diversity

MDPI

Data Descriptor

Biodiversity of Marine Interstitial Ciliates in the Intertidal Zone of the White Sea: A Dataset from the Chernaya River Estuary, Kandalaksha Gulf

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Abstract: (1) Background: An estuary is a zone in which sea and river waters mix. It is a specific area with a very non-stable environment and salinity gradient. However, little is known about the diversity of ciliate communities in estuarine benthic ecosystems in the Arctic. The aim of this paper is to describe the diversity of intertidal ciliates in the Chernaya river estuary (Kandalaksha Gulf, White Sea), which is characterized by a pronounced salinity gradient (0–22‰), on the basis of a recently published dataset. (2) Methods: We conducted our own investigations during the summer periods of 1998–2000. Material was collected at five permanent stations along the salinity gradient (0–22%) of the estuary. For each observation, the coordinates of the sampling sites, the number of individuals observed and the sampling date were recorded. The total effort comprised 35 sampling days, with five sampling sites at each date. (3) Results: The dataset contains 4270 unique occurrences of 119 ciliates taxa (109 species, 8 unidentified species of the genus level and 2 unidentified species on the family level). The total number of specimens represented is 64,475. (4) Conclusions: The largest classes in terms of species diversity are Hypotrichea (27 species), Gymnostomatea (26 species), Oligohymenophorea (17 species) and Karyorelictea (16 species).

Dataset: https://doi.org/10.15468/ccku5d.

Keywords: biodiversity; interstitial ciliates; estuary; dataset; White Sea

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1. Summary

Ciliates are unicellular protists with a high level of diversity and wide distribution [1]. Intertidal sediments are characterized by a high species abundance and richness of ciliates, with up to 2500 cells/mL [2–4]. Hamels et al. [5] detected 53 species from a volume of 0.2 mL of intertidal sediment. Burkovsky and Mazei [6,7] reported 125 ciliate species from an area of one square meter of intertidal sediment during a long-term study. With their high abundance and species richness, interstitial ciliates are suitable for evaluating the distribution patterns of protists and the major factors regulating their dispersal on different spatial scales [8–24]. Previous studies have reported high levels of diversity of interstitial ciliates and other protists in the White Sea [25–41].

High environmental variability and a critical salinity level (3–8‰) cause peculiarities in ciliate community composition and complexity in brackish waters when compared with other biotopes [42–54]. Herein, we describe intertidal ciliate fauna in a non-

stable environment with a pronounced salinity gradient (0–22‰) based on a recently published dataset.

2. Data Description

2.1. Dataset Description

In the dataset (Table 1), each observation includes basic information: the date of observation, coordinates (latitude/longitude), observer name, identifier name and publications (if available). The coordinates were determined using satellite images.

Table 1. Description of the data in the dataset.

Column Label	Column Description
eventID	An identifier for the set of information associated with an event.
occurrenceID	An identifier for the occurrence (as opposed to a particular digital record of the occurrence).
basisOfRecord	The specific nature of the data recorded: LivingSpecimen.
eventDate	The date when material from the trap was collected or the range of dates during which the trap collected material.
Kingdom	The full scientific name of the Kingdom in which the taxon is classified.
scientificName	The full scientific name, including the genus name and the lowest level of taxonomic rank with the authority.
Family	The full scientific name of the Family in which the taxon is classified.
Class	The full scientific name of the Class in which the taxon is classified.
taxonRank	The taxonomic rank of the most specific name in the scientific name.
decimalLatitude	The geographic latitude of location in decimal degrees.
decimalLongitude	The geographic longitude of location in decimal degrees.
countryCode	The standard code for the country in which the location is found.
individualCount	The number of individuals present at the time of the occurrence.
organismQuantity	A number or enumeration value for the quantity of organisms.
organismQuantityType	The type of quantification system used for the quantity of organisms.

The dataset contains 4270 unique occurrences of 119 ciliates taxa (species, genera and families) from the Chernaya River estuary (Kandalaksha Bay, White Sea). The dataset is based on field studies by Yuri A. Mazei and Igor V. Burkovsky which were performed in the period 1998–2000 [29,36].

2.2. Figures, Tables and Schemes

The dataset contains 4270 unique occurrences of 119 ciliates taxa (109 species, 8 genera and 2 families) from the Chernaya River estuary (Kandalaksha Bay, White Sea). The total number of specimens represented is 64,475. Hypotrichea (27 species), Gymnostomatea (26), Oligohymenophorea (17) and Karyorelictea (16) are the largest classes in terms of species richness. Karyorelictea (24,868) and Oligohymenophorea (19,260) are the largest classes in terms of abundance. Class Litostomatea were represented by only one species and one individual (Table 2).

Twenty species presented in the database have corrected names compared to the original studies [29,36,48]: *Biholosticha discocephalus* (Kahl, 1932) Berger, 2003, *Anigsteinia clarissimum* Kahl, 1928, *Anigsteinia salinarum* (Florentin, 1899) Kahl, 1932, *Enchelyodon sulcatus* Kahl, 1930, *Holosticha gibba* (Müller, 1786) Wrzesniowski, 1877, *Kentrophoros fasciolatus* Sauerbrey, 1928, *Kentrophoros latus* Raikov, 1962, *Kentrophoros uninucleatus* (Raikov, 1962) Raikov, 1962, *Pleuronema coronatum* Kent, 1881, *Pleuronema crissum* Dujardin, 1841, *Protogastrostyla pulchra* (Pereyaslawzewa, 1886) Gong, Kim, Kim, Min, Roberts, Warren & Choi, 2007, *Limnostrombidium viride* (Stein, 1867) Krainer, 1995, *Tracheloraphis oligostriata* Raikov, 1962, *Prototrachelocerca caudata* (Dragesco & Raikov, 1966) Foissner, 1986, *Trachelocerca incaudata* Kahl, 1933, *Apotrachelocerca arenicola* (Kahl, 1933), *Trachelostyla pediculiformis* (Cohn, 1866) Borror, 1972, *Trichotaxis multinucleatus* Burkovsky, 1970, *Uroleptus caudatus* (Stokes,

1886) Bardele, 1981, *Uronema marinum* Dujardin, 1841 and *Urosoma caudatum* (Ehrenberg, 1833) Berger, 1999.

Table 2. Species diversity of ciliate classes from the dataset.

Class	Number of Families	Number of Species	Number of Individuals
Cyrtophoria Fauré-Fremiet in Corliss, 1956	3	4	81
Gymnostomatea Bütschli, 1889	10	26	4807
Heterotrichea Stein 1859	4	8	544
Hypotrichea Stein 1859	12	27	7116
Karyorelictea Corliss 1974	5	16	24,868
Kinetofragminophora de Puytorac et al. 1974	2	3	616
Litostomatea Small et Lynn 1981	1	1	1
Oligohymenophorea de Puytorac et al. 1974	11	17	19,260
Oligotrichea Bztschli 1887	2	2	2282
Prostomatea Schewiakoff 1896	3	5	4900
Total	53	109	64,475

In the marine zone (station 1, see Figure 1), the highest species richness was observed. As it moves towards the river mouth, we detected decreases in the abundance and richness of most stenohaline marine species and corresponding increases in marine euryhaline and brackish water (oligohaline) species. We did not find species of freshwater origin in the estuary.

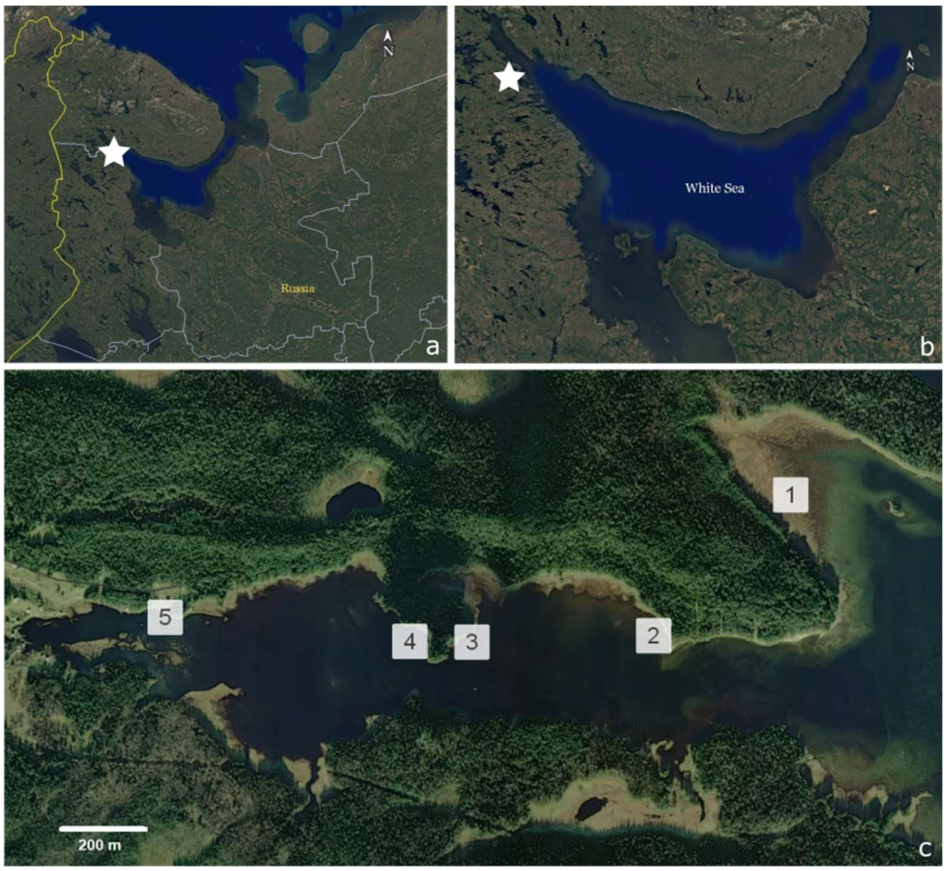

Figure 1. Sampling sites in the White Sea. (**a**,**b**) The white stars on the satellite images showing the location of Chernaya River estuary. The basis for the maps (**a**,**b**) was https://www.google.com/maps/ (accessed on 5 June 2023). (**c**) A scheme of the locations of stations 1–5 in the estuary; numbers in the figure showing exact sampling sites at each station. The basis for the map (**c**) was https://360earthview.com/ (accessed on 5 June 2023).

For the entire period of observation, there were 45 families and 34,191 individuals recorded at station 1, 44 families and 15,223 individuals at station 2, 42 families and 7707 individuals at station 3, 39 families and 4003 individuals at station 4 and 34 families and 3351 individuals at station 5.

Each year, between 21 and 65 taxa were detected in one sample at station 1, between 15 and 46 taxa were detected at station 2, between 7 and 36 taxa were detected at station 3, between 6 and 27 taxa were detected at station 4 and between 8 and 30 taxa were detected at station 5.

The following taxa were found the most often in the most marine part of the estuary at Station 1: *Apotrachelocerca arenicola*, *Cardiostomatella vermiformis*, *Coleps tesselatus*, *Didinium balbiani*, *Diophrys scutum*, *Discocephalus rotatorius*, *Geleia fossata*, *Histobalantium majus*, *Histobalantium marinum*, *Lacrymaria affinis*, *Limnostrombidium viride*, *Pleuronema marina*, *Prorodon*, *Remanella margaritifera*, *Trachelocerca incaudata*, *Urostrongylum caudatum and Uronema marinum*. Moreover, *Apotrachelocerca renicola*, *Histobalantium marinum*, *Remanella margaritifera*, *Trachelocerca incaudata* and *Uronema marinum* were found in each sample the entire period of observation (Table 3).

The most common taxa found at Station 2 were *Cardiostomatella vermiformis*, *Cyclidium fuscum*, *Didinium balbiani*, *Enchelyodon*, *Limnostrombidium viride*, *Histobalantium marinum*, *Prorodon*, *Remanella margaritifera*, *Sonderia vorax*, *Trachelocerca incaudata*, *Trachelocercidae*, *Tracheloraphis kahli*, *Trachelostyla caudata*, *Urostrongylum caudatum* and *Uronema marinum*.

The most common taxa found at Station 3 were *Cardiostomatella vermiformis*, *Coleps tesselatus*, *Cyclidium fuscum*, *Didinium balbiani*, *Enchelyodon*, *Histobalantium marinum*, *Pleuronema crassum*, *Prorodon*, *Sonderia vorax*, *Trachelocercidae*, *Trachelostyla caudata* and *Uronema marinum*.

The most common taxa found at Station 4 were *Anigsteinia clarissimum*, *Cyclidium fuscum*, *Enchelyodon*, *Glaucoma pyriformis*, *Lacrymaria affinis*, *Lacrymaria cohnii*, *Lacrymaria coronata*, *Oxytrichidae*, *Paraprorodon morgani*, *Pleuronema crassum*, *Prorodon* and *Uronema marinum*.

The most common taxa found at Station 5 were *Anigsteinia clarissimum*, *Cyclidium fuscum*, *Cyrtohymena marina*, *Enchelyodon*, *Lacrymaria affinis*, *Lacrymaria cohnii*, *Lacrymaria conifera*, *Lacrymaria coronata*, *Oxytrichidae*, *Paraprorodon morgani*, *Pleuronema crassum*, *Prorodon*, *Uronema marinum* and *Urosoma caudatum*.

The following taxa were found at all stations for the entire period of observation: *Apotrachelocerca arenicola*, *Aspidisca fusca* Kahl, 1928, *Anigsteinia clarissimum*, *Cardiostomatella vermiformis*, *Condylostoma curva* Burkovsky, 1970, *Cyclidium fuscum*, *Didinium balbiani*, *Diophrys scutum*, *Enchelyodon*, *Enchelyodon sulcatus* Kahl, 1930, *Euplotes trisulcatus* Kahl, 1932, *Frontonia fusca* Quennerstedt, 1869, *Frontonia marisalbi* Burkovsky, 1970, *Frontonia tchibisovae*, *Helicostoma notatum* Kahl, 1931, *Histobalantium marinum*, *Lacrymaria affinis*, *Lacrymaria caudata* Kahl, 1933, *Lacrymaria cohnii*, *Lacrymaria conifera*, *Lacrymaria coronata* Claparède & Lachmann, 1859, *Lacrymaria marina* Meunier, 1907, *Limnostrombidium viride*, *Mesodinium pulex* (Claparède & Lachmann, 1859) Stein, 1867, *Oxytrichidae*, *Paraprorodon morgani*, *Pleuronema coronatum* Kent, 1881, *Pleuronema crassum*, *Pleuronema marina*, *Prorodon*, *Sonderia vorax*, *Strombidium sulcatum* Claparède & Lachmann, 1859, *Trachelocercidae*, *Trachelostyla caudata*, *Trachelostyla pediculiformis* (Cohn, 1866) Borror, 1972, *Uroleptus caudatus* (Stokes, 1886) Bardele, 1981, *Uronema marinum*, *Uronychia transfuga* (Müller, 1776) Stein, 1859 and *Urostrongylum caudatum*.

Ciliate species richness was slightly different in different years: 78 taxa in 1998, 79 taxa in 1999 and 94 taxa in 2000. As salinity decreases, the number of species decreases as well. General data on species richness at different stations in 1998, 1999 and 2000 are presented in Figure 2.

Table 3. Abundance (individuals per square centimeter) and number of unique occurrences of most common ciliate species from the dataset.

Species	Stations									
	1		2		3		4		5	
	ab.	occ.	ab.	occ.	ab.	occ.	ab.	occ.	ab.	occ.
Apotrachelocerca arenicola (Kahl, 1933)	645	35	74	18	217	16	2	1	1	1
Anigsteinia clarissimum Kahl, 1928	39	22	63	16	63	15	68	22	72	12
Cardiostomatella vermiformis (Kahl, 1928) Corliss, 1960	438	34	232	31	460	24	16	7	4	2
Coleps tesselatus Kahl, 1930	3315	35	91	18	214	30	12	7	0	0
Cyclidium fuscum Kahl, 1928	186	18	474	28	636	25	678	28	606	18
Cyrtohymena marina (Kahl, 1932) Foissner, 1989	0	0	7	4	66	11	66	10	94	12
Didinium balbiani (Fabre-Domergue, 1888) Kahl, 1930	1366	33	237	26	237	27	48	12	36	7
Diophrys scutum (Dujardin, 1841) Kahl, 1932	218	34	42	13	549	21	15	7	33	6
Discocephalus rotatorius Ehrenberg, 1829	814	34	119	14	6	2	0	0	0	0
Enchelyodon Claparède & Lachmann, 1859	181	24	157	24	146	25	170	24	133	19
Frontonia tchibisovae Burkovsky, 1970	31	13	23	3	246	26	79	9	6	4
Geleia fossata (Kahl, 1933) Foissner, 1998	324	34	20	7	1	1	0	0	0	0
Glaucoma pyriformis (Ehrenberg) Schewiakoff	0	0	4	3	97	14	102	19	12	7
Histobalantium majus Kahl, 1931	470	30	20	10	1	1	1	2	0	0
Histobalantium marinum Kahl, 1933	1976	35	340	31	139	22	18	10	12	5
Lacrymaria affinis Bock, 1952	278	34	85	22	38	13	51	16	62	13
Lacrymaria cohnii Kent, 1881	35	14	5	4	1	1	36	14	35	12
Lacrymaria conifera Burkovsky, 1970	130	19	23	9	21	8	16	8	39	11
Lacrymaria coronata Claparède & Lachmann, 1859	61	12	23	13	47	13	24	14	30	10
Limnostrombidium viride (Stein, 1867) Krainer, 1995	1162	33	289	30	199	21	48	10	47	8
Oxytrichidae Ehrenberg 1838	141	27	34	16	57	12	64	22	62	15
Paraprorodon morgani (Kahl, 1930) Foissner, 1983	39	6	5	2	69	21	36	16	52	16
Pleuronema crassum Dujardin, 1841	3	2	43	11	349	26	622	28	614	14
Pleuronema marina Dujardin, 1841	524	33	20	7	783	5	55	5	134	5
Prorodon Ehrenberg, 1834	792	34	156	27	138	27	157	21	72	11
Remanella margaritifera Kahl, 1933	8814	35	8913	32	125	12	7	3	0	0
Sonderia vorax Kahl, 1928	59	18	97	26	300	27	49	12	7	6
Trachelocerca incaudata Kahl, 1933	1812	35	291	24	57	11	0	0	0	0
Trachelocercidae Kent 1881	675	32	798	33	110	24	33	12	2	2
Tracheloraphis kahli Raikov, 1962	470	30	20	10	1	1	1	2	0	0
Trachelostyla caudata Kahl, 1932	296	27	117	25	148	23	42	7	69	6
Uronema marinum Dujardin, 1841	3820	35	467	27	1139	31	965	32	589	18
Urosoma caudatum (Ehrenberg, 1833) Berger, 1999	0	0	0	0	45	8	88	10	137	13
Urostrongylum caudatum Kahl, 1935	551	33	293	29	30	6	4	5	4	3

ab.—abundance; occ.—umber of unique occurrences.

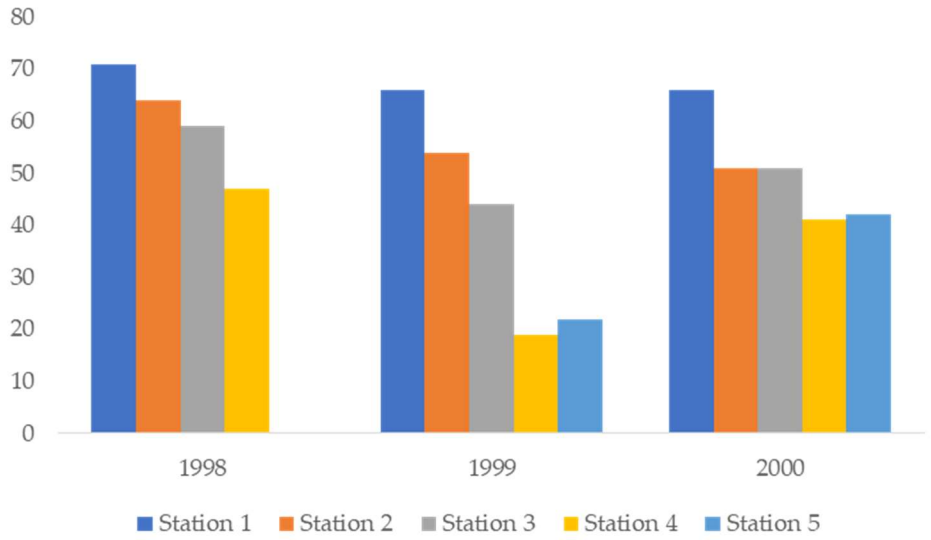

Figure 2. Number of taxa at different stations in all years.

3. Methods

The investigations were conducted during the summer periods of 1998–2000 periods in the Chernaya river estuary (the Kandalaksha Bay, the White Sea). Material was collected at five permanent stations. The stations were located at the middle horizon of the intertidal zone along the estuary on the borders, dividing relatively homogenous zones (Figure 1). The distance from the shore to a station differed at different stations due to the topography characteristics. Thus, at station 1 it was 60 m, at station 2 it was 10 m, at station 3 it was 5 m, at station 4 it was 12 m and at station 5 it was 2 m. The sampling was carried out in intervals of 5–7 days. The total effort comprised 14 sampling days in 1998, 5 sampling days in 1999 and 16 sampling days in 2000.

Each sample was a series of 15 subsamples (1 cm^2 in square, 3 cm in height, which resulted in a 45 cm^3 total sample) collected from a strictly fixed square 50 × 50 cm. A random sampling, corresponding to 1/15 of the total sample (3 cm^3), was examined (i.e., under one mean statistical square centimeter). Fifteen simultaneously taken subsamples allowed one to grade the possible spatial heterogeneity and to receive as much information as possible about the species biodiversity. The ciliates were extracted from the sediment by washing, according to the Uhlig method [55], one hour after sampling. The quantitative counting of ciliates was performed on live individuals under the stereomicroscope BIOMED-9 (Russia) at a magnification of ×32–56. The ciliates were identified on silver-impregnated slides [56], according to Carey [57]. All individuals found were identified at species, genus or family levels. Most of the species were morphologically described in our previous publications [58–61].

Environmental factors (water temperature, salinity and pH) were measured at each station. The interstitial water temperature was measured using an ordinary thermometer (graduated to 0.1 °C), and salinity and pH were measured with a conductivity meter and pH meter, correspondingly (HANNA Instruments, Belgium).

The results of measuring different environmental parameters (Table 4) show that the Chernaya river estuary is a very spatially heterogeneous and temporally unstable environment. The spatial heterogeneity of the biotope is, first of all, connected with the mosaic distribution of mineral and organic sediments in the intertidal zone, which also determines other important environmental characteristics (pH, Eh and the granulometric composition of sediment). Temporal instability is conditioned by tidal rhythms and the unsteadiness of the river flow. More detailed information about environmental parameters for particular sampling points are provided in Table S1.

Table 4. Environmental parameters of samples from five stations.

Factor	Stations				
	1	**2**	**3**	**4**	**5**
Granulometric composition of sediments. Fraction (%):					
>1.0 mm	2.8	15.2	5.7	4.9	4.5
0.50–1.00 mm	16.3	16.8	18.4	12.9	6.6
0.25–0.50 mm	46.2	29.3	53.6	37.3	38.5
0.10–0.25 mm	18.8	12.9	10.5	16.5	20.3
<0.10 mm	15.9	25.8	11.8	28.4	30.1
Amount of suspended organic matter in the sediment (% from sediment weight)	0.3	0.8	0.5	0.9	1.0
Volume of water spaces in the sediment	44.7	41.6	46.9	41.6	41.2
Density of the sediment (% of allevropelite < 0.1 mm)	15.9	25.9	11.8	28.4	30.1
Water salinity, ‰					
1998, average	13.0	10.0	5.7	3.8	1.0
amplitude	3–20	2–18	0–15	0–13	0–8
1999, average	17.1	16.6	12.2	9.9	3.2
amplitude	14–22	10–20	8–18	5–15	0–10
2000, average	13.7	11.5	7.4	5.8	1.8
amplitude	8.3–21	2.5–18.9	0.6–16.6	0–13.1	0–7.1
average for 1998–2000	14.6	12.7	8.4	6.5	2.0
Coefficient of variation, %	15	27.3	40	48	55.5
pH on the surface of the sediment					
1998, average	7.4	6.8	7.0	6.7	6.3
1999, average	7.8	7.4	7.2	6.9	6.3
2000, average	8.2	8.1	7.8	7.7	7.4
Coefficient of variation, %	5.4	8.5	5.6	7.8	9.3

The granulometric compositions of the sediments, amount of suspended organic matter in the sediment and volume of water spaces in the sediment were measured once a year. Water salinity and pH were measured each time when sampling.

All calculations were made with the use of MS Excel and PAST 4.11 packages.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/d15070873/s1, Table S1: Environmental parameters for particular sampling points in the Chernaya river estuary.

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