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Diatom species composition in the sediment core of Plešné Lake (Bohemian Forest, Czech Republic)

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Abstract
Species composition of fossil diatom (Bacillariophyceae) assemblages of a long sediment core (400 cm) from Plešné Lake located in the Bohemian Forest was studied. This core covered a 13 000 year record. Together 183 species of diatoms were recorded; most of them pennate diatoms. Thirty nine species with the abundance >5% were found. Assemblages of diatoms in different layers of sediment varied in species composition and relative abundance. In the upper part of the core acidophilous taxa prevailed (*Tabellaria ventricosa*, *Achnanthes helvetica, Aulacoseira distans, A. alpigena*, *Frustulia rhomboides*, and *F. rhomboides* var. *saxonica*), while in the bottom part alkaliphilous diatoms were the most numerous (*Fragilaria* spp).

Key words: species composition, diatom assemblages, sediment core, Bohemian Forest, Plešné Lake

Introduction

High mountain lakes are considered as excellent indicators of environmental changes. Despite their remoteness and negligible direct human impact in catchments, they are threatened by acid deposition, toxic air pollutants and climate change (Wathne et al. 1995). Lake sediments represent specific primary archives containing important data of past environmental changes. Diatom investigations of the lakes in Europe have been focused mainly on the period of the last 200 years. The investigation of Holocene lake development has not been made so often (e.g. Battarbee 1984, Jones et al. 1989, Renberg 1990, Schmidt et al. 2002, 2006).

The area of mountain lakes in the Bohemian Forest has been studied for a long period from both chemical and biological points of view. Fott et al. (1994) studied mountain lakes in the Bohemian Forest and in the High Tatra Mountains with emphasis on acidification. The history and impact of air pollution of Čertovo Lake, southwestern Czech Republic has been described by Veselý et al. (1993). Kopáček et al. (1998) focused on historical changes in lake acidification. The long-term limnological research of the Bohemian Forest lakes was reviewed by Vrba et al. (2000, 2003). More papers were aimed at ecological research of catchment-lake ecosystems in the Bohemian Forest (for review, see Kopáček & Vrba 2006). In long-term studies, the attention was paid to acidification and recovery of lakes in this area (Vrba et al. 2003, Nedbalová et al. 2006).

The research concerning diatom species composition the lake Plešné has not been performed yet.

Material and methods

Study area

Plešné Lake is situated in the Bohemian Forest (=the Šumava Mountains) at an altitude of 1087 m a.s.l. (48°47' N, 13°52' E) at climatically sensitive place. The small lake is of glacial origin (area of 7.5 ha, volume 617 000 m^3, maximum depth 18 m) and surrounded by steep forested rocky slopes. The watershed of Plešné Lake is 66.6 ha, and the bedrock is made up of granites (Veselý, 1994, Nedbalová et al. 2006). Plešné Lake is a dimictic, oligotrophic up to mesotrophic lake with anoxia in the hypolimnion during both winter and summer stratification periods (Kopáček et al. 2000). The Bohemian Forest was exposed to heavy atmospheric pollution during the last century. Owing to small and geologically sensitive catchments, some changes in acid deposition were reflected in the water composition and biota (Vrba et al. 2000, Kopáček et al. 2001).

Sampling

The sediment core (540 cm) was taken in 1990 by R. Schmidt and co-workers (Institute for Limnology of the Austrian Academy of Sciences, Mondsee, Austria) with a modified Kullenberg piston corer close to the deepest point of the lake and was consequently sectioned into 3 cm intervals. For the analysis of diatoms 0.2 g (from the depth 0–298 cm) or 1 g (from the depth of 298 cm to the bottom part) of sediment was used.

Dating

The dating of selected sediment samples (AMS radiocarbon dating; comparison of rubidium concentration with ^{18}O in Greenland ice) was provided by J. Veselý. The dating and analyses of the long core showed that the sediment record spans the lake history since its de-glaciation ~14 600 years ago (Pražáková et al. 2006).

Laboratory and data analysis

For the diatom analysis permanent slides were prepared following standard preparation techniques (Battarbee 1986) using hydrogen peroxide as an oxidant of the organic matter present in the samples. Cleaned diatom frustules were mounted in a high refractive index medium Naphrax (RI = 1.7). Diatoms were identified using a LEICA DMLB microscope under oil immersion at a objective magnification of 100×. Diatom identification and taxonomy was based mainly on the following publications: Krammer & Lange-Bertalot (1986, 1988, 1991a, b) and Lange-Bertalot & Krammer (1989).

The diatom percentage diagram was created using the program TG VIEW version 2.0.2 (Grimm, 2004). The zones were defined using CONISS (constrained incremental sum of squares cluster-analysis) which is an element of this program.

Results and discussion

Altogether 183 species were identified (Table 1). Species composition from different layers varied mainly in abundance of individual diatom species. Thirty nine species were found in abundance higher than 5%, from those 10 species reached abundance higher than 15%.

On the basis of the presence of diatom taxa and their relative abundance the entire core could be divided into 7 zones with the help of the cluster analysis (Fig. 1).

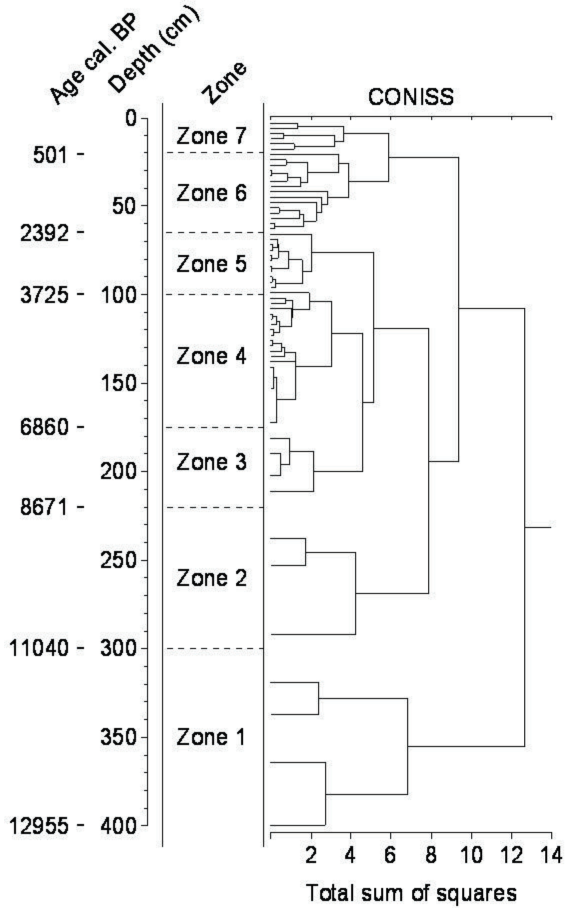

Fig 1. Cluster analysis diagram of diatoms from the sediment core of Plešné Lake.

Zone 1 (400–300 cm, 12995–11040 BP)

In the deepest part of the core, the dominant diatom assemblage consisted of more species of the genus *Fragilaria*, mainly *Fragilaria pseudoconstruens*, which reached proportion higher than 40%. Other abundant *Fragilaria* species were *F. pinnata*, *F. tenera*, and *F. brevistriata*. All these species did not occur in other parts of the sediment. Other diatoms present only in this deepest part were *Achnanthes calcar*, *Aulacoseira italica*, *Caloneis bacillum*, *Navicula schmassmannii*, and *Pinnularia interrupta*.

Zone 2 (300–220 cm, 11040–8671 BP)

In this part of the core centric diatoms *Aulacoseira distans* and *A. pfaffiana* prevailed. The latter one reached the abundance of 20%. *Cymbella gaeumannii* and *Navicula gallica* var. *perpusilla* were also abundant in this zone (reached about 10%), while in other parts of the sediment these species were not present. Numbers of *Tabellaria ventricosa* also increased in comparison with the bottom part of the core.

Zone 3 (220–175 cm, 8671–6860 BP)

Aulacoseira distans and *A. pfaffiana* formed nearly 40% of diatom assemblage. *Brachysira brebissonii*, *Achnanthes subatomoides*, and *Stauroneis gracillima* from this zone formed stable component of the assemblages although the abundance was not high. More species from the genus *Eunotia* – *E. exigua*, *E. incisa*, *E. microcephala*, *E. rhomboidea* were found in the assemblage and occurred in the upper part of the sediment of this zone with proportion about 5%. *Asterionella ralfsii* was recorded for the first time in this zone while in the deeper zones was not found.

Zone 4 (175–100 cm, 6860–3725 BP)

Again, in some layers of this part of the sediment core centric diatoms created more than 30% of all diatoms. From these *Aulacoseira distans* markedly prevailed. Other numerous species were *Eunotia incisa*, *Navicula mediocris*, *Stauroneis gracillima*, and *Tabellaria ventricosa*. Abundance of *Asterionella ralfsii* also increased. *Brachysira brebissoni* (with abundance < 5%) and some *Eunotia* species, mainly *E. incisa* (4–10%) were stable component of diatom assemblages.

Zone 5 (100–65 cm, 3725–2392 BP)

In some parts of the zone 5 (95–78 cm) *Aulacoseira distans* formed as many as ca. 30% of diatom assemblages. As well the *Aulacoseira alpigena* was in these layers the most numerous species along the part of all sediment core. Proportion of *Tabellaria ventricosa* varied between 7 and 15%. Species *Navicula mediocris* and *Stauroneis gracillima* reached abundance from 5 to 9%.

Zone 6 (65–20 cm, 2392–501 BP)

In the layers 65 to 20 cm further changes were recorded. Number of *Asterionella ralfsii* increased markedly, it reached proportion up to 40% of all assemblages in the layers 51–45 cm. In other layers these numbers decreased. *Aulacoseira distans* created stabile part of assemblage with values of abundance > 10%. In the part of the core above 33 cm, numbers of species *Achnanthes helvetica* started to increase. The increase of *N. mediocris* was registered as well, its proportion amounted to 13% in the layers 65–24 cm. Relative quantity of *Stauroneis gracillima* ranged from 5 to 9%. Proportion of *Tabellaria ventricosa* was quite low (4–8%) with the exception of layers between 27 and 20 cm, where it reached 11%.

Zone 7 (20–0 cm, 501–present)

In the upper sediment, the greatest part of the diatom assemblages was created by *Tabellaria ventricosa* (up to 30%), minor part was represented by species such as *Achnanthes helvetica* (up to 14%), *A. marginulata* (up to 11%), numbers of *Aulacoseira distans* decreased. *Frustulia rhomboides* var. *saxonica* and *Gomphonema gracile* reached proportion higher than 5% only in these upper layers.

Conclusions

Species composition of diatom assemblages in Plešné Lake was typical for the mountain lakes. The 540 cm long core covers a period of about 13 000 years. Small benthic alkaliphilic *Fragilaria* taxa prevailed in the bottom part of the lake sediment where these species reached their highest abundance (Fig. 2).

Rich occurrence of *Asterionella ralfsii* mainly from 63 cm to 9 cm of the sediment was very interesting, as the species is typical for acidic waters with high Al concentrations (Dixit

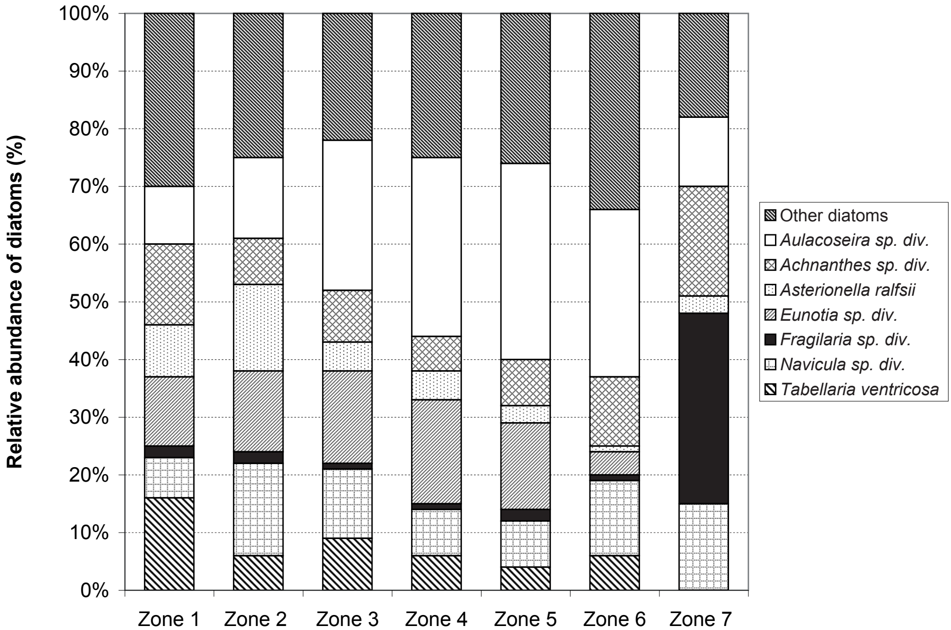

Fig. 2. Relative abundance of the most numerous diatom genera in different zones of the sediment core of Plešné Lake.

et al. 2002). This species was recorded for the first time on the territory of the Czech Republic.

The upper part of the core (ca. 20 cm) was clearly affected by acidification with evident presence of acidophilous taxa such as *Tabellaria ventricosa* (which reached here the highest percentage of the assemblages), *Achnanthes helvetica*, *Aulacoseira distans*, *A. alpigena, Frustulia rhomboides*, and *F. rhomboides* var. *saxonica*. Predominance of the acidophilous species in the upper part of the sediment core was also confirmed in other high mountain lakes with pH lower than 6 (Koinig et al. 1998, Tolotti 2001, Marchetto et al. 2004). The presence of acidobiontic species *Eunotia exigua* and *Navicula subtilissima* in the upper part of the core also denote decreased (low) pH in the lake (Battarbee 1984).

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References

Battarbee R.W., 1984: Diatom analysis and the acidification of lakes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 305: 451–477.

Battarbee R.W., 1986: Diatom analysis. In: *Handbook of Holocene palaeoecology and palaeohydrology*, Berglund B.E. (ed.) John Wiley & Sons, Chicester, 527–570.

Dixit S.S., Dixit A.S. & Smol J.P., 2002: Diatom and chrysophyte transfer functions and inferences of post-industrial acidification and recovery trends in Killarney lakes (Ontario, Canada). *Journal of Paleolimnology*, 27: 79–96.

Grimm E.C., 2004: TGView, version 2.0.2
Jones V.J., Stevenson A.C. & Battarbee R.W., 1989: Acidification of lakes in Galloway, south west Scotland: a diatom and pollen study of the post-glacial history of Round Loch of Glenhead. *Journal of Ecology*, 77: 1–23.
Koinig K.A., Schmidt R., Somaruga-Wograth S., Tessadri R. & Psenner R., 1998: Climate change as the primary cause for pH shifts in a high alpine lake. *Water, Air, and Soil Pollution*, 104: 167–180.
Kopáček J., Hejzlar J., Stuchlík E., Fott J. & Veselý J., 1998: Reversibility of acidification of mountain lakes after reduction in nitrogen and sulphur emissions in Central Europe. *Limnology and Oceanography*, 43: 357–361.
Kopáček J., Hejzlar J., Borovec J., Porcal P. & Kotorová I., 2000: Phosphorus inactivation by aluminum in the water column and sediments: Lowering of in-lake phosphorus availability in an acidified watershed-lake ecosystem. *Limnology and Oceanography*, 45: 212–225.
Kopáček J., Veselý J. & Stuchlík E., 2001: Sulphur and nitrogen fluxes and budgets in the Bohemian Forest and Tatra mountains during the industrial revolution (1850–2000). *Hydrology and Earth System Sciences*, 5: 391–405.
Kopáček J. & Vrba J., 2006: Integrated ecological research of catchment-lake ecosystems in the Bohemian Forest (Central Europe): A preface. *Biologia,* 61/Suppl. 20: 363–370.
Krammer K. & Lange-Bertalot H., 1986: *Bacillariophyceae, 1. Teil: Naviculaceae*. Süßwasserflora von Mitteleuropa 2/1**,** Gustav Fischer Verlag, Jena, 876 pp.
Krammer K. & Lange-Bertalot H., 1988: *Bacillariophyceae, 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae*. Süßwasserflora von Mitteleuropa 2/2, Gustav Fischer Verlag, Jena, 596 pp.
Krammer K. & Lange-Bertalot H., 1991a: *Bacillariophyceae, 3. Teil: Centrales, Fragilariaceae, Eunotiaceae*. Süßwasserflora von Mitteleuropa 2/3, Gustav Fischer Verlag, Stuttgart & Jena, 576 pp.
Krammer K. & Lange-Bertalot H., 1991b: *Bacillariophyceae, 4. Teil: Achnanthaceae, Kritische Erganzungen zu Navicula (Lineolate) und Gomphonema*. Süßwasserflora von Mitteleuropa 2/4, Gustav Fischer Verlag, Stuttgart & Jena, 437 pp.
Lange-Bertalot H. & Krammer K., 1989: *Achnanthes, eine Monographie der Gattung mit Definition der Gatung Cocconeis*. Bibliotheca Diatomologica. Band 18, J. Cramer, Berlin & Stuttgart, 393 pp.
Marchetto A., Mosello R., Rogora M., Manca M., Boggero A., Morabito G., Musazzi S., Tartari G.A., Nocentini A.M., Pugneti A., Bettinetti R., Panzani P., Armiraglio M., Cammarano P. & Lami A., 2004: The chemical and biological response of two remote mountain lakes in the Southern Central Alps (Italy) to twenty years of changing physical and chemical climate. *Journal of Limnology*, 63: 77–89.
Nedbalová L., Vrba J., Fott J., Kohout L., Kopáček J., Macek M. & Soldán T., 2006: Biological recovery of the Bohemian Forest lakes from acidification. *Biologia,* 61/Suppl. 20: 453–466.
Poulíčková A., Lhotský O. & Dřímalová D., 2004: Prodromus siníc a řas České republiky. Review of Cyanobacteria and algae of the Czech Republic. *Czech Phycology,* 4: 19–33.
Pražáková M., Veselý J., Fott J., Majer V. & Kopáček J., 2006: The long-term succession of cladoceran fauna and environmental conditions: a 14,600 – year record from Plešné Lake, the Bohemian Forest. *Biologia,* 61/Suppl. 20: 387–399.
Renberg I., 1990: A 12600 year perspective of the acidification of Lilla Öresjön, southwest Sweden. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 327: 357–361.
Schmidt R., Koinig K.A., Thompson R. & Kamenik C., 2002: A multi proxy study of the last 7000 years of climate and alpine land-use impacts on an Austrian mountain lake (Unterer Landschitzsee, Niedere Tauern). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 187: 101–120.
Schmidt R., Kamenik C., Tessadri R. & Koinig K.A., 2006: Climatic changes from 12,000 to 4,000 years ago in the Austrian Central Alps tracked by sedimentological and biological proxies of a lake sediment core. *Journal of Paleolimnology*, 35: 491–505.
Tolotti M., 2001: Phytoplankton and littoral epilithic diatoms in high mountain lakes of the Adamello-Brenta Regional Park (Trentino, Italy) and their relation to trophic status and acidification risk. *Journal of Limnology*, 60: 171–188.
Veselý J., 1994: Investigation of the nature of the Šumava lakes. A review. *Časopis Národního Muzea Praha, Řada přírodovědná*, 163: 103–120.
Veselý J., 2000: The history of metal recorded in the sediments of Bohemian Forest lakes: Since the Bronze Age to the present. *Silva Gabreta*, 4: 147–165.
Veselý J., Almquist-Jacobson H., Miller L.M., Norton A.N., Appleby P., Dixit A.S. & Smol J.P., 1993. The history and impact of air pollution at Čertovo Lake, southwestern Czech Republic. *Journal of Paleolimnology*, 8: 211–231.
Vrba J., Fott J. & Kopáček J., 2000: Long-term limnological research of the Bohemian Forest lakes and their recent status. *Silva Gabreta*, 4: 7–28.
Vrba J., Kopáček J., Fott J., Kohout L., Nedbalová L., Pražáková M., Soldán T. & Schaumburg J., 2003: Long-

-term studies (1871–2000) on acidification and recovery of lakes in the Bohemian Forest (central Europe). *The Science of the Total Environment*, 310: 73–85.
Wathne B.M., Patrick S.T., Monteith D. & Barth H. (eds), 1995: *AL:PE project part 1: AL:PE – Acidification of Mountain Lakes: Paleolimnology and Ecology. AL:PE 1 Report for the periode April 1991 – April 1993*. Ecosystem Research Report No. 9. European Commission, D-G XII, Brussels, 296 pp.

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Table 1. Species composition of diatoms from the sediment core of Plešné Lake. Diatom identification and taxonomy was based mainly on Krammer & Lange-Bertalot (1986, 1988, 1991a, b) and Lange-Bertalot & Krammer (1989). Explanations: + presence of species in the sediment core (in 7 zones).

Species	Zones	Z7	Z6	Z5	Z4	Z3	Z2	Z1
Achnanthes biasolettiana Grunow			+	+	+	+		
Achnanthes bioretii Germain		+						
Achnanthes calcar Cleve								+
Achnanthes carissima Lange-Bert.							+	
Achnanthes curtissima H.J. Carter					+		+	+
Achnanthes helvetica (Hust.) Lange-Bert.		+	+	+	+	+	+	+
Achnanthes cf. *imperfecta* Schimanski		+		+	+	+		
Achnanthes lacus-vulcani Lange-Bert. et Krammer							+	
Achnanthes lanceolata (Bréb. ex Kütz.) Grunow		+	+			+		
Achnanthes laterostrata Hust.								+
Achnanthes levanderi Hust.						+		+
Achnanthes marginulata Grunow		+	+	+	+	+	+	
Achnanthes minutissima Kütz.		+	+	+			+	+
Achnanthes oblongella Oestrup			+	+	+		+	
Achnanthes pericava Carter			+	+	+	+	+	
Achnanthes subatomoides (Hust.) Lange-Bert.		+	+	+	+	+	+	+
Achnanthes suchlandtii Hust.								+
Achnanthes sp.		+	+	+	+			+
Achnanthes / Navicula			+	+				
Amphora libyca Ehrenb.								+
Amphora pediculus (Kütz.) Grunow				+				+
Brachysira brebissonii R. Ross in Hartley		+	+	+	+	+		
Brachysira serians (Bréb. ex Kütz.) Round & Mann					+			
Brachysira vitrea (Grun.) R. Ross in Hartley				+				
Asterionella formosa Hassall								+
Asterionella ralfsii W. Smith		+	+	+	+	+	+	
Aulacoseira alpigena (Grunow) Krammer			+	+	+	+		
Aulacoseira ambigua (Grunow) Simonsen		+		+	+	+	+	
Aulacoseira distans (Ehrenb.) Simonsen		+	+	+	+	+	+	+
Aulacoseira distans var. *nivalis* (W. Sm.) Brun				+	+	+		
Aulacoseira italica (Ehrenb.) Simonsen								+
Aulacoseira pfaffiana (Reinsch) Krammer					+	+	+	
Aulacoseira valida (Grunow) Krammer			+				+	
Aulacoseira sp.		+	+		+	+	+	+
Caloneis alpestris (Grunow) Cleve								+
Caloneis bacillum (Grunow) Cleve		+						+
Caloneis molaris (Grunow) Krammer							+	
Cocconeis placentula Ehrenb.		+	+				+	
Cymbella cf. *aequalis* W. Sm.			+	+	+	+		
Cymbella caespitosa (Kütz.) Brun								+
Cymbella elginensis Krammer							+	+
Cymbella gracilis (Ehrenb.) Kütz.				+	+	+	+	+
Cymbella gaeumannii Meister		+	+	+	+	+	+	+
Cymbella hebridica (Grunow) Cleve			+	+			+	

Table 1. Continued.

Species	Zones	Z7	Z6	Z5	Z4	Z3	Z2	Z1
Cymbella laevis Naegeli		+	+					
Cymbella minuta Hilse		+		+	+	+		+
Cymbella naviculiformis (Auersw.) Cleve								+
Cymbella perpusilla A. Cleve			+	+	+	+		
Cymbella sinuata Greg.		+						+
Cymbella subaequalis Grunow								+
Cymbella sp.			+					+
Denticula tenuis Kütz.								+
Diatoma tenuis C. Agardh					+			
Diatoma mesodon (Ehrenb.) Kütz.							+	+
Diploneis parma Cleve								+
Eunotia arcus Ehrenb.		+	+		+		+	
Eunotia bilunaris (Ehrenb.) Mills		+	+	+	+	+		
Eunotia circumborealis Lange-Bert. & Nörpel							+	
Eunotia diodon Ehrenb.			+					
Eunotia exigua (Bréb. ex Kütz.) Rabenh.		+	+	+	+	+	+	
Eunotia fallax A. Cleve					+		+	
Eunotia flexuosa (Bréb. ex Kütz.) Kütz.				+				
Eunotia glacialis F. Meister		+	+	+	+	+	+	
Eunotia incisa Gregory		+	+	+	+	+	+	
Eunotia microcephala Krasske		+	+	+	+	+	+	
Eunotia muscicola var. *tridentula* Nörpel & Lange-Bert.					+			
Eunotia naegelii Mig.				+	+	+		
Eunotia nymanniana Grunow				+	+	+	+	
Eunotia paludosa Grunow		+		+	+			
Eunotia praerupta Ehrenb.		+	+	+	+		+	
Eunotia rhomboidea Hust.		+	+	+	+	+	+	
Eunotia serra Ehrenb.		+	+	+	+			
Eunotia serra var. *diadema* (Ehrenb.) Patrick			+					
Eunotia tenella (Grunow) Hust.			+	+	+	+		
Eunotia veneris (Kütz.) De Toni					+			
Eunotia sp.		+			+	+		
Fragilaria arcus (Ehrenb.) Cleve		+						
Fragilaria brevistriata Grunow		+		+				+
Fragilaria capucina Desm.			+	+	+	+	+	+
Fragilaria constricta Ehrenb.		+	+	+	+	+	+	
Fragilaria construens (Ehrenb.) Grunow					+	+	+	+
Fragilaria exigua (W. Smith) Lemmermann				+	+			
Fragilaria lata (Cleve-Euler) Renberg		+	+	+	+		+	
Fragilaria leptostauron (Ehrenb.) Hust.								+
Fragilaria pinnata Ehrenb.								+
Fragilaria pseudoconstruens Marciniak								+
Fragilaria tenera (W. Sm.) Lange-Bert.								+
Fragilaria ulna (Nitzsch) Lange-Bert.			+					
Fragilaria ulna var. *acus* (Kütz.) Lange-Bert.		+	+					
Fragilaria virescens Ralfs		+	+	+	+			

Table 1. Continued.

Species	Zones	Z7	Z6	Z5	Z4	Z3	Z2	Z1
Fragilaria sp.		+	+	+	+	+		
Frustulia rhomboides (Ehrenb.) De Toni		+	+	+	+	+	+	+
Frustulia rhomboides var. *saxonica* (Rabenh.) De Toni		+	+	+	+	+	+	
Gomphonema angustatum Ehrenb.		+						
Gomphonema augur Ehrenb.				+				
Gomphonema clavatum Ehrenb.								+
Gomphonema gracile Ehrenb.		+	+	+	+	+		
Gomphonema olivaceum (Hornem.) Bréb.		+	+		+			
Gomphonema parvulum (Kütz.) Kütz.				+			+	+
Gomphonema pumilum (Grunow) Reichardt & Lange-Bert.			+	+				
Gomphonema tergestinum (Grunow) Fricke					+			
Gomphonema sp.			+	+	+			+
Gyrosigma acuminatum (Kütz.) Rabenh.								+
Hantzschia amphioxys (Ehrenb.) Grunow			+	+	+			
Meridion circulare (Greville) Agardh				+				+
Navicula arvensis Hust.			+	+				
Navicula atomus (Kütz.) Grunow			+				+	
Navicula atomus var. *permitis* (Hust.) Lange-Bert.		+	+	+	+	+	+	+
Navicula cohnii (Hilse) Lange-Bert.				+				
Navicula contenta Grunow		+	+	+	+	+		
Navicula cryptocephala Kütz.			+	+	+	+	+	+
Navicula cryptotenella Lange-Bert.		+	+	+	+	+		
Navicula digitulus Hustedt							+	+
Navicula gallica var. *perpusilla* (Grunow) Lange-Bert.					+		+	+
Navicula krasskei Hust.		+	+	+	+			
Navicula lanceolata (C. Agardh) Ehrenb.		+	+	+				+
Navicula mediocris Krasske		+	+	+	+	+	+	
Navicula menisculus Schum.				+				
Navicula minima Grunow					+		+	
Navicula molestiformis Hust.			+					
Navicula mutica Kütz.		+	+		+			
Navicula pseudoscutiformis Hust.							+	+
Navicula cf. *pseudoventralis* Hust.								+
Navicula pupula Kütz.					+		+	+
Navicula radiosa Kütz.								+
Navicula schmassmannii Hust.					+	+	+	+
Navicula similis Krasske								+
Navicula soehrensis Krasske			+	+	+			
Navicula subminuscula Manguin			+	+	+	+	+	+
Navicula submolesta Hust.					+			
Navicula subrotundata Hust.				+				
Navicula subtilissima Cleve		+	+	+	+	+		
Navicula sp.		+	+	+	+	+	+	+
Neidium affine var. *affine* (Ehrenb.) Pfitzer			+	+	+			
Neidium affine var. *longiceps* (Gregory) Cleve			+	+	+	+	+	
Neidium alpinum Hust.		+	+	+	+	+	+	

Table 1. Continued.

Species	Zones	Z7	Z6	Z5	Z4	Z3	Z2	Z1
Neidium ampliatum (Ehrenb.) Krammer		+	+	+	+			
Neidium bisulcatum (Langerst.) Cleve		+			+	+	+	+
Neidium cf. *dubium* (Ehrenb.) Cleve		+						
Neidium hercynicum A. Mayer			+	+	+	+		
Neidium iridis (Ehrenb.) Cleve		+	+					
Neidium sp.		+			+			
Nitzschia alpina Hust.					+	+	+	+
Nitzschia dissipata var. *dissipata* (Kütz.) Grunow			+					+
Nitzschia fonticola Grunow				+				
Nitzschia gracilis Hantzsch		+	+	+			+	
Nitzschia hantzschiana Rabenh.							+	+
Nitzschia inconspicua Grunow		+		+				
Nitzschia linearis (C. Agardh) W. Sm.				+			+	+
Nitzschia palea (Kütz.) W. Sm.		+	+	+			+	
Nitzschia paleacea (Grunow) Grunow					+			
Nitzschia paleaeformis Hust.				+	+	+		
Nitzschia perminuta (Grunow) Perag.					+			
Nitzschia pusilla Grunow					+	+		
Nitzschia recta Hantzsch							+	+
Nitzschia sp.		+	+	+		+		+
Orthoseira roeseana (Rabenh.) O´Meara								+
Pinnularia appendiculata (C. Agardh) Cleve		+	+	+	+	+		
Pinnularia borealis Ehrenb.							+	
Pinnularia braunii (Grunow) Cleve								+
Pinnularia brevicostata Cleve		+						
Pinnularia divergentissima (Grunow) Cleve								
Pinnularia gibba Ehrenb.			+	+	+	+	+	+
Pinnularia interrupta W. Sm.		+	+	+	+	+	+	+
Pinnularia microstauron (Ehrenb.) Cleve		+	+	+	+	+	+	+
Pinnularia rupestris Hantzsch			+					
Pinnularia subcapitata W. Greg.		+	+	+	+	+	+	+
Pinnularia subrostrata (A. Cleve) Cleve-Euler								+
Pinnularia sudetica (Hilse) Peragallo								+
Pinnularia viridis (Nitzsch) Ehrenb.		+	+	+	+	+		+
Pinnularia sp.		+	+	+	+			+
Stauroneis anceps Ehrenb.		+	+	+	+	+	+	+
Stauroneis gracillima Hust.		+	+	+	+	+	+	
Stauroneis phoenicenteron (Nitzsch) Ehrenb.						+	+	+
Stauroneis smithii Grunow								+
Stenopterobia curvula (W. Sm.) Krammer		+	+	+	+	+	+	
Stenopterobia delicatissima (F.W. Lewis) Bréb.		+	+	+	+	+	+	
Stephanodiscus sp.			+					+
Surirella linearis var. *linearis* W. Sm.		+	+	+	+		+	+
Surirella linearis var. *constricta* (Ehrenb.) Grunow				+				+
Surirella roba Leclercq			+	+	+	+		
Surirella sp.			+	+				
Tabellaria ventricosa Kütz.		+	+	+	+	+	+	+