Picophytoplankton Abundance in the Velikaya Salma Strait, White Sea

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Abstract—In July–August 2009, the abundance of picophytoplankton (Pico) in the Velikaya Salma strait varied from 3.4 × 10^6 to 19.4 × 10^6 cells/L, while its biomass (B) was 0.8–3.3 mg C/m^3. In August 2010, Pico abundance was significantly higher (up to 216 × 10^6 cells/L and 36.8 mg C/m^3). Pico consisted mainly of cyanobacteria. It constituted 13 (2009) to 28% (2010) of the total phytoplankton biomass. In April 2010, Pico numbers varied from 0.1 × 10^6 to 0.22 × 10^6 cells/L and its biomass was 0.05–0.28 mg C/m^3. Picoeukaryotes were predominant. Pico constituted not more than 2.7% of the phytoplankton biomass. In the ice column, the integrated Pico abundance was 430 × 10^6 cells/m^2 and the integrated biomass was 365 µg C/m^2.

Keywords: picophytoplankton, picocyanobacteria, picoeukaryotes, White Sea.

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Picophytoplankton (Pico) comprises cyanobacteria and eukaryotic algae with cell size below 2 µm [1] or below 3 µm, according to more recent publications [2, 3]. These minute photoautotrophs may contribute a major part of the total biomass and production of phytoplankton, especially in oligotrophic environments or in mesotrophic waters during the periods of low abundance of microphytoplankton. The calculated contribution of Pico in the total phytoplankton biomass and primary production in the World Ocean is 8 and 39%, respectively [4]. Abundance of Pico in the White Sea has been assayed only in the Chupa inlet of the Kandalaksha Bay in June—early July [5] and in April [6]. No information on Pico abundance is available for other parts of the sea and other periods of the vegetation season.

The present work provides the data on abundance and biomass of picophytoplankton, as well as on the species composition, abundance, and biomass of nano- and microphytoplankton in the Velikaya Salma strait of the Kandalaksha Bay in April and in July—August.

MATERIALS AND METHODS

The investigation was carried out in 2009–2010 in the Velikaya Salma strait of the Kandalaksha Bay, White Sea, using the White Sea Biological Station, Moscow State University, as a base (66°43′ N, 33°08′ E). For assessment of the spatial variability of the phytoplankton, samples from 2.5-m depth were collected at four stations during the same period (figure). For assessment of the vertical distribution of the phytoplankton, samples from the depths of 0, 2.5, 5, 10, 15, 25, and 50 m were collected at station 3 on August 8, 2009 and August 19, 2009.

For assessment of the composition and abundance of the early spring phytoplankton, samples from the surface layer and 1 m depth were collected from April 14 to April 20, 2010 from the pier of the biological station. The Velikaya Salma strait was free of ice, with only an edge of fast shore ice not exceeding 5 m. The ice cover was disrupted by a deep storm two weeks before the sampling period, and the ice was removed from the strait by tidal currents. Only one core of fast ice was therefore collected at the point 500 m to the west from the pier of the biological station with 0.5-m depth. The core was collected using a titanium 15-cm corer. It was divided into three parts: the upper (0–26 cm), consisting of turbid, matt ice of snow origin; the medium (26–34 cm), consisting of gray semitransparent ice with embedded particles of bottom sediments, Fucus, and filamentous algae; and the lower one (34–52 cm), formed by crystalline ice of water origin with embedded particles of bottom sediments and plant debris. The core fragments were melted in the laboratory for 12 h at room temperature.

For quantitative interpretation of the samples, the linear sizes of the algae belonging to picophytoplankton, nanophytoplankton, and microphytoplankton
were accepted as 0.2–3, 3–20, and 20–200 μm, respectively, according to [1–3].

The numbers of picophytoplankton were assessed using the previously described method [5]. The water sample (10 mL) was placed into a filtration funnel, supplemented with the saturated solution of primulin, incubated for 5–7 min, and fixed with 2% glutaraldehyde. Nuclear filters (0.12 μm pore diameter) prestained with Sudan black were used for filtration. The cells were counted under a LeicaDM2500 epifluorescence microscope at ×100 × 10 × 1.3 magnification. Depending on the concentration of the cells, 30 to 50 microscope fields were examined. In the course of cell counts, the “type” of fluorescence (orange for cyanobacteria and red for eukaryotic algae) and the cell size were determined. Cell volumes were calculated as volumes of the relevant geometrical bodies [7]. Carbon content of the cells was determined from cell volumes using the relevant allometric relations and considering the taxonomic position of the algae [9]. The higher taxonomic ranks of eukaryotes are presented in accordance with the taxonomic system given in [10].

RESULTS

Temporal dynamics of the phytoplankton. Picophytoplankton abundance at station 2 in July–August 2009 varied from $4.8 \times 10^6–13.3 \times 10^6$ cells/L, with the average value of $9.1 \pm 3.1 \times 10^6$ cells/L. Picophytoplankton contained mostly cyanobacteria. The number of eukaryotic algae was, on average, one order of magnitude lower than the number of prokaryotes. The average Pico biomass was $1.6 \pm 0.63$ mg C/m$^3$. Pico contributed 2 to 13% to the overall biomass of phytoplankton (Table 1). The Pico contribution was highest in late June, at the lowest abundance of micro- and nanophytoplankton. During three weeks of observation, the Pico biomass varied within the same range (CV = 34%) as the biomass of micro- and nanophytoplankton. Within the micro- and nanophytoplanktonic community, both the biomass and the structure of the phytoplankton varied, so that the dominant and abundant (contributing over 10% to the total biomass) algal species differed (Table 1). Since late July, the biomass of the diatom *Skeletonema costatum* increased, while the abundance of mixotrophic