# Diversity of benthic diatoms in relation to environmental factors in two Bulgarian reservoirs

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**Abstract.** Littoral diatom communities in two reservoirs in Bulgaria – Koprinka and Zhrebchevo – were studied to determine the qualitative and quantitative composition in relation to major environmental factors. The total number of diatom taxa recorded in the epilithon was 173. Canonical correspondence analysis was used to explore the relationships between environmental variables and patterns in the epilithic diatom assemblages. Transparency, temperature, pH and dissolved oxygen were found to be the most important environmental factors which determined the distribution of diatoms in summer and autumn in the Zhrebchevo Reservoir. Conductivity and concentrations of calcium and bicarbonate ions were the most important environmental factors for the distribution of diatom communities in the Koprinka Reservoir. The Zhrebchevo Reservoir, which is infested by *Dreissena polymorpha*, was characterized by much higher rates of benthic primary productivity than the uninfested Koprinka Reservoir.

**Key words:** abundance, diatoms, *Dreissena polymorpha*, reservoirs, water chemistry

## Introduction

Rapid spread of an invasive bivalve mollusc species from genus *Dreissena* was recently reported in the inland waters of Bulgaria (Hubenov 2002, 2005; Trichkova & al. 2008, 2009). The potential threat of negative ecological and economic impacts necessitates the undertaking of urgent steps, including regular monitoring and risk assessment, along with the control measures for recreation, fishing, aquaculture, and other industrial activities in the reservoirs (Trichkova & al. 2009).

Diatoms have been used extensively as biomonitors of water quality and they are one of the most suitable biological components of aquatic ecosystems for tracking environmental disturbances. Epilithic taxa may be especially useful indicators owing to the fact that: 1. rock substrates are abundant in most regions, whereas some sites lack other substrates, such as macrophytes or filamentous algae; 2. rocks often support a diverse diatom flora, thus increasing the robustness of biomonitoring models; and 3. unlike some taxa living attached to plants, epilithic algae are rather less dependent on the substrate as a nutrient source, hence, epilithic populations are more likely to track ambient water quality (Reavie & Smol 1998).

Most of the published data on diatoms in the reservoirs of Bulgaria were related to phytoplankton investigations (Naidenow & Saiz 1977, 1987; Saiz 1977, 1981, 1987; Beshkova 1995, 1996; Beshkova & Botev 1994, Beshkova & Saiz 2006). Surveys of diatoms in periphytic communities have not been published so far. The present study is the first detailed investigation of the periphytic diatom flora in two reservoirs in Bulgaria within the drainage basin of River Maritsa (Aegean Sea Basin): Koprinka and Zhrebchevo water reservoirs.

The objectives of this study were:

- To explore the relative abundance and diversity of diatom flora;
- To examine the relationship between diatom flora and major environmental factors;
- To compare the community composition of diatoms in the Zhrebchevo Reservoir, which is infested by *Dreissena polymorpha*, with that of Koprinka Reservoir, which is uninfested.

## Material and methods

The Koprinka and Zhrebchevo reservoirs were studied (Fig. 1). They are located along River Tundzha, in the drainage area of River Maritsa, Aegean Sea Basin. The Koprinka Reservoir is located upstream, at an altitude of 397 m a.s.l., it has a surface area of 840 ha and a maximum depth of about 30 m. The Zhrebchevo Reservoir is located at an altitude of 274 m a.s.l., it has a much larger surface area of 2580 ha and a maximum depth of 52 m. The two reservoirs are used for power generation, irrigation, aquaculture, recreation, and recreational fishing. Our preliminary results showed that Zhrebchevo Reservoir was heavily infested by the Zebra Mussel (*Dreissena polymorpha*), while Koprinka Reservoir was uninfested (Tyufekchieva & al. 2010).

Samples of water chemistry were collected in August 2009 and October-November 2010, while samples of diatoms were collected in August 2009, May 2010 and October-November 2010. Three sites were sampled in the Koprinka Reservoir and four sites in the Zhrebchevo Reservoir (Fig. 1).

Water chemistry was sampled from the surface (0.5 m, by means of one litre Friedenger sampler) at each site. Conductivity, pH, dissolved oxygen, and temperature were measured *in situ* by instruments and electrode type WTW Conductometer 3110 Set 3, Electrode KLE 325, WTW pH Meter 3210 Set 2; Electrode SenTix 41 and WTW Oxi Meter 3210 Set 3, Electrode DurOX 325-3, without stirring during measurements. Secchi depth transparency was measured *in situ* as well. The rest of the parameters were measured in the laboratory. Ammonia-nitrogen was measured by spectrophotometry and Indophenol blue. Ortho-phosphate phosphorus was determined by spectrophotometry and ammonium molybdate method with ascorbic acid reduction and total phosphorus, using the same method after persulfate digestion. Total dissolved nitrogen was measured by spectrophotometry, using persulfate digestion with cadmium reduction. Dissolved reactive silica was determined by spectrophotometry ammonium molybdate, KNa-tartarate method with $SnCl_2$ reduction. Sulfate, chloride, nitrate, calcium, magnesium,

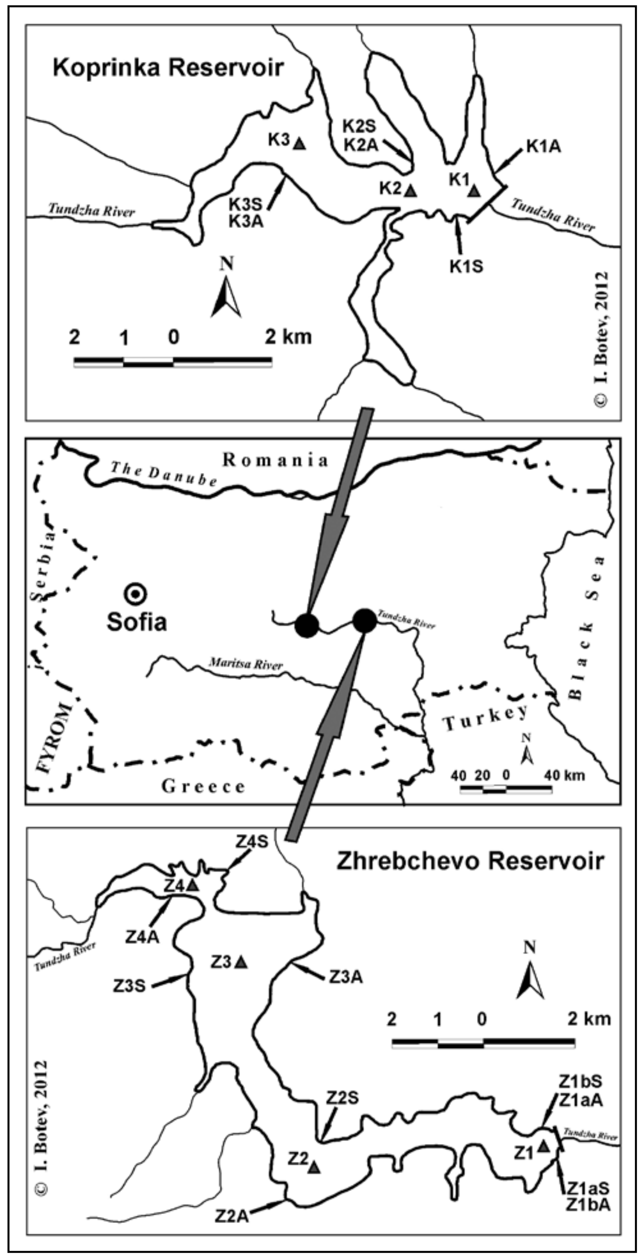



**Fig. 1.** Sketch map of the survey area with studied reservoirs within River Tundzha basin. **K1**, **K2**. **K3**, **Z1**, **Z2**, **Z3**, **Z4** – locations of environmental samples. **K1S**, **K1A**, **K2S**, **K2A**, **K3S**, **K3A**, **Z1aS**, **Z1bS**, **Z1aA**, **Z1bA**, **Z2S**, **Z2A**, **Z3S**, **Z3A**, **Z4S**, **Z4A** – locations of diatom samples. **S** = Summer; **A** = Autumn.

sodium, potassium, all were measured by ion chromatography (DX-120 Dionex), with electrochemical fluent suppression. Total organic carbon was determined by TOC 5000 Shimadzu Analyzer.

A total of 23 epilithic diatom samples were collected in the two reservoirs. Methods for epilithon sampling followed those described by Cameron (1997). The samples were cleaned, according to the standard methods described by Battarbee (1986). The cleaned diatoms were identified and counted under oil immersion at magnification of c. × 800 or × 2000, with a light microscope. A minimum of 300 valves was counted in every sample (Renberg 1990). In general, nomenclature followed Krammer & Lange-Bertalot (1986-1991), Round & al. (1990) and Hofmann & al. (2011). Preparation for scanning electron microscopy followed Hasle & Fryxell (1970) and samples were examined on Jeol JSM-5510. The spectra of physicochemical tolerance of the identified diatom taxa were based mainly on Lowe (1974), Krammer & Lange-Bertalot (1986–1991), Van Dam & al. (1994), and Rakowska (2001).

The minimum-variance clustering (Ward's method) based on squared Euclidean distances was used to group the samples on the basis of their diatom species composition.

Principal component analysis (PCA), based on a correlation matrix by centring and standardization, was used to summarize the major patterns of variation within environmental data. For the purpose of multivariate analysis, diatom species were expressed as relative abundance ( % total diatoms) and only those taxa exceeding 2 % in any single sample were retained. For DCA and CCA analysis, the most diverse diatom sample per lake was chosen. Detrended Correspondence Analysis (DCA) (Hill & Gauch 1980) – detrending by segments – was run with diatom assemblages to estimate the length of gradient as a measure of beta diversity in community composition. When the gradient length was >3, the relationships between the diatom assemblages and environmental variables were explored in more detail, using Canonical Correspondence Analysis (CCA) (ter Braak 1986, 1995; ter Braak & Prentice 1988; ter Braak & Verdonschot 1995). Only the diatom samples and environmental variables from August 2009 and October-November 2010 were included in the analysis. Ordinations were implemented by the CANOCO statistical package (ter Braak & Šmilauer 2002).

## Results

### Water chemistry

The results of all measured environmental data are shown in Table 1. Principal Component Analysis was used to summarize the major patterns of variation within the samples from August 2009, and the results are presented as a PCA correlation biplot in Fig. 2. In the biplot, variables with high positive correlation have generally small angles between their arrows. Variables with long arrows have high variance and are generally more important within the data.

The first two principal components ($\lambda_1 = 0.733$, $\lambda_2 = 0.125$) account cumulatively for 85.8 % of the total variance and capture effectively the main patterns of variation in the environmental data. The first axis is related to conductivity, calcium, magnesium, potassium, bicarbonate ions, sodium, chloride ions, sulphate, dissolved nitrogen, dissolved reactive silica, dissolved organic carbon, pH, orthophosphate, total phosphorus, and contrasts the sites in Zhrebchevo Reservoir – Z1, Z2, Z3, Z4 (with higher values of these parameters) plotted on the left side of the diagram, with the ones in Koprinka Reservoir – K1, K2, K3 (with lower values of the above parameters, but higher orthophosphate and total phosphorus plotted on the right side of the diagram (Table 1). Axis 2 is related to transparency, nitrate nitrogen, ammonium nitrogen, and separates the shallow sites in the two reservoirs – Z4, K3 (located close to the ecotone zone) and plotted on the top of the diagram, which have the lowest values of transparency and nitrate nitrogen, and especially site Z4 which has the highest values of ammonium nitrogen (69 μgN/l) (Table 1). The highest values of transparency (above 350 cm) were measured in deeper sites in the Zhrebchevo Reservoir.

### Relative abundance and diversity of the diatom flora

The total number of diatom taxa recorded in the epilithon and the sediment samples from the surveyed lakes was 173. They were referred to 40 genera, belonging to three classes: Coscinodiscophyceae, Fragilariophyceae and Bacillariophyceae. Nineteen forms could not be identified beyond the generic level, and they were listed as "sp." In terms of taxonomic diversity, the classes Fragilariophyceae and Bacillariophyceae prevailed (90.4 %). Identification of diatoms

**Table 1.** **Physical and chemical parameters of the Koprinka and Zhrebchevo Reservoirs in August 2009 and October and November 2010. $NH_4$-N = ammonium nitrogen; $NO_3$-N = nitrate nitrogen, DN = dissolved nitrogen; $PO_4$-P = ortho-phosphate phosphorus, TP = total phosphorus; DRSi = dissolved reactive silica; DOC = dissolved organic carbon.**

| Parameters \ Site and month, year of sampling | K1_08.2009 | K2_08.2009 | K3_08.2009 | Z1_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Z1_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature, °C | 26.8 | 26.3 | 29.0 | 25.3 | 25.6 | 26.0 | 25.4 | 13.3 | 13.1 | 12.5 | 12.8 | 13.0 | 12.9 | 12.6 |
| pH | 9.13 | 9.03 | 9.04 | 8.70 | 8.70 | 8.71 | 8.69 | 8.00 | 8.08 | 8.33 | 7.95 | 8.04 | 7.97 | 8.03 |
| Conductivity, µS/cm | 195 | 194 | 192 | 322 | 360 | 339 | 341 | 231 | 231 | 230 | 337 | 341 | 345 | 352 |
| Dissolved Oxygen, mg/l | 9.7 | 9.0 | 9.1 | 9.7 | 9.5 | 9.3 | 10.2 | 8.6 | 8.8 | 9.3 | 8.1 | 8.4 | 8.0 | 9.2 |
| Transparency, m | 2.9 | 3.2 | 2.1 | 3.5 | 3.5 | 4.5 | 1.9 | 1.9 | 2.0 | 1.8 | 4.2 | 4.1 | 2.3 | 1.3 |
| $Ca^{2+}$, mg/l | 25.67 | 25.15 | 24.44 | 42.15 | 43.81 | 42.98 | 40.35 | 32.06 | 30.06 | 28.06 | 52.10 | 52.10 | 50.10 | 40.08 |
| $HCO3^{1-}$, mg/l | 109.80 | 106.75 | 106.75 | 134.20 | 155.55 | 167.75 | 158.60 | 128.10 | 128.10 | 128.10 | 158.60 | 164.70 | 161.65 | 167.75 |
| $Mg^{2+}$, mg/l | 7.03 | 6.99 | 7.10 | 12.16 | 12.14 | 12.23 | 12.40 | – | – | – | – | – | – | – |
| $Na^{1+}$, mg/l | 4.68 | 4.71 | 4.80 | 12.03 | 11.89 | 11.93 | 12.26 | – | – | – | – | – | – | – |
| $K^{1+}$, mg/l | 1.32 | 1.33 | 1.29 | 2.19 | 1.99 | 2.03 | 2.00 | – | – | – | – | – | – | – |
| NH4-N, µgN/l | 5 | 31 | 1 | 4 | 3 | 35 | 69 | – | – | – | – | – | – | – |
| NO3-N, µgN/l | 114 | 112 | 10 | 452 | 507 | 322 | 104 | – | – | – | – | – | – | – |
| $SO4^{2-}$, mg/l | 13.82 | 13.82 | 14.45 | 38.26 | 38.18 | 38.28 | 38.89 | – | – | – | – | – | – | – |
| $Cl^{1-}$, mg/l | 2.64 | 2.65 | 2.68 | 9.25 | 9.16 | 9.22 | 9.39 | – | – | – | – | – | – | – |
| $PO_4$-P, µgP/l | 40.9 | 36.2 | 7.9 | 17.4 | 6.8 | 4.4 | 8.2 | – | – | – | – | – | – | – |
| TP, µgP/l | 54.1 | 47.1 | 24.1 | 32.1 | 15.6 | 9.7 | 18.8 | – | – | – | – | – | – | – |
| DN, mgN/l | 0.27 | 0.31 | 0.21 | 0.59 | 0.64 | 0.56 | 0.39 | – | – | – | – | – | – | – |
| DOC, mgC/l | 2.35 | 2.39 | 2.77 | 2.87 | 2.80 | 3.06 | 3.10 | – | – | – | – | – | – | – |
| DRSi, mgSi/l | 1.93 | 1.91 | 1.21 | 2.80 | 3.23 | 2.95 | 2.58 | – | – | – | – | – | – | – |

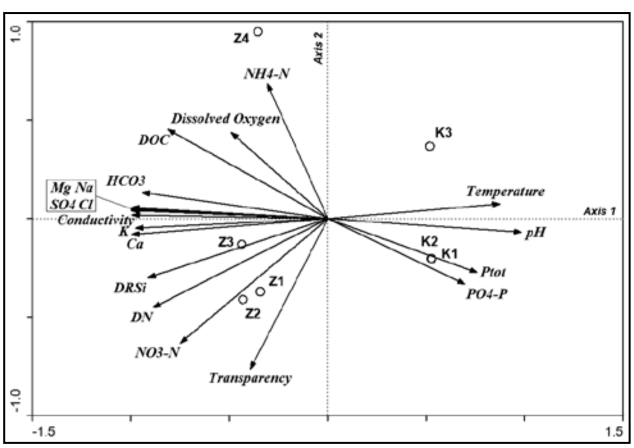
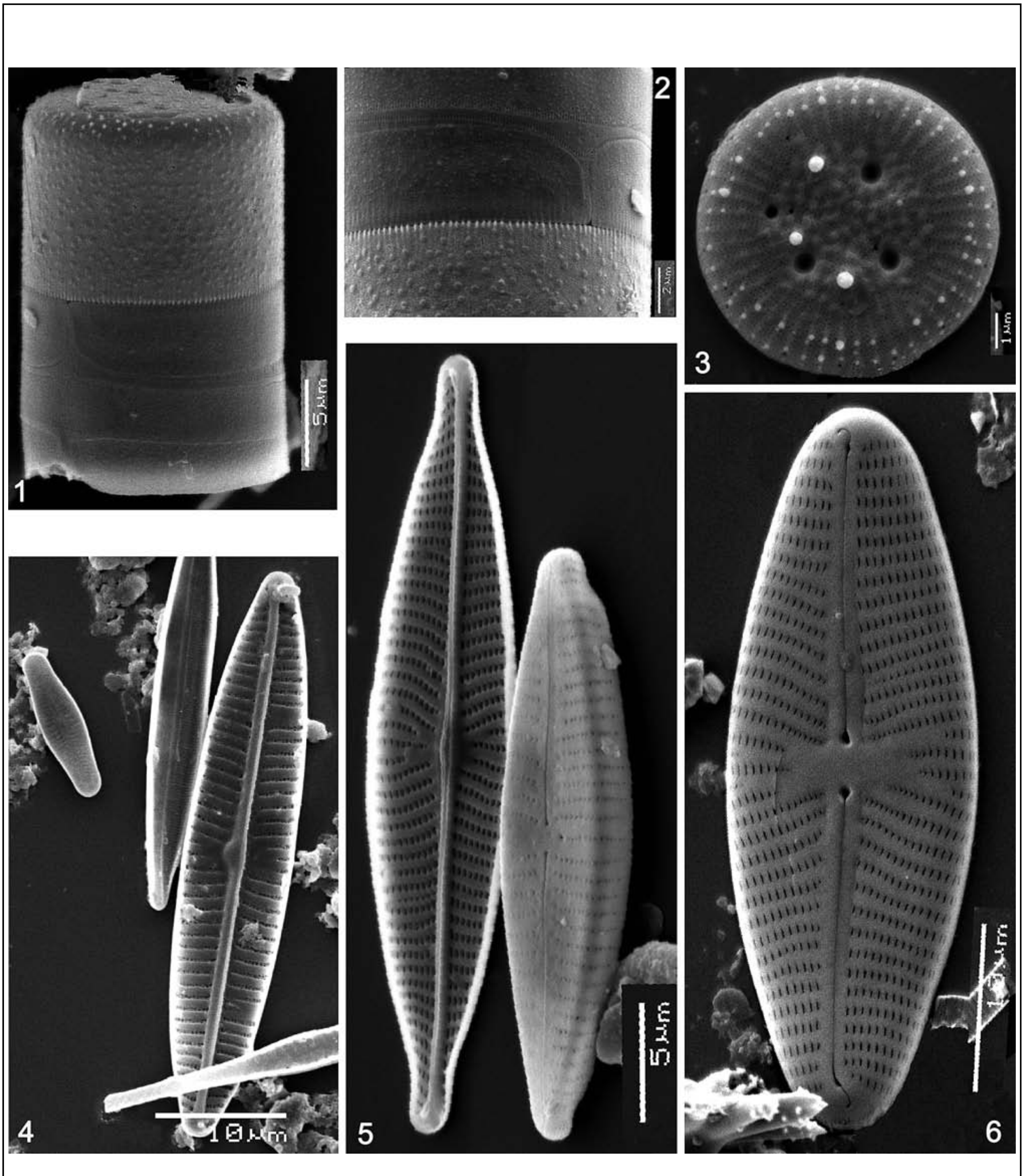



**Fig. 2.** Correlation biplot based on the Principal Component Analysis of 17 chemical variables from the Zhrebchevo and Koprinka reservoirs, sampling August '2009. For abbreviation of chemical variables see title of Table 1. For codes of samples see legend of Fig. 1.

belonging to the genera *Achnanthes* Bory sensu lato, *Fragilaria* Lyngbye sensu lato, *Cymbella* Agardh sensu lato, *Navicula* Bory sensu lato, and *Gomphonema* Agardh followed the accepted names in Hofmann & al. (2011). The order Naviculales showed the greatest generic diversity. Thirteen genera were identified: *Navicula* Bory, *Luticola* D. Mann, *Sellaphora* Mereschk., *Craticula* Grun., *Hippodonta* L.-Bert., Metz., Witk., *Placoneis* Mereshk., *Stauroneis* Ehr., *Pinnularia* Ehr., *Caloneis* Cleve., *Diploneis* Ehr, *Anemoeoneis* Pfitzer, *Neidium* Pfitzer, and *Gyrosigma* Hassall. The most species-rich genera were *Navicula* Bory (32 taxa), followed by *Nitzschia* Hassall (23), *Cymbella* C. Agardh sensu lato (11), and *Fragilaria* Lyngb. (11). The greatest species diversity was identified within genus *Navicula* Bory. Most of these species were well represented in almost all samples, but only some of them were dominant in the diatom association: e.g. *N. capitatoradiata* Germain, *N. cryptotenella* Lange-Bertalot, *N. tripunctata* (O.Müll.) Bory, and *N. veneta* Kützing (Plates 1-2).

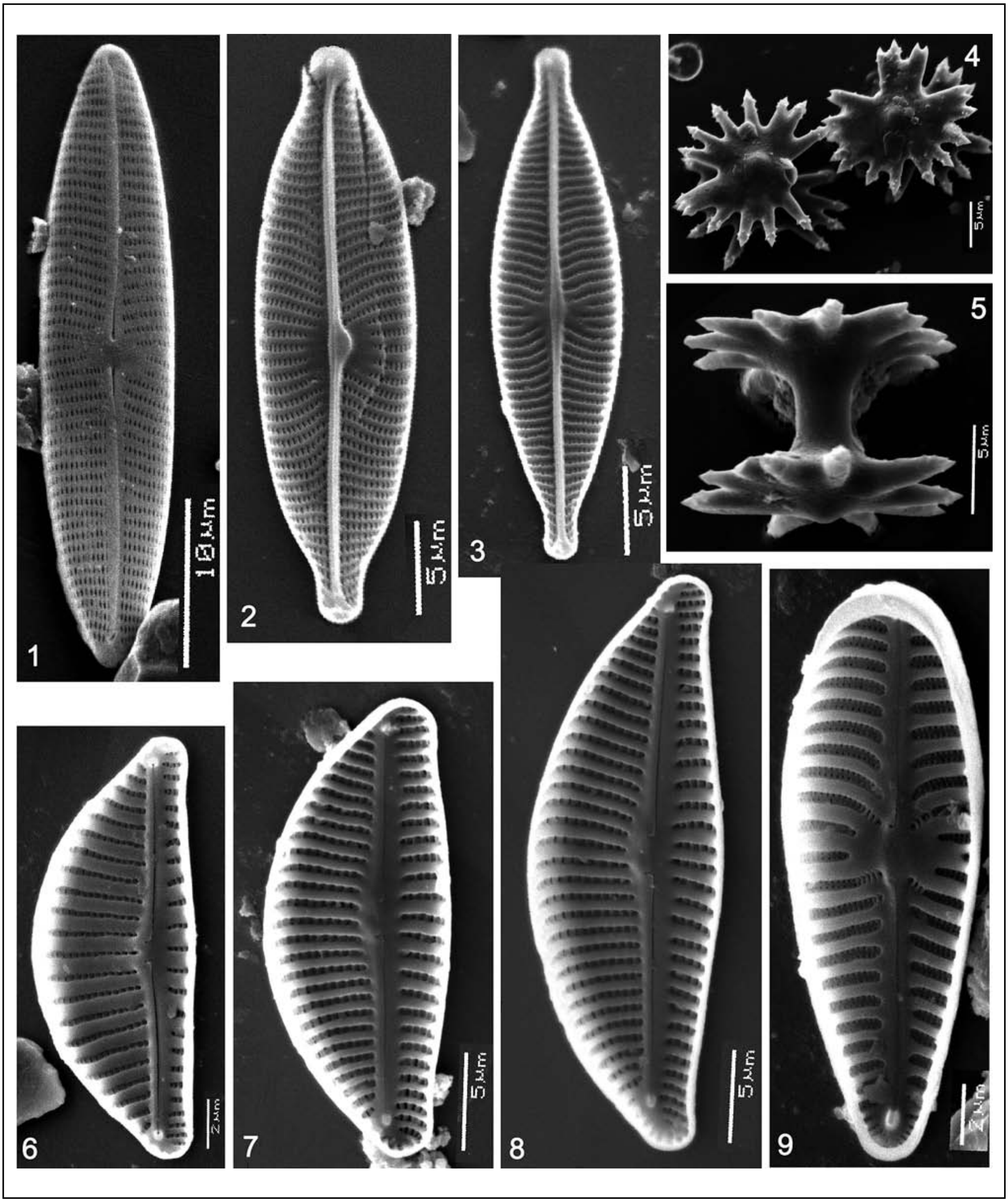
The total number of species found in the two investigated reservoirs was very similar: 138 in the Zhrebchevo Reservoir and 136 in the Koprinka Reservoir. The investigated samples from the Zhrebchevo Reservoir were generally dominated by *Pseudostaurosira brevistriata*, *Achnanthidium minutissimum*, *Amphora pediculus*, and *Nitzschia sinuata* var. *tabellaria*, while the samples from the Koprinka Reservoir were dominated by *Cyclotella ocellata* and *Cymbella affinis*.

**Plate 1**




**1–2.** *Melosira varians* Ag.; **3.** *Cyclotella ocellata* Pant., **4.** *Navicula tripunctata* (O. Müll.) Bory (right – internal valve view) and *Achnanthidium minitissimum* (Kütz.) Czarnecki (left); **5.** *Navicua capitatoradiata* Germain (left – internal valve view) and *Gomphonema parvulum* (Kütz.) Kützing (right); **6.** *Navicula reinchardtii* (Grunow) Grunow.

**Plate 2**




**1.** *Navicula tripunctata* (O. Müll.)Bory; **2.** *Navicula rostellata* Kütz.; **3.** *Navicula capitatoradiata* Germain; **4–5.** Freshwater sponges (*Porifera*); **6.** *Encyonema minutum* (Hilse) D. Mann; **7–8.** *Encyonema caespitosum* Kütz.; **9.** *Gomphonema olivaceum* (Horn.)Brébisson.

More of the accompanying species in the samples from Koprinka Reservoir were insignificantly small in quantity (Table 2).

### Results of the cluster analysis

The first group of clusters (A) combined samples from the Koprinka Reservoir (summer 2009 and autumn 2010) (Fig. 3). All epilithic samples were dominated mostly by *Cyclotella ocellata*, subdominants were *Achnanthidium minutissimum* and *Nitzschia sinuata* var. *tabellaria*. Three subgroups were determined and their taxonomical composition did not differ greatly: the first one ($A_1$) comprised the samples close to the dam (K1S and K1A), the deepest part of the reservoir; the second one ($A_2$) combined the samples from the summer period of 2009; the third one ($A_3$) differed in the subdominants – the abundance of *Achnanthidium minutissimum* and *Nitzschia sinuata* var. *tabellaria* decreased in the autumn 2010 and *Amphora pediculus* appeared in high amounts.

The second group of clusters (B) combined samples from the Zhrebchevo Reservoir (summer 2009 and autumn 2010). There were again three subgroups: the first one ($B_1$) comprised the samples close to the dam (Z1aS and Z1aA). The most abundant species were *Achnanthidium minutissimum*, subdominants were *Cymbella affinis*, *Navicula cryptotenella*, *Nitzschia sinuata* var. *tabellaria*, and *Amphora copulata*. The samples Z1bS and Z2S formed a subgroup $B_2$, only in these samples the highest domination frequency was due to *Pseudostaurosira brevistriata.* The third subgroup ($B_3$) included samples from autumn 2010.

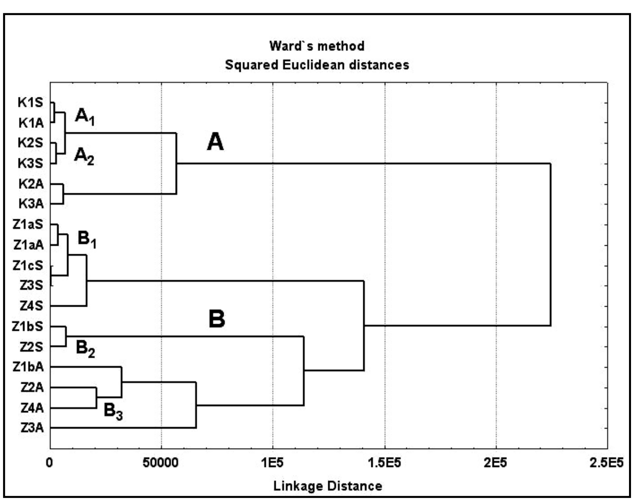



**Fig. 3.** Cluster analysis of all studied epilithic diatom samples of summer ’2009 and autumn ’2009. For codes of samples see legend of Fig. 1.

One of the most abundant species was the planktonic *Cyclotella ocellata*, and subdominants were the species *Cymbella* sensu lato: *C. affinis, Encyonema caespitosum, E. silesiacum*. Sample Z3A was isolated in this subgroup, because *Navicula capitatoradiata* had the highest dominance – exceeding 50 % of all other identified species.

### Relationship between diatom flora and major environmental factors

Biogeographical information was available for 73 (42 % of the total) taxa. The diatom flora was mainly composed of cosmopolitan species (95.8 %). Only 2.7 % of the taxa were classified as “nordic-alpine”, and 1.4 % as “boreal”.

In regards to general and specific habitats (Lowe 1974; Krammer & Lange-Bertalot 1986-1991; Van Dam & al. 1994, Rakowska 2001), periphitic species dominated the flora; but there were several (19.8 %) planktonic and euplanktonic species: *Cyclotella ocellata*, *Aulacoseira granulata*, *Fragilaria ulna*, and *F. danica.* There were a few taxa, “mainly occurring in wet and moist, or temporarily dry places” (Van Dam & al. 1994), i.e. *Hantzschia amphioxys.* Most of these species had lower relative abundance in the diatom association.

Grouping of diatoms according to their pH-preferences showed that alkaliphilous (68.1 %) and pH-indifferent (19.2 %) diatoms clearly predominated.

According to the halobion system, the indifferent oligohalobous taxa predominated, there were only 4.5 % of halophobous taxa. Five halophilous species were determined, but some of them had high abundance, such as: *Navicula menisculus, N. cryptotenella* and *N. minima*.

### Results of the Canonical Correspondence Analysis

The results of the Canonical Correspondence Analysis (CCA) are shown in Fig. 4, as a species-conditional triplot. The length of environmental arrows indicates their relative importance in explaining the variation in the diatom data and their orientation indicates their correlation with the ordination axes.

The first two CCA axes ($\lambda_1 = 0.540$, $\lambda_2 = 0.489$) display 40.4 % of the weighted variance in the abundance of diatom data, and 60.2 % of variance in the weighted averages of species with respect to the environmental variables. Monte Carlo unrestricted permutation tests (499 permutations) of Axis 1 and Axis 2 (with Axis 1 as covariable) indicate that both axes are significant

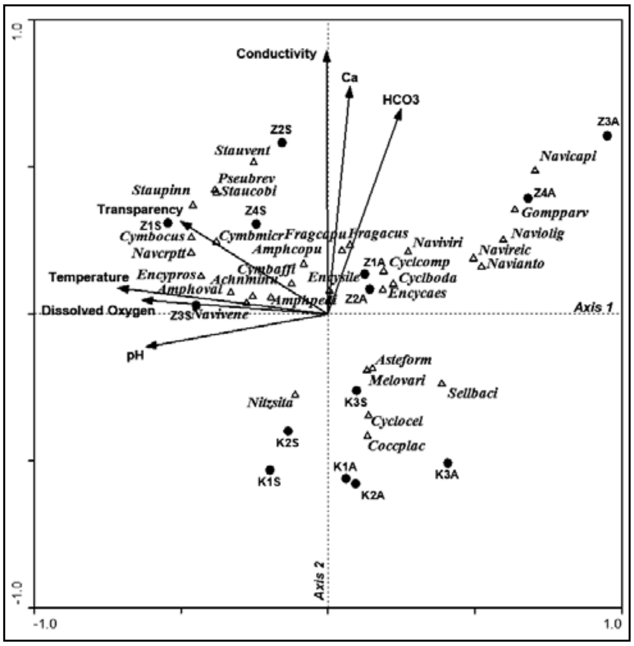



**Fig. 4.** Species-conditional triplot based on Canonical Correspondence Analysis (CCA) of the epilithic diatom assemblages from summer '2009 and autumn '2009. For codes of samples see legend of Fig. 1. For codes of species shown see Table 2.

($P < 0.05$) (ter Braak & Šmilauer 2002). Axis 1 is strongly related to temperature, dissolved oxygen and pH (intraset correlation of –0.72, –63, –0.62, respectively) and contrasts the summer samples of the Zhrebchevo Reservoir (Cluster Groups $B_1$ and $B_2$, with higher values of these parameters), and their dominant species belonging to the genera *Cymbella* Ag. sensu lato, *Fragilaria* Lyngbye sensu lato, and *Amphora* Ehr. plotted on the left side of the diagram with the autumn samples (Cluster Group $B_3$, with lower values of the above-mentioned parameters) of the same reservoir. These samples, with their characteristic planktonic *Cyclotella* species – *Cyclotella compta* and *C. bodanica* and species of genus *Navicula* sensu lato – *N. oligotraphenta, N. antonii, N. reinhardtii, N. viridula* – are plotted on the right side of the diagram. Axis 2 is strongly related to conductivity, calcium and bicarbonate ions (intraset correlation 0.89, 0.77 and 0.70, respectively) and sets aside all samples of the Zhrebchevo Reservoir (Cluster Group B) with higher values of these parameters, plotted on the top of the diagram of all samples from the Koprinka Reservoir (Group A), with lower values of the above-mentioned parameters plotted at the bottom of the diagram, with their constituent taxa *Asterionella formosa, Melosira varians, Sellaphora bacillum, Nitzschia sinuata var. tabellaria, Cyclotella ocellata* and *Cocconeis placentula* (Fig. 4).

## Discussion

Transparency, temperature, pH, and dissolved oxygen are the most important variables that determine the structure of diatom distribution in the Zhrebchevo Reservoir during the three studied seasons (August 2009, May and October-November 2010). The dissolved oxygen interacted significantly with the diatom pattern in sample Z4S, which is located in the tail-end of the reservoir. Species belonging to genus *Amphora*: *A. pediculus*, *A. copulata* and *A. ovalis* appeared in high amounts, which could be explained by nutrient-polluted water (Van Dam & al. 1994).

Taxa plotted at the top in Fig. 4, such as *Fragilaria acus*, *F. vaucheriae, Gomphonema olivaceum,* and especially *Navicula capitatoradiata* (with the highest dominance of over 50 % above all other determined species), are associated with high conductivity (Van Dam & al. 1994).

Well-defined seasonal replacement of diatom assemblages was observed. *Achnanthidium minutissimum* and *Nitzschia sinuata* var. *tabellaria* dominated the summer diatom assemblages. *Achnanthidium minutissimum* was found to be the main component in the samples in August 2009, which is very unusual, because its ecological preferences include high concentrations of dissolved oxygen, as well as low values of nutrients (Passy & al. 1999). According to our data set, water temperature in the summer of 2009 had low values, untypical for the season (Table 1). *Pseudostaurosira brevistriata* was the dominant species in the deeper part of Zhrebchevo Reservoir (Z1S and Z2S), but species of the genus *Amphora* as well as *Cymbopleura cuspidata* appeared in great amounts only during this season.

The species richness, diversity and evenness in the spring assemblages of 2010 were very different. The species of genus *Cymbella* Ag. sensu lato (*C. affinis*, *E. silesiacum*, *E. minutum*) were dominants, suggesting a high river inflow, typical for the season. High abundance of *Cyclotella ocellata* was observed in the 2010 autumn samples. According to Wunsam & al. (1995), the high amount of this species might be explained by high values of conductivity, which is confirmed by our results for that season (Table 1). Planktonic species of high abundance were identified in the deeper parts of the reservoir (Z1bA): *Asterionella formosa*, *Aulacoseira granulata*, *Cyclotella bodanica*, *C. compta*, *Fragilaria acus*, *F. capucina*, and *F. ulna*.

Species richness and evenness of the assemblages at the eutrophic locations before the tail-end of the reservoir and close to the ecotone zone (river/reservoir) were high. *Navicula capitatoradiata* was the dominant species, but the assemblages were dominated almost entirely by typical eutrophic indexes: *Gomphonema parvulum*, *Navicula antonii*, *N. reichardtiana*, *N. viridula*, *Nitzschia palea* and *N. dissipata*.

As in other locations, different dominants were observed in sample Z2A. *Cymbella affinis*, *Encyonema caespitosum*, *E. silesiacum*, *Fragilaria capucina*, *F. ulna*, *Gomphonema olivaceum* and *Sellaphora bacillum* were with high abundance there – species which also indicate a high trophic state (Van Dam & al. 1994). These specific preferences can be explained by the close location of a fish-breeding station.

Conductivity, calcium and bicarbonate ions are the most significant variables, which determine the structure of diatom distribution in the Koprinka Reservoir during the three seasons (August 2009, May and October-November 2010). A well-defined seasonal replacement of the diatom assemblages was observed. All samples in May 2010 had the highest species richness and diversity. Species belonging to genus *Cymbella* Ag. sensu lato ( *C. affinis*, *C. cymbiformis*, *E. silesiacum*, *E. minutum*) appeared in great amounts during the spring season. Subdominants were *Asterionella formosa*, *Aulacoseira granulata* and *Navicula capitatoradiata*. *Achnanthidium minutissimum* and *Nitzschia sinuata* var. *tabellaria* were most abundant in August 2009 and October-November 2010, but their proportions were different. *Achnanthidium minutissimum* was recorded in great amounts in August 2009, while *Cyclotella ocellata* was found in October-November 2010. In the autumn season, the eutrophic species *Melosira varians*, *Amphora pediculus*, *Fragilaria vaucheriae* and *Cocconeis placentula* dominated.

The high abundance and biomass of the *Dreissena* species in the infested reservoirs and their crucial role in the distribution of other benthic macroinvertebrate taxa was reported in our earlier studies (Trichkova & al. 2008, 2013). Colonization of water bodies by the *Dreissena* spp. alters the habitats in several ways, the most pronounced of which is the energy "shunt" (from pelagic to bottom communities) (Mills & al. 2003). Many authors maintain that *Dreissena* may facilitate other macrozoobenthic species by increasing habitat complexity, and by organic enrichment of the sediments (Stewart & Haynes 1994, Mitchell & al. 1996). Our present findings confirm these results in relation to epilithic diatom communities. The quantitative parameters of diatom communities in the Zhrebchevo Reservoir infested by *Dreissena polymorpha* were much higher than in the uninfested Koprinka Reservoir (Table 2). Furthermore, we have found chrysophycean stomatocysts and freshwater sponges (*Porifera*) in the Zhrebchevo Reservoir (Plate 2). These sessile benthic communities can provide additional and complementary information to that of the diatoms only. Garton et al. (1993) predicted that *Dreissena polymorpha* could cause a restructuring of the benthic communities and suggested that the species requiring hard substrates for attachment, such as freshwater sponges may colonize the Zebra Mussel shells. Without knowing the historical and current distributions of native freshwater sponges, however, it is impossible to identify changes in the community composition.

## Conclusions

Transparency, temperature, pH and dissolved oxygen were found to be the most important environmental factors which have determined the distribution of diatoms in summer and autumn in the Zhrebchevo Reservoir. Conductivity and concentrations of calcium and bicarbonate ions were the most important environmental factors for distribution of the diatom community in the Koprinka Reservoir. The Zhrebchevo Reservoir, which is infested by *Dreissena polymorpha*, was characterized by much higher rates of primary benthic productivity than the uninfested Koprinka Reservoir.

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**Table 2.** List of diatoms found in all samples (August 2009, May, October-November 2010), Zhrebchevo Reservoir (Z) and Koprinka Reservoir (K). Taxon names are listed in alphabetical order.

| Taxa \ Site and month, year of sampling | Z1a_08.2009 | Z1b_08.2009 | Z1c_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | Z1_05.2010 | Z1a_10.2010 | Z1b_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 | K1_08.2009 | K2_08.2009 | K3_08.2009 | K1_05.2010 | K2a_05.2010 | K2b_05.2010 | K3a_05.2010 | K3b_05.2010 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Acronym |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Achnanthes*** sp. | | | | | | | | | | 1 | | | | | | | | | | | | | | *Achnsp* |
| ***Achnanthidium** exiguum* (Grun.) Czarnecki | | | | | | | | | | | | 1 | | | | | | | | | 1 | | 1 | *Achnanex* |
| *A. minutissimum* (Kütz.) Czarnecki | 110 | 23 | 168 | 4 | 170 | 95 | 36 | 140 | | 6 | 2 | 3 | 44 | 43 | 85 | 19 | 22 | 102 | 9 | 53 | 28 | 28 | 1 | *Achnanmi* |
| *A. saprophilum* (Kob. & May.) Round & Bukh. | | | | | | | | | | | | | | | | | | | | 3 | | | | *Achnansa* |
| ***Amphora** aequalis* Krammer | | | | | | | | | | | | | | | 2 | | | | | | | | | *Amphaequ* |
| *A. copulata* (Kütz.) Schoeman & Archibald | 10 | 1 | 6 | 4 | 4 | 27 | | 5 | | 17 | 8 | | 8 | 1 | 2 | | 1 | | | | | | 3 | *Amphcopu* |
| *A. inariensis* Krammer | | | | | | | | | | | | 1 | | | | | | | | | 2 | 1 | | *Amphinar* |
| *A. ovalis* (Kütz.) Kützing | 9 | | 5 | | 9 | 6 | | 1 | | | | | | 5 | 6 | | | | | | | 1 | | *Amphovali* |
| *A. pediculus* (Kütz.) Grunow | 4 | 3 | 12 | 4 | 11 | 87 | | | | | | | 7 | 5 | 2 | | | | | | 2 | 24 | 9 | *Amphpedi* |
| *Amphora* sp. | | | | | | | | | | 1 | | | | | | | | | | | | | | *Amphsp* |
| ***Asterionella** formosa* Hassall | | | | | | | | 3 | 7 | | | | | | | 3 | 2 | 10 | 19 | 9 | 5 | 1 | 3 | *Asterform* |
| ***Aulacoseira** ambigua* (Grun.) Simonsen | | | | | | | | | | | | | | | 2 | | | | | | | | | *Aulaambi* |
| *A. granulata* (Ehr.) Simonsen | | | | | | | | | 15 | 1 | | | | | | | 15 | 1 | 3 | 2 | 2 | | 2 | *Aulagran* |
| *A. muzzanensis* (Meister) Krammer | | | | | | | | | | | | | 2 | | | | | | | | | | | *Aulamuzz* |
| *A. subarctica* (O.Müller) Haworth | 1 | | | | | | | | | | | | | 1 | | | | | | | 1 | | | *Aulasuba* |
| ***Caloneis** bacillum* (Grun.) Cleve | | | 1 | | | | | | | | | | | | 1 | | | | | | | | | *Calobaci* |
| *C. schumanniana* (Grun.) Cleve | 2 | 1 | | | | | | | | | | | | 6 | 1 | | 1 | | | | 1 | | | *Caloschu* |
| ***Cocconeis** pediculus* Ehrenberg | | | 1 | | 2 | | | 1 | | | 1 | | | | 1 | | | | | | | | | *Coccpedi* |
| *C. placentula* Ehrenberg | | | | 1 | | | | 1 | | | 1 | | | | | | | | | | 11 | | | *Coccplac* |
| *C. placentula* var. *euglypta* Ehrenberg | | | | | | 1 | | | | | | | | | | | | | | | | | | *Coccpleu* |
| *C. placentula* var. *lineata* (Ehr.) Van Heurck | | | | | | | | 9 | | | | 1 | | | 1 | | | | | | 2 | | 1 | *Coccplli* |
| ***Craticula** ambigua* (Ehr.) D.G. Mann | 1 | | | 2 | | | | | | | 1 | | | 1 | 1 | | | 1 | | | | | | *Cratambi* |
| *C. buderi* (Hust.) Lange-Bertalot | | | | | | | 7 | | | | | | | | | | | | | | | | | *Cratbude* |
| *Craticula* sp. | | | | | | | | | | | | | | | | | 1 | | | | | | | *Cratsp* |
| ***Cyclotella** bodanica* Grunow | 2 | | | 1 | 1 | | | | 10 | 2 | 2 | | | | | | | | | | 2 | | | *Cyclboda* |
| *C. compta* (Ehr.) Kützing | | | | | | | | | 29 | | | 4 | | | | | | | | | | 1 | | *Cyclcomp* |
| *C. krammeri* Håkansson | | | | | | | | 1 | | | | | | | | | | | | | | | | *Cyclkram* |
| *C. meneghiniana* Kützing | | | | | | 1 | | | 1 | | | 1 | | | | | | 1 | | | | | | *Cyclmene* |
| *C. ocellata* Pantocsek | 2 | 1 | | 16 | | | 1 | 34 | 119 | 10 | 12 | 55 | 127 | 155 | 125 | 5 | 1 | 4 | 1 | | 132 | 221 | 291 | *Cyclocel* |
| *C. tripartita* Håkansson | | | | | | | | | | | | | | | | | | 1 | | | | | | *Cycltrip* |
| *Cyclotella* sp. | | | | | | | | 3 | | | | | | | | | | 1 | 1 | | | | | *Cyclsp* |
| ***Cymatopleura** elliptica* (Bréb. ex Kütz) W.Smith | | | | | 1 | | | | | | | | | | | | 1 | | | | 1 | | | *Cymaelli* |
| *C. solea* (Bréb.) W. Smith | 1 | | 1 | 2 | | 2 | | | | | 1 | | | | | | 1 | 4 | 4 | | 2 | | | *Cymasole* |

**Table 2. Continuation.**

| Taxa \ Site and month, year of sampling | Z1a_08.2009 | Z1b_08.2009 | Z1c_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | Z1_05.2010 | Z1a_10.2010 | Z1b_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 | K1_08.2009 | K2_08.2009 | K3_08.2009 | K1_05.2010 | K2a_05.2010 | K2b_05.2010 | K3a_05.2010 | K3b_05.2010 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Acronym |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Cymbella** affinis* Kützing | 41 | 5 | 2 | 1 | 3 | 1 | 137 | 38 | | 32 | | 1 | 6 | 5 | 7 | 280 | 283 | 109 | 205 | 89 | 2 | | 2 | *Cymbaffi* |
| *C. amphicephala* Naegeli | | | | | | | | | | | | | | | | | | | | | | 1 | | *Cymbamph* |
| *C. aspera* (Ehr.) Paragallo | | | | | | | | 1 | | | | | | | | | | | | 1 | | | | *Cymbaspe* |
| *C. cistula* (Ehr.) Kirchner | | | | | | 2 | 1 | | | 1 | | | | 1 | 1 | | 1 | | | | 1 | 1 | | *Cymbcist* |
| *C. cymbiformis* Agardh | | 1 | 1 | 1 | | | 1 | | | | | | | | | 3 | 12 | 29 | 50 | 1 | | | | *Cymbcymb* |
| *C. laevis* Naegeli | | | | | | | | | | | | | | | | | | | | 2 | | | | *Cymblaev* |
| *C. mesiana* Cholnoky | 3 | | | | 4 | 1 | | | | | | | | 4 | 1 | | | | | | | | | *Cymbmesi* |
| *C. microcephala* Grunow | | 3 | 8 | 1 | 5 | 13 | | | | | | | 1 | | | | | | | | | | | *Cymbmicr* |
| *C. tumida* (Bréb.) V. Heurck | | | | | | | | 1 | | | | | | | | | | 1 | | | | 2 | 1 | *Cymbturg* |
| *C. turgidula* Grunow | | | | | | | | 1 | | | | | | | | | | | | | | | | *Cymbtumi* |
| *Cymbella* sp. | | | | | | | | | | | | | | | | | | | | | | | 1 | *Cymbsp* |
| ***Cymbopleura** cuspidata* (Kütz.) Krammer | 9 | 3 | 11 | 3 | 7 | 1 | | | | | | 2 | | | 1 | | | | | | | | | *Cymbocus* |
| *C. naviculiformis* (Auersw.) Krammer | | | | | | | | | | | | | 1 | 1 | | | | | | | | | 1 | *Cymbonav* |
| ***Denticula** kuetzingii* Grunow | | | | | | | | | | | | | | | | | | | | | 3 | | | *Dentkuet* |
| ***Diatoma** vulgaris* Bory | | | | | | | 1 | | | 1 | 4 | | | | | | | | | | | | 1 | *Diatvulg* |
| ***Diploneis** elliptica* (Kütz.) Cleve | | | | | | | | | | | | | | | | | | | | | 1 | | | *Diplelli* |
| *D. puella* (Schumann) Cleve | 1 | | 1 | 1 | | | | | | | | | 5 | 4 | 1 | | | | | | 3 | 3 | 2 | *Diplpuel* |
| ***Discostella** pseudostelligera* (Hust.) Houk & Klee | | | | | | | | | | | | | | | | | | 2 | | | | | | *Discpseu* |
| *D. stelligera* (Cleve & Grunow) Houk & Klee | | | | | | | | | | | | | | | | | | 1 | | | | 1 | | *Discstel* |
| ***Encyonema** caespitosum* Kützing | | 3 | 5 | | 2 | 2 | 2 | 8 | | 83 | 6 | | | 4 | 1 | | | 1 | 1 | | 4 | 1 | 1 | *Encycaes* |
| *E. gaemannii* (Meist.) Krammer | | | | | | | | 5 | | 1 | | | | | | | | | | | | | | *Encygaem* |
| *E. minutum* (Hilse) D.G. Mann | 1 | 2 | | 1 | 1 | | 44 | 1 | 2 | 2 | | | 1 | | | | | 9 | 4 | 138 | | | | *Encyminu* |
| *E. prostratum* (Berk.) Ralfs | 3 | | 6 | | 11 | 2 | | | | 1 | | | | 1 | 1 | | | | | | | | | *Encypros* |
| *E. silesiacum* (Bleisch.) D.G. Mann | 8 | | 2 | 3 | | 2 | 75 | 1 | 4 | 30 | 1 | 1 | 3 | 2 | 1 | 11 | 5 | 21 | 35 | 26 | 1 | 1 | 2 | *Encysile* |
| ***Fragilaria** acus* (Kütz.) Lange-Bertalot | | 1 | 1 | 37 | | | | 12 | 106 | 8 | 3 | | | | | | | | | 1 | | | 2 | *Fragacus* |
| *F. capucina* Desmarières | 5 | | 10 | 5 | | | 3 | | 4 | 34 | 7 | | | | 1 | | 1 | | 5 | | 1 | | | *Fragcapu* |
| *F. danica* (Kütz.) Lange-Bertalot | 5 | | | 1 | 1 | | | | | | | | | | 5 | | | | | | | | | *Fragmeso* |
| *F. mesolepta* Rabenhorst | | | | 5 | | | | | | | | | | | | | | | | | | | | *Fragvauc* |
| *F. ulna* (Nitzsch) Lange-Bertalot | | | | | 1 | 1 | 2 | 4 | 2 | 11 | 2 | 1 | | | | | | | | | | | 1 | *Fragulna* |
| *F. vaucheriae* ( Kütz.) Peterson | | | | | 10 | 5 | | 22 | | | | 2 | 1 | | | | 1 | 2 | | 8 | 5 | 4 | 1 | *Fragdani* |
| *Fragilaria* sp. | | | | | | | | | | | | | | | | | | 1 | | | | | | *Fragsp* |
| ***Gomphonema** acuminatum* Ehrenberg | | | | | | | | | | | | | | | 1 | | | | | | | | | *Gompacum* |
| *G. angustatum* (Kütz.) Rabenhorst | | | | | | | | | | | | | | | | | | 1 | | | | | | *Gompangu* |

**Table 2. Continuation.**

| Taxa / Site and month, year of sampling | Z1a_08.2009 | Z1b_08.2009 | Z1c_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | Z1_05.2010 | Z1a_10.2010 | Z1b_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 | K1_08.2009 | K2_08.2009 | K3_08.2009 | K1_05.2010 | K2a_05.2010 | K2b_05.2010 | K3a_05.2010 | K3b_05.2010 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Acronym |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *G. angustum* C. Agardh | 6 | | 2 | | 7 | 1 | | | | | | | | | | | | | | | | | | *Gompangt* |
| *G. clavatum* Ehrenberg | | | | | 2 | | 1 | | | | | | | | | | | | | | | | | *Gompclav* |
| *G. minutum* (C. Ag.) C. Agardh | | | | | | | | | | 2 | 1 | | | | | | | 3 | | | | | 6 | *Gompminu* |
| *G. olivaceum* (Horn.) Brébisson | 5 | | | 2 | 3 | 5 | 1 | | | 14 | | | | | | | | | | | | | | *Gompoliv* |
| *G. parvulum* (Kütz.) Kützing | | | | 1 | | | 3 | 3 | 2 | 1 | 8 | 29 | | | | | 1 | 1 | 8 | 2 | | 1 | 1 | *Gompparv* |
| *G. pumilum* (Grun.) Reichardt &Lange-Bertalot | | | | | | 1 | | 1 | | | | | 1 | | | | | | | | | | | *Gomppumi* |
| *G. truncatum* Ehrenberg | | | | 1 | | | | 1 | | | | | | | | | | 1 | | | | | | *Gomptrun* |
| *Gomphonema* sp.1 | | | | | | | | | | | | | | | | | | 1 | | | | | | *Gompsp1* |
| *Gomphonema* sp.2 | | | | | | | | | | | | | | | | | | | | | | | 1 | *Gompsp2* |
| ***Gyrosigma*** *acuminatum* (Kütz.) Rabenhorst | | | | | | | | | | | | | | | | | | | | | | | 1 | *Gyroacum* |
| *G. attenuatum* (Kutz.) Rabenhorst | 1 | | 1 | | 1 | 1 | | | | | | | | | | | | | | | | | | *Gyroatte* |
| ***Halamphora*** *veneta* (Kütz.) Levkov | | | | | | 1 | | | | | | | | | | | 13 | | | | | | | *Halavene* |
| ***Hannaea*** *arcus* (Ehr.) Patrick | | | | | | | | | | | | | | | | | | | 1 | | | | | *Hannarcu* |
| ***Hantzschia*** *amphyoxis* (Ehr.) Grunow | | 1 | | | 1 | | | | | | | | | 1 | 1 | | 2 | | | | | | 1 | *Hantamph* |
| ***Hippodonta*** *capitata* (Ehr.) L.-Bert., Metz.&Witk. | | | | | | 1 | | | | 1 | 3 | 11 | | | | | | | | | 1 | 2 | | *Hippcapi* |
| *H. costulata* (Grun.) Lange-Bertalot | | | | | 2 | 4 | | | | | 1 | 1 | | 3 | | | | | | | | | | *Hippcost* |
| ***Luticola*** *muticopsis* (Van Heurck) D.G.Mann | 1 | | | | | | | | | | | | | | | | | | | | | | | *Lutimutc* |
| ***Melosira*** *varians* Agardh | 3 | | | 14 | 3 | | 1 | | | 10 | 7 | 2 | 1 | 1 | | | 1 | 6 | | 1 | 36 | 10 | 16 | *Melovari* |
| ***Meriodon*** *circulare* (Grev.) C.A. Agardh | | | | | | | | | | | | | | | | | | | | 1 | | | | *Mericirc* |
| ***Navicula*** *angusta* Grunow | | | | | | | 1 | | | | | | | | | | | 2 | | | | | | *Naviangu* |
| *N. antonii* Lange-Bertalot | | | | | | | | 2 | | 2 | 2 | 12 | | | | | | 6 | 2 | | | 2 | 3 | *Navianto* |
| *N. capitatoradiata* Germain | 3 | 3 | 11 | 5 | 10 | 8 | | 1 | 1 | 8 | 230 | 89 | 2 | | 1 | 1 | 5 | 25 | 2 | 1 | 1 | | 3 | *Navicapi* |
| *N. cari* Ehrenberg | | | | | | | | | | | 3 | | 2 | | | | | | | | | | | *Navicari* |
| *N. caterva* Hohn & Hellerman | | | | | | | | | | 4 | | | | | | | | | | | | | | *Navicate* |
| *N. cincta* (Ehr.) Ralfs | | | | | | | | | | 2 | 1 | 5 | | | | | | | | | | 1 | 1 | *Navicinc* |
| *N. cryptocephala* Kützing | | | | | | | 1 | | | | | 10 | | | 1 | | | | 1 | 1 | | | | *Navcrptc* |
| *N. cryptotenella* Lange-Bertalot | 17 | | 11 | 1 | | 2 | 1 | | | 5 | | | 3 | 2 | | | | 4 | | | | 1 | 1 | *Navcrptt* |
| *N. digitoradiata* (Greg.) Ralfs | 1 | | | | | | | | | | | | | | | | | 3 | | | | | | *Navidigi* |
| *N. erifuga* Lange-Bertalot | | | | | | | | | | | | 1 | | | | | | | | | | | | *Navierif* |
| *N. exilis* Kützing | | | | | | | | | | | | | | | | | | 1 | | | | | | *Naviexil* |
| *N. gregaria* Donkin | 3 | | | | | | 1 | | | | | | | | | | | 2 | | | | | | *Navigreg* |
| *N. hofmanniae* Lange-Bertalot | | | | | | | | | | 1 | | 4 | | | | | | 1 | | | | | | *Navihofm* |
| *N. lanceolata* (Ag.) Ehrenberg | | | | | | | | | | | | | | 1 | | | | | | | | | | *Navi lanc* |

**Table 2. Continuation.**

| Taxa / Site and month, year of sampling | Z1a_08.2009 | Z1b_08.2009 | Z1c_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | Z1_05.2010 | Z1a_10.2010 | Z1b_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 | K1_08.2009 | K2_08.2009 | K3_08.2009 | K1_05.2010 | K2a_05.2010 | K2b_05.2010 | K3a_05.2010 | K3b_05.2010 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Acronym |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *N. menisculus* Schumann | 2 | | 6 | 4 | 2 | 6 | | | | | | | | | | | | | | | | | | *Navimeni* |
| *N. oligotraphenta* Lange-Bertalot & Hofmann | | | | | | | 4 | | | | | 16 | | | | | 1 | | | | | 3 | | *Naviolig* |
| *N.* aff. *phyllepta* Kützing | | | | | | | | | | | | | | | | | | | | | 1 | | | *Naviafph* |
| *N. radiosa* Kützing | 2 | 2 | | 1 | | | 2 | | | | | | | | 1 | | 1 | 1 | | | | | | *Naviradi* |
| *N. reichardtiana* Lange-Bertalot | | | | | | | | | | 7 | 5 | 8 | | | | | 1 | 1 | | | | 3 | 1 | *Navireic* |
| *N. reinchardtii* (Grun.) Grunow | | | | 1 | | | | | | | | | | | | | | | | | | | | *Navirein* |
| *N. rhynchocephala* Kützing | 2 | 1 | | 1 | 1 | | | | | | | 1 | | | | | | | | | 1 | | 3 | *Navirhyn* |
| *N. rostellata* Kützing | | | | | | | | | | 2 | | | | | | | | | | | | | | *Navirost* |
| *N. salinarum* Grunow | | | | | | | | | | 3 | | | | | | | | 3 | | | | | | *Navisali* |
| *N. tripunctata* (O.Müll.) Bory | 1 | | 1 | 4 | 2 | 4 | 2 | | | 2 | | | 1 | 2 | 1 | | | | | | | 3 | 1 | *Navitrip* |
| *N. trivialis* Lange-Bertalot | | | | | | 1 | | | | 1 | 7 | | | 4 | 3 | | | 2 | 1 | | 3 | | 1 | *Navitriv* |
| *N. veneta* Kützing | 5 | 1 | 1 | 2 | 3 | 8 | | 4 | | | 2 | | 6 | 2 | 3 | | | 1 | 1 | | | | | *Navivene* |
| *N. viridula* (Kütz.) Ehrenberg | | | | | 7 | 3 | | | | | 3 | 11 | | | | | | | | | | 1 | 2 | *Naviviri* |
| *Navicula* sp.1 | | | | | | | | | | 1 | | | | | | | | | | | | | | *Navisp2* |
| *Navicula* sp.2 | | | | | | | | 1 | | | | | | | | | | 1 | | | | | | *Navisp3* |
| *Navicula* sp.3 | | | | | | | | | | | | | | | | | | | | | 2 | | | *Navisp4* |
| *Navicula* sp.4 | | | | | | | | | | | | | | | | | | | | | | 1 | | *Navisp5* |
| *Navicula* sp.5 | | | | | | | | | | 1 | | 1 | | | | | | | | | | | | *Navisp6* |
| ***Nitzschia*** *acicularis* (Kütz.) W.Smith | | | | | | | | 1 | | | | | | | | | | | | | | | | *Nitzacic* |
| *N. agnita* Hustedt | | | | | | | 2 | | | | | 2 | | | | | | 4 | | | | 1 | | *Nitzagni* |
| *N. amphibia* Grunow | | | | | | | | | | | | | | | | | | | | | 1 | 2 | | *Nitzamph* |
| *N. brevissima* Grunow | | | | | | | | | | | | | | | | | | 2 | | | | | | *Nitzbrev* |
| *N. clausi* Hantzsch | | | | | | | | | | | | | | | | | | 1 | | | | | | *Nitzclau* |
| *N. dissipata* (Kütz.) Grunow | 3 | | 2 | | 3 | 4 | 2 | | | 1 | | 4 | | | | 2 | | 6 | 1 | 2 | | | 2 | *Nitzdiss* |
| *N. fonticola* Grunow | | | | | | | 1 | | | | | | | | | | | 1 | | | | | | Nitz*font* |
| *N. hantzschiana* Rabenhorst | | | | | | | | | | | | | | | | | | | | | | 1 | | *Nitzhant* |
| *N. lacuum* Lange-Bertalot | | | | | | | | | | | | | | | | | | | 1 | | | | | *Nitzlacu* |
| *N. linearis* (Agardh) W. Smith | | | | | 1 | | | | | | | | | | | | | | | | | | | *Nitzline* |
| *N. palea* (Kütz.) W.Smith | | | 3 | 2 | 1 | 7 | 1 | | | | | 13 | 5 | 2 | 1 | | | 1 | 1 | 4 | | | 1 | *Nitzpale* |
| *N. paleacea* (Grun.) Grunow | | | | | | | 3 | | | | | | 3 | 2 | | 2 | | 5 | 6 | | | | | *Nitzpalc* |
| *N. perminuta* (Grun.) M. Peragallo | | | | | | | | | | | | | | | | 1 | | | 1 | | | | | *Nitzperm* |
| *N. recta* Hantzsch | | | | | | | | | | | | 5 | | | | | | | | | | | | *Nitzrect* |
| *N. sinuata* Grunow | | | | | | | | | | | | | | | | | | | | | | 2 | | *Nitzsinu* |
| *N. sinuata* var. *tabellaria*(Grun.) Grunow | 28 | 14 | 24 | 6 | 22 | 14 | | 12 | | 9 | 3 | | 101 | 54 | 65 | | | | | | 111 | 17 | 7 | *Nitzsita* |

**Table 2. Continuation.**

| Taxa \ Site and month, year of sampling | Z1a_08.2009 | Z1b_08.2009 | Z1c_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | Z1_05.2010 | Z1a_10.2010 | Z1b_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 | K1_08.2009 | K2_08.2009 | K3_08.2009 | K1_05.2010 | K2a_05.2010 | K2b_05.2010 | K3a_05.2010 | K3b_05.2010 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Acronym |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *N. sublinearis* Hustedt | 1 | 1 | 2 | 1 | 1 | | | | | | | | | | | | | | | | | | | *Nitzsubl* |
| *N. subtilis* Grunow | | | | 4 | | | | | | | | | | | | | | | | | | | | *Nitzsubt* |
| *N. umbonata* (Ehr.) Lange-Bertalot | | | | | | | | | | | | | | | | | | | | | | | 1 | *Nitzumbo* |
| *N. vermicularis* (Kütz.) Hantzsch | | | | | | | 1 | | | | | | | | | | | 1 | | 2 | | | | *Nitzverm* |
| *Nitzschia* sp.1 | | | | | | | | | | | | | | | | | 1 | | | | | | | *Nitzsp1* |
| *Nitzschia* sp.2 | | | | | | | | | 2 | | | | | | | | | 1 | | | | | | *Nitzsp2* |
| *Nitzschia* sp.3 | | | | | | | | | | | 1 | | | | | | | | | | | | | *Nitzsp4* |
| ***Pinnularia** borealis* Ehrenberg | | | | | 1 | | | | | | | | | | | | | | | | | 1 | | *Pinnbore* |
| *P. brebissonii* (Kütz.) Rabenhorst | | | | | | | | | | | | 1 | | | | | | | | | | | | *Pinnbreb* |
| ***Placoneis** clementis* (Grun) Cox | | | | | | | | | | 1 | | | | | | | | | | | | | | *Placclem* |
| *P. elginensis* (Greg.) Cox | | | | | 1 | 2 | | | | | | | | | | | | | | | | 1 | | *Placelgi* |
| *P. pseudoanglica* Cox | | 1 | | 1 | | 1 | | | | | | | | | 2 | | | | | | | | | *Placpseu* |
| ***Planothidium** delicatulum* (Kütz.) Round & Bukh. | | | | | | | | | | | | 1 | | | | | | 1 | | | 1 | 4 | | *Plandeli* |
| *P. frequentissimum* (L.-Bert.) Lange-Bertalot | | 1 | | | | | | | | | | | | | | | | | | | | | | *Planfreq* |
| *P. hauckianum* (Grun.) Round & Bukh. | | | | | | | | | | | | | | | | | | | | | | 7 | 1 | *Planhauc* |
| *P. lanceolatum* (Bréb. ex Kütz ) Lange-Bertalot | | | | | 2 | | | | | 1 | 1 | | | | | | | | 3 | | | 1 | | *Planlanc* |
| ***Psammothidium** subatomoides* (Hust.) Bukh&Round | | | | | | | | 1 | 1 | 1 | | | 1 | | | | | | | | | | | *Psamsuba* |
| ***Pseudostaurosira** brevistriata* (Grun.) Williams&Round | | 214 | 1 | 150 | | 1 | | | | | | | | | | | | | | | | | | *Pseubrev* |
| *P. parasitica* (W.Smith) Morales | | | | | | | | | 2 | | | | | | | | | | | | | | | *Pseupara* |
| ***Reimeria** sinuata* (Greg.) Kociolek & Stoermer | | | | | | | | | | | | 1 | | | 3 | | | | | | | | | *Reimsinu* |
| ***Rhoicosphaenia** abbreviata* (C. Ag.) Lange-Bertalot | | | | 1 | 4 | | | | | | | | 2 | | 2 | | | | | | | | | *Rhoiabbr* |
| ***Sellaphora** bacillum* (Ehr.) D.G. Mann | | | | | | | | | | | 3 | 7 | | | 4 | | | | | | 5 | 2 | 8 | *Sellbaci* |
| *S. pupulla* (Kütz.) Mereschkowsky | | | | 3 | 3 | 2 | | | | | 1 | 1 | 1 | 1 | 1 | | | | | | 1 | | 6 | *Sellpupu* |
| ***Staurosira** construens* Ehrenberg | | | | | | | | 4 | | 1 | | | | | | | 1 | 1 | | | | 1 | | *Staucons* |
| *S. construens* var. *binodis* (Ehr.) Hamilton | | 9 | | 6 | | 1 | | 2 | 1 | | | | | | | | | | | | | | | *Staucobi* |
| *S. pinnata* Ehrenberg | | 36 | | 10 | | | | | 1 | | | | | | | | | | | | | | | *Staupinn* |
| *S. venter* (Ehr.) H. Kobayasi | 2 | | 1 | 9 | | | | | | | | | | | | | | | | | | | | *Stauvent* |
| ***Stephanodiscus** hantzschii* Grunow | | | | 1 | | | | | | | | | | | | 1 | 2 | 2 | | 1 | 1 | 1 | 1 | *Stephant* |
| *S. medius* Håkansson | | | | | | | | | 4 | | | 2 | | | | | | 1 | | | | | | *Stepmedi* |
| *S. minutulus* (Kütz.) Cleve & Moller | | | | 1 | | | | | | | | | | | | | | | | | | | | *Stepminu* |

**Table 2.** Continuation.

| Taxa \ Site and month, year of sampling | Z1a_08.2009 | Z1b_08.2009 | Z1c_08.2009 | Z2_08.2009 | Z3_08.2009 | Z4_08.2009 | Z1_05.2010 | Z1a_10.2010 | Z1b_10.2010 | Z2_10.2010 | Z3_10.2010 | Z4_10.2010 | K1_08.2009 | K2_08.2009 | K3_08.2009 | K1_05.2010 | K2a_05.2010 | K2b_05.2010 | K3a_05.2010 | K3b_05.2010 | K1_11.2010 | K2_11.2010 | K3_11.2010 | Acronym |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *S. neoastrea* Håkansson & Hickel | | | | | | | | | | | | 6 | | | | | | 1 | | | | | | *Stepneoa* |
| *Stephanodiscus* sp.1 | 1 | | | | | | | | | | | | | | | | | | | | | | | *Stepsp1* |
| *Stephanodiscus* sp.2 | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | *Stepsp2* |
| ***Surirella** angusta* Kützing | | | | | | | | | | 1 | 1 | | | | | 3 | 1 | 2 | 2 | | 1 | | | *Suriangu* |
| *S. linearis* W. Smith | | | | | | | | | | | | | | | | | | | | | | 1 | 2 | *Suriline* |
| *S. minuta* Brébisson & Kützing | | | | | | | 1 | | | | | | | | | | 1 | 5 | | | | | | *Suriminu* |
| *S. subsalsa* W. Smith | | | | | | | | | | | | | | | | | | 1 | | | | | | *Surisubs* |
| *Surirella* sp. | | | | | | | | 1 | | | | | | | | | | | | | | | | *Surisp* |
| ***Tryblionella** angustata* W. Smith | | | | 2 | | | 1 | | | | | | | | 1 | | | | | | | | | *Trybangu* |
| *T. gracilis* W.Smith | | | | | | | | | | | | | | | | | | 1 | | | | | | *Trybgrac* |
| **Total:** | **305** | **331** | **307** | **327** | **326** | **327** | **340** | **327** | **314** | **324** | **334** | **317** | **335** | **314** | **340** | **331** | **379** | **405** | **368** | **348** | **379** | **361** | **397** | |

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