UCL ENVIRONMENTAL CHANGE RESEARCH CENTRE

UK Acid Waters Monitoring Network (UKAWMN)

Allt na Coire Nan Con, Loch Chon and Loch Grannoch

Annual Summary Progress Report to Forest Research. April 11 - March 12

E. M. Shilland, L. Irvine & I. A. Malcolm

2012

UK ACID WATERS MONITORING NETWORK (UKAWMN)

ALLT NA COIRE NAN CON, LOCH CHON AND LOCH GRANNOCH

ANNUAL SUMMARY PROGRESS REPORT TO FOREST RESEARCH. April 2011 - March 2012.

Ewan M. Shilland[1], Lynne Irvine[2] & Iain A. Malcolm[3]

2012

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Cover Photo: Allt na Coire nan Con, 10th July 2011 © Ewan Shilland

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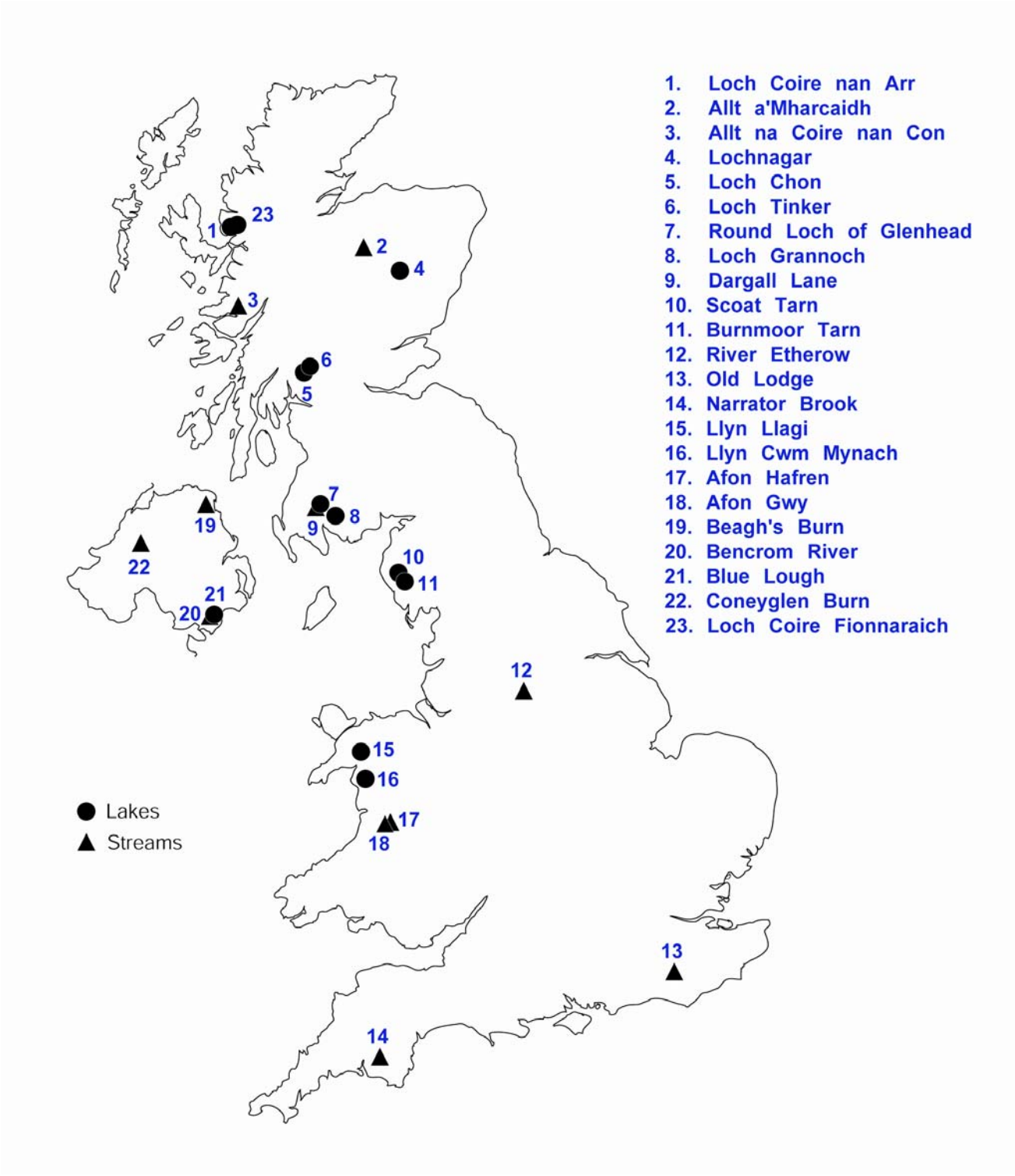
2 INTRODUCTION

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 2011-2012 at three Scottish forested sites currently supported in part by Forest Research: Allt na Coire nan Con, Loch Chon and Loch Grannoch. The UKAWMN gratefully acknowledges Forest Research for providing resources that contribute towards the continuation of monitoring at these sites, and especially recognises Pete Madden for sample collection at Allt na Coire nan Con. We would also like to thank Marine Scotland, Queen Mary University of London, the NERC Centre for Ecology and Hydrology (CEH) and ENSIS Ltd who support the rest of the programme at the three sites.

In order to present the Forest Research funded aspects of the UKAWMN in context, all sampling performed in 2011-12 is described and time series summary data are presented for the full suite of chemical and biological measurements taken from the start of monitoring up to April 2011.

Detailed analysis of data has been presented in four interpretative reports, Kernan *et al* (2010), Monteith and Shilland (2007), Monteith (2005) and Monteith and Evans (2000) dealing with 20, 18, 15 and 10 years of accumulated results respectively. All four 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 methods web page.

3 LOCATION OF UKAWMN SITES



4 SUMMARY OF WORK UNDERTAKEN 2011-2012

4.1 Summary Overview

During the period from April 2011 to March 2012 the majority of chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at all three sites. It was not possible to collect invertebrate samples from Loch Grannoch in spring 2011 nor fish the outflow in autumn 2011. At Loch Chon the 2010-11 sediment trap/thermistor array could not be re-located.

4.2 Water Chemistry

Samples were collected from the two lochs in early June, September and December 2011 and March 2012 by Marine Scotland Pitlochry. Monthly dip samples were collected from Allt na Coire nan Con by a local Forestry Commission operative, Pete Madden. All except the slightly delayed October 2011 Allt nan Coire nan Con sample were delivered to the analytical laboratories at Marine Scotland and CEH on schedule and have been analysed and archived in the UKAWMN central chemistry database at CEH Lancaster. Quality control was performed on the data prior to it being presented in the annual UKAWMN data report and online on the UKAWMN website.

4.3 Sediment Traps

Sediment traps were recovered and replaced on the 25th of July 2011 at Loch Grannoch. Despite a thorough search at Loch Chon on the 27th of July 2011 the sediment trap array could not be found and a new array was installed. The loss was most likely due either to the effects of ice rafting or interference from the public. Diatoms in the sediment retrieved from the Loch Grannoch trap are currently being analysed.

4.4 Thermistors

As the thermistors are attached to the sediment traps, neither the top nor bottom thermistor was recovered from Loch Chon on the 27th of July 2011. Top and bottom thermistors were removed and replaced on the 25th of July 2011 at Loch Grannoch. The top thermistor had functioned well during the previous year and the data were added to the ENSIS thermistor water temperature database. Unfortunately the bottom thermistor had failed and the unit was replaced.

4.5 Epilithic Diatoms

Epilithic diatoms were retrieved from three sampling points around Loch Chon on the 27th of July 2011 and at four sampling points around Loch Grannoch on the 25th of July

2011. Three samples were retrieved from Allt na Coire nan Con on the 10th of July 2011. All the samples were made into slides and have been analysed by Dr H. Yang.

4.6 Macroinvertebrates

Aquatic macroinvertebrates were sampled at Allt na Coire nan Con by QMuL on the 5th of May 2011 and at Loch Chon by UCL on the 1st of May 2011. No samples were collected from Loch Grannoch in 2011. Five 1 minute kick samples were performed at the two sites and the samples from both were counted at QMuL and the data sent to ENSIS Ltd. The data are being quality screened and will be added to the UKAWMN biological database at ENSIS.

4.7 Fish

Fish surveying was performed on the 15th of September and 15th of November 2011 at Allt na Coire nan Con and on the 16th of November Loch Chon by Marine Scotland Science, Pitlochry. Poor weather prevented fish sampling at Loch Grannoch in autumn 2011 and also prevented a second reach being surveyed at Loch Chon. The fish data have been checked and added to the Marine Scotland fish database.

4.8 Aquatic Macrophytes

Aquatic macrophytes were not surveyed at either of the two loch sites in the 2011-2012 period. Allt na Coire nan Con was surveyed successfully on the site visit dated 10th of July 2011.

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 reporting period.

The 2010-2011 annual report (Shilland *et al*. 2012) has been uploaded to the AWMN web site, and the sections on Allt na Coire nan Con, Loch Chon and Loch Grannoch appear in section 7 below.

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:	Time series graphs of key spot sampled chemical determinands for individual samples. Summary table for key chemical determinands including: the mean over the 1988-1993 baseline period; the mean for the current year (2010-2011) and the standard deviation for the current year. The normal number of observations per year is 4 for lakes and 12 for streams.
Section 2:	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. Macroinvertebrate summary statistic time series: 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: 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:	Salmonids. Summary histogram of mean density of trout and salmon, if present, in three 50m reaches (number of individuals caught per m^2 survey area) for each year of the monitoring period. (0+ = new recruits, "fry", >0+ = all fish over one year of age, "parr").
Section 4:	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. Epilithic diatom summary statistic time series. Mean, maximum and minimum for: 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), reconstructed from the diatom data using C2 (Juggins, 2007) running the Weighted Averaging Partial Least Squares method and using pH training set data from the SWAP project (Stevenson et al. 1991). Bootstrapping was performed to choose the best Component to use for the reconstruction. Component 2 improved the model prediction by over 5% and was therefore chosen, and is

	shown here alongside the diatom percentage abundance stratigraphy. 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.
Section 5:	Aquatic macrophytes. For lakes relative species abundance determined on a five point scale (comparable to the DAFOR scoring system, Palmer *et al*. 1992) following shoreline survey, shore transects and deep water grapnel trawls, as follows: 1. rare/infrequent 2. occasional but not abundant 3. widespread but not abundant 4. locally abundant 5. widespread and abundant 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.
Section 6:	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.
Section 7:	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.

6 REFERENCES

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

Juggins. S. 2007 C2 Version 1.5 User guide. Software for ecological and palaeoecological data analysis and visualisation. Newcastle University, Newcastle upon Tyne, UK. 73pp.

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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.

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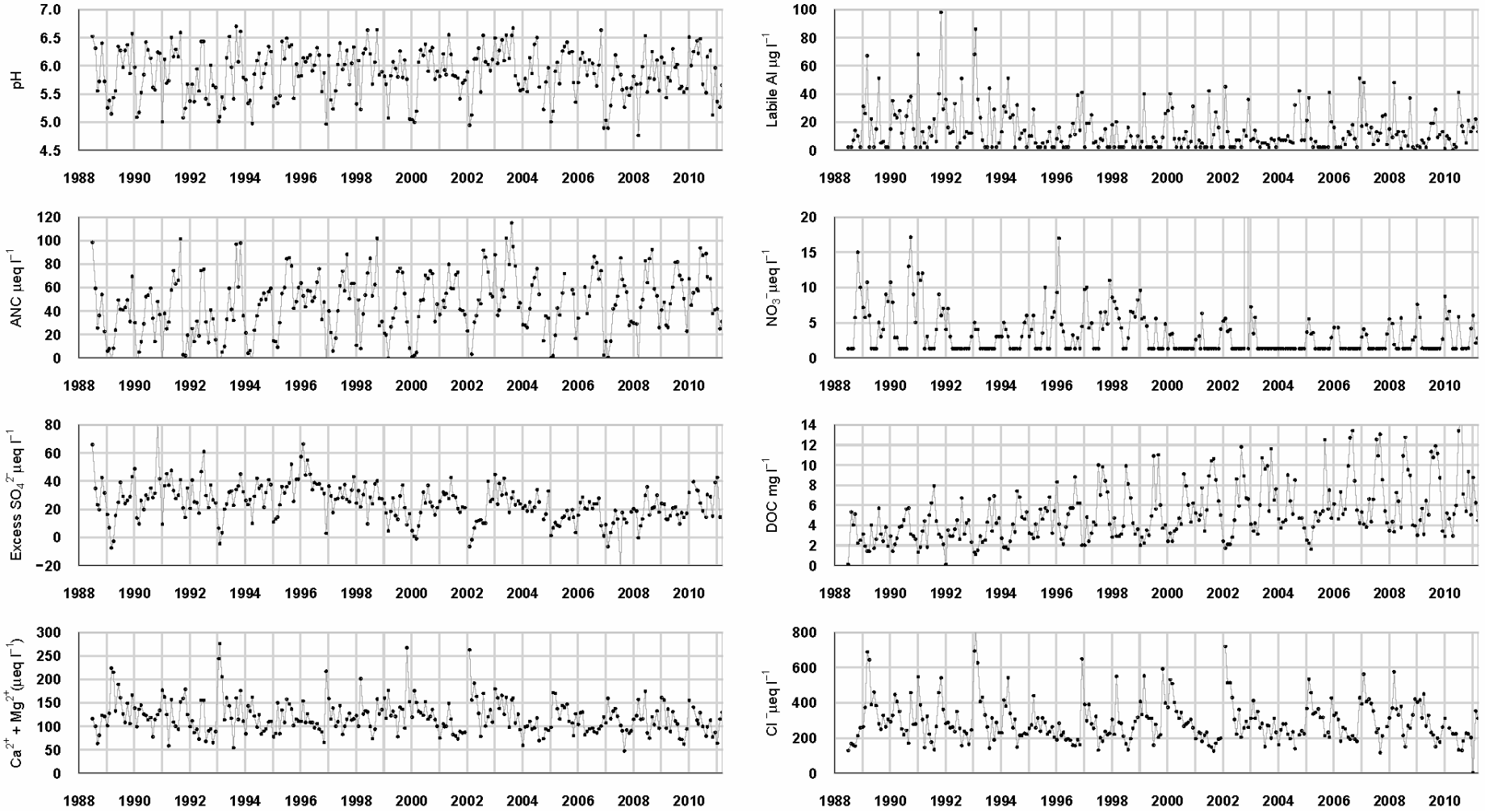
Stevenson, A. C., Juggins, S., Birks, H. J. B., Anderson, N. J., Battarbee, R. W., Berge, F., Davis, R. B., Flower, R. J., Haworth, E. Y., Jones, V. J., Kingston, J. C., Kreiser, A. M., Line, J. M., Munro, M. A. R. & Renberg, I. 1991 *The surface waters acidification project palaeolimnology programme: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

7 SITE DATA

7.1 Allt na Coire nan Con

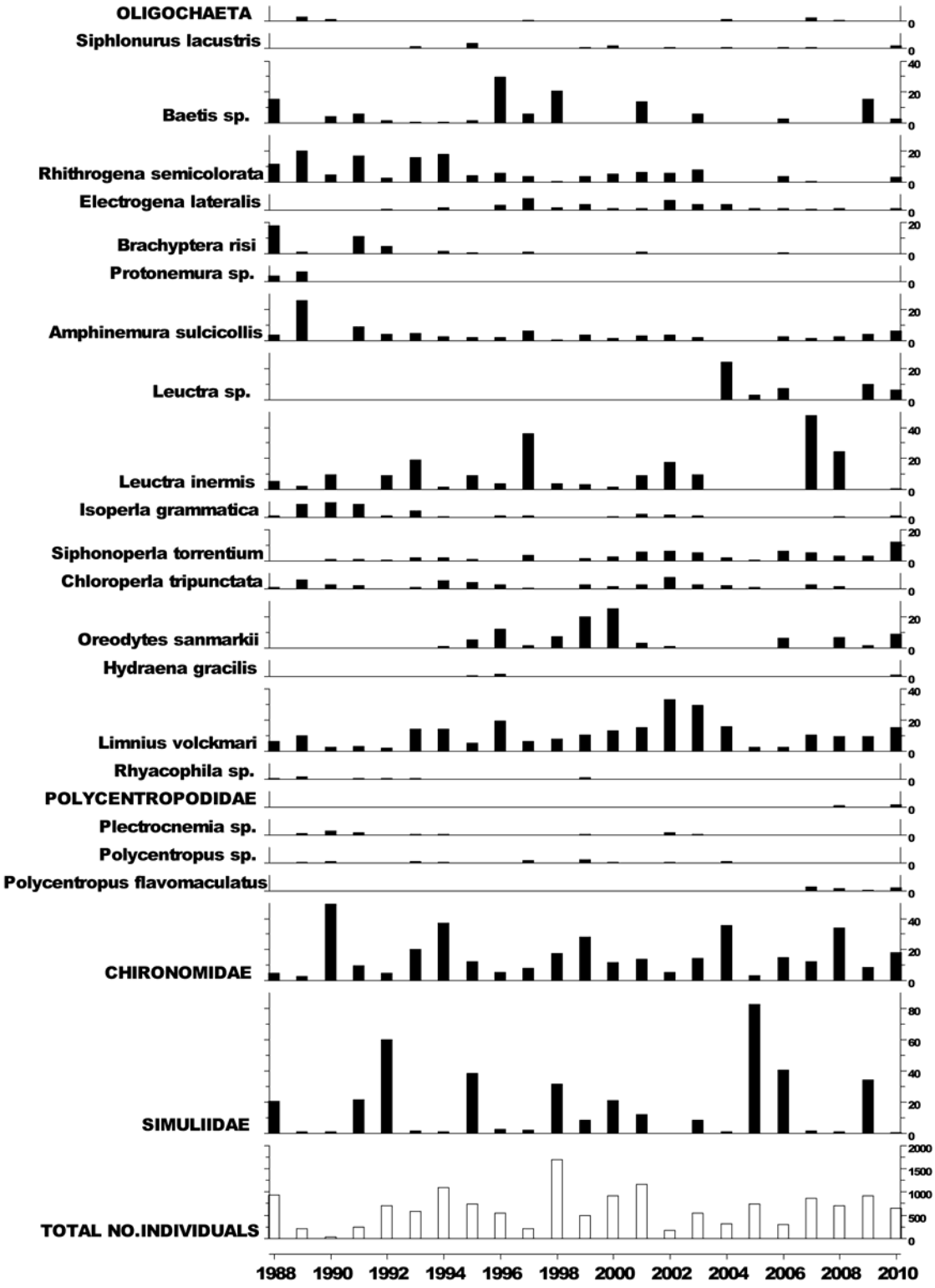
7.1.1 Spot sampled chemistry data



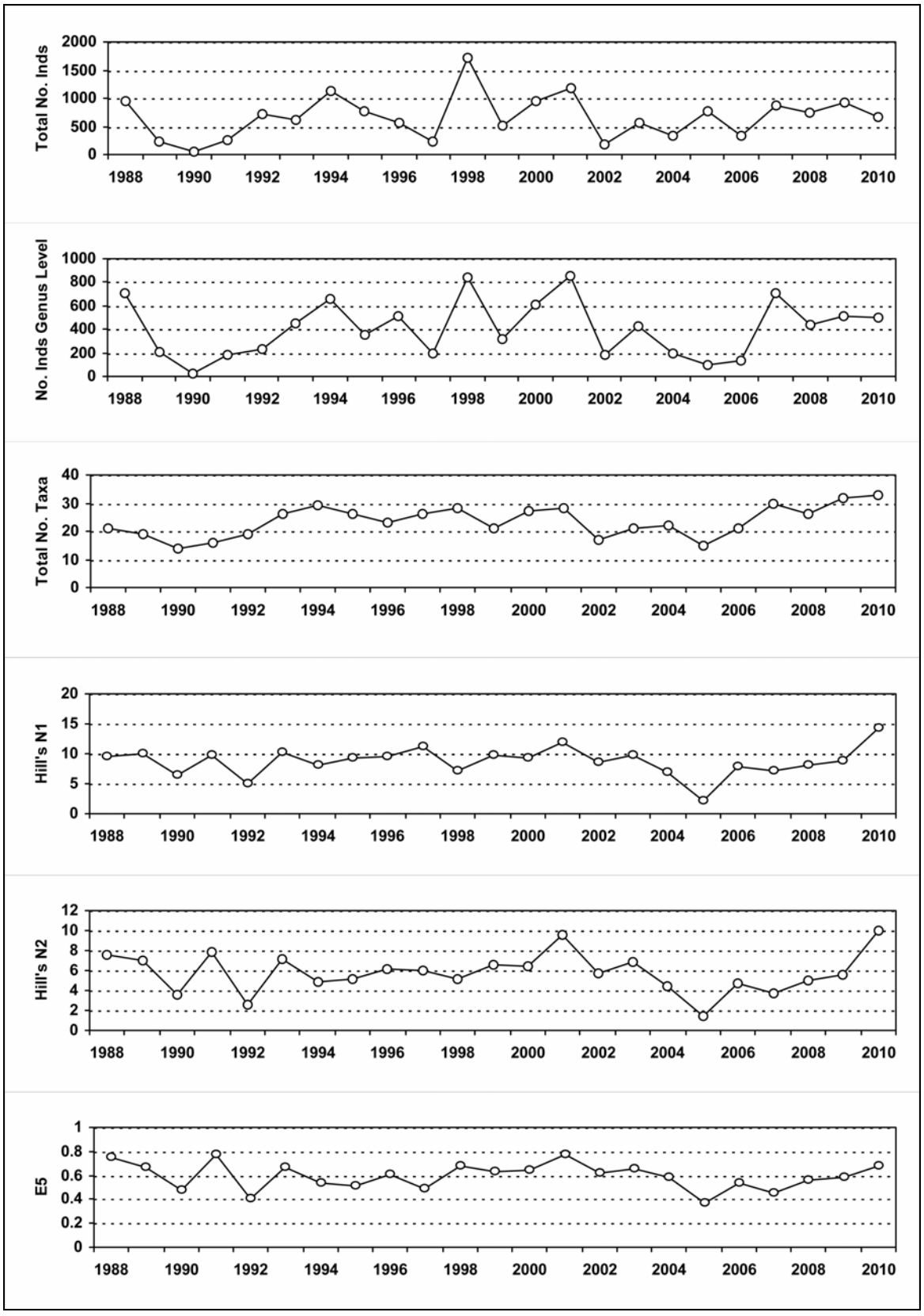
µeq l $^{-1}$, *µg l $^{-1}$, **mg l $^{-1}$	pH	ANC	Ca $^{2+}$	Mg $^{2+}$	Na $^{+}$	K $^{+}$	*Soluble Al	*Labile Al	Cl $^{-}$	*SO$_4$ $^{2-}$	xSO$_4$ $^{2-}$	NO$_3$ $^{-}$	**DOC
Mean 1st 5 yrs	5.81	32.14	58.91	70.20	274.34	9.14	64.76	21.47	325.23	62.07	27.96	4.79	3.18
10-11 mean	5.84	58.10	45.94	54.60	212.53	7.10	74.58	13.92	201.76	46.76	25.60	2.49	7.40
10-11 std dev	0.47	23.59	12.44	11.41	40.70	1.75	34.80	11.20	89.40	9.98	10.27	1.81	3.67

7.1.2 Macroinvertebrate data

7.1.2.1 Percentage abundance summary, Allt na Coire nan Con

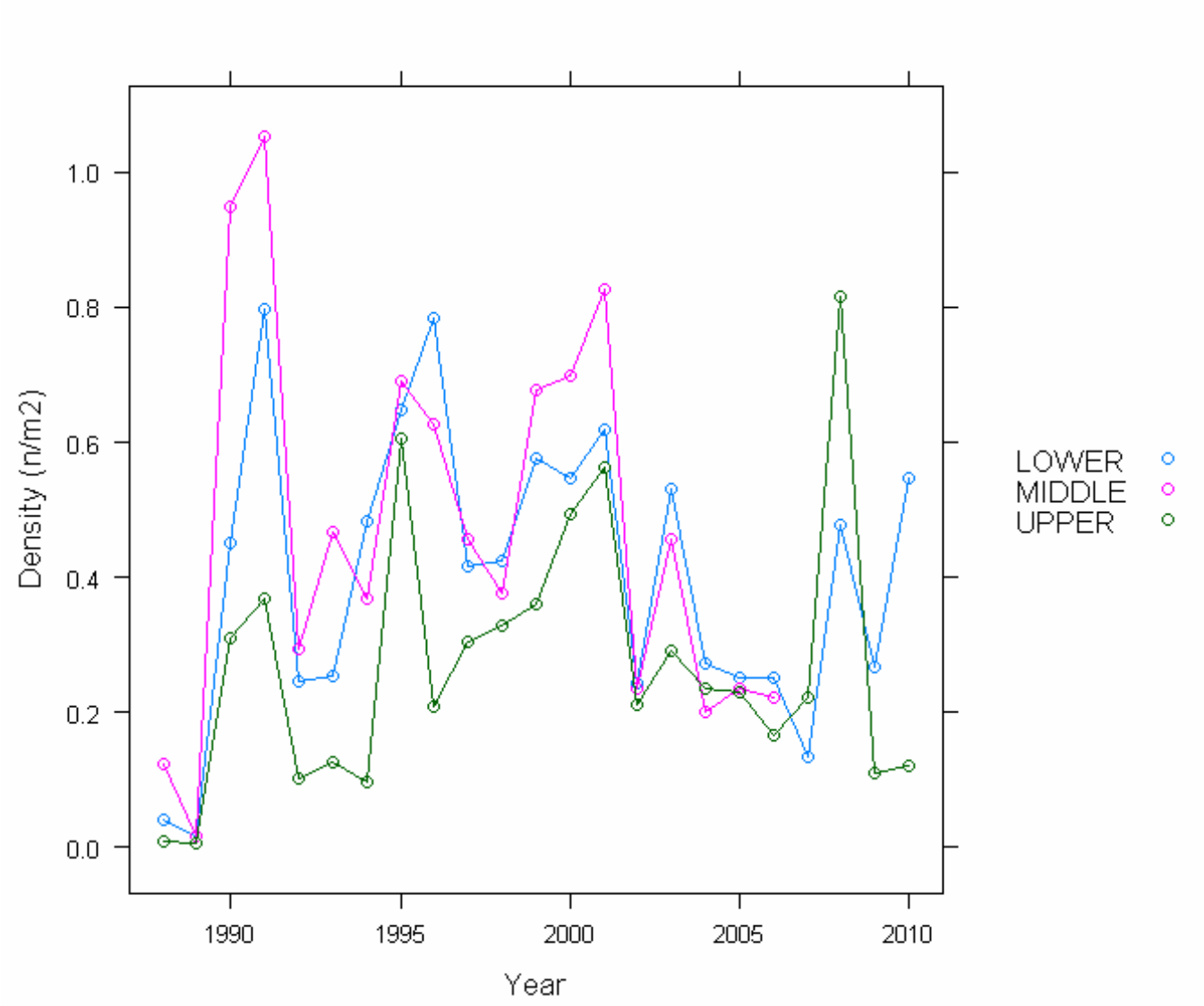


7.1.2.2 Summary statistics, Allt na Coire nan Con



7.1.3 Fish data

7.1.3.1 Summary of Salmon fry densities (numbers m^{-2}), Allt na Coire nan Con



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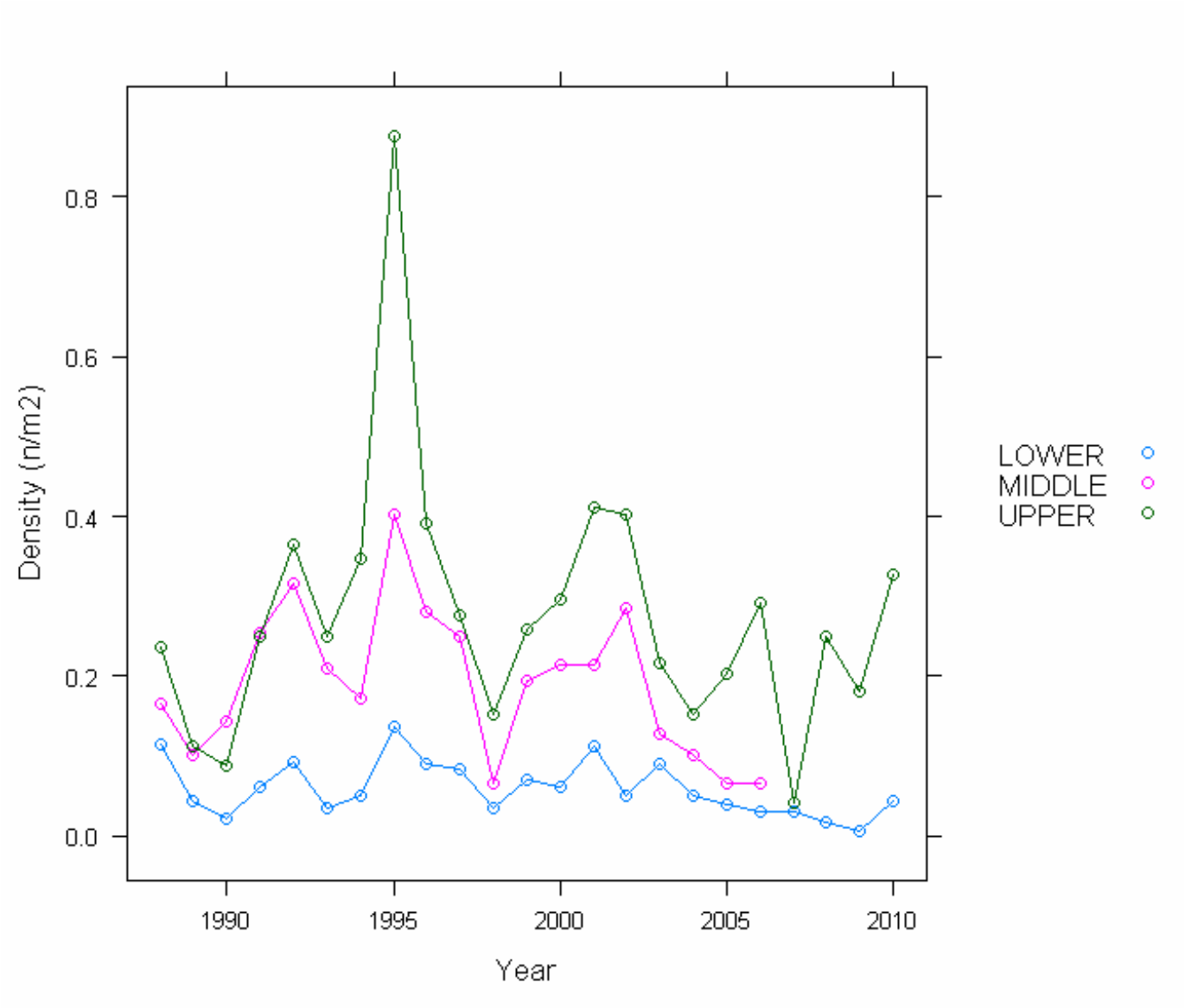
Pink series = Reach 2
Green series = Reach 3

7.1.3.2 Summary of Salmon parr densities (numbers m^{-2}), Allt na Coire nan Con



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Green series = Reach 3

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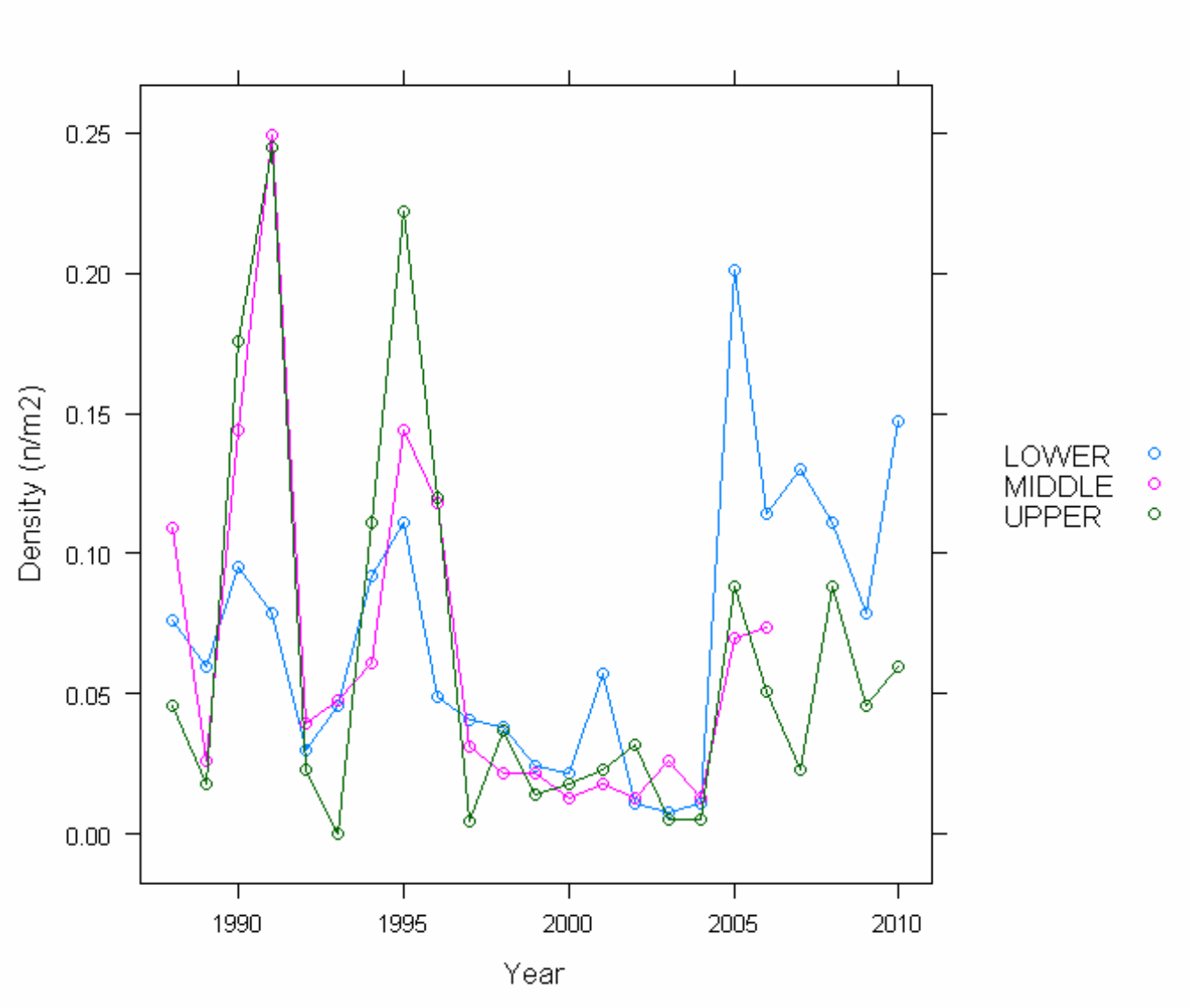
7.1.3.3 Summary of Trout fry densities (numbers m^{-2}), Allt na Coire nan Con



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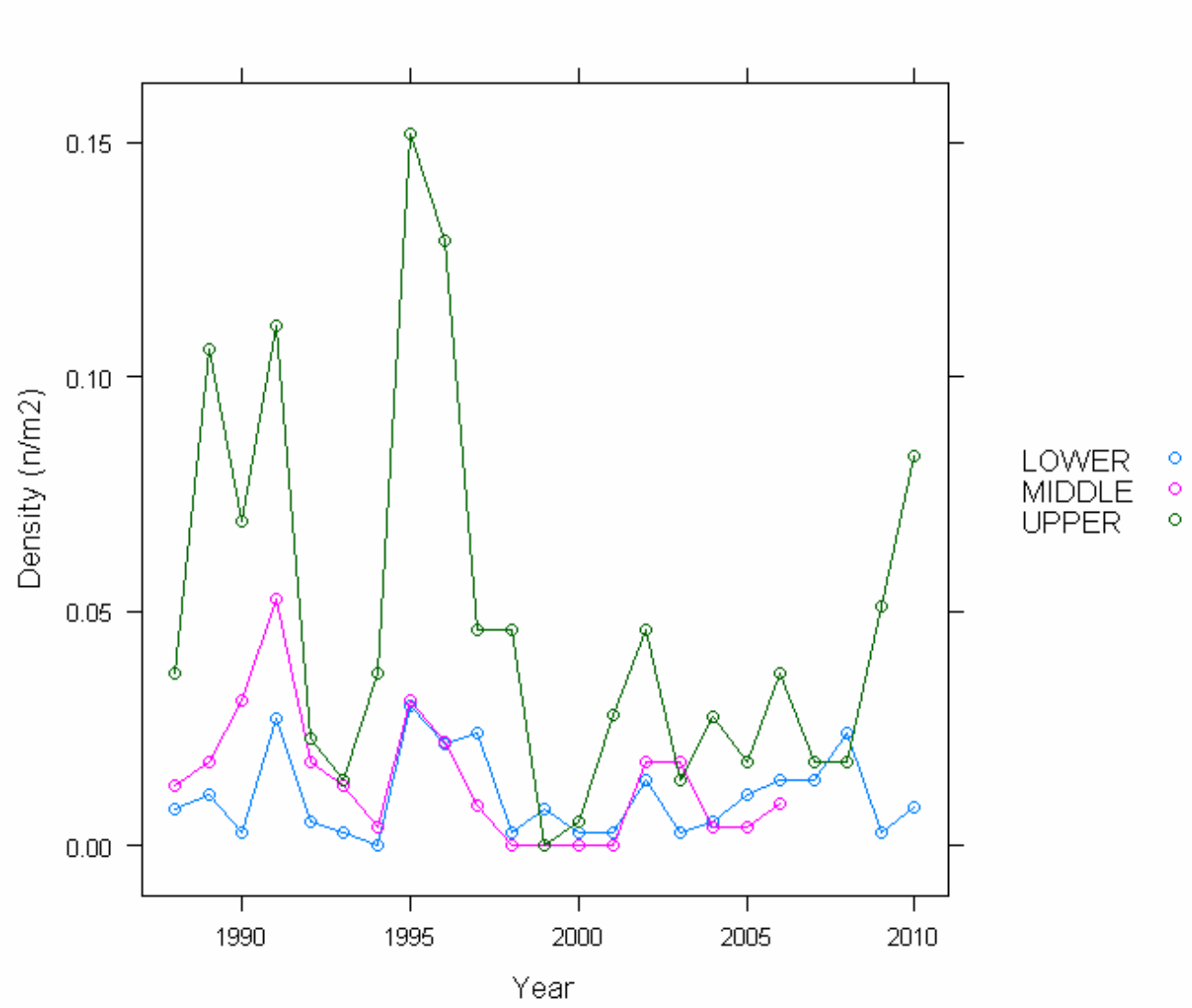
Green series = Reach 3

7.1.3.4 Summary of Trout parr densities (numbers m^{-2}), Allt na Coire nan Con



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Pink series = Reach 2
Green series = Reach 3

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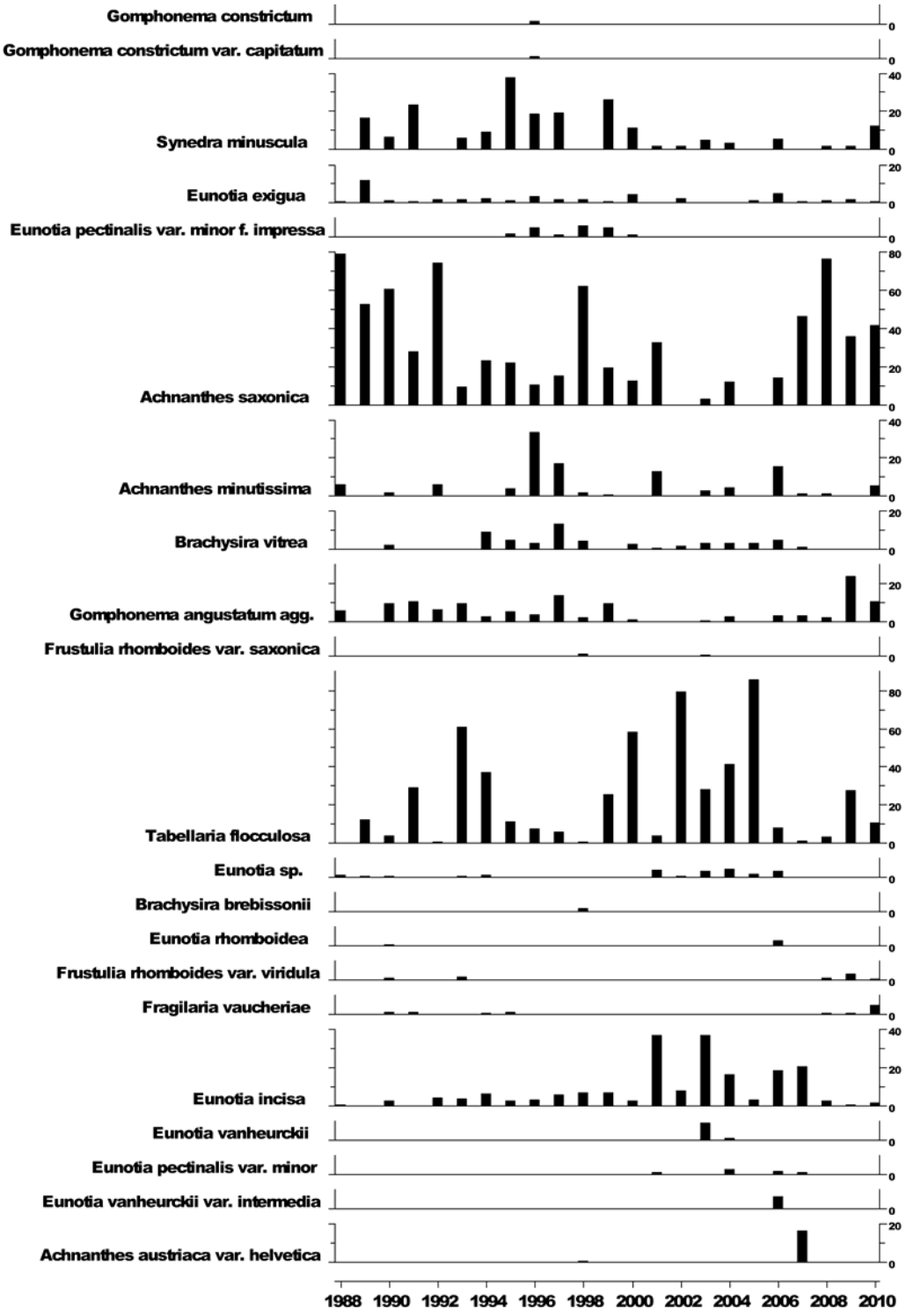
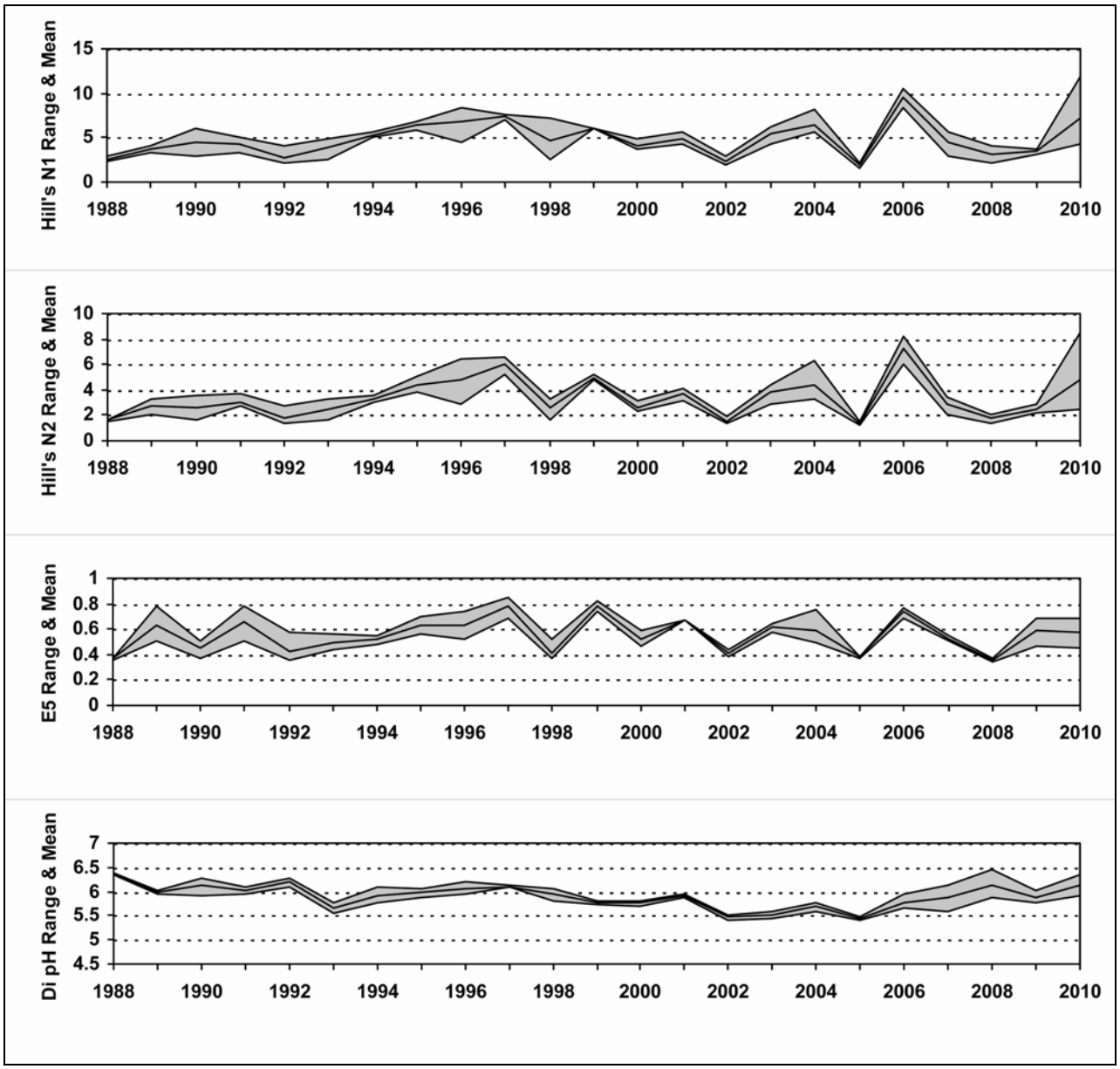
7.1.4 Epilithic diatom data

7.1.4.1 Percentage abundance summary, Allt na Coire nan Con

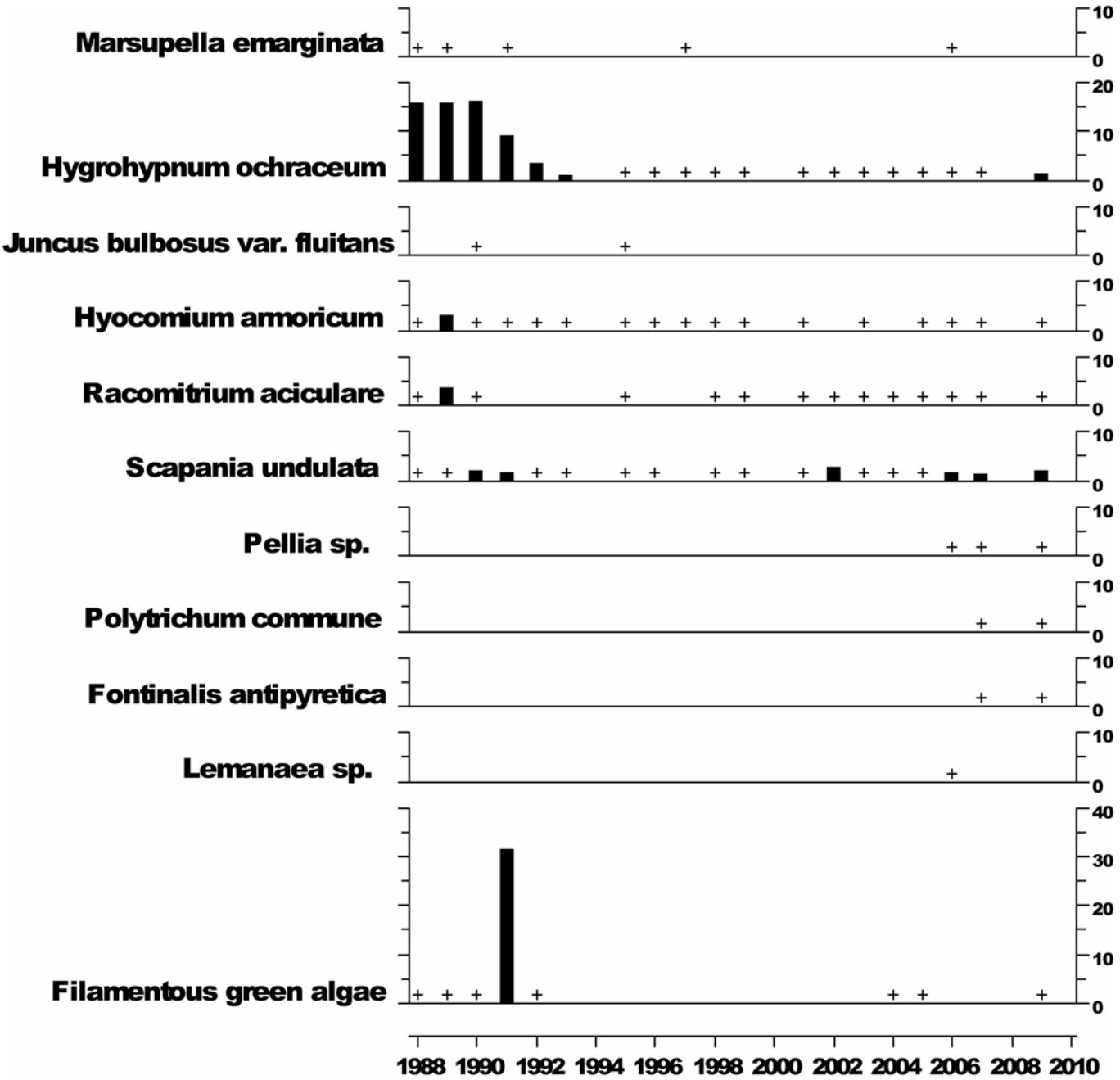


7.1.4.2 Summary statistics, Allt na Coire nan Con



7.1.5 Aquatic macrophyte data, Allt na Coire nan Con

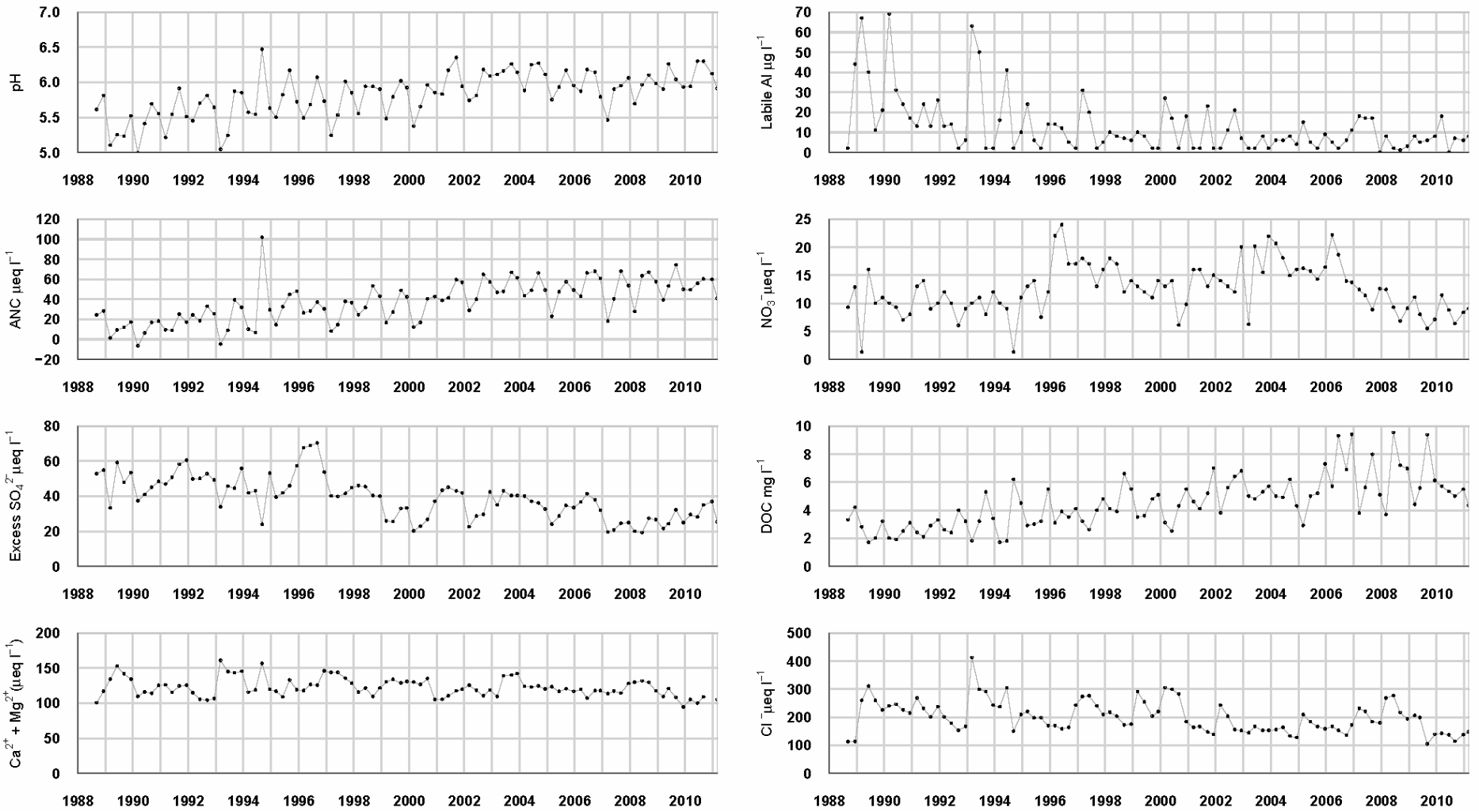
Percentage Species Cover



\+ Represents <0.5% abundance
No survey in 2008 and 2010 due to spate conditions

7.2 Loch Chon

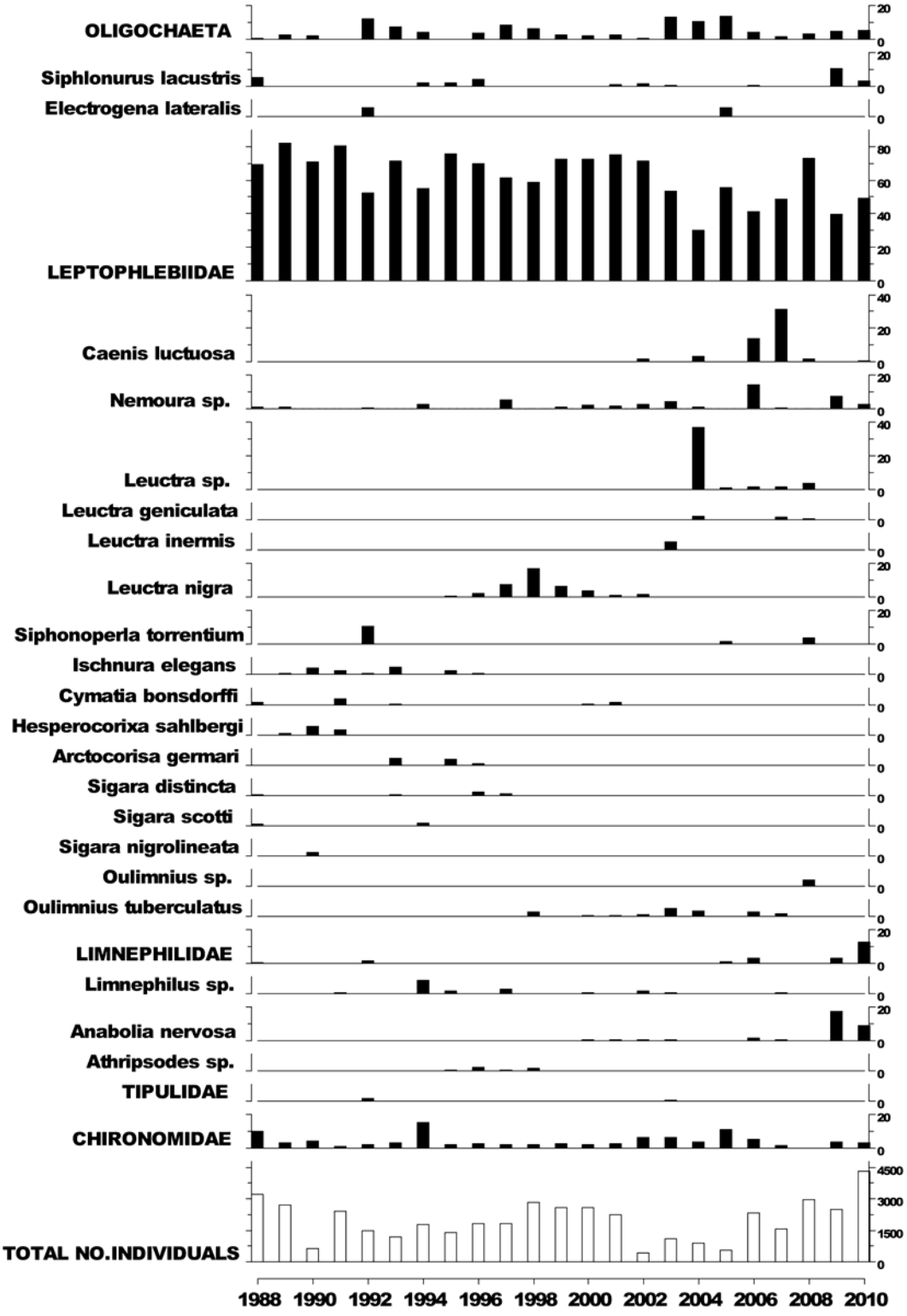
7.2.1 Spot sampled chemistry data



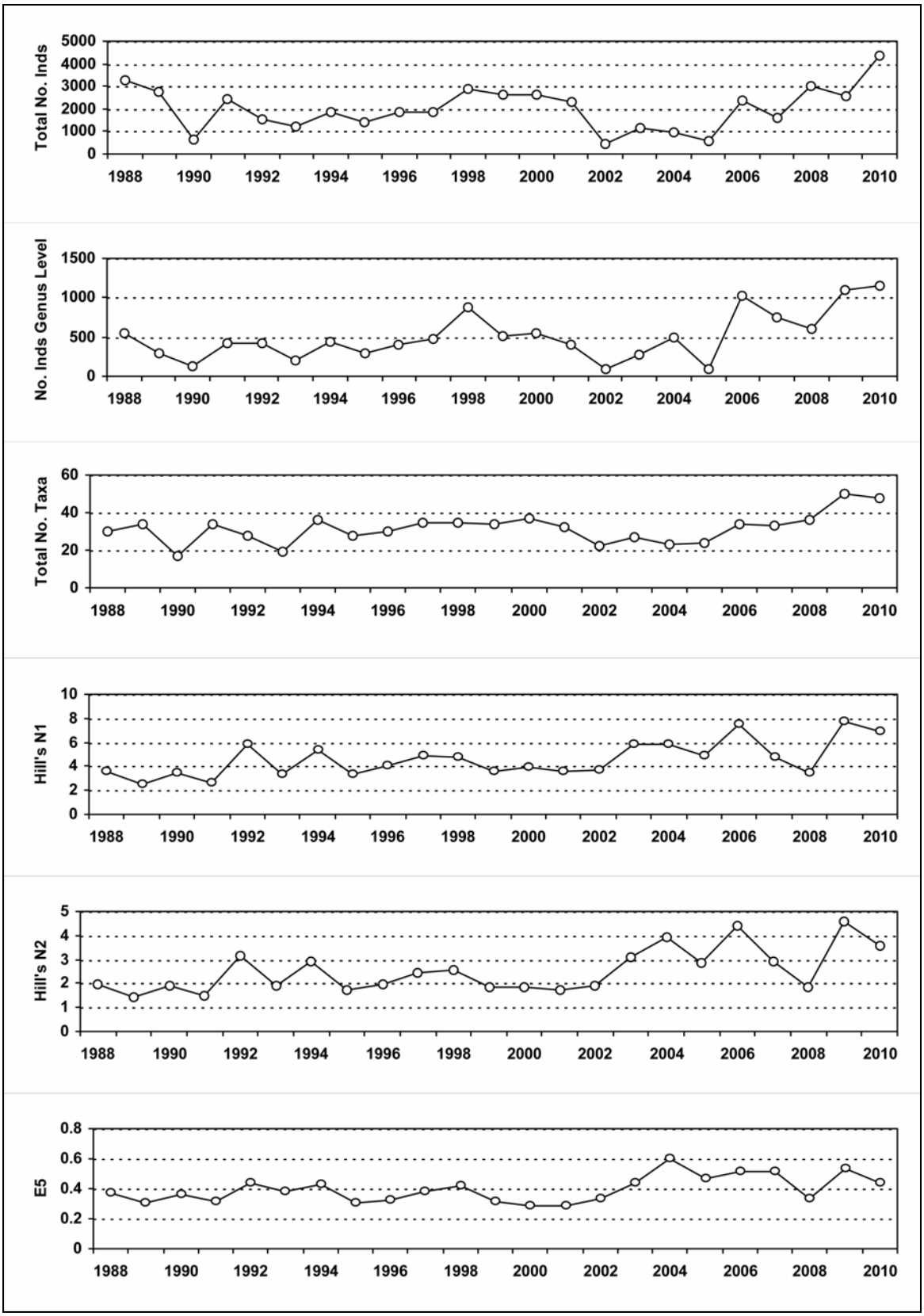
µeq l $^{-1}$, *µg l $^{-1}$, **mg l $^{-1}$	pH	ANC	Ca $^{2+}$	Mg $^{2+}$	Na $^{+}$	K $^{+}$	*Soluble Al	*Labile Al	Cl $^{-}$	*SO_4 $^{2-}$	xSO_4 $^{2-}$	NO_3 $^{-}$	**DOC
Mean 1st 5 yrs	5.46	14.54	76.17	47.42	189.44	5.79	66.65	27.50	227.51	72.38	48.53	9.94	2.73
10-11 mean	6.16	54.12	66.87	37.70	131.23	4.60	31.75	5.25	133.64	45.31	31.28	8.14	5.04
10-11 std dev	0.19	9.13	3.49	2.00	6.10	0.39	7.50	3.59	14.12	4.75	5.50	1.23	0.52

7.2.2 Macroinvertebrate data

7.2.2.1 Percentage abundance summary, Loch Chon

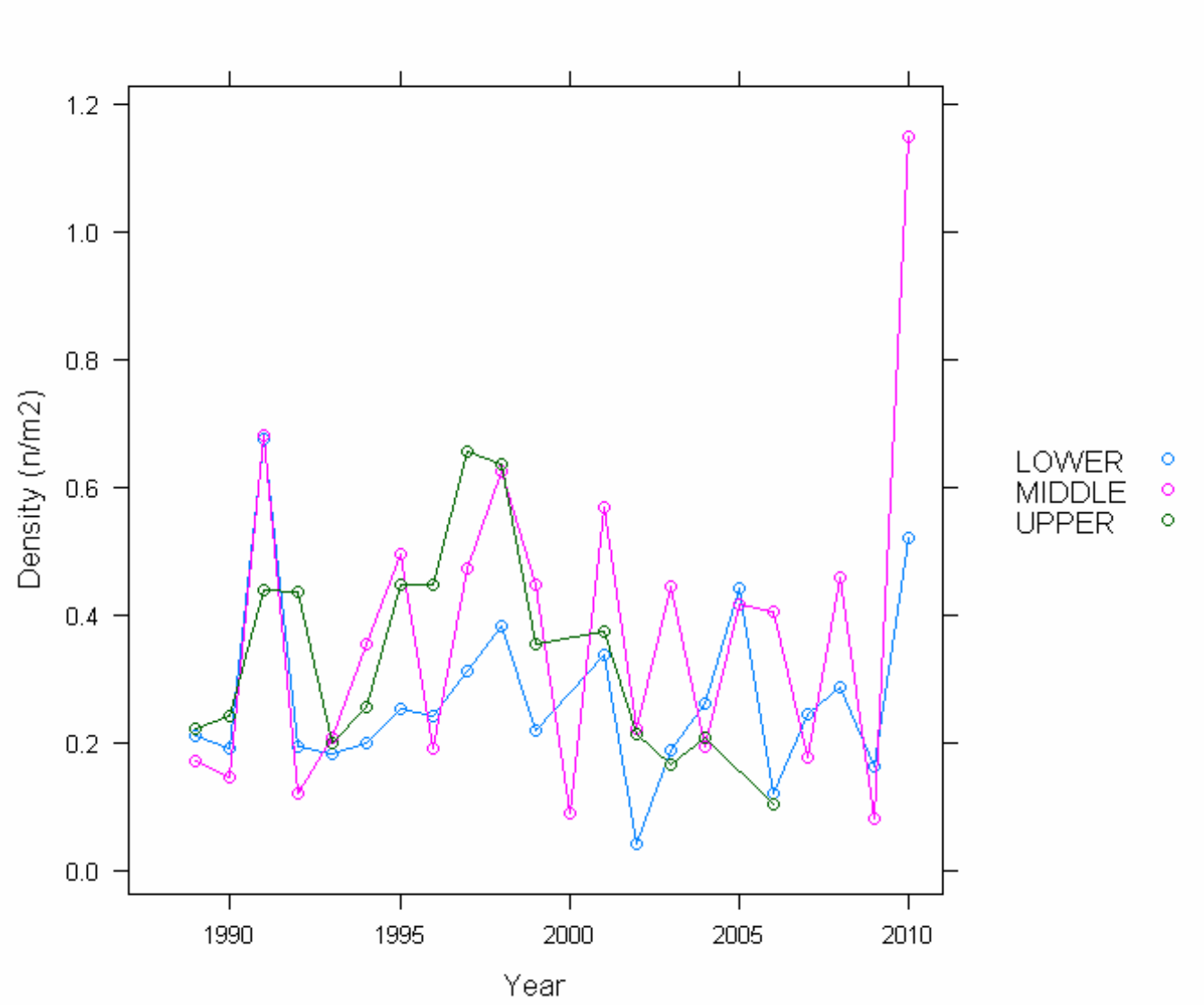


7.2.2.2 Summary statistics, Loch Chon



7.2.3 Fish data (for outflow stream)

7.2.3.1 Summary of Trout fry densities (numbers m^{-2}), Loch Chon



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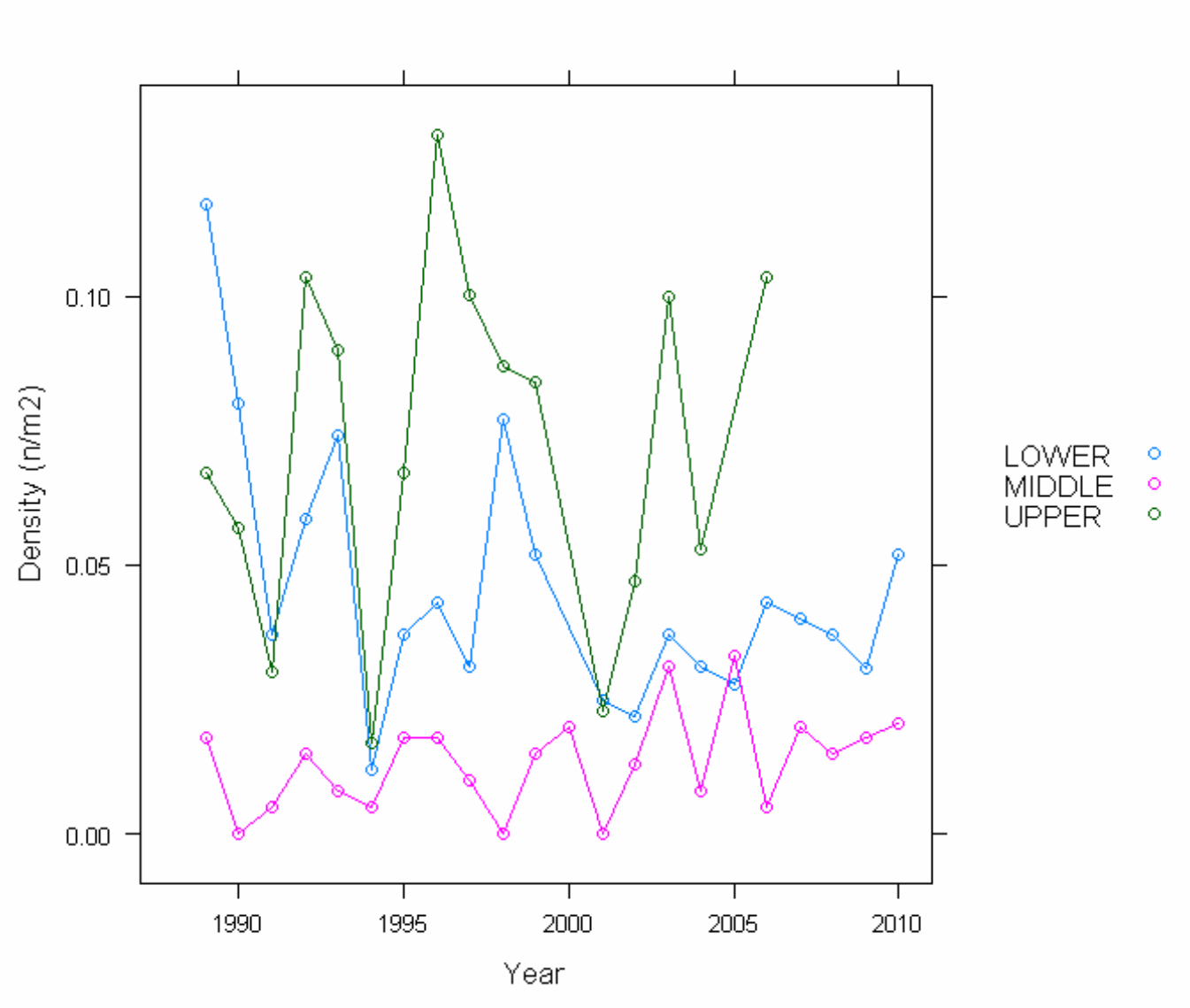
Pink series = Reach 2
Green series = Reach 3

7.2.3.2 Summary of Trout parr densities (numbers m^{-2}), Loch Chon



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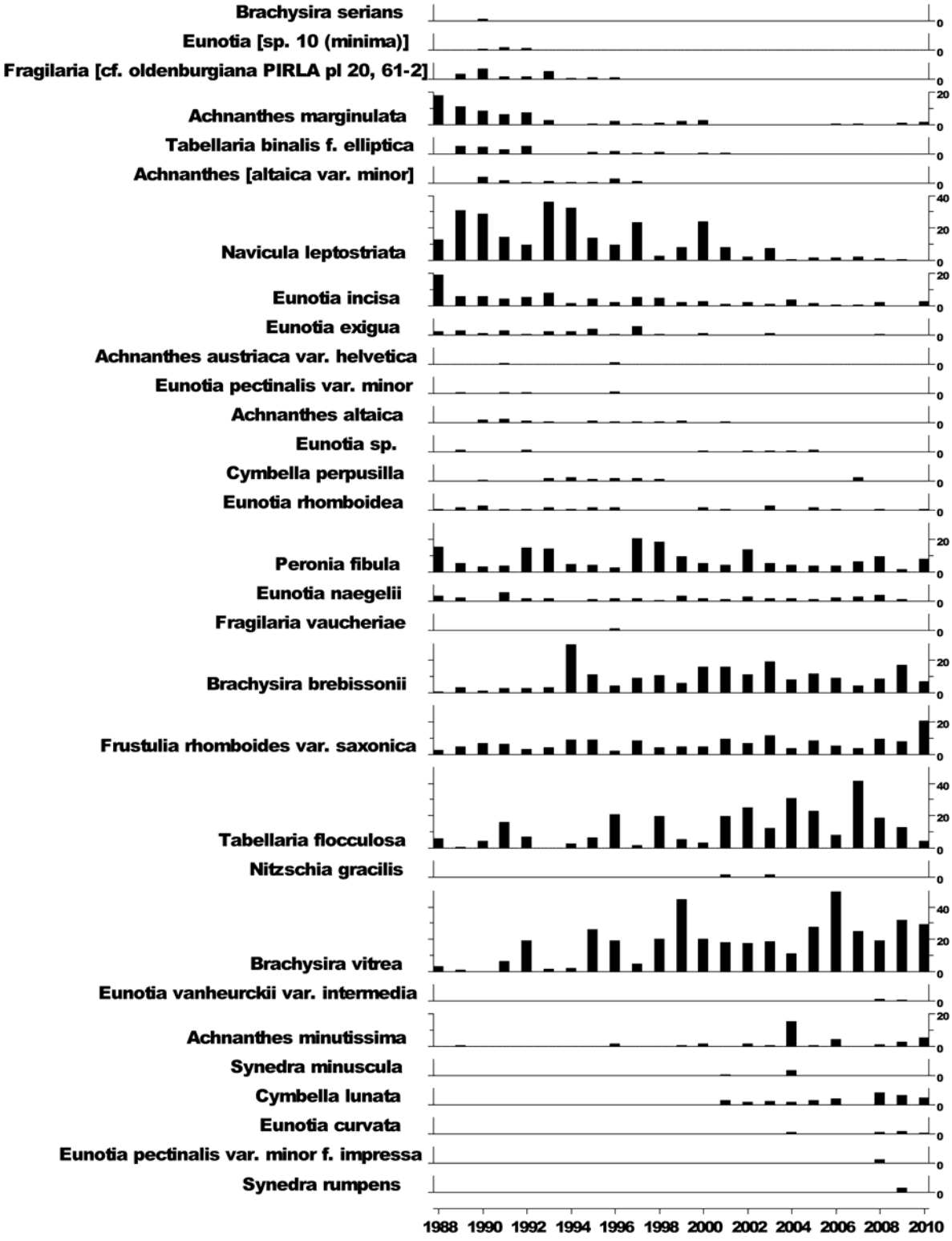
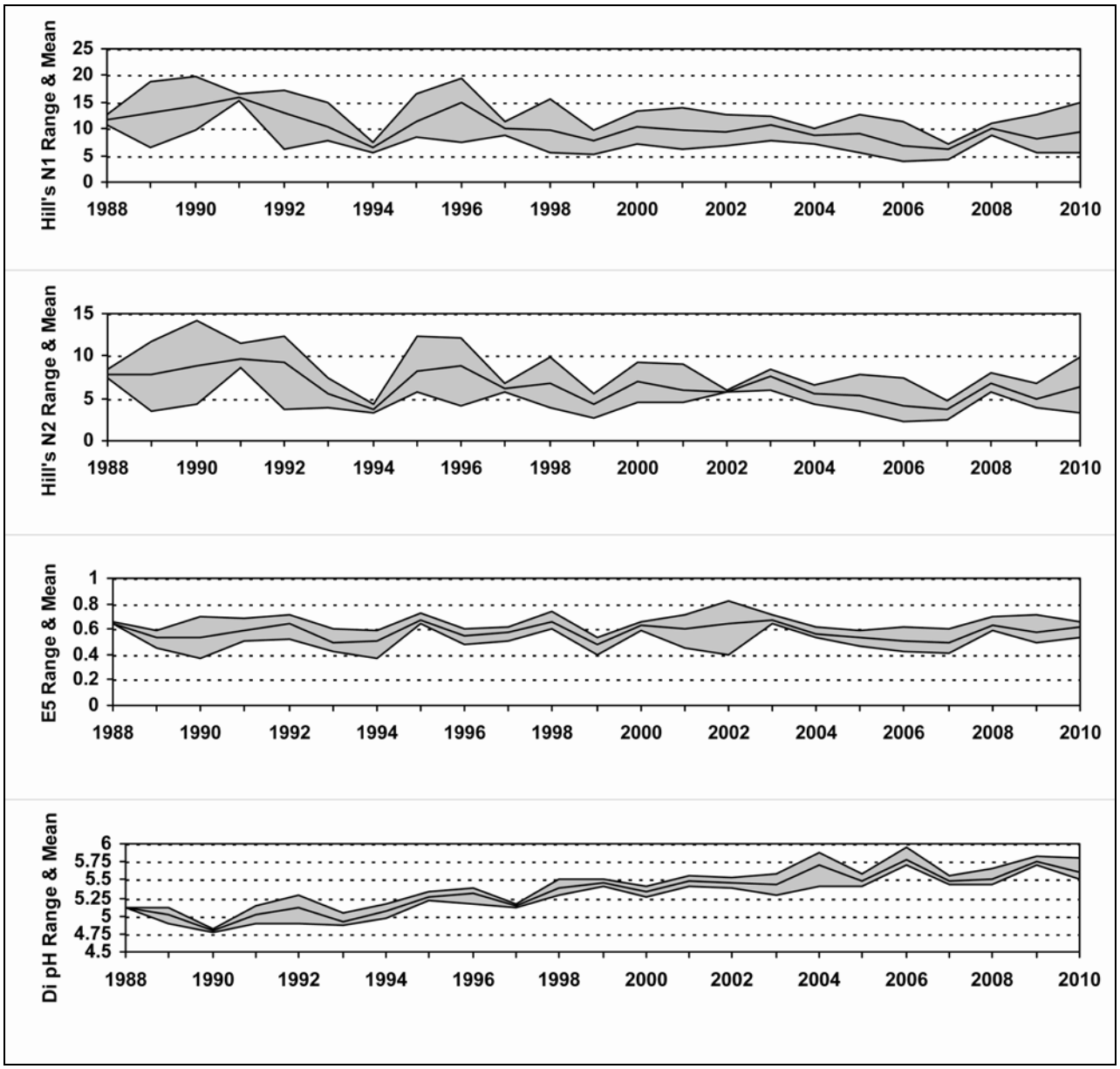
Green series = Reach 3

7.2.4 Epilithic diatom data

7.2.4.1 Percentage abundance summary, Loch Chon

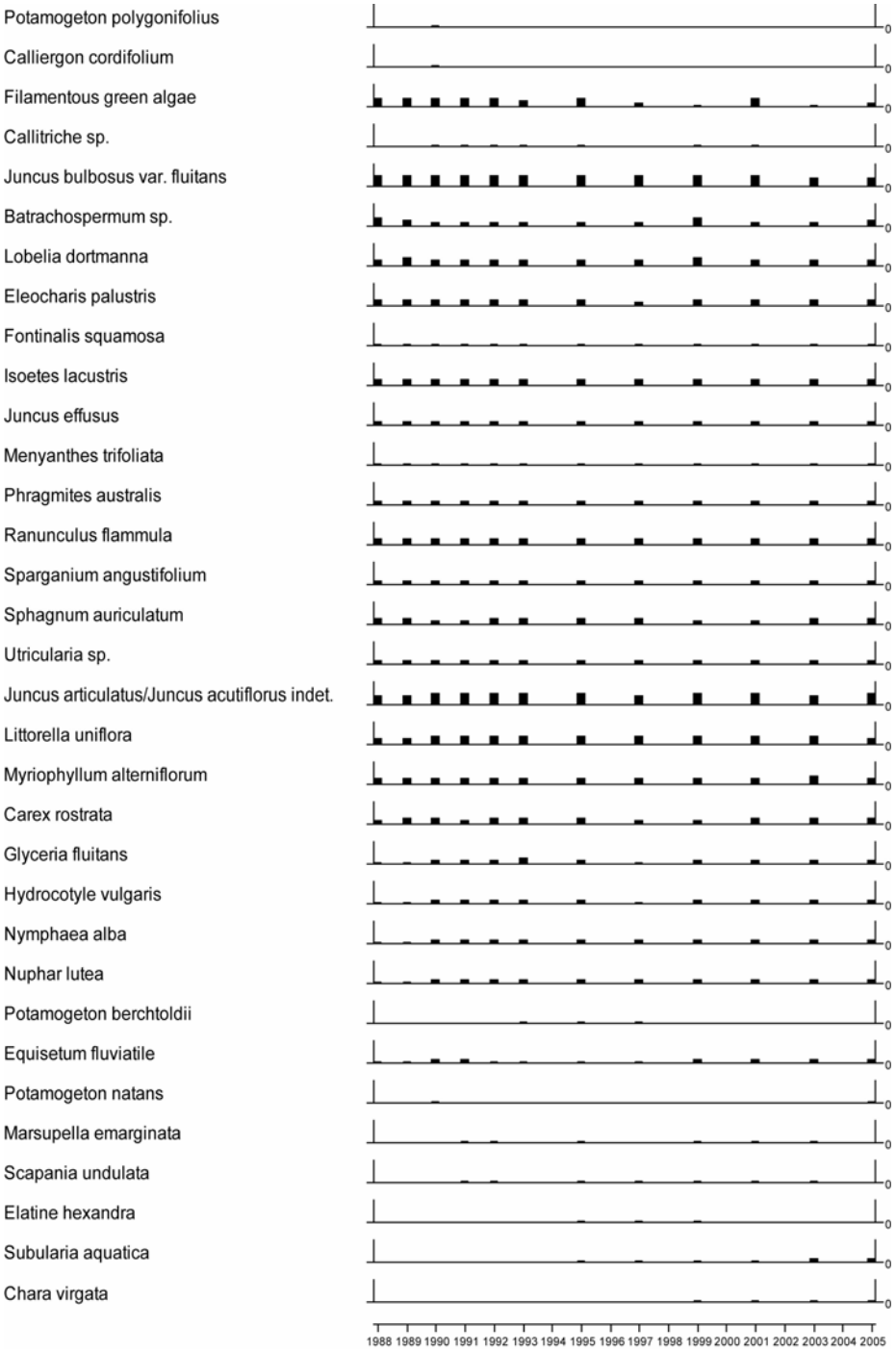


7.2.4.2 Summary statistics, Loch Chon



7.2.5 Aquatic macrophyte data, Loch Chon

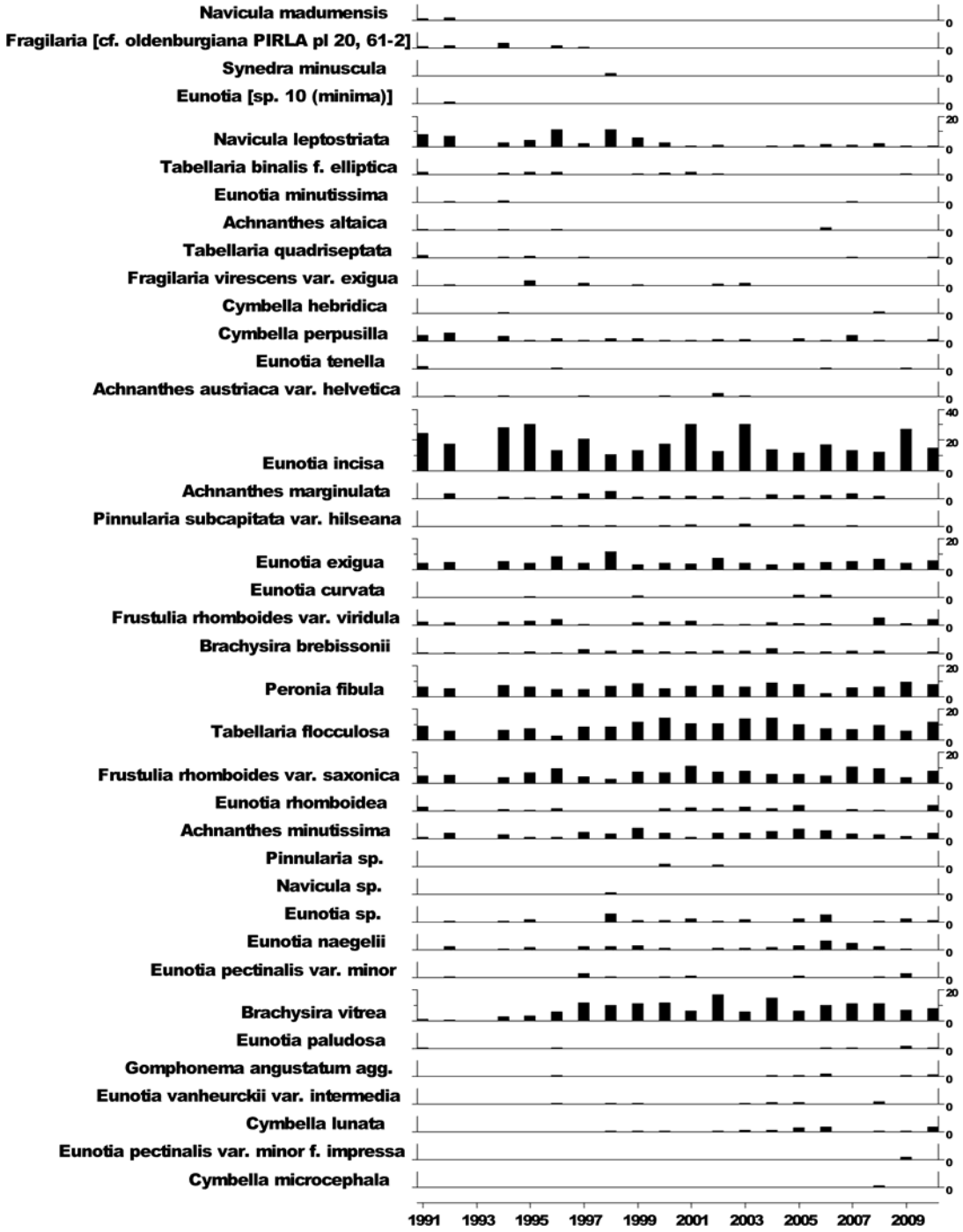
Species Scores (1-5)



No surveys since 2007 due to funding cuts

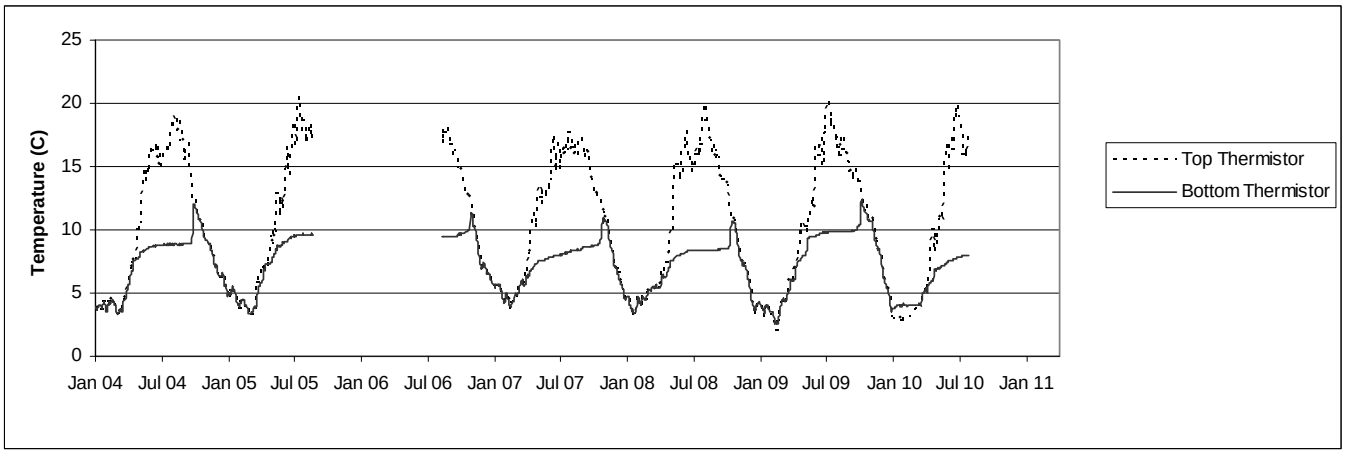
7.2.6 Sediment trap data, Loch Chon

Relative percentage frequency of diatom taxa



Traps not recovered in 1993

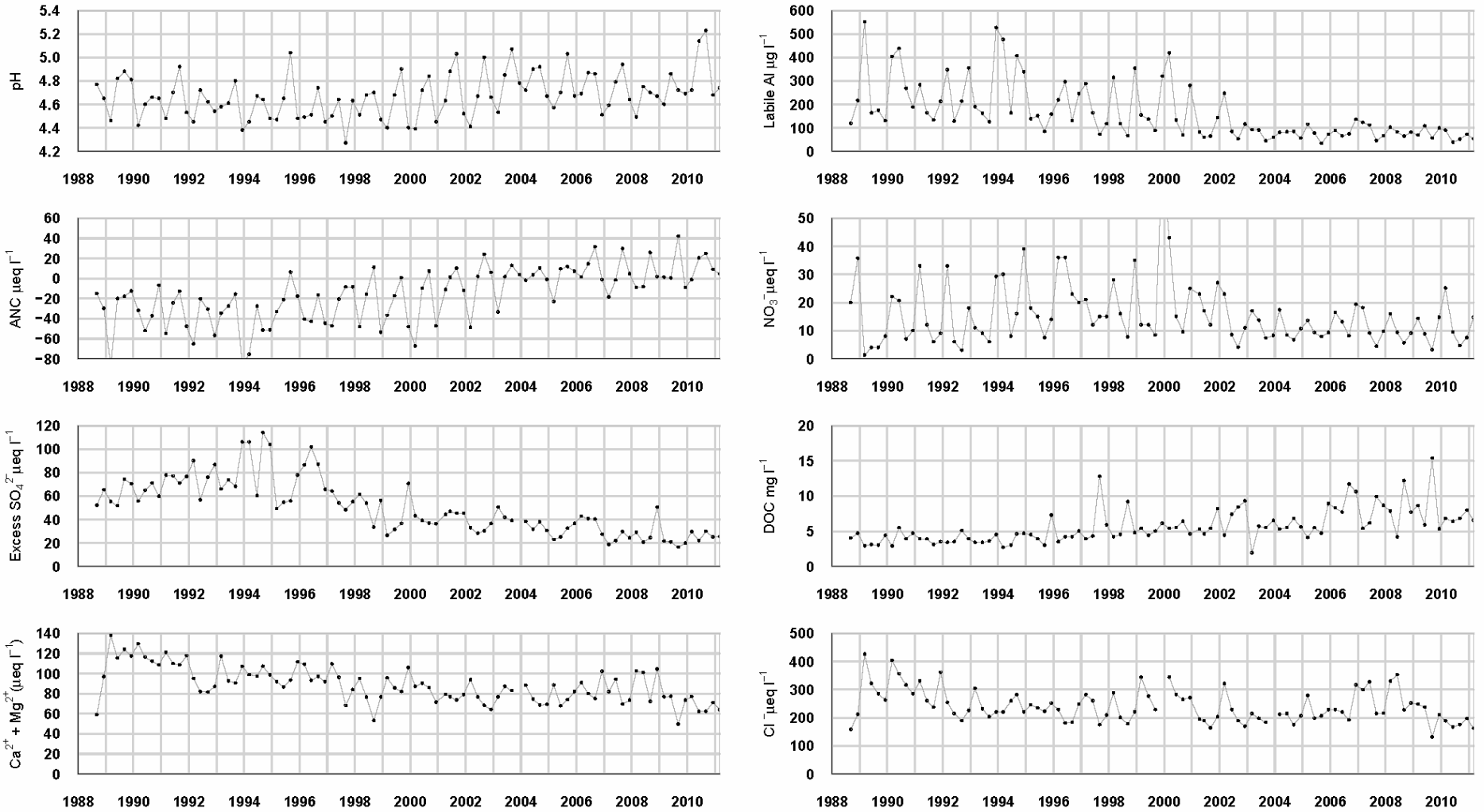
7.2.7 Thermistor data, Loch Chon



Thermistors not recovered in 2006 or 2011

7.3 Loch Grannoch

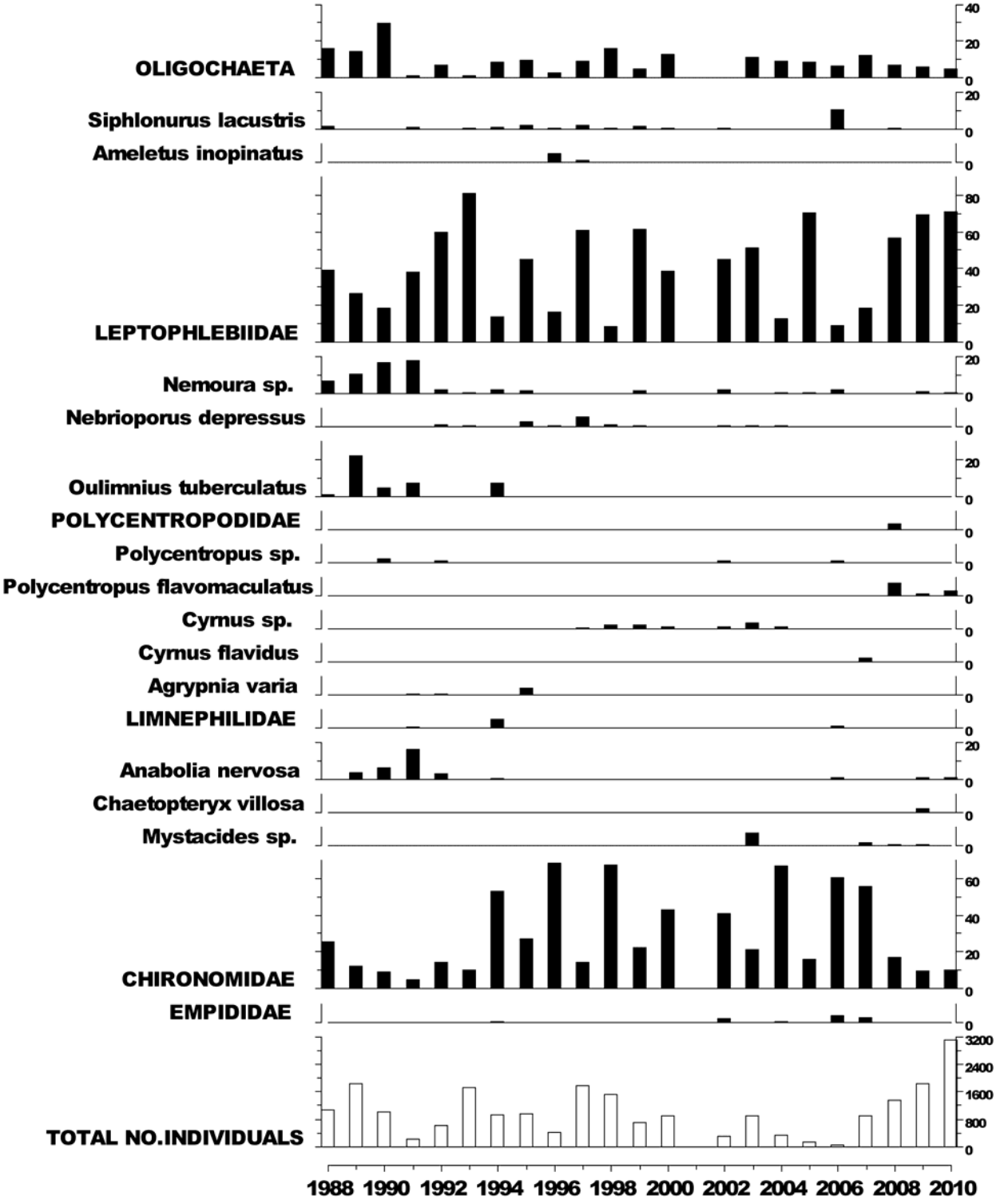
7.3.1 Spot sampled chemistry data



µeq l $^{-1}$, *µg l $^{-1}$, **mg l $^{-1}$	pH	ANC	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	*Soluble Al	*Labile Al	Cl^{-}	$*SO_4^{2-}$	xSO_4^{2-}	NO_3^{-}	**DOC
Mean 1st 5 yrs	4.64	-34.33	50.92	55.53	237.51	4.82	310.95	241.85	281.54	98.11	68.59	13.64	3.81
10-11 mean	4.95	14.69	28.62	36.15	160.95	6.12	145.50	53.50	174.97	43.90	25.54	9.09	6.93
10-11 std dev	0.28	9.51	1.51	3.34	8.53	0.81	25.88	14.01	15.40	3.80	3.23	4.25	0.73

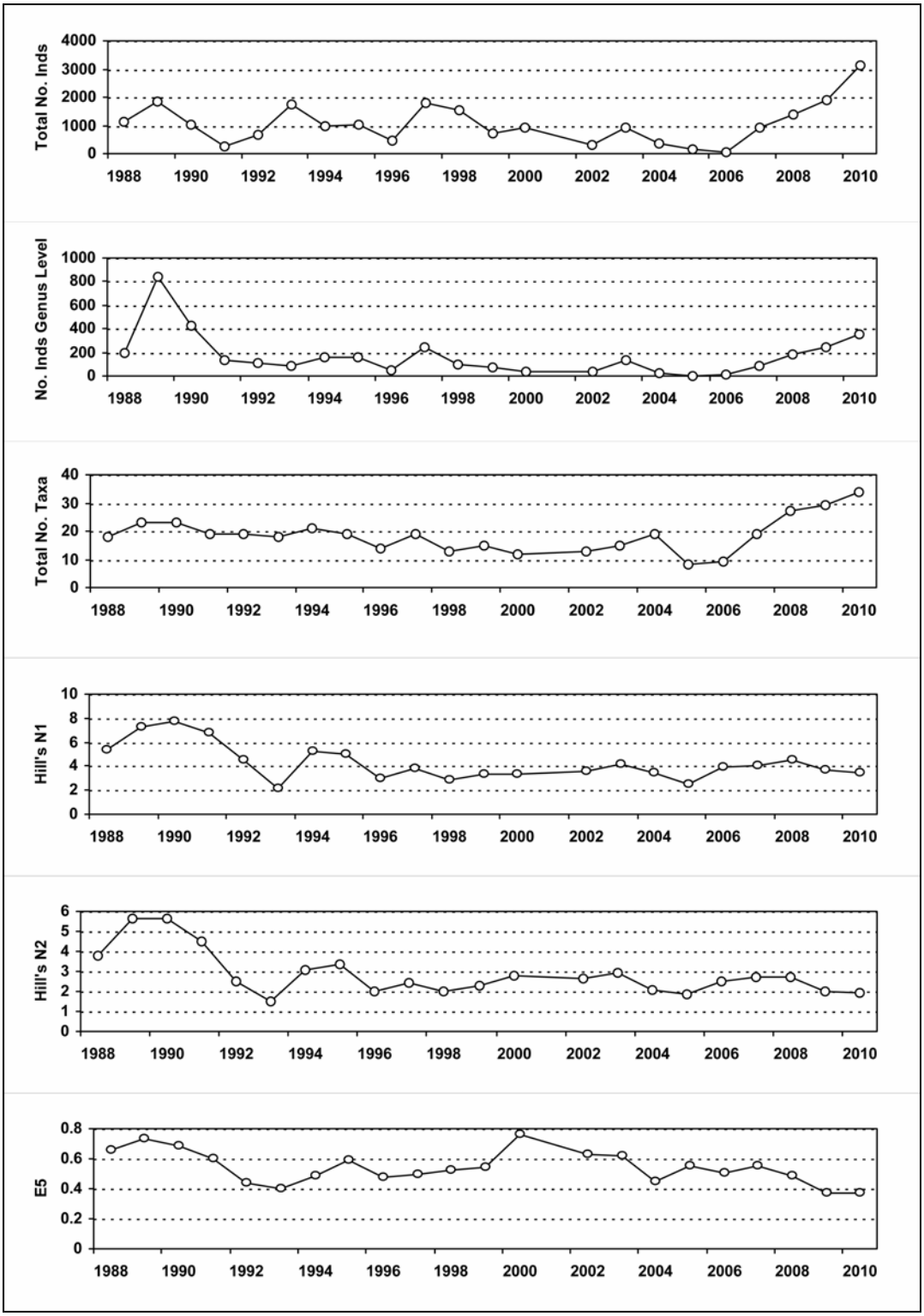
7.3.2 Macroinvertebrate data

7.3.2.1 Percentage abundance summary, Loch Grannoch



No sampling in 2001 due to Foot and Mouth restrictions.

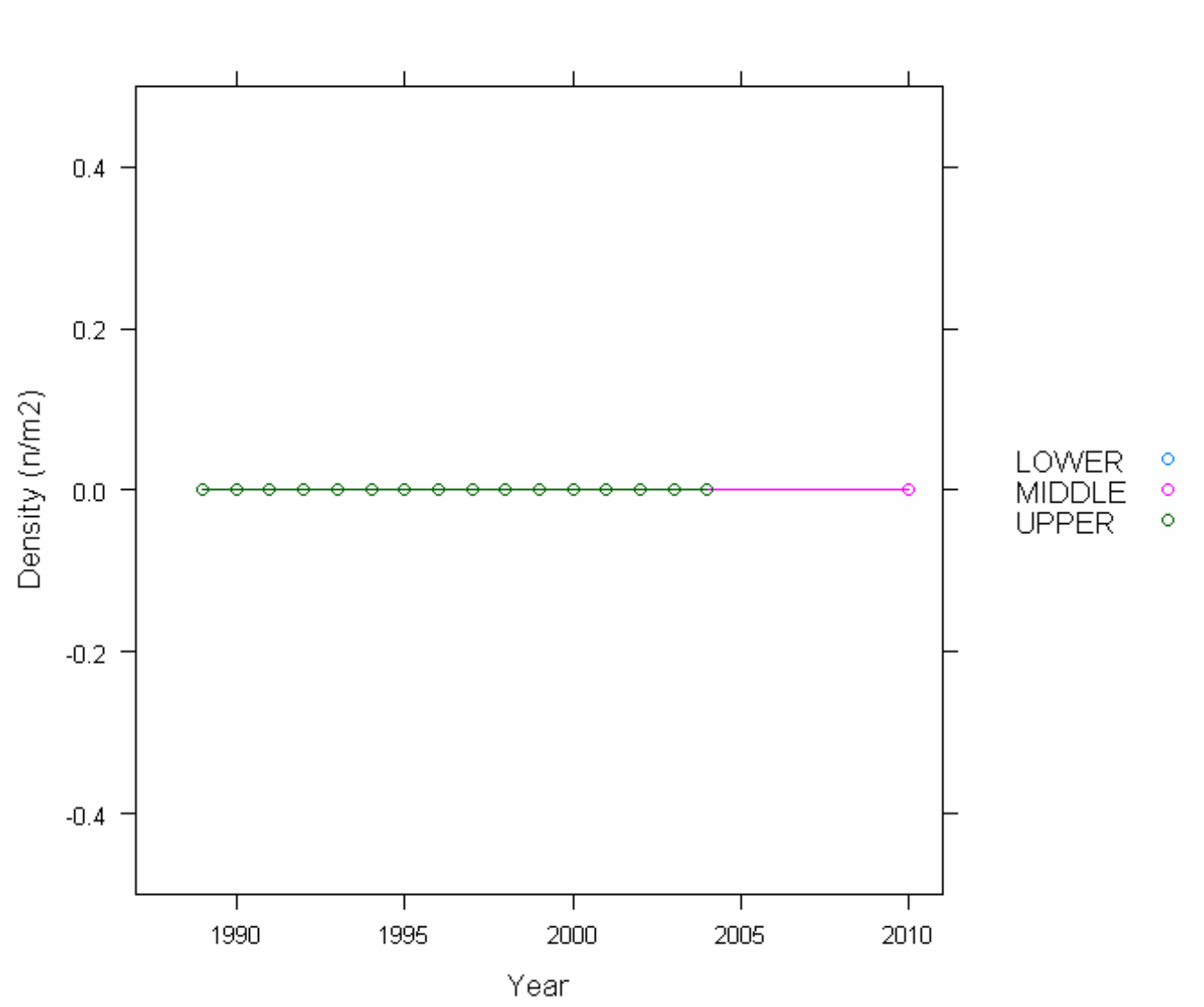
7.3.2.2 Summary statistics, Loch Grannoch



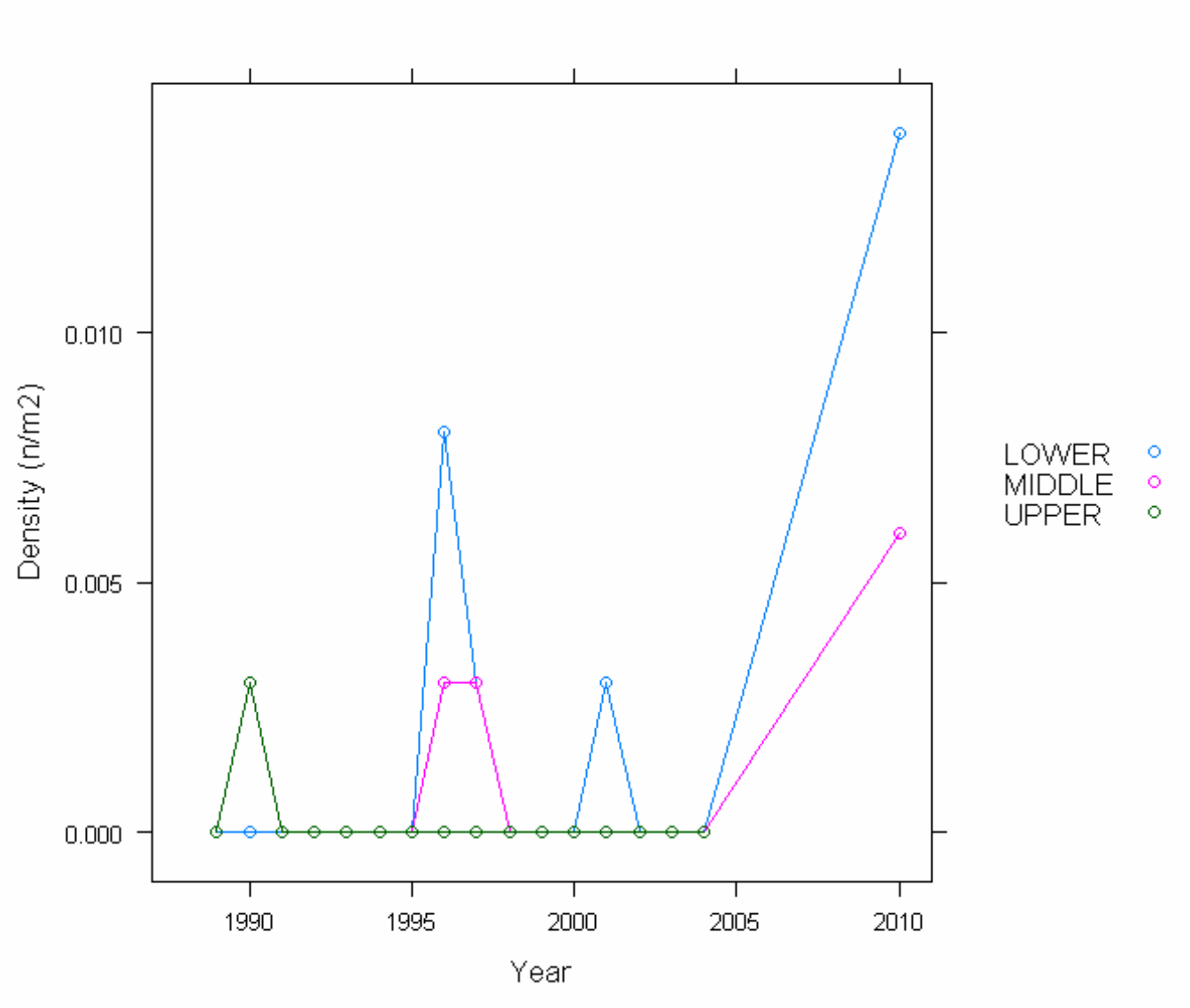
No sampling in 2001 due to Foot and Mouth restrictions.

7.3.3 Fish data (for outflow stream)

7.3.3.1 Summary of Trout fry densities (numbers m^{-2}), Loch Grannoch

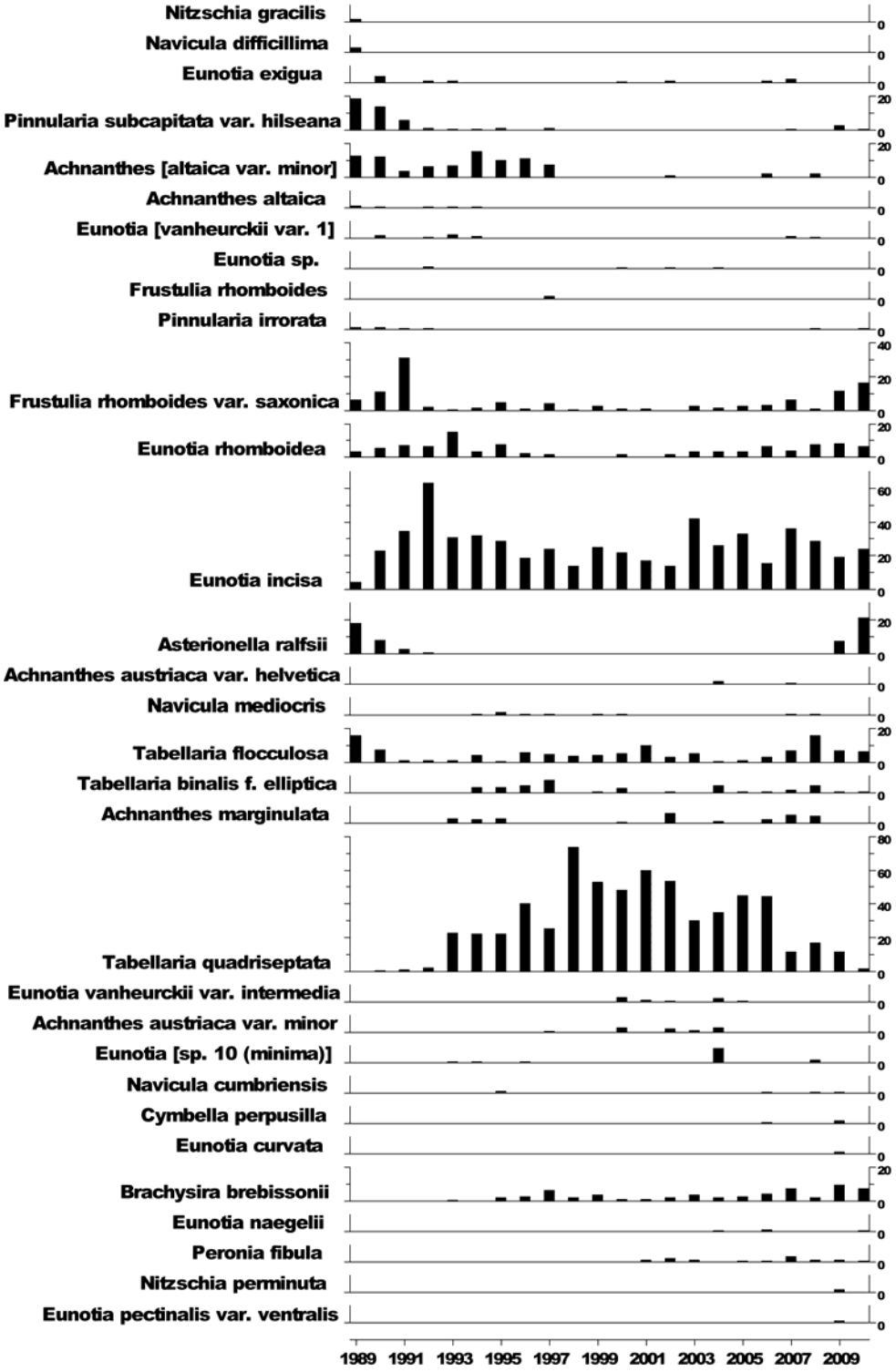


7.3.3.2 Summary of Trout parr densities (numbers m^{-2}), Loch Grannoch

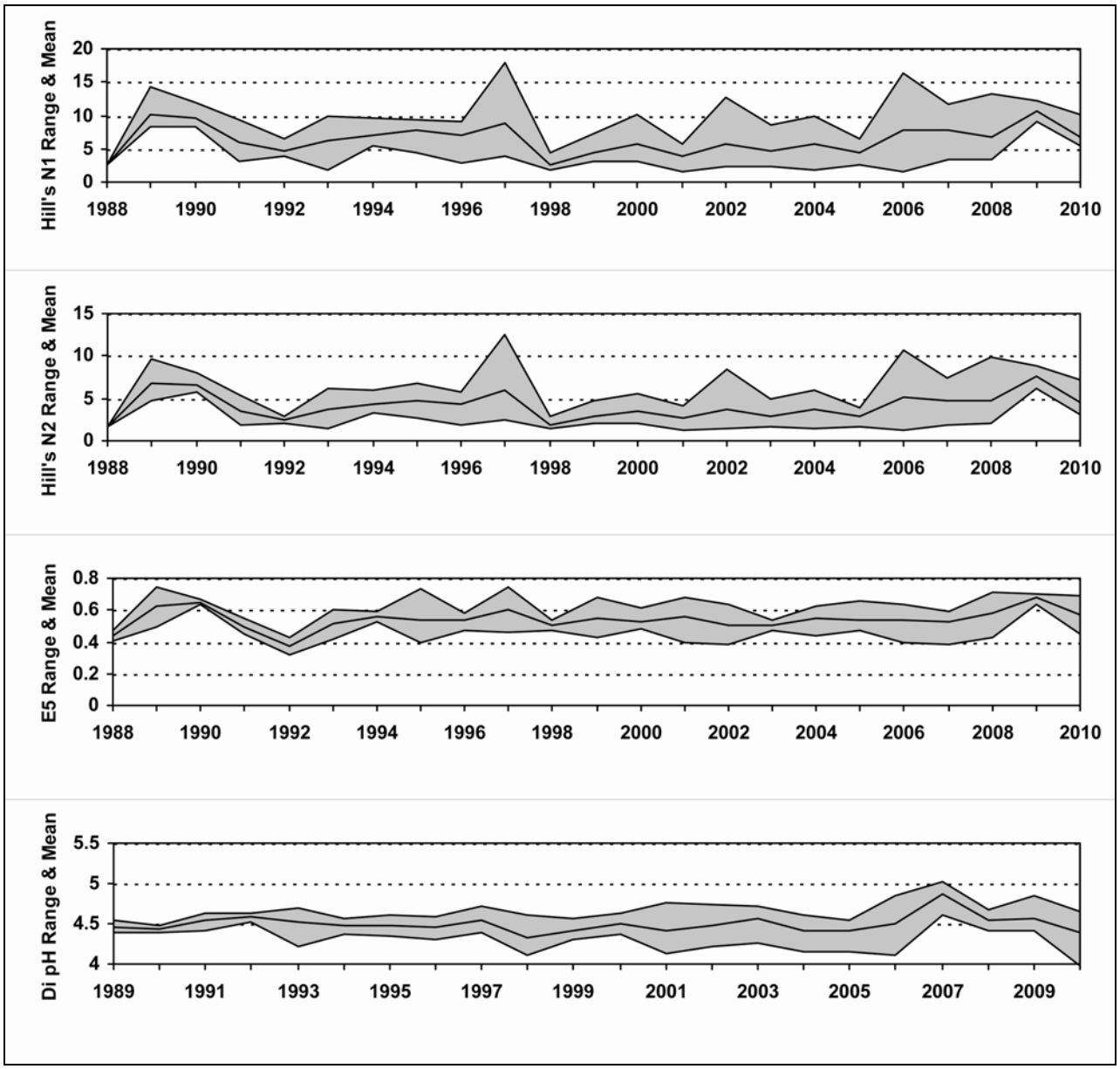


7.3.4 Epilithic diatom data

7.3.4.1 Percentage abundance summary, Loch Grannoch

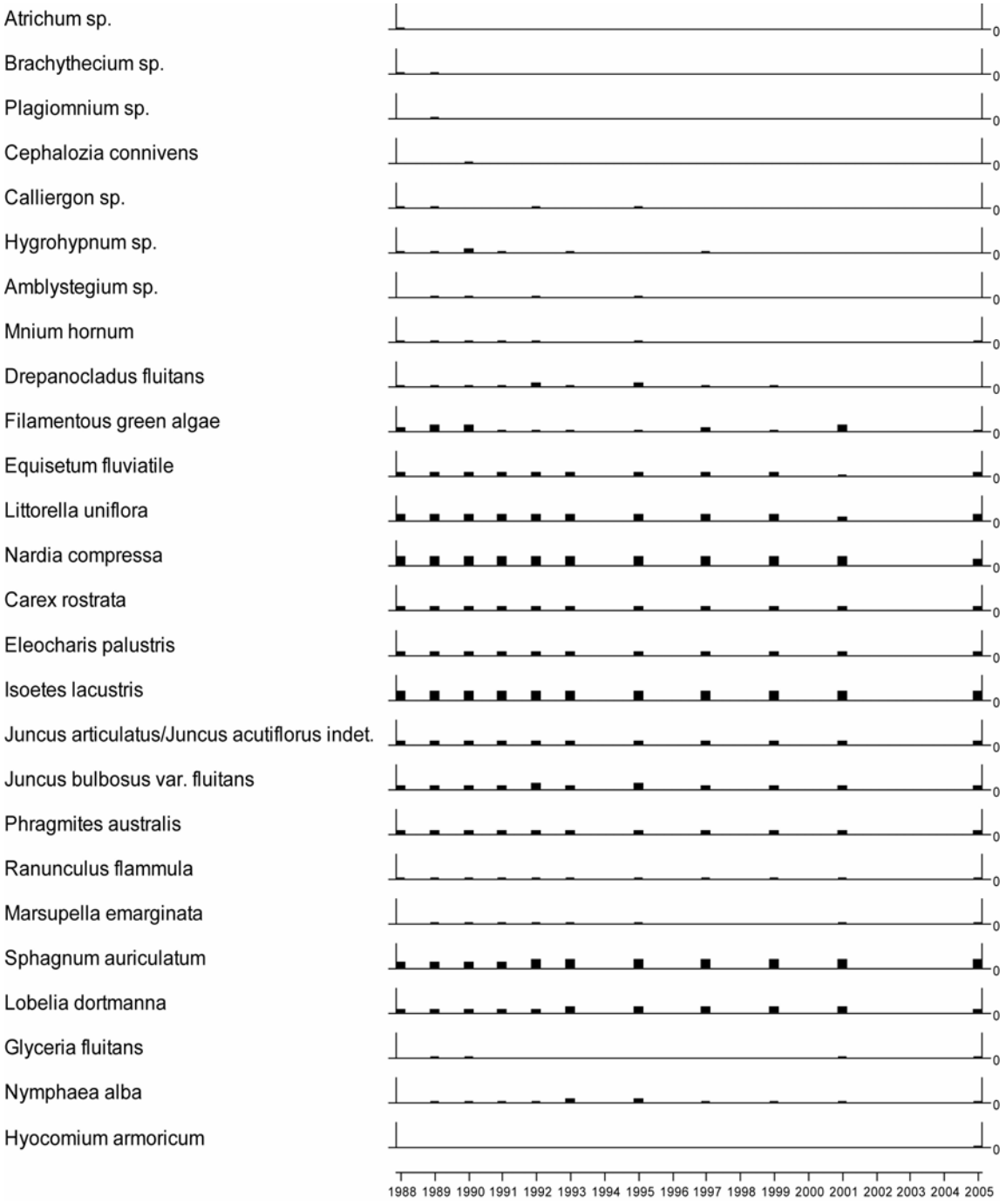


7.3.4.2 Summary statistics, Loch Grannoch



7.3.5 Aquatic macrophyte data, Loch Grannoch

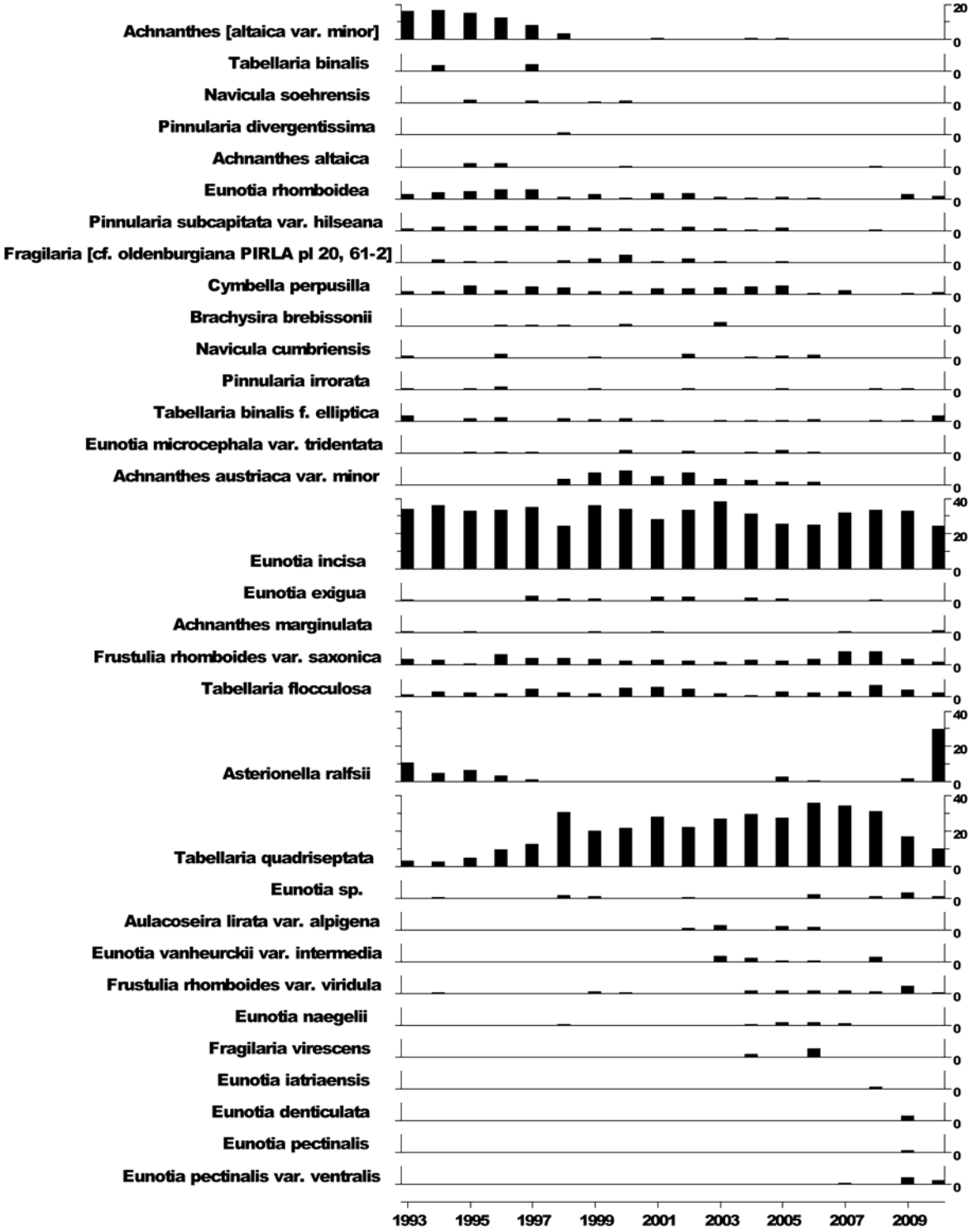
Species Scores (1-5)



No aquatic macrophyte survey in 2003.
No surveys since 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