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Benthic communities and habitats in the near shore zone of the Curonian Spit (the south–eastern part of the Baltic Sea)

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Abstract Benthic communities classified according to species diversity, abundance and composition of dominant complex were defined and mapped. Maps compiled represent the distribution of bottom sediment types, substrata, bathymetry and benthic communities in the pilot area. Combination of data on community distribution and several abiotic habitat features (grain size, substrate types, and photic conditions) allowed recognizing several benthic habitats, according to HELCOM habitat classification. New data on features of coastal benthic biotopes made evident the existence of unique seascape "ancient lagoon mud" in the study area and allowed recommending further establishment of new marine protected areas.

Keywords *• benthic communities • swath bathymetry • side scan imaging • habitats • ancient lagoon mud • bottom sediments • substrate types mapping*

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INTRODUCTION

There are a number of bottom mapping projects for the south–eastern part of the Baltic Sea (Russian sector) including comprehensive geological surveys and a set of produced geological maps. However, biological aspects of underwater habitats were not taken into account sufficiently. The selected pilot site is close to the ongoing oil extraction at the Kravtsovskoye oil field (D-6). GIS-based atlas of bottom habitats could be an effective tool while assessing the potential environmental impact to the coastal zone and solving relevant ecological problems related to accidental oil spills. The aim of current study was local habitat mapping offshore Curonian Spit in order to develop methodological approach for further more extensive (large-scale mapping) activity in the area. The study was carried out in frames of Project "Development of solutions for effective oil spill management in the South–Eastern Baltic" aiming to create a set of maps reflecting different bottom conditions and delineate the most sensitive benthic habitats in the area.

MATERIAL AND METHODS

Study area

The study area is located alongside the root of the Curonian Spit (Russian part) at water depth of 10–30 m (Fig. 1). The selection of the location was determined by high diversity of bottom features (sediment type, bottom relief) and specific underwater landscape. Sandy sediments of different grain size prevail on the bottom surface, where outcrops of so called "ancient lagoon mud" was recently identified at a depth from 5 to 15 m (Zhamoida *et al*. 2009).

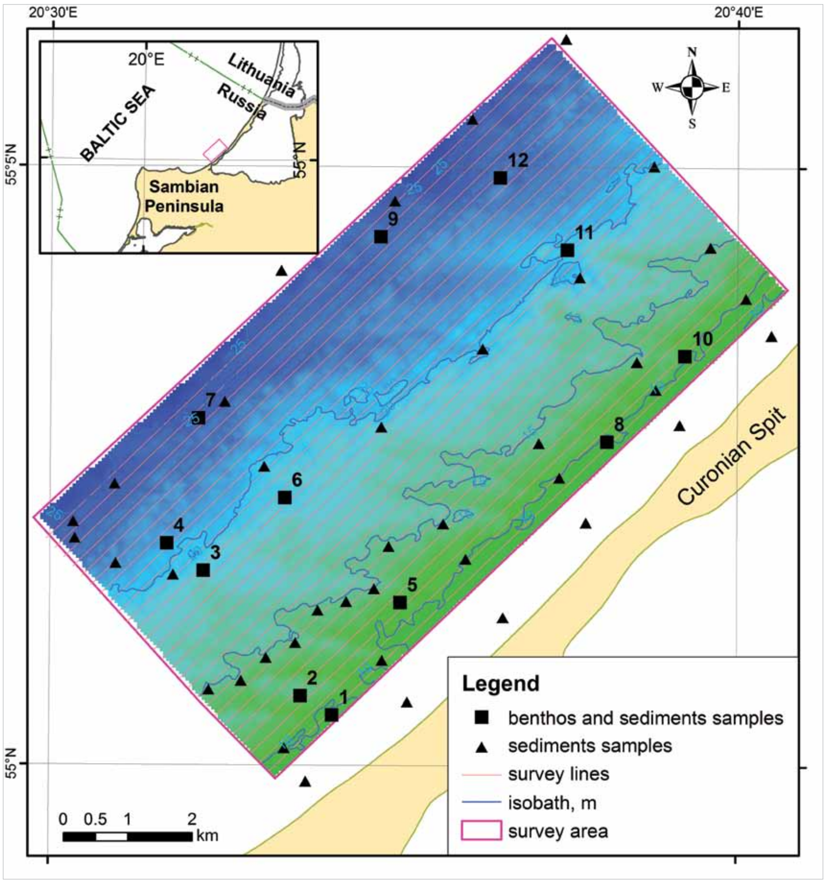

Fig. 1 Study area. Compiled by D. Dorokhov, 2014.

Salinity regime during the year is rather stable and variation is small (from 6.5 to 8.0 PSU). Sand of medium grain size prevails at the near shore (up to 5 m) and along the shore (Boldyrev, Zinchenko 1985). Content of suspended matter fluctuates from 0.2 to 12.4 mg·l^{-1} (3.3 mg·l^{-1} in average). The characteristic feature of this coastal area is an active along-shore current, which mainly transports suspended matter northward mainly (Boldyrev *et al.* 1979). The along-shore transportation of suspended matter occurs at depths up to 25–30 m, but is most intensive at the depth of 5–10 m. Phytoplankton biomass in the near shore zone up to 25 m varies from 0.31 to 1.89 gr·m^{-3}. Trophic state of this marine area can be considered as meso–throphic (Oil… 2012). Photic conditions for benthic organisms are defined by water transparency. The Secchi depth measured in the Lithuanian part of the coastal zone varied between 2–8.5 m with a mean of 4.5±1.7 m (Bučas 2009). These values correspond to the euphotic zone (Urbanski, Szymelfenig 2003). The same values have been estimated during current study (spring season) when water transparency varied in the range of 3.5–9.0 m (6.0 m in average).

Abiotic features

Hydrographic system *Teledyne Benthos C3D* for swath bathymetry and side scan imaging was used to provide high accuracy data for sediment and bottom micro-relief mapping. The system operates at frequency 200 kHz and acquires high-resolution side scan imagery (up to 4.5 cm) and bathymetry (up to 5.5 cm) data. Operational towing speed is 1 to 8 knots. The most distinct advantage of Benthos C3D compared to other systems is a wide coverage at shallow depths (up to 300 m at the water depth of 5–30 m).

26 profiles have been surveyed (Fig. 1) using Benthos C3D system. Total length of surveyed lines exceeds 300 km, spacing between lines was 200 m, coverage of side scan imagery swath was 300 m and bathymetry swath was 100 m. Thus, 150 % bottom coverage of side scan data and 50 % of swath bathymetry data were achieved. The results of multi-beam survey have been used in order to compile the bathymetric map of the area. The mosaicking of side scan images was executed using Hypack "Side scan targeting and mosaicking" tool. The resolution of the mosaic is 0.07 m. Bottom sediments have been classified automatically using Hypack *GEOCODER* tool, which allows to identify the sediment classes according to the side scan imagery. The average distance between reference points for identified class is about 50 m. Boundaries of the sediment distribution have to be digitized manually based on side scan mosaic taking into account *GEOCODER* data and results of grain size analyses of sediment samples. The most accurate results of automatic classification with well-defined boundaries were achieved for homogeneous sediments. In this case, distinguished sediment classes matched well with the results of the grain size analysis. However, automatic classification was not correct when dealing with complicated bottom morphology and complex distribution of different type of sediments. In this case, the *GEOCODER* data was not used.

Bottom sediments classification was based on grain size analyses of 51 sediment samples. Grain size analysis of sandy sediments was carried out using a vibratory sieve shaker *Analysette–3* (by FRITCH) and dry sieving according Wentworth scale (Wentworth 1922). Two samples of muddy deposits were analysed using a laser diffraction particle size analyzer *SALD 2300* (by SHIMADZU). Sediment type and calculation of the main statistic parameters – mean size and sorting was made using *GRADISTAT* software (Blott, Pye 2001). The program provides a physical description of the sediment type after Folk (1954). The mean grain size was described using a modified Udden–Wentworth grade scale (Udden 1914; Wentworth 1922). According to the applied classification, gravel is redefined as a fraction containing five subclasses ranging from very fine (2 mm) to very coarse (64 mm). The combination of Folk classifications and Udden-Wentworth scale used in *GRADISTAT* program allows describing the sediment types in more detail.

The mapping of distribution of bottom sediments and benthic communities, bathymetry and substrate types was done using *ArcGIS* software (by ESRI). Substrate types have been mapped according to the classification used in the European project *BALANCE* (Al-Hamdani, Reker 2007).

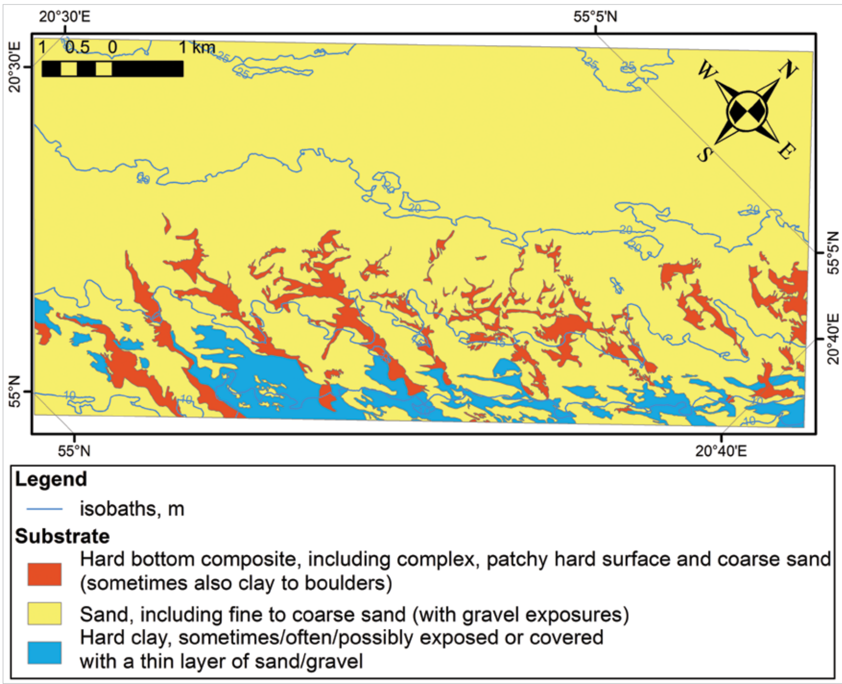

Fig. 2 Types of the substrate (the location of the area is provided in Fig. 1). Compiled by D. Dorokhov, 2014.

Zoobenthos data

The preliminary spatial distribution of the zoobenthos sampling sites (see Fig. 1) was based on the earlier studies of bottom relief and sediment distribution (Zhamoida *et al.* 2009, Atlas… 2010). The number of the samples followed the standard recommendation for the primary research of benthos distribution (Salazkin *et al*. 1984) in order to represent each distinct biotope by 2–3 sampling points. The sampling grid was slightly specified according to the results of current survey. 24 zoobenthic samples (with 2 replicas per sampling site) were collected in 12 May 2014. The sampling was made on R/V *Nord-3* using Van Veen grab (0.025 m^2). Additionally, water salinity, temperature and transparency (Secchi depth) at each sampling site were measured.

The zoobenthic samples were treated in accordance with standard methods (Salazkin *et al.* 1984). Samples were washed out on the mesh № 15 (0.36 mm^2), then fixed with 4 % neutral formaldehyde. Organisms were identified to species level when possible. Wet weight and numbers of every taxa per sample were determined, than recalculated to biomass ($gWWm^{-2}$) and density ($ind.m^{-2}$). Benthic communities were derived based on Bray-Curtis similarity index and rank abundance plot for biomass data (Zenkevich, Brotskaya 1937; Field *et al.* 1982; Shitikov *et al.* 2003).

RESULTS

Substrate types

Three substrate types were distinguished at the investigated area (Fig. 2).

1. Hard clay exposed or covered with sand and gravel was identified at the near shore bottom at the water depth from 10 to 15 m. Different types of sediments are distributed in the area: sandy mud, sand of different grain size, gravel and boulders. The prevailing deposits are densely laminated sandy mud with high content of C_{org}. These are the relict (result of diagenesis of lagoon mud, marl, gyttja) sediments of Curonian palaeolagoon (Zhamoida *et al*. 2009). Former lagoon mud was compacted and dehydrated by the pressure of dunes moving eastwards during the Litorina Sea transgression. These sediments are the unique substrate with particular mechanical properties favourable for cavities formation and clearly visible on the sonar images (Fig. 3).

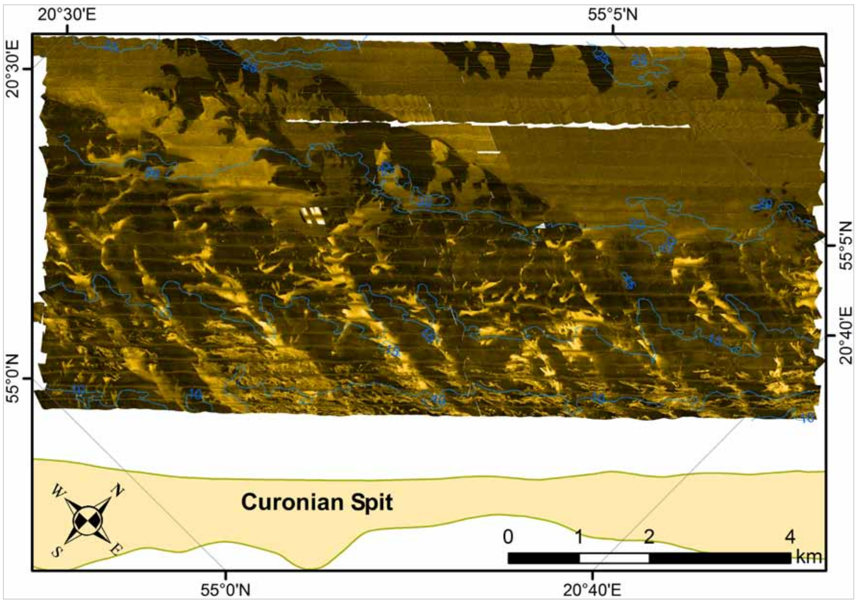

Fig. 3 Mosaic of side scan images (the location of the area is provided in Fig. 1). Compiled by D. Dorokhov, 2014.

Table 1. Grain size composition and main statistical parameters of collected sediment samples. Compiled by E. Dorokhova, 2014

Station №	Depth, m	Fractions (mm) content, %									Mean (Md), mm	Sorting (So)	Sediment type
		>8.0	8.0-2.0	2.0-1.0	1.0-0.5	0.5-0.25	0.25-0.125	0.125-0.063	0.063-0.004	<0.004			
1	9	0.0	0.0	4.3	12.9	12.6	34.7	33.8	1.6	0.0	0.19	2.2	Fine sand
2	14	0.0	6.3	34.8	42.1	15.6	1.1	0.1	0.0	0.0	0.87	1.8	Gravelly sand
3	19	52.7	0.0	0.0	0.5	8.4	29.0	9.0	0.5	0.0	2.73	13.5	Sandy gravel
4	21	0.0	0.0	0.0	1.2	9.7	40.5	45.7	3.0	0.0	0.12	1.7	Very fine sand
5	12	46.5	3.9	0.7	11.5	24.0	12.8	0.5	0.0	0.0	3.09	9.7	Sandy gravel
6	19	0.0	20.7	8.8	62.8	5.0	2.0	0.7	0.0	0.0	0.96	2.3	Gravelly sand
7	25	0.0	0.0	0.0	0.2	0.6	7.6	84.1	7.4	0.0	0.09	1.6	Very fine sand
8	9,5	0.0	0.0	0.0	0.0	0.0	7.0	20.7	63.6	8.7	0.02	3.1	Sandy silt
9	14	0.0	0.0	0.0	0.2	0.5	4.8	87.2	7.3	0.0	0.09	1.5	Very fine sand
10	12	0.0	0.0	0.0	0.0	2.5	17.0	24.4	47.4	8.8	0.04	3.7	Sandy silt
11	20	2.4	9.2	6.2	73.3	7.0	1.4	0.5	0.0	0.0	0.91	2.4	Gravelly sand
12	24	0.0	5.4	67.3	26.2	0.4	0.3	0.5	0.0	0.0	1.15	1.5	Gravelly sand

The outcrops of densely packed deposits form a complicated micro-relief of folded mud of gradient up to 5 m and sand and gravel sediments in the depressions between (Fig. 4). According to the grain size analyses (Table 1) this is the very poorly sorted (So= 3.7 and 3.1) mixture of silt and sand sediments (ss. 8, 10 in Fig. 1). The content of sand fraction is quite high and varies from 28 % (in sample of ss. 8) to 44 % (in sample of ss. 10).

2. Hard bottom composite, including complex, patchy hard surface and coarse sand identified at the depth of 10 to 20 m. Those sediments are composed of gravel exposed in the clearly expressed elongated towards the shoreline depressions of the seabed (Fig. 4).

3. Sand, including fine to coarse sand (with gravel exposures) covers the bottom at the depth from 10 to 25 m. The fine sand is prevailing on the elevations of the underwater slope at the depth of 10 to 20 m. The sand is fine grained and poorly sorted (Md ~ 0.17 mm, So ~ 1.9). Seaward, at the depth of 20 m to 25 m bottom relief becomes more flat. Those areas are covered by gravely coarse sand and some fields of very fine sands accumulated in the local depressions (Fig. 4). The gravely sands with boulders observed on the seabed surface are relicts of glacial till deposits (Atlas… 2010). According to grain size analyses gravely sand is very poorly sorted (average So=3) with mean size around 1.3 mm. The very fine-grained sand (Md ~0.11 mm) is also poorly sorted (So ~2.0). Individual boulders can also be observed on side scan sonar images.

Taxonomic diversity of zoobenthos

31 macroinvertebrate species and taxa were recorded in the study area. Those are common for the south–eastern part of the Baltic Sea bivalves *Macoma balthica, Mya arenaria, Cerastoderma glaucum, Mytilus edulis;* gastropod *Hydrobia ulvae,* polychaetes *Marenzelleria neglecta, Hediste diversicolor, Streblospio benedicti, Pygospio elegans, Harmatoe imbricata, Fabricia stellaris;* crustaceans *Amphibalanus improvisus, Jaera albifrons, Leptocheirus pilosus, Corophium volutator, Diastylis rathkei.* The diversity varies from four to 17 taxa. The most impoverished benthic associations record two–four taxa per sample. The richest ones (such as *M. edulis* associations) count to 17 taxa per sample. Some of animals have not been identified to a species level; those are Hydrozoa, Oligochaeta, Chironomidae, Harpacticoidae, Nemertea and Turbellaria.

The highest species diversity was observed in the near shore area along the central part of the study area where the fields of boulders with the pebbles and/or so called "ancient lagoon mud" are exposed.

Benthic communities

According to the classification of biological samples using Bray–Curtis similarity coefficient samples were grouped in four main clusters (Fig. 5).

Two clusters diverging at 18 % of similarity level have been defined. The first one, unifying stations 5 and 10 is representing hard substrate (sandy gravel) and "ancient lagoon mud" (hard clay). Hard clay is very dense and often covered by biogenic crust of bryozoans and others. Similarity between sampling station was less than 50 %. The total biomass (mean value) of benthos representing this cluster was not high (19.5 gWWm-2), but the biodiversity was very high, i.e. 17 species. The cluster is characterized by species assemblages with predominance of bivalve M. edulis with several variations determined by presence of different combinations of co-dominant and sub-dominant species due to different micro-biotopic conditions in the sampling sites.

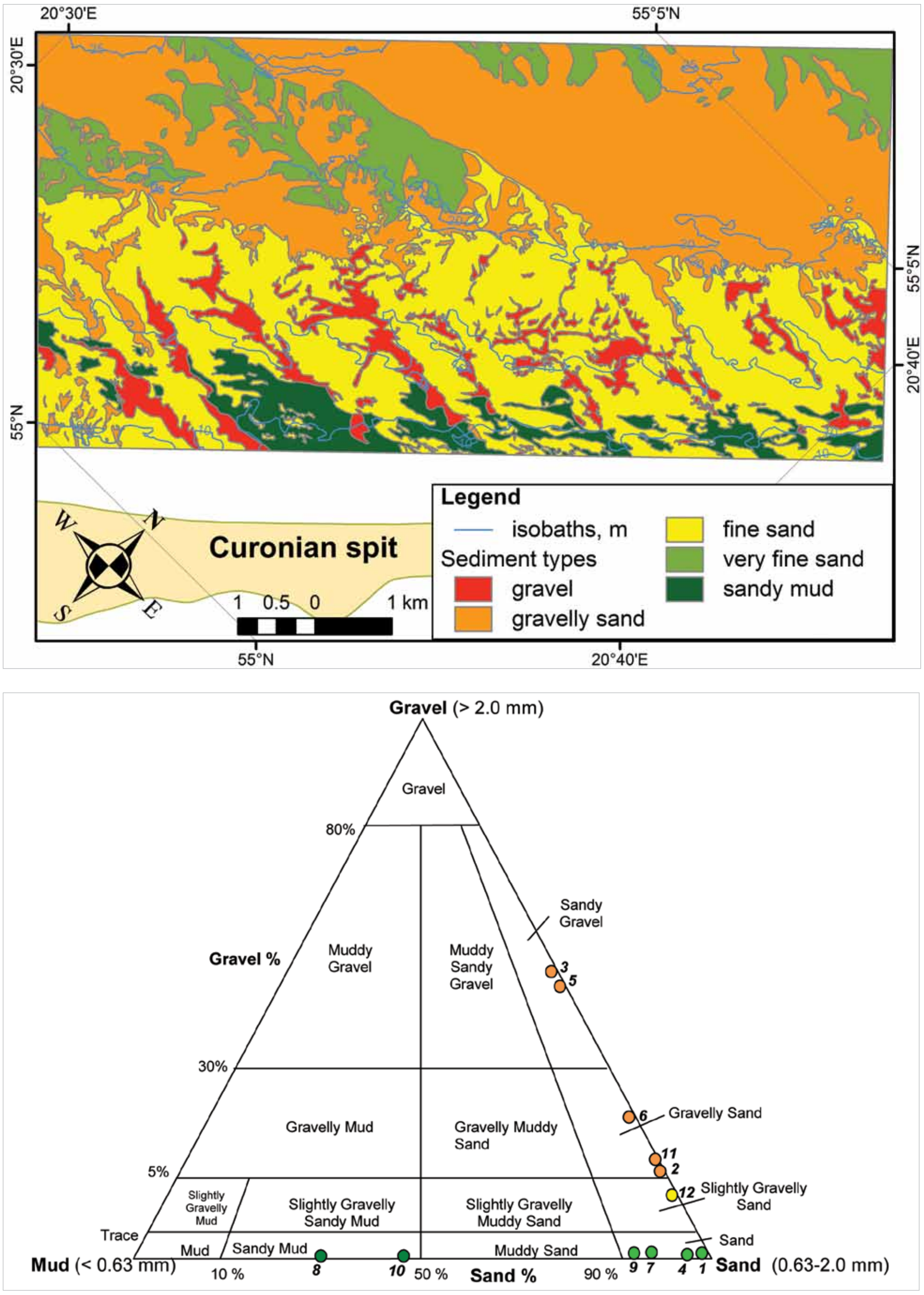

Fig. 4 Map of bottom sediments distribution (the location of the area is provided in Fig. 1) and ternary diagram of sediment samples (after Folk 1954). Compiled by D. Dorokhov and E. Dorokhova, 2014.

Second cluster unifies three groups of samples diverging at different level of similarity (22–80 %). The first group, represented by stations 2 and 11 (similarity level 23 %), is characterizing bottom covered by gravelly sand. The biodiversity here is rather low – 4–8 taxa identified, the biomass is also low – 11.3 gWWm^{-2}, represented by Oligochaetes mostly. Second group unifies sampling stations 3, 4, 6, 7, 9, 12 (similarity level 55 %). The biomass of total benthos in the samples of this group is 102.5 gWWm^{-2} on average. Despite some variations of the assemblage (depending on micro-biotope conditions), bivalve *M. balthica* is dominating in all stations of this group. Third group is unifying stations with different dominant organisms – molluscs (in the station 1) and polychaetes (in the station 8). The common feature of those two sampling sites – biomass level, which does not exceed 7.4 gWWm^{-2}, (av. 6.4 gWWm^{-2}) and species richness ca. 8–10.

The presented clusterization is based on the amount and abundance of considered taxa, but it does not allow let to identify and compare community structure, including complex of dominant and sub-dominant species. Therefore, further classification was based on index of abundance in accordance with Brotskaya–Zenkevich (1937). Five groups were distinguished based on this index (Table 2). Thus, five main bottom communities have been identified in the area: *M. edulis* (ss. 5, 10), *M. balthica* (ss. 1, 3, 4, 6, 7, 9, 12), Oligochaeta (ss. 2), *Polychaeta* (*M. neglecta+H. diversicolor*) (ss. 8) and Oligochaeta+ *S. benedicti* (ss. 11).

Communities, dominated by *M. balthica* and *M. edulis* occupy comparatively large bottom areas. Taking into account the abundance and amount of sub-dominant species there were number of main communities variations identified, those are: four variations of *M. balthica* community*:* M. *balthica*+Oligochaeta+*H. diversicolor, M. balthica+M. neglecta, M. balthica+H. diversicolor and M. balthica+C. glaucum;* and two variations of *M. edulis* community: M. *edulis+C. volutator* and *M. edulis+C. volutator+M. arenaria* (Fig. 6). The main abiotic parameters, measured during sampling and results of rank distribution are given in Table 3.

M. edulis community was found on the hard bottoms represented by «ancient lagoon mud" (hard clay) and hard bottom composite substrates (ss. 10 and 5). Variation of *M. edulis* community is characterized by set of specific co–dominant of

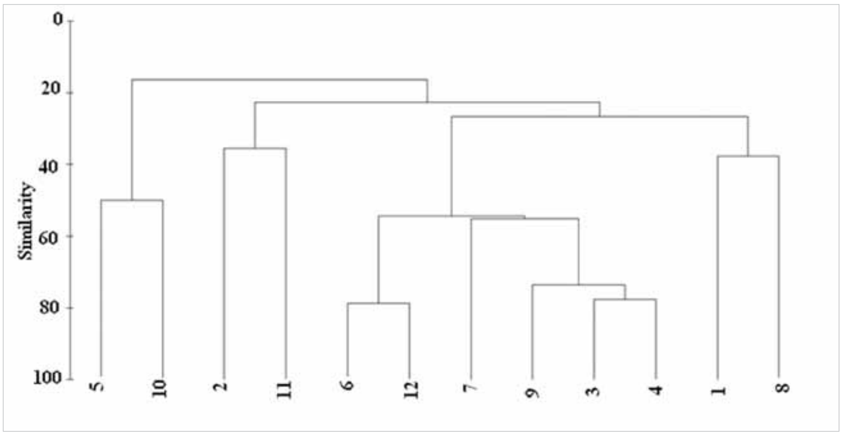

Fig. 5 The dendrogram of the similarity of sampling sites, based on Bray–Curtis single-bound method (1957). Compiled by O. Kocheshkova and E. Ezhova, 2014.

Table 2 Groups of sampling sites, resulted from rank abundance plot in accordance to Brotskaya–Zenkevich index. Compiled by O. Kocheshkova and E. Ezhova, 2014.

Sampling site No.	Dominant species	Share of dominant in total biomass, %
5, 10	*M. edulis*	60
2	Oligochaeta	97
3, 4, 6, 12, 7, 9, 1	*M. balthica*	64
8	*M. neglecta+H. diversicolor*	38
11	Oligochaeta+ *S. benedicti*	74

species: *M. edulis+C. volutator* (st. 5), *M. edulis+C. volutator+M. arenaria* (st. 10), and small benthic biomass up to 30 gWWm^{-2} only. The level of richness of observed species is typical for this community. The most typical organisms for this community are *M. edulis*, Oligochaetes, small polychaetes and *H. ulvae*. Full composition and the quantitative characteristics of *M. edulis* community in the study area are given in Table 4.

M. balthica community occupies the biggest part of the research area. This community is spread on the different types of sediments at the depths from 9 to 25 m Species composition of *M. balthica* community changes along with a changing sediment type and depth. At the depths of 23–25 m (ss. 7, 9) where fine-grained sand is the prevailing lithological type of bottom sediments, community variation dominated of *M. balthica and H. diversicolor* is being developed. In the coarse-grained sand, the presence of oligochaete worms was observed among the co-dominant forms of the *M. balthica* community, i.e. *M. balthica+H. diversicolor*+Oligochaeta (ss. 6, 12).

At the depths of 19–21 m on the substrate composed of sand with pebbles and gravel two bivalves *M. balthica+C. glaucum* (ss. 3, 4) are marked as a dominant species of the given community variation. In the sediments with higher amount of fine-grained fractions, bivalve *C. glaucum* is substituted by spionid worm *M. neglecta* (ss. 1).

In the community variation of *M. balthica+H. diversicolor* and *M. balthica+H. diversicolor*+Oligochaeta the characteristic organisms are Nemertea indet., polychaetes, snail *H. ulvae,* amphipod *C. volutator* and priapulid worm *Halicryptus spinulosus*. In the community variation of *M. balthica+C. glaucum* and *M. balthica+M. neglecta* the characteristic species are different: *H. diversicolor*, *P. elegans*, Oligochaete worms, and amphipods *C. volutator, B. pilosa*. Composition and quantitative characteristics of the *M. balthica* community are given in Table 5.

Oligochaeta and **Oligochaeta+*S. benedicti*** communities are dominated by oligochaetes or oligochaetes together with small spionid polychaetes which are developed on the coarse-grained sand at the depths of 10–20 m. Biomass of those species does not exceed 15 gWWm^{-2}. Characteristic species are represented by different worms: polychaetes *M. neglecta, H. diversicolor* and Nemertea *indet.* The typical traits of Oligochaeta community are given in Table 6.

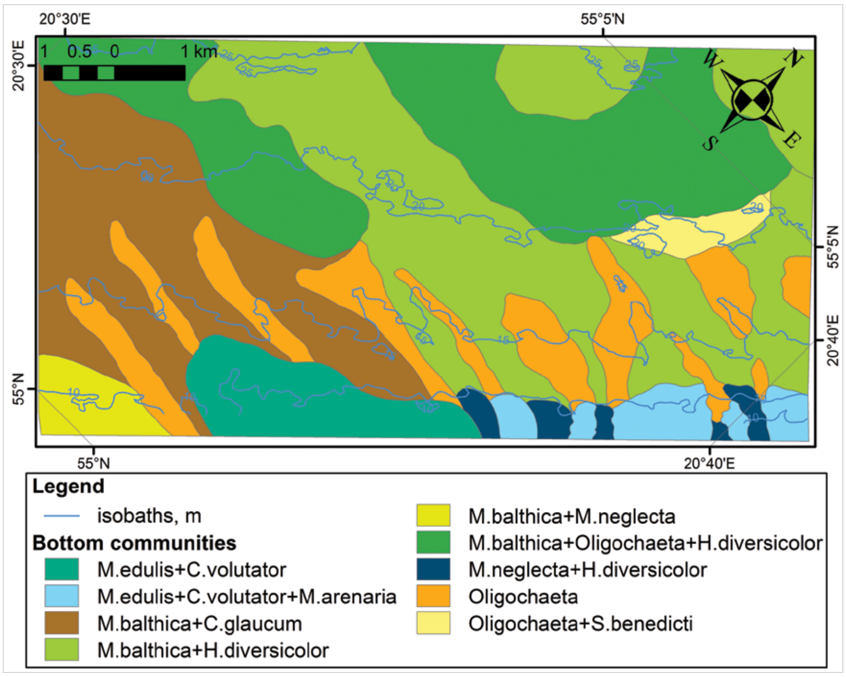

Fig. 6 Distribution of main macrozoobenthic communities and its variations (the location of the area is provided in Fig. 1). Compiled by O. Kocheshkova and E. Ezhova, 2014.

Table 3 Abiotic and biotic features at the sampling sites. Compiled by O. Kocheshkova and E. Ezhova, 2014.

Station №	Salinity, PSU	Depth, m	Secchi depth, m	Temperature, °C	Sediment type	Biomass, $gWWm^{-2}$	Number of Species	Dominant species	Sub-dominant species
1	7.11	9	5.2	10.22	Fine sand	7.37	10	*M. balthica, M. neglecta, P. caudatus*	*H. diversicolor S. benedicti*
2	7.11	14	5.5	9.81	Gravelly sand	3.06	4	Oligochaeta	Nemertea
3	7.15	19	9.0	8.47	Sandy gravel	113.18	11	*M. balthica, C. glaucum*	*P. elegans, S. benedicti*
4	7.18	21	9.0	7.43	Very fine sand	158.56	12	*C. glaucum, M. balthica*	*M. neglecta, Oligochaeta, C. volutator*
5	7.13	12	6.0	9.69	Sandy gravel	8.32	9	*M. edulis, C. volutator*	*Oligochaeta, P. elegans, F. stellaris, H. ulvae*
6	7.17	19	8.3	7.64	Gravelly sand	82.30	9	*M. balthica, H.diversicolor*, Oligochaeta	Nemertea
7	7.17	25	8.4	6.33	Very fine sand	25.70	11	*M. balthica, H. diversicolor*	*Oligochaeta, M. neglecta, H. ulvae, C. volutator*
8	7.14	9,5	6.6	9.79	Sandy silt	5.41	8	*M. neglecta, M. arenaria*	*M. edulis, H. diversicolor*
9	7.25	23	5.8	5.37	Very fine sand	131.70	13	*M. balthica*	*H.diversicolor, C. glaucum*
10	7.14	12	5.0	9.67	Sandy silt	30.72	17	*M. edulis, M. arenaria, C. volutator*	*E. crustulenta, H. ulvae, M. neglecta*
11	7.16	20	8.5	8.46	Gravelly sand	19.48	8	*S. benedicti*, Oligochaeta, *H. diversicolor*	Nemertea, *M. edulis*
12	7.22	24	6.3	6.11	Gravelly sand	103.78	8	*M. balthica*, Oligochaeta, *H. diversicolor*	Nemertea, *H. spinulosus*

Polychaete community *M. neglecta+H. diversicolor* has been observed in the shallow waters (up to 8–10 m depth) on the sea bottom substrate composed of sandy silt of “ancient lagoon mud”. This community was identified at the one (ss. 8) sampling station only, but the results are well matching the data of former (performed in 2001–2003) studies. The community is characterised by very low biomass and abundance (Table 7). The average biomass is 5.90 $gWWm^{-2}$ and not more than 7 species recorded (see Ezhova, Spirido 2007).

In May 2014, single specimens of *M. arenaria* juveniles were marked here (biomass of 2.40 $gWWm^{-2}$), and this occasional finding formally move the species at a place of dominant. However, it was regarded that these findings are a temporary element of polychaete community, which cannot define community traits at coarse sands biotope, unfavorable for sand gapers, because of further elimination.

Benthic habitats

Taking into account all above presented, seven benthic habitats were determined in accordance with HELCOM Biotope classification (2013). The classification is based on bottom relief, sediment types, and penetration of the light, salinity, hydrodynamic conditions, composition and structure of the bottom communities. Those are:

1. Baltic photic hard clay exposed with sand and gravel dominated by Mytilidae

Station: 5, 10.

Taxonomic and domination structure:

9–17 species and taxonomic groups, *domination M. edulis – C. volutator* or *M. edulis – C. volutator – M. arenaria* followed by oligochaetes, polychaetes (*F. stellaris, P. elegans, M. neglect*a) and *Hydrobiid snails.*

Table 4 Composition and the quantitative characteristics of Mytilus edulis community. Compiled by O. Kocheshkova and E. Ezhova, 2014.

Taxa	Density, ind. m^{-2}	Biomass, gWWm^{-2}	Occurrence frequency, %
Einhornia crustulenta	"+	0.16	50
Oligochaeta	100	0.04	75
Marenzelleria neglecta	250	0.11	25
Pygospio elegans	140	0.04	50
Fabricia stellaris	700	0.08	100
Hediste diversicolor	110	0.52	75
Halicryptus spinulosus	170	0.03	50
Macoma balthica	80	0.05	50
Mya arenaria	10	4.40	25
Mytilus edulis	370	11.72	100
Hydrobia ulvae	450	0.26	75
Corophium volutator	550	2.04	100
Totally	**3350±51.4**	**19.5±3.9**	

Table 5 Composition and the quantitative characteristics of Macoma balthica community. Compiled by O. Kocheshkova and E. Ezhova, 2014.

Taxa	Density, ind.m^{-2}	Biomass, gWWm^{-2}	Occurrence frequency, %
Nematoda	1254	0.44	43
Einhornia crustulenta	"+	0.14	14
Nemertea	1020	0.41	29
Oligochaeta	7220	5.16	100
Marenzelleria neglecta	629	3.46	100
Streblospio benedicti	326	0.77	71
Pygospio elegans	314	0.69	64
Harmatoe imbricata, juv.	14	0.34	36
Hediste diversicolor	643	6.85	100
Priapulus caudatus	6	0.41	7
Halicryptus spinulosus	209	0.05	7
Tunicata	3	2.09	7
Mya arenaria	131	0.73	50
Macoma balthica	723	53.23	93
Mytilus edulis	6	0.14	14
Cerastoderma glaucum	57	14.13	36
Hydrobia ulvae	543	1.30	57
Leptocheirus pilosus	3	0.07	7
Corophium volutator	37	0.70	43
Totally	**13249±126.5**	**88.94±8.3**	

Table 6 Composition and the quantitative characteristics of Oligochaeta community. Compiled by O. Kocheshkova and E. Ezhova, 2014.

Taxa	Density, ind. m^{-2}	Biomass, gWWm^{-2}	Occurrence frequency, %
Nematoda	1040	0.04	75
Nemertea	790	0.07	100
Oligochaeta	14820	4.88	100
Marenzelleria neglecta	40	0.64	25
Streblospio benedicti	130	3.84	50
Hediste diversicolor	80	1.70	25
Mytilus edulis	10	0.08	25
Totally	**16970±4126.58**	**11.27±4.15**	

Table 7 Composition and the quantitative characteristics of Polychaeta community. Compiled by O. Kocheshkova and E. Ezhova, 2014.

Taxa	Density, ind. m^{-2}	Biomass, gWWm^{-2}	Occurrence frequency, %
Marenzelleria neglecta	620	2.00	100
Hediste diversicolor	20	0.80	100
Mya arenaria	20	2.40	50
Mytilus edulis	100	0.20	50
Totally	**960±113.14**	**5.41±1.17**	

Spatial distribution:

Hard bottom represented by sandy silt and sandy gravel at a depth range of 5–12 m.

2. Baltic aphotic sand dominated by Baltic tellin (*Macoma balthica*)

Stations: 6, 7, 9, 12.

Taxonomic and domination structure:

9–13 species and taxonomic groups, domination of *M. balthica*+*H. diversicolor or M. balthica*+Oligochaeta+*H. diversicolor or M. balthica*+*M. neglecta* followed by nemertines, polychaetes, hydrobiids, corophiids and oligochaetes.

Spatial distribution:

Very fine sand and gravelly sand at a depth range of 23–28 m.

3. Baltic photic sand dominated by Baltic tellin (*Macoma balthica*)

Station: 1.

Taxonomic and domination structure:

10 species and taxonomic groups, domination of *M. balthica+M. neglecta*, followed by oligochaetes and polychaete *H. diversicolor*.

Spatial distribution:

Fine sand at a depth range of 9 m.

4. Baltic photic sand dominated by multiple infaunal polychaete species: *Pygospio elegans, Marenzelleria neglecta, Hediste diversicolor*)

Station: 8.

Taxonomic and domination structure:

8 species and taxonomic groups, domination of *M. neglecta+H. diversicolor* followed by *M.edulis* and *M. arenaria.*

Spatial distribution:

Sandy silt, depth range of 10 m.

5. **Baltic aphotic sand dominated by multiple infaunal bivalve species: *Cerastoderma spp., Macoma balthica***

Station: 3, 4.

Taxonomic and domination structure:

12 species and taxonomic groups, domination of *M. balthica+C. glaucum*, followed by oligochaetes and polychaetes (*M. neglecta*, *P. elegans*).

Spatial distribution:

Sandy gravel and very fine sand at a depth range of 13–21 m.

This habitat cited in the list of Baltic habitats (HELCOM, 2013) with other set of dominating bivalves *Cerastoderma spp., M. balthica, Astarte borealis, Arctica islandica, M. arenaria,* but astartids are not inhabitants of the south–eastern Baltic coastal waters. Other traits of the habitat are similar.

6. **Baltic photic coarse sediment characterized by infaunal polychaetes**

Stations: 2.

Taxonomic and domination structure:

2 taxonomic groups, domination of Oligochaeta followed by nemertines.

Spatial distribution:

Gravelly sand at the depth range of 14 m.

In the list of Baltic habitats (HELCOM, 2013) such a habitat is characterised by other set of dominant polychaete than in this study area.

7. **Baltic aphotic coarse sediment characterized by infaunal polychaetes**

Stations: 11.

Taxonomic and domination structure:

10 species and taxonomic groups, domination Oligochaeta+*S. benedicti* followed by nemertines and polychaete *H. diversicolor*.

Spatial distribution:

Gravelly sand at the depth range of 20 m.

In the list of Baltic habitats (HELCOM, 2013) such a habitat is characterised by other set of dominant polychaete than in this study area.

DISCUSSION

More than 80 % of the bottom of the study area is occupied by *M. balthica* community. *M. balthica* is marine eurytermic, euryhalinous, polytopic species. It tolerates well euthrophic conditions and is present throughout the Baltic Sea. *M. balthica* is the species mostly contributing to the total benthos biomass in the Baltic Sea (Baltic... 1984). The species is being observed at the depths of 10 to 30 m. *M. balthica* community inhabits sandy bottoms preferably. The conditions on the loose substrata (substrate type 2 and 3) are different (Okolotovich 1984) and changing grain size influences the structure of *M. balthica* community. Sub-dominant species could substitute each other and structure of this community may slightly change.

Comparatively small part of study area is inhabited by *M. edulis* community (at depths of up to 15 m). *M. edulis* is a marine eurytermic, euryhalinous and lithophylic, filter-feeding species, which prefers active near bottom hydrodynamic. The species of this community are typically developed on the substrata presented by rock, pebble and gravel (substrate number 2) and where few algae species are present (Baltic... 1984). The identified specific substrate of "ancient lagoon mud" (substrate number 1) is dense enough to support mussels setting, but not suitable for the development of typical mussel beds with high biomass and absolute predominance. However, this community and corresponding habitat was marked as one of the most diverse.

In the study area (at the depths up to 30–35 m), the community *M. arenaria* (average biomass 46.6 gWWm^{-2}) was recognized earlier (Lukšėnas 1969). The investigations carried out in 2001–2005 (Ezhova, Spirido 2007) have shown that the *M. arenaria* community is completely replaced by *M. balthica* (average biomass 152.22±71.70 gWWm^{-2}) and *M. edulis* (average biomass 1065.0±247.0 gWWm^{-2}). Community structure has also changed. In 1980–1990, isopod *Mesidotea entomon* and polychaete *Bylgides sarsi* were very typical members of *M. edulis* community (Apollov 1992). Now, both *M. entomon* and *B. sarsi* are rare in the community, while snails *Hydrobia spp*., Theodoxus *fluviatilis* and gammarids have become very common. *M. entomon* is now rare also and in the *M. balthica* community. The most common and abundant characteristic species in this community is polychaete *H. diversicolor* and *M. arenaria*. Invasive polychaete *M. neglecta* is currently as abundant as aboriginal spionid *P. elegans*. Share of clam *C. glaucum* increased in some locations as was marked earlier (Ezhova, Spirido 2007).

CONCLUSIONS

Data of current study provided much more detail information on bottom abiotic features in comparison with earlier studies. The results of modern sea bottom survey allowed execution of a well targeted benthos sampling. The results show much higher level of community and habitat diversity, than it was supposed earlier. One of the important results is delineation of specific underwater landscape and community – to identify the distribution of the area of "ancient lagoon mud" (habitat No. 1). Such a habitat was not present in the list of Baltic biotopes (by HELCOM) and should be considered for further investigations and importance for conservation purposes.

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