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# DIATOMS OF TEMPORARY AND PERMANENT WATERCOURSES IN SOUTHERN EUROPE (PORTUGAL)

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### ABSTRACT

The potential importance of benthic diatoms in Mediterranean watercourses has received limited academic attention historically. This study sought to provide baseline information for this poorly studied group. Temporary and permanent watercourses in Portugal differ in catchment characteristics, climatic variables and water chemistry. The benthic diatom communities were characterized in terms of ecological preferences and conservation status for taxa with relative abundance above 1% in at least one site covering 39 temporary sites (109 taxa) and 53 permanent sites (130 taxa). The low-profile guild dominated both temporary and permanent watercourses, followed by the high-profile and motile guilds. Indicator value analysis indicated that *Amphora copulata, Cocconeis placentula, Diploneis separanda, Encyonopsis subminuta, Fragilaria radians, Gomphonema olivaceum, Gomphonema truncatum, Halamphora veneta, Navicula radiosa, Navicula veneta, Sellaphora seminulum and Ulnaria acus were indicators of temporary watercourses, whereas <i>Encyonema minutum, Eunotia minor, Fragilaria rumpens, Fragilaria* cf. socia and Navicula rhynchocephala were characteristic of permanent watercourses. Ecological preferences of indicator taxa were inferred on the basis of environmental variables that differed significantly between temporary and permanent watercourses. The importance of temporary watercourses for the maintenance of diatom biodiversity is discussed and explored. Copyright © 2014 John Wiley & Sons, Ltd.

KEY WORDS: diatoms; ecological guilds; ecological preferences; indicator taxa; seasonality

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## INTRODUCTION

Rivers that periodically cease to flow comprise a substantial proportion of the total number, length and discharge of the world's rivers (Tooth, 2000). Temporary rivers are not restricted to arid regions; they occur in most terrestrial biomes between 84°N and S latitudes (Larned *et al.*, 2010). During the next century, the number and length of rivers that become temporary may increase in regions experiencing drying trends as a result of climate change and water abstraction for socio-economic uses (Rosado *et al.*, 2012). An increase of 50% in the use of water for agriculture and industry is also predicted by 2025 (Tockner and Stanford, 2002). Furthermore, it is assumed that climate change will result in significant aquatic biodiversity losses due to changes in population dynamics resulting from an increasingly harsh environment.

The Mediterranean Region is predicted to experience greater flood frequency, punctuated by warmer, drier conditions that will lead to more frequent and prolonged droughts

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during the summer months, on the basis of most climate change models (Barceló and Sabater, 2010; IPCC, 2014) and represents a prominent 'hot spot' for potential change in water availability (Giorgi and Lionello, 2008). In Portugal, for instance, current estimates indicate that the total surface area drained by temporary rivers represents more than 80% of the Portuguese territory. Furthermore, in the south-east of the country, the driest region, the only permanent water-courses are the large rivers Guadiana, Sado and Mira, and ~90% of watercourses are temporary in character (Morais, unpublished data).

The extension and vulnerability of these aquatic systems have led to an increase in research on temporary rivers in the Mediterranean Region (e.g. Morais *et al.*, 2004; Feio *et al.*, 2010; Dodkins *et al.*, 2012). Nevertheless, phytobenthos has generally been overlooked in temporary rivers, and until recently, research undertaken on the use of diatoms as indicators of ecological status in Mediterranean temporary streams (e.g. diatom metrics and indices) has been limited (e.g. Martín *et al.*, 2010; Delgado *et al.*, 2012).

Despite the importance of temporary rivers in the Mediterranean region, the European Union Water Framework Directive (Directive 2000/60/EC) does not explicitly recognize their value or importance, probably because intermittency

is a naturally occurring phenomena. Nevertheless, the effects of a temporary flow regime and measures to address this (where appropriate) should be included in any update of river basin management plans. However, to propose appropriate measures, a detailed knowledge of the biotic components of temporary watercourses is crucial.

This topic requires specific attention because the implementation of the Water Framework Directive (Directive 2000/60/EC) requires European countries to assess lotic ecosystem quality using diatoms in addition to other biological elements. Diatoms are considered excellent environmental indicators because they represent a large part of the freshwater algal diversity, occur in almost all aquatic habitats and respond directly to many physical, chemical and biological changes in aquatic ecosystems. Furthermore, the value of diatoms as ecological indicators has been demonstrated in a variety of surface waters, primarily lakes and reservoirs (e.g. Novais et al., 2012). A biological indicator approach based on diatom growth forms, capacity to tolerate nutrient limitation and physical disturbance was proposed by Passy (2007) and is currently being widely tested across Europe (Berthon et al., 2011; Gottschalk and Kahlert, 2012).

The aim of this study is to enhance the baseline knowledge available concerning benthic diatoms in Mediterranean watercourses. The objectives of this research were as follows: (i) to provide an abiotic characterization of watercourses in the South of Portugal; (ii) to characterize benthic diatoms in temporary and permanent watercourses in Southern Portugal by assessing several indicators including ecological guilds, species richness, diversity and conservation status; and (iii) to determine ecological preferences of taxa that are characteristic of temporary and permanent watercourses.

## METHODS

## Sampling sites

A total of 92 sites were sampled in southern and central Portugal during spring 2006, when differences in the flow regime were already apparent but prior to temporary watercourses drying during late spring. The sites comprised 39 temporary and 53 permanent watercourses, according to the hydrological regime determined using a surface runoff model within a geographic information system (INAG, 2008a), and were located within the following watersheds: Ribeiras do Algarve (17), Guadiana (12), Mira and Sado (13) and Tejo (50) (Figure 1). The sites selected were subject to low anthropogenic pressure in accordance with the objectives of the study. The site selection was initially based on the REFCOND (2003) criteria developed by the National Water Institute. The environmental characterization of each site was intended to be comprehensive and addressed watershed characteristics, climatological, hydromorphological and

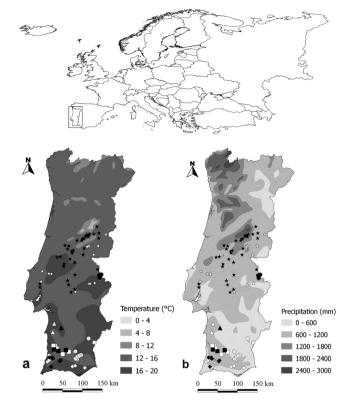


Figure 1. Map of Europe indicating the location of Portugal. Map of Portugal indicating (a) average annual temperature and (b) average annual precipitation (source: Atlas do Ambiente Digital—IA). Symbols on the maps indicate the catchments examined in this study: circle = Guadiana; triangle = Sado; square = Mira; diamond = Ribeiras do Algarve; and star = Tejo. Solid/black = permanent watercourses and open/white = temporary watercourses

water chemistry parameters. For each site, elevation, catchment area upstream of the sample site, distance to source, average annual runoff, thermal amplitude, coefficient of variation of annual precipitation, and mean annual temperature and precipitation were derived from the National Water Institute database. In addition, land use within the watershed, urban area, presence and characteristics of the riparian vegetation, sediment loads, level of hydromorphological alteration and changes to river connectivity caused by the presence of dams were recorded. The potential effects of toxicity, acidification and organic contamination were identified and explored by collecting water quality samples and analysis of the following parameters: dissolved oxygen  $\geq 5 \text{ mg O}_2 \text{ L}^{-1}$ ,  $6 \le pH \le 9$ , ammonium  $\le 1 \text{ mg NH}_4^+ \text{L}^{-1}$ , nitrates  $\le 25 \text{ mg}$  $NO_3^-L^{-1}$ , total phosphorus  $\leq 0.13 \text{ mg P }L^{-1}$  and biological oxygen demand  $\leq 6 \text{ mg O}_2 \text{ L}^{-1}$  (INAG, 2009).

Hydromorphological characterization was undertaken simultaneously with diatom community and water quality sample collection; water temperature, pH, oxygen saturation and conductivity were measured *in situ* with portable meters calibrated in the field. Additional field measurements of flow velocity, percentage of channel shaded, channel depth, channel width and wetted width and the presence or absence and type of riparian vegetation were recorded. Environmental standard methods for water chemical analyses were carried out according to APHA (1995), and all variables examined are summarized in Tables I and II.

## Diatom sampling and processing

Benthic epilithic diatoms were sampled following a standard methodology (European Committee for Standardization, 2003; INAG, 2008b), which consisted in brushing at least five wellilluminated stones (cobbles if available) occurring in the main flow under stable conditions. All samples were preserved with a formaldehyde solution (4% v/v) immediately after sampling. Samples were treated using hydrogen peroxide (35%) and HCl (37%) in order to obtain a suspension of clean frustules. Permanent slides were mounted with Naphrax® (Brunel Microscopes Ltd, Wiltshire, UK). Diatoms were identified to a specific or sub-specific level using light microscopy (Leica DMRX with 100x oil immersion objective, Leica Microsystems, Wetzlar, Germany). At least 400 valves were identified and counted from each slide to estimate the relative abundance of each taxon. Identification was based on diatom reference floras (e.g. Krammer and Lange-Bertalot, 1986, 1988, 1991a, 1991b), as well as recent bibliographic sources, including the series 'Diatoms of Europe', 'Iconographia Diatomologica', 'Bibliotheca Diatomologica' and relevant taxonomic papers.

## Data analysis—environmental variables

Environmental variables were standardized and log transformed prior to analysis. The Shapiro–Wilk normality test was conducted using SigmaPlot 12.0 (Systat Software Inc., Chicago, IL). To verify which variables differed significantly between temporary and permanent watercourses, the nonparametric Mann–Whitney U test was used. Subsequently, a comparison between climatological, hydromorphological and water chemistry variables was undertaken by means of non-parametric Spearman rank correlations. Both Mann– Whitney *U* tests and Spearman rank correlations were undertaken using STATISTICA 6.0 (StatSoft, Inc., Tulsa, OK).

## Data analysis—diatoms

Diatom taxa were characterized in terms of habitat, flow velocity (when flowing), moisture content, pH, trophic state, ecology and conservation status according to the diatom 'Red List' compiled by Lange-Bertalot and Steindorf (1996) for German watercourses (based on Denys, 1991; Van Dam *et al.*, 1994; Lange-Bertalot and Steindorf, 1996) and the 2012 OMNIDIA v. 5.3 (Omnis Software, Inc.) database (Lecointe *et al.*, 1993). Ecological guilds were assigned to all taxa identified following the classification of Passy (2007) and Berthon *et al.* (2011): low-profile, high-profile and motile guilds. To examine the influence of environmental variables on ecological guilds' relative abundance and to compare information provided by the Specific Pollution Sensitivity Index (SPI) and ecological guilds, Spearman rank correlations were calculated using STATISTICA 6.0 (StatSoft, Inc.).

The indicator value (IndVal) method was used to identify the key species (indicators) of temporary and permanent watercourses (Dufrêne and Legendre, 1997), using PC-Ord 6.0 (MjM Software Ltd., 217-219 Hamstel Road, Southend on Sea Essex SS2 4LB). This provides IndVals for each species, based on the combination of information on the specificity and fidelity of occurrence of a taxon in a group. The statistical significance of the species IndVal was evaluated using Monte Carlo random permutation tests. Ecological preferences of indicator species were inferred on the basis of the environmental variables that differed significantly between temporary and permanent watercourses.

For each sample, taxa richness (S), Shannon index of diversity (H') and Pielou's evenness index (J') were determined.

Table I. Catchment and climatological characteristics of the temporary and permanent watercourses examined in the southern Portugal study area

		Temporary		Permanent
Variable	Median	Interquartile range	Median	Interquartile range
Elevation (m above sea level)	138.91	61.03-214.46	129.80	66.00-342.18
Catchment area upstream** (km <sup>2</sup> )	57.34	33.32-150.81	127.36	66.36-984.55
Distance to source <sup>**</sup> (m)	18999.26	12282.53-28865.43	29920.60	16849.90-72644.10
Average annual runoff* (mm)	175.00	175.00-250.00	350.00	175.00-700.00
Thermal amplitude (°C)	10.34	9.99-11.30	10.39	9.70-11.23
Average annual temperature** (°C)	15.62	15.11-15.99	15.18	13.70-15.35
Average annual precipitation** (mm)	668.00	633.75-763.50	804.00	686.00-1042.00
Coefficient of variation of annual precipitation	0.31	0.29-0.32	0.30	0.29-0.31

Variables that differ between temporary and permanent watercourses are indicated by

 $\ast p < 0.05$  and  $\ast \ast p < 0.001$  using the Mann–Whitney U test.

Table II. Physical and water chemistry characteristics of the temporary and permanent watercourses examined in the study area.

		Temporary		Permanent
Variable	Median	Interquartile range	Median	Interquartile range
Current velocity** (m s <sup>-1</sup> )	0.32	0.00-0.58	0.67	0.41-0.91
Water temperature* (°C)	19.36	15.85-20.94	23.52	17.70-26.19
Conductivity (Cond)** ( $\mu$ S cm <sup>-1</sup> )	392.50	223.75-586.50	143.00	109.00-333.00
pH*	7.49	6.94-7.85	7.12	6.64-7.48
Oxygen $(O_2)^{**}$ (%)	72.95	67.78-81.60	84.60	73.20-99.20
Alkalinity** (mg $L^{-1}$ )	62.50	46.50-167.50	40.00	34.00-61.00
Hardness** (mg $L^{-1}$ )	96.50	51.75-173.50	32.00	10.00-85.00
Phosphate $(PO_4^{-3})$ (µg L <sup>-1</sup> )	24.00	11.25-49.00	32.00	9.00-52.00
Total phosphorus (Ptot) ( $\mu g L^{-1}$ )	19.50	8.75-29.75	21.00	9.00-32.00
Soluble reactive phosphorus (SRP) ( $\mu g L^{-1}$ )	8.00	3.75-16.00	10.00	3.00-17.00
Total organic carbon (TOC) $(mg L^{-1})$	2.96	1.70-6.13	2.90	1.40-4.70
Chemical oxygen demand (COD) $(mg L^{-1})$	12.00	6.00-18.00	9.00	4.00-13.00
Biological oxygen demand $(BOD_5) (mg L^{-1})$	1.00	0.00-4.00	2.00	0.00-4.00
Ammonium $(NH_4^+)$ (µg L <sup>-1</sup> )	2.00	2.00-23.75	2.00	2.00-20.00
Kjeldahl nitrogen ( $\mu g L^{-1}$ )	1120.00	560.00-1680.00	1120.00	560.00-1120.00
Nitrate $(NO_3^-)$ (µg L <sup>-1</sup> )	275.50	159.75-487.25	315.00	220.00-386.00
Nitrite $(NO_2^-)$ (µg L <sup>-1</sup> )	1.00	0.00-10.00	10.00	0.00-20.00
Total nitrogen (mg $L^{-1}$ )	1335.00	985.86-1979.00	1355.00	898.00-1795.00
Chloride $(Cl^{-})^*$ (mg L <sup>-1</sup> )	40.45	23.80-88.68	19.40	17.40-31.30
Sulfate $(SO_4^{-2})$ (mL <sup>-1</sup> )	22.40	9.98-29.73	13.60	9.33-18.10
Sodium $(Na^+)^* (mg L^{-1})$	3.70	2.33-6.03	2.70	1.10-5.20
Manganese $(Mn^{2+})$ $(mg L^{-1})$	0.01	0.01-0.05	0.02	0.01-0.08
Magnesium $(Mg^{2+})^*$ $(mgL^{-1})$	8.02	4.37-13.55	4.86	3.16-7.05
Calcium $(Ca^{2+})^*$ $(mgL^{-1})$	19.50	11.25-33.93	12.40	8.00-22.00

Variables that significantly differ between temporary and permanent watercourses are indicated by \*p < 0.05 and \*\*p < 0.001 using the Mann–Whitney U test.

The SPI was also calculated from diatom abundances (Coste in Cemagref, 1982), using the OMNIDIA v. 5.3 software (Lecointe *et al.*, 1993). OMNIDIA was selected because it has been developed for assessing the quality of running waters and has been recommended as reference index for several Iberian basins (Gomà *et al.*, 2005; Blanco *et al.*, 2008).

The relationship between taxa richness (S), Shannon index of diversity (H'), Pielou's evenness index (J'), SPI and the 11 environmental variables that varied significantly between temporary and permanent watercourses was investigated by least squares stepwise multiple linear regression with experiment-wise type I error rates of 0.05 for coefficients calculated using the Dunn-Šidák method (Ury, 1976). The complete candidate model included one qualitative variable, namely the watercourse regime (which was binary coded as 0 or 1), 11 environmental variables and all interactions between watercourse regime and environmental variables. Variance inflation factors and Durbin-Watson d were examined to evaluate multicollinearity and serial correlation. Equations were fitted using Statgraphics 4.2 (STCS, Inc., Rockville, MD). Only taxa with relative abundances over 1% from at least one site were considered in the analyses in order to reduce the influence of rare taxa.

## RESULTS

Environmental characterization of temporary and permanent streams

Descriptive statistics of the environmental parameters recorded from the temporary and permanent watercourses are presented in Tables I and II. On the basis of the Mann-Whitney U test, temporary and permanent watercourses differ in catchment characteristics (p < 0.001), climatological variables (average annual temperature and precipitation, both p < 0.001, and average annual runoff, p < 0.05), current velocity (p < 0.001) and several water chemistry variables (Table II). A detailed examination of the data indicated that catchment area upstream of the sample point, distance to source, average annual precipitation, average annual runoff, current velocity, dissolved oxygen saturation and water temperature were higher in permanent watercourses. In contrast, average annual temperature, conductivity, alkalinity, hardness, pH, chloride, magnesium, sodium and calcium were higher in temporary watercourses.

The application of the Mann–Whitney U test to the hydromorphological variables only detected significant differences for water current between the two groups (with

p < 0.001; Table II). Because statistical differences were not observed for other hydromorphological variables, a series of charts were plotted to explore the variability of hydromorphological parameters among the groups (Figure 2). Temporary watercourses were typically less shaded, with a greater proportion of sites with no shade or <30% of the river channel shaded. Temporary and permanent watercourses had similar proportions of sites >60% shaded, and there was a higher percentage of permanent sites with 30-60% of the channel shaded. These results were reinforced by examination of the type of riparian vegetation (Figure 2e). Temporary watercourses were generally narrower and had smaller channels, as illustrated by a higher percentage of low-river-width (between 1–5 and 5–10 m) and lower-channel-width (<1 m) sites. Permanent sites had a greater percentage of sites that were >20 m wide (Figure 2b, c), although they also had relatively high proportions of sites with low channel width (1-5 m being the most common). Both temporary and permanent watercourses had high percentages of shallow sites (<0.25 m); temporary systems were dominated by the 0.25- to 0.5-m depth class and permanent rivers by the 0.5- to 1- and >1-m classes. The absence of sites in temporary watercourses with >1-m depth is noticeable (Figure 2d).

Climatological variables were clearly different between groups with temporary watercourses typically located in areas with higher average annual temperature and lower average annual runoff and annual precipitation (Table I and Figure 1). In the south-east of the country, the driest region, the majority of watercourses were temporary (Figure 1), whereas precipitation and average annual runoff were higher and more variable in permanent watercourses typical of the central region (Table I and Figure 1).

Spearman correlation coefficients between catchment characteristics and climatological and hydromorphological variables indicated that elevation was positively correlated (p < 0.001) with climatological variables including average annual runoff (r=0.56) and average annual precipitation (r=0.53). Elevation was also negatively correlated with the average annual temperature (r=-0.59). Catchment area and distance to source were strongly correlated (p < 0.001)

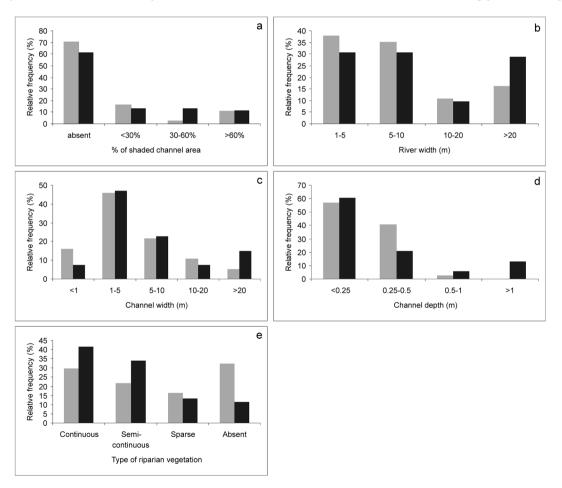


Figure 2. Comparison of mean values of characteristics of temporary (grey) and permanent (black) watercourses within the study area expressed as frequencies for: (a) percentage of channel area shaded; (b) river width; (c) channel width; (d) channel depth; and (e) type of riparian vegetation

with hydromorphological variables such as river width (r=0.56 and r=0.61, respectively) and channel width (r=0.48 and r=0.56, respectively).

The Spearman correlations between catchment characteristics, climatological and hydromorphological variables and water chemistry were used to explore the contribution of each of these variables to the changes in water chemistry observed. The only catchment characteristic correlated with water chemistry was elevation, which is negatively correlated (p < 0.001) with conductivity (r = -0.61), calcium (r = -0.57), chloride (r = -0.62), hardness (r = -0.56) and sodium (r = -0.52). For the climatological variables, negative correlations (p < 0.001) were observed between the average annual runoff and conductivity (r = -0.55), alkalinity (r = -0.52), calcium (r = -0.57), chloride (r = -0.63), hardness (r = -0.55) and magnesium (r = -0.49). Average annual precipitation was negatively correlated (p < 0.001)with conductivity (r = -0.50), chloride (r = -0.56), chemical oxygen demand (r = -0.50) and hardness (r = -0.52)and positively correlated with water temperature (r=0.50)and nitrite (r=0.53). It was interesting to note that neither riparian vegetation nor current velocity was correlated with any water chemistry parameters.

## Diatom communities' characterization

A total of 322 diatom taxa were identified in the dataset; from these, 229 were recorded in temporary watercourses and 250 from permanent systems. Only 109 taxa were present with a relative abundance above 1% from at least one temporary watercourse and 130 taxa from permanent water bodies. Within temporary watercourses, taxa with relative abundance above 1% comprised 34 genera: Gomphonema (15 taxa) and Achnanthidium (11 taxa); and from perennial flowing sites, the most frequently sampled genera comprised Achnanthidium (16 taxa), Fragilaria (14 taxa), Gomphonema (13 taxa), Nitzschia (14 taxa) and Navicula (13 taxa). Appendix A includes the taxa with relative abundances above 1% from at least one site, their ecological preferences and conservation status (based on published literature), maximum relative abundance and frequency of occurrence within each group. Achnanthidium minutissimum, Amphora pediculus, Cocconeis euglypta, Gomphonema rosenstockianum, Planothidium frequentissimum, Nitzschia inconspicua and Reimeria sinuata were among the most abundant taxa and occurred at more than 50% of sites in temporary watercourses. Within permanent watercourses, the most abundant and frequently recorded taxa were A. minutissimum, Eolimna minima, Karayevia oblongella, P. frequentissimum and R. sinuata.

The Red List status (Lange-Bertalot and Steindorf, 1996) was available for  $\sim$ 70% of the taxa (Appendix A). From these,  $\sim$ 12.5% are classified as endangered to varying degrees. Among the diatoms recorded, *Achnanthidium lineare* 

and Stauroforma exiguiformis have been classified as 'endangered' (category 3); S. exiguiformis only occurs in permanent watercourses, whereas A. lineare also occurs in temporary waterbodies infrequently. Gomphonema lagenula and Navicula cataracta-rheni are classified as 'extremely rare' (R). Gomphonema lagenula was found in low abundances in both temporary and permanent watercourses, whereas N. cataracta-rheni was typically present in low abundance within temporary watercourses. Achnanthidium subatomoides, Fragilaria nanana, Gomphonema exilissimum, Karayevia oblongella and Pinnularia microstauron are classified as 'decreasing' (V). Among these taxa, G. exilissimum and K. oblongella were present in more than 10% of both temporary and permanent watercourses, and K. oblongella was also abundant in both groups (>40% maximum relative abundance). In contrast, A. subatomoides, F. nanana and P. microstauron were only recorded from permanent watercourses in low abundances. For Eunotia implicata, Eunotia soleirolii, Navicula notha and Ulnaria biceps, threats to their long-term conservation exist (category G). All were recorded from both groups, although E. soleirolii and N. notha were more abundant and occurred more frequently in permanent watercourses.

Information regarding trophic preferences (for  $\sim 70\%$  of the taxa) and pH (for  $\sim 75\%$  of the taxa) was available for the majority of the taxa. Nevertheless, 48.5% of the taxa lacked information regarding their habitat preferences; 51.5% had no details regarding current velocity, and 38.6% lacked details regarding moisture preferences (Appendix A).

## Ecological guilds

The majority of the taxa identified within temporary watercourses belonged to the low-profile guild (44.0%) followed by the high-profile (31.2%) and motile (24.8%) guilds. Permanent sites were dominated by low-profile taxa (35.4%); nevertheless, there was a higher percentage of high-profile and motile taxa (33.8% and 30.8%, respectively). Although there were no significant differences among the number of taxa assigned to each guild per group, it is clear that the low-profile guild dominated the relative abundance in both groups (77.5% temporary and 75.8% permanent watercourses), followed by high-profile (12.3% in both groups) and motile guilds (10.2% temporary and 11.9% permanent watercourses). No strong Spearman rank correlations ( $\rho > 0.5$ , p < 0.05) were observed between any ecological guilds' relative abundance and environmental variables. Significant correlations were recorded between low-profile and motile guilds and the SPI index, although these were not strong ( $\rho = 0.39$ and  $\rho = -0.38$ , respectively, p < 0.05).

## Characteristic diatom taxa and their ecological preferences

Indicator value analysis undertaken to identify diatom taxa that are characteristic of temporary or permanent watercourses demonstrated that Amphora copulata, Cocconeis placentula, Diploneis separanda, Encyonopsis subminuta, Fragilaria radians, Gomphonema olivaceum, Gomphonema truncatum, Halamphora veneta, Navicula radiosa, Navicula veneta, Sellaphora seminulum and Ulnaria acus were indicators of temporary watercourses, whereas Encyonema minutum, Eunotia minor, Fragilaria rumpens, Fragilaria cf. socia and Navicula rhynchocephala were characteristic of permanent watercourses (Table III). The taxa characteristic of temporary watercourses were also common in highly intermittent, waterlogged (wet subaerial-four taxa) and moist soils (moist subaerial-three taxa); only two taxa were considered aquatic, although data were not available for three taxa. Most taxa indicative of temporary waterbodies were indifferent to the current velocity (eight taxa; Appendix A). As for the pH preferences, five taxa were classified as alkaliphilous (class 4), four as neutrophilous and two as alkalibiontic, and there was no information available for D. separanda. Regarding the trophic preferences, five taxa were classified as eutraphentic, two as meso-eutraphentic and one as oligotraphentic (E. subminuta), and *D. separanda* and *F. radians* were not classified. Three of these taxa were not present in the Red List classification (Appendix A).

The five taxa indicative of permanent watercourses were also commonly present in non-permanent water bodies; they were largely indifferent regarding current velocity preferences. Three taxa lack information regarding moisture preferences, whereas E. minutum is strictly aerophilous and N. rhynchocephala is occasionally aerophilous. Their pH preferences were quite diverse, as E. minor is acidophilous, E. minutum and F. rumpens are neutrophilous and *N. rhynchocephala* is alkaliphilous. Data on trophic preferences were only available for F. rumpens (eutraphentic) and N. rhynchocephala (indifferent). Fragilaria cf. socia was not classified in the Red List (Appendix A). Because these were taxa characteristic of both types of watercourses, their ecological preferences are highlighted for the environmental variables that statistically separate temporary and permanent watercourses (Table IV). Taxa characteristic of temporary watercourses have a clear preference for sites with lower current velocity and higher conductivity and pH

Table III. Indicator values for the characteristic taxa of temporary or permanent watercourses examined in this study

			Temp	orary	I	Permar	nent
Code	Taxon name	F	S	IndVal	F	S	IndVal
ACOP	Amphora copulata (Kützing) Schoeman & R.E.M. Archibald 1986	23	83	19	8	17	1
CPLA DSEP	Cocconeis placentula Ehrenberg 1838 Diploneis separanda Lange-Bertalot 2004	10 31	99 92	10 28	2 8	1 8	0 1
ENMI	<i>Encyonema minutum</i> (Hilse in Rabenhorst) D.G. Mann 1990	13	18	2	38	82	31
ESUM	<i>Encyonopsis subminuta</i> Krammer & E. Reichardt 1997	10	100	10	0	0	0
EMIN	Eunotia minor (Kützing) Grunow 1881	5	2	0	23	98	22
FRAD	<i>Fragilaria radians</i> (Kützing) D.M. Williams & Round 1987	13	100	13	0	0	0
FRUM	<i>Fragilaria rumpens</i> (Kützing) G.W.F. Carlson 1913	21	29	6	43	71	31
FSOC	<i>Fragilaria</i> cf. <i>socia</i> (N.M. Wallace) Lange- Bertalot 1980	0	0	0	25	100	25
GOLI	<i>Gomphonema olivaceum</i> (Hornemann) Brébisson 1838	13	100	13	0	0	0
GTRU	Gomphonema truncatum Ehrenberg 1832	18	89	16	4	11	0
HVEN	<i>Halamphora veneta</i> (Kützing) Levkov 2009	33	93	31	6	7	0
NRAD	Navicula radiosa Kützing 1844	18	90	16	8	10	1
NRHY	Navicula rhynchocephala Kützing 1844	5	16	1	21	84	17
NVEN	Navicula veneta Kützing 1844	67	72	48	42	28	12
SSEM	<i>Sellaphora seminulum</i> (Grunow) D.G. Mann 1989	36	81	29	23	19	4
UACU	Ulnaria acus (Kützing) Aboal 2003	18	100	18	0	0	0

Monte Carlo random permutations tests were used to assess the significance of each taxon as a group-specific indicator (p < 0.05). Fidelity (F) and specificity (S) values are also presented.

		ACOP	CPLA	DSEP	EMIN	ENMI	ESUM	FRAD	FRUM
Current velocity $(m s^{-1})$	WA	0.12	0.02	0.27	0.44	0.53	0.88	0.87	0.67
	Range	1 - 0.73	0-0.64	0-0.80	0-0.85	0-0.97	0.61-1.18	0.61-1.18	0 - 1.41
T (°C)	WA	22.2	25.9	20	24.6	24.1	17.5	19.7	20.8
	Range	13.0-29.4	21.0-28.7	9.4-28.7	14.1-28.2	13.0-32.6	13.3-20.1	13.3-20.1	11.8-28.0
Conductivity (mS cm $^{-1}$ )	WA	663	365	606	162	125	189	223	157
	Range	109-860	98-409	98-1393	55-428	55-543	124-230	124-230	55-637
pН	WA	8.0	6.9	7.3	6.4	6.9	6.9	6.8	7.1
	Range	6.6-8.6	6.7-8.2	6.6-8.6	5.7-8.2	5.7-8.9	6.3-7.7	6.3-7.7	6.3-8.5
DO (%)	WĂ	109.9	79.5	78.4	83.7	80.9	74.8	84.6	77.9
	Range	38.3-128.6	66.3–98.6	42.9-128.6	31.5-116.8	31.5-148.2	59.8-91.9	59.8-91.9	42.9-116.8
Alkalinity $(mg L^{-1})$	WĂ	222	130	167	46	42	43	49	42
<b>3</b> ( <b>8</b> )	Range	28-274	46-172	31-386	26-157	25-225	31-53	31-53	24-110
Calcium (mg $L^{-1}$ )	WĂ	62.2	30.8	44.3	22.9	10.5	15.2	10.7	10.1
	Range	8.0-107.0	4.8-43.3	4.8-144.0	6.0-58.0	4.6-87.0	10.0-24.0	10.0-24.0	5.6-24.0
Chloride (mg $L^{-1}$ )	WĂ	88.2	50.6	72.3	27.8	17.2	25.6	28.3	27.9
	Range	16.4-148.9	13.9-57.1	13.9-163.8	7.7-37.7	5.0-99.3	20.8-29.8	20.8-29.8	5.9-163.8
Hardness (mg $L^{-1}$ )	WĂ	251	110	208	27	27	69	52	34
	Range	10-312	10-182	10-528	6-182	10-242	46-100	46-100	10-160
Magnesium (mg $L^{-1}$ )	WA	20.9	8.2	25.5	3.8	5.8	7.5	5.9	5.9
	Range	2.7-28.2	2.9-23.8	1.9-85.5	0.7-23.8	0.4-28.2	4.4–9.7	4.4–9.7	0.5-25.2
Sodium (mg $L^{-1}$ )	WA	7.7	4.9	7	2.3	2.2	6	3.1	3.2
(6 )	Range	0.7–11.8	0.7–5.8	0.7–15.8	0.7–9.8	0.7–9.8	2.4–11.2	2.4–11.2	0.7–13.1

Table IV. Abundance-weighted averages (WA) and range for the 11 environmental variables that were significantly different between temporary and permanent watercourses

The taxa reflect a spectrum of taxa from temporary and permanent watercourses. The names of the taxa corresponding to the codes (in four letters) are provided in Table III.

(except for *Encyonopsis minuta*). Similar preferences were detected for alkalinity, chloride, hardness, magnesium and sodium, which were generally higher for taxa characteristic of temporary watercourses. When considering the percentage oxygen saturation, with the exception of *A. copulata*, there were no significant differences detected among the groups, probably because all sites were not subject to strong anthropogenic pressures.

## Diatom metrics and environmental variables

The mean values, standard deviation, median and interquartile range for taxa richness (S), Shannon index of diversity (H'), Pielou's evenness index (J') and the SPI are presented in Table V. Results of regressions between environmental parameters that differed significantly between temporary and permanent watercourses and taxa richness (S), Shannon index of diversity (H'), Pielou's evenness index (J') or SPI are presented in Table VI. There was no evidence of multicollinearity, and no positive or negative serial correlations were recorded at p = 0.05, except a slightly positive autocorrelation in evenness (J'). There were significant differences for taxa richness (S) between temporary and permanent watercourses because of an interaction between average annual runoff and the qualitative variable (temporary/permanent). The qualitative variable (temporary or permanent) explained 47.3% of the variation of taxa richness, whereas oxygen explained 35.4% and calcium 17.3%. No significant differences were recorded between watercourses for H' and J' with pH explaining 98.9% and 99.2% of their variation or for the SPI, where average annual runoff explained 44.1%, alkalinity 21.6%, current velocity 18.8% and oxygen 15.5% of the variance in the data.

### DISCUSSION AND CONCLUSIONS

The environmental characterization of watercourses in the south of Portugal clearly differentiated temporary and permanent sites on the basis of catchment characteristics and climatological variables. Among the hydromorphological variables, only current velocity was statistically different between the two stream types, whereas other variables only differed slightly between the temporary and permanent waterbodies. The lack of significant hydromorphological differences reflects the characteristics of Mediterranean watercourses generally, independent of the hydrologic regime. It is important that further research is undertaken on headwater temporary watercourses, characterized by short distances to source and small catchment area, and especially their role in the supply, transport and fate of water resources and solutes (including pollutants; Barceló and Sabater, 2010). Temporary watercourses experience greater variation in annual precipitation (Lillebø et al., 2007). This fact, coupled with their smaller watersheds,

FSOC	GOLI	GTRU	HVEN	NRAD	NRHY	NVEN	SSEM	UACU
0.27	0.28	0.12	0.23	0.41	0.57	0.35	0.4	0.35
0.02-1.41	0-1.19	0-0.87	0-1.06	0-0.97	0.17-0.97	0-1.63	0-1.63	0-1.18
23.3	19.3	17.8	20.7	18.8	24.4	19.4	17.4	18.6
16.3-32.6	17.2-20.1	13.0-29.2	11.8-28.7	13.0-26.8	11.8-29.2	9.4-29.2	9.4-29.4	17.1-20.0
101	460	300	411	241	210	396	441	426
69-200	223-543	78-411	98-1361	55-472	65-616	55-1393	76-1361	223-1348
7.3	7.3	7.7	7.7	7	6.7	7.4	7.6	7.1
6.3-8.9	6.3-7.9	6.2-8.6	6.2-8.8	6.2-8.6	5.7-7.7	5.7-8.8	5.7-8.9	6.2-8.9
72.8	77.3	84.2	83.8	76.3	82.3	74.0	74.8	74.3
66.1-148.2	75.3-91.9	69.0-99.0	67.5-103.7	51.4-115.3	31.5-106.5	31.5-128.6	31.5-121.0	49.7-84.6
51	171	98	100	57	43	93	71	94
24-56	48-225	36-174	25-225	28-174	25-157	25-386	25-268	46-270
8.9	63.3	15.4	26.9	11.5	14.3	27.7	19.9	28.1
5.6-18.4	10.0-87.0	4.6-22.0	4.8-87.0	5.6-19	5.6-58.0	5.6-144.0	4.6-92.0	10.0-107.0
8.1	29	40.8	64.3	48.7	34.1	70.8	100.8	80.9
5.9-31.3	23.8-93.5	8.9-66.5	8.4-292.8	7.7-140	9.9-163.8	2.8-292.8	8.4-421.8	26.3-421.8
12	185	114	98	54	40	106	79	92
11963	46-242	44835	10-242	10-224	10-165	7-528	7-282	50-257
4.8	6.7	14.4	8.2	7.9	4.6	11	9	5.6
0.7 - 7.1	4.4-10.5	0.4-28.2	1.7 - 28.2	1.0 - 28.2	0.7-11.9	0.7-85.5	0.4 - 24.5	2.7 - 10.5
1.3	1.8	3.4	4.2	3.4	4.3	4.9	4.7	3.4
0.7–9.8	1.1–3.7	0.7-8.9	0.7–13.1	0.7–9.8	0.7–13.1	0.7–15.8	0.7–13.1	2.4-8.6

Table IV. (Continued)

helps explain the high inter-annual and intra-annual variability of the flow regime and their unpredictability.

Water chemistry parameters and indicators of anthropogenic contamination did not differ between temporary and permanent watercourses. This reflects the sample design focussed on relatively unimpaired sites. Nevertheless, indicators of organic enrichment were more abundant in permanent watercourses (Table II) and reflect the greater catchment area and agricultural/pastoral practices (Hlúbiková *et al.*, 2014). However, it was interesting to note that contrary to the findings of authors such as Moore *et al.* (2005) and Studinski *et al.* (2012), the percentage of riparian vegetation did not have a significant effect on stream temperature and may reflect the sclerophyllous and evergreen riparian vegetation typical of southern Portugal and the wider Mediterranean region (Gasith and Resh, 1999).

The low-profile guild dominated the relative abundance of both temporary and permanent watercourses, reflecting the frequent disturbance and low nutrient content. These environmental conditions favour small taxa that are able to persist in low-nutrient environments, withstand extreme flow events and recolonize sites rapidly. These results support observations of Berthon et al. (2011) and Hlúbiková et al. (2014), who reported a dominance of low-profile diatoms in nutrient-poor environments. Even though the temporary and permanent watercourses studied differed significantly with regard to a number of environmental parameters, such as watershed characteristics, climatological variables, current velocity and water chemistry, diatom guilds did not reflect these differences. In addition, light availability and shading did not appear to influence the diatom ecological guilds, probably because of the riparian vegetation associated with

Table V. Mean values, standard deviation, median and interquartile range for the taxa richness (S), Shannon index of diversity (H'), Pielou's evenness index (J') and Specific Pollution Sensitivity Index for the temporary and permanent watercourses examined in this study

		Tempora	ary		Permane	ent
	Mean ± SD	Median	Interquartile range	Mean ± SD	Median	Interquartile range
Taxa richness	$26.87 \pm 8.83$	28.00	19.00-33.00	$25.91 \pm 1.00$	23.00	19.00-33.00
Shannon index of diversity $(H')$	$2.72 \pm 0.91$	2.93	2.08-3.49	$2.64 \pm 0.85$	2.78	2.06-3.16
Pielou's evenness index (J') Specific Pollution Sensitivity Index	$0.57 \pm 0.15$ $15.93 \pm 1.86$	0.60 15.70	0.48-0.70 14.45-17.45	$0.56 \pm 0.14$ 16.76 ± 1.99	0.58 17.50	0.50–0.65 15.0–18.5

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Table VI. Regression coefficients for equations fitted to taxa richness (*S*), Shannon index of diversity (*H'*), Pielou's evenness index (*J'*) and Specific Pollution Sensitivity Index of temporary and permanent watercourses examined in this study

Variable	Watercourses	Y intercept	AverageCurrentannualvelocityWatercoursesY interceptrunoff (mm) $(m s^{-1})$	$\begin{array}{c} Current \\ velocity \\ (m  s^{-1}) \end{array}$		Oxygen (%)	Alkalinity $(\operatorname{mg} L^{-1})$	$\begin{array}{c} Calcium \\ (mgL^{-1}) \end{array}$	Oxygen Alkalinity Calcium Coefficients (%) $(mg L^{-1})$ $(mg L^{-1})$ $(p)$	F	Significance of Model $R_{adj}^2$ VIFs d	$R^2_{ m adj}$	VIFs	р
Taxa richness (S) Temporary	Temporary	16.401	0			0.190		-0.102	≤0.0025	8.15 (3,88)	$10^{-4}$	$0.191 \le 1.1  1.89$	≤1.1	1.89
Shannon index	Temporary	10.401	C10.0-		0.406	061.0		-0.102 -0.010	≤0.0009	522.10 (2,90)	$<\!10^{-5}$	0.920 1.0 1.55	1.0	1.55
Pielou's evenness					0.085			-0.002	≤0.0007	820.59 (2,90)	$<\!10^{-5}$	0.947 1.0 1.42	1.0	1.42
Index (J') Specific Pollution Sensitivity Index	rermanent Temporary Permanent	17.607	0.003	1.182		-0.024	-0.024 -0.008		≤0.0097	15.28 (4,87)	$<\!10^{-5}$	$0.386 \le 1.3 2.04$	≤1.3	2.04
The greater significance level of coefficients, <i>F</i> -values (with degrees of freedom within parentheses), significance levels of models, adjusted $R^2$ values ( $R^2_{adj}$ ), the variance inflation factors (VIFs) and Durbin–Watson statistics ( <i>d</i> )	nce level of coeffi stics (d)	icients, F-value	s (with degrees	of freedom	within p	arentheses),	significance	levels of mo	dels, adjusted $I$	$R^2$ values $(R^2_{adj})$ , the	e variance infla	tion facto	rs (VIFs)	) and

Mediterranean rivers. Therefore, nutrient content appears to be the primary main factor driving ecological guild abundance in the rivers examined. This is in marked contrast to Swedish low-acidity lakes, where grazing and light levels might play an important role in determining their distribution (Gottschalk and Kahlert, 2012). In addition, current velocity did not appear to influence ecological guild abundance, suggesting that under nutrient-deficient conditions, flow plays a secondary role (Larson and Passy, 2012).

Even though only a few taxa were classified as threatened, a number of other taxa had conservation designations independently of being temporary or permanent water specialists, highlighting the need to manage and conserve 'unimpacted' watercourses, independently of their hydrological regime. Additionally, ~30% of the identified taxa were not recorded on the Red List of Lange-Bertalot and Steindorf (1996), and little or no information was available regarding the ecological preferences of several taxa indicative of both permanent and temporary watercourses. This may also reflect the fact that some taxa have only recently been described, such as *Pseudostaurosira alvareziae* or *Geissleria lusitanica* (Cejudo-Figueiras *et al.*, 2011; Novais *et al.*, 2013).

The importance of temporary watercourses for the maintenance of diatom biodiversity has been clearly demonstrated by the results of this study, as the variation in diatom taxa richness (higher in temporary watercourses) was directly linked with the average annual runoff. Diatom species richness increased with natural hydrological disturbance (drying), in accordance with the intermediate disturbance theories. Williams et al. (2003) also reported an increase in aquatic diversity in association with disturbance (physical habitat complexity), although their field observations suggested that seasonality reduced the richness of some ponds compared with species-rich river sites. Further studies are therefore required to explore the wider applicability of the results reported, as the relationship between species richness and connectivity is determined by a series of complex factors, with species richness maxima for different faunal and floral elements occurring at different positions along hydrological connectivity and permanence gradients (Ward et al., 2002).

Further studies centred on phytobenthos in temporary Mediterranean watercourses are required, not only for biodiversity conservation purposes but also for the determination of diatom richness along the riverine connectivity gradient and to provide a greater understanding of physiological aspects of diatom adaptation to drought.

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(991), 0—unknown, 2—aquatic, 3—also commonly in periodic water or wet subaerial, 4—also commonly moist subaerial, 5—also commonly dry subaerial; C = current (Denys, 1991), 0--unknown, 1---irrelevant, 2--rheobiontic, 3--rheophilous, 4---indifferent, 5---linnophilous. Ecological preferences according to Van 0 → mot threatened, D—insufficient data, •—widespread, z—not listed. MRA = maximum relative abundance in each group. FREQ = percentage of sites in which the aerophilous, OK-oligotraphentic alkaliphilous, OD-oligotraphentic acidophilous, OG-oligotraphentic, HP-halophilous, EU-meso to eutraphentic, ww-not isted. RL = Red List species (Lange-Bertalot and Steindorf, 1996), 3—endangered, G—presumed endangered, R—extremely rare, V—decreasing, \*—not estimated, List of taxa recorded with relative abundance above 1% from at least one site and a summary of their ecological preferences and distribution. H = habitat (Denys, Dam et al. (1994). M = moisture, 1—strictly aquatic, 2—occasional aerophilous, 3—aquatic to subaerial, 4—aerophilous strict, 5—terrestrial; pH, 1—acidobiont, mesotraphentic, 4--meso-eutraphentic, 5---eutraphentic, 7---indifferent. E=Ecological preferences according to Lange-Bertalot and Steindorf (1996), AE----Ч 1—oligotraphentic, 2—oligo-mesotraphentic, axon was recorded. Bold = characteristic/indicative taxa of temporary or permanent watercourses based on IndVal analysis (see details presented in Table III). 3—neutrophilous, 4—alkaliphilous, 5—alkalibionts, 6—indifferent; T=trophic state, 2-acidophilous,

										Temp	Temporary	Permanent	anent
Code	ode	Taxon name	H H	J	М	Hq	Н	Щ	RL	MRA	FREQ	MRA	FREQ
		Achnanthidium aff. saprophilum (H. Kobayasi & Mayama) Round & Bukhtivarova 1996	0	0	0	0	0			16.3	5.1	84.65	7.55
AD	ADCV	Achnanthidium caravelense Novais & Ector 2011	0	0	0	0	0	WΜ	z	9.5	5.1	17.00	7.55
AD	ADCT	Achnanthidium catenatum (J. Bílý & Marvan) Lange-Bertalot 1999	0	0	0	0	0	EU	*	2.2	12.8	5.78	18.87
AD	ADEU	Achnanthidium eutrophilum (Lange-Bertalot) Lange-Bertalot 1999		0	ŝ	б	2	WΜ	z	4.0	28.2	3.76	43.40
AD	ADEG	Achnanthidium exiguum (Grunow) Czarnecki 1994	ŝ	4	3	4	L	EU	$\diamond$	1.7	5.1	1.48	13.21
AD	ADJK	Achnanthidium jackii Rabenhorst 1861		0	0	б	0	ΜM	D	3.9	15.4		
AC	ACLI	Achnanthidium lineare W. Smith 1855		0	0	e	0	0	б	1.23	2.56	16.26	5.66
AD	ADMA	Achnanthidium macrocephalum (Hustedt) Round & Bukhtiyarova 1996		4	0	0	0	WΜ	D	1.23	7.69	1.21	5.66
AD	ADMI	Achnanthidium minutissimum (Kützing) Czarnecki 1994	S.	4	ŝ	e	7	TOL	$\diamond$	75.6	82.1	72.21	69.81
		Achnanthidium minutissimum (Kützing) Czarnecki 1994 s.l.								34.9	10.3	70.44	30.19
AD	ADPY	Achnanthidium pyrenaicum (Hustedt) H. Kobayasi 1997	0	0	0	4	ŝ	TOL	$\diamond$	23.8	28.2	57.34	24.53
		Achnanthidium sp. 1										29.16	1.89
		Achnanthidium sp. 2										24.34	3.77
		Achnanthidium sp. 3										10.84	1.89
п.:-		Achnanthidium sp. 4										98.06	3.77
AD	ADSB	Achnanthidium straubianum (Lange-Bertalot) Lange-Bertalot 1999		0	ŝ	Э	4	ΜM	z			1.23	5.66
QV Pro 4	ADSO	Achmanthidium subatomoides (Hustedt) O. Monnier, Lange-Bertalot & Ector 2007	0	0	-	7	0	мм	>			2.46	7.55
AD	ADSH	Achnanthidium subhudsonis (Hustedt) H. Kobayasi 2006	0	0	0	4	З	ΜM	z	18.8	12.8	38.33	43.40
AD	ADMS	Adlafia minuscula (Grunow) Lange-Bertalot 1999	0	0	4	4	-	TOL	*			0.97	9.43
AC	ACOP	Amphora copulata (Kützing) Schoeman & R.E.M. Archibald 1986	ŝ	4	1	4	5	TOL	$\diamond$	14.6	23.1	1.22	7.55
AN.	AMID	Amphora indistincta Levkov 2009	0	0	0	0	0	ΜM	z	4.5	17.9		
AP	APED	Amphora pediculus (Kützing) Grunow 1875		4	ŝ	4	2	TOL	$\diamond$	83.2	71.8	33.01	47.17
AA 13	AAMB	Aulacoseira ambigua (Grunow) Simonsen 1979		4	-	4	5	EU	$\diamond$			1.24	3.77
AU	AUPU	Aulacoseira pusilla (F. Meister) Tuji & Houki 2004	0	0	0	0	0	ММ	Z			8.70	1.89
2014)												(Co	(Continues)

uneHC97997900979010000400000400001000010000200003434334343434335434364433743438434394243642437434384243844343838343944343944343834439443439443439443439443439443439443439443439443439443439443439443439443439443439443344443439443439	1996 & Round 1986 87 mmer 2003 1990 1990 80		X 0w00400-000-0044	H 000004444404044444404	Η 0-00 ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	E E C C C C C C C C C C C C C C C C C C	RL * \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	MRA 1.0 78.6 7.9 7.9 7.9 7.9 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2	FREQ 5.1 2.6 61.5 2.8.2 2.8.2 2.8.2 2.8.2 2.8.2 2.8.2 2.8.2 2.5.6 7.7 7.7 7.7 7.7 7.7 7.7 7.7 7.7 7.1 5.1 7.7 7.7 7.7 7.7 7.7 7.1 7.7 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.1 7.7 7.7	MRA 1.45 8.63 8.63 8.19 8.19 8.19 8.19 8.19 2.5.78 1.20 1.20 2.20	FREQ 3.77 16.98 37.74 9.43 9.43 22.64 9.43 22.64 7.55 7.55
Aulacoseira tenella (Nygaard) Simonsen 1979       90       0         Brachystira brebissonii R. Ross 1986       00       0         Brachystira neglectissima Lange-Bertalot 2004       0       0         Caloneis luncentia (Schulz) Lange-Bertalot & Witkowski 1996       0       0         Caloneis neglectissima Lange-Bertalot & Witkowski 1996       0       0         Channeepinuularia Sp.       0       0       0         Cocroneis neglypta Ehrenberg 1854       3       4         Cocroneis peudolineata Brenberg 1838       3       4         Cocroneis peudolineata (Geitler) Lange-Bertalot 2004       3       4         Cocroneis pergarva Kraimae Sturizing 1844       3       4       4         Cymbella ercits Kitizing 1844       5       5       4       4       4         Cymbella ercits Kitizing 1844       5       5       4       5       4       5       4       5       4       5       4       5 <th>1996 2 Round 1986 87 mmer 2003 1990 1990 80</th> <th></th> <th>0 % 0 0 4 0 0 - 0 0 0 % - 0 0 0 0 - 0 % 4 %</th> <th>00004444404044444404</th> <th>0-00 ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~</th> <th>ww ww ww ww EU EU EU EU EU Ww ww ww ww Ww</th> <th><math display="block"> N \ast \ N \ N \ast \diamond \diamond \diamond \diamond \diamond O \ N \diamond \diamond \diamond \ast </math></th> <th><math display="block">\begin{array}{c} 1.0\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3</math></th> <th>5.1 2.6 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5</th> <th>1.45 8.63 8.63 8.63 68.81 56.10 8.19 8.19 8.19 2.5.78 1.20 1.20</th> <th>3.77 3.77 16.98 37.74 9.43 9.43 9.43 9.43 22.64 22.64 7.55 7.55</th>	1996 2 Round 1986 87 mmer 2003 1990 1990 80		0 % 0 0 4 0 0 - 0 0 0 % - 0 0 0 0 - 0 % 4 %	00004444404044444404	0-00 ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	ww ww ww ww EU EU EU EU EU Ww ww ww ww Ww	$ N \ast \ N \ N \ast \diamond \diamond \diamond \diamond \diamond O \ N \diamond \diamond \diamond \ast $	$\begin{array}{c} 1.0\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3\\ 2.3$	5.1 2.6 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5	1.45 8.63 8.63 8.63 68.81 56.10 8.19 8.19 8.19 2.5.78 1.20 1.20	3.77 3.77 16.98 37.74 9.43 9.43 9.43 9.43 22.64 22.64 7.55 7.55
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Cocconets lineaue Ehrenberg 1834       3         Cocconets lineaue Ehrenberg 1838       3         Cocconets preudolineata (Geitler) Lange-Bertalot 2004       3         Cocconets preudolineata (Gritler) Lange-Bertalot 2004       3         Cocconets preudolineata (Gritler) Lange-Bertalot 2004       3         Corconetis preudolineata (Gritler) Lange-Bertalot 2003       3         Cyclostella meneghiniana Kützing 1844       3         Cymbella perpara Krammer 2002       5         Cymbella perpara Krammer 2002       5         Cymbella perpara Krammer 2002       5         Cymbella nunida (Brébisson in Kützing) Van Heurck 1882–1885       3         Cymbella perpara Krammer 2002       5         Cymbella perpara Krammer 2003       3         Diplomeis eliptica (Kutzing) [844       2         Diplomeis separanda Lange-Bertalot 2004       2         Diplomeis separanda Lange-Bertalot 2004       2         Diplomeis separanda Lange-Bertalot 2004       2         Diplomeis separanda Lange-Bertalot 2004 <td>k Round 1986 87 anner 2003 1990 1990 ann 1990</td> <td></td> <td>v 0 - 0 0 0 m - 0 0 0 0 - 0 m 4 m</td> <td>4 4 4 4 <b>0</b> 4 <i>0</i> 4 <i>4</i> 4 4 4 <i>0</i> 4</td> <td>η ν ν ν Ο Ο ν ν ν ν ν Ο 4 ν α</td> <td>IOL EU EU EU Www Www Www Www Www Www</td> <td><math>\diamond</math> <math>\diamond</math> <math>\diamond</math> <math>\diamond</math> <math>\land</math> <math>\land</math> <math>\diamond</math> <math>\diamond</math> <math>*</math></td> <td>78.0 7.9 7.9 7.9 7.9 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2</td> <td>281.5 282.2 29.5 28.2 28.2 2.5 5.1 2.5 5.1 2.5 5.1 2.5 5.1</td> <td>8.81 56.10 8.19 25.78 1.20 2.20 2.20</td> <td>2.1.74 22.64 9.43 32.08 22.64 7.55 7.55 13.21</td>	k Round 1986 87 anner 2003 1990 1990 ann 1990		v 0 - 0 0 0 m - 0 0 0 0 - 0 m 4 m	4 4 4 4 <b>0</b> 4 <i>0</i> 4 <i>4</i> 4 4 4 <i>0</i> 4	η ν ν ν Ο Ο ν ν ν ν ν Ο 4 ν α	IOL EU EU EU Www Www Www Www Www Www	$\diamond$ $\diamond$ $\diamond$ $\diamond$ $\land$ $\land$ $\diamond$ $\diamond$ $*$	78.0 7.9 7.9 7.9 7.9 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2	281.5 282.2 29.5 28.2 28.2 2.5 5.1 2.5 5.1 2.5 5.1 2.5 5.1	8.81 56.10 8.19 25.78 1.20 2.20 2.20	2.1.74 22.64 9.43 32.08 22.64 7.55 7.55 13.21
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Encyonema ventricosum (C. Agardh) Grunow 187534Encyonema ventricosum (C. Agardh) Grunow 189700Encyonopsis subminutaKrammer & E. Reichardt 199700Eolimna minima (Grunow in Van Heurck) Lange-Bertalot 199844Epithemia adnata (Kützing) Brébisson 183834Epithemia sorex Kützing 184434Epithemia turgida (Ehrenberg) Kützing 184434Epithemia turgida var. granulata (Ehrenberg) Brun 188000	i 2010	-	0	0	0	WM	z	10.6	12.9	10.45	33.96
Encyonopsis subminutaKrammer & E. Reichardt 199700Eolimna minima (Grunow in Van Heurck) Lange-Bertalot 199844Epithemia adnata (Kützing) Brébisson 183834Epithemia sorex Kützing 184434Epithemia turgida (Ehrenberg) Kützing 184434Epithemia turgida var. granulata (Ehrenberg) Brun 188000			0	ŝ	0	ΜM	*	2.2	28.2	4.43	37.74
Eolimna minima (Grunow in Van Heurck) Lange-Bertalot 199844Epithemia adnata (Kützing) Brébisson 183834Epithemia sorex Kützing 184434Epithemia turgida (Ehrenberg) Kützing 184434Epithemia turgida var. granulata (Ehrenberg) Brun 188000		-	0	С	-	WM	z	1.0	10.3		
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Epithemia sorex Kützing 184434Epithemia turgida (Ehrenberg) Kützing 184434Epithemia turgida var. granulata (Ehrenberg) Brun 188000			0	S	4	EU	$\diamond$	29.4	10.3		
<i>Epithemia turgida</i> (Ehrenberg) Kützing 1844 3 4 <i>Epithemia turgida</i> var. <i>granulata</i> (Ehrenberg) Brun 1880 0 0			6	5	5	EU	$\diamond$			1.22	3.77
Epithemia turgida var. granulata (Ehrenberg) Brun 1880 0			С	5	4	EU	*	1.0	2.6		
			З	5	4	WM	*			0.98	1.89
3 4			e	9	7	TOL	$\diamond$			0.99	1.89
& Lange-Bertalot 1991 0 0	ot 1991	-	С	7	0	OD	IJ	15.3	10.3	17.32	9.43
Eunotia minor (Kützing) Grunow 1881 4 4			4	0	0	TOL	*			17.56	20.75
0 0		-	С	Э	1	OD	IJ	1.0	5.1	2.68	11.32
nik) Lange-Bertalot 1997 0 0	stalot 1997	0 0	ŝ	Э	5	EU	$\diamond$			5.84	7.55

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Table. (Continued)

#### DIATOMS OF TEMPORARY AND PERMANENT WATERCOURSES

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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	· · · · · · · · · · · · · · · · · · ·												
Taxon name Taxon na										Temp	orary	Perm	anent
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Code	Taxon name	Η	C	М	Hq	Г	Э	RL	MRA	FREQ	MRA	FREQ
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	FCAP	Fragilaria capucina Desmazières 1825	3	4	0	3	3	EU	$\diamond$	1.0	2.6	1.72	33.96
Freglatist narmal Lange-Bertalot 1991         0         0         3         2         TOL         2         2         1         2.66           Freglatist narmal Lange-Bertalot 1991         Freglatist narmal Lange-Bertalot 1991         0	FCRO	Fragilaria crotonensis Kitton 1869	0	0		4	m	TOL	$\diamond$	5.2	5.1	2.21	7.55
	FGRA	<i>Fragilaria gracilis</i> Østrup 1910	0	0	0	e	0	TOL	*	25.2	23.1	2.66	24.53
Fagilaria (Farmine (Granov) Lange-Bertalot 303       Frequent and Specification (Stating) DM Williams & Round 1987       Frequent and Specification (Stating) DM Williams & Round 1987       Frequent at some (Kluzing) DM Williams & Round 1987       Frequent at some (Kluzing) DM Williams & Round 1987       Frequent at some (Kluzing) DM Williams & Round 1987       Frequent at some (Kluzing) IB Wetsen 1938       Frequent at some (Kluzing) IB Wetsen 1936       Grasherin distance (Kluzing) IB Wetsen 1938       Grasherin distance (Kluzing) IB Wetsen 1938       Grasherin distance (Kluzing) IB Wetsen 1938       Grasherin distance (Kluzing) IB Wetsen 1936       Grasherin distance (Kluzing) IB Wetsen 1936       Grasherin distance (Kluzing) IB Wetsen 1940       Grasherin distance (Kluzing) IB Wetsen 114       Grasherin distance (Kluzing) IB Wetsen 114       Grasherin distance (Kluzing) IB Wetsen 114       Grasherin distance (Kluzing) IB Wetsen 1133       Grasherin dis	FNAN		0	0	0	б	0	WΜ	$^{N}$			1.99	30.19
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	FPAV	<i>Fragilaria parva</i> Tuji & D.M. Williams 2008	0	0	0	0	0	WΜ	z			4.43	7.55
Fraginaria rangens (Kuring) G.W. Carlson 193 $0$ $0$ $3$ $0$ $\infty$ $z$ $6$ $133$ <i>Fraginaria rangens</i> (Kuring) G.W. Carlson 193 $0$ <td>FPEM</td> <td>Fragilaria perminuta (Grunow) Lange-Bertalot 2004</td> <td>0</td> <td>0</td> <td>0</td> <td>б</td> <td>0</td> <td>EU</td> <td>*</td> <td></td> <td></td> <td>13.58</td> <td>15.09</td>	FPEM	Fragilaria perminuta (Grunow) Lange-Bertalot 2004	0	0	0	б	0	EU	*			13.58	15.09
Proglam         Component         Constraint	FRAD	Fragilaria radians (Kützing) D.M. Williams & Round 1987	0	0	0	б	0	ΜM	Z	6.4	12.8		
Program         <	FRUM	Fragilaria rumpens (Kützing) G.W.F. Carlson 1913	0	0	0	ю	2	TOL	*	2.0	20.5	4.34	43.40
Fraginitio qu.         Fraginitio qu. $0$ 0         0         0         w         z         29         03         33.86           Fraginitio quarkition undering (Kuring) IB. Petersen 1938 s.1. $0$ $0$ $3$ $4$ $5$ EU $2$ $1$ $1$ $2$ $2$ $2$ $2$ $1$ $1$ $1$ $1$ $2$	FSOC	Fragilaria cf. socia (N.M. Wallace) Lange-Bertalot 1980	0	0	0	0	0	ΜM	Z			40.69	24.53
Fragilaria variebration (Rutzing) I.B. Petersen 1938.       0       1       4       5       EU       0       2.1       38.5       2.11         Fragilaria variebratiae (Kutzing) I.B. Petersen 1938.       7       4       4       5       EU       0       2.1       38.5       2.11         Fragilaria variebratiae (Kutzing) I.B. Petersen 1938.       7       4       4       5       H       0       2.1       38.5       2.11         Getskrein dustimuce Novais & Exter 2013       6       0       0       0       0       w       2       9       2.05         Gomphonema arguarisatum (Kuting)       Rabe       3       4       0       0       0       w       2       1.23       1.26         Gomphonema discutificant (Ruting)       B       0       0       0       0       w       2       1.43       1.07         Gomphonema discutificant (String)       B       0 </td <td>FRAS</td> <td>Fragilaria sp.</td> <td>0</td> <td>0</td> <td>0</td> <td></td> <td>0</td> <td>ΜM</td> <td>Z</td> <td>2.9</td> <td>10.3</td> <td>13.08</td> <td>16.98</td>	FRAS	Fragilaria sp.	0	0	0		0	ΜM	Z	2.9	10.3	13.08	16.98
$ \begin{array}{rcrc} Farginaris vandervise (Ktizing) 1B. Petesen 1938. Fragilaris Members 1864 frame. Fragilaris Members 1864 frames and the statement of the statement (Ktizing) 1B. Petesen 1939. Fragilaris Members 1864 frames frame. The statement of the statement frame (Tamow) Lange-Bertalot 1990 frame and the statement of the sta$	FUAN	Fragilaria ulna Sippen angustissima (Grunow) Lange-Bertalot 1991	0	0	-	4	7	WΜ	z			2.73	1.89
Taginario aurderiae (Kinzing). I.B. Petersen 1938 s.1.       117       117         Gristeria decusis (Ostrup). Large-Bertalot & Meraclin 1996       0       3       4       TOL       117         Gristeria decusis (Ostrup). Large-Bertalot & Meraclin 1996       0       0       3       4       TOL       117         Gristeria decusis (Ostrup). Large-Bertalot & Meraclin 1996       0       0       0       0       ww       z       149       128         Gromphonema commutation Grunovo 1.880       0       0       0       0       ww       z       149       128         Gomphonema degenitismum E. Reichardt & Lange-Bertalot & E. Reichardt 1996       0       0       0       ww       z       123       1795       139         Gomphonema degenitismum E. Reichardt & Lange-Bertalot 1999       0       0       0       ww       z       123       1795       139         Gomphonema degenitism (Kuting Bs4       1       3       3       4       1       5       5       10       139       121       130         Gomphonema degenitism (Kuting Bs4       1       1       3       3       4       1       5       149       125       169       135       120       139       150       130 <td>FVAU</td> <td>Fragilaria vaucheriae (Kützing) J.B. Petersen 1938</td> <td>4</td> <td>4</td> <td>ю</td> <td>4</td> <td>S</td> <td>EU</td> <td><math>\diamond</math></td> <td>2.1</td> <td>38.5</td> <td>2.41</td> <td>1.89</td>	FVAU	Fragilaria vaucheriae (Kützing) J.B. Petersen 1938	4	4	ю	4	S	EU	$\diamond$	2.1	38.5	2.41	1.89
Coinstant description longer between the filting field unifamical transition of the filting field unifamical transition for the filting field unifamily filting field unifamily field unif		Fragilaria vaucheriae (Kützing) J.B. Petersen 1938 s.l.										1.17	3.77
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	GDEC	Geissleria decussis (Østrup) Lange-Bertalot & Metzeltin 1996	0	0	З	4	4	EU	$\diamond$			1.73	9.43
Complement angentum (Kitzing) Rabenhorst 1864         3         4         7 0L         *         7 0T           Complement commutant (Kitzing) Rabenhorst 1864         3         4         0         3         4         7 0L         *         7 07           Complement commutant (Kitzing) Rabenhorst 1864         3         3         4         0         0         0         0         0         0         0         www         Y         7 44         128         819           Complement system         Grouphonenu system         Excinate 11996         0         0         0         0         www         Y         7 44         128         819           Complement system         Kithous Name         3         4         3         3         4         3         3         2         3         4         3         3         5         1         9         5 <td< td=""><td></td><td>Geissleria lusitanica Novais &amp; Ector 2013</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1.21</td><td>3.77</td></td<>		Geissleria lusitanica Novais & Ector 2013										1.21	3.77
Complementation Granow 1880         0         0         0         0         0         0         0         w         z         149         1282 <i>Complonema exginistum</i> (Ennow) Lange-Bertalor 2011         0         0         0         0         0         w         z         149         128 <i>Complonema exgissitum</i> (Ennow) Lange-Bertalor 2011         0         0         0         0         w         z         143         513         199         123         1795         1199 <i>Complonema exgissitum</i> (Ennow) Lange-Bertalor 1999         0         0         0         0         w         X         44         128         519         266 <i>Complonema luiculum</i> E. Reichardt & Lange-Bertalor 1999         0	GANG	Gomphonema angustatum (Kützing) Rabenhorst 1864	З	4	0	б	4	TOL	*			7.07	1.89
Comploment elegantissimul E. Reichardt & Lange-Bertalot 2011         0         0         0         w         z         9.9         2.6 <i>Comploment elissimum</i> (Grunov)         3         3         1         w         7         4.4         1.28         8.19 <i>Comploment elissimum</i> (Grunov)         3         3         4         3         3         w         D         1.23         1.195         8.19 <i>Comploment insigniforme E. Reichardt</i> & Lange-Bertalot 1999         0         0         0         ww         Z         1.23         1.28         2.19         2.66         1.98 <i>Comploment insigniforme E. Reichardt</i> 2001         0         0         0         0         ww         Z         1.23         1.28         2.66         1.98 <i>Comploment algenula</i> furction         1831         0         0         0         0         0         0         3.7         2.66         1.98 <i>Comploment algenula</i> furction         1849         3         4         3         5         EU         3.7         2.6         1.98 <i>Comploment algenula</i> furction         1849         3         4         3         5         EU         3.3         0.	GCOM	Gomphonema commutatum Grunow 1880	0	0	0	0	0	WΜ	z	1.49	12.82		
<i>Gomphonema exilissium</i> (Grunow) Lange-Bertaloi & E. Reichardt 1996       0	GELG		0	0	0	0	0	WΜ	z	9.6	2.6		
<i>Gomphonema gracile</i> Ehrenberg 1838       3       4       3       3       4       3       3       ww       D       123       1795       1.99       0       0       0       ww       Z       1.42       S.13       0       0       0       ww       Z       1.42       S.13       0       0       0       ww       Z       1.42       S.13       1.98       0       0       0       ww       Z       1.23       1.95       1.98       0       0       0       0       ww       Z       1.42       S.13       2.56       1.98       0 </td <td>GEXL</td> <td>Gomphonema exilissimum (Grunow) Lange-Bertalot &amp; E. Reichardt 1996</td> <td>0</td> <td>0</td> <td>З</td> <td>б</td> <td>-</td> <td>WΜ</td> <td>&gt;</td> <td>4.4</td> <td>12.8</td> <td>8.19</td> <td>15.09</td>	GEXL	Gomphonema exilissimum (Grunow) Lange-Bertalot & E. Reichardt 1996	0	0	З	б	-	WΜ	>	4.4	12.8	8.19	15.09
Complonenta insigniforme E. Reichardt & Lange-Bertalot 1999000wwz1,425,13Complonenta lagendla Kitcing 184434000wwz1,282.66Complonenta lagendla Kitcing 18440000wwz1,282.66Complonenta lagendla Kitcing 18440000wwz1,232.66Complonenta lagendla Kitcing 18440000wwz1,232.66Gomphonenta aprindum Kitcing 184934155EU03.71.282.66Gomphonenta parvulum Kitcing 184934155EU03.71.94Gomphonenta parvulum Var. parvulum f. sprophilun Lange-Bertalot 199100000wwz1.94Gomphonenta parvulum Var. rigidum E. Reichardt & Lange-Bertalot 19910000wwz3.11.94Gomphonenta rombium Var. rigidum E. Reichardt & Lange-Bertalot 19910000wwz3.14.65Gomphonenta rombium Parvetaum Enveloped8434333.24.46Gomphonenta rombium var. rigidum E. Reichardt & Lange-Bertalot 19910000wwz3.14.46Gomphonenta rombium var. rigidum E. Reichardt & Lange-Bertalot & Lange-Bertalo	GGRA	Gomphonema gracile Ehrenberg 1838	З	4	З	б	З	ΜM	D	1.23	17.95	1.99	30.19
Complonent lagenda Kütcing 184434000wwR2.72.61.98Gomphonent attricting 1844Gomphonent attricting 18440000wwR2.72.61.98Gomphonent attricting 1849Gomphonent attricting 18490000003.72.61.98Gomphonent attricting 1849Gomphonent attricting 184934335FU03.72.61.94Gomphonent approxima Kitzing 1849340007EU03.251.94Gomphonent approximaGomphonent approximation (Grunow) E. Reichardt 19910007EU3.25.641.95Gomphonent approximaGomphonent approximation (Grunow) E. Reichardt 1991000000003.41.94Gomphonent approximation Schnidture R. Reichardt 1991000000000.33.51Gomphonent approximation Schnidture R. Reichardt 200534224.464.46Gomphonent approximation Enclorating Levico 2009343340000000000000000000000000000000000000 <td>GISF</td> <td></td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>WΜ</td> <td>z</td> <td>1.42</td> <td>5.13</td> <td></td> <td></td>	GISF		0	0	0	0	0	WΜ	z	1.42	5.13		
Gomphonema laricollum E. Reichardt 2001       0       0       0       0       ww       z       12.3       2.56         Gomphonema laricollum (C. Agardh) C. Agardh 1831       3       0       3       5       EU $0$ 3.7       1.28       2.66         Gomphonema parvulum var. parvulum f. xgrophilum Lange-Bertalot &       3       4       3       5       FU $0$ 3.7       12.8       2.66         Gomphonema parvulum var. parvulum f. xgrophilum Lange-Bertalot 1991       0       0       0       7       EU $0$ 3.3       194         Gomphonema punilum var. parvulum f. xgrophilum Lange-Bertalot 1991       0       0       0       0       ww       z       20.0       33.3       10.37         Gomphonema punilum var. rigidum E. Reichardt & Lange-Bertalot 1991       0       0       0       0       ww       z       20.0       33.3       10.37         Gomphonema punilum var. rigidum E. Reichardt & Lange-Bertalot 1991       0       0       0       ww       z       20.0       33.51       30.37         Gomphonema runuum var. rigidum E. Reichardt & Lange-Bertalot 1991       0       0       0       ww       z       21.7       493         Gomphonema runuum var. Reichardt & Lan	GLGN	Gomphonema lagenula Kützing 1844	ŝ	4	0	0	0	WΜ	R	2.7	2.6	1.98	7.55
Gomphonema minutum (C. Agardh 1831       0       0       0       3       5       EU $\otimes$ 3.7       12.8       2.66         Gomphonema aninutum (C. Agardh 1831       3       4       1       5       5       EU $\otimes$ 3.7       12.8       2.66         Gomphonema parvulum Kitzing 1849       3       4       1       5       5       EU $\otimes$ 3.5       10.4       3.97       3.97         Gomphonema parvulum Kitzing 1849       3       4       0       3       6       EU $\otimes$ 3.25       10.4       3.97       3.97         Gomphonema pumilum var. rgiulum Exage-Bertalot 8       Lange-Bertalot 8       Lange-Bertalot 997       0       0       0       0       wwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwww	GLTC	Gomphonema laticollum E. Reichardt 2001	0	0	0	0	0	ΜM	z	1.23	2.56		
Gomphonema ofivaceum (Hornemann) Brébisson 1838       3       4       1       5       5       EU $\circ$ 2.5       12.8         Gomphonema parvulum Kützing 1849       3       4       0       3       6       EU $\circ$ 3.97         Gomphonema parvulum Kützing 1849       3       4       0       3       6       EU $\circ$ 3.97         Gomphonema parvulum Var. parvulum f. saprophilum Lange-Bertalot 1991       0       0       0       7       EU $\circ$ 3.97       3.97         Gomphonema punilum (Grunow) E. Reichardt & Lange-Bertalot 1991       0       0       0       0       0       0       3.51       6.57       4.46         Gomphonema restrokieum Lange-Bertalot & E. Reichardt 1993       0       15       6	GMIN	Gomphonema minutum (C. Agardh) C. Agardh 1831	0	0	0	б	ŝ	EU	$\diamond$	3.7	12.8	2.66	13.21
Gomphonema parvulum Kützing 1849       3       4       3       5       TOL       5       3.2       56.4       1955         Gomphonema parvulum var. parvulum f. saprophilum Lange-Bertalot $\&$ 3       4       0       3       5       FUL       5       3.9       10.3       1.94         Gomphonema purilum var. parvulum f. saprophilum Lange-Bertalot 1991       0       0       0       7       EU       *       3.9       10.3       1.94         Gomphonema purilum var. rigidum E. Reichardt & Lange-Bertalot 1997       0       0       0       0       www       *       18.9       25.6       32.51         Gomphonema rhombicum M. Schmidt 1904       Comphonema rhombicum M. Schmidt 1904       0       0       0       0       www       *       18.9       25.6       32.51         Gomphonema rhombicum M. Schmidt 1904       0       0       0       0       0       www       *       18.9       25.6       32.51         Gomphonema rhombicum Lange-Bertalot Watzeltin & Witkowski 1993       0       0       0       0       www       *       12.3       30.77       4.93         Halamphorema runserhombicum Lange-Bertalot, Metzeltin & Witkowski 1996       3       4       3       4       4 <t< td=""><td>GOLI</td><td>Gomphonema olivaceum (Hornemann) Brébisson 1838</td><td>ŝ</td><td>4</td><td><del>, ,</del></td><td>S</td><td>ŝ</td><td>EU</td><td></td><td>2.5</td><td>12.8</td><td></td><td></td></t<>	GOLI	Gomphonema olivaceum (Hornemann) Brébisson 1838	ŝ	4	<del>, ,</del>	S	ŝ	EU		2.5	12.8		
Gomphonema parvulum var. parvulum f. saprophilum Lange-Bertalot & 3       4       0       3       6       EU $\diamond$ 3.97         E. Reichardt 1993       E. Reichardt (Sunow) E. Reichardt & Lange-Bertalot 1991       0       0       0       7       EU $\ast$ 3.9       10.3       1.94         Gomphonema pumilum (Grunow) E. Reichardt & Lange-Bertalot 1997       0       0       0       0       wwwwwart       20.0       33.3       10.37         Gomphonema pumilum var. rigidum E. Reichardt & Lange-Bertalot 1997       0       0       0       0       wwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwww	GPAR	Gomphonema parvulum Kützing 1849	ŝ	4	ŝ	ŝ	ŝ	TOL	◇ ·	3.2	56.4	19.55	67.92
Gomphonema punilum (Grunow) E. Reichardt & Lange-Bertalot 19910007EU*3.910.31.94Gomphonema punilum var. rigidum E. Reichardt & Lange-Bertalot 19070000wwz20.033.310.37Gomphonema rhombicum M. Schmidt 190400000wwz31.569.24.46Gomphonema rhombicum M. Schmidt 190400000wwz31.569.24.46Gomphonema rhombicum Lange-Bertalot 8 E. Reichardt 19930000wwz31.569.24.46Gomphonema runserhombicum Lange-Bertalot 8 E. Reichardt 19930000wwz31.569.24.46Gomphonema runserhombicum E. Reichardt 2005243435517.99.3Gomphonema uniserhombicum E. Reichardt 200534343424.46Hippodonema uniserhombicum Bukhiyarova 2006343434277.15Karayeia cleving (Grunow) Bukhiyarova 20063414470L*1.2110.262.44Karayeia cleving (Grunow) Bukhiyarova 200660000074.132.351.1677.15Luticola goeppertiana (Biston) Abal 20031.4134343432.442.34 <trr>Karayeia cleving (</trr>	GPAS	<i>Gomphonema parvulum</i> var. <i>parvulum</i> f. <i>saprophilum</i> Lange-Bertalot & F. Reichardt 1993	n	4	0	ŝ	9	EU	$\diamond$			3.97	3.77
Gomphonema pumium vortune       Component pumium vortune       Component pumium vortune       Comphonema pumium vortune       Comphonema vortu	GPLIM	Gomuhanama 1995 Gomuhanama numilum (Grunow) F Reichardt & I ange-Rentalot 1001	C	0	0	0	Ľ	HI1	*	3 0	10.3	1 04	0 43
Complorent pointerNon-Second Po	GPRI	Compronenta panatan (Otanow) 1. Mortana & Lange-Detator 1721 Comphonenta numilian var rividum F Reichardt & I anne-Bertalot 1007					~ 0		•	0.00	33.3	10.37	26.47
Gomphonema rosenstockianum Lange-Bertalot & E. Reichardt 19930000wwz31.569.24.46Gomphonema truncatumElmenberg 183224247.0L*2.217.9Gomphonema uniserhombicum E. Reichardt 200524355EU $\otimes$ 1.2330.77Halamphora veneta (Kützing) Levkov 200934355EU $\otimes$ 1.2330.77Halamphora veneta (Grunow) Lange-Bertalot, Metzeltin & Witkowski 199634344Wwz4.27.74.93Karayevia clevei (Grunow) Bukhtiyarova 20063434144Ww*1.2110.262.44Karayevia clevei (Grunow) Bukhtiyarova 200534144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200534144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200534144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200534144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200554435TOL $\%$ 3.231.715Luticola goeppertiana (Kützing) D.G. Mann 199054435705.23Luticola	GRHB	Gomphonema rhombicum M. Schmidt 1904						mm.	•	18.9	25.6	32.51	26.42
Gomphonema truncatumEhrenberg183224247143Gomphonema uniserhombicum E. Reichardt20050000000000123432141144133311133000	GROS	Gomphonema rosenstockianum Lange-Bertalot & E. Reichardt 1993	0	0	0	0	0	MM	Z	31.5	69.2	4.46	37.74
Gomphonema uniserhombicum E. Reichardt 2005000000wwz4.27.74.93Halamphora veneta (Kitizing) Levkov 200934355EU $\diamond$ 1.2330.77Halamphora veneta (Grunow) Lange-Bertalot, Metzeltin & Witkowski 199634355EU $\diamond$ 1.2330.77Hippodonta hungarica (Grunow) Bukhtiyarova 200634144Ww*1.2110.262.44Karayevia clevei (Grunow) Bukhtiyarova 20060034144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200634144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200634144Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 200634145Ww*1.2410.262.44Karayevia clevei (Grunow) Bukhtiyarova 2006342452077.15Luticola goeppertiana (Beisch in Rabenhorst) D.G. Mann 199054245Ww%5.23Luticola mutica (Kitizing) D.G. Mann 199034245Ww%5.833.31.72Melosira varians C. Agardh 182734245Ww%5.833.31.72 <t< td=""><td>GTRU</td><td>Gomphonema truncatum Ehrenberg 1832</td><td>2</td><td>4</td><td>2</td><td>4</td><td>4</td><td>TOL</td><td>*</td><td>2.2</td><td>17.9</td><td></td><td></td></t<>	GTRU	Gomphonema truncatum Ehrenberg 1832	2	4	2	4	4	TOL	*	2.2	17.9		
Halamphora veneta (Kitzing) Levkov 200934355EU $\diamond$ 1.2330.77Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin & Witkowski 199634344EU*1.2110.26Karayevia clevei (Grunow) Bukhtiyarova 200634144Ww*1.2410.262.44Karayevia oblongella (Østrup) Aboal 2003003345EU $\diamond$ 41.128.277.15Luticola goeppertiana (Bleisch in Rabenhorst) D.G. Mann 199000345EU $\diamond$ 2.23Luticola mutica (Kützing) D.G. Mann 199054435TOL $\diamond$ 5.23Luticola mutica Kützing) D.G. Mann 199034245Ww $\diamond$ 5.23Luticola mutica Kützing) D.G. Mann 199034245Ww $\diamond$ 5.23Navicula agnita Hustedt 195534245Ww $\diamond$ 5.33.3	GURH	Gomphonema uniserhombicum E. Reichardt 2005	0	0	0	0	0	ΜM	z	4.2	T.T	4.93	15.09
Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin & Witkowski 1996 $3$ $4$ $3$ $4$ $1$ $4$ $1$ <	HVEN	Halamphora veneta (Kützing) Levkov 2009	ю	4	ю	S	S	EU	$\diamond$	1.23	30.77		
Karayevia clevei (Grunow) Bukhtiyarova 200634144ww*1.2410.262.44Karayevia oblongella (Østrup) Aboal 2003003310V41.128.277.15Luticola goeppertiana (Bleisch in Rabenhorst) D.G. Mann 199000345EU $\diamond$ 2.23Luticola mutica (Kützing) D.G. Mann 199054435TOL $\diamond$ 5.24Melosira varians C. Agardh 182734245ww $\diamond$ 5.833.31.72Navicula agnita Hustedt 195521000000wwz5.56	<b>HHUN</b>	Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin & Witkowski 1996	Э	4	3	4	4	EU	*	1.21	10.26		
Karayevia oblongella (Østrup) Aboal 2003       0       0       3       3       1       0       V       41.1       28.2       77.15         Luticola goeppertiana (Bleisch in Rabenhorst) D.G. Mann 1990       0       0       3       4       5       EU $\diamond$ 2.23         Luticola mutica (Kützing) D.G. Mann 1990       5       4       4       3       5       TOL $\diamond$ 6.52         Melosira varians C. Agardh 1827       3       4       2       4       5       ww $\phi$ 5.3       1.72         Navicula agnita Hustedt 1955       2       1       0       0       0       ww $z$ 1.33       2.56	KCLE	Karayevia clevei (Grunow) Bukhtiyarova 2006	З	4	-	4	4	ΜM	*	1.24	10.26	2.44	15.09
Luticola goeppertiana (Bleisch in Rabenhorst) D.G. Mann 199000345EU $\diamond$ 2.23Luticola mutica (Kützing) D.G. Mann 199054435TOL $\diamond$ 6.52Melosira varians C. Agardh 182734245ww $\diamond$ 5.833.31.72Navicula agnita Hustedt 195521000wwz1.332.56	KOBG	Karavevia oblongella (Østrup) Aboal 2003	0	0	Э	ю	1	0	>	41.1	28.2	77.15	56.60
Luticola mutica (Kützing) D.G. Mann 1990       5       4       4       3       5       TOL       6       6.52         Melosira varians C. Agardh 1827       3       4       2       4       5       ww       6       5.8       33.3       1.72         Navicula agnita Hustedt 1955       2       1       0       0       0       ww       2       1.33       2.56	LGOE	Luticola goeppertiana (Bleisch in Rabenhorst) D.G. Mann 1990	0	0	ŝ	4	Ś	EU	$\diamond$			2.23	3.77
Melosira varians C. Agardh 1827         3         4         2         4         5         ww         0         5.8         33.3         1.72           Navicula agnita Hustedt 1955         2         1         0         0         0         ww         z         1.33         2.56	LMUT	Luticola mutica (Kützing) D.G. Mann 1990	ŝ	4	4	ŝ	ŝ	TOL	$\diamond$			6.52	1.89
<i>Navicula agnita</i> Hustedt 1955 2.56 2.56	MVAR	Melosira varians C. Agardh 1827	З	4	0	4	S	WΜ	$\diamond$	5.8	33.3	1.72	33.96
(Continue)	NAGI	Navicula agnita Hustedt 1955	0	1	0	0	0	WΜ	z	1.33	2.56		
												0	1 and in the second

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Table. (Continued)

(Continues)

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Code NANT NA NCTT NA NCRY NA NCTE NA NGRE NA	Taxon name		Σ	11	E	ţ	, I	VID V	EDEO		
		Н		Ηd	-	Щ	RL	MINA	ZUEX	MRA	FREQ
	Navicula antonu Lange-Bertalot 2000	60 C C	0 0	4 0	S	EU	\$ \$	1.24	20.51		
	Navicula cataracta-rheni Lange-Bertalot 1993		⊃ (	⊃ (	) r		¥ <	7.7	0.1		- - -
	Navicula cryptocepnata Nulshig 1044	→ t n t	4 0	o ∠	- ٢		> <	2.C 1 40	C.UI	17.1	17.01
	Navicula cryptotenella Lange-Bertalot 1963	υ ( 4 -	10	4 .	- 1	IUL	> <	1.40	10.02	00.71	52.08
	Navicula gregaria Donkin 1861	-	S.	4	0	HAL	⊳ '	I4.9	48.7	5.95	54.72
	Navicula lanceolata (C. Agardh) Kützing 1844		c	4	S	EU	$\diamond$			3.86	9.43
	Navicula notha J.H. Wallace 1960	0 0	0	0	0	0	IJ	3.0	T.T	6.90	22.64
NRAD No	Navicula radiosa Kützing 1844	ъ 4	ŝ	С	4	TOL	$\diamond$	4.2	20.5		
NRCH No	Navicula reichardtiana Lange-Bertalot 1989	0 0	0	4	0	EU	$\diamond$			0.99	5.66
NRHY No	Navicula rhvnchocephala Kützing 1844	ю 4	0	4	L	TOL	$\diamond$			2.47	18.87
	Navicula rostellata Kützing 1844	2 0	0	4	5	EU	$\diamond$	1.22	2.56	2.47	13.21
	Navicula sublucidula Hustedt 1950			- C		EII	*	66 U	2.56	i	
	Navicula symmetrica R M Patrick 1044	0 4 0	о (f	7	v	FII	<	1 47	10.26	1 73	1 80
	Navicula trinunctata (O.F. Miiller) Rory 1877	. 4	) (r	- 4	v	EII	• <	307	12.80	22.20	16.98
	Navioula neparata (O.1. Multa) DOLJ 1021 Manipula nonota Viitzina 1944	) < 1	<i>0</i> 9	+ -	n v	БЦ П	> <	1 1 1 1	0.21 66.7	2 60	11 51
	unuuu reneuu nuusiiig 1077 Herolois aaidoolimata Lonco Domoloi 1076	+ <	<i>.</i> .	t (	0 C		> *		1.00	00.0	10.01
			n d	<del>،</del> ں	n i		)	1.0	14.0	1. 0.1 0.1	10.01
	Nitzschia amphibia Grunow 1862	4	n,	4	<b>n</b>	IOL	K	1.6	0.02	7.07	24.53
	Nitzschia brevissima Grunow 1881	ю 4	ŝ	c	S	HAL	$\diamond$			2.17	3.77
NCPL Ni	Nitzschia capitellata Hustedt 1922	3 0	ŝ	4	9	EU	$\diamond$			1.86	9.43
NCLA Ni	Nitzschia clausii Hantzsch 1860	3 0	Э	4	5	EU	$\diamond$	1.23	5.13		
NDIS Ni	Nitzschia dissipata (Kützing) Grunow 1862	ъ 4	С	4	4	EU	$\diamond$			2.56	20.75
NFON Ni	Nitzschia fonticola (Grunow) Grunow 1881	8	1	4	4	EU	$\diamond$	2.7	10.3	8.94	15.09
NIFR Ni	Nitzschia frustulum (Kützing) Grunow 1880	4	ŝ	4	S	EU	$\diamond$			1.24	5.66
NHAN Ni	Nitzschia hantzschiana Rabenhorst 1860	ю 4	4	З	З	TOL	*			5.58	3.77
NINC Ni	Nitzschia inconspicua Grunow 1862	0 0	З	4	S	EU	$\diamond$	32.8	69.2	21.21	41.51
NMIC Ni	Nitzschia microcephala Grunow 1880	ъ 4	1	4	S	HAL	$\diamond$	3.2	17.9	1.49	11.32
NPAL Ni	Nitzschia palea (Kützing) W. Smith 1856	4	e	ŝ	9	EU	$\diamond$			1.46	13.21
NPAE Ni	Nitzschia paleacea Grunow in Van Heurck 1881	ъ 4	0	4	5	EU	$\diamond$			0.99	13.21
NIPM Ni	Nitzschia perminuta (Grunow in Van Heurck) M. Peragallo 1903	0 0	С	4	0	TOL	*	3.2	5.1		
NIPU Ni	Nitzschia pusilla (Kützing) Grunow emend. Lange-Bertalot 1976	0 0	б	З	Г	EU	$\diamond$			0.99	1.89
_	Nitzschia supralitorea Lange-Bertalot 1979	3 0	4	Э	5	EU	$\diamond$	1.22	25.64	1.20	16.98
	<i>Pinnularia gibba</i> Ehrenberg 1843	ъ 4	0	ŝ	L	EU	$\diamond$			0.98	1.89
PMIC Pi	Pinnularia microstauron (Ehrenberg) Cleve 1891	4	С	ω	L	OD	>			1.23	7.55
PNCO PI	Planothidium conspicuum (A. Mayer) Aboal 2003	0 0	1	С	7	ΜM	z			0.98	3.77
PTDE PI	Planothidium delicatulum (Kützing) Round & Bukhtiyarova 1996	33	С	5	ю	ΜM	*			2.44	5.66
PLEN PI	Planothidium engelbrechtii (Cholnoky) Round & Bukhtivarova 1996	0 0	0	S	0	ΜM	*	2.0	7.7		
	Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot 1999	0 0	0	4	L	EU	$\diamond$	76.9	84.6	37.16	71.70
PGRN PI	Planothidium granum (M.H. Hohn & Hellerman) Lange-Bertalot 1999	0 0	С	0	0	ΜM	•			0.98	3.77
PHAY PI	Planothidium haynaldii (Schaarschmidt) Lange-Bertalot 1999	0 0	С	4	7	ΜM	D			4.19	3.77
PTLA PI	Planothidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot 1999	4	ŝ	4	2	TOL	$\diamond$	13.4	43.6	6.67	35.85
_	Planothidium minutissimum (Krasske) Lange-Bertalot 1999	0 0	0	0	0	ΜM	z	20.2	2.6		
PLEV PI	Pleurosira laevis (Ehrenberg) Compère 1982	3 0	Э	5	5	HAL	$\diamond$			2.72	1.89

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Table. (Continued)

DIATOMS OF TEMPORARY AND PERMANENT WATERCOURSES

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Table. (C	Table. (Continued)										
								Temp	Temporary	Permanent	anent
Code	Taxon name	Н (	C		pH T	Щ	RL	MRA	FREQ	MRA	FREQ
PALV PSBR DSSE	Pseudostaurosira alvareziae Cejudo-Figueras, E. Morales & Ector 2011 Pseudostaurosira brevistriata (Grunow) D.M. Williams & Round 1987	0 % 0	040		044	MM	N 🔷 *	5.7	20.5	31.01 15.14 5.54	16.98 1.89 0.42
RSIN	Pseudostatuostra etupica (Schultanti) Educati, E. Motales & S.A. Spaulding 2006 Reineria strutata (W. Gregory) Kociolek & Stoermer emend. S.E. Sala, M. G. S. S. S. 1003	0 m	- 4 - 6		+ m	TOL	<	26.6	61.5	+C.C	60.38
RUNI	J.M. GUERTERO & FERTATIO 1993 Reimeria uniseriata S.E. Sala, J.M. Guerrero & Ferrario 1993	0		0	0	ww	z	12.5	33.3	2.72	18.87
RABB	Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot 1980				4 5	EU	$\diamond$	4.5	28.2	9.36	18.87
RADT	Rhoicosphenia adriatica Caput Mihalić & Levkov 2010					MM	Z	1		42.64	1.89
RGIB	Rhopalodia gibba (Ehrenberg) O. Müller 1895	ς, τ Γ	4 -		v v v	EU	* <	2.7	5.6 7 1		
SSEM	<i>Seuapnora puputa</i> (Kutzing) Merescinkowsky 1902 Sellamhora seminulum (Grunow) D G Mann 1989		7 7 7 7			EU	> <	0.1 ح 4	33.3	1 24	24 53
SEXG	Stauroforma exiguiformis (Lange-Bertalot) Flower, Jones &				. 1	MM	ŝ	2		6.01	1.89
SBND	Staurosira binodis (Ehrenberg) Lange-Bertalot 2011	3	+	°,	4	ММ	*	2.5	2.6	0.96	7.55
SSPE	Staurosira sp.	0	0	- -	0	WM	z	2.2	7.7		
SSVE	Staurosira venter (Ehrenberg) H. Kobayasi 2002	3	+		4		$\diamond$	29.7	28.2	36.30	26.42
SPIN	Staurosirella pinnata (Ehrenberg) D.M. Williams & Round 1987	4	4	e,	4 7	TOL	$\diamond$	3.4	10.3	2.64	7.55
TFLO	Tabellaria flocculosa (Roth) Kützing 1844	-	4				$\diamond$	0.99	2.56		
NUHT	Tryblionella hungarica (Grunow) D.G. Mann 1990	3			4 5		$\diamond$			1.40	11.32
UACU	Ulnaria acus (Kützing) Aboal 2003		4		4 5	-	*	1.0	17.9		
UBIC			0 0			0	IJ	2.6	23.1	3.47	28.30
UDEL	Ulnaria delicatissima (W. Smith) Aboal & P.C. Silva 2004	0	0		000	ΜM	z	13.6	2.6		
NULN	Ulnaria ulna (Nitzsch) Compère 2001	3	+		4	WM	*	8.6	20.5	1.72	35.85

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