

# Influence of *Zostera marina* L. and *Z. noltei* Hornem. (Zosteriales: Liliopsida) on the composition, species richness and coenotic diversity of the phytobenthos of the Azov Sea

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**Abstract.** The influence of marine higher plants *Zostera marina* and *Z. noltei* on the composition, species richness and coenotic diversity of the phytobenthos of sandy and silty soils of the Taman Bay in the Azov Sea at the depths from 0.5 to 3 m has been investigated. It is shown that 1) macrophytobenthic communities with a high degree of *Z. noltei* and *Z. marina* dominance (DD), both at very small and relatively large sites, are characterized by lower species richness than the communities with low DD; 2) that being said, for the majority of co-occurring species it is possible to grow in coenoses with any DD; 3) accordingly, about the same number of species can grow at the small community sites with low DD and at the larger sites with high DD; 4) DD has little to no influence on the species diversification of coenoses. However, both the growth of *Zostera marina* and *Z. noltei* and the decrease in their participation can lead to considerable drop in occurrence of some macroalgae species or to disappearance of those species from a community.

## 1 Introduction

Dominant species are considered to be an important internal factor that regulates species richness in plant communities [1]. However, for the reason that the manner, in which various dominant species influence communities of various types, can differ substantially, the knowledge concerning this aspect of plant cover structure is still tentative and vague, especially when considered in the context of different spatial scales.

Thuswise, dominant species can affect other (co-occurring) plant species, limiting their space or mineral supply. Such manner of influence entails non-selective (random) displacement of other species, which means that any species has a certain probability of occurring at any site within a coenosis with any participation of a dominant species (a

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degree of species dominance, or DD). Accordingly, about the same number of species can grow at a small community site with low DD and at a larger site with high DD.

However, there are other ways, in which dominant species can exert an impact on co-occurring species — for instance, by means of ecotope transformation or allelopathy [2, 3]. In this case, some species can prove to be more susceptible to such influence than the other ones, and, when dominant species strengthen their position, some co-occurring species may completely disappear from large sites of plant communities. Additionally, in the communities of extreme habitats, both terrestrial and aquatic (sea bottom), mutually favorable relationships between plant species are a common occurrence. For this reason, deterioration of the dominant species populations in such coenoses may lead to the decrease in the species richness, and not vice versa [3-6].

The Azov Sea is characterized by low and unstable salinity (5-15 ‰) and considerable turbidity of its water. Such conditions are detrimental for the formation of macroalgae communities, so their propagation here is very limited. The main dominant species in these coenoses are flowering plants *Zostera noltei* and *Z. marina* [7]. As these species comprise the major share of the biomass of macrophytobenthos, it may be assumed that they have a significant influence on its species composition and coenotic diversity. However, relevant information in the literature is virtually absent. This work is aimed at filling this gap in knowledge.

## 2 Materials and Methods

This study is based on 165 samples of the macrophytobenthos collected in the Taman Bay of the Azov Sea in summer, 2020; the sampling was conducted in 6 homogenous areas of coenoses with dominance or participation of *Z. noltei* and *Z. marina*, located at the depths ranging from 0.5 to 3 m near settlements Sennoy, Taman and Garkusha (coordinates: 44°65.150'–44°80.786'N, 37°37.065'–37°77.264'E). Within each selected community site, 25–30 sampling plots of 0.5× 0.5 m size were set; some of them were set in a regular pattern shaped as one or two transects comprising 10 plots each; the other ones were set in series, 5–15 plots per a site. In the second case, the investigated communities were chosen to have options with high and low total projected cover of *Zostera*, which was assessed visually. All macrophytes from each frame were collected in a separate gauze bag. Each sample was sorted out by species, dried with absorbent filter paper and weighted, separately for each species [8]. Algae were identified according to identification guides [9, 10] with regard to the most recent changes in their nomenclature [11].

For each sample (plot), the values of the following parameters were estimated: 1) total wet biomass of the macrophytes in 0.25 m<sup>2</sup> (W); 2) total biomass of *Z. noltei* и *Z. marina* (WC); 3) degree of participation (dominance) of *Zostera* (DD = WC/W); 4) number of co-occurring species of macrophytes in 0.25 m<sup>2</sup> (SS).

In order to assess and characterize the influence of *Z. noltei* and *Z. marina* on the species richness of macroalgae communities and on the species' frequency of occurrence, the samples were ranked based on DD (from the lowest to the highest) and divided into four equal groups. For each group, the average number of co-occurring species in the sample (provisional local species richness), the total number of such species in all samples of the group (provisional regional species richness), and their frequency of occurrence have been estimated, and the values of these parameters were then compared.

To assess the influence of *Z. noltei* and *Z. marina* on the diversification of species composition in the communities (beta diversity), we estimated species similarity between all six sites; it was done separately for the groups of samples with the lowest and the highest DD (10 samples per each group). For this purpose, the Sørensen coefficient was used ( $K_s = 2C/(A+B)$ , where A and B are the number of species in 10 samples with the

lowest (or the highest) DD, collected at the sites under comparison; and C is the total number of species in the groups of samples collected at the sites under comparison). It is assumed that the lower is the similarity coefficient, the higher is the diversification of a community in terms of its species composition.

### 3 Results

The samples with differing *Zostera* participation are characterized, on average, by significantly differing species richness in 0.25 m<sup>2</sup> (ANOVA,  $F_{2,66} = 11.71$ ,  $P = 0.05$ ): the higher DD is, generally the lower are the values of SS, average for the group. It should also be noted that three groups of the samples with  $DD > 0.88$  are characterized by a similar total number of species ( $N_s = 22, 17,$  and  $19$ ), which is significantly lower than the total number in the group of samples with  $DD < 0.88$  (30 species). However, when the total number of species in all the samples with DD both more and less than 0.88 (41 and 122 samples with the total areas 10.3 and 30.5 m<sup>2</sup>, respectively) is considered, it appears to be similar: 30 and 27 species.

The comparison of the frequencies of occurrence of macroalgae species in the groups of samples with different DD has shown that 23 species occur in the samples both with relatively low and very high DD (among them, 6 species have a considerable higher frequency of occurrence in the coenoses with low DD; only *Ruppia maritima* shows a much higher frequency of occurrence in the coenoses with high DD). Seven species occur only in the samples with a relatively low DD, and four species are found only in the samples with a very high one. Some species from the second group are rare to occur in *Zostera* communities in general. For instance, *Ulva rigida* actively propagates in eutrophic waters, while *Zostera* is averse to such environment. *Stuckenia pectinata* prefers fresh waters, and it is uncommon for it to enter the waters with the salinity exceeding 5–7 ‰, which is the opposite for *Zostera*. Therefore, it would be unwarranted to assume that the absence of these species in *Zostera* thickets is the result of their competition for space and/or resources. It is more plausible that their distribution is influenced by other factors. As for the species in the first group, an increasing share of *Zostera* participation can threaten the well-being of Charophyceae *Lamprothamnium papulosum* and *Chara baltica*. They are negatively affected by the increase in density of *Z. noltei* и *Z. marina* thickets, and have been recorded only in isolated sites of the investigated area.

The average values of the Sørensen coefficient of species similarity between the sites of coenoses with low *Z. noltei* and *Z. marina* participation ( $DD = 0.69 \pm 0.04$ ) were  $0.49 \pm 0.04$ ,  $n = 15$ , and for the ones with high DD ( $DD = 0.99 \pm 0.00$ ) they were  $0.56 \pm 0.04$ ,  $n = 15$ . That is, the sites of coenoses with high DD are slightly more homogenous in terms of species composition than the ones with low DD, however this difference is not statistically significant (ANOVA,  $F_{4,20} = 1.27$ ,  $P = 0.05$ ).

As it follows, the results of this investigations show that 1) macrophytobenthic communities with a relatively high *Z. noltei* and *Z. marina* participation, both at very small and relatively large sites (in the groups of biomass samples), are characterized by lower species richness than the communities with relatively low DD; 2) for the majority of co-occurring species it is possible to grow in coenoses with any degree of *Zostera* participation, and the frequency of occurrence of the vast majority of them has next to no association with *Z. noltei* and *Z. marina*; 3) about the same number of species can grow at the small community sites with low DD and at the larger sites with high DD; 4) the sites of coenoses with high and low DD are characterized by a similar degree of diversification of their species composition. However, both the growth of *Z. marina* and *Z. noltei* and the decrease in their participation in coenoses can lead to the decrease in occurrence of some

co-occurring species and, subsequently, make them more vulnerable to the influence of other factors.

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## References

1. H. Hillebrand, D. M. Bennett, M. W. Cadotte, *Ecol.* **89**, 1510–1520 (2008)
2. T. A. Rabotnov, *Phytocenology* (MSU Publ., 1983)
3. V. G. Onipchenko, *Functional phytocenology. Synecology of plants* (Krasand, 2013)
4. B. B. Hughes, *J. Exp. Mar. Biol. and Ecol.* **393**, 90–99 (2010)
5. J. Templado, Future trends of Mediterranean biodiversity, in *The Mediterranean Sea: its history and present challenges*. (Netherlands, Springer, 2014)
6. A. M. Ellison, *iSci.* **13**, 254–268 (2019)
7. A. A. Kalugina-Gutnik, *Phytobenthos of the Black Sea*. (Naukova dumka, 1975)
8. G. G. Minicheva, D. F. Afanasyev, A. B. Kurakin, *Black Sea monitoring guidelines: Macrophytobenthos*. (Istanbul, 2014)
9. A. D. Zinova, *Identification manual to green, brown and red algae of the southern seas of the USSR* (Nauka, 1967)
10. Juliet Brodie; Christine A Maggs; D M John; Jaanika Blomster *Green seaweeds of Britain and Ireland*. (London, British Phycol. Society, 2007)
11. M. D. Guiry, G. M. Guiry, *AlgaeBase*. World-wide electronic publication (2021)  
<https://www.algaebase.org/>