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FLORISTIC COMPOSITION OF THE PHYTOBENTHOS AND ITS LONG-TERM CHANGES IN THE GULF OF RIGA, THE BALTIC SEA

Abstract. In the samples collected in the Gulf of Riga in 1984, 1987, and 1990 11 taxa of red algae, 9 species of brown algae, 15 species of green algae, 3 species of charophytes, and 13 species of phanerogams were identified.

The species composition of bottom vegetation in the Gulf of Riga has drastically changed as compared to that 60—70 years ago. This is due to the increasing pollution load, which has exerted the greatest influence on the macrophytes in the southern part of the Gulf.

Several species, including *Cladophora fracta*, *Anfeltia plicata*, *Polysiphonia violacea*, *Hildenbrandtia rubra*, *Callithamnion roseum*, *Dictyosiphon chordaria*, *Chorda filum*, and *Elachista lubrica*, do not occur in this region any more. All the species of charophytes have also disappeared.

The floristic composition of the bottom vegetation in the northern part of the Gulf has also changed; however, these changes are local and concern first of all the bays of Pärnu and Kuressaare and the Salme-Ansekϋla area on the east coast of the Sõrve Peninsula.

Key words: Gulf of Riga, floristic composition, phytobenthos, long-term changes, pollution.

Introduction

Research into the species composition of the phytobenthos in the Gulf of Riga was started in 1847 when Eichwald studied the bottom vegetation in the area of Kaugern; in 1852 he conducted investigations in Kuressaare Bay (Eichwald, 1847, 1852). Buhse (1866) mentioned macrophytes from the vicinity of Dubel. Gobi (1874) registered bladder wrack in Kuressaare Bay.

Dwarf forms of bladder wrack from Kuressaare Bay were dealt with in later works as well (Арциховский, 1902, 1905, 1907). The Latvian algologist Skuja (1924) conducted large-scale studies in the southern Gulf of Riga between Mersrags and Ragaciems. Some information about marine vegetation in shallow water and seaweeds cast up on the shore can be found in Lippmaa (1936) and Häyrén (1936—1937). Data on the bottom vegetation in the Gulf of Riga were published by Kireyeva (Киреева, 1960) and Blinova (Блинова, 1977).

Trei-Pullisaar (Pullisaar, 1961; Трей, 1986) and Kukk and Martin (1992) have given a rather detailed survey of the species composition and communities of the bottom vegetation in Pärnu Bay from the temporal aspect. Vinogradova (Виноградова, 1974) investigated green algae in Pärnu Bay. Pullisaar (1962) studied the distribution of bladder wrack cast up on the shore of Saaremaa Island. In the 1970s, Trei published a thorough review of the macrophytes in the Gulf of Riga (Trei, 1973, 1975; Трей, 1973, 1976, 1977). Data on the species composition of the bottom vegetation in the Ragaciems—Saulkrasti area in the southern Gulf of Riga was published by Kumsare et al. (Кумсаре et al., 1974).

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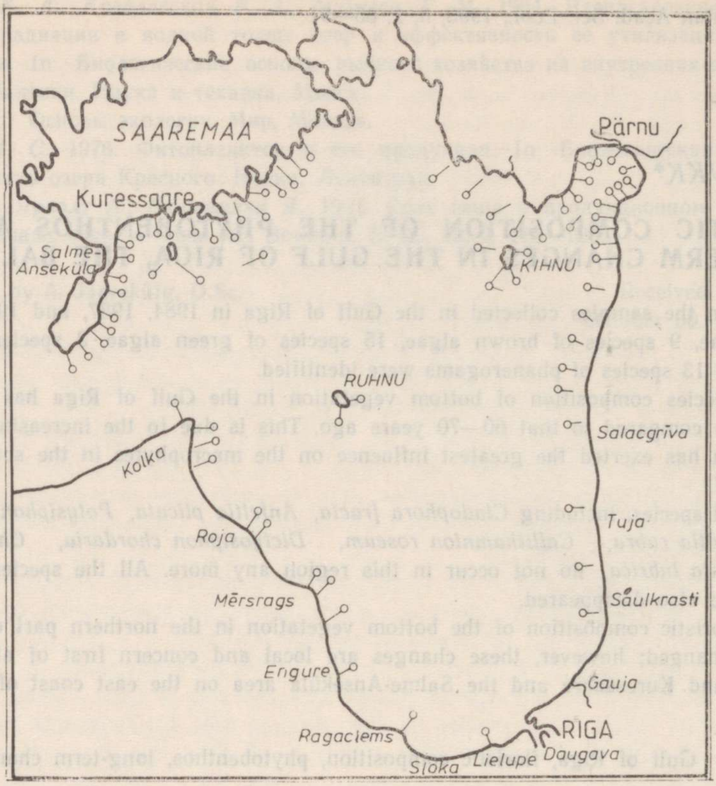

Sketch of the Gulf of Riga with the transects of bottom vegetation sampling.

The material for the present work was collected in 1984, 1987, and 1990 from 191 stations (Figure). The samples were taken by SCUBA divers within a frame with a surface area of 0.25 m^2. In 1984 and 1990 samples were also taken from shallow water. In that case SCUBA divers were not needed.

Results and Discussion

The author identified 11 taxa of red algae, 9 species of brown algae, 15 species of green algae, 3 species of charophytes, and 13 species of phanerogams in the samples collected from the Gulf of Riga (Table). The Table presents the species identified by Skuja in 1924, those registered by Kumsare et al. and by Trei in the mid-1970s and in 1986. The last column of the Table presents the species recorded by Kukk in 1984, 1987, and 1990.

Skuja (1924) described 29 taxa of green algae from the southern Gulf of Riga; among them were *Vaucheria* but also unicellular green algae occurring in sand. He is somewhat inconsistent in identifying species from the genera *Enteromorpha* and *Cladophora*; the same could be said about Kumsare et al. (Кумсаре et al., 1974). Skuja mentioned 17 taxa of brown algae, 11 taxa of red algae, and 8 taxa of charophytes. Arranging these taxa according to the currently acknowledged taxonomic units, there remain 14 species of green algae, 6 species of charophytes, 11 species of brown algae, and 8 species of red algae. For Kumsare et al. these figures are 10, 0, 7, and 6, respectively.

The Baltic Sea macroflora, including the bottom vegetation of the Gulf of Riga, differs from that of the euhaline bodies of water in its relatively great number of fresh and brackish water species. The low salinity of water affects both the species composition and their morphology and reproduction. Red algae are especially sensitive to the decrease in salinity. At the same time, the share of green algae increases.

The tides in the Baltic are insignificant, and therefore in the Gulf of Riga the species which are common in the littoral zone of the seas with tides and ebbs occur in the sublittoral zone.

The species composition and distribution of the bottom vegetation are also controlled by the substrate, water transparency, nutrient supply, and pollution load.

As the vast majority of the species of bottom vegetation inhabit hard bottoms with only charophytes and phanerogams being able to grow on sediment bottom one should consider the composition of bottom sediments in drawing comparisons between different areas. The bottom in the southern Gulf of Riga is prevailingly sandy. Sand occurs between Saulkrasti and Sloka, Ragaciems and Engure, and Roja and Kolka Spit. Those areas do not provide favourable conditions for the development of communities with high coverage, as one can see in the northern part of the Gulf where stony bottoms prevail. Besides, the northern part of the Gulf abounds in shoals, the numerous niches of which favour the development of marine vegetation. The coastal zone is gently sloping and indented by numerous bays.

At 60% of the sampling sites the bottom was rocky or sandy with stones. Soft bottoms made up 40%, of those 26% were sandy. The samples were taken at a depth less than 1 m in 7% of the cases, 15% were taken at a depth less than 3 m, 19% at a depth of 3—5 m, 50% at a depth of 5—10 m, and 9% at a depth greater than 15 m. The vegetation did not spread down to depths greater than 13 m. The salinity of water ranged from 4.9 to 6.4‰.

Furcellaria lumbricalis was the most frequent red alga in the Gulf of Riga. It was found 76 times and it made up 40% of the total number of samples. *Ceramium tenuicorne* (61 times), *Polysiphonia nigrescens* (59), and *Rhodomela confervoides* (36) were also frequent.

Brown algae were dominated by *Pilayella littoralis* (39), *Ectocarpus siliculosus* (34), *Sphacelaria arctica* (33), and *Fucus vesiculosus* (31).

The four most frequent species of green algae were *Cladophora glomerata* (66), *Spirogyra* sp. (18), *Zygnema* sp. (12), and *Rhizoclonium riparium* (12). The species of green algae common in shallow water were represented to a lesser degree, because due to technical reasons only 10% of the samples were collected at a depth less than 1 m.

The share of charophytes was modest: only three species were registered from the relatively well protected bays in the northern Gulf of Riga. In 1924 Skuja identified six species of charophytes in the southern part of the Gulf, but Kumsare et al. (Кумсаре et al., 1974) could not find them there in 1974. *Potamogeton filiformis*, *P. pectinatus*, *Zannichellia palustris*, and *Schoenoplectus tabernaemontanii* were the most frequent phanerogams recorded by both Trei (Трей, 1976, 1977, 1986) and the present study.

In comparison with the 1960s and 1970s, the species composition of the bottom vegetation in the northern Gulf of Riga has considerably changed. This concerns, first of all, the areas with high industrial and municipal pollution load, among them Pärnu Bay, especially its northern part, Kuressaare Bay, and the coastal waters of the Sõrve Peninsula in the Salme—Anseküla region.

Check-list of the phytobenthos of the Gulf of Riga

Taxa	According to			
	Skuja, 1924	Кумсаре et al., 1974	Трей, 1976, 1977, 1986	Present study
1	2	3	4	5
Rhodophyta				
1. *Anfeltia plicata* (Huds.) Fries.	+	–	–	–
2. *Asterocytis ramosa* (Thwaites in Harvey) Gobi ex Schmitz	–	–	+	+
3. *Polyides rotundus* (Huds.) Grev.	–	–	+	+
4. *Callithamnion roseum* (Roth.) Lungb.	+	–	+	+
5. *Ceramium tenuicorne* (Kütz.) Waern	+	+	+	+
6. *C. rubrum* (Huds.) C. Ag.	–	–	+	+
7. *Furcellaria lumbricalis* (Huds.) Lamour.	+	+	+	+
8. *Hildenbrandtia rubra* (Sommerf.) Menegh.	+	+	+	+
9. *Phyllophora truncata* (Pallas) Zinova f. angustissima (C. Ag.) Sjöstedt	–	–	+	+
10. *Polysiphonia nigrescens* (Huds.) Grev.	+	+	+	+
11. *P. violacea* (Roth.) Spreng.	+	+	+	+
12. *Rhodomela confervoides* (Huds.) Silva	+	+	+	+
	8	6	11	11
Phaeophyta				
1. *Pilayella littoralis* (L.) Kjellm.	+	+	+	+
2. *Ectocarpus siliculosus* (Dillw.) Lyngb.	+	+	+	+
3. *Sphacelaria arctica* Harvey	+	–	+	+
4. *Sph. plumigera* Holmes	–	–	+	+
5. *Pseudolithoderma subextensum* (Waern) Lund	+	+	+	+
6. *Elachista lubrica* Rupr.	+	–	+	+
7. *Stictyosiphon tortilis* (Rupr.) Reince	+	+	+	+
8. *Dictyosiphon foeniculaceus* (Huds.) Grev.	+	+	+	+
9. *D. chordaria* Aresch.	+	–	–	–
10. *Eudesme virescens* (Carm.) J. Ag.	+		+	
11. *Chorda filum* (L.) Stackh.	+	+	–	–
12. *Fucus vesiculosus* L.	+	+	+	+
	11	7	10	9
Chlorophyta				
1. *Ulothrix tenerrima* Kütz.	+	+	–	+
2. *U. subflaccida* Wille.	+	–	–	+
3. *U. zonata* (Weber et Mohr.) Kütz.	–	+	–	–
4. *Capsosiphon fulvescens* (C. Ag.) Setch. et Gardn.	–	–	+	–
5. *Enteromorpha ahlneriana* Bliding	+	+	+	+
6. *E. intestinalis* (L.) Link	+	+	+	+
7. *E. prolifera* (O. F. Müll.) I. Ag.	+	+	+	+
8. *E. pilifera* Kütz.	–	–	+	+
9. *Percusaria percursa* (C. Ag.) Bory in Duperrey	+	–	+	–
10. *Chaetomorpha linum* (O. F. Müll.) Kütz.	+	+	–	+

1	2	3	4	5
11. *Cladophora fracta* (O. F. Müll.) ex Vahl) Kütz.	+	+	−	+
12. *C. glomerata* (L.) Kütz.	+	+	+	+
13. *C. rupestris* (L.) Kütz.	+	+	+	+
14. *Rhizoclonium riparium* (Roth) Harvey	+	+	+	+
15. *Urospora penicilliformis* (Roth) Aresch.	+	−	+	+
16. *Oedegonium* sp.	−	−	+	+
17. *Spirogyra* sp.	+	−	+	+
18. *Zygnema* sp.	+	−	+	+
	14	10	13	15
Charophyta				
1. *Chara aspera* Willd.	+	−	+	+
2. *Ch. baltica* Bruz. em Wahlst.	+	−	+	−
3. *Ch. canescens* Desv. et Lois.	+	−	+	+
4. *Ch. connivens* Salzm.	+	−	−	−
5. *Ch. tomentosa* L.	+	−	−	−
6. *Tolypella nidifica* Braun.	+	−	+	+
	6	0	5	3
Magnoliophyta				
1. *Myriophyllum spicatum* L.			+	+
2. *Najas marina* L.			+	+
3. *Potamogeton filiformis* Pers.			+	+
4. *P. pectinatus* L.			+	+
5. *P. perfoliatus* L.			+	+
6. *Ranunculus baudothii* Godr.			+	+
7. *Ruppia maritima* L.			+	+
8. *Zannichellia palustris* L.			+	+
9. *Zostera marina* L.			+	+
10. *Schoenoplectus lacustris* L. Palla			+	+
11. *Sch. tabernaemontanii* (C.Ch.Gmel.) Palla			+	+
12. *Bolboschoenus maritimus* (L.) Palla			+	+
13. *Phragmites australis* (Cav.) Trin. ex Steud			+	+
	0	0	13	13

Changes have also taken place north of Salacgrīva. At the present time several species which were registered in the northern part of Pärnu Bay in the late fifties (Pullisaar, 1961; Трей, 1976, 1986) do not occur there. These are the red alga *Phyllophora truncata* f. *angustissima*; the brown alga *Stictyosiphon tortilis*; the green algae *Cladophora rupestris*, *Enteromorpha ahlneriana*, and *Zygnema* sp.; the charophytes *Tolypella nidifica*, *Chara canescens*, *Ch. aspera*, *Ch. tomentosa*, *Ch. connivens*; and the phanerogam *Ruppia maritima*. At the same time, the area of the green alga *Cladophora glomerata* has considerably widened (Kukk and Martin, 1992).

Fifteen years ago the bladder wrack community occurred almost everywhere north of Salacgrīva on stony bottoms. At present, only occasional specimens were identified at some sampling sites. The frequency of *Cladophora glomerata* and *Ceramium tenuicorne* has considerably increased.

The species composition of the bottom vegetation in Kuressaare Bay has also changed, especially in its inner part, which is the area of the discharge of municipal sewage. According to Trei (Трей, 1984), the brown alga *E. siliculosus* and the phanerogam *P. pectinatus* were dominants in the inner part of Kuressaare Bay in 1976. In 1990, we failed to find *E. siliculosus*. *P. pectinatus* formed occasional scattered tufts. *Myriophyllum spicatum* was dominant, with *C. glomerata* and *P. littoralis* in the open part of the bay growing as epiphytes on it. Blue-green algae and diatomophyceae were abundant. *Potamogeton perfoliatus* and *P. filiformis* were also identified.

In the area between Salme and Ansekϋla, where according to Trei-Pullisaar (Pullisaar, 1962) 300—400 tons of bladder wrack (in dry weight) were washed up on the shore, the bladder wrack community has practically perished because of the pollution caused by the waste water of a fish processing enterprise.

However, it should be pointed out that this kind of damage in the bottom vegetation of the northern Gulf of Riga is local and has been recorded only in areas with a high pollution load (in the immediate vicinity of pollution sources).

The changes are much greater in the southern Gulf of Riga where the sandy bottoms do not favour luxurious growth of the vegetation. On the other hand, this area is affected by large rivers, including the Gauja, Lielupe, and Daugava, which carry into the Gulf 26 km^3 of polluted fresh water annually (Кумсаре et al., 1974). This exercises a certain effect on the species composition of the bottom vegetation.

The earliest hints of the reduction of the habitats of *F. lumbricalis* and *F. vesiculosus* in the area of Ragaciems, Skulte, Tuja, and Salacgrīva date from 1973. Since 1984, luxurious growth of pollution-resistant species, particularly of filamentous green algae, has been recorded in the southern Gulf of Riga. The habitat of *F. lumbricalis* and *F. vesiculosus* has decreased. We failed to find charophytes and the species *C. fracta*, *A. plicata*, *Polysiphonia violacea*, *H. rubra*, *C. roseum*, *D. chordaria*, *C. filum*, and *E. lubrica*, which were there in 1924 (Skuja, 1924) and most of them even at the end of the 1970s (Кумсаре et al., 1974).

Already in 1924 Skuja mentioned the abundant occurrence of epiphytes on *F. vesiculosus* near Ragaciems. He found *P. littoralis*, *D. foeniculaceus*, *S. tortilis*, *Ectocarpus confervoides*, *C. tenuicorne*, and the blue-green algae *Rivularia atra* as epiphytes on bladder wrack at a depth of 2—3 m. Skuja explained this with the lack of other substrates for those species to attach to. However, we tend to think that this phenomenon was due to local eutrophication as early as the 1920s. Eichwald (1847) was the first to describe the "blooming of water" in the Gulf of Riga in July. Kumsare et al. (Кумсаре et al., 1974) consider the area weakly polluted. However, we are of the opinion that the southern Gulf of Riga is a strongly polluted body of water, as the disappearance of several species of bottom vegetation indicates. Changes of bottom vegetation have considerably worsened the spawning conditions for fish and invertebrates, and the self-purification ability of the Gulf has decreased.

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