RESEARCH PAPER

SEAGRASS ZOSTERA IN THE RUSSIAN SECTION OF THE BALTIC SEA

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Received: February 1th, 2021 / Accepted: April 24th, 2022 / Published: June 30th, 2022
https://DOI-10.24057/2071-9388-2022-013

ABSTRACT. Information on seagrass in the Russian section of the Baltic Sea – Sambia Peninsula, Curonian Spit, and Gulf of Finland (water area of Kaliningrad and Leningrad regions) is generalized based on a recent survey, literature search, and study of herbarium samples. Seagrasses are found in the emissions of most of the coast of the Kaliningrad region, but they are extremely few. All discovered seagrasses belong to one species – *Zostera marina L.* In the absence of an opportunity to distinguish the emissions of *Zostera marina* brought in by currents from other regions of the Baltic Sea from local emissions, the possibility of the presence of a small number of single individuals of this species in the seawater area of the Sambia Peninsula and the Curonian Spit remains. Specimens of *Zostera marina* brought in by storms from the western part of the Baltic Sea, as well as an individual found during diving studies in 2009, can take root and form small meadows in the future, provided they are protected from surf waves and a stable substrate, settling with the help of vegetative shoots. Poorly rooted seagrasses can also be washed ashore. The mobile sandy ground found in most of the study area may be the reason why seagrass plants do not form stable communities. In the Russian section of the Gulf of Finland, seagrass had not been recorded. Probably, they occur in small numbers in its northern part.

KEYWORDS: seagrasses, Zosteraceae, *Zostera marina*, Baltic Sea

CITATION: Iurmanov A.A., Romanov M.S., Gerb M.A., Volodina A.A., Baikova I.B., Popov I.Y., Markovets M.Y. (2022). Seagrass Zostera In the Russian Section Of the Baltic Sea. Geography, Environment, Sustainability, 2(15), p. 111-115
https://DOI-10.24057/2071-9388-2022-013

ACKNOWLEDGEMENTS: A. Iurmanov and M. Romanov acknowledge the support of the Russian Foundation for basic research, the project No 19–34–90164, and the project of Main Botanical Garden No 18–118021490111–5. The work was carried out by M. Romanov in accordance with institutional research project No 122042700002-6. The work by M. A. Gerb took place in a framework of the project 0128-2021-0012 Shirshov Institute of Oceanology. M. Markovets acknowledges the project AAAA-A19-119021190073-8 by Zoological Institute, RAS.

Conflict of interests: The authors reported no potential conflict of interest.

INTRODUCTION

Seagrasses are a group of monocots (Monocotyledoneae – Alismatales) that live underwater (Hogarth 2015). Their aggregations form «underwater meadows» which are valuable habitats including diverse animal species (Den Hartog 1970). In the Baltic Sea, such meadows are notable for the fact that they can be the habitat of the European eel Anguilla anguilla (Boström et al. 2003), a valuable commercial fish, the number of which is declining catastrophically (Pike et al. 2020). In the Baltic Sea, seagrasses are represented only by the Zosteraceae family (Borum et al. 2004), including *Zostera marina* L., which is widespread in semi-surf-protected conditions throughout the Baltic Sea (Blinova 2007) and Zostera noltii Horneman, a species with a narrower area, the eastern border of which in the Baltic Sea is located in the Vistula Lagoon, in the territorial waters of Poland. There are also reports of findings of Zostera noltii in the waters of Lithuania (Labanauskas 2009). Seagrasses are of economic value since they are used as «straw» – the raw material for the manufacture of packaging materials, paper, compost, etc. (Kardakova 1957; Kulepanov 2005). Moreover, various substances extracted from seagrasses are supposed to be useful in pharmacology and cosmetology (Aminina 2005). Economic activities in the coastal zone directly or indirectly lead to an increase in water turbidity, which harms seagrasses (Duarte 2002; Short et al. 2011; Unsworth et al. 2014). Many species suffer a catastrophic decline (Orth 2006; Waycott and Williams 2006). The peak of seagrass decline in the Baltic Sea occurred in the 1980s, but they have not yet fully recovered (Krause-Jensen et al. 2020). This circumstance determines the need for their research. In the Baltic Sea, seagrass habitats have been identified mainly in

its western part (Boström et al. 2003). The coastal waters of the Russian section of the sea have been little studied in this respect. Information about seagrasses was usually collected along the way in the course of work on other topics (Volodina 2011; Volodina and Gerb 2013; Gerb and Volodina 2020; Gorbunova and Esiukova 2020). The article at hand aimed to summarize all available information about the seagrasses near the Russian coasts of the Baltic Sea. We addressed to the relevant publications and museum collections; generalized the results of our own surveys.

MATERIAL AND METHODS

Using the Russian Science Citation Index, Scopus and Web of Science resources we looked for the publications reporting on seagrasses in the Russian section of the Baltic Sea, that is, the coastal waters of the Kaliningradskaya oblast and Leningradskaya oblast. We also examined the samples of seagrasses in herbarium collections: Immanuel Kant Baltic Federal University, Institute of Living Systems (KLGU), Komarov Botanical Institute (LE), Saint Petersburg State University (LECB), Tsitsin Main Moscow Botanical Garden of Academy of Sciences (MHA), Moscow State University Faculty of Biology (MW) and Faculty of Geography (MWG), Atlantic Branch of the Institute of Oceanology, P.P. Shirshov of the Russian Academy of Sciences (AB IO RAS, Kaliningrad, the acronym of the herbarium is missing), the Museum of the World Ocean (MWO, Kaliningrad, the acronym of the herbarium is missing). Based on the obtained data we identified the coastal areas, where the occurrence of seagrasses could be expected. We observed them from 23 to 29 September 2020; 1 km of the coastline was surveyed at each site. We described, collected, and photographed the beached remains of seagrasses. In June 2021 the surveyed sections were partly explored by snorkeling. Moreover, we summarized the results of our previous studies performed in Kaliningradskaya oblast from 2008 to 2012 (Volodina and Gerb 2013) and Leningradskaya oblast from 2017 to 2021. The latter took place in process of the expedition of the Russian geographic society «Gogland Island»; we observed the shores of the Islands of the Gulf of Finland (Gogland, Bolshoy Tyuters, Sommers, Moshchny, Maly) to register beached seagrasses. To specify the taxonomy we used the guide by N. N. Tsveliov (2000) and the World atlas of seagrasses (Green and Short 2003).

Fig. 1. Beached fragment of *Zostera marina*, Sambia peninsula

RESULTS

The publications and herbarium samples indicate that seagrasses occur only in Kaliningradskaya oblast. Such reports are relatively numerous (table 1). From 1982 to 2021 the remains of seagrasses were registered in Kaliningradskaya oblast in 12 locations (Fig. 1, 2; Table 1). Only one living specimen was noted. It was found in 2009 at a depth of 2 m together with perennial and annual algae (location № 6 in Figure 2). All recorded specimens belong to *Zostera marina* species. In most cases, discarded leaves of seagrasses were found, while the bigger parts of the plants occurred rarely. The largest accumulation of leaves was noted at Cape Gvardeysky (location № 5 in Figure 2) – 244 leaf fragments from 7 to 35 cm long, 211 of them on 50 meters of the route. Underwater surveys showed that there is a rocky bottom in the sections without beached remains of seagrasses; it is covered with an almost continuous layer of filamentous algae. In areas where emissions have been detected, the bottom is sandy.

As for the Russian section of the Gulf of Finland, we failed to find information of seagrasses occurrence, although the relevant studies are rather numerous. Neither herbarium samples, nor reports presented in publications are known. The relevant reports pointed out low salinity at the coasts (e.g. Gubelit 2011), it is hardly suitable for seagrasses. The salinity is enough high at the islands located in the central part of the Gulf, but only algae were registered there among macrophytes so far (Kukk 1988). Our attempts to find the beached remains of seagrasses on the islands were also unsuccessful, only the algae were noted in the wrack.

The seagrasses have been noted at the Russian-Finnish borderline from the Finnish side. Ten samples of beached remains of *Zostera marina* were collected from 1965 to 1989. The nearest congregations of seagrasses in Finland are located at a distance of hundred kilometers westwards (Uotila 2021). No similar records are known for the Russian-Estonian borderline. The nearest site of seagrass registration is far from the state borderline there (Möller and Martin 2007).

DISCUSSION

The beached remains of seagrasses indicate the fact that *Zostera marina* does grow in the coastal waters of the Kaliningrad region. Had the remains been transferred to it in large quantities from afar, then they would be recorded over the whole coastline; moreover, Zostera noltii, would also be encountered as it inhabits the neighboring areas (Labanauskas 2000). However, the small number of remains and the failures to find bottom-growing specimens indicate that seagrasses are scarce; they hardly form big underwater meadows.

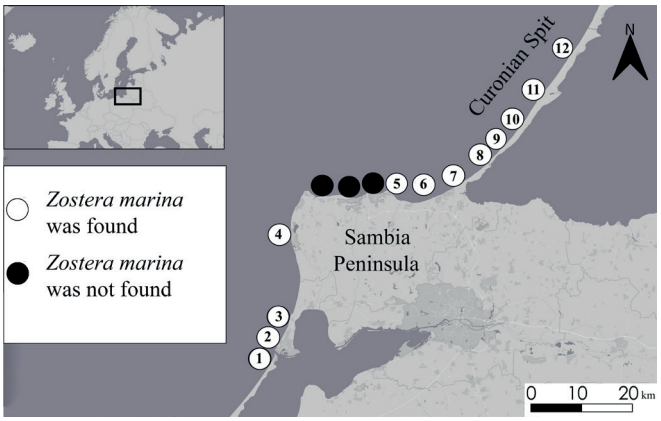

Fig. 2. Locations of the sites under study in Kaliningradskaya oblast, the legend is in Table 1

Table 1. Records of *Zostera marina* in Kaliningradskaya oblast, the numbers correspond to the Figure 2.

№	Coordinates (start/ end of the route for results of a survey performed in 2020)	Date of sampling	Herbarium (* – results of a survey performed in 2020)	Coast survey site	Collected samples	
					Number of leaves	Number of shoots
1	N 54.623689, E 19.866867	12.08.1999	KLGU	Vistula Spit, Kosa village	0	3
	N 54.634332, E 19.876196	01.07.2010	AB IO RAS		0	6
2	N 54.647137, E 19.874504 / N 54.653843, E 19.884376	25.09.2020	IO RAS *	Sambian Peninsula, city of Baltiysk	8	2
3	N 54.680224, E 19.910671	19.08.1995	KLGU	Sambian Peninsula, Mechnikovo village	1	3
4	N 54.867211, E 19.932228 / N 54.876120, E 19.931143	26.09.2020	IO RAS *	Sambian Peninsula, Yantarnyy village	2	4
5	N 54.960471, E 20.258877 / N 54.961471, E 20.271548	29.09.2020	IO RAS *	Sambian Peninsula, Cape Gvardeisky	244	0
6	N 55.046111, E 20.363056	09.09.2009	AB IO RAS	Rooted on the shallows (at a depth of 2 meters, sandy substrate)	0	1
7	N 54.963427, E 20.479510	26.06.2011	AB IO RAS	Sambian Peninsula, Zelenogradsk	0	10
8	N 55.013775, E 20.605672	04.07.2000	KLGU	Curonian Spit, Lesnoye village	1	1
	N 55.016148, E 20.610391 / N 55.023418, E 20.620873	23.09.2020	IO RAS *		42	6
9	N 55.049810, E 20.666673 / N 55.056441, E 20.677567	29.09.2020	IO RAS *	Curonian Spit, Dyuna village	76	12
10	N 55.091755, E 20.727132	20.07.2020	MWO	Curonian Spit, Fringilla Ornithological Station	0	1
	N 55.091141, E 20.726306 / N 55.098690, E 20.735431	27.09.2020	IO RAS *		28	8
11	N 55.134817, E 20.776143	06.08.1982	KLGU	Curonian Spit, campsite Khvoynoye	0	1
12	N 55.223326, E 20.888577 / N 55.230760, E 20.897399	27.09.2020	IO RAS *	Curonian Spit, Dune Efa	10	8

A certain number of seagrasses are regularly brought to the surveyed territory. The transportation of the plant fragments over the sea is one of the dispersion modes of the seagrasses (Den Hartog 1970; Iurmanov 2022). The fragments with shortened vegetative shoots torn off from the maternal rhizome are moved by waves and currents and then root in other suitable places (Vekhov 1992). In the western part of the Baltic Sea, underwater meadows have survived, and therefore they can serve as a source of such planting material. However, it is hardly abundant. In our case, the rooting of such plants is hampered by the fact that most of the bottom of the coastline is covered by moving sands. In a relatively small area at the center of the surveyed coast, the bottom surface is more stable, since it is covered mainly with boulders, pebbles, and gravel; between the rocky substrate, there are areas with

sandy soil (Spiridonov et al. 2010). Seagrasses could exist in some numbers in such plots, but in this very area, there are effluents from treatment facilities of settlements, which leads to an increase in eutrophication and turbidity, i.e. negative impacts on seagrasses.

Since seagrasses have been hardly explored in Kaliningradskaya oblast in the past, it remains unknown whether their numbers have recently declined, or they were not abundant «initially». In neighboring coastal waters of Poland a sharp decline of «underwater meadows» took place since the 1950s (Boström et al. 2003). At present, the aggregations of algae have expanded instead, i. e. the same we observed in a part of the surveyed area. It is possible that seagrasses declined in the same way in Kaliningradskaya oblast.

As for the northern section of the Russian part of the Baltic Sea, the situation seems to be similar there: seagrasses have not been studied in the past, and therefore it is not clear how natural their absence is. Due to strong desalination and the proximity of settlements, the conditions for the seagrasses are unfavorable in most of these waters. However, in its western part the formation of suitable habitats is possible. The coastal waters near the islands located close to the center of the Gulf of Finland are relatively clean and saline. We surveyed only a part of the islands and probably the unexplored islands are promising in this regard.

The decline of seagrasses in the Baltic Sea might have been related to overfishing: it results in the small number of top predatory fishes, the lack of them increases intermediate predatory fishes, the big numbers of these small fishes increase the pressure on small invertebrates; all this contribute the nutrient enrichment of water, the overgrowth of filamentous algae, which influence negatively the seagrasses (Baden et al. 2012). Such data have been obtained for the western side of the Baltic Sea, but similar processes over the studied territory are likely as overfishing has been continuously progressing there over the centuries (Popov 2017). The number of top predatory fishes is insignificant compared to the «initial» or «normal» one. Algae thickets exist in coastal waters. Probably, a part of them replaced the seagrasses beds existing in the past.

The absence of «underwater meadows» is an undesirable phenomenon, since they are a valuable habitat. In such a situation the question of artificial cultivation of seagrasses arises (Meyer and Nehring 2006). Probably some potential habitats have not been lost completely. Moreover the disease of seagrasses which caused their rapid decline several decades ago might have been weakened recently (Brakel et al. 2019) therefore some possibilities to increase the seagrass abundance do exist. A part of the coastal waters of the Russian part of the Baltic Sea may be suitable for such projects.

CONCLUSIONS

In the Russian section of the Baltic Sea the seagrasses *Zostera marina* occur in small numbers only in the southern part, i. e. Kaliningradskaya oblast. They hardly form underwater meadows of noticeable areas. Most of the potential habitats have been lost because of increased water turbidity resulting from anthropogenic pressure on the coastal areas. This situation is an additional illustration of the global decline of seagrasses and the impoverishment of the Baltic Sea ecosystems.

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