

UK ACID WATERS MONITORING NETWORK (UKAWMN)

**ALLT NA COIRE NAN CON, LOCH CHON AND LOCH
GRANNOCH**

**ANNUAL SUMMARY PROGRESS REPORT TO FOREST
RESEARCH. April 2008 - March 2009.**

Ewan M. Shilland & Mike Hutchins

March 2009



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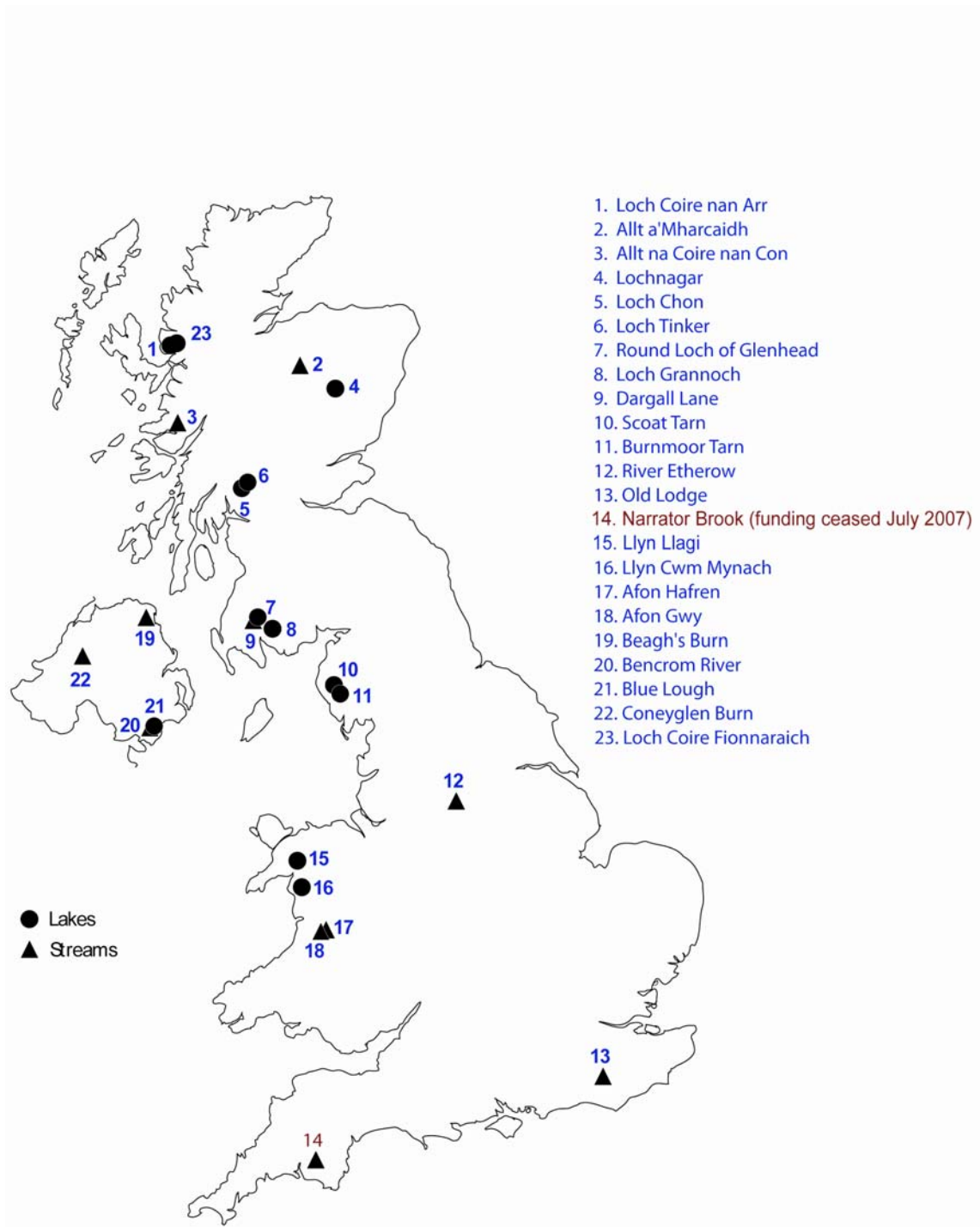
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2 INTRODUCTION

The UK Acid Waters Monitoring Network (UKAWMN) has been operating continuously since 1988. This report presents a summary of work undertaken in the contract year 2008-2009 at three Scottish forested sites supported by Forest Research: Allt na Coire nan Con, Loch Chon and Loch Grannoch. Time series summary data are also presented for the full suite of measurements taken from the start of monitoring up to April 2008.

Detailed analysis of data has been presented in three interpretative reports, Monteith and Shilland (2007), Monteith (2005) and Monteith and Evans (2000) dealing with 18, 15 and 10 years of accumulated results respectively. All three can be found in the reports section of the [UKAWMN](#) web site. A full description of sampling methods and analytical procedures, together with site descriptions, is also presented on the UKAWMN web page.

3 LOCATION OF UKAWMN SITES



4 SUMMARY OF WORK UNDERTAKEN 2008-2009

4.1 Summary Overview

Chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at Allt na Coire nan Con, Loch Chon and Loch Grannoch during the period from April 2008 to March 2009.

4.2 Water Chemistry

Samples were collected in early June, September and December 2008 at the two lochs and monthly at Allt na Coire nan Con. They have been delivered to the analytical laboratories on schedule and have been analysed and archived in the UKAWMN central chemistry database at CEH Wallingford. March 2009 samples have been collected and are in the process of being analysed. Quality control on the data will be performed before summary data is presented in the annual UKAWMN data report in late 2009.

4.3 Sediment Traps

Sediment traps were recovered and replaced on the 13th of August 2008 at Loch Chon and the 14th of August 2008 at Loch Grannoch. Diatoms in the sediment retrieved from the traps are currently being analysed.

4.4 Thermistors

Lake top and bottom thermistors were removed and replaced on the 13th of August 2008 at Loch Chon and the 14th of August 2008 at Loch Grannoch. All four had functioned well during the previous year and the data were added to the ENSIS thermistor water temperature database.

4.5 Epilithic Diatoms

Epilithic diatoms were retrieved from three sampling points around Loch Chon on the 13th of August 2008 and at four sampling points around Loch Grannoch on the 14th of August 2008. Three samples were retrieved from Allt na Coire nan Con on the 11th of August 2008. The samples have been made into slides and are currently in the process of being analysed.

4.6 Macroinvertebrates

Aquatic macroinvertebrates were sampled by QMuL on the 8th May 2008 at Allt na Coire nan Con, by UCL on the 1st of May 2008 at Loch Chon and by UCL on the 5th of

May 2008 at Loch Grannoch. Five 1 minute kick samples were performed at each site. The samples from Loch Chon and Loch Grannoch were counted at QMuL and the data sent to ENSIS Ltd. After quality screening the data was added to the UKAWMN biological database at ENSIS. It is hoped resources will be found to count the samples from Allt na Coire nan Con.

4.7 Fish

Fish surveying was performed in Autumn 2008 by the Fisheries Research Services, Faskally, who are checking the data before forwarding it to ENSIS Ltd.

4.8 Aquatic Macrophytes

Aquatic macrophytes were not surveyed at any of the three sites in the 2008-2009 period.

4.9 Data Management and Reporting

No problems or hiatus with the collation and transfer of data within methodological programmes, or to the UKAWMN databases occurred during the period.

The 2007-2008 annual report was uploaded to the AWMN web page in February 2009, and the sections on Allt na Coire nan Con, Loch Chon and Loch Grannoch appear in section 7 below.

An interpretative report detailing 20 years of the UKAWMN is currently in the early stages of preparation and should be published in autumn 2009.

5 DATA FORMAT

The chemical and biological data are presented in a series of sections, summarised below, on a site-by-site basis.

Section 1:	<p>Time series graphs of key spot sampled chemical determinands for individual samples.</p> <p>Summary table for key chemical determinands including: the mean over the 1988-1993 baseline period; the mean for the current year (2007-2008) and the standard deviation for the current year. The normal number of observations per year is 4 for lakes and 12 for streams.</p>
Section 2:	<p>Macroinvertebrates. Time series of macroinvertebrate taxon % abundance in annual aggregated samples (5 kick samples from lake littoral habitats or from riffle areas in streams), and annual total number of individual animals. Some species occurring at less than 1% relative abundance are omitted.</p> <p>Macroinvertebrate summary statistic time series:</p> <ol style="list-style-type: none"> 1) total number of individuals; 2) number of individuals identified at Genus level only (excludes some ubiquitous groups such as the chironomids and oligochaetes); 3) total number of taxa; 4) Diversity Indices: <ol style="list-style-type: none"> a) Hill's N_1, the exponent of Shannon's Index and a measure of the number of abundant species in a sample (Hill, 1973). b) Hill's N_2, the reciprocal of Simpson's Index and a measure of the number of very abundant species in a sample (Hill, 1973). c) E_5, a measure of evenness based on the ratio $(N_2-1):(N_1-1)$. As a single species becomes more and more dominant, E_5 tends to zero.
Section 3:	<p>Salmonids. Summary histogram of mean density of trout and salmon, if present, in three 50m reaches (number of individuals caught per 100m² survey area) for each year of the monitoring period. (0+ = new recruits, >0+ = all fish over one year of age).</p>
Section 4:	<p>Epilithic diatoms. Time series of annual mean percentage frequency (from 3-4 replicate samples) of taxa occurring at greater than 2 % abundance in any one sample.</p> <p>Epilithic diatom summary statistic time series. Mean, maximum and minimum for:</p> <ol style="list-style-type: none"> a) Hill's N_1 (see above) b) Hill's N_2 (see above) c) E_5 (see above) d) Diatom inferred pH (Di pH), based on the weighted average of species pH optima in the surface sediments of the 167 lake Surface Water Acidification Project dataset (Stevenson <i>et al.</i> 1991). <p>pH reconstructions are intended only for application to sedimentary diatoms but directional trends in inferred pH of epilithic assemblages should provide an indication of the direction of a response to changing acidity.</p>

Section 5:	<p>Aquatic macrophytes. For lakes relative species abundance determined on a five point scale (comparable to the DAFOR scoring system, Palmer <i>et al.</i> 1992) following shoreline survey, shore transects and deep water grapnel trawls, as follows:</p> <ol style="list-style-type: none"> 1. rare/infrequent 2. occasional but not abundant 3. widespread but not abundant 4. locally abundant 5. widespread and abundant <p>For streams, total macrophyte cover estimated for 5m sections of a 50m survey stretch and each then partitioned into proportional species abundance to provide percentage cover for each species. Data analysed for this report are the mean species cover estimates for the 50m stretches.</p>
Section 6:	<p>For lake sites only. Histogram of diatom species composition from annually retrieved sediment traps. Species occurring at less than 1% abundance in all years are omitted.</p>
Section 7:	<p>For lake sites only. Time series graphs of annual data from thermistors attached to the sediment traps. Thermistor pairs are used, one 1.5m from the lake bottom and the other 1m from the water surface.</p>

After the site by site data a final section presents sediment trap Mercury, Lead and Spheroidal Carbonaceous Particle concentrations for the two lake sites.

6 REFERENCES

Hill, M. O. 1973 Diversity and evenness: a unifying notation and its consequences. *Ecology*, **54**, 427-31.

Juggins, S., Flower, R. J. & Battarbee, R. W. (1996) Palaeolimnological evidence for recent chemical and biological changes in UK Acid Waters Monitoring Network sites. *Freshwater Biology* **36**, **1**, 203-219.

Monteith, D. T. (Ed.) 2005 *UK Acid Waters Monitoring Network: 15 Year Report. Analysis and Interpretation of Results, April 1988-March 2003*. ENSIS Ltd, London.

Monteith, D. T. & Evans, C. D. (Eds.) 2000 *UK Acid Waters Monitoring Network: 10 Year Report. Analysis and Interpretation of Results, April 1988-March 1998*. ENSIS Ltd, London.

Monteith, D. T. & Shilland, E. M. (Eds.) 2007 *The United Kingdom Acid Waters Monitoring Network Assessment of the First 18 Years of Data. Data Summary Annex Accompanying Research Project Final Report. Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160)*. ENSIS Ltd, London.

Palmer, M. A., Bell, S. L. & Butterfield, I. 1992 A botanical classification of standing waters in Britain: applications for conservation and monitoring. *Aquatic conservation: marine and freshwater ecosystems*, **2**, 125-143.

Patrick, S. T., Waters, D., Juggins, S. & Jenkins, A. (Eds.) 1991 *The United Kingdom Acid Waters Monitoring Network. Site descriptions and methodology report*. ENSIS Ltd, London.

Patrick, S. T., Monteith, D. T. & Jenkins, A. 1995 *UK Acid Waters Monitoring Network: The First Five Years. Analysis and interpretation of results, April 1988 - March 1993*. ENSIS Ltd, London.

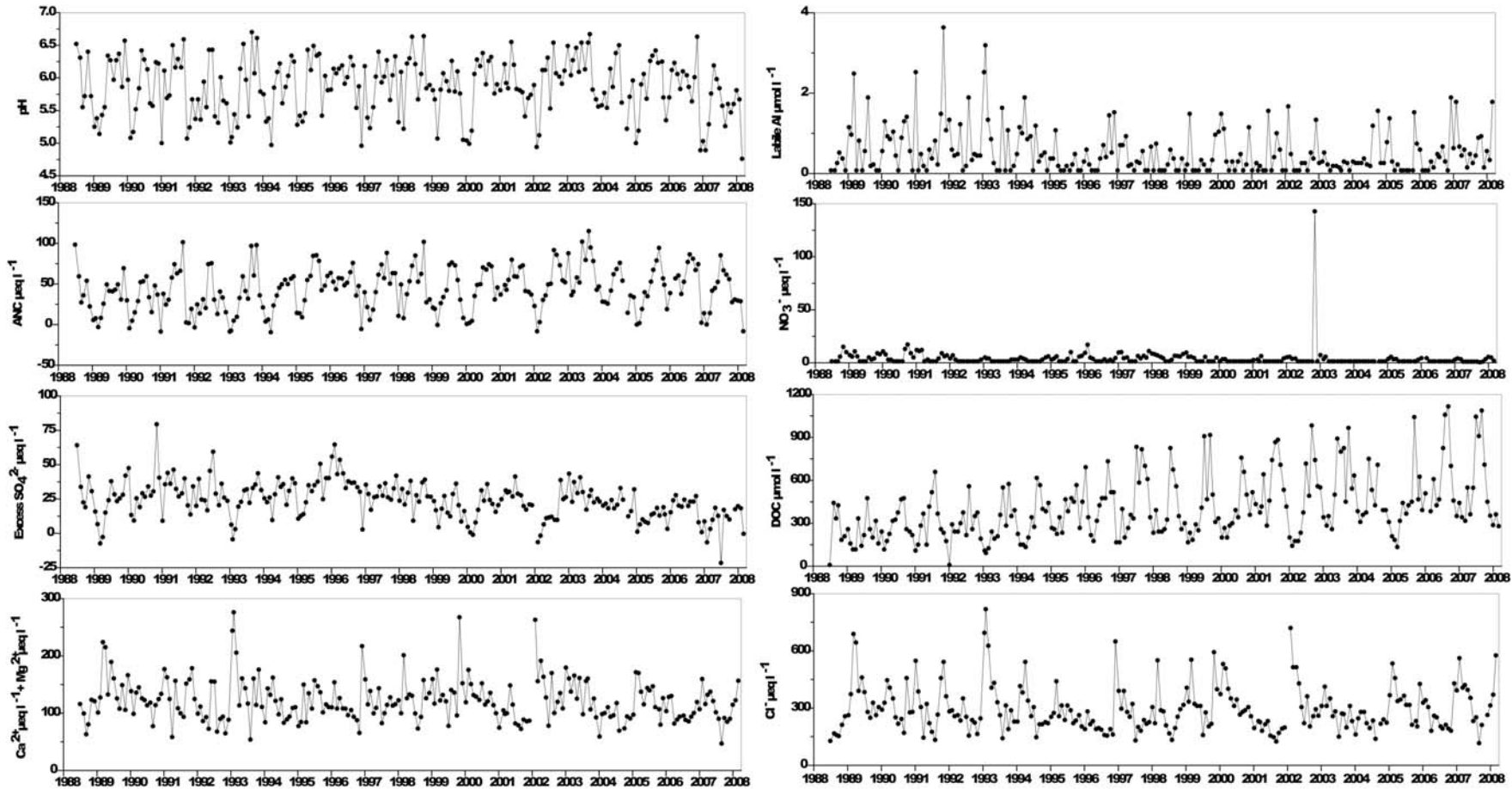
Rose, N. L., Harlock, S., Appleby, P. G. & Battarbee, R. W. 1995 Dating of recent lake sediments in the United Kingdom and Ireland using spheroidal carbonaceous particle (SCP) concentration profiles. *The Holocene*, **5**, **3**, 328-335.

Stevenson, A. C., Juggins, S., Birks, H. J. B., Anderson, N. J., Battarbee, R. W., Berge, F., Davis, R. B., Flower, R. J., Haworth, E. Y., Jones, V. J., Kingston, J. C., Kreiser, A. M., Line, J. M., Munro, M. A. R. & Renberg, I. 1991 *The surface waters acidification project palaeolimnology programme: Modern diatom/lake-water chemistry data-set*. ENSIS Ltd, London.

7 SITE DATA

7.1 Allt na Coire nan Con

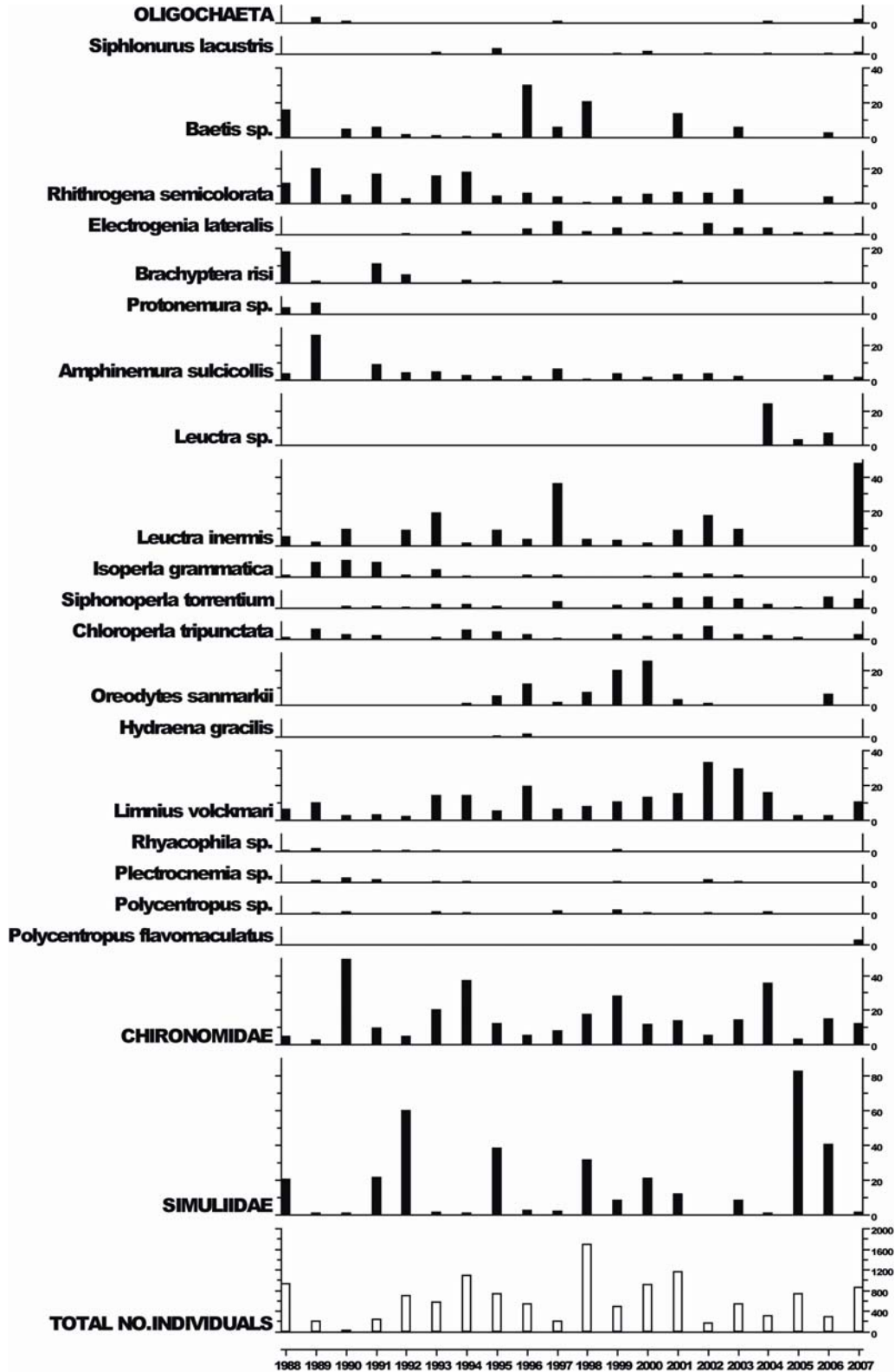
7.1.1 Spot sampled chemistry data



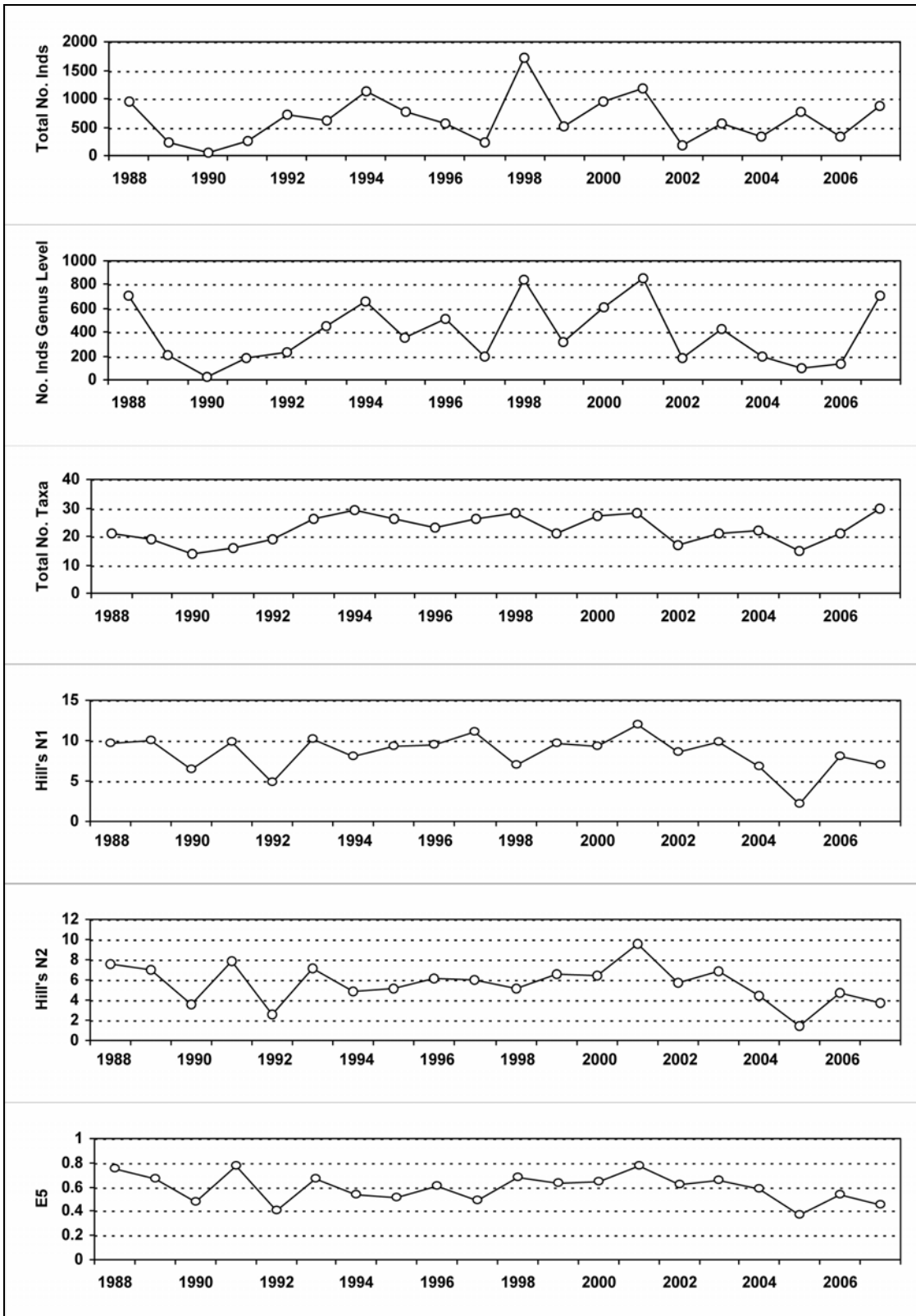
$\mu\text{eq L}^{-1}$ except * ($\mu\text{mol L}^{-1}$)	pH	*ANC	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	Si	*Soluble Al	*labile Al	Cl ⁻	SO ₄ ²⁻	Excess SO ₄ ²⁻	NO ₃ ⁻	DOC
mean 1st 5 yrs	5.81	32.53	58.97	70.89	272.00	9.14	65.54	2.40	0.80	321.50	61.95	28.19	4.91	266.70
07-08 mean	5.63	43.04	45.71	61.65	262.39	10.09	141.63	2.77	0.58	318.00	43.96	10.63	1.91	577.73
07-08 std.dev	0.36	24.02	10.98	20.18	78.83	2.25	64.51	1.09	0.45	124.10	17.82	12.39	1.70	292.09

7.1.2 Macroinvertebrate data

7.1.2.1 Percentage abundance summary, Allt na Coire nan Con

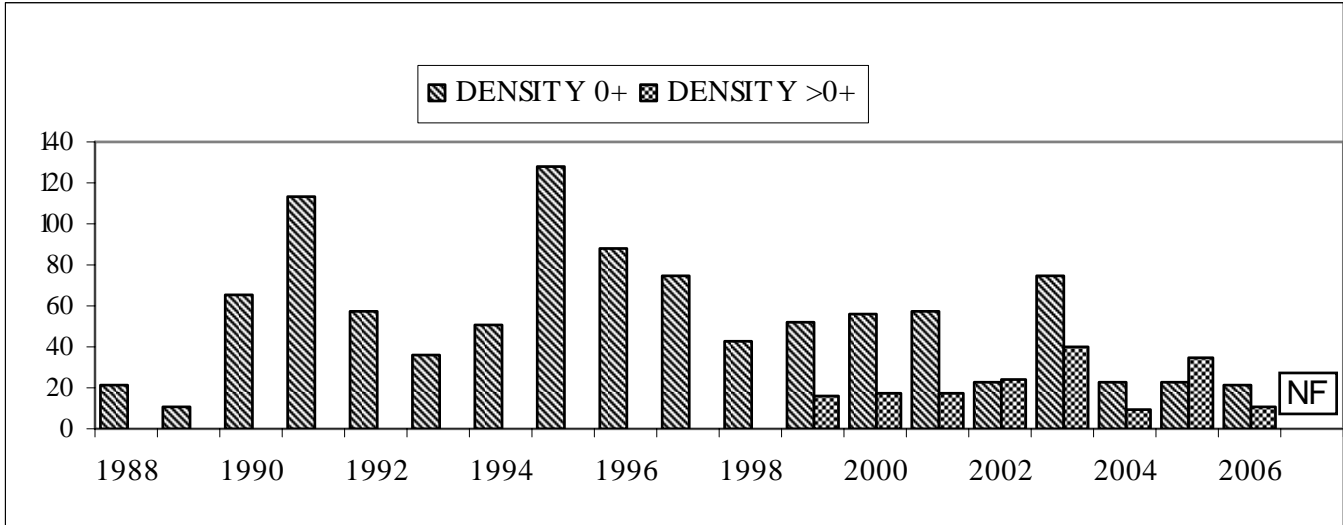


7.1.2.2 Summary statistics, Allt na Coire nan Con



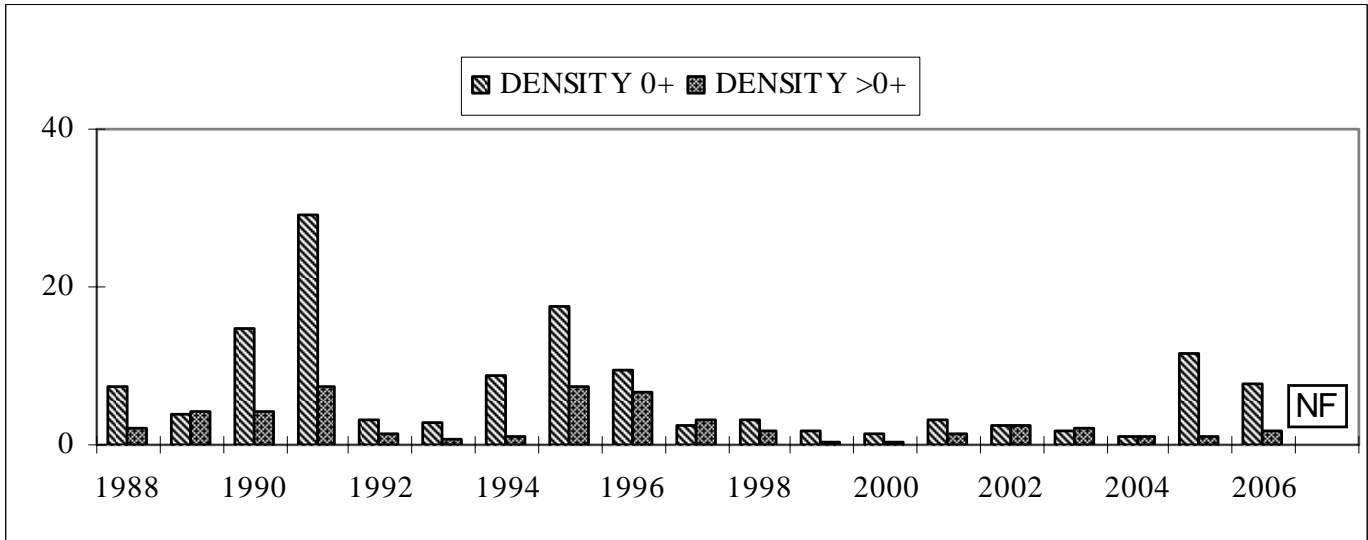
7.1.3 Fish data

7.1.3.1 Summary of mean Salmon density (total numbers 100m⁻²), Allt na Coire nan Con



Salmon age groups not split prior to 1999
No fishing in 2007 due to funding cuts.

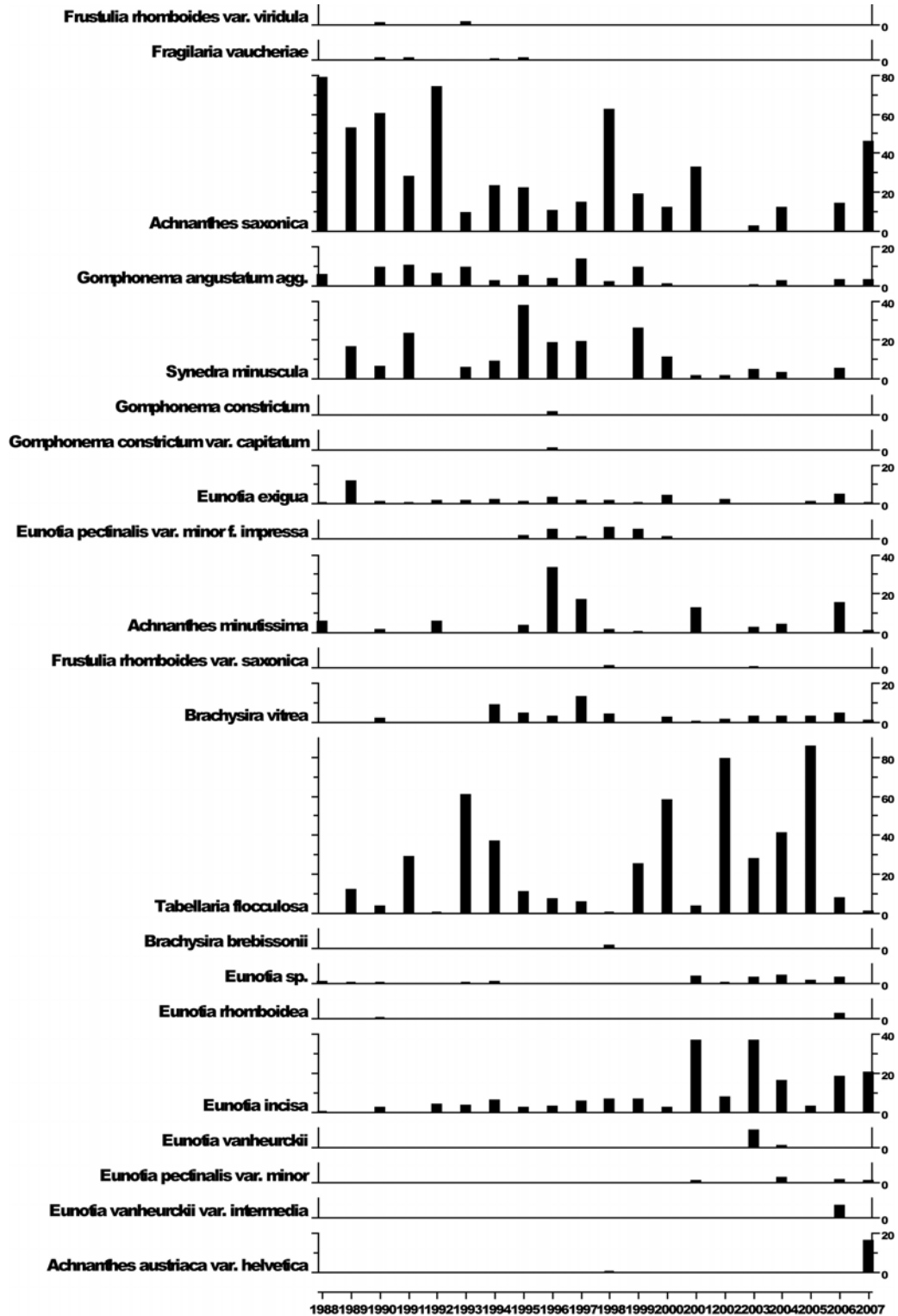
7.1.3.2 Summary of mean Trout density (numbers 100m⁻²), Allt na Coire nan Con



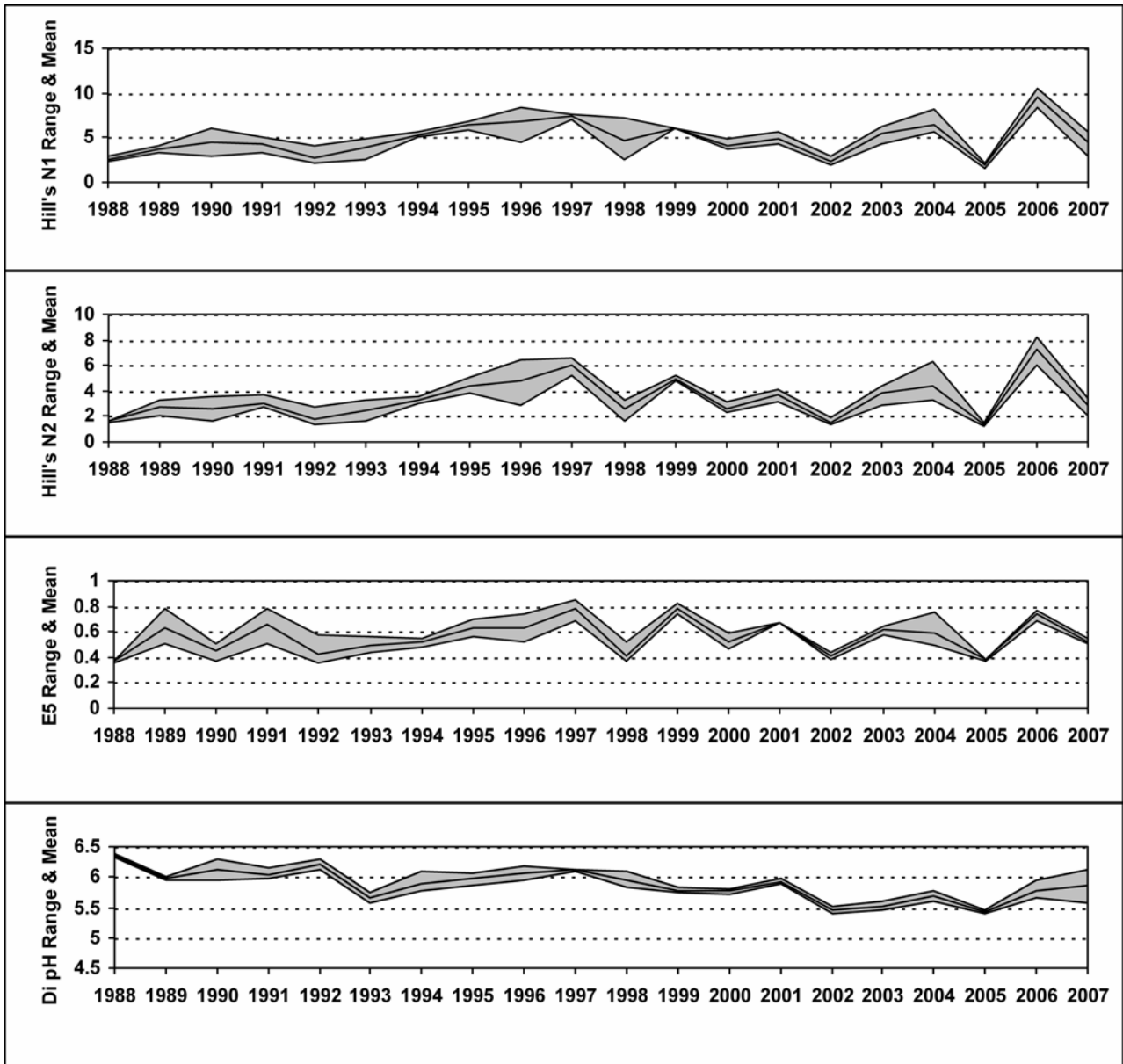
No fishing in 2007 due to funding cuts.

7.1.4 Epilithic diatom data

7.1.4.1 Percentage abundance summary, Allt na Coire nan Con

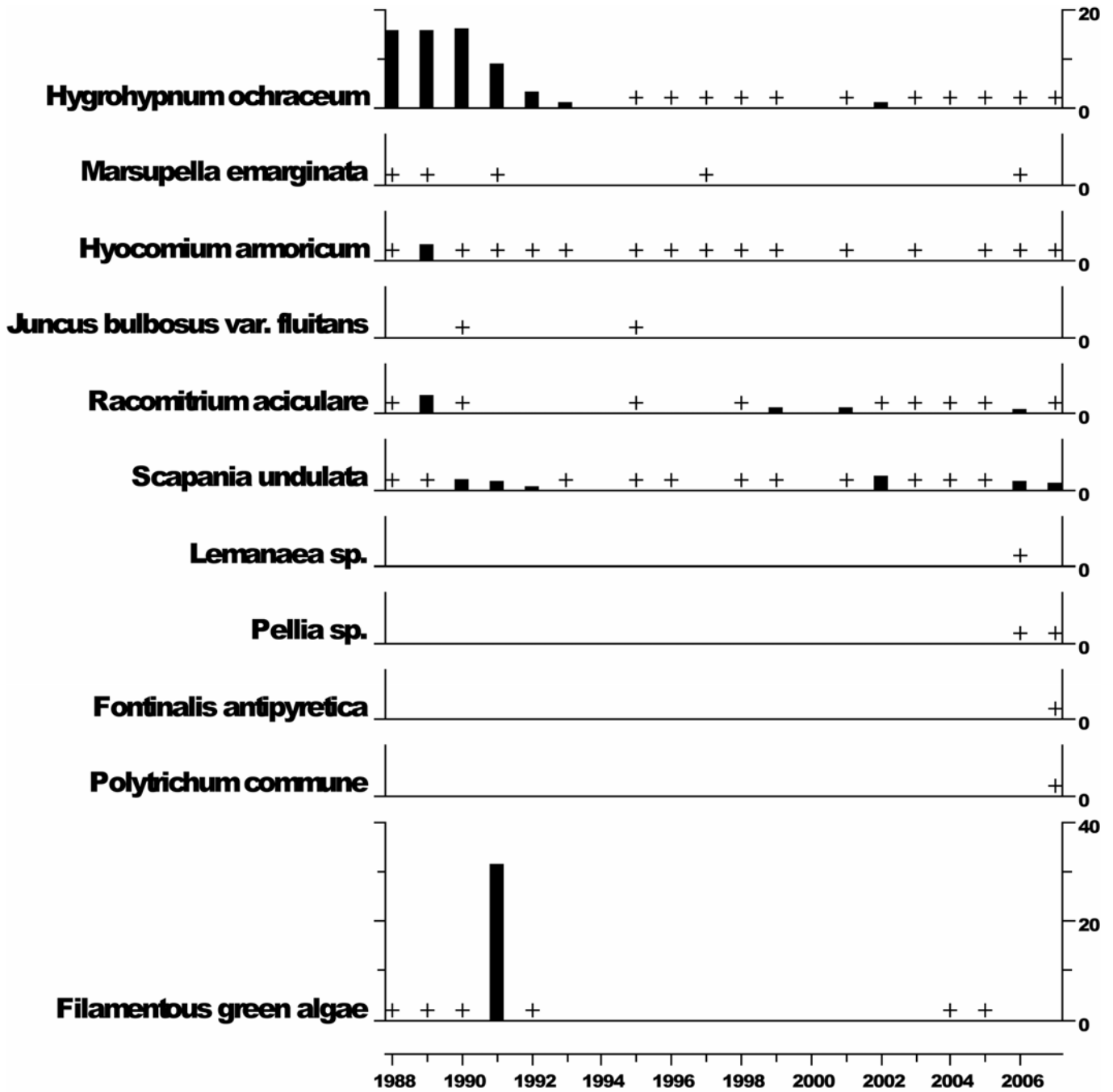


7.1.4.2 Summary statistics, Allt na Coire nan Con



7.1.5 Aquatic macrophyte data, Allt na Coire nan Con

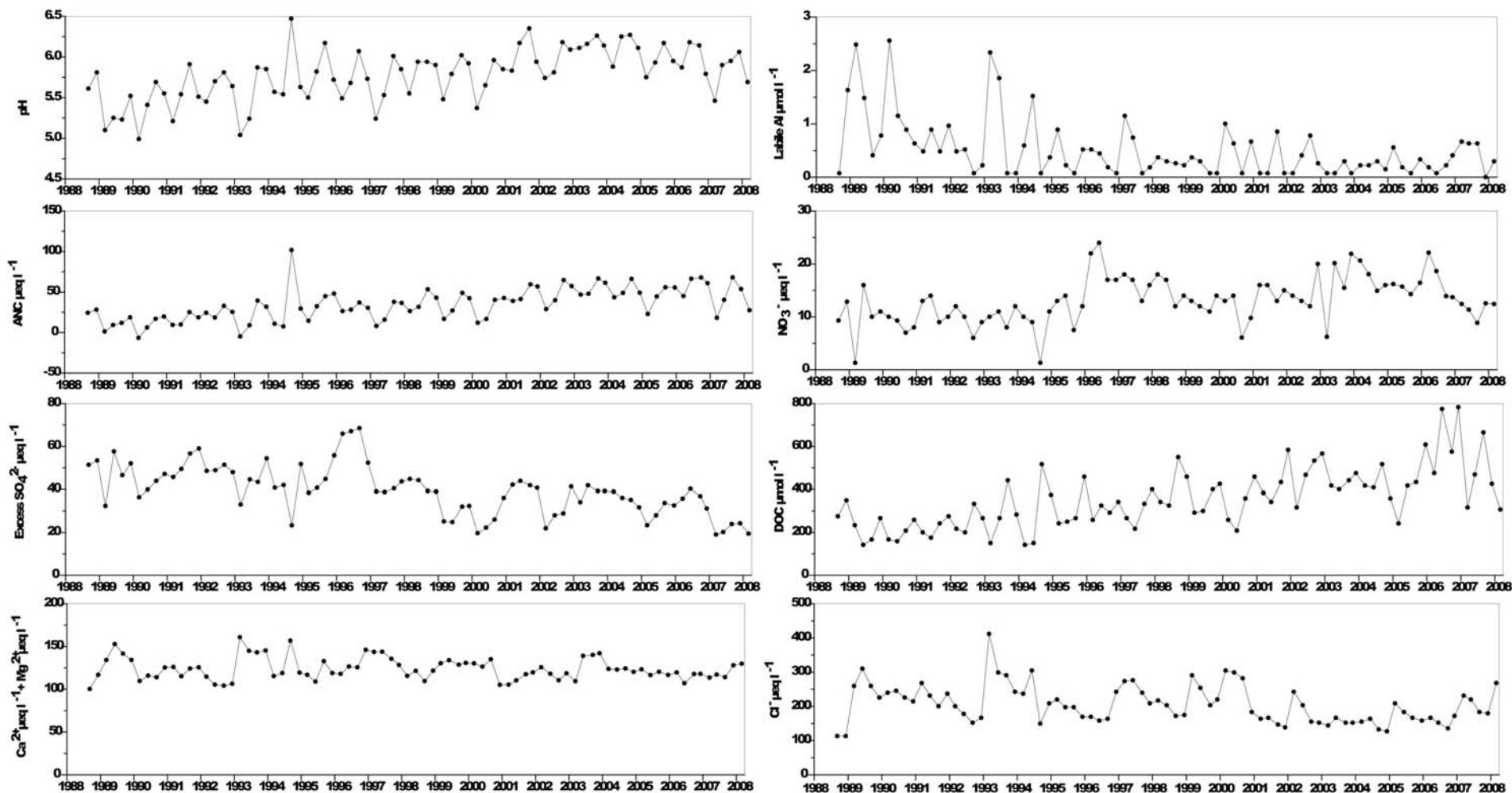
Percentage Species Cover



+ Represents <0.5% abundance

7.2 Loch Chon

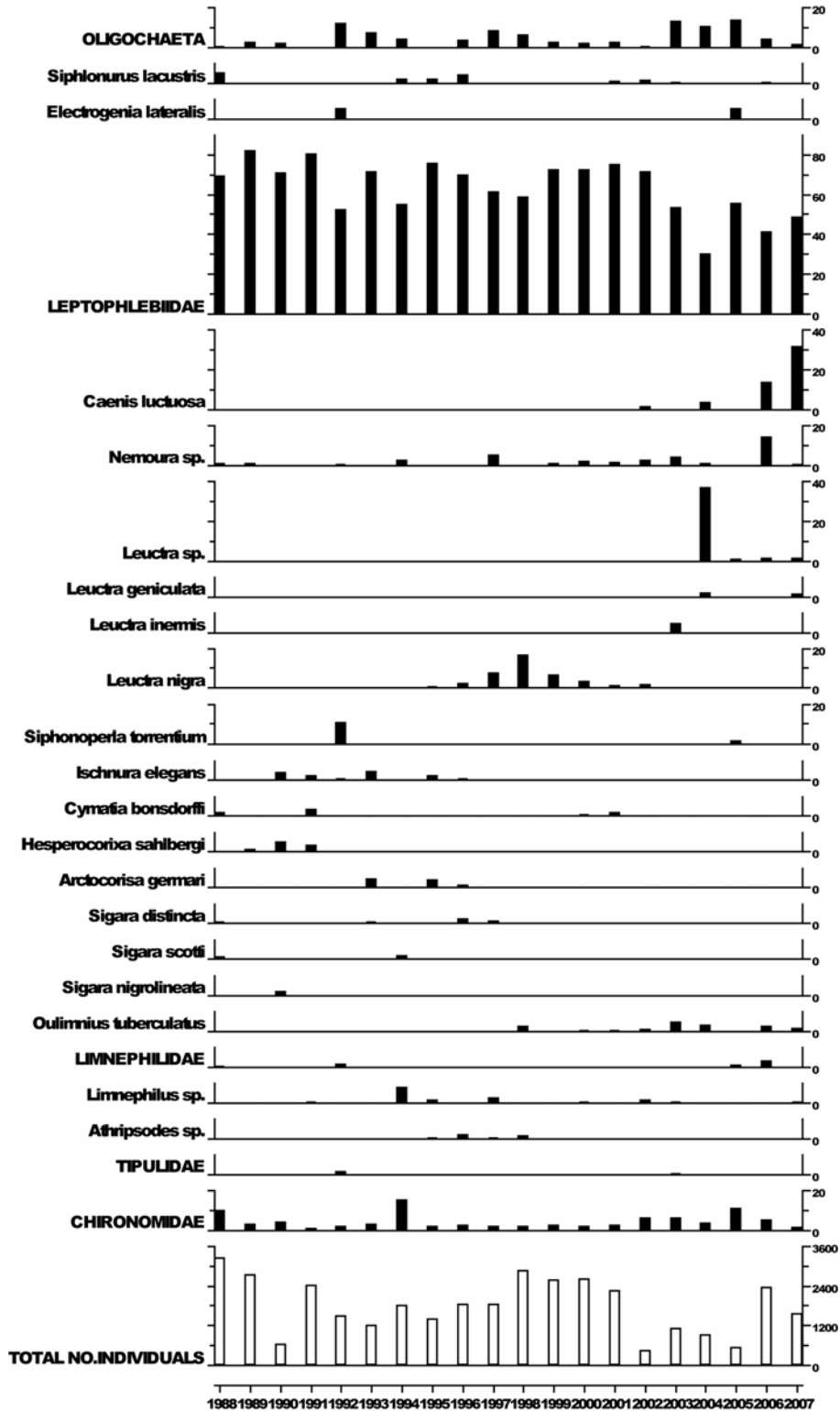
7.2.1 Spot sampled chemistry data



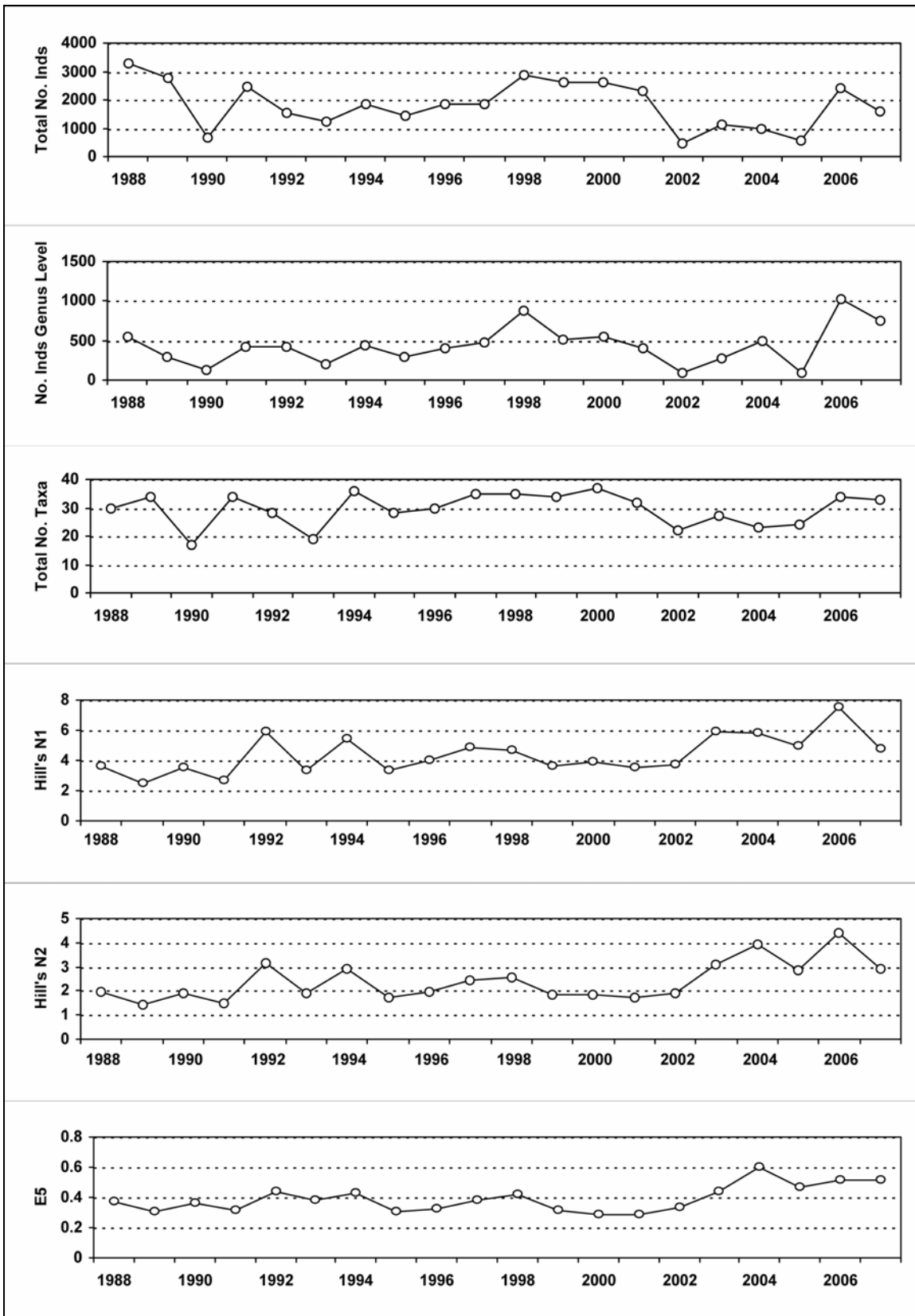
$\mu\text{eq L}^{-1}$ except * ($\mu\text{mol L}^{-1}$)	pH	*ANC	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	Si	*Soluble Al	*labile Al	Cl ⁻	SO ₄ ²⁻	Excess SO ₄ ²⁻	NO ₃ ⁻	DOC
mean 1st 5 yrs	5.47	14.84	75.74	47.50	186.30	5.65	31.58	2.43	0.97	223.40	72.15	48.69	9.88	225.40
07-08 mean	5.90	47.31	73.73	48.55	169.11	7.42	46.80	1.59	0.39	212.77	44.78	22.49	11.29	465.82
07-08 stLdev	0.16	17.41	5.71	3.77	25.63	2.60	17.75	0.49	0.30	41.28	2.16	2.56	1.72	148.94

7.2.2 Macroinvertebrate data

7.2.2.1 Percentage abundance summary, Loch Chon

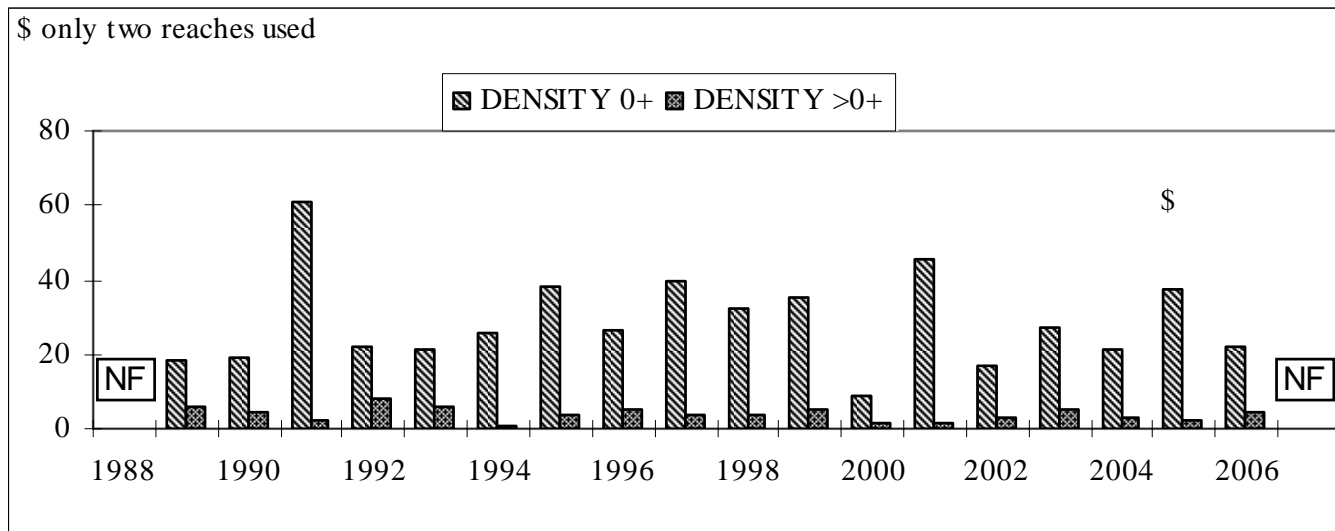


7.2.2.2 Summary statistics, Loch Chon



7.2.3 Fish data (for outflow stream)

7.2.3.1 Summary of mean Trout density (numbers 100m⁻²), Loch Chon

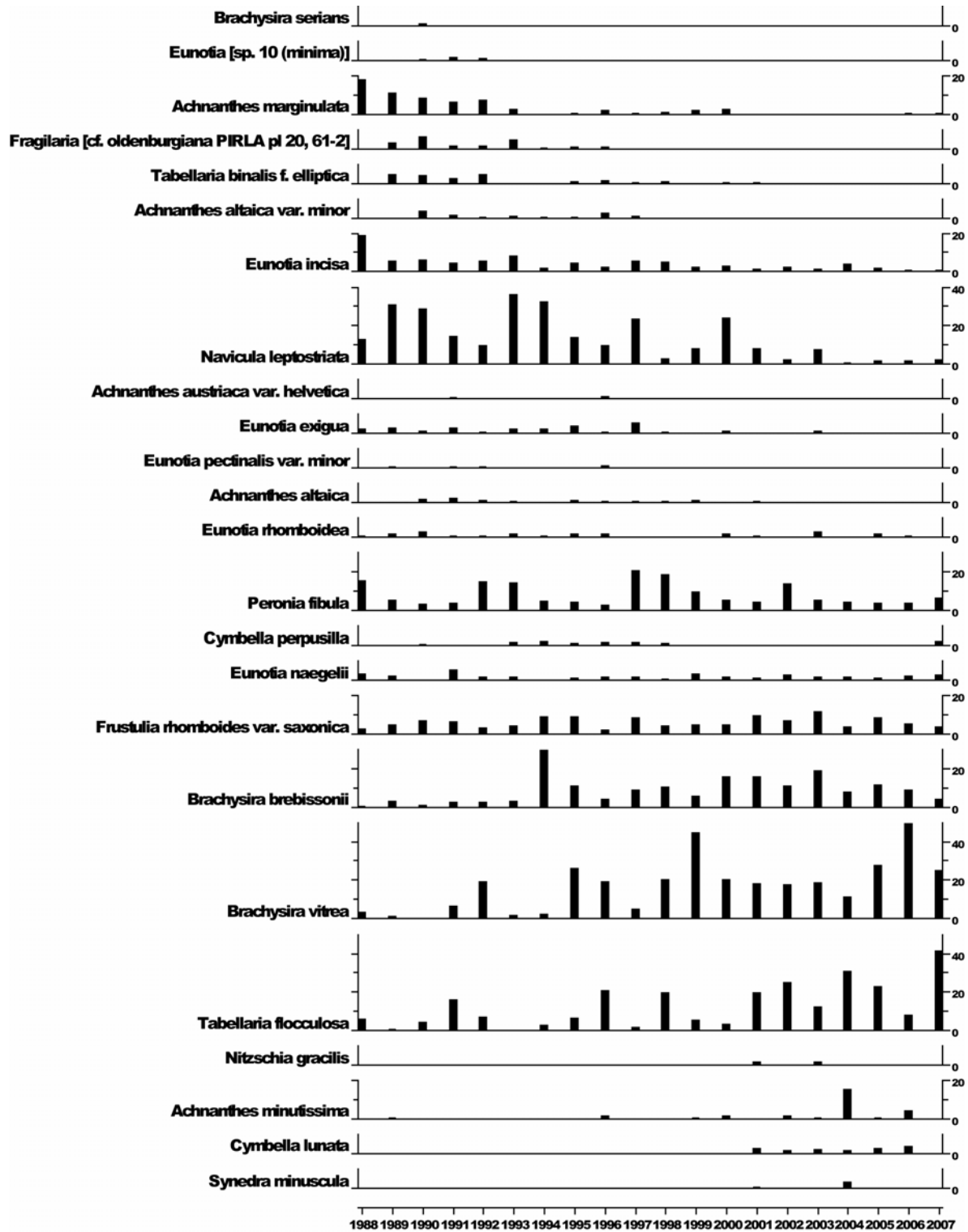


NF = Not fished

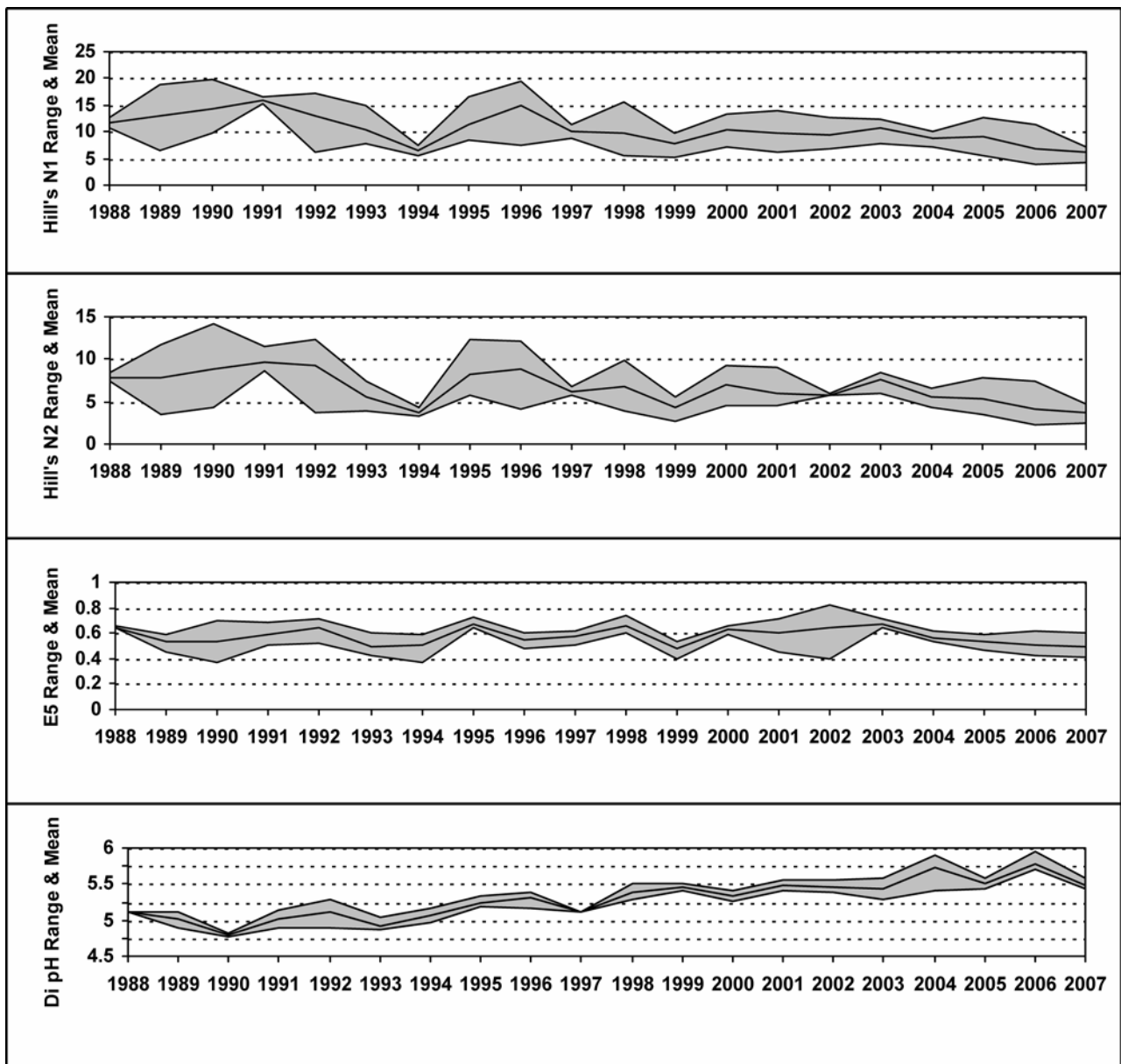
No fishing in 2007 due to funding cuts.

7.2.4 Epilithic diatom data

7.2.4.1 Percentage abundance summary, Loch Chon

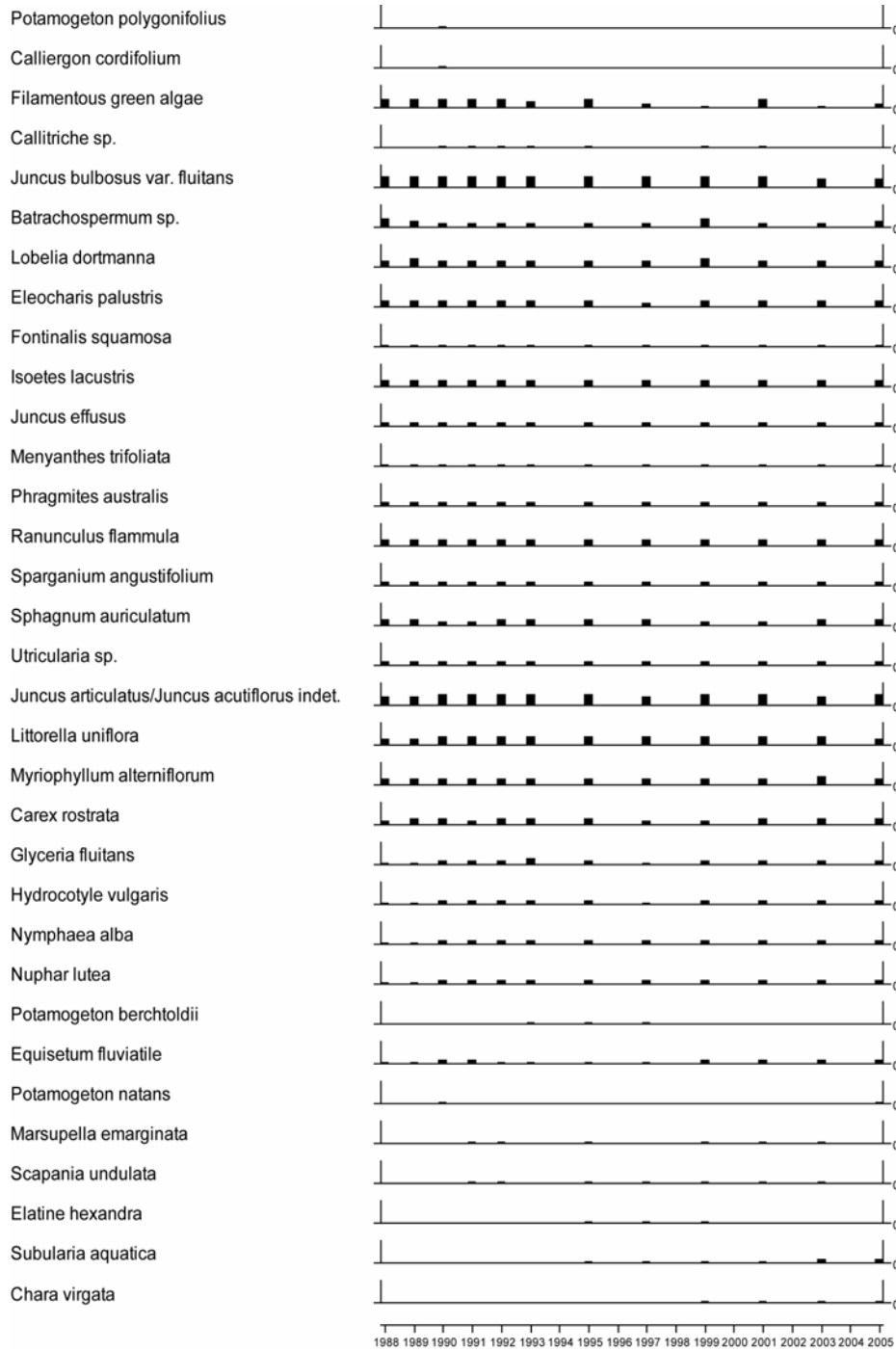


7.2.4.2 Summary statistics, Loch Chon



7.2.5 Aquatic macrophyte data, Loch Chon

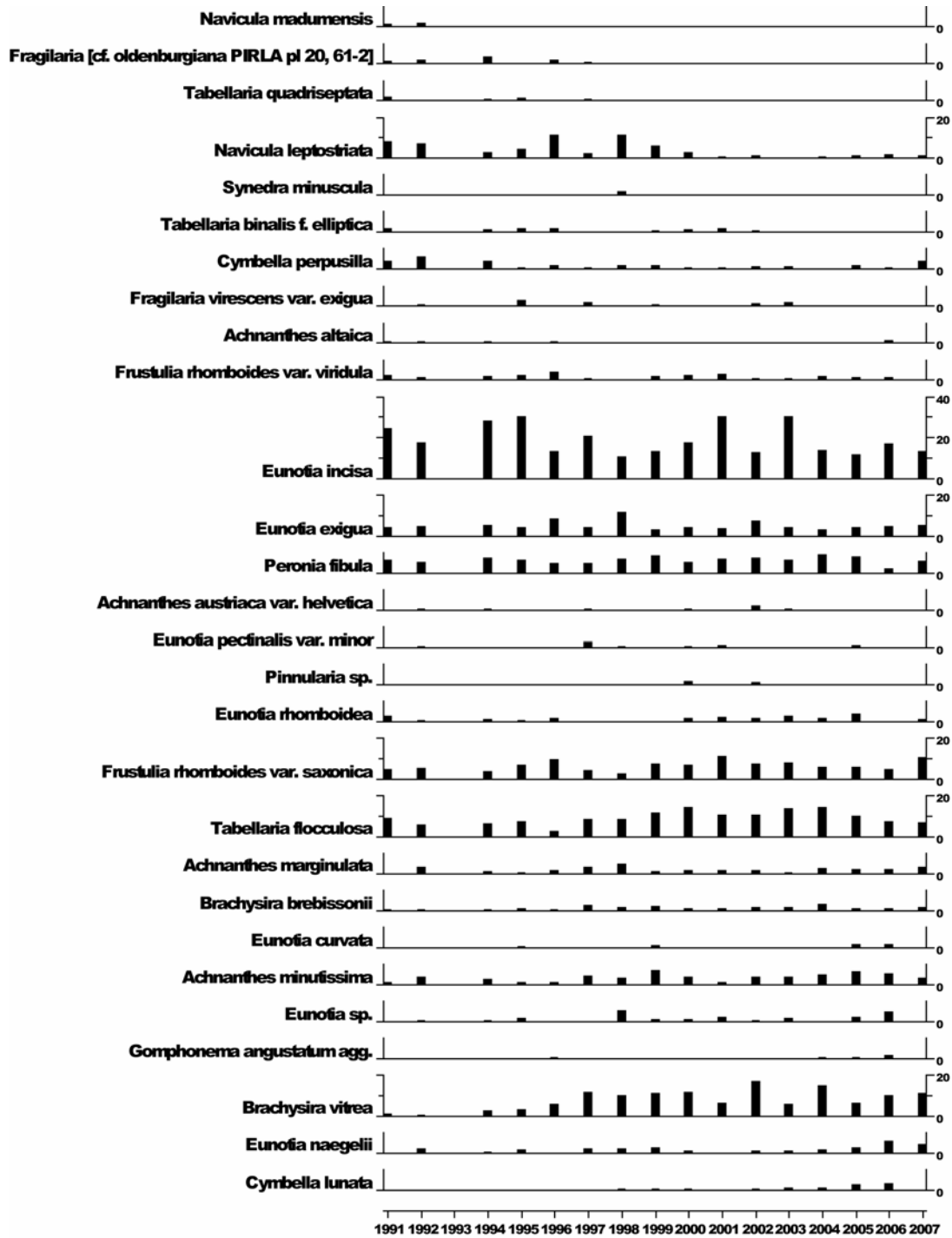
Species Scores (1-5)



No survey in 2007 due to funding cuts

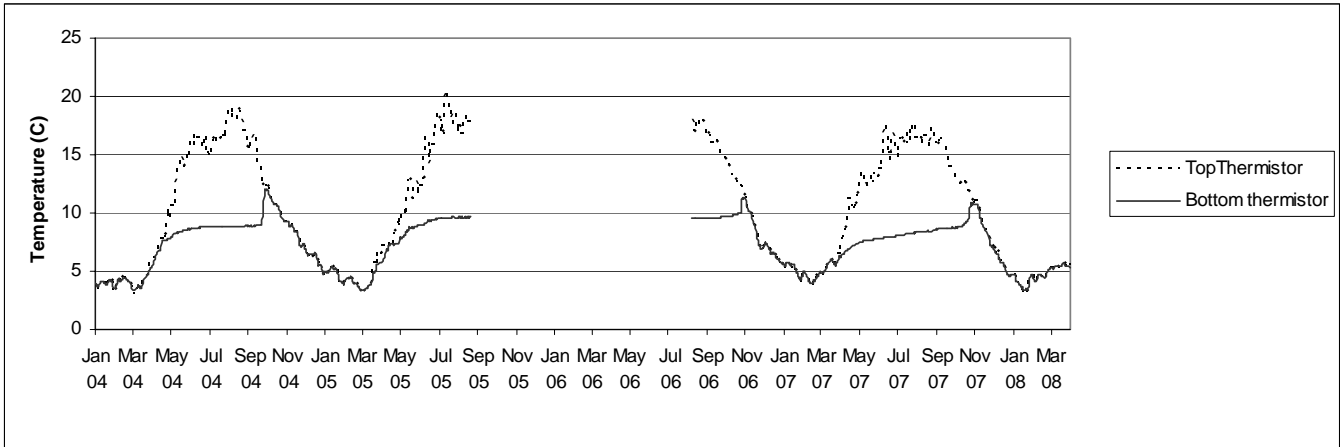
7.2.6 Sediment trap data, Loch Chon

Relative percentage frequency of diatom taxa



Traps not recovered in 1993

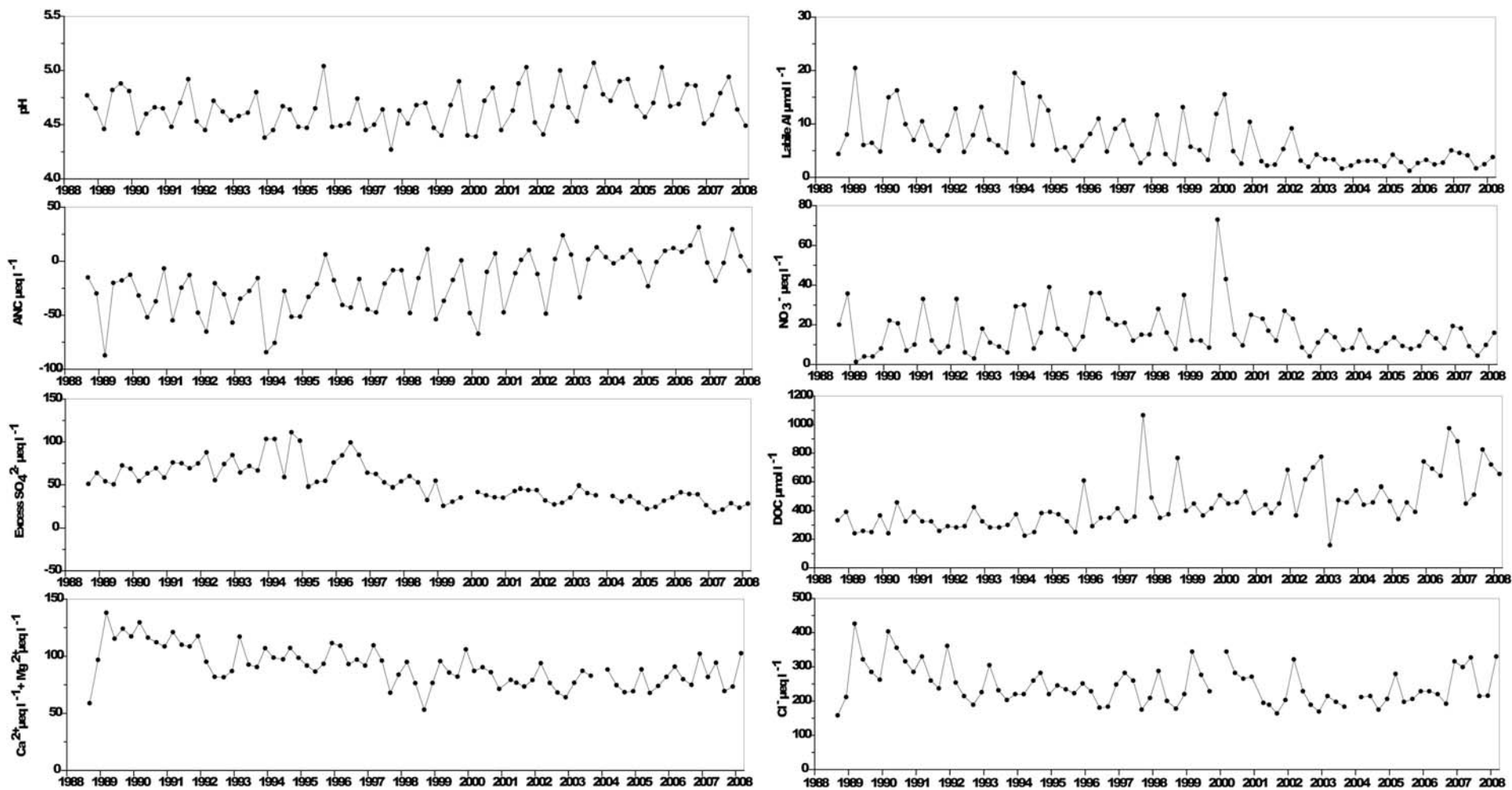
7.2.7 Thermistor data, Loch Chon



Thermistors not recovered in 2006

7.3 Loch Grannoch

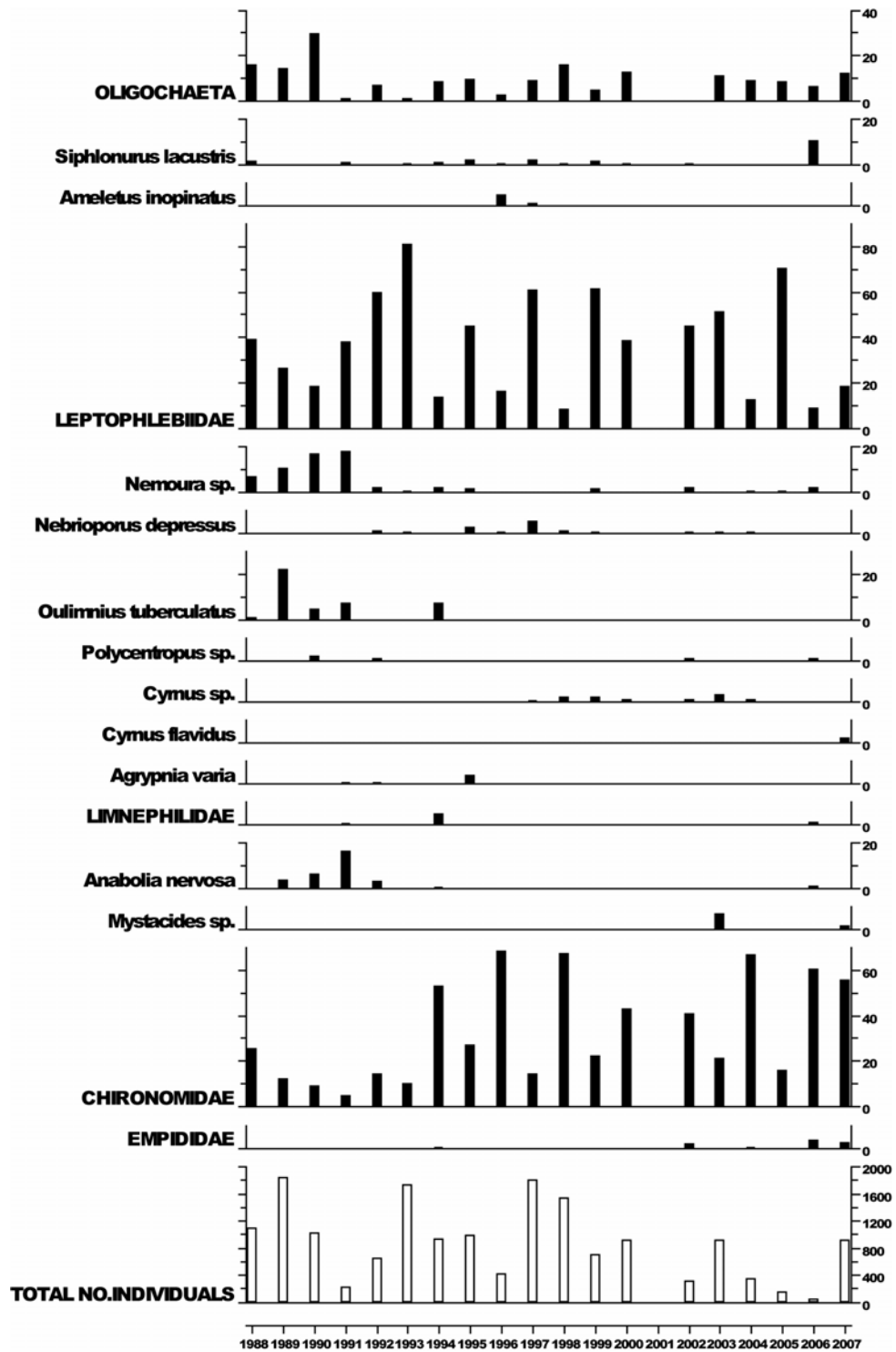
7.3.1 Spot sampled chemistry data



$\mu\text{eq L}^{-1}$ except * ($\mu\text{mol L}^{-1}$)	pH	*ANC	Ca^{2+}	Mg^{2+}	Na^+	K^+	Si	*Soluble Al	*labile Al	Cl	SO_4^{2-}	Excess SO_4^{2-}	NO_3^-	DOC
mean 1st 5 yrs	4.65	-34.68	51.47	56.54	239.10	4.73	59.02	11.72	9.12	283.80	98.14	68.34	13.89	319.30
07-08 mean	4.72	5.88	36.08	48.81	220.65	7.30	106.37	6.00	3.00	271.80	54.67	26.18	9.81	677.71
07-08 std.dev	0.19	16.76	5.67	10.45	39.42	3.10	62.12	0.81	1.14	65.65	7.11	3.73	4.72	131.09

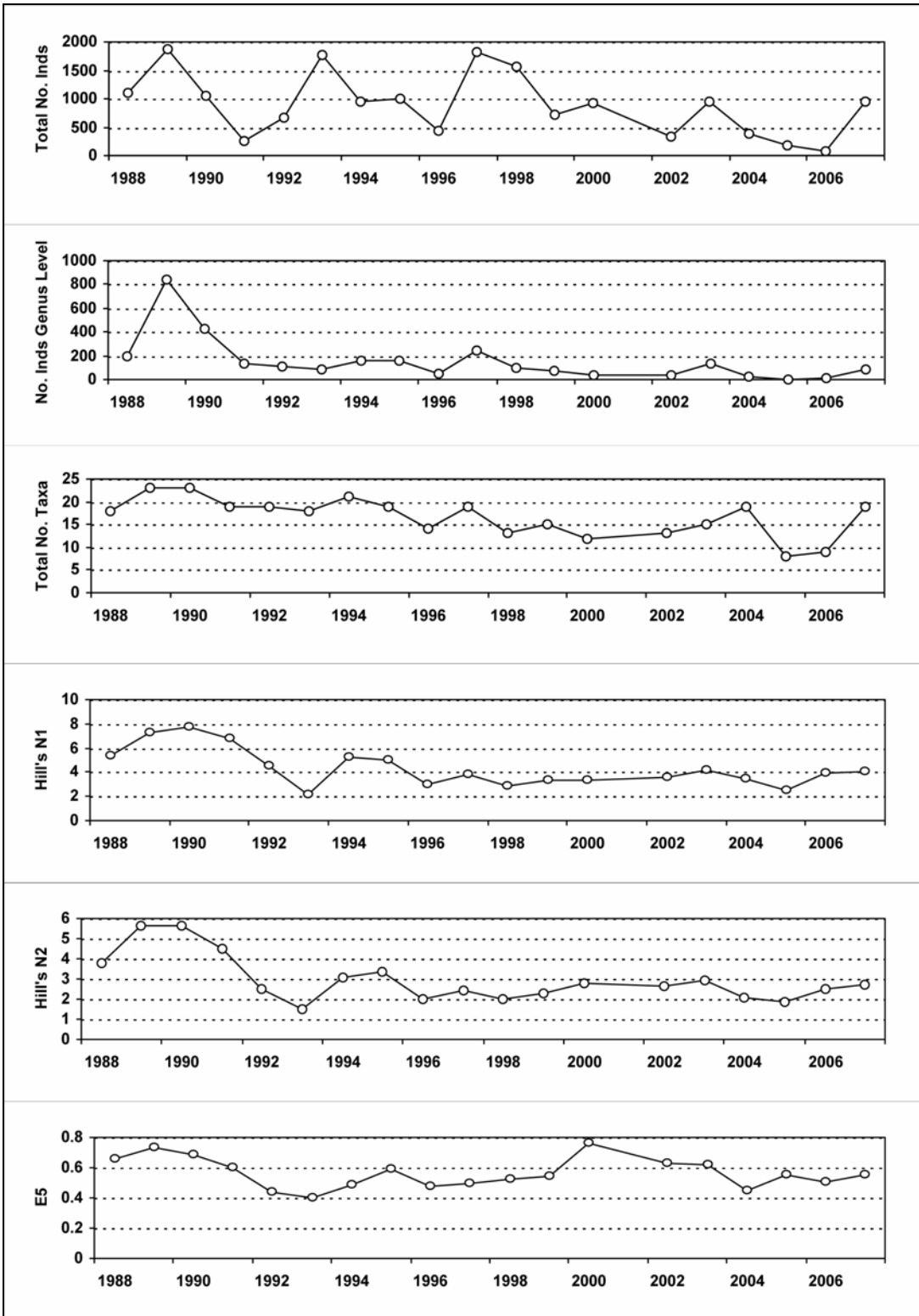
7.3.2 Macroinvertebrate data

7.3.2.1 Percentage abundance summary, Loch Grannoch



No sampling in 2001 due to Foot and Mouth restrictions.

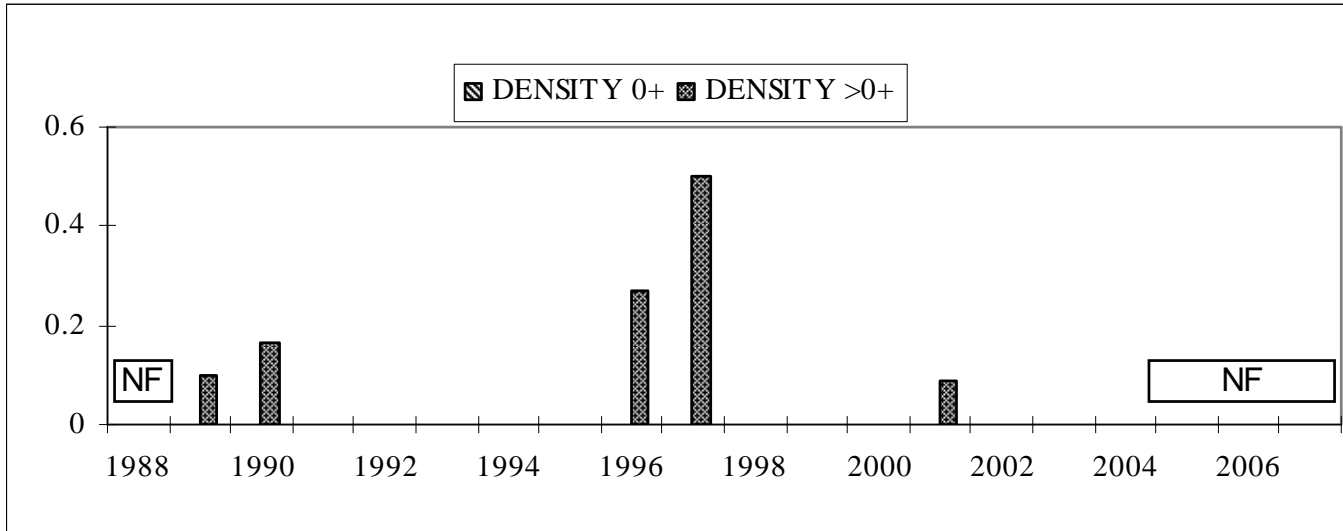
7.3.2.2 Summary statistics, Loch Grannoch



No sampling in 2001 due to Foot and Mouth restrictions.

7.3.3 Fish data (for outflow stream)

7.3.3.1 Summary of mean Trout density (numbers 100m⁻²), Loch Grannoch

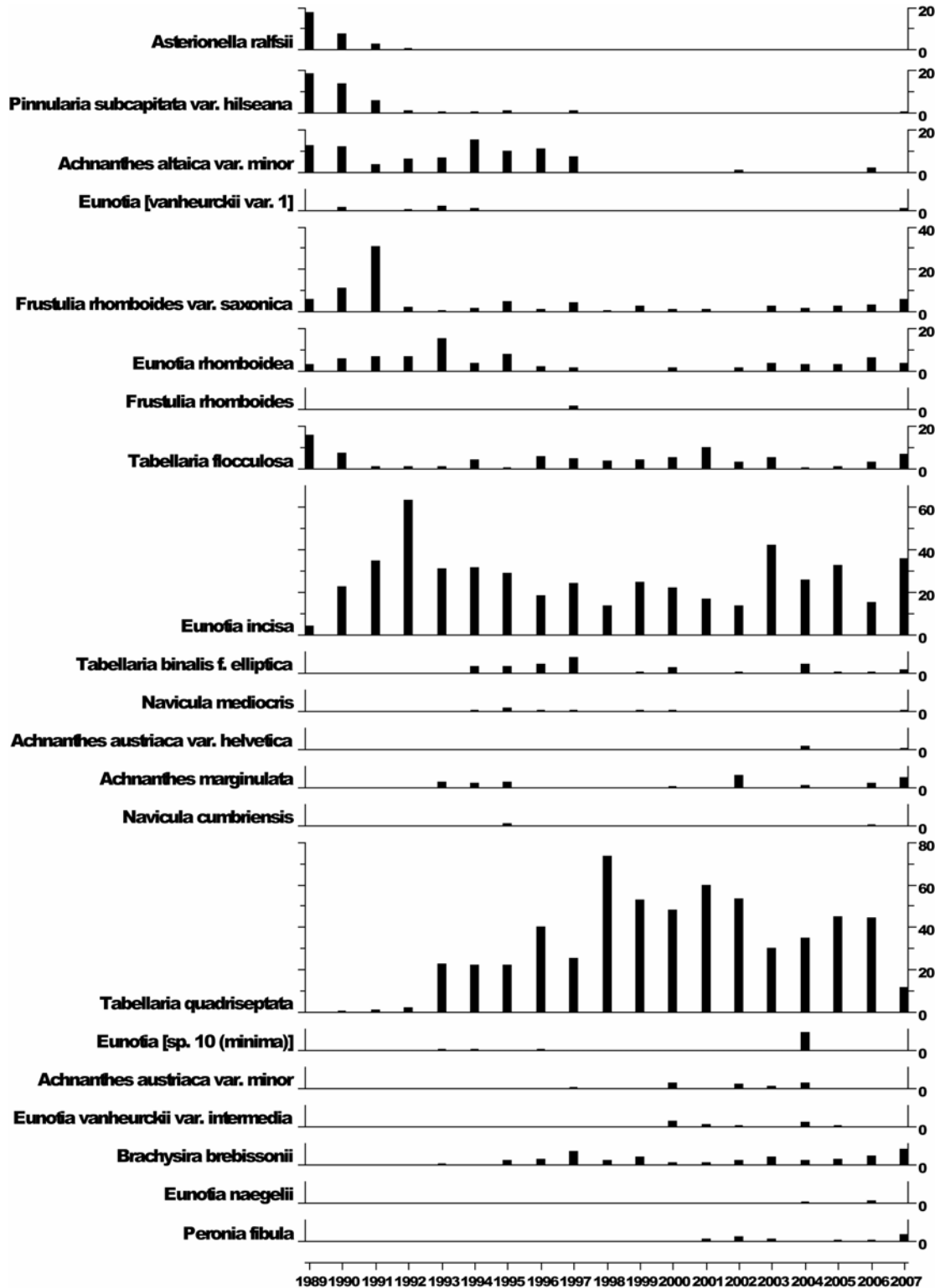


NF = Not fished

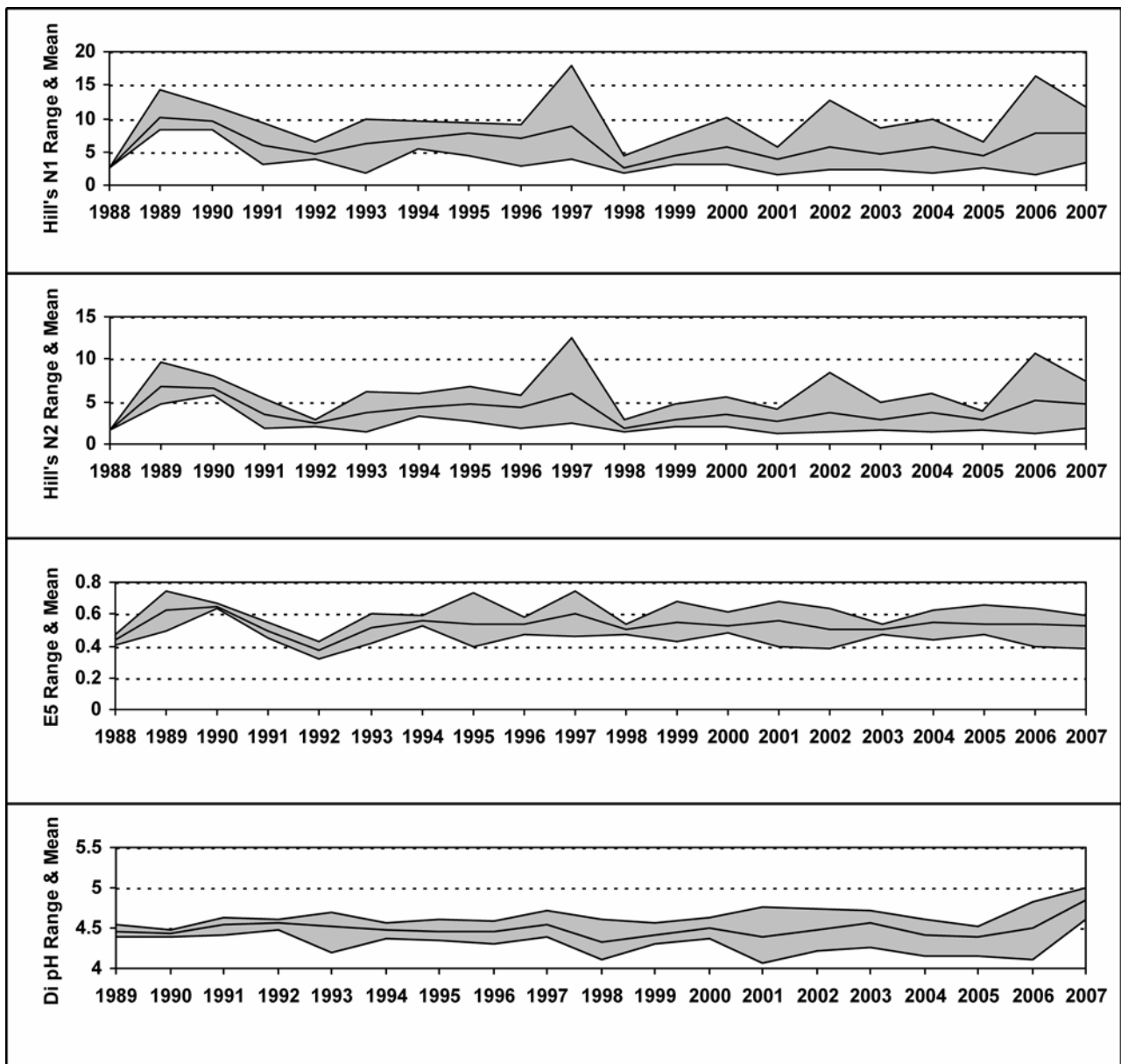
No fishing in 2007 due to funding cuts.

7.3.4 Epilithic diatom data

7.3.4.1 Percentage abundance summary, Loch Grannoch

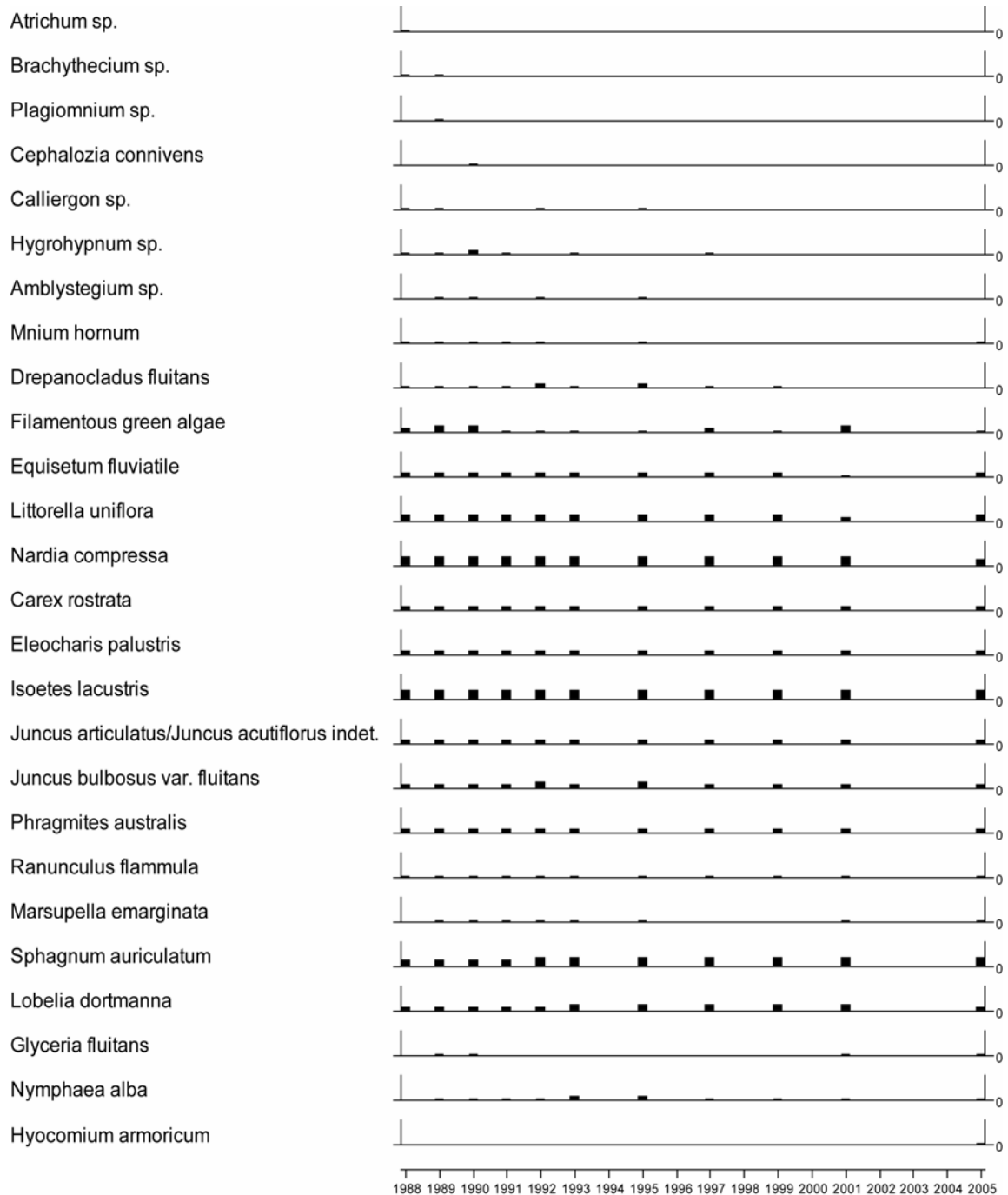


7.3.4.2 Summary statistics, Loch Grannoch



7.3.5 Aquatic macrophyte data, Loch Grannoch

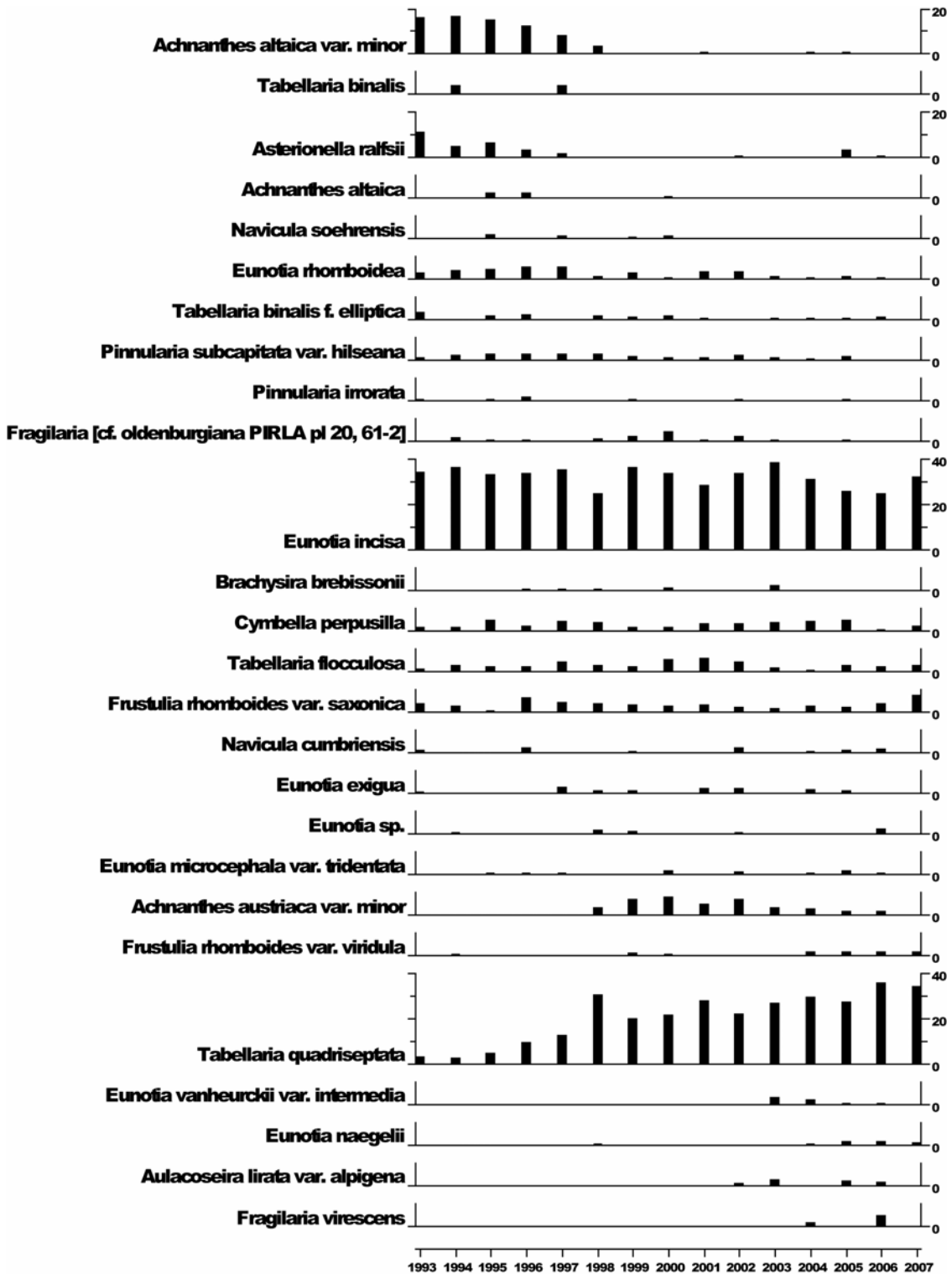
Species Scores (1-5)



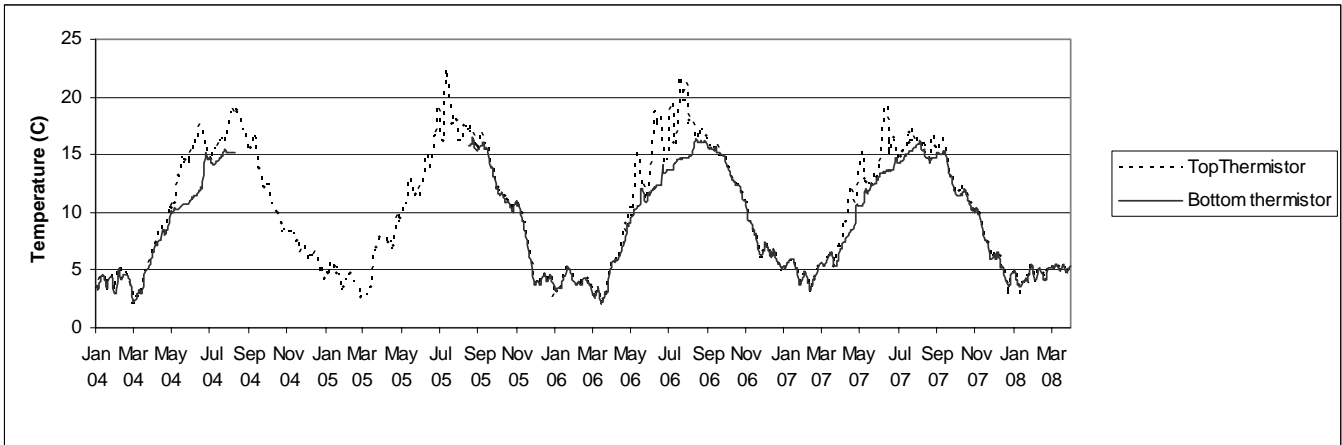
No aquatic macrophyte survey in 2003.
No survey in 2007 due to funding cuts

7.3.6 Sediment trap data, Loch Grannoch

Relative percentage frequency of diatom taxa

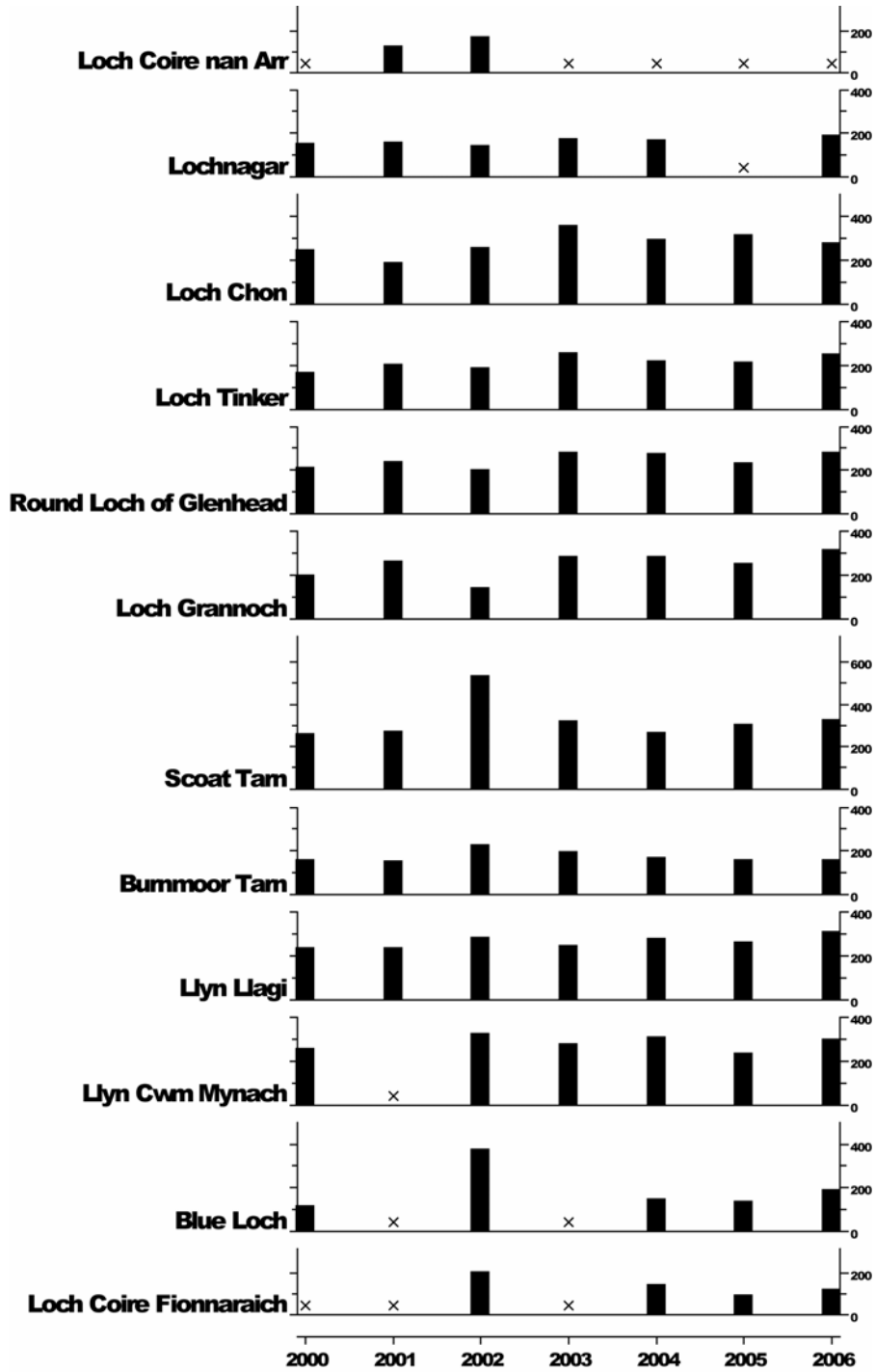


7.3.7 Thermistor data, Loch Grannoch



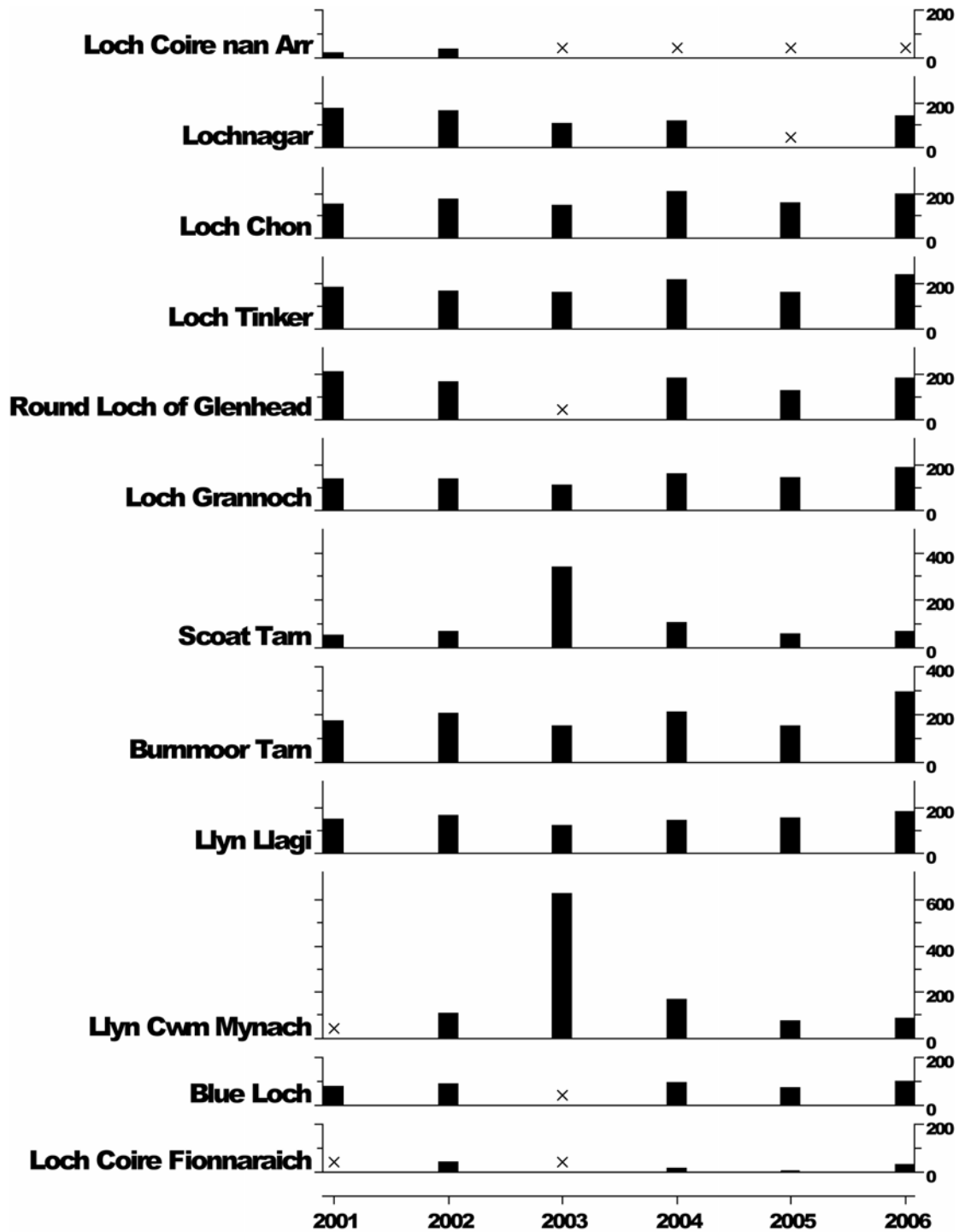
7.4 Sediment Trap Metals Data

7.4.1 Sediment Trap Mercury Concentrations (ng g⁻¹)



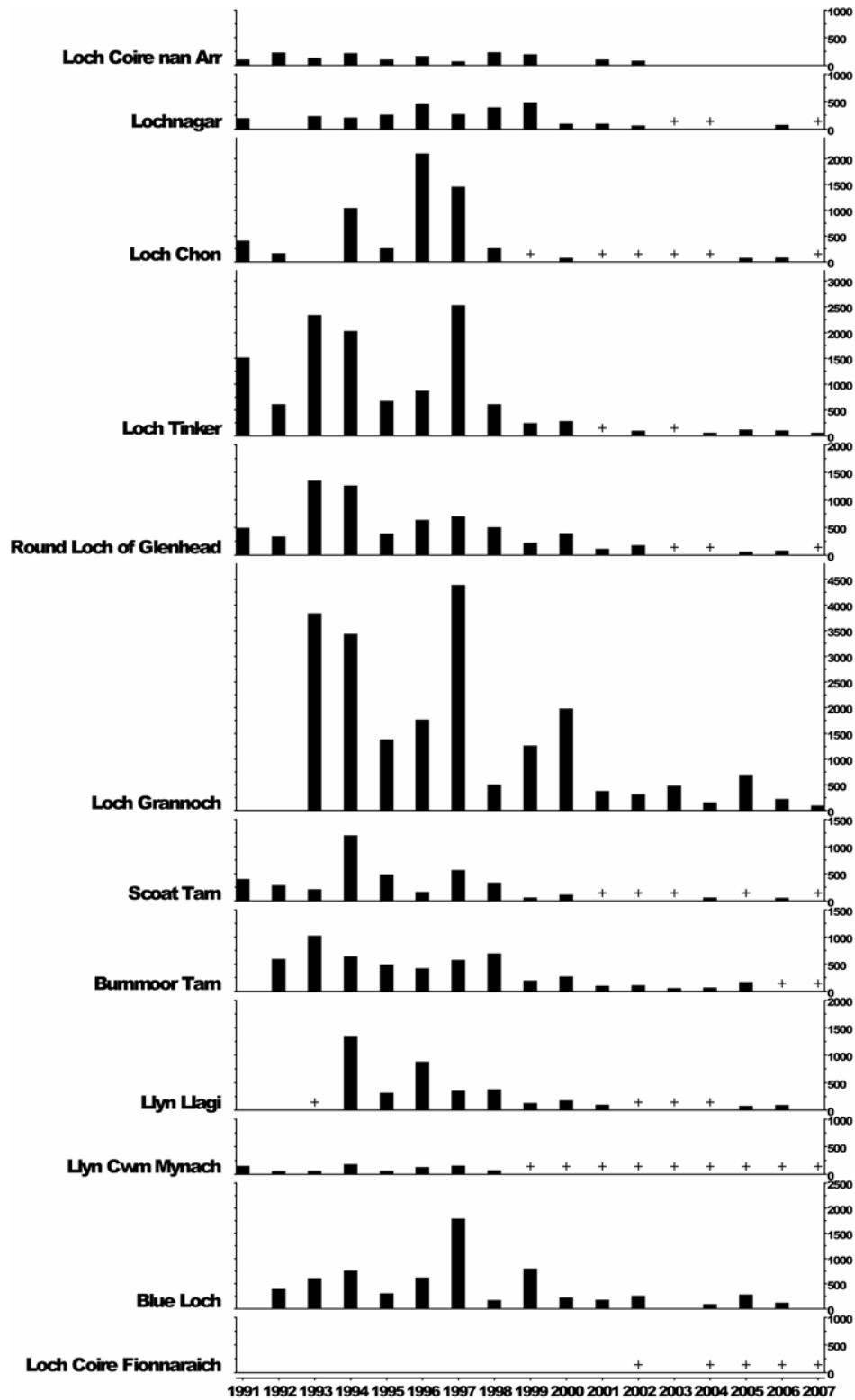
x = no sample
2007 data pending

7.4.2 Sediment Trap Lead Concentrations ($\mu\text{g g}^{-1}$)



x = no sample
2007 data pending

7.5 Sediment Trap Carbonaceous Particle Flux (no. cm⁻² yr⁻¹)



+ represents < 50 cm⁻² yr⁻¹