2:00 pm) x 10^3 cells ml^{-1}. These concentrations were greater at 2 cm with values from 470 (5:00 am) to 835 (8:00 pm) x 10^3 cells ml^{-1} (Fig. 3.).

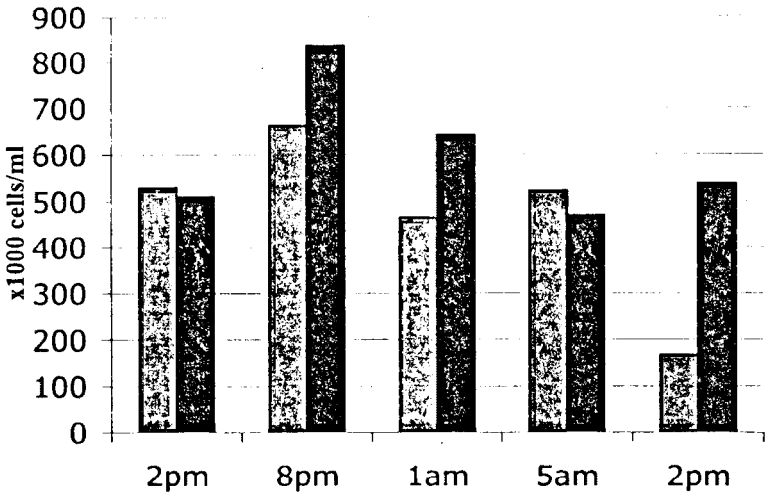

Fig. 3. Autrotrophic picoplankton abundance within the pond on June 8-9, 2004, for the surface layer (gray) and at 2cm layer (black).

DISCUSSION AND SUMMARY

The phytoplankton composition in the surface neuston layer was generally similar to the phytoplankton composition at 2 cm below the surface. This supports the premise that subsurface waters are the major source of algae occupying the neuston layer. The changing environmental conditions over this time period indicated a variety of factors that could have influenced the exchange and development of phytoplankton within these strata. In addition, the surface neuston composition exhibited greater shifts in abundance relationships

among the dominant flora over 24 hours than occurred at the 2 cm depth. This was most evident regarding chlorophyte levels of development, and that major differences in algal abundance and the ratios between the different algal categories took place over short time periods. In contrast, the 2 cm depth exhibited less variability between the relative abundance among the algal categories over time, showing that generally comparable relations were maintained over this time period between chlorophytes, diatoms, cryptomonads, and cyanobacteria. The influence of these changing environmental conditions on the phytoplankton composition within these strata decreased rapidly with depth.

In summary, both the surface layer and waters 2 cm below the surface contained a diverse and changing assemblage of phytoplankton. There was no distinct assemblage that was unique to the surface (neuston) layer over the 24-hour period. The surface layer's populations included taxa common to flora at 2 cm. The degree of influence that the general daily environmental conditions had on the presence of these algae was greater at the surface compared to the 2 cm depth. The surface populations existed in a thin and fragile layer more directly exposed to the daily environmental conditions that changed during the 24-hour period. These environmental influences resulted in a dynamic and unstable surface environment compared to waters at the 2 cm depth where the phytoplankton composition, abundance relationships, and stability were greater.

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