Features of the composition and productivity of Tuloma river’s estuarine hydrofytocenoses

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Abstract. The species composition and productivity of communities of higher aquatic vegetation in the Tuloma River estuary, in the North-Western part of the Kola Peninsula, is studied. Samples with streamside vegetation were taken several times during the 2019 growing season from the littoral and sublittoral zones. Subsequent investigations revealed that macrophyte growth begins in April (offshoots of Ranunculus schmalhausenii), the mass germination period is estimated at the end of May to early June (representatives of the genera Potamogeton, Callitriche). The beginning of the growing season is influenced by ice conditions. The last vegetative plants are found in November (Potamogeton, Elatine, Batrachium). Analysis of the species composition of the samples revealed that the most environmentally plastic plants are water-starwort (r. Callitriche), pondweed (Potamogeton perfoliatus L) and water moss (Fontinalis sp.): occurring in the drained zone and on the sublittoral. The production of the studied phytocenoses reaches its peak in August (up to 110 g/m² of absolutely dry mass), the main contribution to which is made by pondweeds. The distribution of accumulated phytomass over the horizons shows that the communities that are least susceptible to drainage are characterised by maximum productivity. These results may be important when monitoring hydrobiocenoses of the Tuloma river basin.

1. Introduction

An estuary as a border area between a river and the sea is a semi-enclosed aquatic ecosystem characterised by a variety of interconnected and biotic and abiotic structural components regularly changing in space and time, as well as by intensive physical and chemical-biological processes occurring in the salinity gradient [1], [2].

The river ecosystem has been experiencing various human economic impacts for a long time. The Tuloma River is of great fishing and water management importance for the Kola Peninsula, as well as an important source of hydroelectric power. The river's flow is regulated by the hydroelectric power stations, on the one hand. On the other hand, the tidal activity of the Kola Bay of the Barents Sea creates fluctuations in the water level at the mouth of the river, thereby naturally forming a littoral zone on the streamside and a salinity gradient in the estuary. The river's estuary is 14 km long, has a maximum width of 1.5 km, with regular semidiurnal tides observed. Water salinity in the estuary increases from its upper part to the confluence with the top of the Kola Bay from 1% to 22% (in syzygian tides), and the salinity decreases significantly at low tide. The streamside section of the river is strongly drained at low tide (in some areas up to 300 m); at low tide, the upper horizon of the littoral is drained for 2.5 hours on average, the middle for 45 minutes, and the lower for 25 minutes [3], [4].
The productivity of aquatic vegetation in such a dynamically changing area of the aquatic ecosystem is of scientific importance [5].

2. Materials, methods and characteristics of the study area
The study was conducted at the upper part of the Tuloma River estuary (salinity 0 ‰), from April to November 2019 at stationary sites (Figure 1).

![Figure 1. Study area](image)

Two transects were laid from the upper border of the water's edge across the current with 6 stations: station 1, 2 – littoral, station 3 – upper sublittoral. 2nd transect stations are marked with an asterisk (*).

Phytomass sampling (mowing) was carried out manually using a metal frame of area 0.25 m² in three-fold repetition at low tide. Phytomass was analysed, disassembled and dried to a fully dry mass calculated per 1 m². Annual production was calculated using I.P. Raspopov’s formula (1972): 

\[
P = 1.2 \times V_{\text{max}}
\]

where \( P \) is the annual production, above-ground phytomass (conditionally during the mass flowering period) [6], [7], [8] [9], [10].

3. Results
The growing season for aquatic vegetation on the littoral begins in late April to early May when the littoral is freed from ice and the water masses and soil warm up. In April, the littoral is mostly deserted, with occasional Caltha palustris sprouting on the streamside areas freed from ice, and green patches of Ranunculus schmalhausenii of area 0.25 m² in the sublittoral zone, which together with Nitella sp. form the main phytobenthos biomass during this period. With further warming up of the water and soil, the rest of the aquatic vegetation begins to grow.
The following was observed in early June: mass germination of pondweed turions (Figure 2 B), germination of seeds of water starwort, Elatine, etc. The biomass volume gradually increases and, as mentioned above, this occurs more intensively in the upper sublittoral. Vegetation growth on the 2nd transect was delayed as the fast ice remained longer in this section and the biomass results were subsequently significantly lower compared to the first transect.

The maximum growth of aquatic vegetation occurs in late August to beginning of September (Figure 2, 3). The wet mass of the vegetation can reach 1.5 kg/m² during this period, and the completely dry mass is about 110 g/m² on sublittoral sections of the estuary, and on the remaining part of the littoral up to 100/10 g/m² wet/dry, respectively.

By November 2019, the phytobenthos biomass decreases significantly due to destructive processes: plants are partially being carried away by the current, settling to the bottom, and the average biomass is 25/2.5 g/m² on the littoral and on the sublittoral up to 240/18.3 g/m². Therefore, the average net annual production in the Tuloma River estuary of aquatic vegetation in 2019 in the littoral areas is 11 g/m² and in the upper sublittoral – 72 g/m² of fully dry mass.
Figure 3. Biomass of aquatic vegetation in the Tuloma River estuary at different times (fully dry, g/m²)

The main contribution to the production of biomass in the littoral as per the results of observations at stationary sites is divided between representatives of the genera Potamogeton and Callitriche, while the sublittoral site is dominated by Potamogeton. In the littoral areas, the mass-occurring water starwort and Elatine make a significant contribution. Figure 4 shows the ratio of the contribution of various groups of aquatic plants in August 2019 to the biomass.

Figure 4. Share of various genera in biomass (August 2019, %)
During the observation period, representatives of the species Callitriche, Potamogeton, Fontinalis and Elatine are most frequently found in samples (Table.1). The main biomass in the littoral zone is formed by the Potamogeton species, where the Potamogeton perfoliatus is found both on the littoral and on the upper sublittoral zones. P. pectinatus is observed only on the littoral sections while P. gramineus and P. tenuifolius are observed only on sublittorals.

### Table 1. Occurrence of species in samples during the observation period

|                       | 1 transect | 2 transect |
|-----------------------|------------|------------|
| 1         | 2         | 3         |
| 1*        | 2*        | 3*        |
| Callitriche sp.       | ***       | ***       |
| Elatine sp.           | **         | ***       |
| Potamogeton perfoliatus L. | ***       | *         |
| P. pectinatus L.      | **         | **         |
| P. gramineus L.       | *          | *          |
| P. tenuifolius Rafin. |            | **         |
| Potamogeton sp.       | *          | *          |
| Fontinalis sp.        | *          | *          |
| Subularia aquatica L. |            | ***       |
| Ranunculus schmalhausenii Lyferov | *** | * |
| Zannichellia repens Boenn. | * | |
| Sparganium sp.        |            | **         |
| Eleocharis acicularis L. | ** | |

Note: The presence of this species of plants in the analysed samples from April to November is noted by an asterisk (*).

### Conclusion

Therefore, the development of macrophyte vegetation in the Tuloma River estuary was observed in 2019 from late April to November. Wintering offshoots of the Ranunculus schmalhausenii and helophytes begin sprouting along the river bank earlier than other species. Mass sprouting of aquatic vegetation is observed from late May to early June. The closest period of the growing season of the communities is the restas, warriors and mulberries, maintaining telomes until late November.

Phytocoenosis production reaches its peak in August, varying from 10 to 16 g/m² of fully dry mass on the littoral and from 10 to 110 g/m² on the sublittoral zones. Consequently, the average net annual production of aquatic vegetation in the Tuloma River estuary in 2019 in littoral zones is 11 g/m² and in the upper sublittoral zones 72 g/m² of fully dry mass. The main contribution to the annual production is made by representatives of the species Potamogeton, Callitriche, Fontinalis and Elatine.

The study resulted in the discovery of representatives of 9 families and genera in the samples, mainly represented by 1 species, except for the Potamogetonaceae family with 5 species, Callitrichaceae-2, Elatinaceae-2.

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