



# UCL



**Title: A palaeolimnological study of Loch Shin, Scotland**

**Final report to SEPA and the Forestry Commission**

ECRC Research Report Number 171

H. Bennion, B. Goldsmith, H. Yang & S. Goodrich

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## **Ensis Ltd.**

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Cover photo: View from the south basin looking north (top left), view of the dam from the fishing club at the south of the loch (bottom left), short core from Loch Shin (SHIN1) (right)

## Executive summary

This project reports on analysis of a sediment core collected from the lower basin of Loch Shin in Sutherland, Scotland on 24 August 2015, spanning a total sediment depth of 31.5 cm. Palaeoecological techniques, principally diatom analysis of a dated core, were employed to assess environmental change at the loch since 1850 AD. The project aims to determine the reference conditions of the loch and to establish the onset, rate and magnitude of any changes in the diatom flora. The Scottish Environment Protection Agency are particularly interested in any changes in the loch that may have occurred in association with fish farming and forestry practices and whether the hydropower scheme has had any impact.

Radiometric methods were applied to the core in order to date the recent sediments, revealing that the 31.5 cm core dates back to ~1850 AD. There is an increase in sedimentation rates before the 1920s, followed by small changes around a mean value of  $0.026 \text{ g cm}^{-2} \text{ yr}^{-1}$  until the 2000s, after which the sedimentation rates increase slightly again in recent years to  $0.038 \text{ g cm}^{-2} \text{ yr}^{-1}$ .

Diatom analysis was carried out on 21 samples distributed throughout the core and a diatom-total phosphorus (TP) transfer function was applied to the diatom data to reconstruct trophic status. There were marked changes in the diatom assemblages during the 160 year period represented by the core and cluster analysis revealed four major zones with the most significant split, reflecting floristic change, at 7.75 cm which corresponds to 1994.

In the period from 1860 to 1930 (Zone 1), the sedimentary diatom assemblages of Loch Shin were very stable with a diatom flora typical of nutrient-poor, deep lakes and the diatom-inferred TP concentrations were low and stable at  $5 \mu\text{g L}^{-1}$  indicating oligotrophic conditions. The diatom reference conditions of Loch Shin can thus be described as a community of oligotrophic, acidophilous-circumneutral taxa, particularly *Cyclotella kuetzingiana*, *Achnanthydium minutissimum* and *Brachysira vitrea*. The diatom assemblages began to change from ~1930 with the arrival of taxa more typically associated with mesotrophic waters, namely *Aulacoseira subarctica* and *Asterionella formosa*, marking an initial enrichment phase (Zone 2). The progressive and gradual nature of the shifts suggests a response to the cumulative effect of increasing pressures in the catchment during the mid to late twentieth century including dam construction and the consequent water level rise in the 1950s, as well as forestry plantation and fertilisation which took place from the 1960s.

A more pronounced enrichment phase was evident from the mid-1990s with the expansion of *Aulacoseira subarctica*, the arrival of *Fragilaria crotonensis* and the decline, and in some cases the loss, of numerous taxa seen in the early part of the record (Zone 3). The diatom-inferred TP concentrations increased to  $16 \mu\text{g L}^{-1}$ . While the exact causes of these shifts cannot be established, the most marked changes in the diatoms are coincident with the arrival of the fish farms on the loch in 1994-1995 suggesting that aquaculture may have played a role. Since 2009 *Fragilaria crotonensis* has disappeared although the reasons for this are not clear (Zone 4). *A. subarctica* remains the dominant species and the planktonic component of the assemblages remains high at 50-60%. The diatom-inferred TP concentrations decreased to  $11 \mu\text{g L}^{-1}$  at the core surface, indicating that there may be a recent phase of reduction in trophic status. However, given that there are no reported changes in land use or management since 2009 and that diatoms respond to a host of factors in addition to nutrient concentrations, it would be unwise to suggest that the disappearance of *F. crotonensis* from the recent sediment record is reflective of improving water quality. Clearly a more detailed study of recent management practices in the catchment and fish farms is required to establish whether there have been any real reductions in nutrient loads to the loch.

With the exception of the dramatic rise and fall of *Fragilaria crotonensis*, the diatom shifts in the Loch Shin core were gradual rather than abrupt, reflecting a process of relative decline in taxa associated with low nutrient concentrations and their replacement with taxa typically found in more nutrient-rich waters. The data provide evidence that while Loch Shin remains on the border of oligotrophic to mesotrophic, it has changed ecologically in response to recent enrichment and could not therefore be classed as in reference condition. The recent assemblages are less diverse and contain fewer benthic taxa and fewer taxa indicative of oligotrophic conditions than those found in the early part of the sediment record.

### **Acknowledgements**

We are grateful to Ian Milne at SEPA for providing site background, to David Ross, the Chairman of the Lairg Angling Club, for granting access to their launch points, to Ian Patmore and Lucia Lencioni at UCL for assistance with the fieldwork in difficult conditions and to Shaun Dowman at UCL for carrying out some of the laboratory work.

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## 1. SPECIFICATION

### 1.1 Statement of understanding, purpose and aims of project

The aim of this project was to investigate the environmental history of Loch Shin, a large, deep, low alkalinity loch in Sutherland, Scotland using palaeoecological techniques. The project employs diatom analysis of a dated sediment core to assess environmental change at the loch since 1850 AD. The project aims to determine the reference conditions of the loch and to establish the onset, rate and magnitude of any changes in the diatom flora. The Scottish Environment Protection Agency (SEPA) are particularly interested in any changes in the loch that may have occurred in association with fish farming and forestry practices and whether the hydropower scheme, introduced in the 1950s, has had any impact on water quality. Phosphorus is a long-standing issue in the loch, leading to concerns about any land use activities in the catchment or in-loch activities that could contribute additional nutrients.

### 1.2 Site details

Loch Shin is a large, freshwater loch located near Lairg in Sutherland, Scotland with three main basins (Fig. 1). The main site characteristics are listed in Table 1. According to the UK Lake Typology it is classed as 'Low altitude, Large, Deep, Low alkalinity and Humic'. The loch has a mean alkalinity of  $46 \mu\text{eq L}^{-1}$ , mean colour of  $44.3 \text{ mgPt L}^{-1}$  and mean dissolved organic carbon content of  $6.35 \text{ mg L}^{-1}$  (UK Lakes Portal). The annual mean pH over the period 2007-2015 is in the range of 6.0-6.3 pH units (SEPA monitoring data) indicating that the loch is slightly acid. A Secchi depth of 1.6 m was recorded on 24 August 2015 (this study) which reflects the brownish colour of the water. Loch Shin is designated as a Heavily Modified Waterbody (HMWB) for 'Water Storage - Hydropower Generation' and overall it was classified in 2011 as Bad Ecological Potential (BEP) due to hydrological modification. The Lairg Dam on the outflow was constructed over the period 1954-1957, raising the level of the loch by ~10 metres, as part of a hydro-electric scheme which became fully operational in 1959.

The soils comprise peaty gleyed podzols with dystrophic semi-confined peat and peaty gleys. The parent material consists of drifts derived from schists, gneisses, granulites and quartzites (Soil Survey of Scotland Staff, 1981). The catchment land cover is comprised of ~40% open dwarf shrub heath, 17% bog (deep peat), 15% coniferous woodland and 11% acid grassland with a range of other cover types making up the remainder (CEH Land Cover Map of Great Britain, 2000). There are four fairly distinct blocks of forestry within the Loch Shin catchment. The largest area of coniferous forest is around Dalchork in the south of the catchment which was planted in the 1960s, mostly with Lodgepole pine but also some Sitka spruce and Scots pine (Shah & Nisbet, 2015). The site was fertilised with phosphorus (P) around the time of planting. Approximately 6.5k ha was commercially afforested over a period of 35 years between 1960 and 1995. Small scale felling started around 1990 but by 2000 the scale had increased significantly with further large scale felling around 2012. The felled areas were usually restocked five years after felling. Smaller areas of forestry are found at Fiag (planted in the 1960s), Overscaig (planted in the early to mid 1980s) and Sallachy Area (planted at various times since 1960). There are two cage fish farm sites within Loch Shin, and a small one in Loch Merkland, which is upstream of Loch Shin. The Sallachy Site in the southern part of the loch was established in 1994 with a capacity of 60 tonnes. The Jubilee Site in the northern part of the loch was established in 1995 with an initial capacity of 30 tonnes, which was increased to 60 tonnes in 2010. The Loch Merkland site was established in 1992 with a capacity of 10 tonnes.



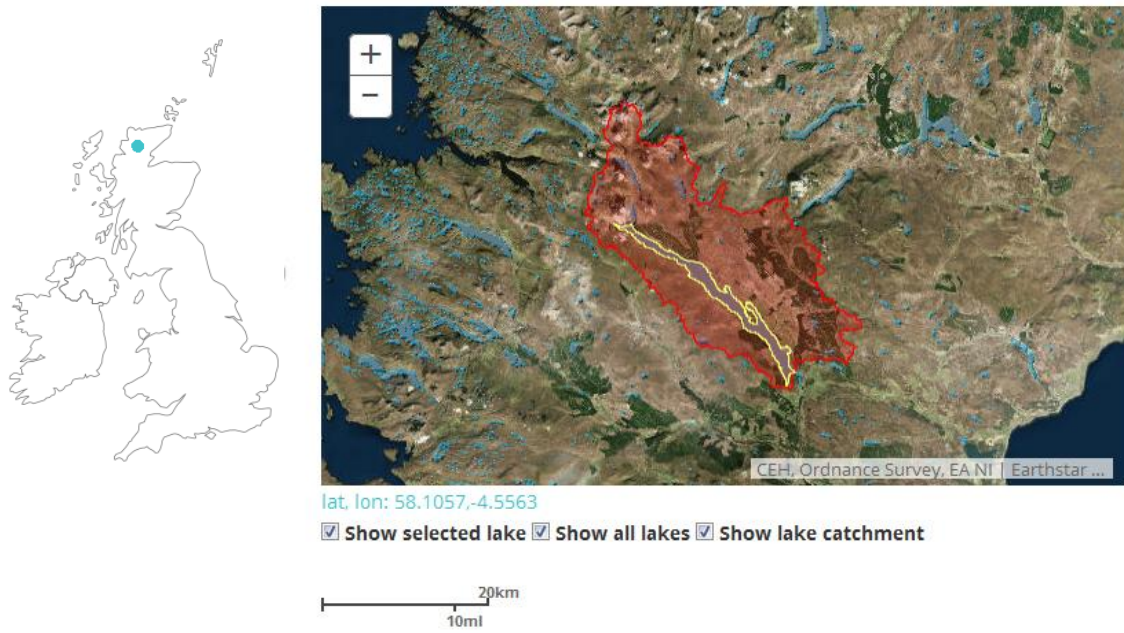
The annual mean total phosphorus (TP) concentrations over the period 2007-2015 are in the range of 7-10  $\mu\text{g L}^{-1}$  (SEPA monitoring data from the lower basin at the Lairg Sailing Club) which results in a classification of oligotrophic, with no notable change over the last ten years. However, the TP classification for Loch Shin in the Water Framework Directive (WFD) Classification of 2011 was Moderate as the Site Specific Total Phosphorus Standards require TP to be  $\leq 8 \mu\text{g L}^{-1}$  to achieve Good status and the mean TP of Loch Shin for the period 2009-2011 was  $9 \mu\text{g L}^{-1}$ . Denoon (2013) applied the Phosphorus Land Use and Slope (PLUS+) Model to Loch Shin to estimate the main sources of P to the loch (Fig. 2). The model predicted that the largest input of P ( $953 \text{ kg yr}^{-1}$ ) comes from upstream inputs which the author thought was likely due to the large network of waterbodies in this system. The model outputs indicate that the upstream Loch Merkland may be a significant source of P as it is also downgraded to Moderate for TP. The second largest P input ( $876 \text{ kg yr}^{-1}$ ) was estimated to be from fish farms with those at Jubilee and Sallachy inputting directly to the loch. The P input from heather was predicted to be the third largest source ( $870 \text{ kg yr}^{-1}$ ), most likely because heather makes up a relatively large proportion of the land cover in the catchment and is predominantly on steep slopes. Coniferous plantations were modelled to be the fourth largest source of P to the loch ( $591 \text{ kg yr}^{-1}$ ). In a study to examine the impacts of forest fertiliser application in sensitive catchments, Shah & Nisbet (2015) reported negligible response in P levels in neighbouring streams to hand fertiliser application in a sub-catchment of Loch Shin at South Dalchork in August-September 2014. Data from the River Tirry control stream, however, indicated a considerable background level of P which varied markedly in response to weather (particularly storm events) and seasonal factors (Shah & Nisbet, 2015). Shah & Nisbet (2015) offered natural (weathering), historic fertiliser applications or forest felling activity as potential sources of this P but stated that further studies are required of the soils and past land use and management to help identify the main nutrient sources.

**Table 1 Site characteristics of Loch Shin**

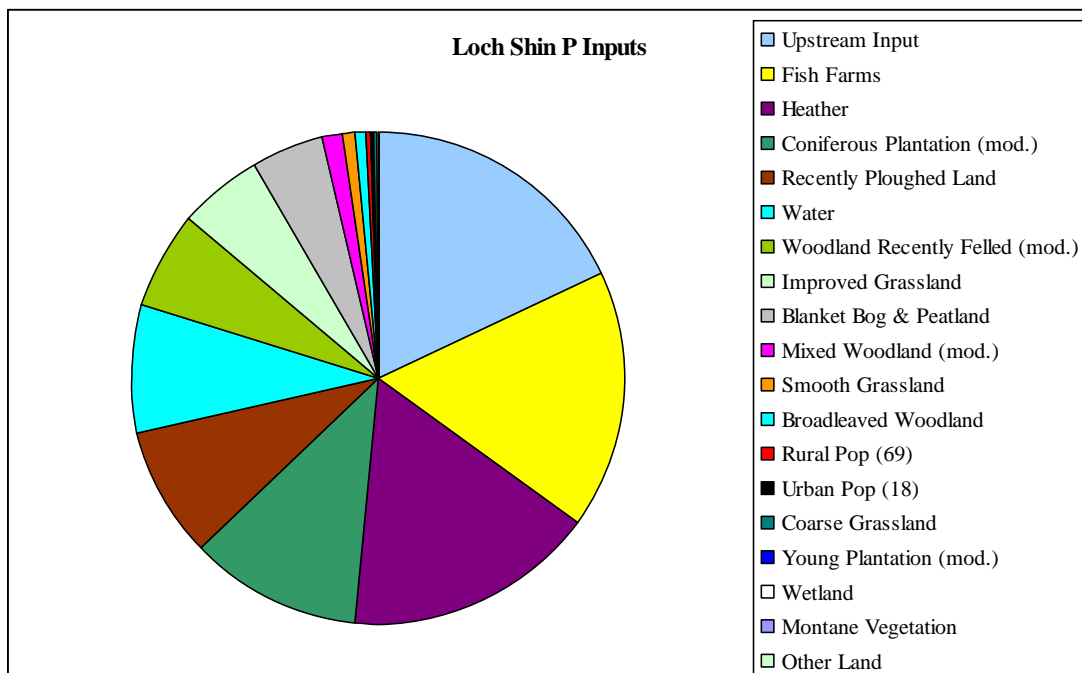
(source: UK Lakes Portal <https://eip.ceh.ac.uk/apps/lakes/detail.html#wbid=9048>)

Water Body ID (WBID)	9048
UK Grid Reference	NC 4947 1581
Altitude	95 m asl
Surface Area	3293 hectares or $32.93 \text{ km}^2$
Mean Depth	15.6 m (NB SEPA Hydrologists record a higher value of 23.8 m due to artificial management of the loch)
Maximum Depth	49.4 m
Catchment Area	48465 hectares or $484.65 \text{ km}^2$
Lake Volume	$513784097 \text{ m}^3$
Perimeter Length	82 km
Fetch Distance	19 km
Catchment to Lake ratio	14.7





**Figure 1 Location of Loch Shin in Sutherland, Scotland and a map of the catchment (shown in red)**  
 (source: UK Lakes Portal <https://eip.ceh.ac.uk/apps/lakes/detail.html#wbid=9048>)



**Figure 2 Summary of phosphorus input to Loch Shin from PLUS+ model**  
 (source: Denoon, 2013)

## 2. METHODS

### 2.1 Core collection and extrusion

An HTH (Renberg & Hansson, 2008) gravity core, 31.5 cm in length, was collected from Loch Shin in the southern or lower basin in a water depth of 37 m at location 58.0694 N, 4.4716 W (UK grid reference NC 55265 09972) on 24 August 2015. The core, named SHIN1, was extruded in the field at 0.5 cm intervals throughout. The rationale for coring in the south basin was that the main forestry input is from the River Tirry, which feeds into that basin, and the fish farm at the Sallachy Site is also in the southern part of the loch and hence any influence of these activities would likely to be better detected in a core from the southern basin than from the central or upper basins. Furthermore SEPA have a routine water quality monitoring point in the south basin at the Lairg Sailing Club.

### 2.2 Lithostratigraphic analyses

The percentage dry weight (DW) which gives a measure of the water content of the sediment, the percentage loss on ignition (LOI) which gives a measure of the organic matter content and the percentage carbonate (CO<sub>3</sub>) content were undertaken using standard techniques (Dean, 1974; Heiri *et al.*, 2001) on every sample from SHIN1 at UCL.

### 2.3 Dating

Dried sediment samples from SHIN1 were analysed for <sup>210</sup>Pb, <sup>226</sup>Ra, <sup>137</sup>Cs and <sup>241</sup>Am by direct gamma assay in the Environmental Radiometric Facility at University College London, using ORTEC HPGe GWL series well-type coaxial low background intrinsic germanium detector. <sup>210</sup>Pb (half-life 22.3 years) is a naturally-produced radionuclide, derived from atmospheric fallout (termed unsupported <sup>210</sup>Pb). <sup>137</sup>Cs (half-life 30 years) and <sup>241</sup>Am are artificially produced radionuclides, introduced to the study area by atmospheric fallout from nuclear weapons testing and nuclear reactor accidents. They have been extensively used in the dating of recent sediments (Appleby, 2001). <sup>210</sup>Pb was determined via its gamma emissions at 46.5keV, and <sup>226</sup>Ra by the 295keV and 352keV gamma rays emitted by its daughter isotope <sup>214</sup>Pb following three weeks storage in sealed containers to allow radioactive equilibration. <sup>137</sup>Cs and <sup>241</sup>Am were measured by their emissions at 662keV and 59.5keV (Appleby *et al.*, 1986). The absolute efficiencies of the detector were determined using calibrated sources and sediment samples of known activity. Corrections were made for the effect of self absorption of low energy gamma rays within the sample (Appleby *et al.*, 1992).

### 2.4 Diatom analysis

One of the most widely used biological groups in palaeolimnological studies is the diatoms (Bacillariophyceae), unicellular, siliceous algae (e.g. Battarbee *et al.*, 2001; Stoermer & Smol, 2010). Diatoms are sensitive to water quality and are good indicators of lake trophic status (Hall & Smol, 2010). They have been employed both qualitatively, whereby shifts in diatom assemblages over time coupled with ecological information can provide a record of ecological change, and quantitatively, whereby transfer functions have been developed to model the relationship between diatom assemblage composition and water chemistry in a training set of lakes (Birks, 1998). With respect to eutrophication, diatom-P transfer functions have been the most commonly developed models for inferring past nutrient concentrations in lakes (Hall & Smol, 2010).

A total of 21 samples throughout SHIN1 were prepared for diatom analysis following the methods of Battarbee *et al.* (2001). At least 300 valves (siliceous component of the cell wall bearing the taxonomic features) were counted from each sample using a research

microscope with a 100x oil immersion objective and phase contrast. Principal floras used in identification were Krammer & Lange-Bertalot (1986-1991). All slides are archived at the ECRC. A summary diagram of the diatom stratigraphy (showing only those taxa present with a percentage relative abundance of >2 % in at least one sample) was produced using C2 (Juggins, 2003) – see Figure 7. All diatom taxa identified in the core are listed in Appendix 1.

Summary statistics of the diatom data were calculated for each sample in the core including the number of taxa observed and the Hill's N2 diversity score which is an estimate of the effective number of taxa and reflects both the evenness and species richness (Hill, 1973). It is generally considered that a shift from benthic to planktonic dominance occurs with eutrophication (Vadeboncoeur *et al.*, 2003) and such a shift has been noted in the diatom assemblages in several palaeoecological studies (e.g. Battarbee, 1978; Sayer *et al.*, 1999). Hence, the percentage of planktonic taxa versus non-planktonic taxa was calculated for each sample. A simple classification was used such that all centric diatoms, *Asterionella formosa*, *Tabellaria flocculosa* (long) and *Fragilaria crotonensis* were classed as planktonic and all others as non-planktonic taxa. This was considered sufficient for revealing the broad habitat shifts. Cluster analysis was performed on the diatom data to identify the major zones in the diatom profile using CONISS (Grimm, 1987), implemented by Tilia version 1.7.16 (Grimm, 1991). CONISS is a program for stratigraphically constrained cluster analysis by the method of incremental sum of squares.

Principal components analysis (PCA), an indirect ordination technique (ter Braak & Prentice, 1988), was used to analyse the variance downcore within the diatom assemblages using C2 (Juggins, 2003). The technique summarises the main changes in the data and helps to identify points of change within complex species-rich data sets. The sample scores for PCA axis 1 are given. Where scores between two neighbouring samples in the core differ markedly this indicates that the assemblages have undergone substantial change between these two points in the core. The scores are also plotted in the stratigraphic diagram to illustrate the timing of any shifts and whether these were gradual or abrupt. The degree of floristic change between the core base sample and every other sample in the core was assessed using the squared chord distance (SCD) dissimilarity coefficient (Overpeck *et al.*, 1985) computed in C2 (Juggins, 2003). This provides a measure of deviation from the reference assemblage. SCD values range from 0 to 2 where a value of 0 indicates that two samples are perfectly similar and a value of 2 perfectly dissimilar. A score less than 0.39 indicates insignificant floristic change at the 2.5th percentile (Simpson *et al.*, 2005) and, as in other studies, is used here to define low floristic change (Bennion & Simpson, 2011).

A diatom-TP transfer function was applied to the diatom data to reconstruct trophic status using a training set of 56 relatively large, deep lakes (> 10 m maximum depth) from Scotland, Northern Ireland, Cumbria, southern Norway and central Europe with annual mean TP concentrations ranging from 1-73  $\mu\text{g TP L}^{-1}$  and a median value of 22  $\mu\text{g TP L}^{-1}$  (Bennion *et al.*, 2004); the best model was generated with simple weighted averaging and inverse deshrinking (ter Braak & van Dam, 1989); this model has a coefficient of determination ( $r^2$ ) between observed and inferred values of 0.75 and a root mean squared error of prediction (RMSEP based on the jack-knifing cross validation method) of 0.25  $\log_{10} \mu\text{g TP L}^{-1}$ . The reconstruction was implemented using C2 (Juggins, 2003).

### 3. Results

#### 3.1 Lithostratigraphic analyses

The SHIN1 core was very dark brown throughout with no visible colour or structural changes (Fig.3). DW% was relatively low with a gradual decrease from 15% at the base of the core to 2% at the surface (Fig. 4), reflecting the higher water content in the less consolidated upper part of the record. The core was relatively organic throughout with LOI% ranging from ~30-35%, the higher values generally occurring above 18 cm (after mid-1950s). The carbonate content was low at less than 5% with relatively higher values in the core section 27-29cm and in the upper 10 cm of the core (Fig. 4). There were so sharp peaks and troughs and thus no evidence of major inwash layers although %DW was slightly elevated at 7.5-8.5 cm (~mid-1990s) with a value of 13%.



Figure 3 Photograph of SHIN1

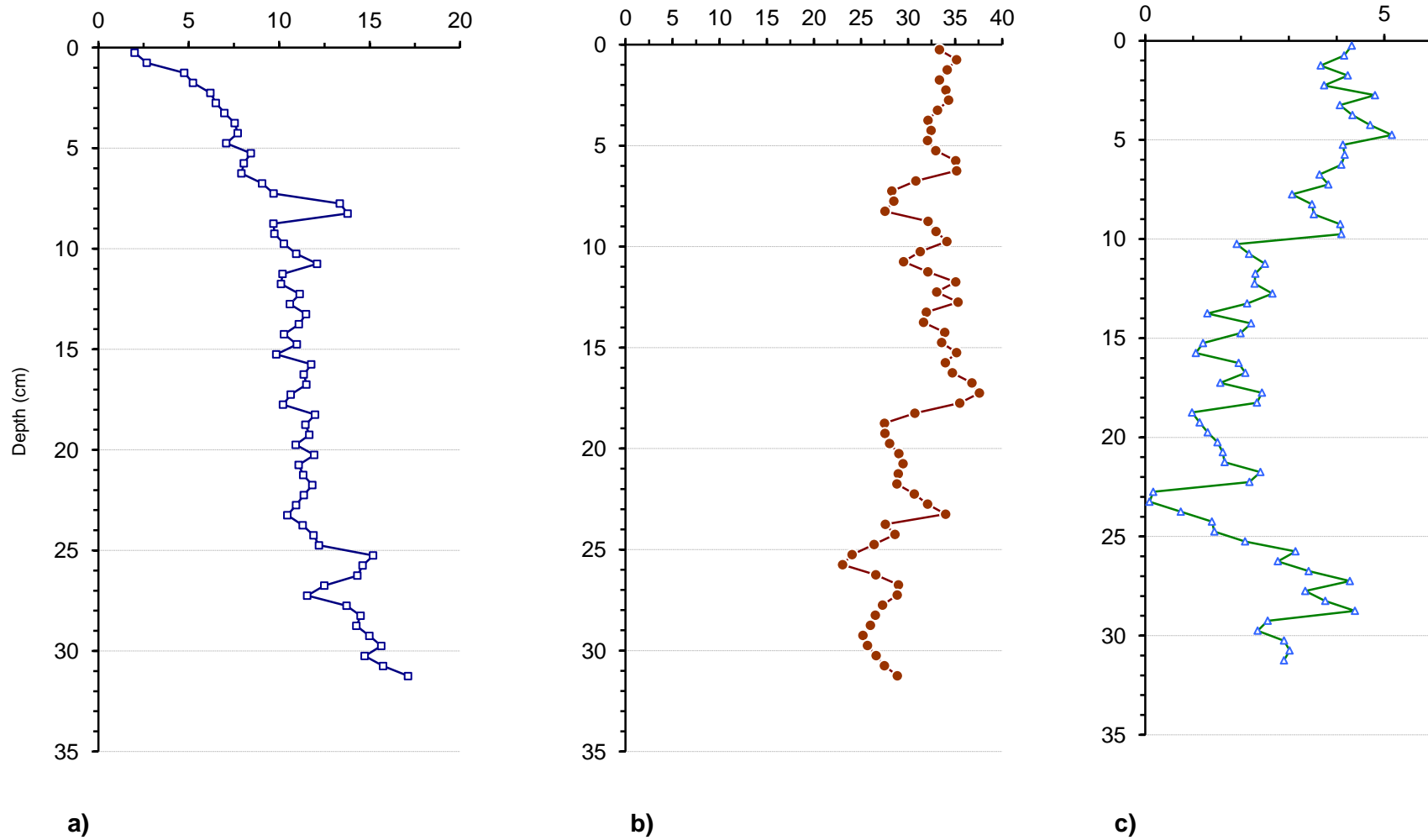


Figure 4 Percentage a) dry weight (DW), b) organic matter (LOI) and c) carbonate (CO<sub>3</sub>) profiles of SHIN1

### 3.2 Dating

Total  $^{210}\text{Pb}$  activity just reaches equilibrium depth with supported  $^{210}\text{Pb}$  activity at the base of the core (Table 2, Fig. 5a). Unsupported  $^{210}\text{Pb}$  activities, calculated by subtracting supported  $^{210}\text{Pb}$  activity from total  $^{210}\text{Pb}$  activity, decline irregularly with depth (Fig. 5b). There is a decline in unsupported  $^{210}\text{Pb}$  activities in the top 6 cm, suggesting an increase in sedimentation rates in recent years. From 6 to 26 cm, unsupported  $^{210}\text{Pb}$  activities decline with depth with many small departures, suggesting relatively uniform sedimentation rates. The  $^{137}\text{Cs}$  activity versus depth profile shows two well-resolved peaks at 16.75 and 8.75 cm (Fig. 5c), which are certainly derived from the atmospheric testing of nuclear weapons with maximum fallout in 1963 and the 1986 fallout of the Chernobyl accident, respectively. A peak at 16.75 cm in the  $^{241}\text{Am}$  profile confirmed that the  $^{137}\text{Cs}$  peak at the same depth is derived from the atmospheric testing of nuclear weapons (Table 3, Fig. 5c).

Use of the constant initial concentration (CIC) dating model was precluded by the non-monotonic variation in unsupported  $^{210}\text{Pb}$  activities of the core (Appleby, 2001). Hence the constant rate of  $^{210}\text{Pb}$  supply (CRS) dating model was used. The CRS model places 1963 and 1986 depths at between 15.25 and 16.75 cm and at 9.75 cm, respectively, which are in agreement with the  $^{137}\text{Cs}$  and  $^{241}\text{Am}$  records indicating that the chronology is robust. The chronologies and sedimentation rates are given in Table 4 and shown in Figure 6 revealing that the 31.5 cm core dates back to ~1850 AD. There is an increase in sedimentation rates before the 1920s, followed by small changes around a mean value of  $0.026 \text{ g cm}^{-2} \text{ yr}^{-1}$  until the 2000s, after which the sedimentation rates increase slightly again in recent years to  $0.038 \text{ g cm}^{-2} \text{ yr}^{-1}$ .

**Table 2  $^{210}\text{Pb}$  concentrations in core SHIN1**

Depth cm	Dry Mass $\text{g cm}^{-2}$	Total		Pb-210 Supported		Unsupp		Cum Unsupported Pb-210	
		Bq $\text{Kg}^{-1}$	$\pm$	Bq $\text{Kg}^{-1}$	$\pm$	Bq $\text{Kg}^{-1}$	$\pm$	Bq $\text{m}^{-2}$	$\pm$
0.5	0.0134	782.78	36.93	132.71	9.15	650.07	38.05	86.5	5.6
1.75	0.0681	744.57	32.41	99.66	6.75	644.91	33.11	441	24.3
2.75	0.1309	841.53	25.09	87.33	4.76	754.2	25.54	879.8	37.9
3.75	0.2042	764.98	46.28	74.47	9.08	690.51	47.16	1408.5	51.7
4.75	0.2863	873	47.24	74.36	8.21	798.64	47.95	2018.4	70.9
5.75	0.373	904.8	30.95	72.44	4.99	832.36	31.35	2725.7	87.9
6.75	0.4634	626.64	22.55	64.02	3.99	562.62	22.9	3348.3	97
7.75	0.5723	442.46	34.13	65.72	6.21	376.74	34.69	3853.1	104.1
8.75	0.6967	430.87	20.5	70.41	4.06	360.46	20.9	4311.3	113.2
9.75	0.8143	457.19	22.81	58.53	4.37	398.66	23.22	4757.3	118.2
11.25	0.9826	386.07	16.13	74.44	3.39	311.63	16.48	5352.2	126.3
12.25	1.096	277.33	15.69	67.95	3.42	209.38	16.06	5643.8	128.9
13.75	1.2733	256.51	15.57	56.92	3.09	199.59	15.87	6006.4	132.7
15.25	1.4376	260.07	9.69	64.87	2.06	195.2	9.91	6330.6	135.9
16.75	1.6063	195.97	14.57	67.75	3.36	128.22	14.95	6599.4	137.9
18.25	1.7838	233.54	15.36	76.54	3.65	157	15.79	6851.8	141
19.75	1.9665	227.92	14.19	78.08	3.47	149.84	14.61	7132	144.5
21.25	2.1532	214.95	8.79	81.81	2.01	133.14	9.02	7395.7	147.2
22.75	2.3347	126.39	13.69	78.11	3.7	48.28	14.18	7547.6	148.7
24.25	2.5109	156.86	11.48	78.57	3.07	78.29	11.88	7657	150.7
25.75	2.7352	117.64	11.74	76.87	3.11	40.77	12.14	7786	153
27.25	2.9419	120.77	7.19	69.8	1.81	50.97	7.41	7880.4	154.9
28.75	3.1637	93.24	8.61	72.81	2.37	20.43	8.93	7954.5	155.9
30.25	3.4065	90.54	7.84	77.33	1.95	13.21	8.08	7994.7	157.3

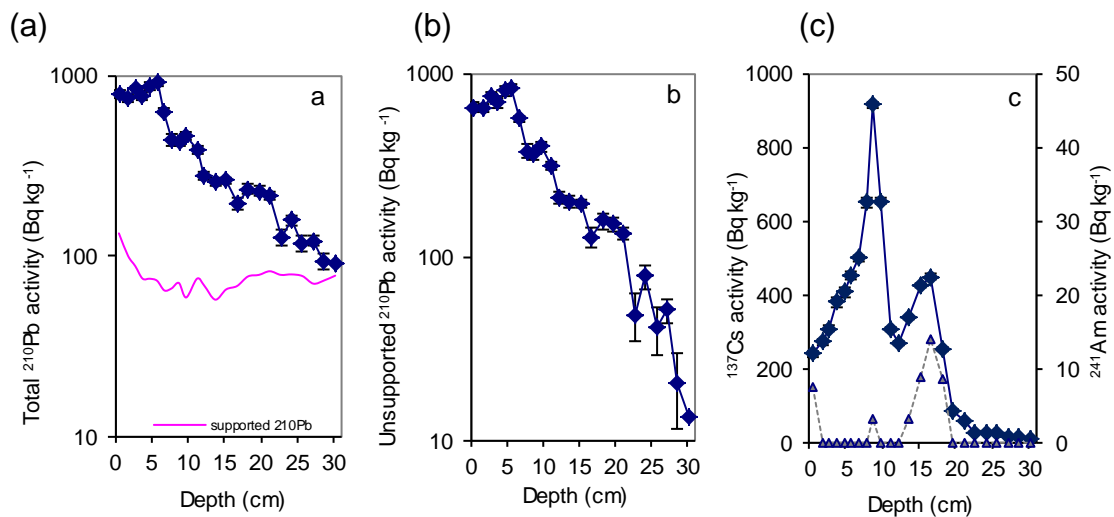
**Table 3 Artificial fallout radionuclide concentrations in core SHIN1**

Depth cm	Cs-137		Am-241	
	Bq Kg <sup>-1</sup>	±	Bq Kg <sup>-1</sup>	±
0.5	238.52	7.75	7.48	2.85
1.75	270.54	7.68	0	0
2.75	307.79	6.32	0	0
3.75	380.95	13.53	0	0
4.75	405.81	13.3	0	0
5.75	451.23	8.66	0	0
6.75	498.97	7.42	0	0
7.75	650.73	13.67	0	0
8.75	914.14	9.84	2.98	1.5
9.75	652.96	9.34	0	0
11.25	303.76	4.87	0	0
12.25	266.05	4.98	0	0
13.75	335.32	5.12	3.01	1.1
15.25	424.92	3.57	8.77	0.79
16.75	448.6	6.17	13.82	1.39
18.25	249.61	4.92	8.53	1.29
19.75	85.21	3.11	0	0
21.25	56.69	1.51	0	0
22.75	25.85	2.29	0	0
24.25	25.76	1.74	0	0
25.75	21.82	1.71	0	0
27.25	12.47	0.85	0	0
28.75	10.92	1.1	0	0
30.25	6.6	0.9	0	0

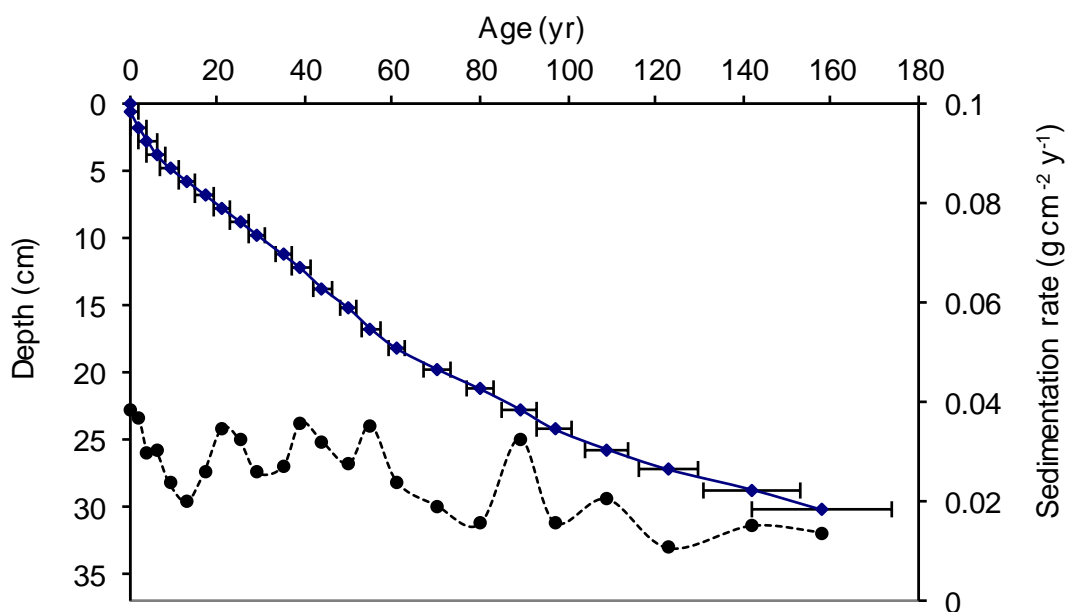


**Table 4  $^{210}\text{Pb}$  chronology of core SHIN1**

Depth cm	Dry mass $\text{g cm}^{-2}$	Chronology			Sedimentation Rate		
		Date AD	Age yr	$\pm$	$\text{g cm}^{-2} \text{ yr}^{-1}$	$\text{cm yr}^{-1}$	$\pm \%$
0	0	2015	0				
0.5	0.0134	2015	0	2	0.0382	0.981	6.2
1.75	0.0681	2013	2	2	0.0368	0.704	5.5
2.75	0.1309	2011	4	2	0.0296	0.435	4
3.75	0.2042	2009	6	2	0.03	0.386	7.2
4.75	0.2863	2006	9	2	0.0235	0.279	6.4
5.75	0.373	2002	13	2	0.0199	0.225	4.5
6.75	0.4634	1998	17	2	0.026	0.261	4.9
7.75	0.5723	1994	21	2	0.0347	0.298	9.6
8.75	0.6967	1990	25	2	0.0323	0.267	6.5
9.75	0.8143	1986	29	2	0.0257	0.225	6.6
11.25	0.9826	1980	35	2	0.027	0.239	6.4
12.25	1.096	1976	39	2	0.0358	0.308	8.5
13.75	1.2733	1971	44	2	0.0319	0.28	9
15.25	1.4376	1965	50	2	0.0275	0.247	7
16.75	1.6063	1960	55	2	0.0353	0.306	12.8
18.25	1.7838	1954	61	2	0.0238	0.198	11.6
19.75	1.9665	1945	70	3	0.0191	0.155	12
21.25	2.1532	1935	80	3	0.0154	0.125	11.5
22.75	2.3347	1926	89	4	0.0326	0.273	31.2
24.25	2.5109	1918	97	4	0.0157	0.118	19.6
25.75	2.7352	1906	109	5	0.0204	0.142	33.4
27.25	2.9419	1892	123	7	0.0105	0.074	26.2
28.75	3.1637	1873	142	11	0.015	0.097	54
30.25	3.4065	1857	158	16	0.0137	0.087	64.8



**Figure 5 Fallout radionuclide concentrations in core SHIN1 showing (a) total  $^{210}\text{Pb}$ , (b) unsupported  $^{210}\text{Pb}$  and (c)  $^{137}\text{Cs}$  and  $^{241}\text{Am}$  concentrations versus depth.**



**Figure 6 Radiometric chronology of core SHIN1, showing the CRS model  $^{210}\text{Pb}$  dates and sedimentation rates.** The solid line shows age, while the dashed line indicates sedimentation rate.

### 3.3 Diatom analysis

Diatoms were abundant throughout the sediment core and were generally well preserved in all samples. The 21 samples analysed, along with the summary statistics, are given in Table 5. A total of 132 diatom taxa were recorded from the core (Appendix 1) with between 36 and 59 taxa per sample. The Hills N2 diversity scores show that samples were less diverse and less even above ~7 cm, indicating dominance by a relatively small number of taxa in the upper core. Between 81 to 92% of the diatom taxa in the fossil samples from the core were present in the training set and therefore diatom-TP reconstructions are considered to be reliable. There were some marked changes in the diatom assemblages during the 160 year period represented by the core (Fig. 7). The cluster analysis revealed four major zones with the most significant split, reflecting floristic change, at 7.75 cm which corresponds to 1994.

In Zone 1 (below 22 cm), corresponding to a period from approximately 1850 to 1930 AD, the diatom assemblage appears relatively stable with *Brachysira vitrea* and *Achnantheidium minutissimum* dominating the benthic component of the flora and the species *Cyclotella kuetzingiana* var. *planetophora* and *Aulacoseira distans* being the main components of the planktonic community. The assemblages were predominantly benthic, however, with the planktonic component representing only ~20%. The SCD scores were low (<0.39) indicating insignificant change from the reference sample in this zone. The diatom-inferred TP concentrations were low and stable at  $5 \mu\text{g L}^{-1}$ .

In Zone 2 (21-8 cm), representing approximately ~1930-1994, there is a gradual but marked shift in the assemblage as evidenced by the increase in diversity (Hill's N2) and decrease in the PCA axis 1 scores (Fig. 7). The relative abundance of *B. vitrea*, *A. minutissimum*, *C. kuetzingiana* var. *planetophora*, *A. distans* and *Fragilariforma exigua* all decrease and conversely *Aulacoseira subarctica*, *Tabellaria* species and *Asterionella formosa* increase. Consequently, there is an increase in planktonic taxa from ~20% to ~40%. The SCD scores also steadily increase during this zone from 0.44 to 1.25, indicating the progressive and

significant deviation from the reference sample. Diatom-inferred TP concentrations gradually increased from 6 to 10  $\mu\text{g L}^{-1}$  through this zone.

In Zone 3 (7.5-3.75 cm), representing ~1996-2009, *Aulacoseira subarctica* became dominant with both short and long forms of *Tabellaria flocculosa* present and, to a lesser extent, *Tabellaria fenestrata*. Many of the taxa observed in Zones 1 and 2 disappeared from the assemblage. Therefore, this level in the core (i.e. 7.75 cm, representing 1994) was identified by cluster analysis as the most significant point of change in the diatom community. Notably, between 4-6 cm, the long planktonic forms of *T. flocculosa* and *A. formosa* were replaced in part by a peak in the planktonic species *Fragilaria crotonensis*, a species otherwise almost absent from the core samples. The diversity and species richness were consequently lower in this zone and the % planktonic taxa rose to a peak of 68% at 4.25 cm (=2007 AD). The SCD values continued to increase to a maximum of 1.45 units at 4.25 cm reflecting continued deviation from the reference sample. Diatom-inferred TP concentrations rose further and peaked at 16  $\mu\text{g L}^{-1}$  at 4.25 cm in line with the peak in *F. crotonensis*.

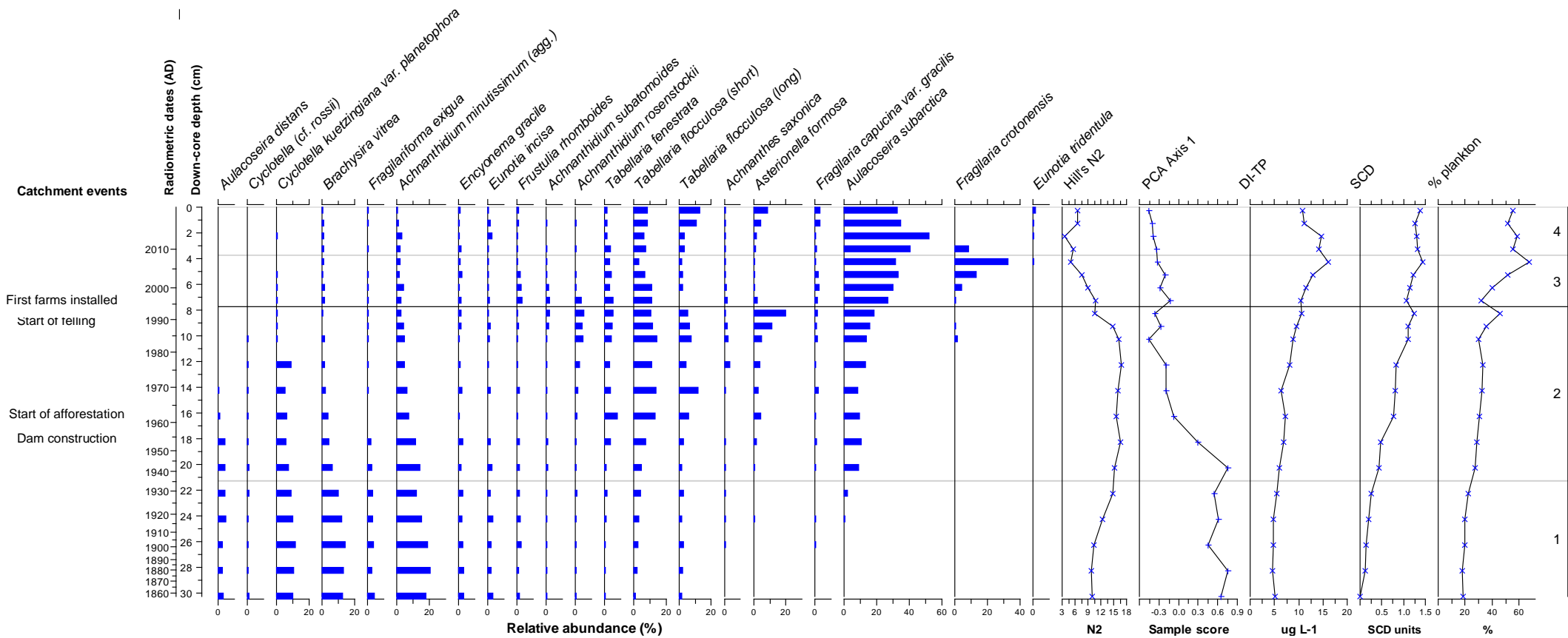
In Zone 4 (3.5-0 cm), representing 2010-2015, *A. subarctica* remained dominant but *F. crotonensis* decreased and eventually disappeared from the assemblage while the long form of *T. flocculosa* and *A. formosa* increased to relative abundances similar to those observed in Zone 2. The % plankton (50-60%) and SCD (~1.3 units) scores remained high and were quite stable in this zone reflecting relative stability in the diatom assemblages in the last five years. Diatom-inferred TP concentrations gradually decreased to 11  $\mu\text{g L}^{-1}$  at the core surface and therefore returned to values similar to those inferred for the upper part of Zone 2.

Throughout the core there was a relatively high number of non-planktonic species, mostly *Eunotia* spp. and small monoraphid “*Achnanthes*” type species”, as well as *Frustulia rhomboides* and *Encyonema gracile*, that remained more or less constant at low relative abundances.

**Table 5 Summary of diatom analysis from SHIN1**

Depth (cm)	No. of taxa	Hill's N2	% plankton	DI-TP $\mu\text{g L}^{-1}$	SCD	PCA axis 1 scores
0.25	36	6.7	56	11	1.38	-0.46
1.25	49	6.7	51	11	1.27	-0.41
2.25	42	3.6	58	15	1.31	-0.39
3.25	45	5.6	56	14	1.32	-0.33
4.25	42	4.9	68	16	1.45	-0.32
5.25	48	7.5	51	13	1.23	-0.20
6.25	54	9.1	40	11	1.14	-0.29
7.25	52	10.8	32	10	1.07	-0.13
8.25	49	10.6	46	11	1.25	-0.36
9.25	53	14.8	36	10	1.10	-0.27
10.25	56	16.2	30	9	1.11	-0.45
12.25	52	16.8	33	8	0.83	-0.19
14.25	55	15.9	33	6	0.81	-0.19
16.25	58	15.7	31	7	0.77	-0.07
18.25	59	16.5	29	7	0.47	0.30
20.25	55	15.1	27	6	0.44	0.75
22.25	59	14.8	22	5	0.25	0.54
24.25	57	12.3	20	5	0.20	0.61
26.25	51	10.3	20	5	0.13	0.45
28.25	53	9.9	18	5	0.13	0.76
30.25	55	10.1	18	5	0.00	0.65

**Figure 7 Summary stratigraphy for selected diatom taxa in the Loch Shin core SHIN1**



## 4. Discussion

The palaeolimnological study revealed marked changes in the diatom assemblages during the 160 year period represented by the core and identified four main periods in the history of the loch.

### **Reference conditions (pre-1930)**

In the period from 1860 to 1930, the sedimentary diatom assemblages of Loch Shin were very stable with a diatom flora typical of oligotrophic, deep lakes (Bennion *et al.*, 2004). When the reference diatom assemblages in the core bottoms of 26 Scottish lochs representing ~1850 were classified, Bennion *et al.* (2004) reported that Group 1 was comprised of large, deep, oligotrophic, slightly acid lochs characterized by oligotrophic, acidophilous-circumneutral taxa, particularly *Cyclotella kuetzingiana*, *Cyclotella comensis*, *Tabellaria flocculosa*, *Achnanthes minutissima* (since renamed *Achnantheidium minutissimum*) and *Brachysira vitrea*. Therefore, the flora at the base of the Loch Shin core is remarkably similar to that observed in the bottoms of cores from other large, deep lochs and could feasibly be described as the reference diatom community of the loch. Indeed, *Cyclotella kuetzingiana* and *Achnanthes minutissima* dominated the assemblages of Lochs Eck, Lubnaig, Maree, Rannoch and Shiel throughout the sediment records and thus these five sites were identified as minimally impacted lochs (Bennion *et al.*, 2004). Prior to ~1930, the diatom-inferred TP concentrations were low and stable at 5  $\mu\text{g L}^{-1}$  indicating oligotrophic conditions and are similar to the values of 3–5  $\mu\text{g L}^{-1}$  inferred for the Group 1 lochs by Bennion *et al.* (2004).

### **First phase of enrichment (~1930 to mid-1990s)**

From around 1930, the diatom assemblages started to change, albeit gradually, with a progressive shift away from the reference assemblages and SCD scores consequently rising to 1.25 at the boundary of Zones 2 and 3. Most notably, the oligo-mesotrophic taxa *Aulacoseira subarctica* and *Asterionella formosa* arrived and the *Tabellaria* taxa expanded, and in contrast a decline was observed in taxa typically associated with unproductive waters. While the benthic taxa still dominated the assemblages, these changes resulted in an increase in planktonic taxa to around 40%. The ecological shifts, therefore, suggest a degree of enrichment and this is reflected in an increase in the DI-TP concentrations from 6 to 10  $\mu\text{g L}^{-1}$  within this period.

Such shifts have been seen in other lakes in initial phases of enrichment, such as Lochs Awe, Doon, Earn, Lomond and Lake of Menteith, where diatom changes followed similar trajectories from a *Cyclotella*–*Achnanthes* assemblage to a planktonic assemblage typical of more mesotrophic waters (e.g. *Asterionella formosa*, *Aulacoseira subarctica*, *Fragilaria crotonensis*) (Bennion *et al.*, 2004). Information on catchment history was not available for the period prior to dam construction in the mid-1950s and thus the causes of this first phase of enrichment cannot be firmly established. Nevertheless, the progressive and gradual nature of the shifts suggest that the diatoms are responding to the cumulative effect of increasing pressures in the catchment during the mid to late twentieth century including dam construction and the consequent water level rise which may have reduced benthic habitat, as well as forestry plantation and fertilisation which took place from the 1960s. It is interesting to note that there were no major periods of minerogenic soil inwash (as shown by the DW% data) associated with the dam construction in the 1950s or afforestation in the 1960s, although the organic matter content (LOI%) did increase after the mid-1950s which could reflect increased within-loch production and/or more organic inputs from the catchment.

### **Second phase of enrichment (~mid-1990s to 2009)**

The diatom assemblages experienced more marked changes from the mid-1990s with the expansion of *Aulacoseira subarctica*, the arrival of *Fragilaria crotonensis* and the decline, and in some cases the loss, of numerous taxa seen in the early part of the record. These

same shifts have been observed in numerous European lakes during periods of increased nutrient loading (e.g. Anderson, 1997; Lotter, 1998, 2001; Bennion *et al.*, 2011, 2015) and, therefore, provide a useful indication of ecological change associated with eutrophication. *F. crotonensis* is characteristic of circumneutral waters with moderate nutrient levels and frequently peaks in summer months. It is considered as an indicator of nutrient enrichment in temperate lakes (e.g. Tilman, 1982). *Aulacoseira subarctica* is commonly associated with oligo-mesotrophic lakes (Krammer & Lange-Bertalot, 1991) but Kauppila *et al.* (2002) found this species in the sediments of eutrophic lakes in Finland and Jones *et al.* (1997) discovered that *A. subarctica* increased with nutrient enrichment in Loch Ness. *A. subarctica* tends to peak in late winter to early spring in most lakes and because it has resting stages it can quickly accumulate numbers from the sediments and thus competes well in lakes with rapid flushing rates. While data on retention times in Loch Shin before and after dam construction were not available, it might be possible that the flushing rates have increased since the water levels were raised and managed in the mid-1950s, hence favouring *A. subarctica*. The decline, or loss, of many of the benthic taxa present in the early part of the record led to a further increase in the planktonic component of the assemblages to a maximum of 68%. A shift from benthic to planktonic dominance typically occurs with eutrophication (Vadeboncoeur *et al.*, 2003) and such a shift has been noted in the diatom assemblages in several palaeoecological studies (e.g. Battarbee, 1978; Sayer *et al.*, 1999; Bennion *et al.*, 2015).

Marked species shifts indicative of enrichment, similar to those observed in Loch Shin, were seen in Lochs Awe North and South Basins, Lomond South Basin, Doon and Earn, where SCD scores between the reference and top samples were relatively high, ranging from 0.65 to 1.63 (Bennion *et al.*, 2004). In Loch Shin, the SCD scores increased to a maximum of 1.45 at 4.25 cm, which dates to 2007, reflecting continued and significant deviation from the reference sample at the base of the core. The changes in the diatom assemblages of some of the lochs named above were sufficient to result in two- to threefold increases in DI-TP concentrations (Bennion *et al.*, 2004). Similarly in Loch Shin, the shift to dominance by taxa more typical of mesotrophic waters resulted in a further increase in DI-TP concentrations which peaked at  $16 \mu\text{g L}^{-1}$  at 4.25 cm in line with the peak in *F. crotonensis*. This represents a threefold increase over the baseline DI-TP concentrations of  $5 \mu\text{g L}^{-1}$  inferred in Zone 1.

The sources of nutrients to the enriched waters identified in the Bennion *et al.* (2004) study are many. For example, Lochs Lomond, Awe and Earn receive diffuse agricultural and forestry inputs, and sewage effluent from villages and hotels. In the latter two cases, there are additional sources of nutrients from fish cages. At Loch Shin the major changes in the diatoms from the mid-1990s coincide with both the installation of the fish farms in 1994-1995 and the start of tree felling at around this time, although the latter did not take place on a large scale until around 2000. The waste from fish farms, primarily in the form of end products of digestion and unutilised feed, can add a significant P load to fresh waters (Wallace, 1993; Tacon & Forster, 2003). Indeed fish farms were identified by Denoon (2013) as the second largest P input ( $876 \text{ kg yr}^{-1}$ ) to Loch Shin. In a comparable palaeoecological study of an un-named loch (referred to as Loch A) in north-west Scotland, Sayer *et al.* (2012) provide evidence of major shifts in the diatoms after 1985, coincident with the arrival of the fish farm on the loch. They conclude that oligotrophic lochs such as Loch A appear to be highly sensitive to eutrophication, most likely because of their extremely nutrient-poor, natural condition, and this statement could apply equally to Loch Shin. While the enrichment inferred from the diatom shifts in Loch Shin cannot be firmly attributed to the establishment of the two fish farms on the loch, the coincidental timing of the most marked changes in the diatoms with the arrival of the fish farms suggests that aquaculture may have contributed in some way to alterations in water quality.



### ***A recent phase of slight reduction in trophic status? (2009-2015)***

In the uppermost part of the core, from 2009 to present, several changes in the diatoms were seen. Most notably *F. crotonensis*, which had dramatically arrived in Zone 3, declined and then disappeared, while the long form of *T. flocculosa* and *A. formosa* increased to relative abundances similar to those observed in Zone 2. Nevertheless, *A. subarctica* remained the dominant species and the planktonic component of the assemblages remained high at 50-60%. These shifts resulted in a gradual reduction in diatom-inferred TP concentrations to  $11 \mu\text{g L}^{-1}$  at the core surface, indicating that there may be a recent phase of reduction in trophic status. The diatom-inferred TP value of  $11 \mu\text{g L}^{-1}$  for the surface sample was in very good agreement with the current measured mean TP of  $9 \mu\text{g L}^{-1}$  suggesting that the transfer function gives reliable nutrient inferences for Loch Shin. Importantly, in spite of the small 'reversal' in the diatom community, the recent diatom assemblages are still very different from those seen prior to 1930 with a relatively high SCD score of 1.38 between the top and bottom samples of the core. The recent assemblages are less diverse and contain fewer benthic taxa and fewer taxa indicative of oligotrophic conditions than those found towards the base of the core.

It is difficult to explain the recent shifts in the diatom assemblages given that there are no reported changes in land use or management since 2009. Diatoms respond to a host of factors in addition to nutrient concentrations, such as light availability, flushing rate, weather conditions and grazing pressure, and large inter-annual variability in phytoplankton communities has been observed in other Scottish lochs, most famously by Bailey-Watts *et al.* (1990) in Loch Leven. It would be unwise, therefore, to suggest that the disappearance of *F. crotonensis* from the recent sediment record of Loch Shin is reflective of improving water quality. Clearly a more detailed study of recent management practices in the catchment and fish farms is required to establish whether there have been any real reductions in nutrient loads to the loch.

## **5. Summary**

Based on the palaeoecological study, the reference conditions of Loch Shin can be described as a stable diatom community of oligotrophic, acidophilous-circumneutral taxa, particularly *Cyclotella kuetzingiana*, *Achnanthydium minutissimum* and *Brachysira vitrea*. The diatom assemblages began to change from ~1930 with the arrival of taxa more typically associated with mesotrophic waters, namely *Aulacoseira subarctica* and *Asterionella formosa*, marking an initial enrichment phase. The progressive and gradual nature of the shifts suggests a response to the cumulative effect of increasing pressures in the catchment during the mid to late twentieth century including dam construction and the consequent water level rise in the 1950s, as well as forestry plantation and fertilisation which took place from the 1960s. A more pronounced enrichment phase was evident from the mid-1990s with the expansion of *Aulacoseira subarctica*, the arrival of *Fragilaria crotonensis* and the decline, and in some cases the loss, of numerous taxa seen in the early part of the record. The diatom transfer function infers a threefold increase in TP concentrations from the baseline value of  $5 \mu\text{g L}^{-1}$ . While the exact causes of these shifts cannot be established, the most marked changes in the diatoms are coincident with the arrival of the fish farms on the loch in 1994-1995 suggesting that aquaculture may have played a role. Since 2009 *Fragilaria crotonensis* has disappeared although the reasons for this are not clear.

With the exception of the dramatic rise and fall of *Fragilaria crotonensis*, the diatom shifts in the Loch Shin core were gradual rather than abrupt, reflecting a process of relative decline in taxa associated with low nutrient concentrations and their replacement with taxa typically found in more nutrient-rich waters. The data provide evidence that while Loch Shin remains on the border of oligotrophic to mesotrophic, it has changed ecologically in response to recent enrichment and could not therefore be classed as in reference condition.



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**Appendix 1 List of all diatom taxa in SHIN1 (data are expressed as % relative abundance and columns represent depth in cm)**

CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
AC141A	<i>Achnanthes bioretii</i>	0.0	0.6	1.0	1.3	1.3	0.3	0.3	0.9	0.3	1.7	1.3	1.0	0.9	0.9	1.3	0.0	0.3	0.3	0.3	0.0	0.0
AC167A	<i>Achnanthes daonensis</i>	1.3	0.9	1.3	1.7	1.0	0.7	0.0	0.9	0.7	1.3	0.3	1.0	0.3	0.0	0.7	0.0	0.7	0.7	1.3	2.2	1.6
AC025A	<i>Achnanthes flexella</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.7	1.3	0.7	0.3	0.6	0.6	0.0
AC197A	<i>Achnanthes impexiformis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC083A	<i>Achnanthes laevis</i>	0.3	0.0	0.0	0.0	0.0	0.3	0.3	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.7	0.0	0.3	0.6	0.3	0.3
AC001A	<i>Achnanthes lanceolata</i>	0.0	0.3	0.0	0.0	0.6	0.7	0.3	0.6	0.0	0.3	0.6	0.3	0.0	0.6	0.7	0.0	0.3	1.0	0.6	0.0	0.3
AC022A	<i>Achnanthes marginulata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC013A	<i>Achnanthes minutissima</i> var. <i>minutissima</i>	1.3	1.5	3.8	2.7	2.9	2.3	4.5	3.1	3.0	5.0	5.4	5.5	6.9	7.7	11.8	14.7	12.6	16.0	19.7	21.1	18.6
AC105A	<i>Achnanthes petersenii</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
AC004A	<i>Achnanthes pseudoswazi</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AC035A	<i>Achnanthes pusilla</i> var. <i>pusilla</i>	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
AC182A	<i>Achnanthes rosenstockii</i>	0.0	0.3	0.0	0.3	0.0	0.3	1.0	4.1	5.6	5.0	5.1	3.2	1.9	1.5	0.3	0.3	1.7	0.3	0.3	0.9	0.3
AC028A	<i>Achnanthes saxonica</i>	1.3	0.9	1.0	1.3	0.6	1.3	1.9	2.2	1.3	2.0	2.6	3.9	0.3	0.0	0.7	1.0	0.7	0.3	0.6	0.0	0.0
AC9999	<i>Achnanthes</i> sp.	0.3	0.3	0.0	0.7	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
AC136A	<i>Achnanthes subatomoides</i>	0.0	0.3	0.0	0.7	1.0	0.7	1.9	2.8	2.6	2.3	1.0	1.3	0.6	0.3	1.3	1.3	1.0	1.0	1.3	0.6	0.3
AC161A	<i>Achnanthes ventralis</i>	0.3	0.6	1.0	0.7	0.0	0.3	0.3	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.3	0.7	1.0	0.3	0.0	0.3	0.0
AS001A	<i>Asterionella formosa</i> var. <i>formosa</i>	9.1	4.7	1.9	1.7	0.6	1.3	1.3	2.5	20.3	11.6	5.1	4.5	3.1	5.1	2.0	0.7	0.0	0.3	0.0	0.0	0.0
AU005A	<i>Aulacoseira distans</i> var. <i>distans</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.8	4.9	4.7	5.0	5.2	3.2	3.4	3.5
AU020A	<i>Aulacoseira subarctica</i>	33.1	35.1	52.6	41.0	32.2	33.4	30.7	27.3	19.0	16.2	14.1	13.6	8.8	9.8	11.2	9.3	2.6	0.7	0.0	0.0	0.0

CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
BR006A	<i>Brachysira brebissonii</i> fo. <i>brebissonii</i>	0.0	0.0	0.0	0.0	0.6	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.3	0.0	0.3	0.6	0.3
BR004A	<i>Brachysira styriaca</i>	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BR001A	<i>Brachysira vitrea</i>	1.0	1.8	1.6	1.3	1.6	1.3	1.9	1.9	1.3	0.0	1.9	1.9	2.5	4.5	4.6	7.0	10.6	12.7	14.5	13.7	13.2
CA018A	<i>Caloneis tenuis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
CO067A	<i>Cocconeis neothumensis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0
CO001B	<i>Cocconeis placentula</i> var. <i>euglypta</i>	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CY9994	<i>Cyclotella</i> [cf. <i>comensis</i> ]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.3	1.0	0.7	0.3	0.3	0.0	0.3
CY9986	<i>Cyclotella</i> [cf. <i>rossii</i> ]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.9	0.3	1.0	1.7	1.7	1.0	1.3	0.9	1.6
CY006B	<i>Cyclotella kuetzingiana</i> var. <i>planetophora</i>	0.0	0.0	0.3	0.0	0.0	0.3	0.6	1.3	0.3	0.7	0.3	9.4	5.7	6.8	6.3	8.0	9.3	10.4	11.9	11.2	10.7
CY003A	<i>Cyclotella meneghiniana</i> var. <i>meneghiniana</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CM035A	<i>Cymbella angustata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
CM018A	<i>Cymbella gracilis</i>	1.6	1.2	1.3	2.0	1.6	2.6	1.3	2.2	2.0	2.0	0.6	1.6	2.8	1.2	3.0	2.3	3.3	2.6	2.9	3.7	3.5
CM017A	<i>Cymbella hebridica</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.6	0.3	0.6	0.0	0.3	0.0	0.0	0.3	0.3	0.0	0.0
CM013A	<i>Cymbella helvetica</i> var. <i>helvetica</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3	0.3	0.6
CM004A	<i>Cymbella microcephala</i> fo. <i>microcephala</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.0	2.3	1.3	2.3	2.6	2.5	1.6
CM031A	<i>Cymbella minuta</i> var. <i>minuta</i>	0.0	0.0	0.0	0.3	0.6	0.3	0.0	0.3	0.0	0.3	0.3	0.0	0.0	0.3	0.3	0.0	0.7	0.3	0.0	0.0	0.0
CM009A	<i>Cymbella naviculiformis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.3	0.0	0.3	0.0	0.6	0.7	0.0	0.3	1.0	1.9	2.2	2.8
CM010A	<i>Cymbella perpusilla</i>	0.0	0.3	1.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3	0.3	0.0	0.0	0.0
CM107A	<i>Cymbella subcuspidata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DT004A	<i>Diatoma tenue</i> var. <i>tenue</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6	0.9	0.9	0.3	0.0	0.3	0.0	0.0	0.0	0.0
DP9999	<i>Diploneis</i> sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
EP007A	<i>Epithemia adnata</i> var. <i>adnata</i>	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
EU013A	<i>Eunotia arcus</i> var. <i>arcus</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.3	0.0	0.0	0.0	0.0	0.0
EU070B	<i>Eunotia bilunaris</i> var. <i>mucophila</i>	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU049A	<i>Eunotia curvata</i> var. <i>curvata</i>	1.3	1.5	1.3	1.3	1.0	1.6	1.0	1.6	2.0	1.3	2.2	1.9	1.9	1.5	2.0	1.3	1.7	0.7	2.3	1.6	2.2
EU043A	<i>Eunotia elegans</i>	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU009A	<i>Eunotia exigua</i> var. <i>exigua</i>	2.3	1.8	0.3	0.7	0.3	1.0	0.6	0.6	0.0	0.3	0.3	0.3	0.0	1.2	0.3	0.3	0.0	1.0	0.3	0.3	0.0
EU025A	<i>Eunotia fallax</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU107A	<i>Eunotia implicata</i>	1.0	1.2	0.0	0.7	1.0	1.6	1.6	2.2	1.0	2.0	0.6	2.3	1.9	2.7	2.3	3.0	4.0	3.3	1.6	2.2	2.5
EU047A	<i>Eunotia incisa</i>	1.3	2.4	3.2	1.0	0.6	0.7	1.3	1.6	0.7	2.0	1.6	1.3	1.9	0.0	2.3	3.0	2.3	3.6	2.6	2.8	3.5
EU108A	<i>Eunotia intermedia</i>	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU110A	<i>Eunotia minor</i>	0.0	0.9	1.6	0.7	0.6	0.3	0.3	0.6	0.0	0.3	0.0	0.3	0.0	0.6	0.3	1.0	0.3	0.3	0.6	1.2	0.6
EU048A	<i>Eunotia naegeli</i>	1.6	0.6	0.3	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU040A	<i>Eunotia paludosa</i>	0.6	0.6	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU002A	<i>Eunotia pectinalis</i> var. <i>pectinalis</i>	1.0	0.6	0.6	0.7	0.3	0.3	0.6	0.6	0.3	0.7	1.6	0.3	0.3	0.0	0.7	0.3	1.0	0.7	0.0	0.0	0.6
EU003A	<i>Eunotia praerupta</i> var. <i>praerupta</i>	0.0	0.3	1.0	0.3	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU011A	<i>Eunotia rhomboidea</i>	0.0	0.3	1.0	1.3	1.0	1.6	0.3	0.6	0.0	0.3	0.3	0.6	0.9	0.9	0.3	0.0	0.7	0.3	0.6	0.3	0.6
EU106A	<i>Eunotia rhyncocephela</i>	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU105A	<i>Eunotia subarcuoides</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	1.3	0.3	0.7	0.0	0.3	0.0
EU021A	<i>Eunotia sudetica</i>	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU004A	<i>Eunotia tenella</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU053A	<i>Eunotia tridentula</i>	2.3	1.2	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR009A	<i>Fragilaria capucina</i> var. <i>capucina</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.3
FR009H	<i>Fragilaria capucina</i> var. <i>gracilis</i>	3.6	3.8	1.3	1.7	1.3	2.6	2.9	2.2	2.3	1.3	2.2	1.3	2.8	0.9	1.6	0.7	0.0	0.3	0.6	0.0	0.0
FR009G	<i>Fragilaria capucina</i> var. <i>rumpens</i>	0.3	0.6	0.3	0.0	0.0	0.7	1.6	1.3	1.0	0.3	2.6	1.6	1.9	1.5	1.3	1.7	2.0	2.0	1.0	0.6	0.9

CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
FR010A	<i>Fragilaria constricta</i> fo. <i>constricta</i>	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR008A	<i>Fragilaria crotonensis</i>	0.0	0.0	0.0	9.0	33.1	13.4	4.5	0.6	0.0	0.3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR018A	<i>Fragilaria elliptica</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.0	0.3	0.7	0.3	0.0	0.0
FR064A	<i>Fragilaria exigua</i>	0.3	0.6	0.0	0.3	0.0	0.7	1.3	1.3	0.7	0.3	1.3	1.0	1.3	0.0	2.6	3.0	3.6	3.9	4.2	3.1	4.7
FR013A	<i>Fragilaria oldenburgiana</i>	0.3	0.6	0.3	0.0	0.0	0.0	0.3	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR001A	<i>Fragilaria pinnata</i> var. <i>pinnata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FR056A	<i>Fragilaria pseudoconstruens</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
FR007A	<i>Fragilaria vaucheriae</i> var. <i>vaucheriae</i>	0.6	0.3	0.0	0.3	0.0	0.7	0.3	0.6	0.3	0.3	0.6	1.6	0.6	1.5	1.3	0.7	1.0	0.0	0.3	0.0	0.3
FR005A	<i>Fragilaria virescens</i> var. <i>virescens</i>	0.3	0.3	0.0	0.7	0.0	0.7	0.3	0.6	0.0	0.3	0.3	0.0	0.0	0.3	0.3	0.0	0.3	0.0	0.3	0.6	0.3
FU002A	<i>Frustulia rhomboides</i> var. <i>rhomboides</i>	1.6	1.8	1.3	0.7	0.3	2.6	3.2	3.4	0.3	1.3	1.3	1.0	1.9	0.9	2.3	2.0	2.3	2.6	2.9	1.6	2.2
FU002B	<i>Frustulia rhomboides</i> var. <i>saxonica</i>	0.6	0.3	0.0	0.0	0.3	2.3	1.0	1.3	1.0	1.0	0.3	0.6	1.3	0.3	1.3	1.7	2.3	1.6	1.6	1.6	1.9
GO006A	<i>Gomphonema acuminatum</i> var. <i>acuminatum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.3	0.3	0.0	0.0	0.3	0.0	0.3	0.0
GO003A	<i>Gomphonema angustatum</i> var. <i>angustatum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
GO004A	<i>Gomphonema gracile</i>	0.3	0.6	0.0	1.0	0.6	0.3	0.6	0.3	0.3	0.7	0.3	0.6	0.0	0.3	1.3	1.7	1.0	1.6	0.6	0.9	0.6
GO013A	<i>Gomphonema parvulum</i> var. <i>parvulum</i>	3.2	3.2	2.2	2.3	0.3	1.6	2.6	2.2	1.6	2.3	2.2	5.8	2.8	3.6	2.6	1.0	2.3	3.6	2.9	2.8	3.8
GO080A	<i>Gomphonema pumilum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GO023A	<i>Gomphonema truncatum</i> var. <i>truncatum</i>	0.0	0.0	0.0	0.0	0.0	0.3	1.3	0.6	0.3	0.3	0.0	0.6	0.0	0.0	0.0	0.7	0.3	0.7	0.3	0.0	0.3
MR001A	<i>Meridion circulare</i> var. <i>circulare</i>	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.6	1.0	1.0	0.0	0.0	0.0	0.6	0.3	0.0	0.3	0.0	0.3	0.6	0.6
NA037A	<i>Navicula angusta</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA038A	<i>Navicula arvensis</i>	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
NA066A	<i>Navicula capitata</i> var. <i>capitata</i>	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA066B	<i>Navicula capitata</i> var. <i>hungarica</i>	0.0	0.3	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA032A	<i>Navicula cocconeiformis</i> var. <i>cocconeiformis</i>	0.0	0.3	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.3
NA299A	<i>Navicula costulata</i>	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.6	0.7	1.0	0.3	0.3	0.3	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
NA007A	<i>Navicula cryptocephala</i> var. <i>cryptocephala</i>	0.0	0.3	0.6	0.3	0.0	0.3	0.0	0.3	0.7	1.0	1.0	1.0	0.6	0.9	0.0	0.0	0.3	0.0	0.3	0.0	0.9
NA115A	<i>Navicula difficillima</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
NA039A	<i>Navicula festiva</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
NA068A	<i>Navicula impexa</i>	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA006A	<i>Navicula mediocris</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA042A	<i>Navicula minima</i> var. <i>minima</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA013A	<i>Navicula pseudoscutiformis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.7	0.3	0.0	0.6	0.3
NA010A	<i>Navicula pygmaea</i>	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA003A	<i>Navicula radiosa</i> var. <i>radiosa</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA008A	<i>Navicula rhyncocephala</i> var. <i>rhyncocephala</i>	0.0	0.3	0.0	0.0	0.3	0.0	0.3	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NA033A	<i>Navicula subtilissima</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.3	0.7	0.3	0.3	0.6
NA669A	<i>Navicula suchlandtii</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0
NE036A	<i>Neidium ampliatum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NE013A	<i>Neidium densestriatum</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NI020A	<i>Nitzschia angustata</i> var. <i>angustata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0
NI015A	<i>Nitzschia dissipata</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.3
NI017A	<i>Nitzschia gracilis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NI009C	<i>Nitzschia palea</i> var. <i>debilis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
NI009A	<i>Nitzschia palea</i> var. <i>palea</i>	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NI033A	<i>Nitzschia paleacea</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NI193A	<i>Nitzschia perminuta</i>	0.0	0.3	0.0	0.7	0.0	0.3	0.6	0.9	0.7	1.0	0.0	0.6	0.6	0.0	0.3	1.0	0.7	1.0	0.3	0.6	0.3
NI152A	<i>Nitzschia pusilla</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
NI025A	<i>Nitzschia recta</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.6
NI166A	<i>Nitzschia sociabilis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NI9999	<i>Nitzschia</i> sp.	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
NI048A	<i>Nitzschia tubicola</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
PE002A	<i>Peronia fibula</i>	0.0	0.3	0.0	0.3	0.6	0.3	0.3	0.6	0.3	0.0	0.0	0.0	0.0	0.6	0.3	0.7	0.3	0.7	0.0	0.3	0.3
PI014A	<i>Pinnularia appendiculata</i>	1.0	1.2	0.6	1.0	0.6	1.0	0.0	0.6	0.3	1.3	2.9	1.6	2.5	1.2	0.3	0.0	0.0	0.0	0.0	0.3	0.6
PI012A	<i>Pinnularia borealis</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PI004A	<i>Pinnularia interrupta</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.7	0.7	0.0	0.3	0.3
PI011A	<i>Pinnularia microstauron</i> var. <i>microstauron</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.3	1.0	0.6	0.6	0.3	0.6	0.7	0.3	0.3	0.7	0.3	0.0	0.6
PI9999	<i>Pinnularia</i> sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PI022A	<i>Pinnularia subcapitata</i> var. <i>subcapitata</i>	0.0	0.3	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SL001A	<i>Sellaphora pupula</i> var. <i>pupula</i>	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.6
SA001A	<i>Stauroneis anceps</i> var. <i>anceps</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.3	0.0	0.0	0.0	0.0	0.3	0.3
SA008A	<i>Stauroneis producta</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SP9999	<i>Stenopterobia</i> sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SU017A	<i>Surirella amphioxys</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SY003C	<i>Synedra acus</i> var. <i>angustissima</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.7	1.3	1.7	1.3	0.3	1.9	1.3
SY013A	<i>Synedra tenera</i>	1.3	1.5	0.3	0.0	0.3	1.0	1.3	0.6	1.0	1.3	0.6	1.0	0.3	1.2	0.3	0.7	1.0	0.3	0.6	0.0	0.3
SY001A	<i>Synedra ulna</i> var. <i>ulna</i>	0.0	0.0	0.3	0.0	0.3	0.7	1.3	1.3	0.3	0.3	0.6	0.3	0.0	0.6	0.3	0.0	0.7	0.3	0.3	0.6	0.3
TA9998	<i>Tabellaria [flocculosa (long)]</i>	13.3	11.5	3.5	4.0	1.9	3.0	2.6	0.0	5.9	6.9	8.0	4.9	12.6	6.5	3.3	2.0	3.0	2.0	3.2	2.5	2.2

CODE	Taxon Name	0.25	1.25	2.25	3.25	4.25	5.25	6.25	7.25	8.25	9.25	10.25	12.25	14.25	16.25	18.25	20.25	22.25	24.25	26.25	28.25	30.25
TA9997	<i>Tabellaria [flocculosa (short)]</i>	9.1	9.1	7.1	7.7	3.5	7.5	11.7	11.6	10.8	12.2	14.7	11.7	14.2	13.7	7.9	5.3	5.0	3.6	3.2	2.8	1.6
TA002A	<i>Tabellaria fenestrata</i>	2.3	2.4	2.2	4.3	3.9	4.9	3.6	5.6	5.6	5.3	4.5	3.9	4.4	8.3	4.3	1.3	2.3	1.6	1.3	0.3	0.6