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ECRC Research Report # 145

Epilithic diatoms from the Trout Beck, North Pennines: 1997-2008

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May 2010

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Report to the Environmental Change Network

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1 SITE DESCRIPTION

"The Trout Beck is a headwater stream of the R. Tees which drains Great Dun Fell, Hard Hill and Knock Fell in the North Pennines (Figure 1). The ECN sampling point (Grid Ref NY758335) is at 535m altitude and the catchment above this covers 1146 ha, rising to 848 m altitude. The geology is alternating strata of Carboniferous limestones, sandstone and shales. Blanket peat covers 90% of the catchment with skeletal soils towards the fell tops and small areas of limestone soils and alluvial soils. Vegetation is dominated by ling heather (*Calluna vulgaris*), cotton grass (*Eriophorum spp*) and *Sphagnum* moss. The catchment lies in Moor House National Nature Reserve which is owned by English Nature. Discharge is measured at a Compound Crump Gauging Station operated by the Environment Agency. The pH of Trout Beck averages 6.2 although there are wide fluctuations associated with the discharge. The site has a long history of ecological research." (ECN website, 2009).

2 INTRODUCTION

Since 1997 the ECRC has received nine epilithic diatom samples per year from the Trout Beck, the principal stream draining the Moor House NNR and ECN site. The samples were taken and continue to be taken on three occasions each year (Spring, Summer and Autumn) from three close-by but different sampling stations in the stream (Figure 2):

- Location S01: just below the confluence with Netherhearth Sike
- Location S02: a few metres downstream – just before the start of the solid rock stream bed
- Location S03: a bar of loose stones across the solid rock stream bed

The analyses presented in this report are for the full suite of samples taken from 1997 until 2008 (Appendix 4) with the exception of three missing samples as follows:

- Location S01 on 31/03/2004
- Location S01 on 04/04/2007
- Location S01 on 26/09/2007

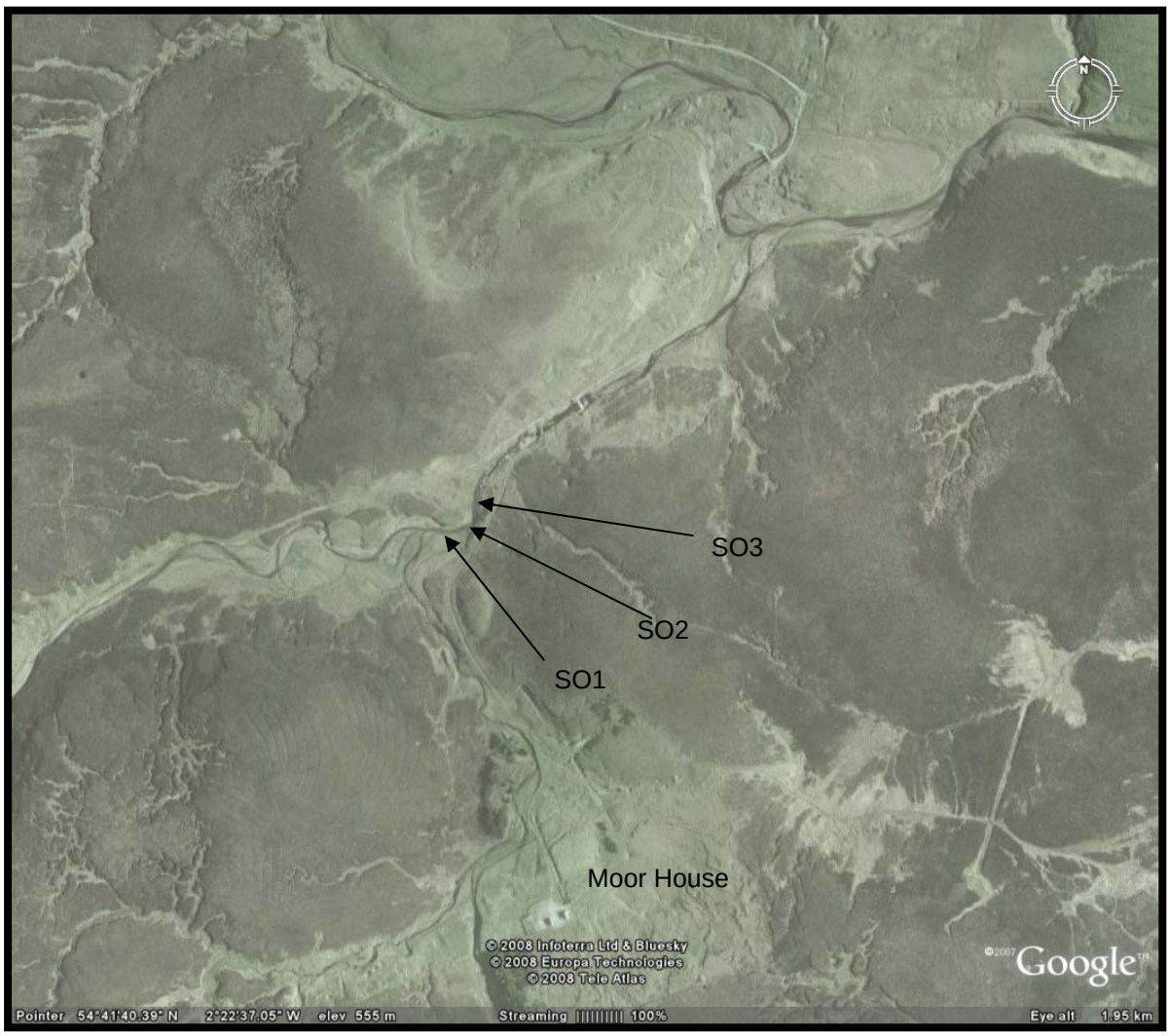
Diatoms were collected from the Trout Beck ECN site and prepared for analysis following protocols described in the United Kingdom Environmental Change Network's "Protocols for Standard Measurements at Freshwater Sites" (Sykes *et al.,* 1999).

A sub-set of 17 samples (SO2 samples from April 1997 to October 2001) was analysed earlier by Annette Kreiser (Kreiser *et al*. 2002). These samples have not been re-analysed but are included here along with the matching SO1 and SO3 replicates from those dates together with those post-dating October 2001 through to the end of 2008.

Comparisons of counts of the same samples by Kreiser and Battarbee showed no obvious taxonomic inconsistencies. Diatoms were examined at 1200 x magnification using a Leitz SM-Lux compound microscope (Kreiser) and at 1000 x using a Leitz Orthoplan microscope (Battarbee) using phase contrast illumination. A minimum of 300 valves were identified and counted for each slide. Some taxonomic difficulties were encountered, mainly in differentiating between *Gomphonema* taxa when observed in girdle view. Taxa are coded according to the ECRC diatom database coding system DIATCODE and a full list of taxa observed is shown in Appendix 1.

Figure 1 Trout Beck Sampling Area

Figure 2 Trout Beck Sampling Locations



3 DATA ANALYSIS AND PRESENTATION

Data are held on a central Access database at the Environmental Change Research Centre (ECRC). In this report we present the primary data with graphs and summary statistics. Diatom diagrams show percentage abundances of individual species for each year of sampling or for each individual sample point. Only species occurring with a minimum abundance of 1% are presented.

We also present a series of diversity indices including:

- **Hill's N1** that approximates to the number of abundant species (Hill, .
- **Hill's N2** that approximates to the number of very abundant species in the sample**.**
- **Hill's E5** that is a measure of the evenness of species occurrences in a sample. E5 approaches zero as a single species becomes more dominant in the assemblage.

Multivariate statistical methods were applied to the epilithic diatom data. The linear method of Principal Components Analysis (PCA) was selected. PCA is an indirect gradient approach that provides a sensitive measure of between sample variance in the species assemblage. The analysis was performed using the program C2 (Juggins, 2007).

4 OBJECTIVES

The objectives of the analyses were:

- to identify the diatoms present in the samples and to compare the composition of the assemblages between replicate stations, between seasons within a year, between the same season between years, and between years over time;

- to identify any evidence for long-term trends in species composition and overall biodiversity over time; and

- to examine the relationship between count size and species richness to assess the optimum count size for stream biodiversity studies.

A longer term aim of this study is to relate variation in diatom composition over time to environmental factors, including stream water chemistry and hydrology.

5 RESULTS

5.1 Floristic change

The diatom data are shown in Figures 3-9. Figure 10 shows a PCA plot for species and sample scores.

Figure 3 shows the pattern of seasonal (spring, summer and autumn) and inter-annual variability in diatom composition over the 12 year period from 1997-2008. One species, *Achnanthes minutissima,* is dominant in all seasons and all years, varying from approximately 30 to 80% of the total count. There are two occasions in the time series when its relative abundance declines, first in 1998-1999 and second in 2004-2005. In both cases there are corresponding increases in the relative abundance of *Gomphonema* taxa, especially *G. pumilum*. The reason for this reciprocal variability is unknown as the taxa concerned have similar lifeforms and similar water quality requirements. Moreover, although the relative abundance of all *Gomphonema* taxa increase as *A. minutissima* decreases the different *Gomphonema* species also behave independently (cf. Figure 10), suggesting that there are fine controls on the competitive success of individual taxa within the *Gomphonema* genus.

Overall, however, the similarities between the assemblages at the beginning and end of the record show that no significant longer term changes in environmental conditions have occurred in the stream over the last 12 years.

Figures 4-6 show data for the three sample points, SO1, SO2, SO3, illustrating differences between epilithic assemblages within the ~50 m reach of stream sampled (cf. Figure 2). Whilst there is considerable variability between samples all three sites show the same temporal pattern as described above. They are also structured in a very similar way, suggesting that there are no significant micro-scale differences in habitat or environmental conditions between the sample points.

Figures 7-9 present the data by season: spring (Figure 7), summer (Figure 8) and autumn (Figure 9). Again the relative abundances of the different taxa between season are broadly the same, showing no evidence for a regular seasonal succession in floristic composition. *A. minutissima* dominates in all samples and all seasons and *Gomphonema* taxa show the same inter-annual patterns irrespective of season. The single, clear outlier is autumn 2002 where all three samples show relatively low abundances of *A. minutissima* and relatively high abundances of *Fragilaria capucina* var. *gracilis*, *Synedra ulna* and *Diatoma tenue* var. *elongatum.* These samples and species are clearly differentiated in the PCA (Figure 10). Again the reason for these differences is unknown, but the between-sample consistency of this assemblage suggests that environmental conditions in the autumn of 2002 were different from both previous and following years. Examination of hydrochemical conditions over this period of time might provide an explanation.

5.2 Diversity

Figure 11 shows the number of taxa encountered for: (i) each sample (combined field sample from five stones) after a count of 300 valves per sample (SO1, SO2, and SO3); (ii) for the site as a whole for any one season (SO1, SO2, and SO3 combined) giving a count size of 900 valves and; (iii) for the site as a whole for any one year, by combining three samples and three seasons to generate a count size of 2,700. The mean number of taxa observed for these three sample groups were 15.3, 23.9 and 37.4 respectively. This compares with the 100 taxa encountered overall across the 12 year data-set representing a total combined count of approximately 31,500 valves (12 years x 3 seasons x 3 samples x 300 valves per sample, minus 900, representing the three missing samples). As there has been little or no overall change in environmental conditions over the last 12 years, indicated by the stability of the diatom assemblage, it is probable that this represents the total diatom species pool in the Trout Beck at any one time.

Figures 12-18 show Hill's N1, Hill's N2 and E5 as additional measures of diversity. Figure 12 shows the pattern of seasonal (spring, summer and autumn) and inter-annual variability in diatom species diversity over the 12 year sample period, averaged for all three sampling locations.

Figures 13-15 show diversity data for the three sample points, SO1, SO2, SO3, illustrating differences between epilithic assemblages within the reach of stream sampled (cf. Figure 2) and Figures 16-18 present the data averaged over the three

sampling locations by season: spring (Figure 16), summer (Figure 17) and autumn (Figure 18).

The data show relatively little change over time, although there is a peak in Hill's N1 and N2 for the Summer and Autumn samples of 1998 (Figs 12, 14 and 15), and there is a steady increase over time in Hill's N1 and N2 in spring samples (Fig. 16).

6 SUMMARY AND CONCLUSIONS

Analysis of the epilithic diatom samples from the Trout Beck covering 12 years from 1997 to 2009 show a relatively stable flora dominated by *Achnanthes minutissima*, an abundant and globally widespread benthic diatom found in both lakes and streams of circumneutral pH. It is a diatom that is very sensitive to acidification, very rarely found in waters with pH < 5.5, and an indication here that the Trout Beck has retained a relatively high acid neutralising capacity over recent decades despite its location in a relatively high acid deposition area in the UK.

Its dominance is somewhat reduced both in the early part of the time-series and in 2004-2005 when the abundance of *Gomphonema* taxa increase reciprocally. It is also much less common in the autumn samples of 2002, when it is replaced by *Fragilaria capucina* var. *gracilis*, *Synedra ulna* and *Diatoma tenue* var. *elongatum.*

The influence of these different taxa on the structure of the assemblages is seen clearly in the PCA (Fig 10).

As these floristic switches occur quite abruptly, either inter-annually or seasonally, and as there is little evidence from their pH affinity that the species changes are caused by acid episodes (that might be expected at more acid sensitive sites), it is more probable that the occasional depressions in the abundance of *A. minutissima* are related to physical factors such as changes in discharge and consequent alterations to the physical habitat of the stream bed, rather than to changes in water chemistry.

There is little overall change in diatom diversity over the time period monitored. Species richness is similar to that of other epilithic stream habitats in the UK uplands. Typically 15 taxa are encountered in a standard count of 300 diatom valves from a species pool of approximately 100..

Further work is required to establish an improved estimate of the total species pool and to evaluate whether the count size used to detect floristic trends is also appropriate in measuring diversity.

Combined analysis of the diatom data and environmental data (especially for chemistry and flow) is required to explain the floristic changes identified here.

Figure 3 Trout Beck Diatom Time Series – 3 Samples Amalgamated By Date

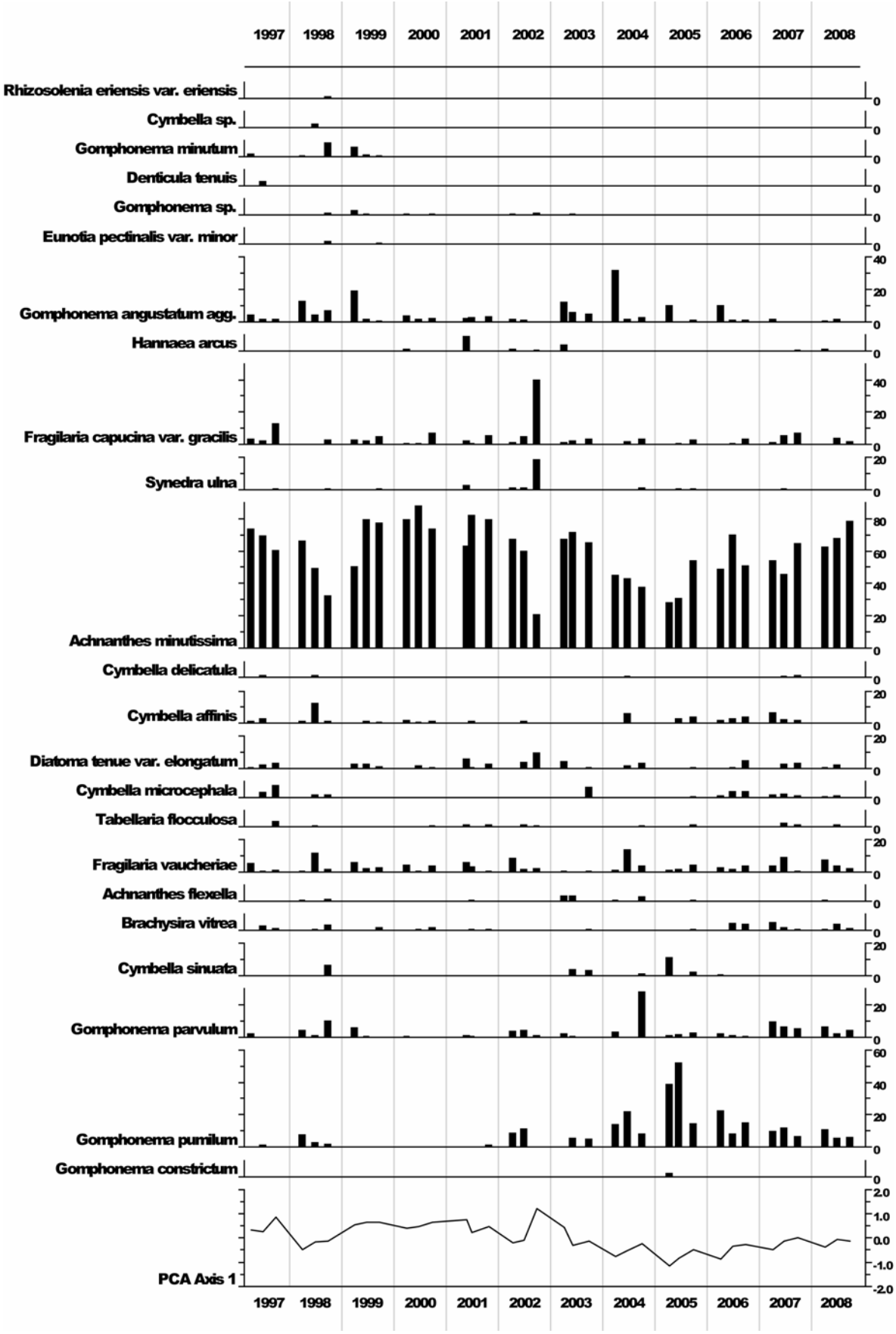


Figure 4 Trout Beck Diatom Percentage Abundances from Sampling Point S01

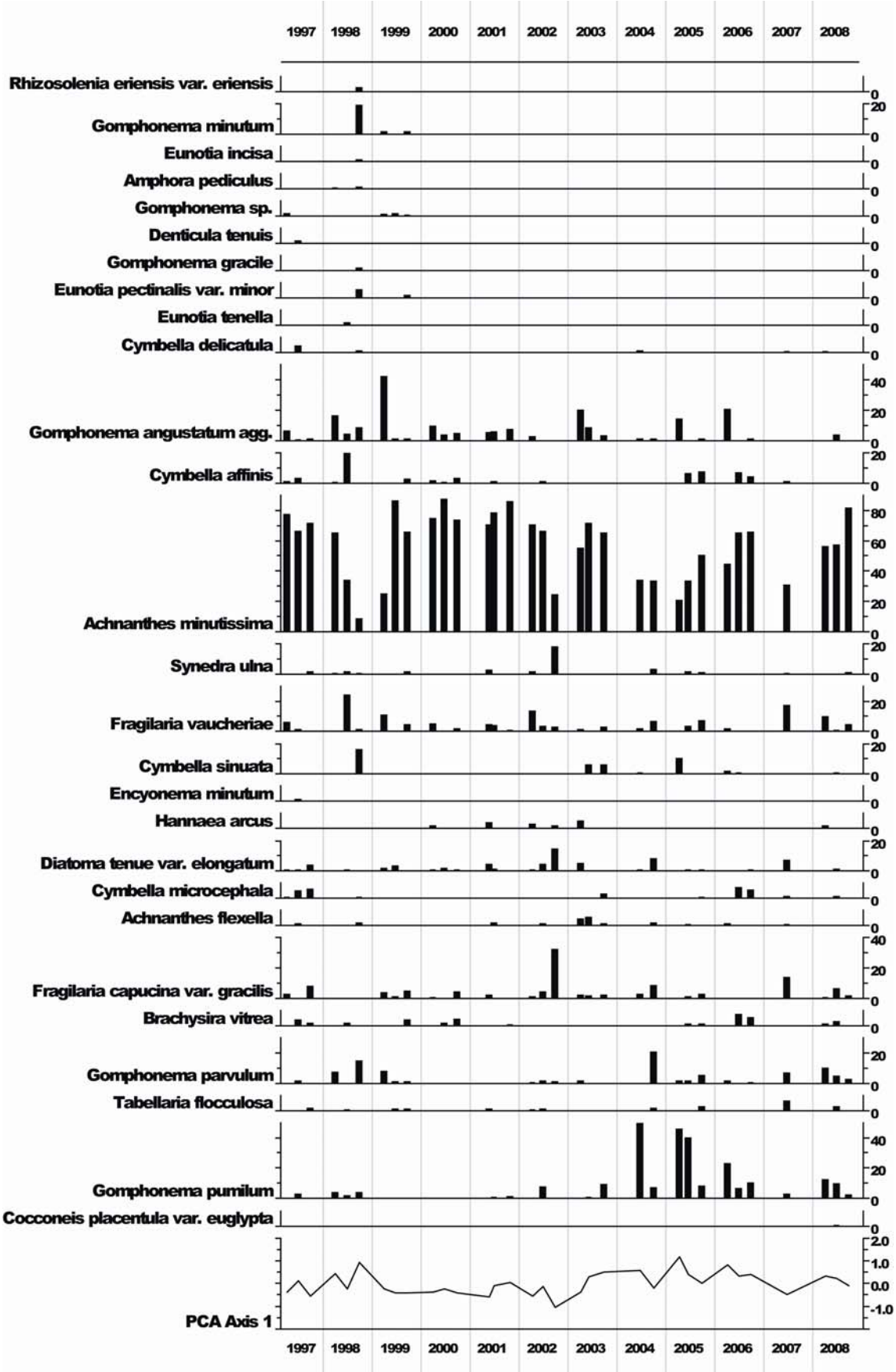


Figure 5 Trout Beck Diatom Percentage Abundances from Sampling Point S02

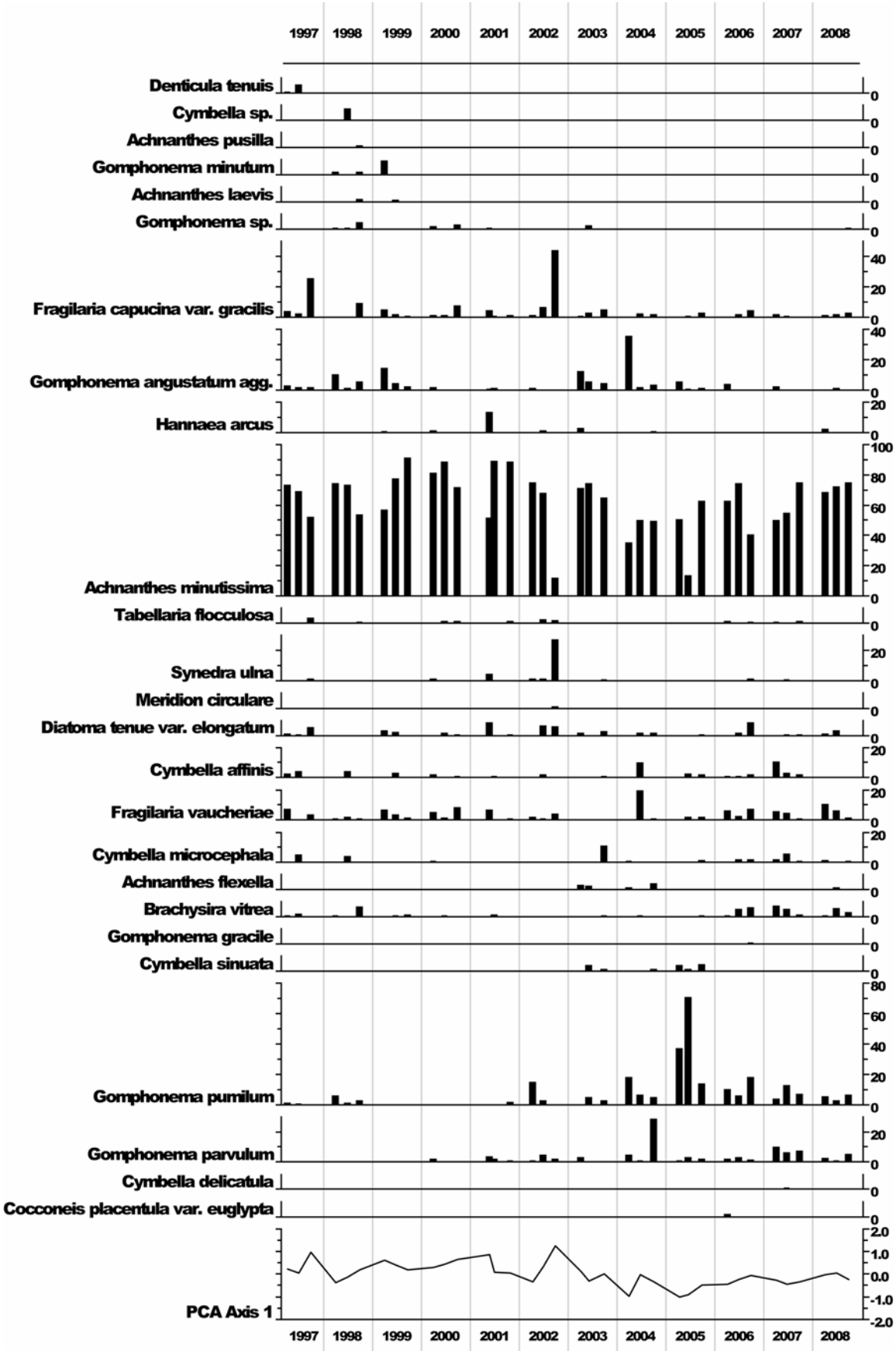


Figure 6 Trout Beck Diatom Percentage Abundances from Sampling Point S03

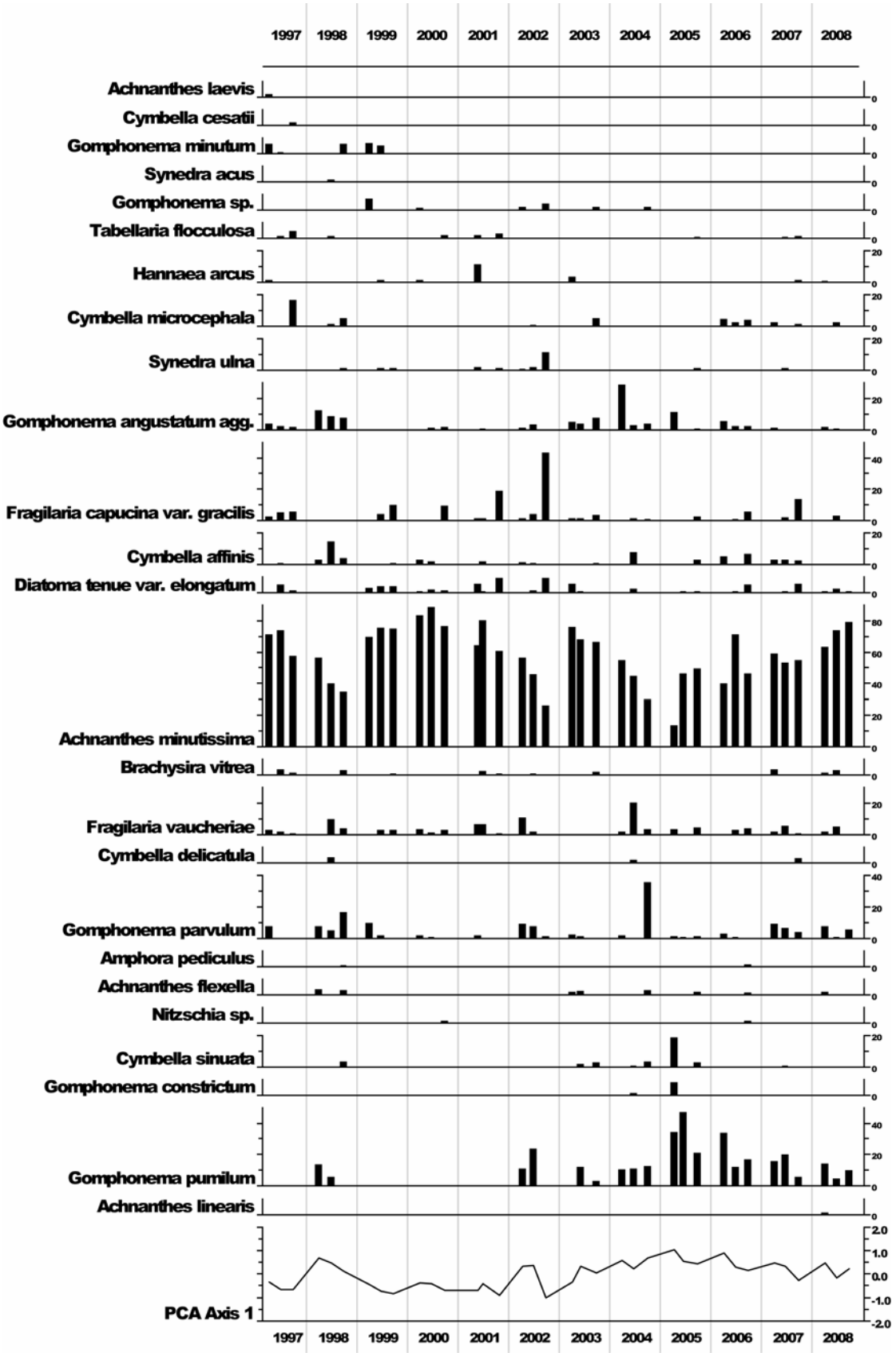


Figure 7 Trout Beck Diatom Percentage Abundances from S01, S02 and S03 Spring Samples

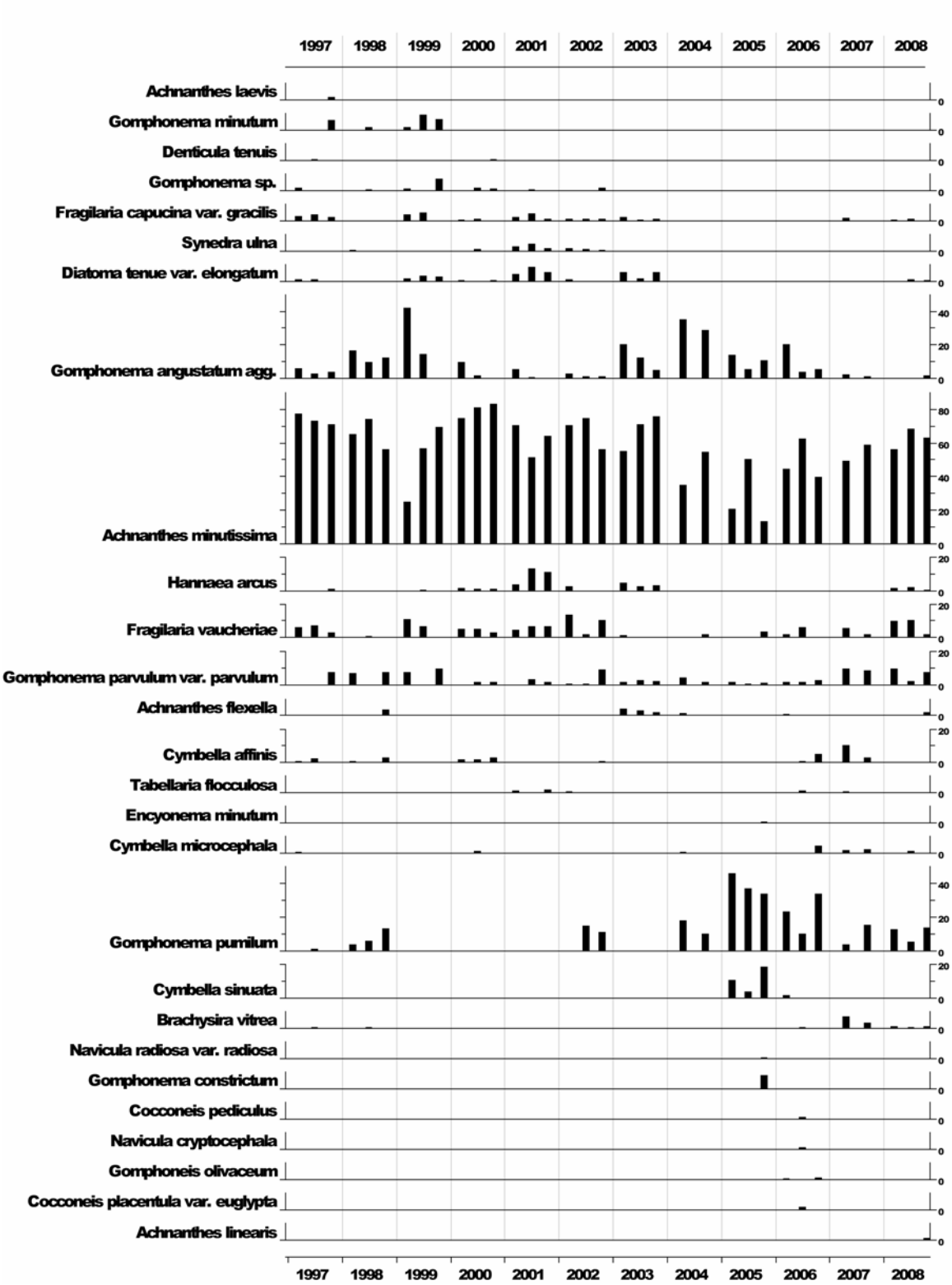


Figure 8 Trout Beck Diatom Percentage Abundances from S01, S02 and S03 Summer Samples

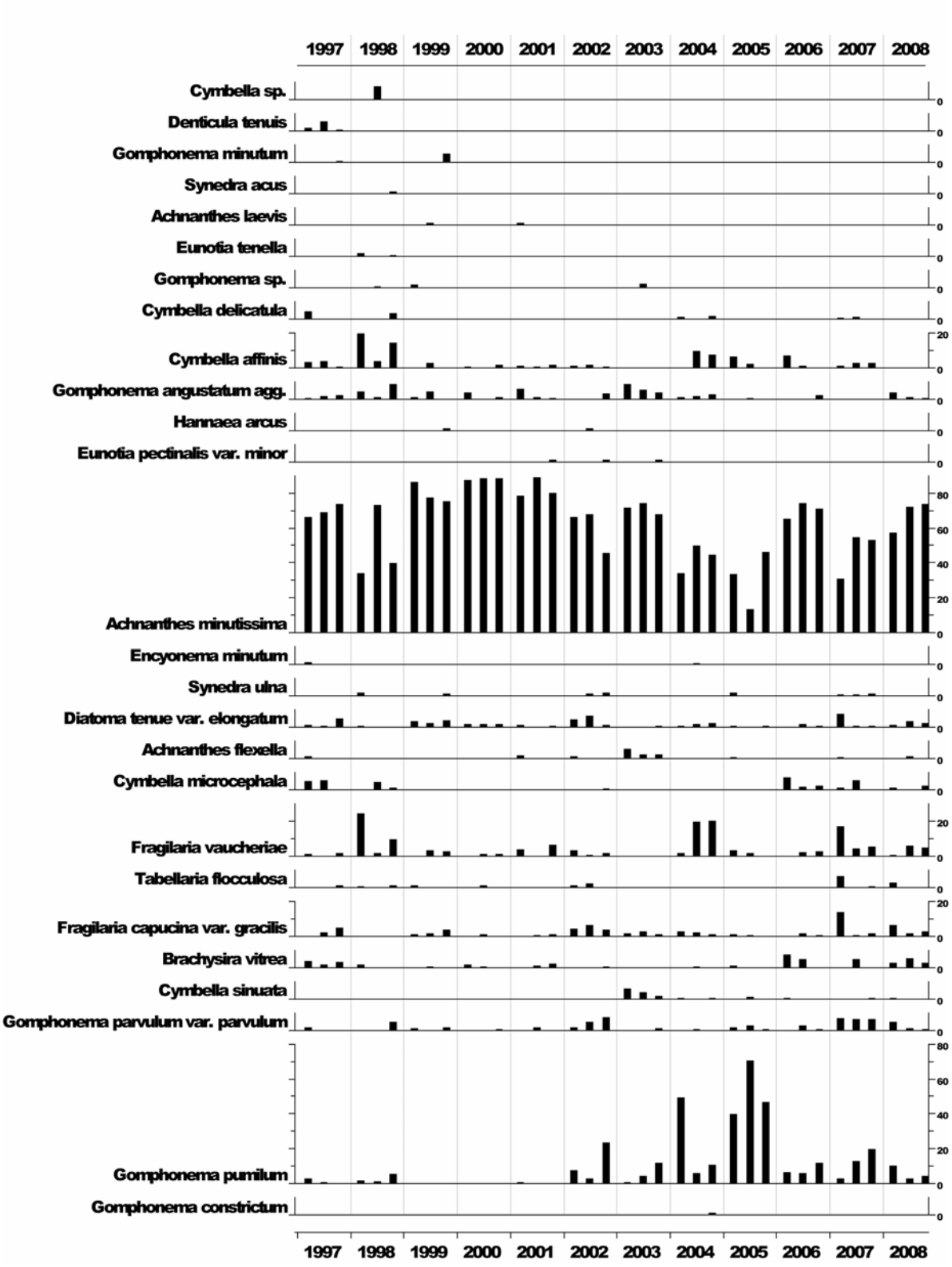


Figure 9 Trout Beck Diatom Percentage Abundances from S01, S02 and S03 Autumn Samples

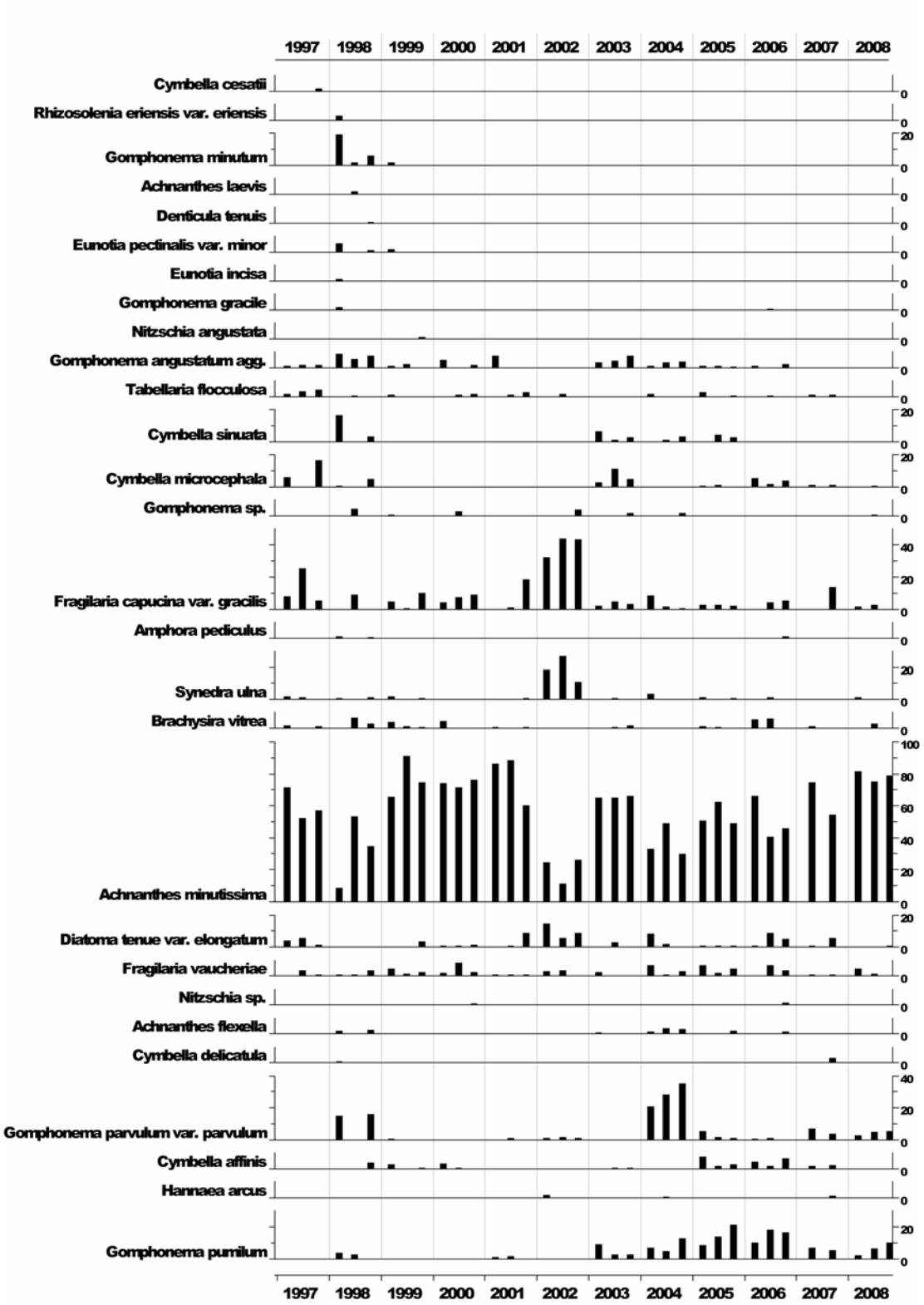


Table 1 Diatom PCA Statistics

	λ^{PCA}
Axis 1 Eigenvalue	0.29
Axis 2 Eigenvalue	0.17
Axis 3 Eigenvalue	0.12
Axis 4 Eigenvalue	0.07

Figure 10 Trout Beck Diatom PCA species and Sample Scores

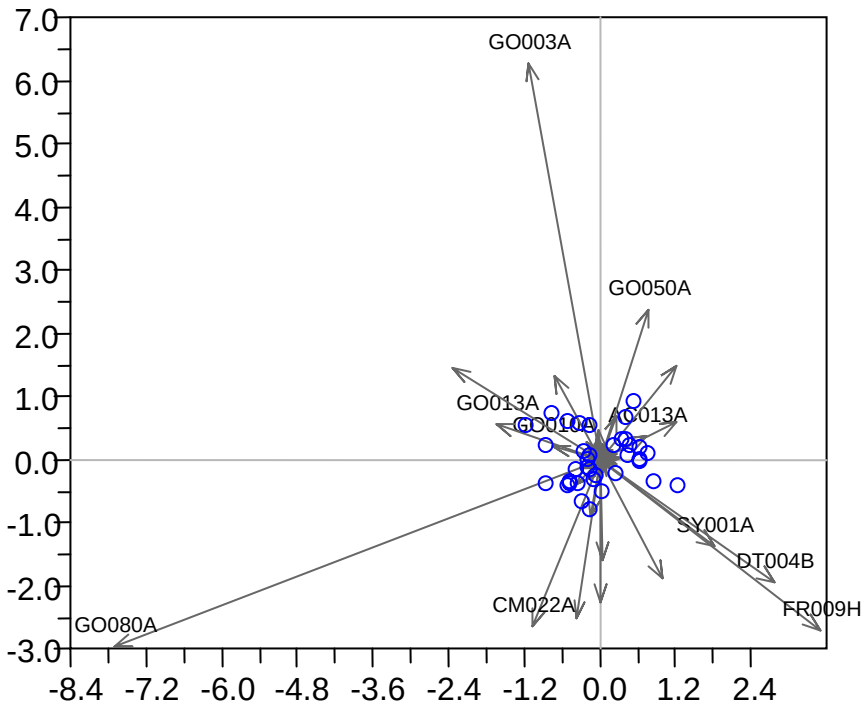


Figure 11 Number of Diatom Species per Sample, Date, Year and Overall Total

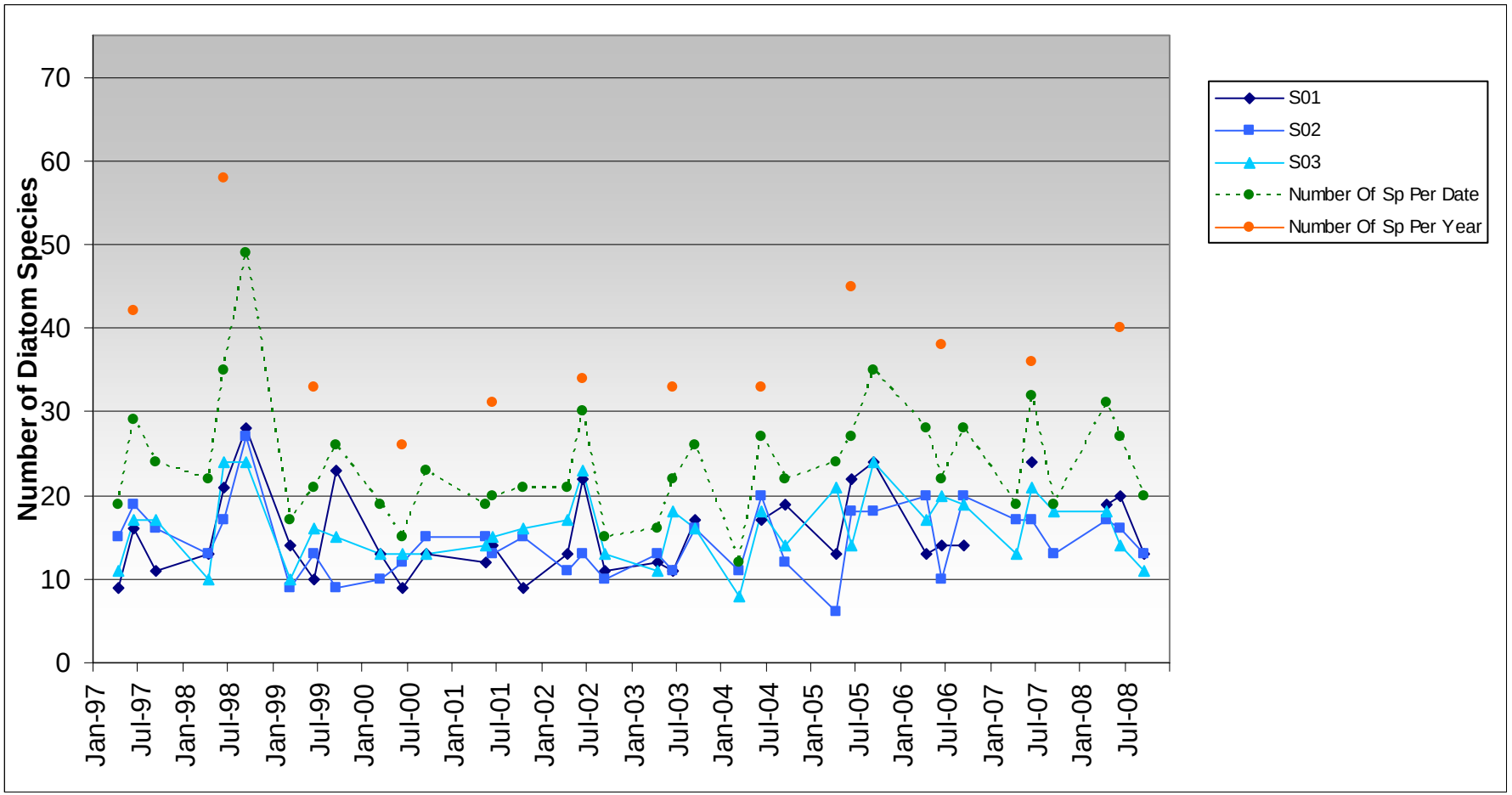


Figure 12 Trout Beck Diatom Diversity Statistics Mean of Points S01, S02 and S03

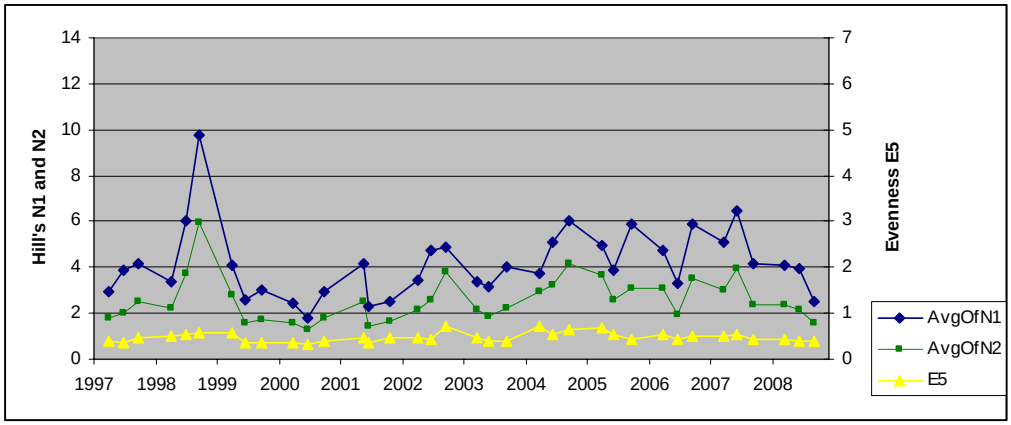


Figure 13 Trout Beck Diatom Diversity Statistics from Sampling Point S01

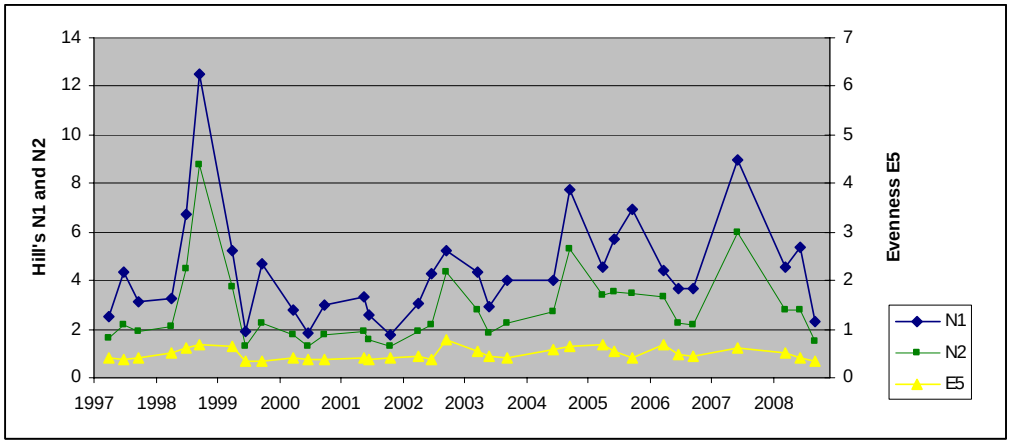


Figure 14 Trout Beck Diatom Diversity Statistics from Sampling Point S02

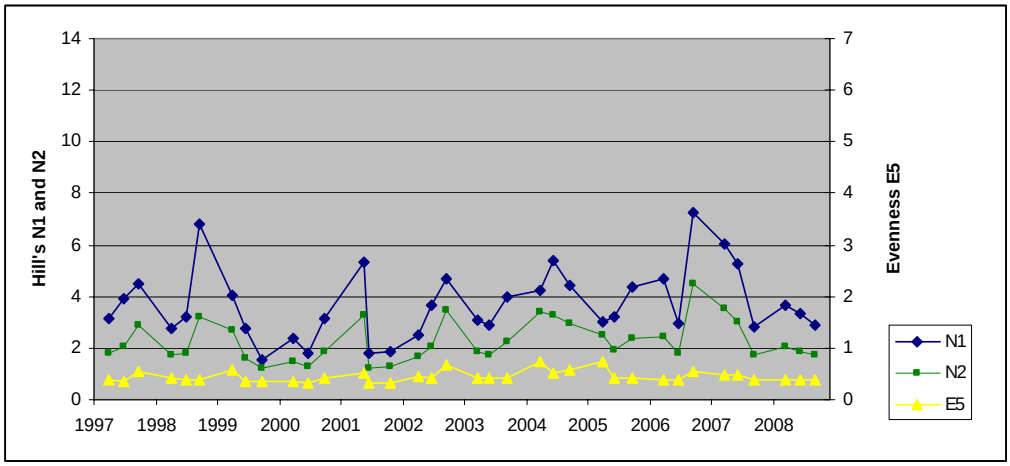


Figure 15 Trout Beck Diatom Diversity Statistics from Sampling Point S03

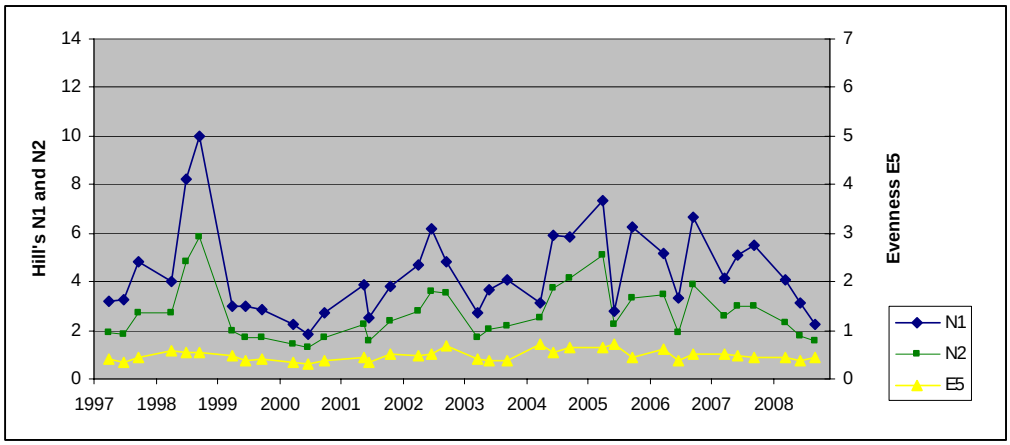


Figure 16 Trout Beck Diatom Diversity Statistics Mean of Points S01, S02 and S03: Spring Samples

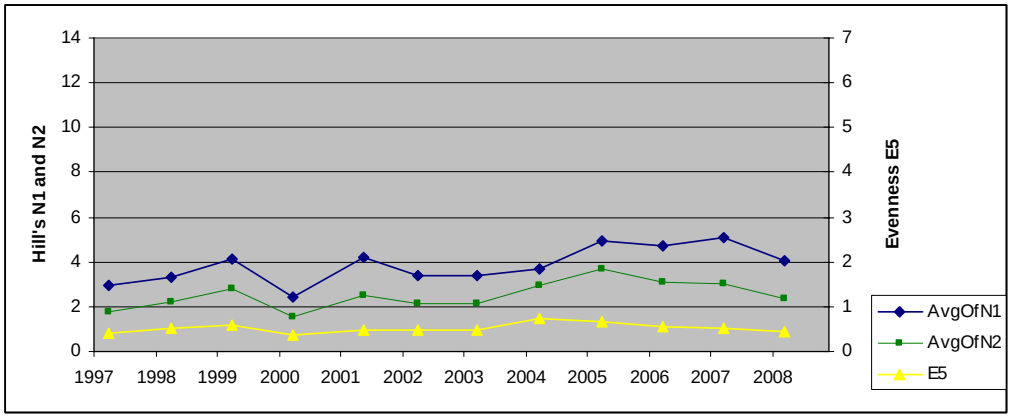


Figure 17 Trout Beck Diatom Diversity Statistics Mean of Points S01, S02 and S03: Summer Samples

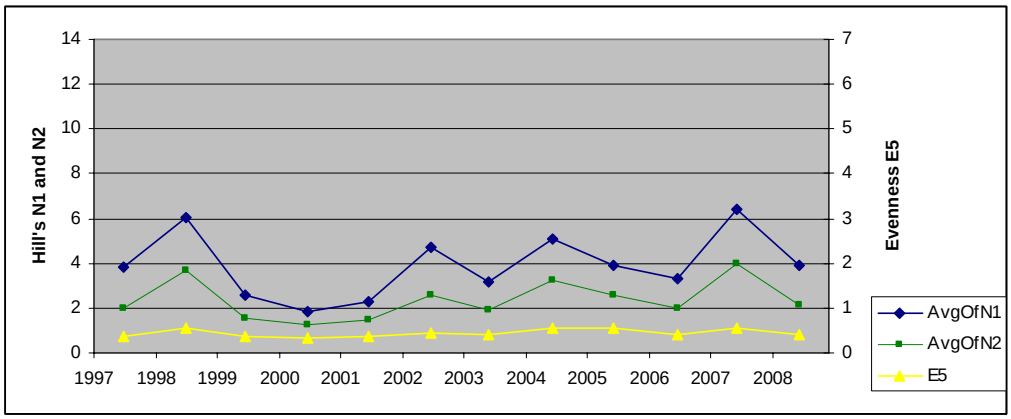


Figure 18 Trout Beck Diatom Diversity Statistics Mean of Points S01, S02 and S03: Autumn Samples

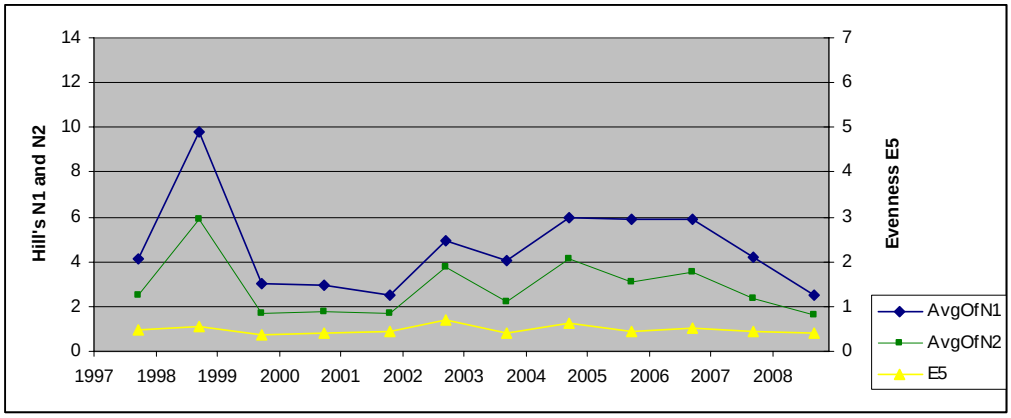
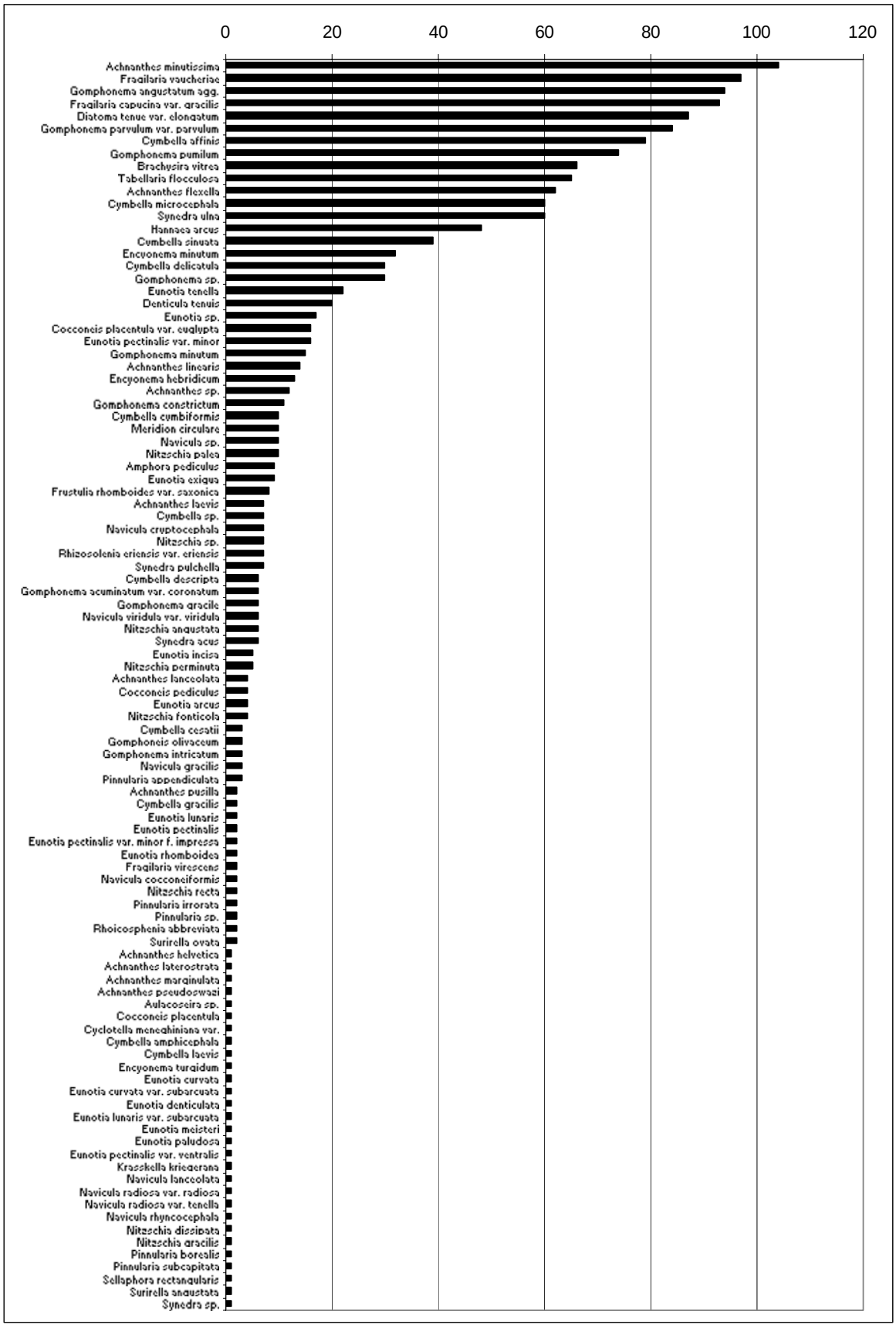


Figure 19 Diatom Species Ordered by Number of Occurrences (N_{max} 105)



7 ACKNOWLEDGEMENTS

Funding for this work was provided by the Environmental Change Network. Bev Dodd undertook much of the field sampling and Simon Turner and Kevin Roe prepared the diatom slides. Seventeen samples were counted by Annette Kreiser under an earlier contract (Kreiser et al. 2002).

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9 APPENDICES

Appendix 1 Trout Beck Diatom Species and ECRC Database DIATCODES

Taxon	Taxon Code
Achnanthes flexella	AC025A
Achnanthes helvetica	AC134A
Achnanthes laevis	AC083A
Achnanthes lanceolata	AC001A
Achnanthes laterostrata	AC018A
Achnanthes linearis	AC002A
Achnanthes marginulata	AC022A
Achnanthes minutissima	AC013A
Achnanthes pseudoswazi	AC004A
Achnanthes pusilla	AC035A
Achnanthes sp.	AC9999
Amphora pediculus	AM012A
Aulacoseira sp.	AU9999
Brachysira vitrea	BR001A
Cocconeis pediculus	CO005A
Cocconeis placentula	CO001A
Cocconeis placentula var. euglypta	CO001B
Cyclotella meneghiniana var. meneghiniana	CY003A
Cymbella affinis	CM022A
Cymbella amphicephala	CM016A
Cymbella cesatii	CM015A
Cymbella cymbiformis	CM007A
Cymbella delicatula	CM038A
Cymbella descripta	CM052A
Cymbella gracilis	CM018A
Cymbella laevis	CM012A
Cymbella microcephala	CM004A
Cymbella sinuata	CM003A
Cymbella sp.	CM9999
Denticula tenuis	DE001A
Diatoma tenue var. elongatum	DT004B
Encyonema hebridicum	EY003A
Encyonema minutum	EY011A
Encyonema turgidum	EY018A
Eunotia arcus	EU013A
Eunotia curvata	EU049A
Eunotia curvata var. subarcuata	EU049B
Eunotia denticulata	EU015A
Eunotia exigua	EU009A
Eunotia incisa	EU047A
Eunotia lunaris	EU006A
Eunotia lunaris var. subarcuata	EU006B

Taxon	Taxon Code
Eunotia meisteri	EU020A
Eunotia paludosa	EU040A
Eunotia pectinalis	EU002A
Eunotia pectinalis var. minor	EU002B
Eunotia pectinalis var. minor f. impressa	EU002E
Eunotia pectinalis var. ventralis	EU002C
Eunotia rhomboidea	EU011A
Eunotia sp.	EU9999
Eunotia tenella	EU004A
Fragilaria capucina var. gracilis	FR009H
Fragilaria vaucheriae	FR007A
Fragilaria virescens	FR005A
Frustulia rhomboides var. saxonica	FU002B
Gomphoneis olivaceum	GM001A
Gomphonema acuminatum var. coronatum	GO006C
Gomphonema angustatum agg.	GO003A
Gomphonema constrictum	GO010A
Gomphonema gracile	GO004A
Gomphonema intricatum	GO014A
Gomphonema minutum	GO050A
Gomphonema parvulum var. parvulum	GO013A
Gomphonema pumilum	GO080A
Gomphonema sp.	GO9999
Hannaea arcus	HN001A
Krasskella kriegerana	KR001A
Meridion circulare	MR001A
Navicula cocconeiformis	NA032A
Navicula cryptocephala	NA007A
Navicula gracilis	NA029A
Navicula lanceolata	NA009A
Navicula radiosa var. radiosa	NA003A
Navicula radiosa var. tenella	NA003B
Navicula rhyncocephala	NA008A
Navicula sp.	NA9999
Navicula viridula var. viridula	NA027A
Nitzschia angustata	NI020A
Nitzschia dissipata	NI015A
Nitzschia fonticola	NI002A
Nitzschia gracilis	NI017A
Nitzschia palea	NI009A
Nitzschia perminuta	NI005A
Nitzschia recta	NI025A
Nitzschia sp.	NI9999
Pinnularia appendiculata	PI014A
Pinnularia borealis	PI012A
Pinnularia irrorata	PI023A
Pinnularia sp.	PI9999

Taxon	Taxon Code
Pinnularia subcapitata	PI022A
Rhizosolenia eriensis var. eriensis	RZ011A
Rhoicosphenia abbreviata	RC002A
Sellaphora rectangularis	SL007A
Surirella angustata	SU001A
Surirella ovata	SU002A
Synedra acus	SY003A
Synedra pulchella	SY008A
Synedra sp.	SY9999
Synedra ulna	SY001A
Tabellaria flocculosa	TA001A

Appendix 2 Trout Beck Diatom Species in Order of Number of Occurrences

Taxon	Taxon Code	Number of Samples With Taxon Present
Achnanthes minutissima	AC013A	105
Fragilaria vaucheriae	FR007A	98
Gomphonema angustatum agg.	GO003A	95
Fragilaria capucina var. gracilis	FR009H	94
Diatoma tenue var. elongatum	DT004B	88
Gomphonema parvulum var. parvulum	GO013A	84
Cymbella affinis	CM022A	80
Gomphonema pumilum	GO080A	74
Brachysira vitrea	BR001A	66
Tabellaria flocculosa	TA001A	65
Achnanthes flexella	AC025A	62
Cymbella microcephala	CM004A	61
Synedra ulna	SY001A	60
Hannaea arcus	HN001A	48
Cymbella sinuata	CM003A	39
Encyonema minutum	EY011A	32
Gomphonema sp.	GO9999	31
Cymbella delicatula	CM038A	30
Eunotia tenella	EU004A	22
Denticula tenuis	DE001A	20
Eunotia sp.	EU9999	17
Cocconeis placentula var. euglypta	CO001B	16
Eunotia pectinalis var. minor	EU002B	16
Gomphonema minutum	GO050A	15
Achnanthes linearis	AC002A	14
Achnanthes sp.	AC9999	13
Encyonema hebridicum	EY003A	13
Gomphonema constrictum	GO010A	11
Cymbella cymbiformis	CM007A	10
Meridion circulare	MR001A	10
Navicula sp.	NA9999	10
Nitzschia palea	NI009A	10
Amphora pediculus	AM012A	9
Eunotia exigua	EU009A	9
Frustulia rhomboides var. saxonica	FU002B	8
Achnanthes laevis	AC083A	7
Cymbella sp.	CM9999	7
Navicula cryptocephala	NA007A	7
Nitzschia sp.	NI9999	7
Rhizosolenia eriensis var. eriensis	RZ011A	7
Synedra pulchella	SY008A	7
Cymbella descripta	CM052A	6
Gomphonema acuminatum var. coronatum	GO006C	6
Gomphonema gracile	GO004A	6
Navicula viridula var. viridula	NA027A	6

Taxon	Taxon Code	Number of Samples With Taxon Present
Nitzschia angustata	NI020A	6
Synedra acus	SY003A	6
Eunotia incisa	EU047A	5
Nitzschia perminuta	NI005A	5
Achnanthes lanceolata	AC001A	4
Cocconeis pediculus	CO005A	4
Eunotia arcus	EU013A	4
Nitzschia fonticola	NI002A	4
Cymbella cesatii	CM015A	3
Gomphoneis olivaceum	GM001A	3
Gomphonema intricatum	GO014A	3
Navicula gracilis	NA029A	3
Pinnularia appendiculata	PI014A	3
Achnanthes pusilla	AC035A	2
Cymbella gracilis	CM018A	2
Eunotia lunaris	EU006A	2
Eunotia pectinalis	EU002A	2
Eunotia pectinalis var. minor f. impressa	EU002E	2
Eunotia rhomboidea	EU011A	2
Fragilaria virescens	FR005A	2
Navicula cocconeiformis	NA032A	2
Nitzschia recta	NI025A	2
Pinnularia irrorata	PI023A	2
Pinnularia sp.	PI9999	2
Rhoicosphenia abbreviata	RC002A	2
Surirella ovata	SU002A	2
Achnanthes helvetica	AC134A	1
Achnanthes laterostrata	AC018A	1
Achnanthes marginulata	AC022A	1
Achnanthes pseudoswazi	AC004A	1
Aulacoseira sp.	AU9999	1
Cocconeis placentula	CO001A	1
Cyclotella meneghiniana var. meneghiniana	CY003A	1
Cymbella amphicephala	CM016A	1
Cymbella laevis	CM012A	1
Encyonema turgidum	EY018A	1
Eunotia curvata	EU049A	1
Eunotia curvata var. subarcuata	EU049B	1
Eunotia denticulata	EU015A	1
Eunotia lunaris var. subarcuata	EU006B	1
Eunotia meisteri	EU020A	1
Eunotia paludosa	EU040A	1
Eunotia pectinalis var. ventralis	EU002C	1
Krasskella kriegerana	KR001A	1
Navicula lanceolata	NA009A	1
Navicula radiosa var. radiosa	NA003A	1
Navicula radiosa var. tenella	NA003B	1

Taxon	Taxon Code	Number of Samples With Taxon Present
Navicula rhyncocephala	NA008A	1
Nitzschia dissipata	NI015A	1
Nitzschia gracilis	NI017A	1
Pinnularia borealis	PI012A	1
Pinnularia subcapitata	PI022A	1
Sellaphora rectangularis	SL007A	1
Surirella angustata	SU001A	1
Synedra sp.	SY9999	1

Appendix 3 Trout Beck Diatom Abundances Combined by Date

DIATCODE	02/04/1997	24/06/1997	24/09/1997	01/04/1998	30/06/1998	23/09/1998	31/03/1999	22/06/1999	22/09/1999	29/03/2000	20/06/2000	27/09/2000	23/05/2001	26/06/2001	24/10/2001	10/04/2002	25/06/2002	25/09/2002	02/04/2003	01/06/2003	24/09/2003	31/03/2004	23/06/2004	29/09/2004	12/04/2005	15/06/2005	28/09/2005	05/04/2006	28/06/2006	27/09/2006	04/04/2007	20/06/2007	26/09/2007	02/04/2008	25/06/2008	24/09/2008
AC001A						1											1																2				
AC002A							1		1						1		3			3	1								1	1		2		5	1	1
AC004A						2																														
AC013A	728	639	558	670	452	298	462	736	718	745	886	716	644	813	821	609	543	186	609	642	590	272	399	354	258	283	491	444	632	460	328	426	390	563	613	714
AC018A									1																											
AC022A						1																														
AC025A		5		13	1	15	2	1	1	1	5	2	4	9	1		7	4	31	34	6	5	4	29	5	6	11	7	2	5	1	4	2	8	5	2
AC035A	1					5																														
AC083A	8			3		6	2	5						7																						
AC134A	1																																			
AC9999	1					2											1	1		2		1	2	4	3	1	1						1		
AM012A				3	2	7																					3	2		4						
AU9999						1																														
BR001A	4	30	14	5	9	31	2	5	20	3	13	18	2	12	9		4				10	2	4			4	8	3	41	38	33	20	6	11	36	14
CM003A		1		1	1	61			1											37	33	3	7	17	103	7	25	10	4	4		3			3	2
CM004A	4	33	72	3	20	19		2	4	5		3	2	2	1		3			1	60	3	3			2	9	14	36	37	14	24	9	8	14	3
CM007A		1																		2			3				1	3		1	3	1		1		
CM012A					2																															
CM015A		3	7		1																															
CM016A																								1												
CM018A												1													1											
CM022A	17	28	4	16	117	13		13	12	22	12	17	6	15		5	13	2	4	1	6	2	58	2	1	29	39	20	28	41	41	23	14	5	2	
CM038A		15			13	5	1	2	2	1		2					2			3			11	1		2	2	1	1	1		9	10	3	2	
CM052A		1	2			2		1		2		1																								
CM9999		3	2	1	24							4		1																						
CO001A					1																															
CO001B						3											1				1		2			1	1	9	2	2		1	1	1	3	
CO005A																									1		3	5								
CY003A																												3								
DE001A	5	28			3	4	1			3		2	2	3			2									1					2			1	
DT004B	12	22	36	1	6	2	27	31	13	7	22	12	65	11	34	4	39	90	42	4	11		18	33	1	7	10	3	10	46	3	31	21	8	24	5
EU002A						3											1																			
EU002B					2	21			8					5		1	5			5	3			1		1	3							1		
EU002C																													1							
EU002E			2			4																														
EU004A		2	3	1	9	7	1		2			2	1			1	1							2					1		2		1	1	
EU006A																1															1				
EU006B																											2									
EU009A			1																	1	4			1							1		1	1	1
EU011A			2																				1													
EU013A					3			1																							2					
EU015A			1																																	
EU020A																															1					
EU040A						1																														
EU047A					2	4			2																		2	1								
EU049A																													1							
EU049B																	2																			
EU9999								1	1	2	2	5	2				3				1		2		2		1					2		1	2
EY003A					1	1									1								1		1	1	2	2			2		1	2	
EY011A		4	2	1	4										1	2	1		3		5		5	3	3	3	5	1	1	3	1	2		1	2	2

DIATCODE	02/04/1997	24/06/1997	24/09/1997	01/04/1998	30/06/1998	23/09/1998	31/03/1999	22/06/1999	22/09/1999	29/03/2000	20/06/2000	27/09/2000	23/05/2001	26/06/2001	24/10/2001	10/04/2002	25/06/2002	25/09/2002	02/04/2003	01/06/2003	24/09/2003	31/03/2004	23/06/2004	29/09/2004	12/04/2005	15/06/2005	28/09/2005	05/04/2006	28/06/2006	27/09/2006	04/04/2007	20/06/2007	26/09/2007	02/04/2008	25/06/2008	24/09/2008
EY018A											1																									
FR005A						3									1																					
FR007A	58	12	14	8	110	20	56	24	30	45	9	43	62	37	10	82	20	24	9	2	9	8	132	37	12	20	43	29	19	36	25	87	6	69	38	22
FR009H	34	26	121	3	2	31	29	24	50	8	9	70	29	10	63	13	46	356	16	22	35	1	22	37	1	9	27	1	10	32	9	54	44	7	37	17
FU002B					1	2						1											1		2									1		
GM001A						1																						8								
GO003A	45	17	18	131	45	68	176	20	12	41	22	27	29	33	36	18	13	2	116	58	49	194	19	30	96	6	12	94	12	13	13	3	2	9	20	2
GO004A				1		8																								3		1		1		
GO006C			2			2								1	1												2							1		
GO010A																					2		4		25	2	1	1		1	2	1			1	
GO013A	24	6		47	16	96	55	10	5	12	4	4	17	10	7	36	44	15	24	8	1	22	3	266	15	19	30	22	12	9	59	64	35	63	23	43
GO014A		2														2					3															
GO050A	22	5		8	2	83	57	15	8																											
GO080A	7	14		79	28	21							2	6	14	79	106		2	54	48	87	205	79	355	476	133	205	77	138	61	110	40	99	54	60
GO9999	7		2	4	3	14	28	8	3	10	2	12	6		2	9	2	14		8	7			7										2		5
HN001A	4	2			2		7	4		16	3		94	3		12	6	8	36	2	1		3	5		2			1	1	2	3	5	16		2
KR001A														1																					
MR001A									1	2					1	1		5	1					1		1									1
NA003A																									3										
NA003B						2																														
NA007A						1											1						3					5		2						
NA008A																																	1			
NA009A						1																														
NA027A																										6	2	1	1							
NA029A													1												3											
NA032A						1																				1										
NA9999			4		1											3	1								6		1	1				1				
NI002A						1																	3							2						
NI005A		1			1		1																										1	1		
NI009A			6						1						3	2		1		2	1				2											
NI015A																											2									
NI017A								3																												
NI020A									6																		2		1			1				
NI025A																			2															1	
NI9999		2							2			4			1										1					5				1	
PI012A																																	1			
PI014A																															1	1	1			
PI022A																					2															
PI023A			2			2																														
PI9999												4								1																
RC002A																										2	2									
RZ011A		4		2	6	12																														
SL007A						2																														
SU001A																											1									
SU002A																			1															1		
SY001A	1	1	11	3	7	8		6	12	7	6	2	34	2	5	14	12	168	3		3		3	15	1	8	9	1		7	1	12				6
SY003A					6	1										2	3																			
SY008A																											3			1	1			2	1	
SY9999		1																																		
TA001A		6	32		8	5		7	6	2	5	12	14	3	17	4	14	8	1	2	4		3	8		1	13	6	4	4	3	25	9	3	12	1

Appendix 4 Diatom sampling dates

Sampling date	Number of Samples
02/04/1997	3
24/06/1997	3
24/09/1997	3
01/04/1998	3
30/06/1998	3
23/09/1998	3
31/03/1999	3
22/06/1999	3
22/09/1999	3
29/03/2000	3
20/06/2000	3
27/09/2000	3
23/05/2001	3
26/06/2001	3
24/10/2001	3
10/04/2002	3
25/06/2002	3
25/09/2002	3
02/04/2003	3
01/06/2003	3
24/09/2003	3
31/03/2004	2
23/06/2004	3
29/09/2004	3
12/04/2005	3
15/06/2005	3
28/09/2005	3
05/04/2006	3
28/06/2006	3
27/09/2006	3
04/04/2007	2
20/06/2007	3
26/09/2007	2
02/04/2008	3
25/06/2008	3
24/09/2008	3