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 10 - March 11

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

2011

UK ACID WATERS MONITORING NETWORK (UKAWMN)

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ANNUAL SUMMARY PROGRESS REPORT TO FOREST RESEARCH. April 2010 - March 2011.

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

2011

[1] ENSIS Ltd, ECRC, UCL
[2] CEH Lancaster
[3] Marine Scotland, Pitlochry

Cover Photo: Loch Chon © Ewan Shilland

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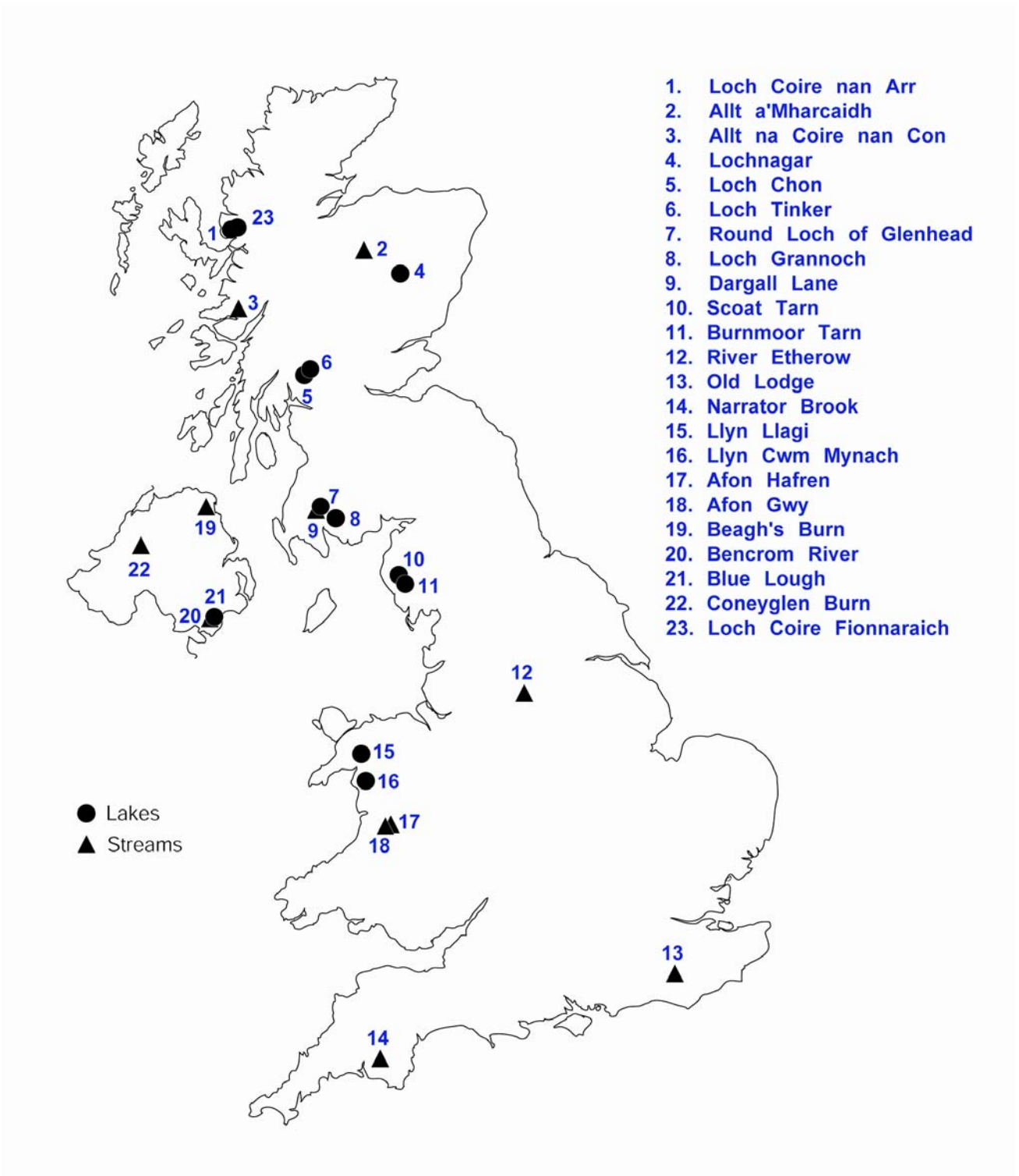
2 INTRODUCTION

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 2010-2011 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 Centre for Ecology and Hydrology 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 2010-11 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 2010.

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 2009-2010

4.1 Summary Overview

During the period from April 2010 to March 2011 chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at Loch Chon and Loch Grannoch. At Allt na Coire nan Con spate conditions prevented an aquatic macrophyte survey being performed during the site visit on 8th of July 2010.

4.2 Water Chemistry

Samples were collected from the two lochs in early June, September and December 2010 and March 2011 by Marine Scotland Pitlochry. Monthly dip samples were collected from Allt na Coire nan Con by a local Forestry Commission operative, Pete Madden. They 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 2010 at Loch Chon and the 9th of August 2010 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 25th of July 2010 at Loch Chon and the 9th of August 2010 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 25th of July 2010 and at four sampling points around Loch Grannoch on the 9th of August 2010. Three samples were retrieved from Allt na Coire nan Con on the 8th of July 2010. The samples were made into slides and have been analysed by Dr R. J. Flower from UCL.

4.6 Macroinvertebrates

Aquatic macroinvertebrates were sampled at Allt na Coire nan Con by QMuL on the 5th May 2010, at Loch Chon by UCL on the 29th of April 2010 and at Loch Grannoch by UCL also on the 29th of April 2010. Five 1 minute kick samples were performed at each site. The samples from all three sites were counted at QMuL and the data sent to ENSIS Ltd. The data has been quality screened and added to the UKAWMN biological database at ENSIS.

4.7 Fish

Fish surveying was performed at Allt na Coire nan Con, Loch Chon and Loch Grannoch in autumn 2010 by Marine Scotland, Pitlochry, who have checked the data and added it to the Marine Scotland fish database.

4.8 Aquatic Macrophytes

Aquatic macrophytes were not surveyed at either of the two Loch sites in the 2010-2011 period. Allt na Coire nan Con was not surveyed on the site visit dated 8th of July 2010 due to spate conditions.

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 2009-2010 annual report has been uploaded to the new AWMN web page, 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 results from the UKAWMN was produced in 2010 and is available on the UKAWMN website.

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 (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.
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 $(N_2\text{-}1):(N_1\text{-}1)$. 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

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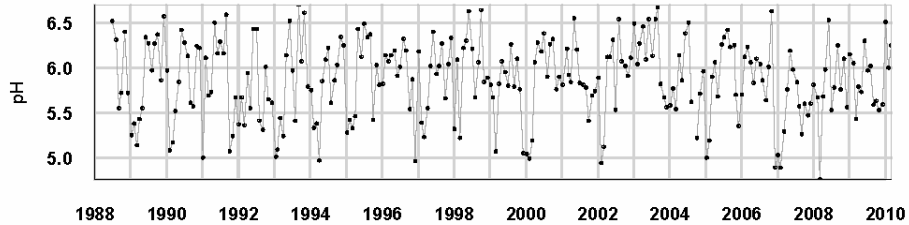
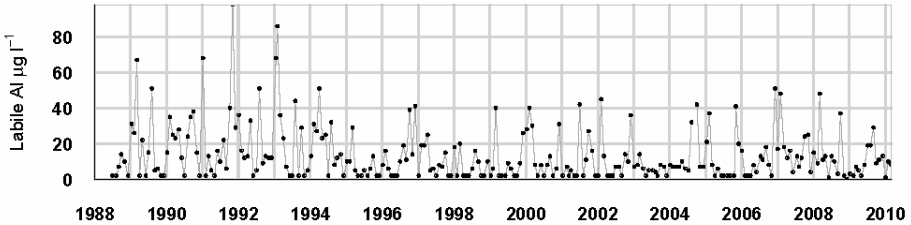
Stevenson, A. C., Juggins, S., Birks, H. J. B., Anderson, N. J., Battarbee, R. W., Berge, F., Davis, R. B., Flower, R. J., Haworth, E. Y., Jones, V. J., Kingston, J. C., Kreiser, A. M., Line, J. M., Munro, M. A. R. & Renberg, I. 1991 *The surface waters acidification project palaeolimnology programme: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

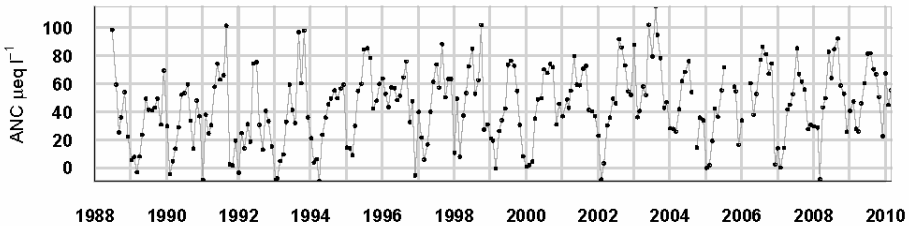
7 SITE DATA

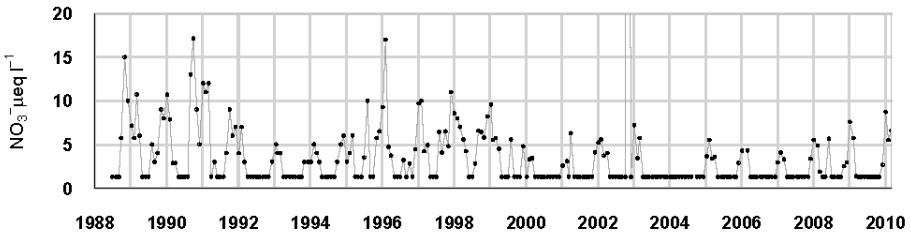
7.1 Allt na Coire nan Con

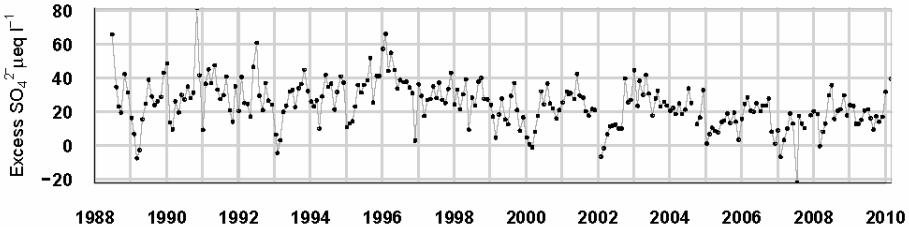
7.1.1 Spot sampled chemistry data

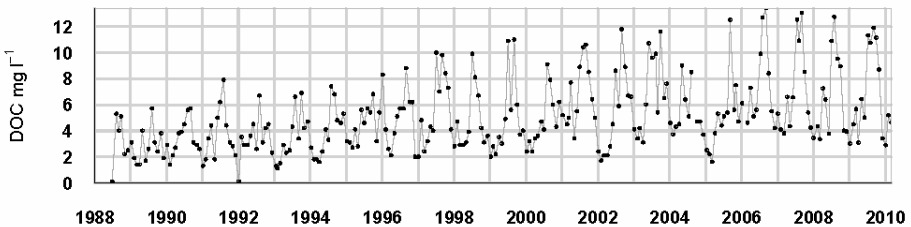


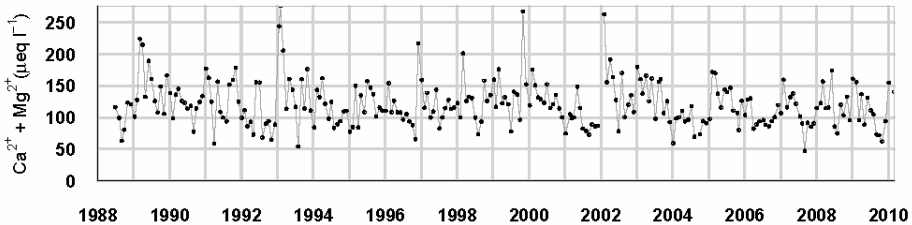


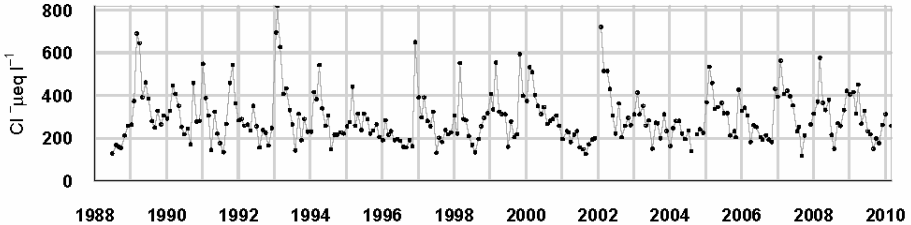








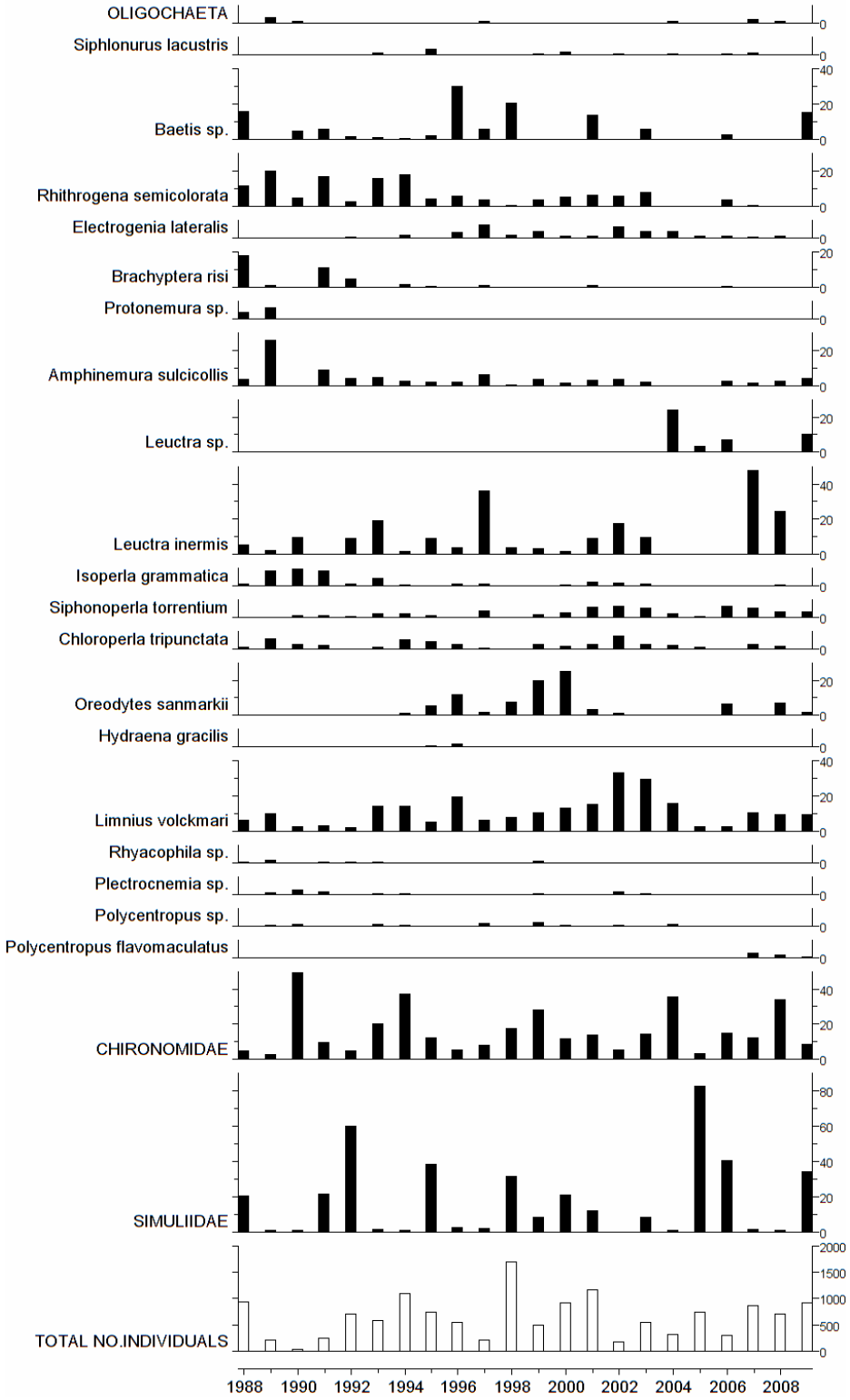




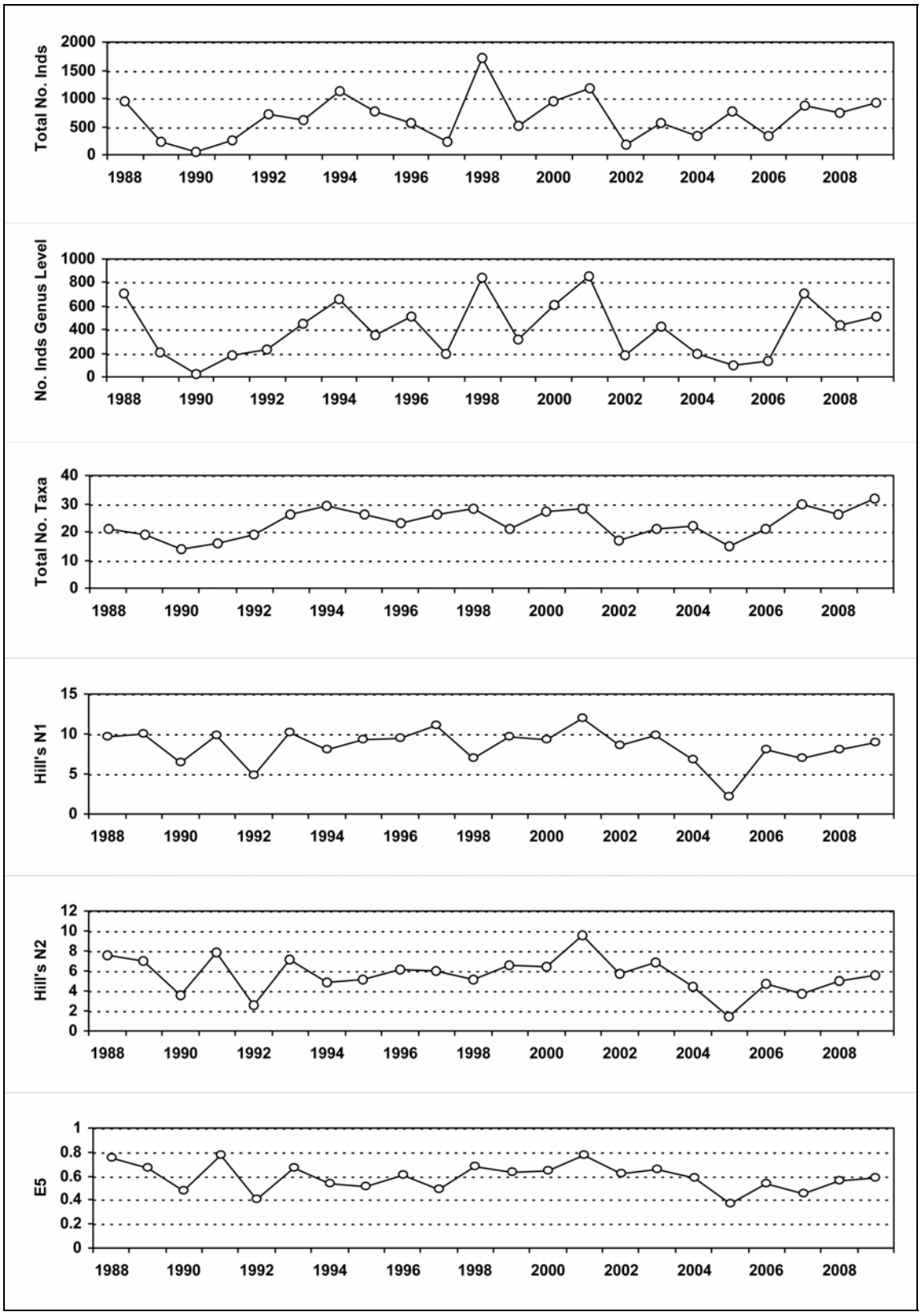
µeq l $^{-1}$, *µg l $^{-1}$, **mg l $^{-1}$	pH	ANC	Ca $^{2+}$	Mg $^{2+}$	Na $^{+}$	K $^{+}$	*Soluble Al	*Labile Al	Cl $^{-}$	*SO$_4$ $^{2-}$	xSO$_4$ $^{2-}$	NO$_3$ $^{-}$	**DOC
Mean 1st 5 yrs	5.81	32.14	58.91	70.20	274.34	9.14	64.76	21.47	325.23	62.07	27.96	4.79	3.18
08-09 mean	5.90	55.73	52.11	66.69	276.88	8.60	64.00	8.50	319.95	54.52	20.98	2.51	6.72
08-09 std dev	0.33	21.69	15.88	16.10	50.01	2.16	35.11	10.17	84.84	11.63	8.11	2.47	3.17

7.1.2 Macroinvertebrate data

7.1.2.1 Percentage abundance summary, Allt na Coire nan Con

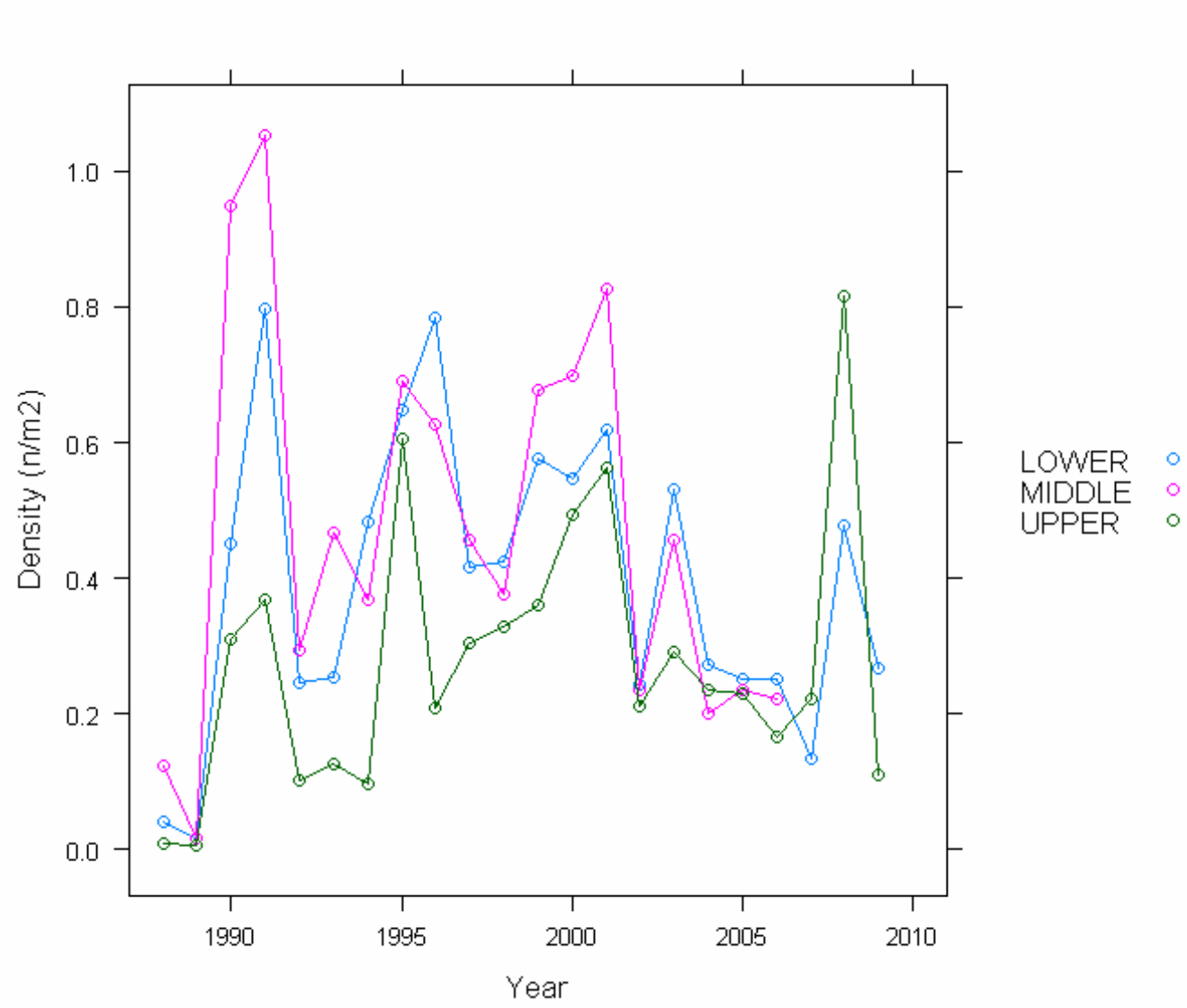


7.1.2.2 Summary statistics, Allt na Coire nan Con



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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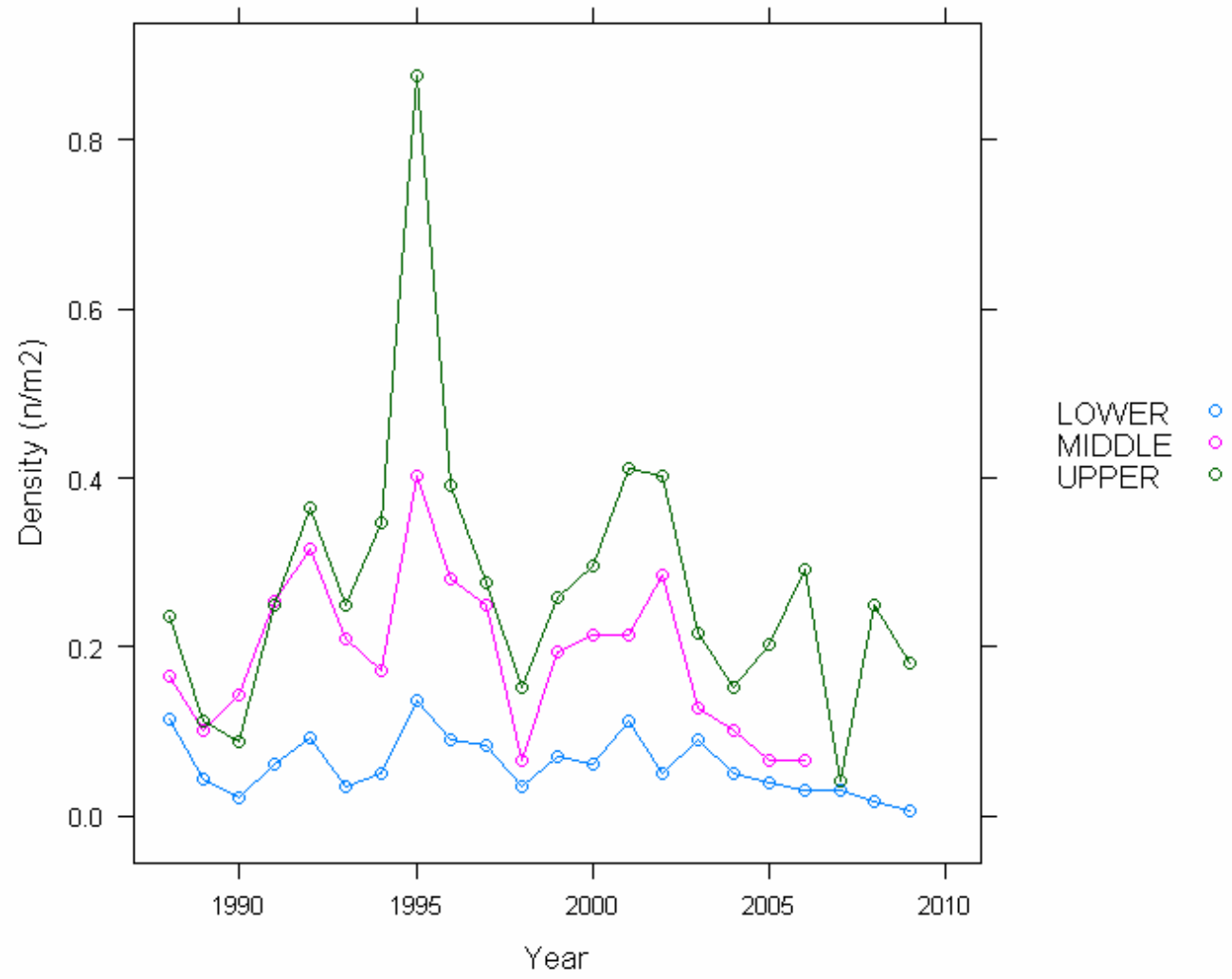
Pink series = Reach 2
Green series = Reach 3

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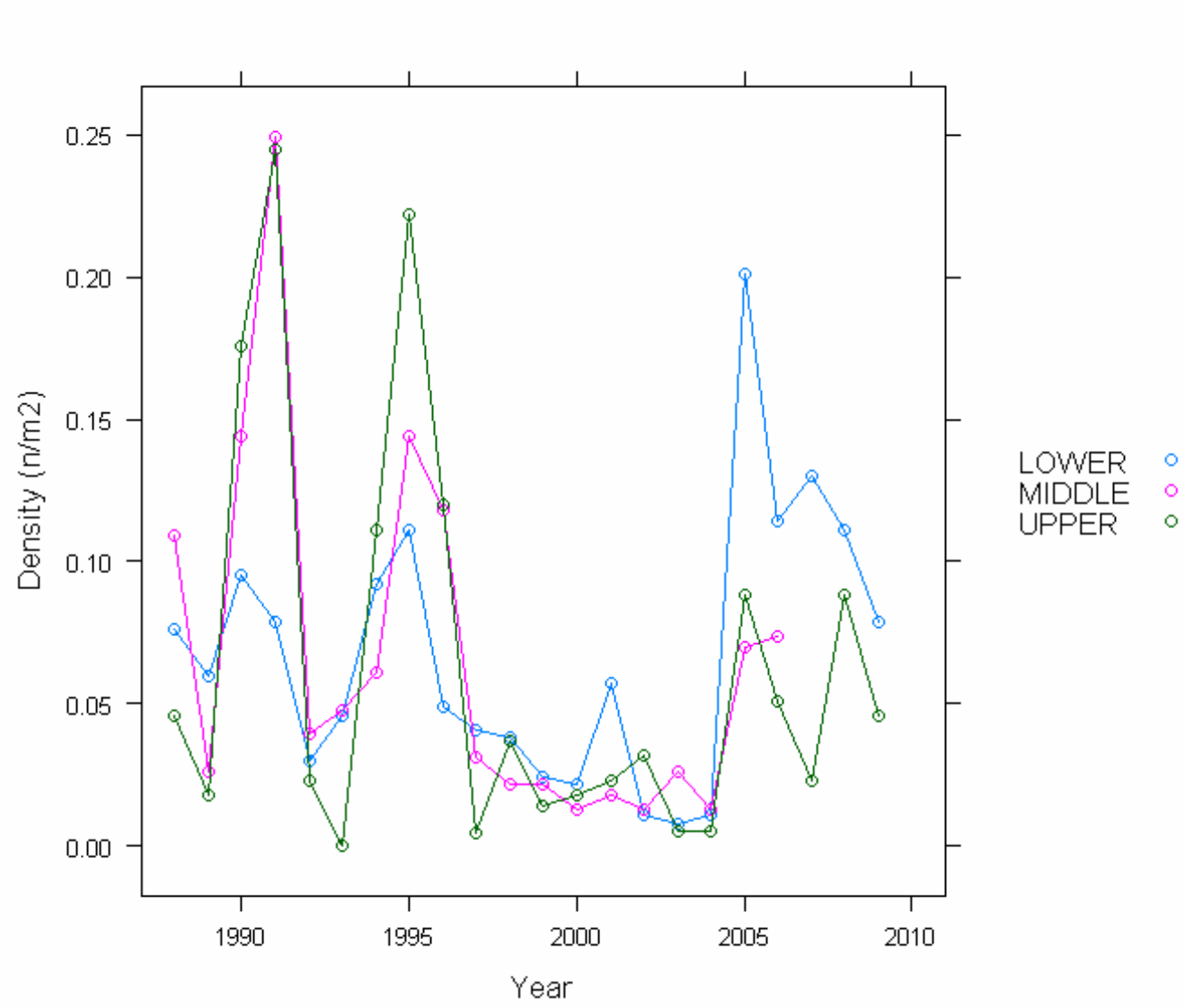
7.1.3.3 Summary of Trout fry densities (numbers m^{-2}), Allt na Coire nan Con



Blue series = Reach 1
Pink series = Reach 2
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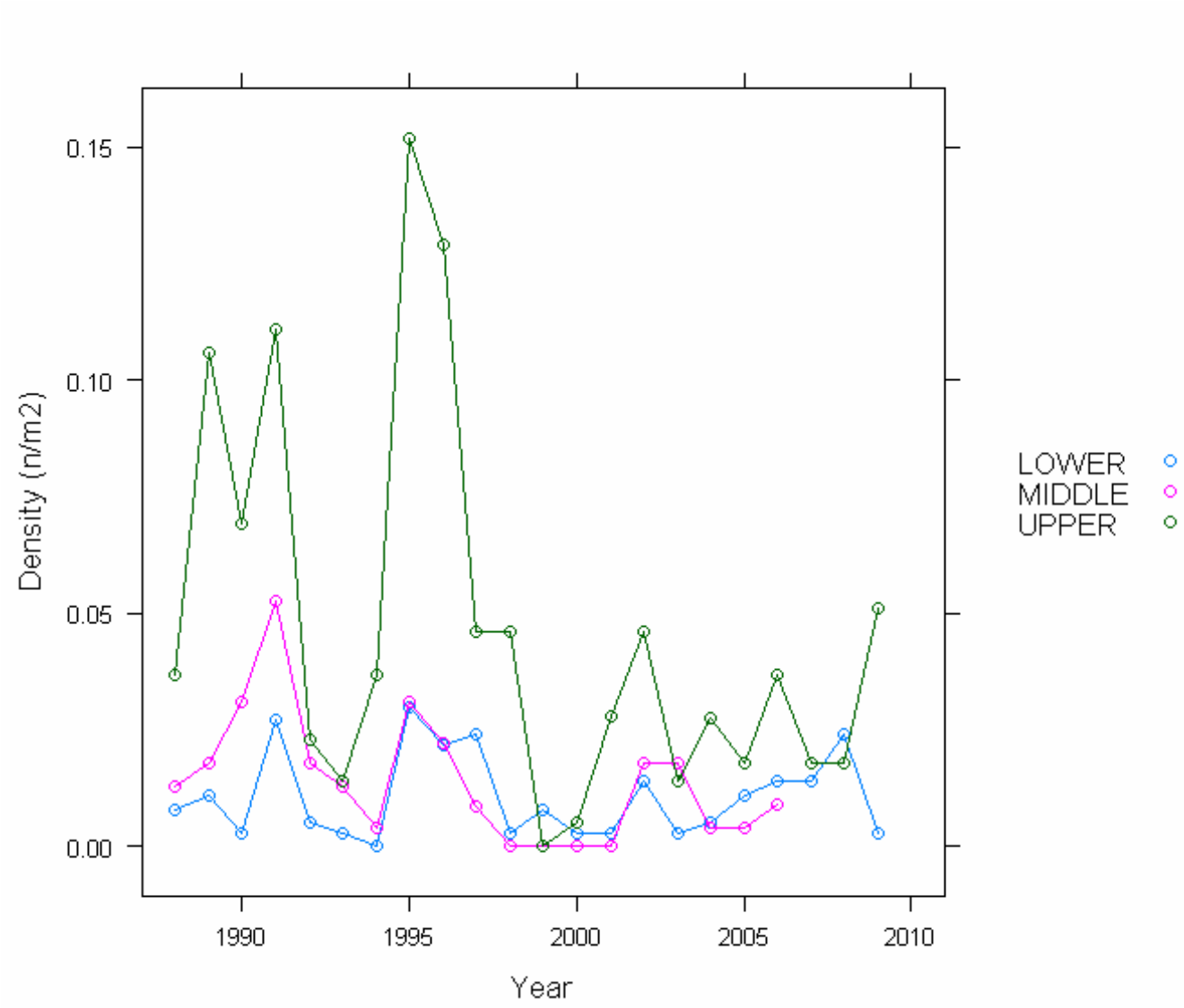
7.1.3.4 Summary of Trout parr densities (numbers m^{-2}), Allt na Coire nan Con



Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

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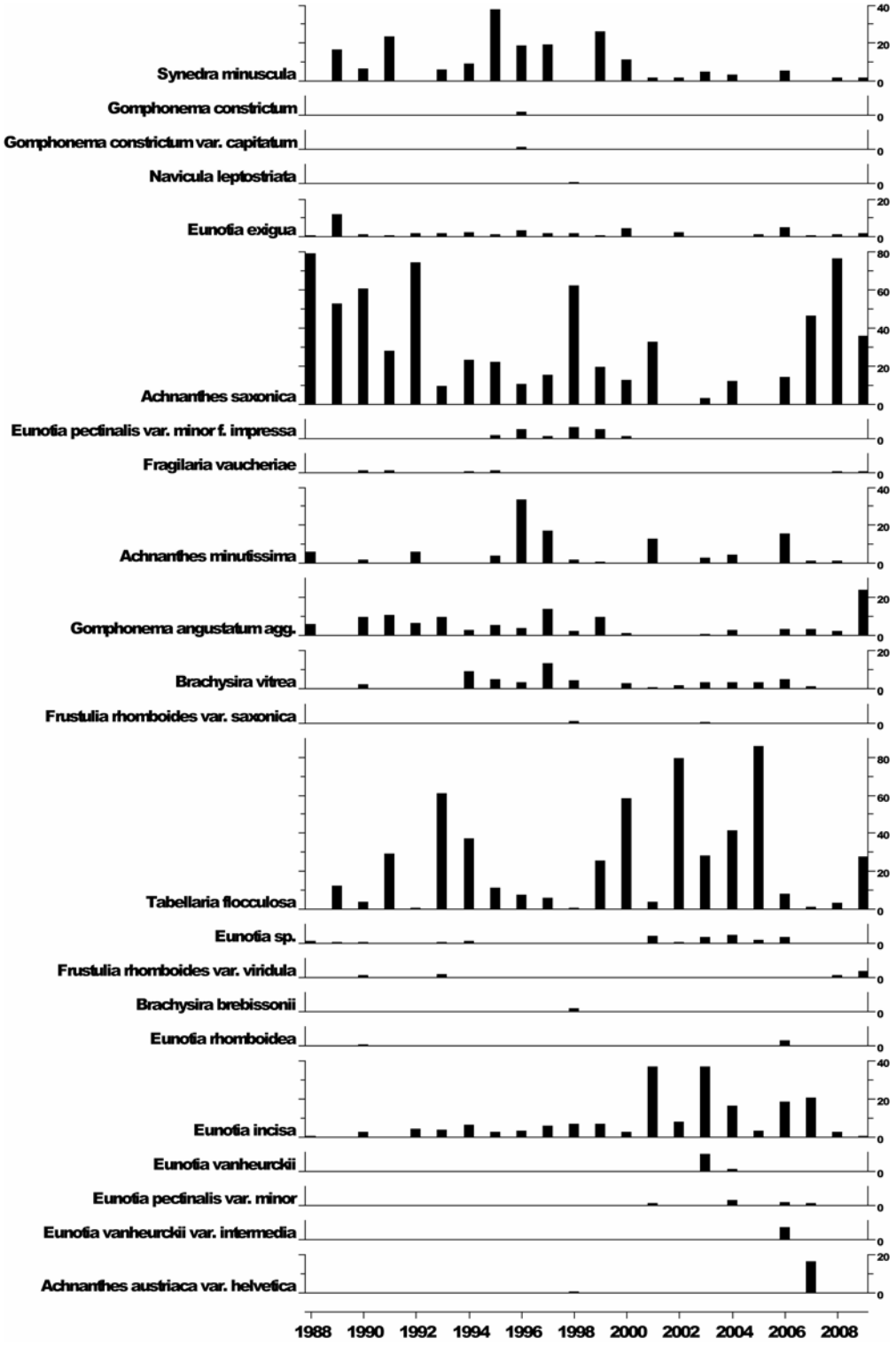
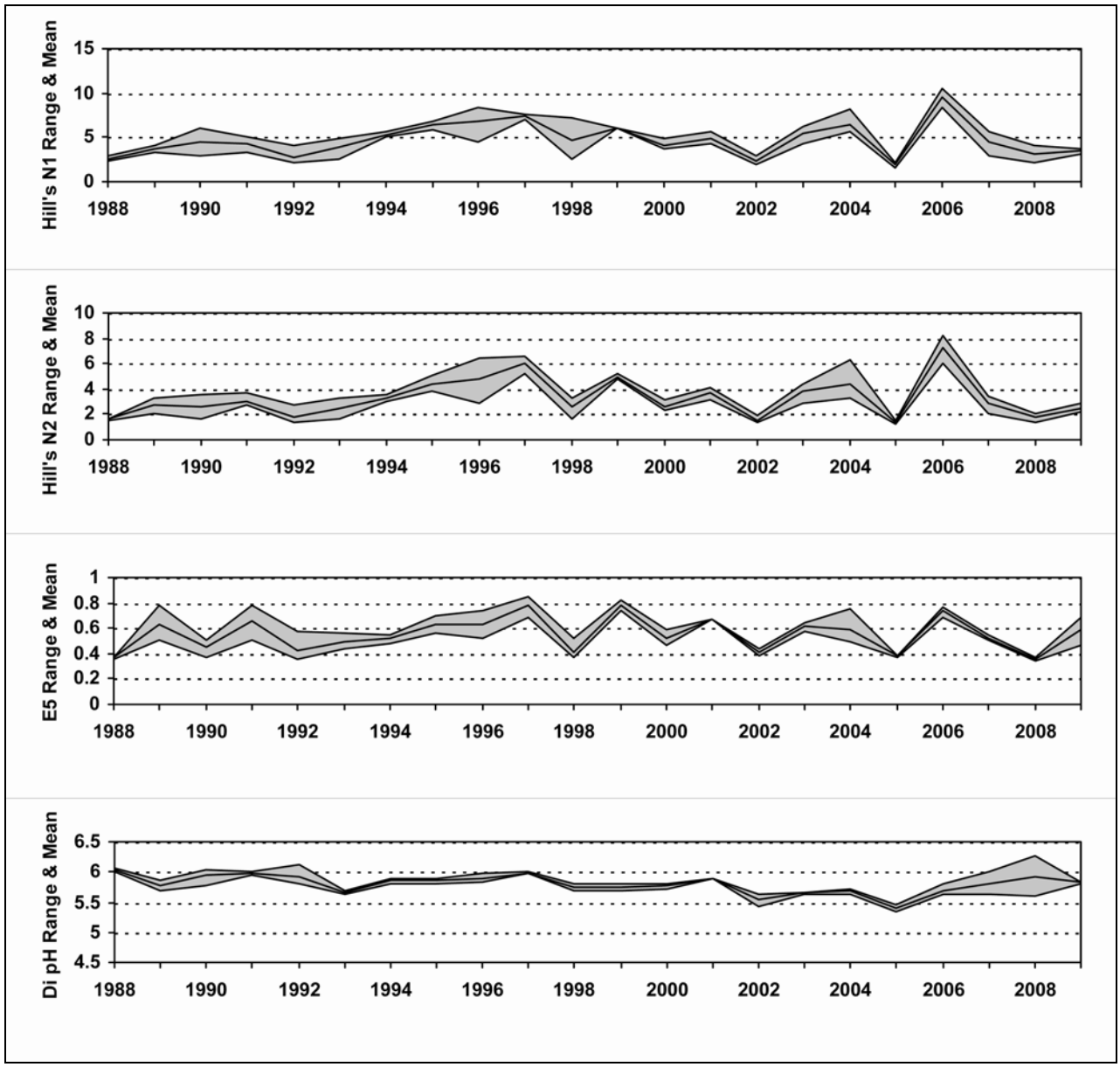
7.1.4 Epilithic diatom data

7.1.4.1 Percentage abundance summary, Allt na Coire nan Con

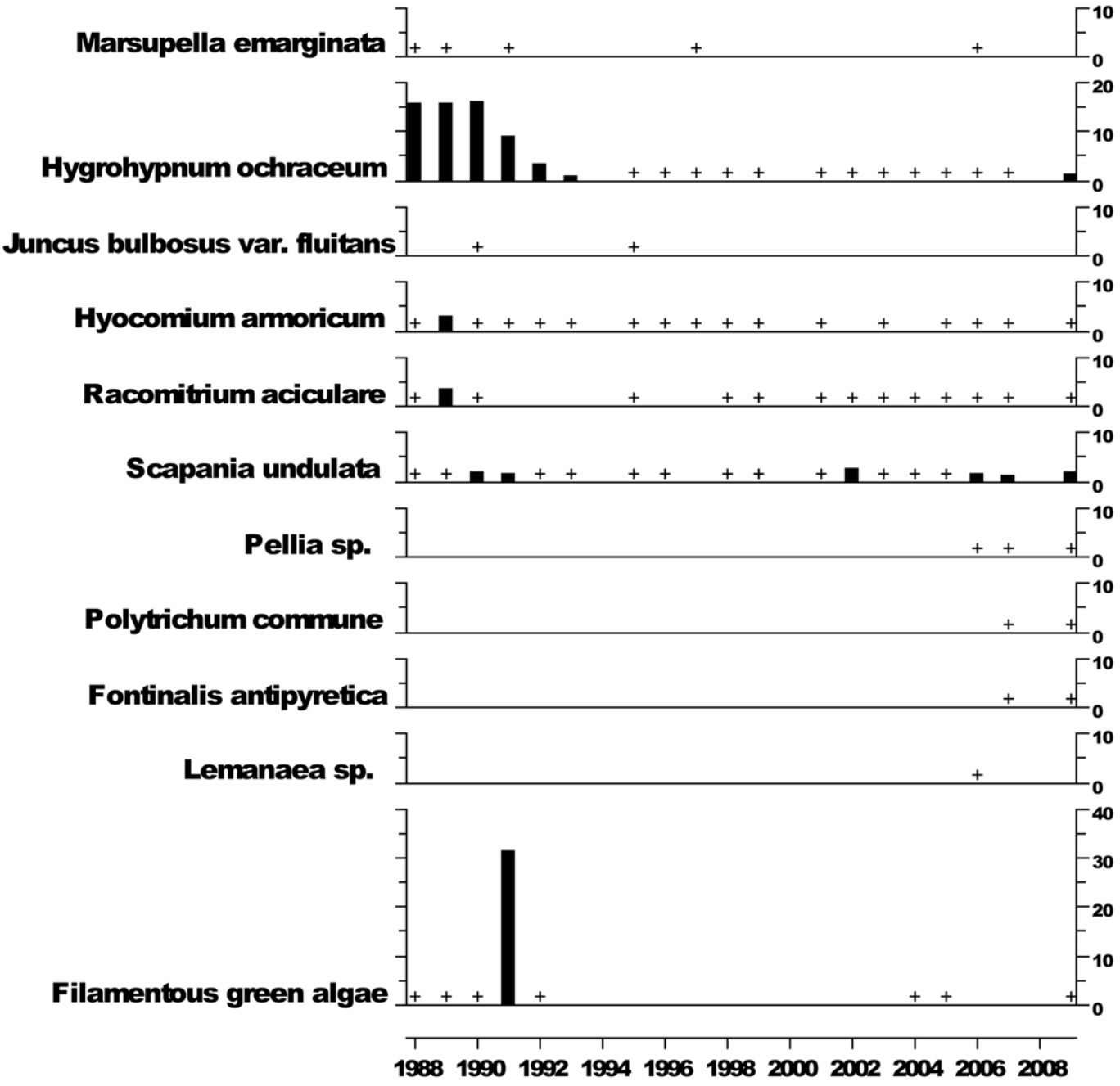


7.1.4.2 Summary statistics, Allt na Coire nan Con



7.1.5 Aquatic macrophyte data, Allt na Coire nan Con

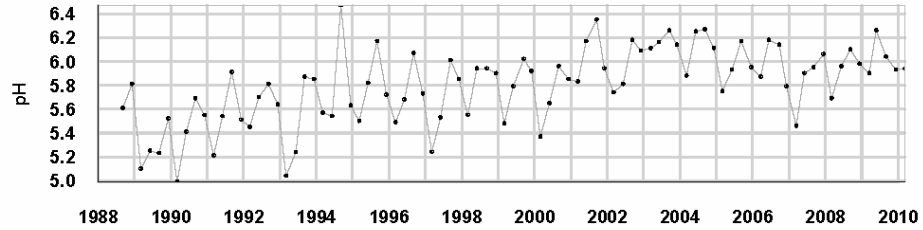
Percentage Species Cover

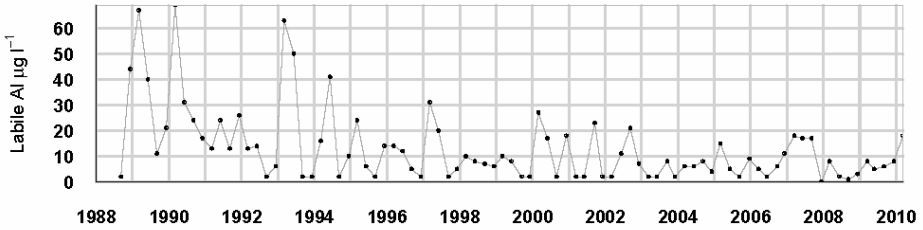


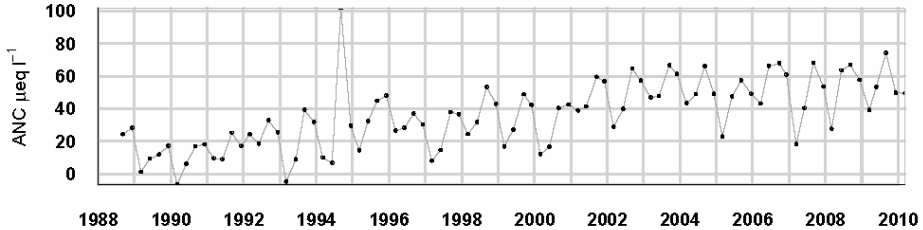
\+ Represents <0.5% abundance
No survey in 2008 due to spate conditions

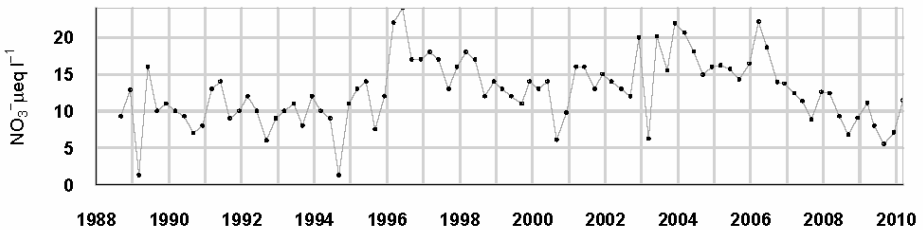
7.2 Loch Chon

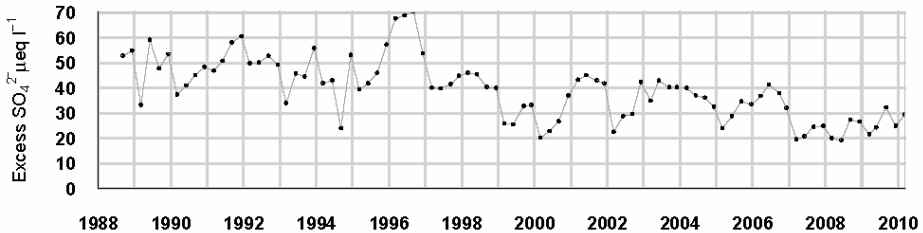
7.2.1 Spot sampled chemistry data

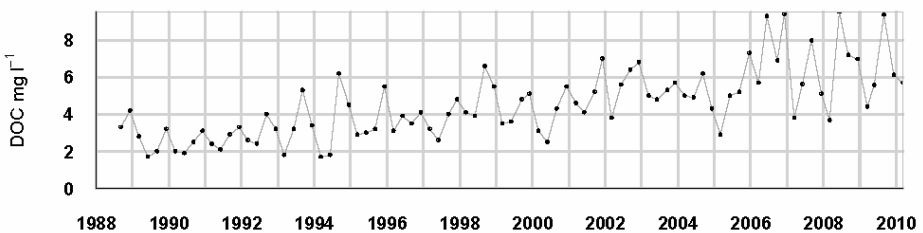


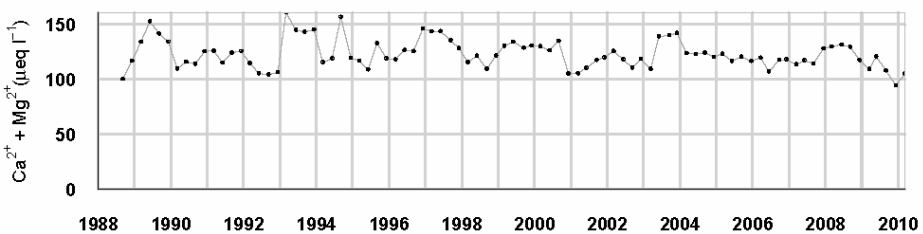


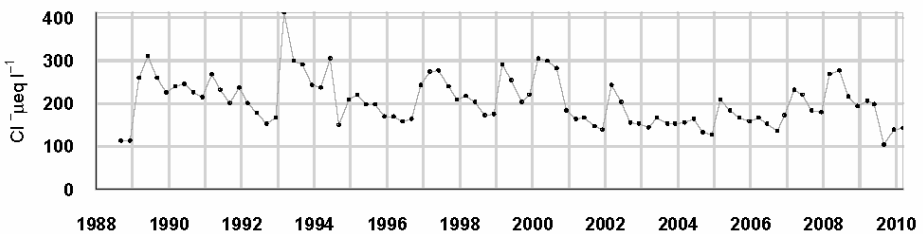








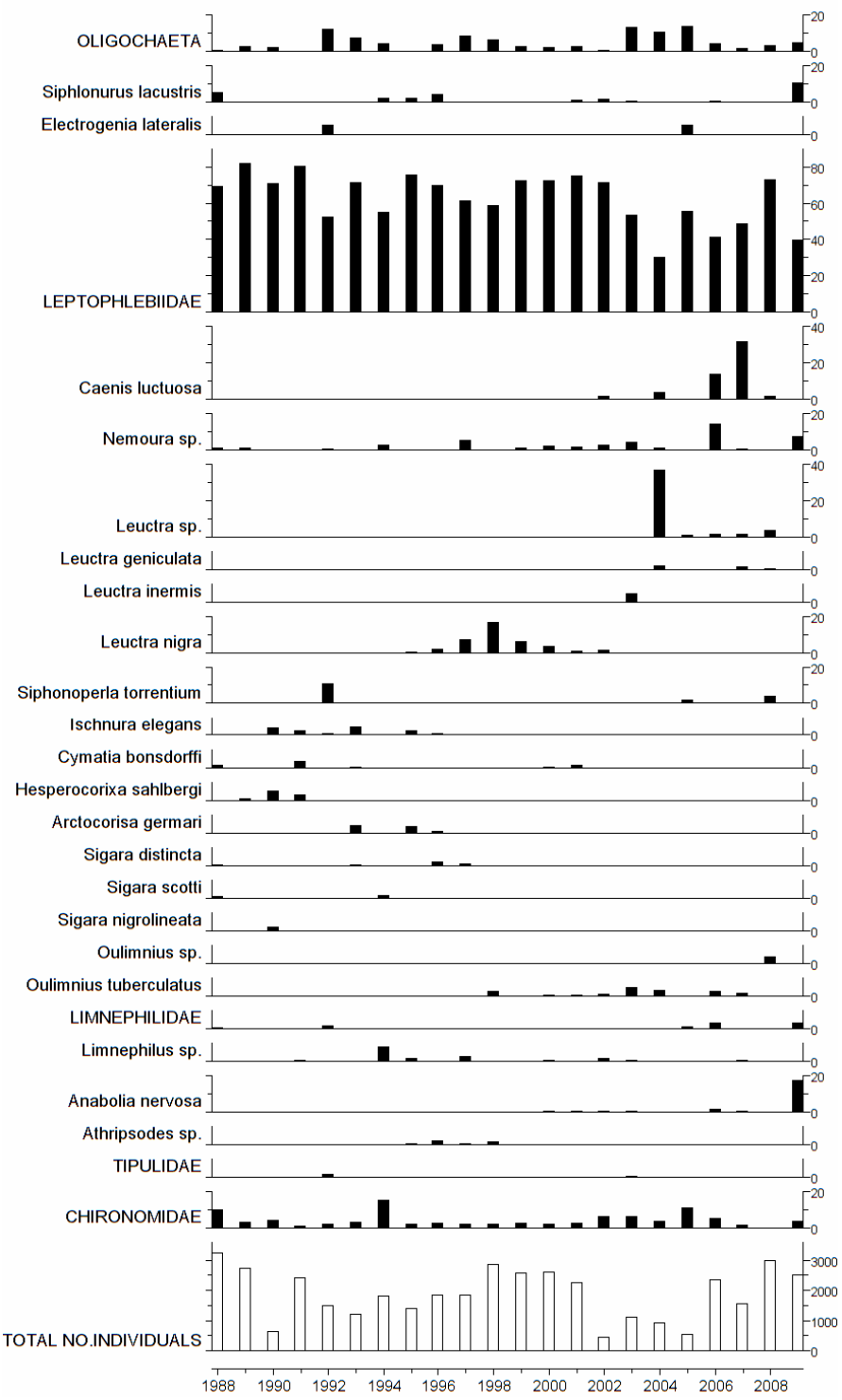




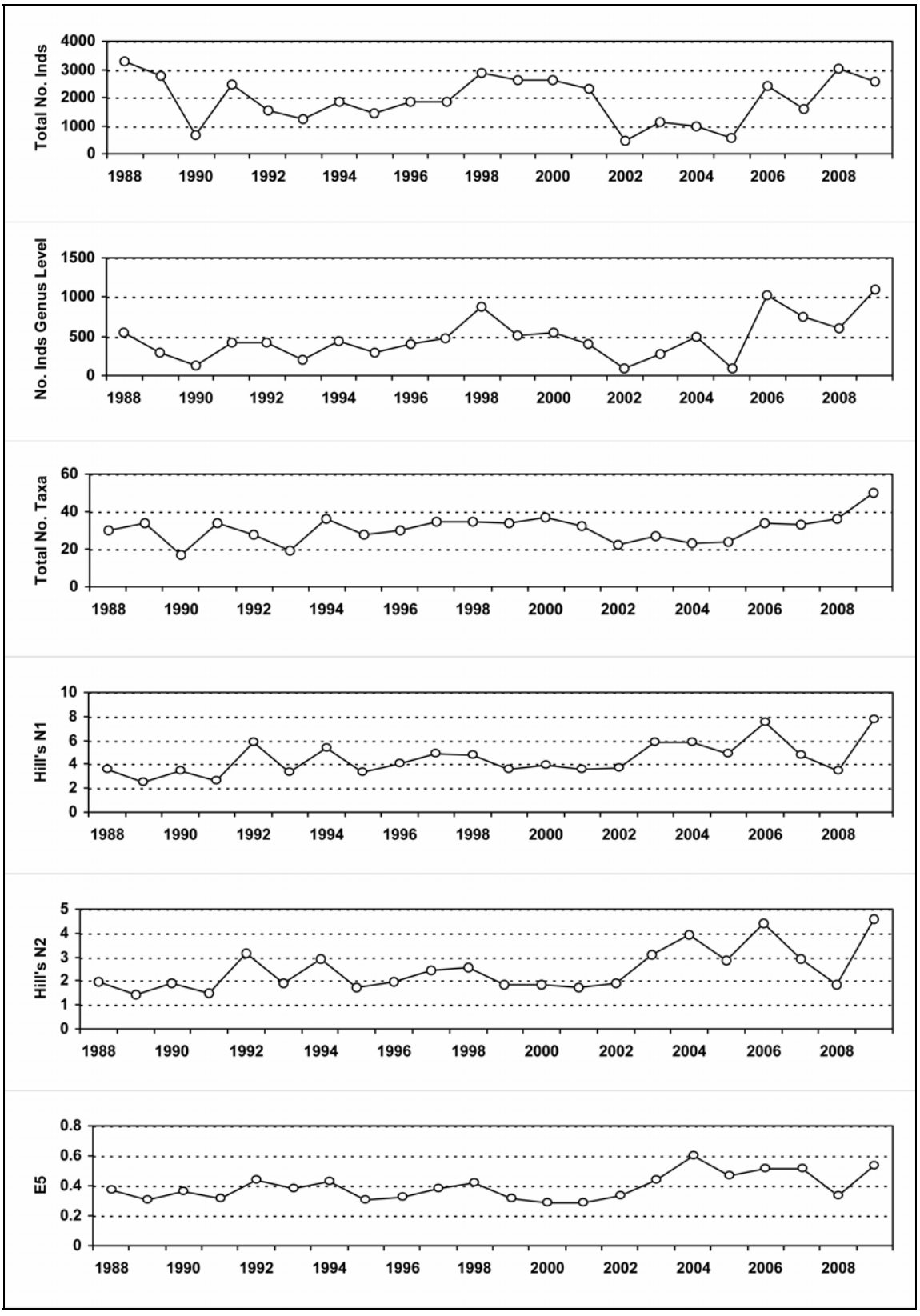
µeq l $^{-1}$, *µg l $^{-1}$, **mg l $^{-1}$	pH	ANC	Ca $^{2+}$	Mg $^{2+}$	Na $^{+}$	K $^{+}$	*Soluble Al	*Labile Al	Cl $^{-}$	*SO_4 $^{2-}$	xSO_4 $^{2-}$	NO_3 $^{-}$	**DOC
Mean 1st 5 yrs	5.46	14.54	76.17	47.42	189.44	5.79	66.65	27.50	227.51	72.38	48.53	9.94	2.73
08-09 mean	5.99	56.75	73.23	48.66	186.94	5.96	38.25	3.50	223.07	47.02	23.63	9.05	7.03
08-09 std dev	0.08	12.35	5.64	5.14	23.12	0.44	10.87	3.11	36.95	2.90	3.97	1.76	2.09

7.2.2 Macroinvertebrate data

7.2.2.1 Percentage abundance summary, Loch Chon

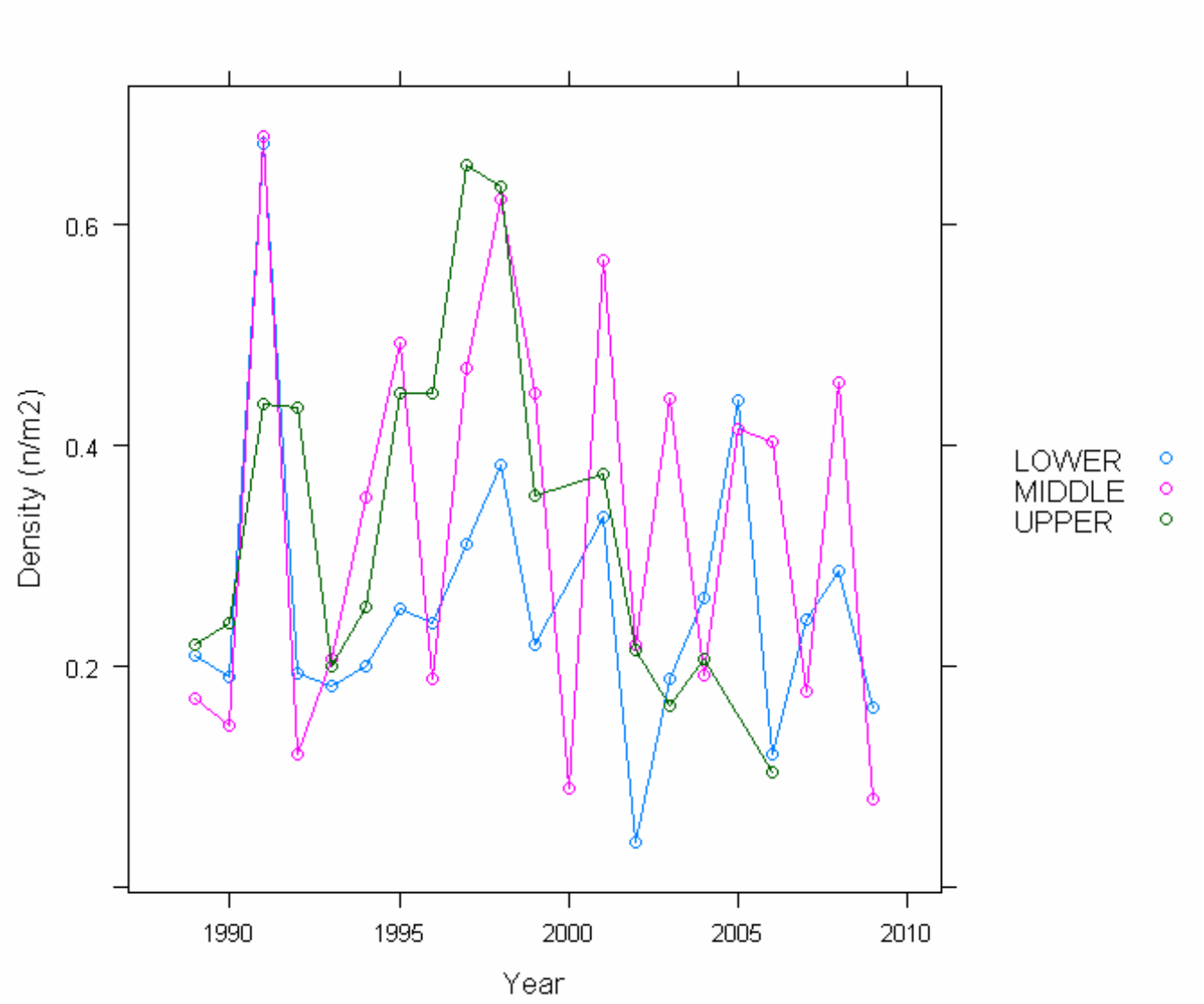


7.2.2.2 Summary statistics, Loch Chon



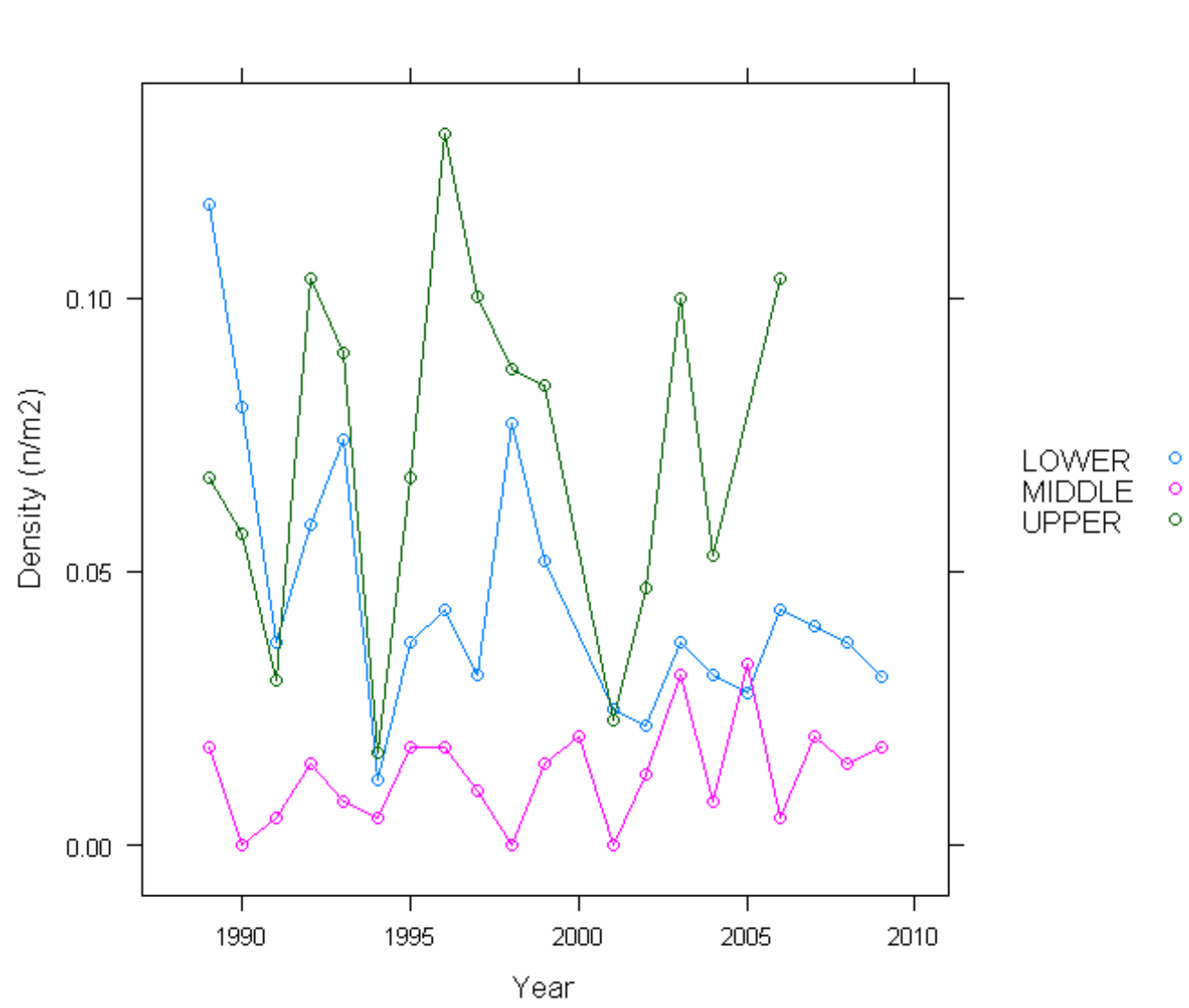
7.2.3 Fish data (for outflow stream)

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



Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

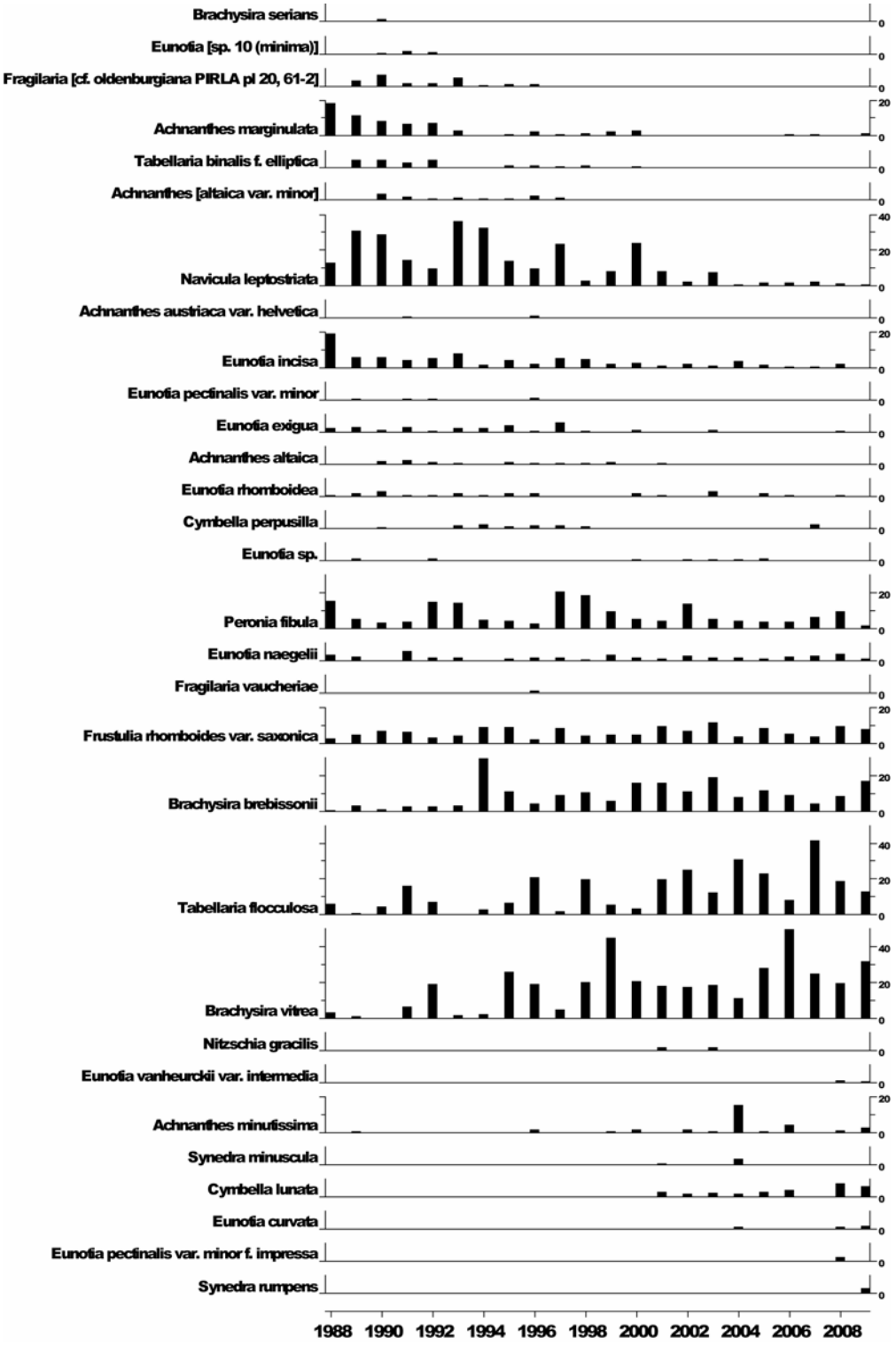
7.2.3.2 Summary of Trout parr densities (numbers m^{-2}), Loch Chon



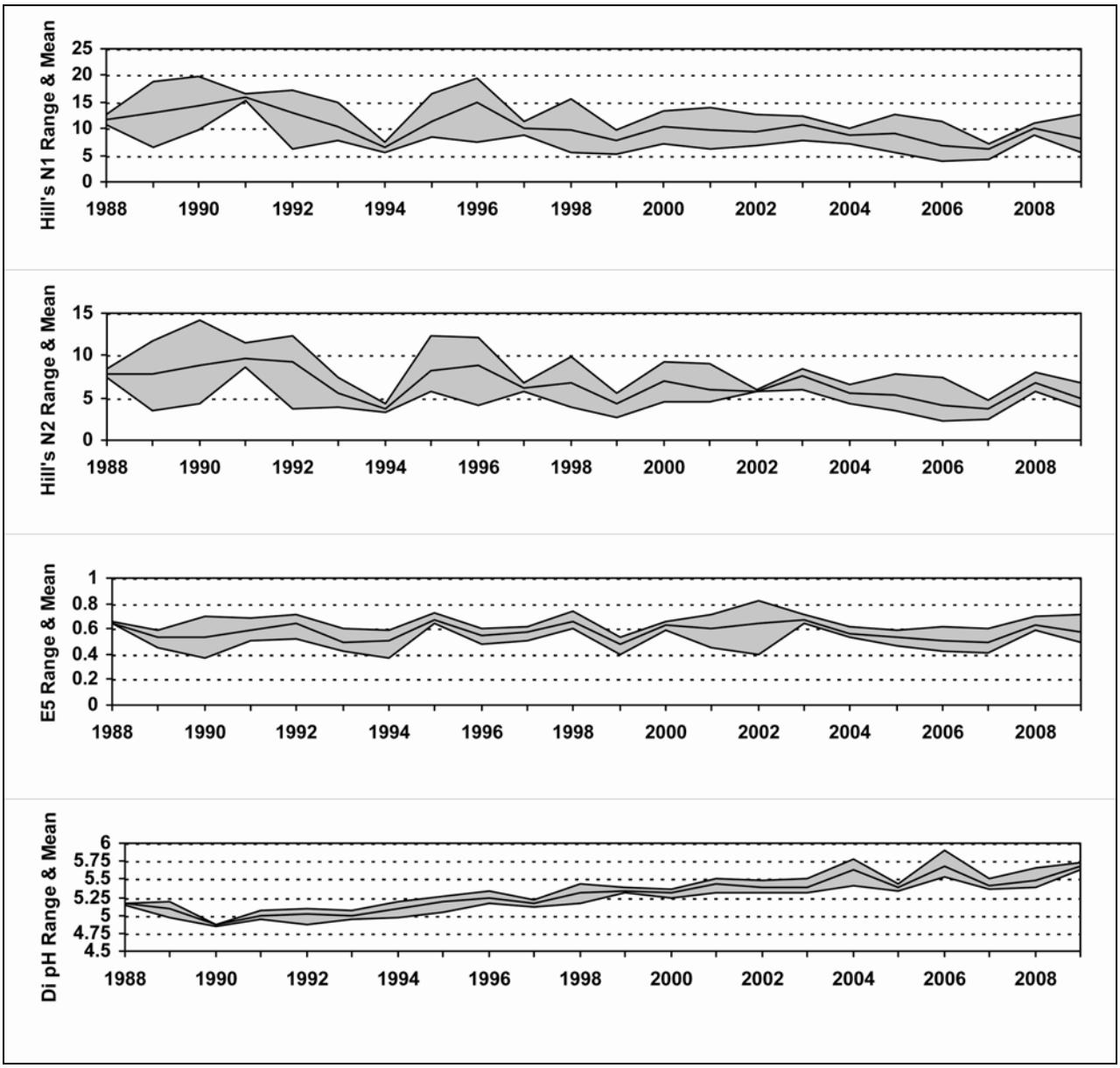
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

7.2.4 Epilithic diatom data

7.2.4.1 Percentage abundance summary, Loch Chon

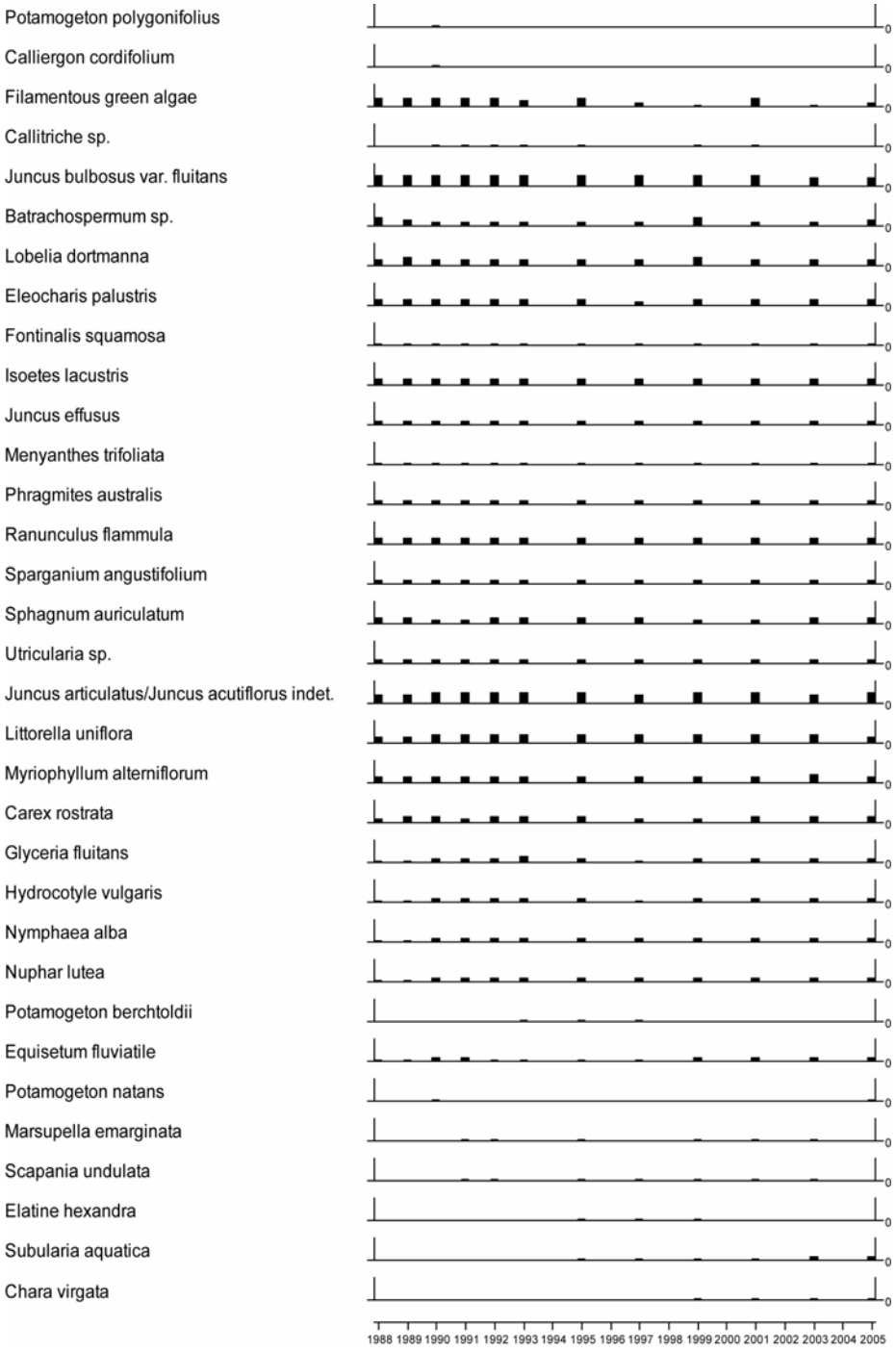


7.2.4.2 Summary statistics, Loch Chon



7.2.5 Aquatic macrophyte data, Loch Chon

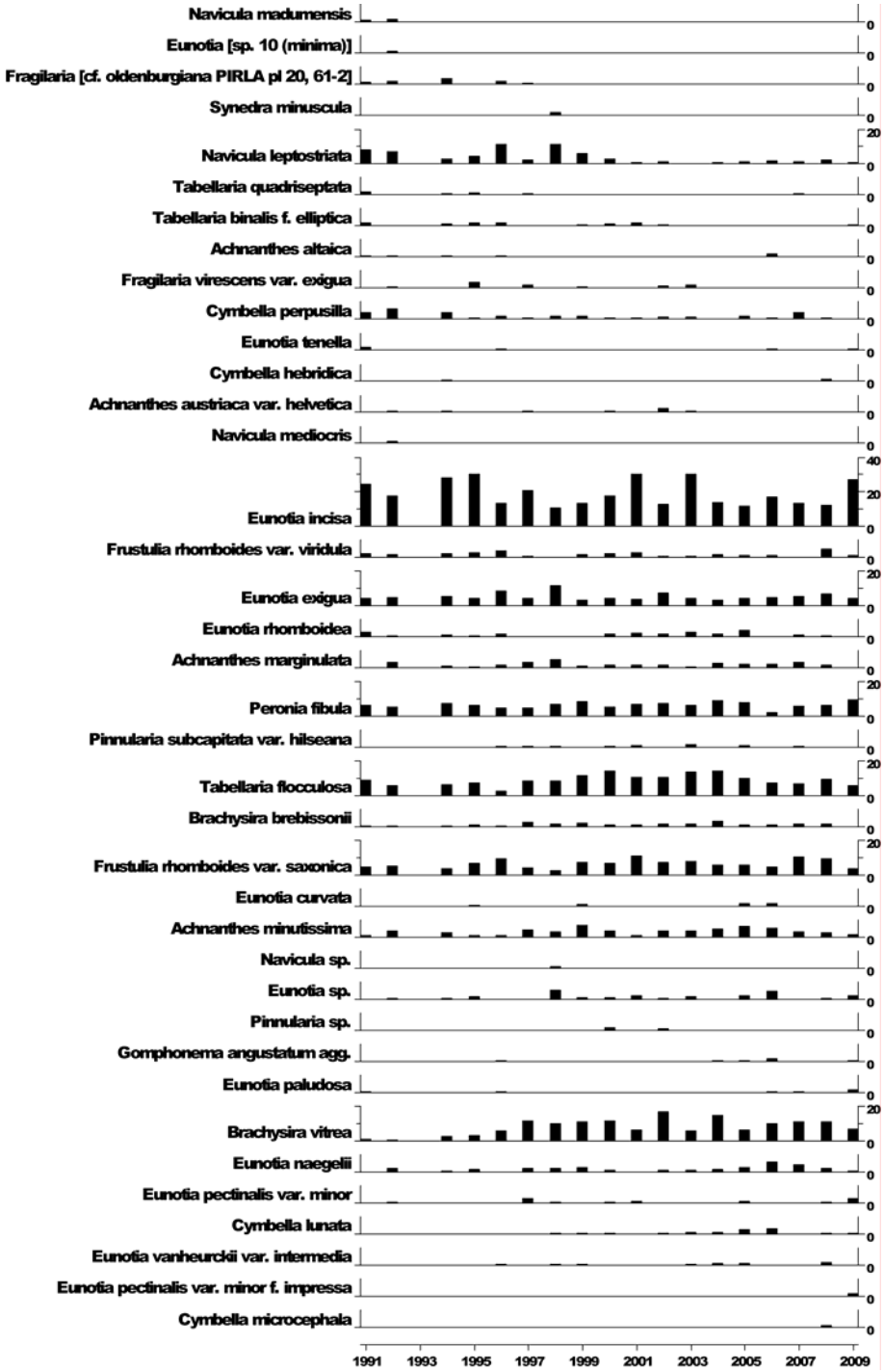
Species Scores (1-5)



No surveys since 2007 due to funding cuts

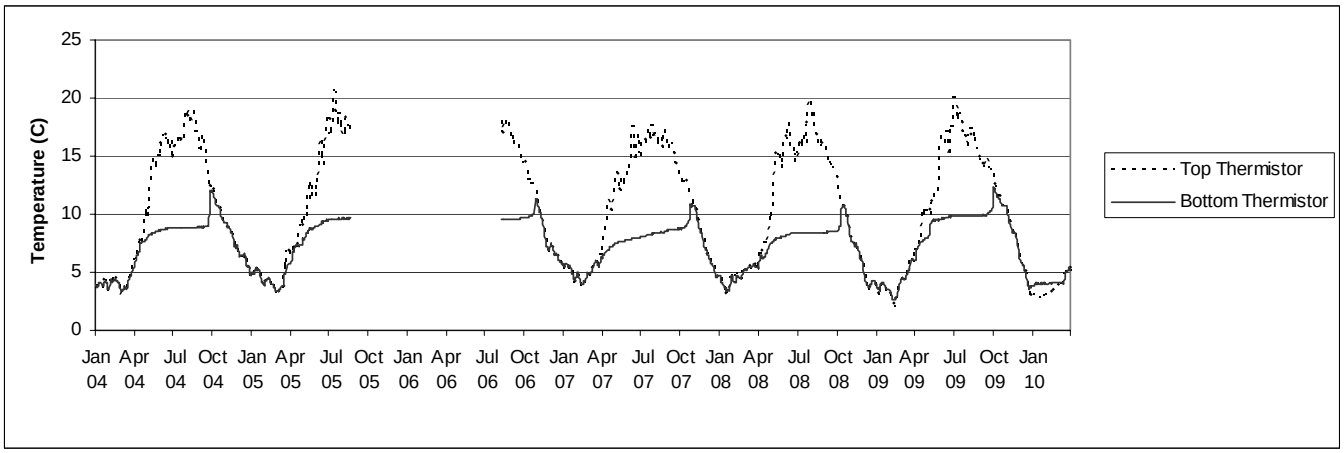
7.2.6 Sediment trap data, Loch Chon

Relative percentage frequency of diatom taxa



Traps not recovered in 1993

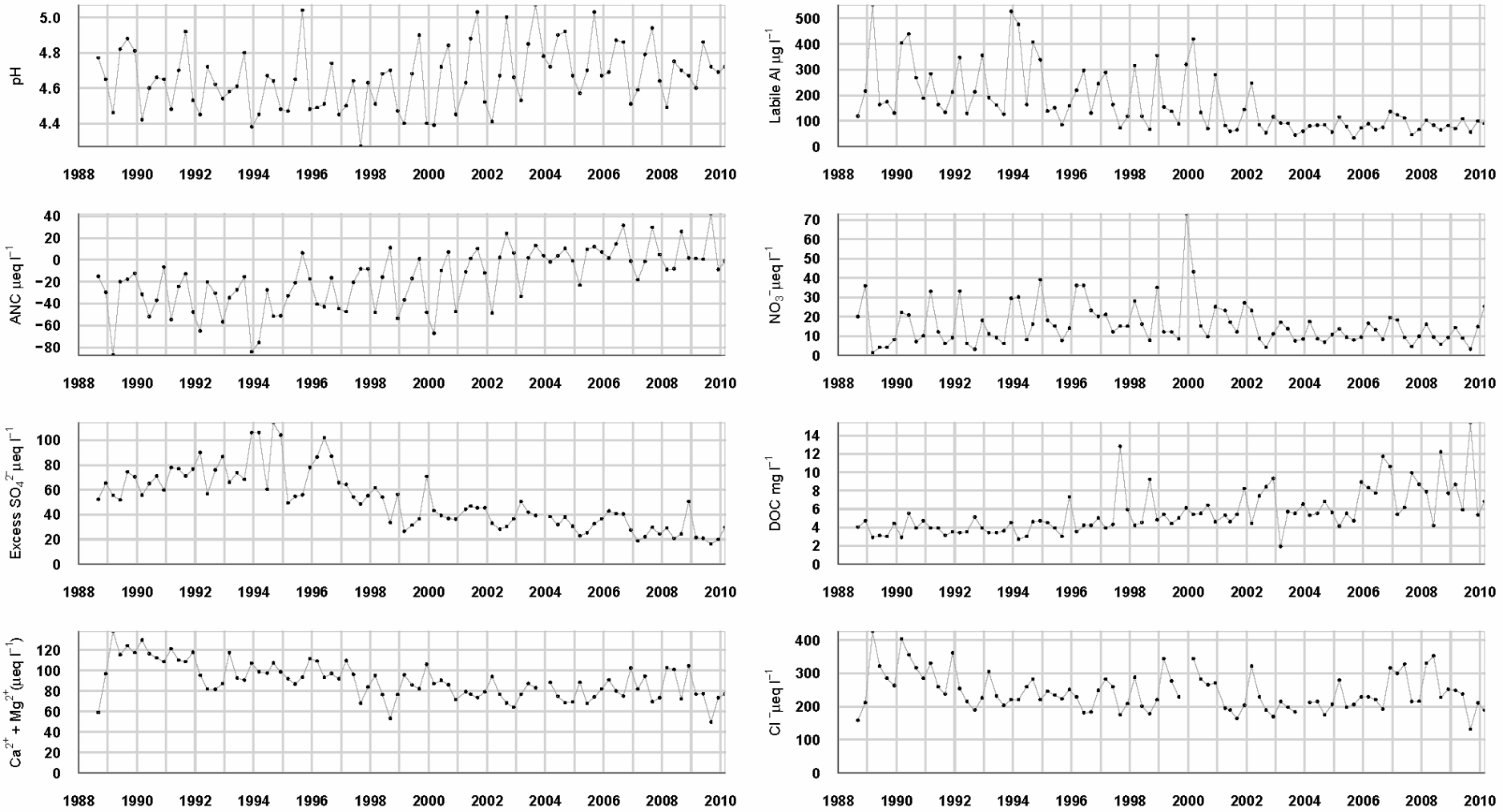
7.2.7 Thermistor data, Loch Chon



Thermistors not recovered in 2006

7.3 Loch Grannoch

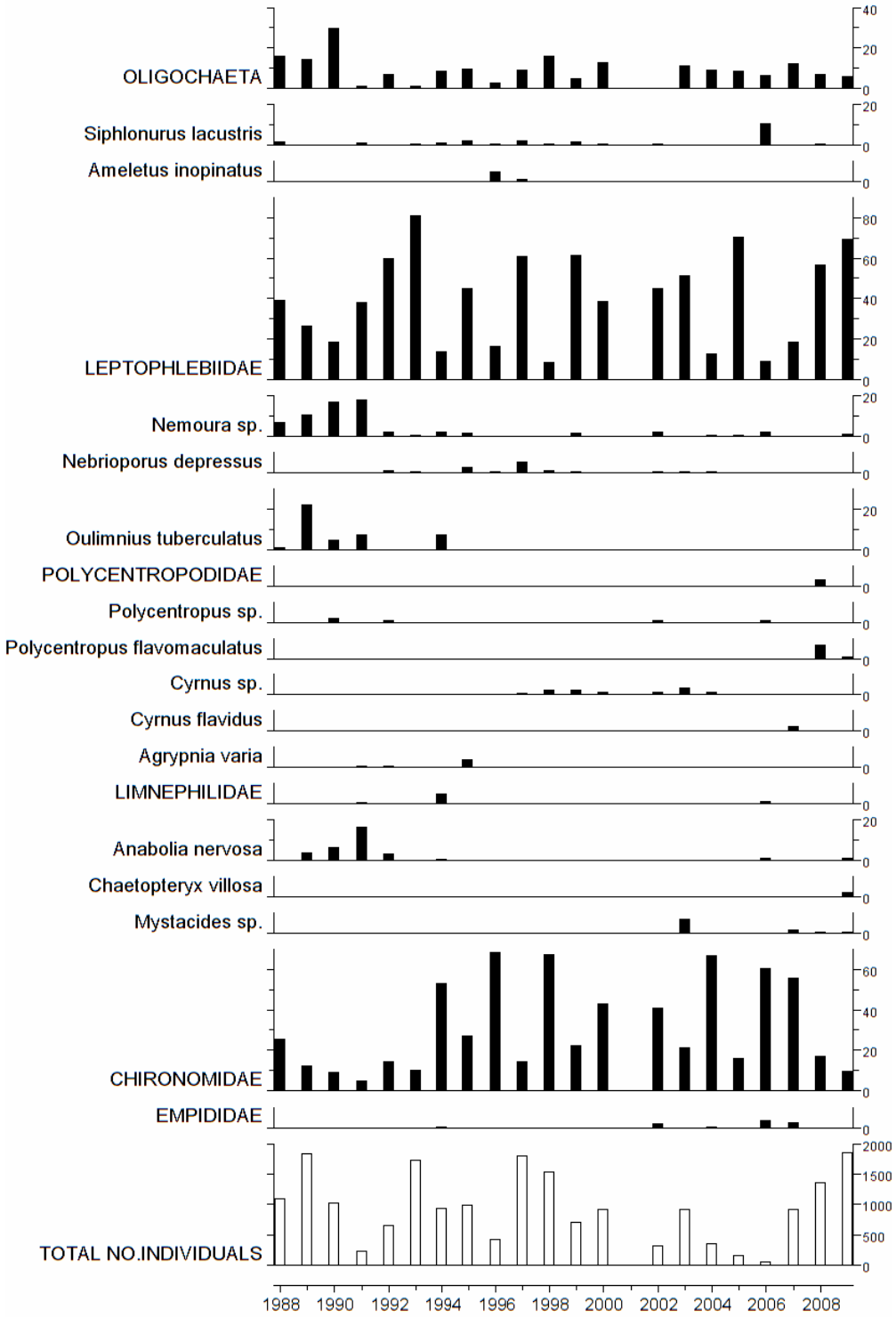
7.3.1 Spot sampled chemistry data



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
08-09 mean	4.68	5.07	38.80	49.75	232.40	6.58	175.50	74.00	269.90	57.49	29.19	9.59	8.18
08-09 std dev	0.06	14.53	12.74	8.69	33.94	2.04	28.59	8.91	56.21	13.70	14.28	3.56	3.29

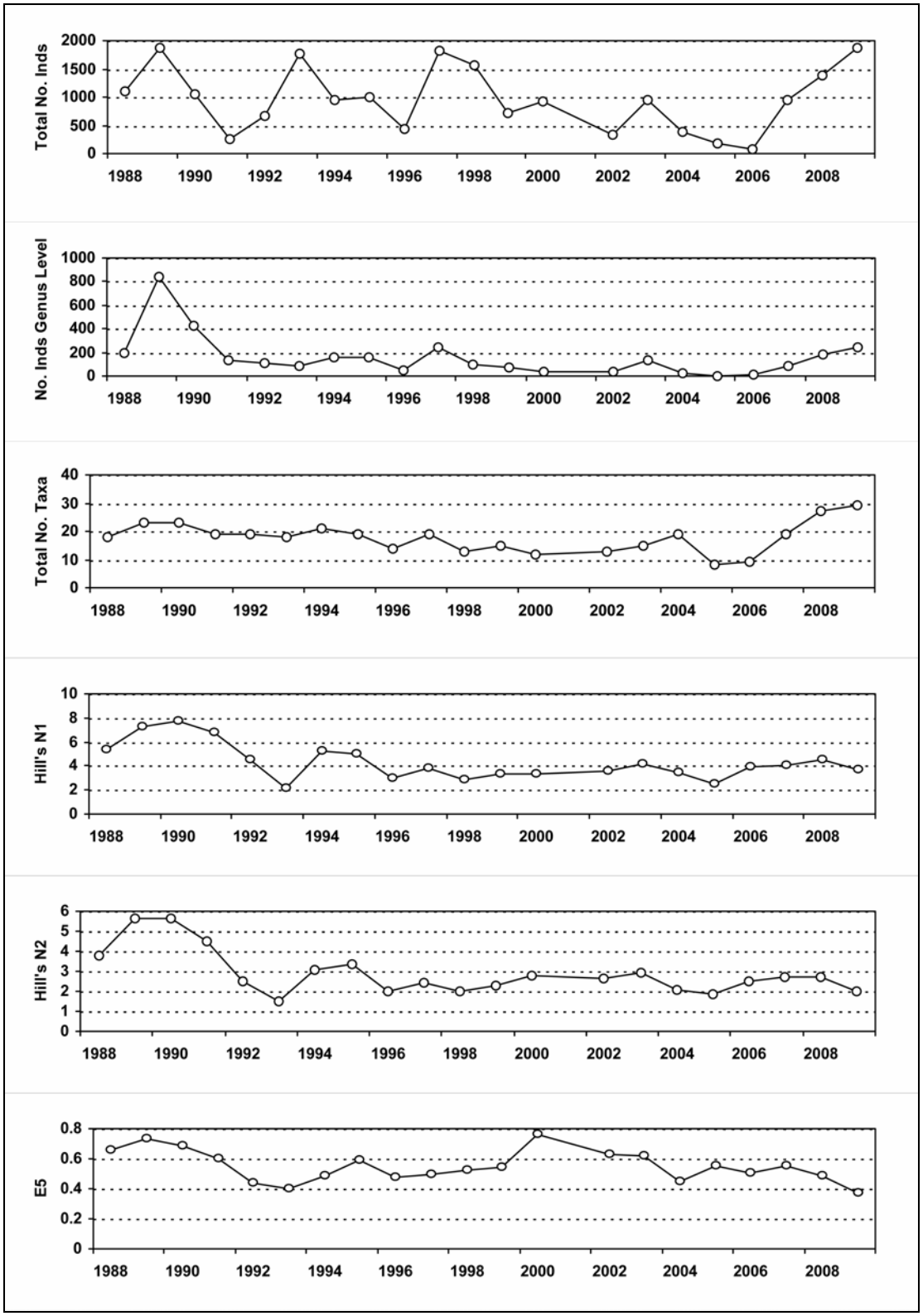
7.3.2 Macroinvertebrate data

7.3.2.1 Percentage abundance summary, Loch Grannoch



No sampling in 2001 due to Foot and Mouth restrictions.

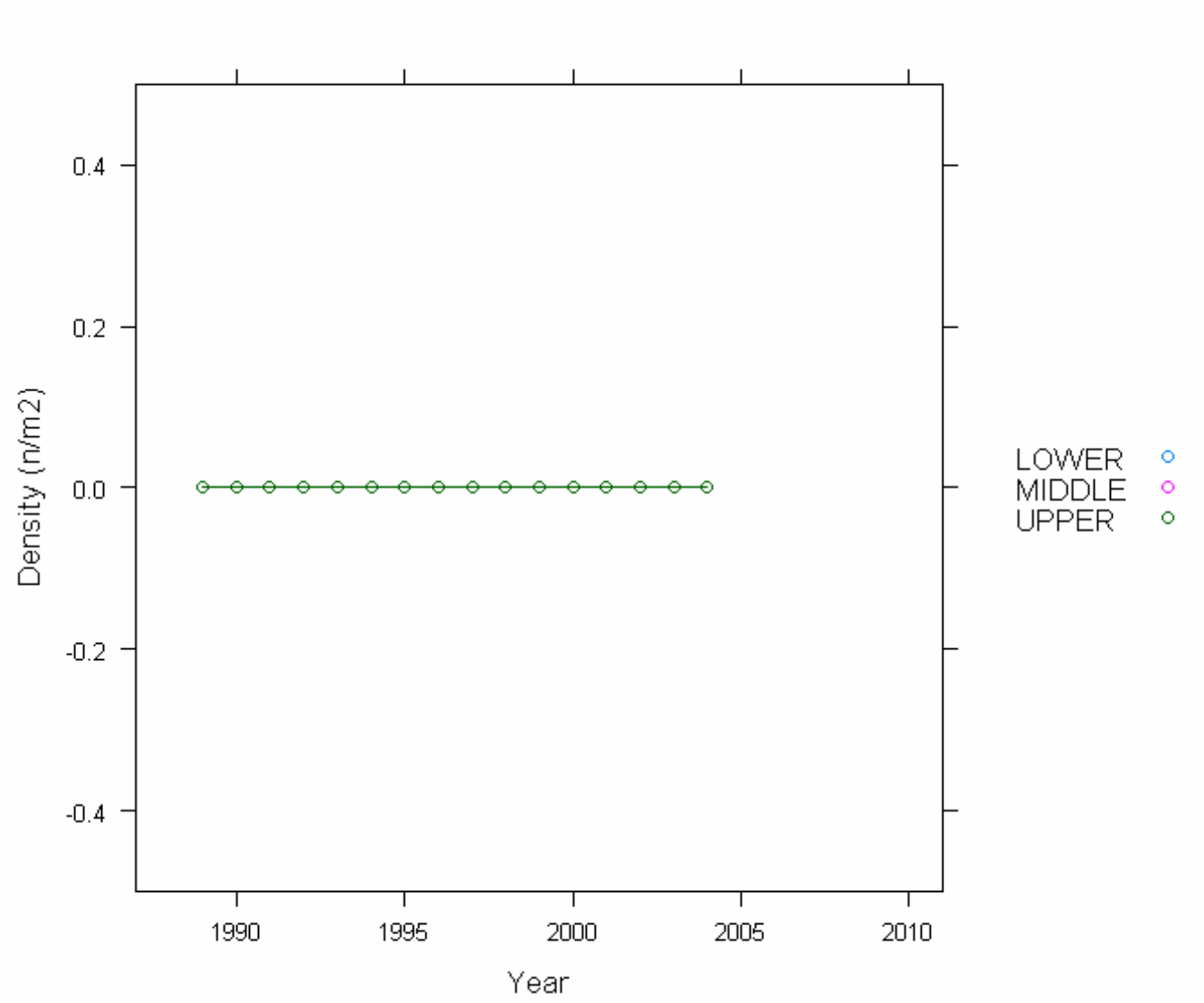
7.3.2.2 Summary statistics, Loch Grannoch



No sampling in 2001 due to Foot and Mouth restrictions.

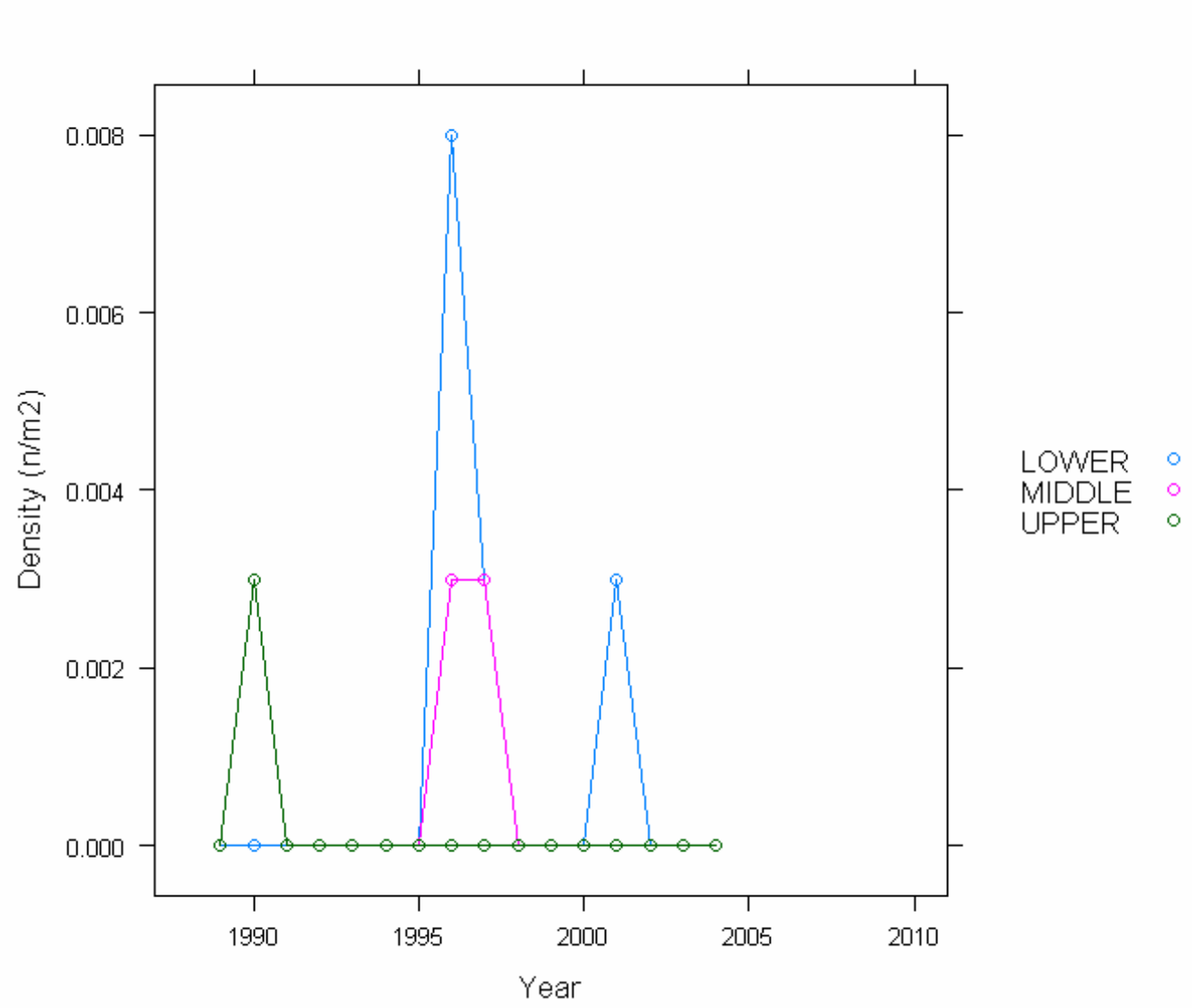
7.3.3 Fish data (for outflow stream)

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



Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

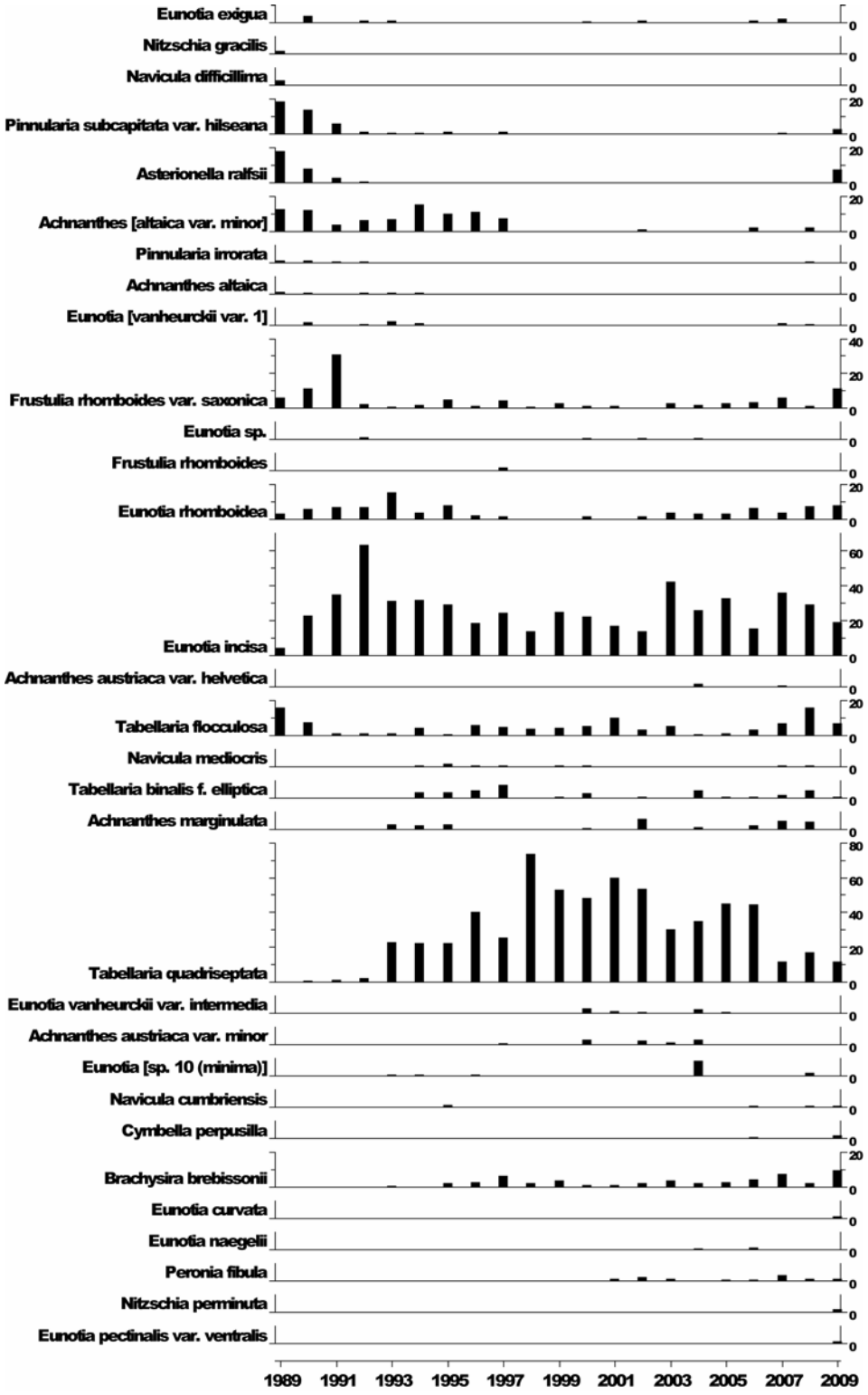
7.3.3.2 Summary of Trout parr densities (numbers m^{-2}), Loch Grannoch



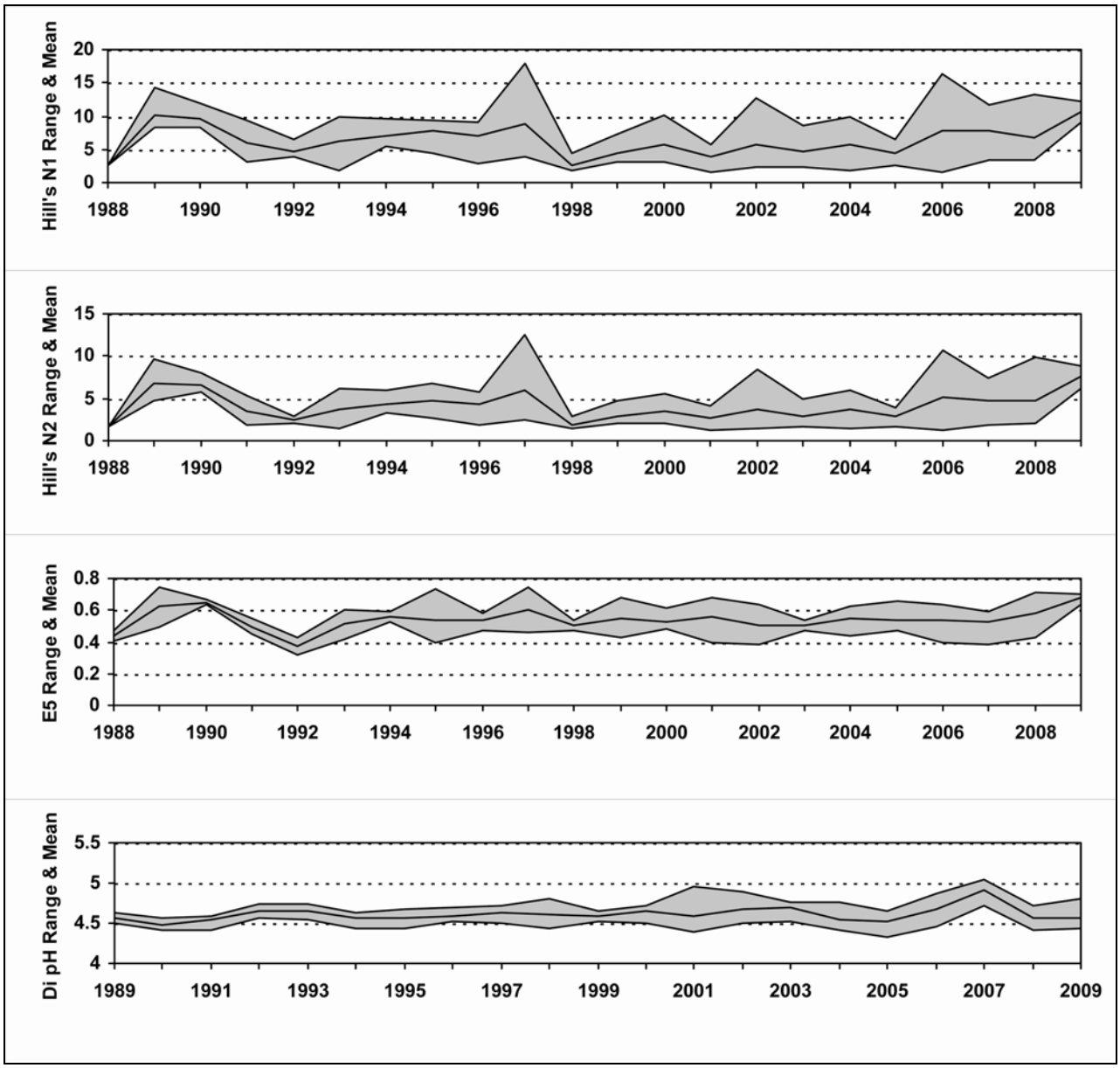
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

7.3.4 Epilithic diatom data

7.3.4.1 Percentage abundance summary, Loch Grannoch

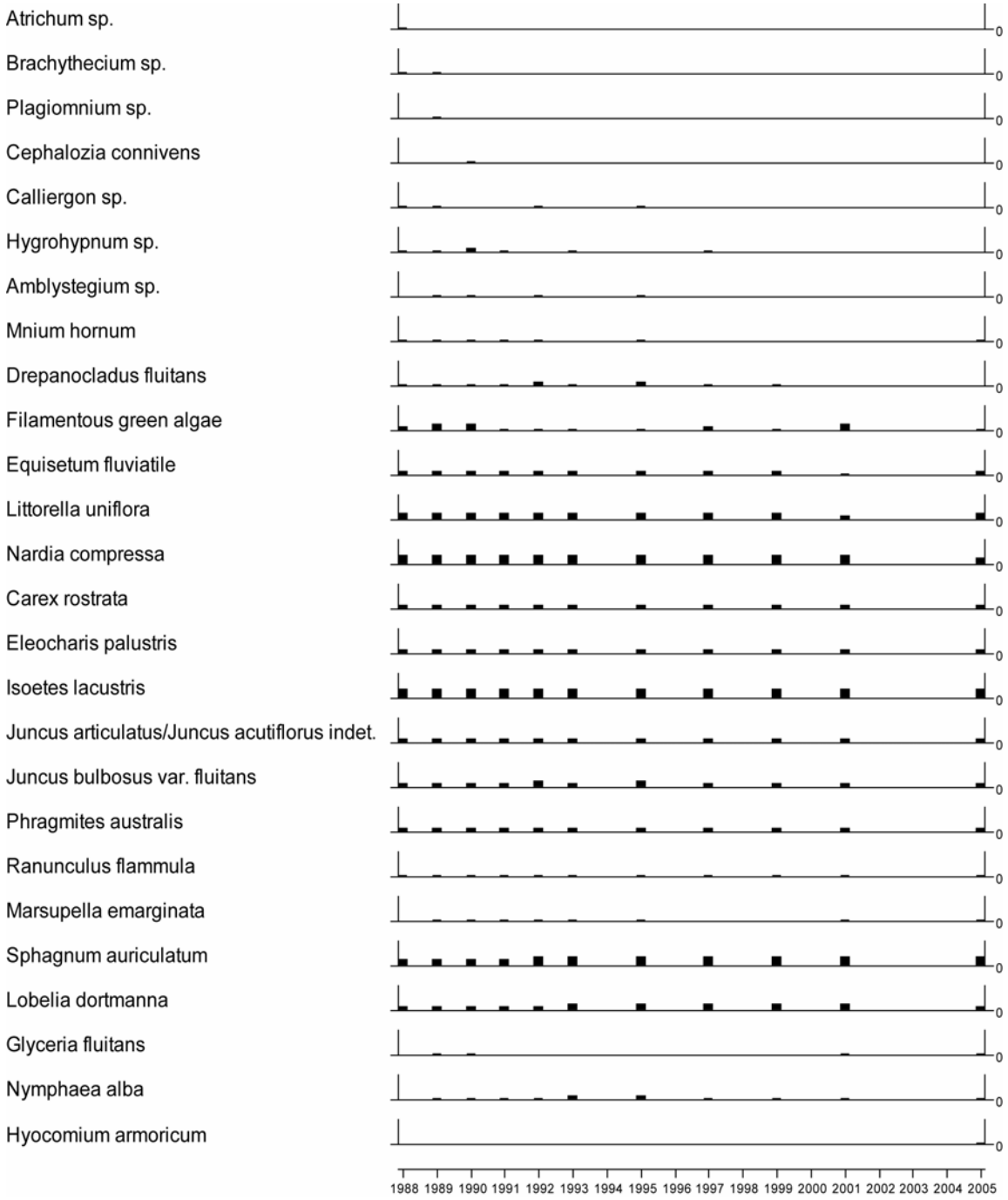


7.3.4.2 Summary statistics, Loch Grannoch



7.3.5 Aquatic macrophyte data, Loch Grannoch

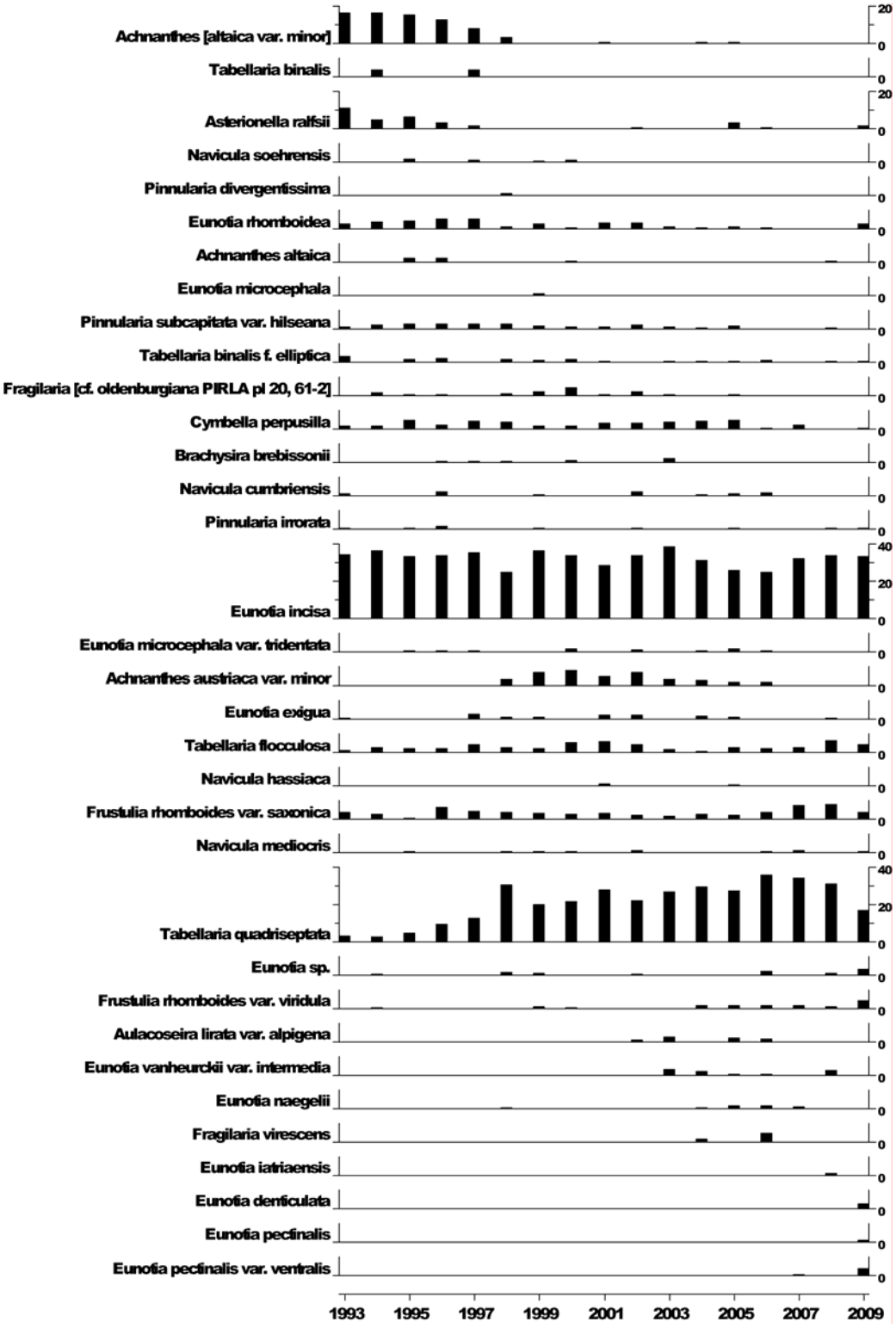
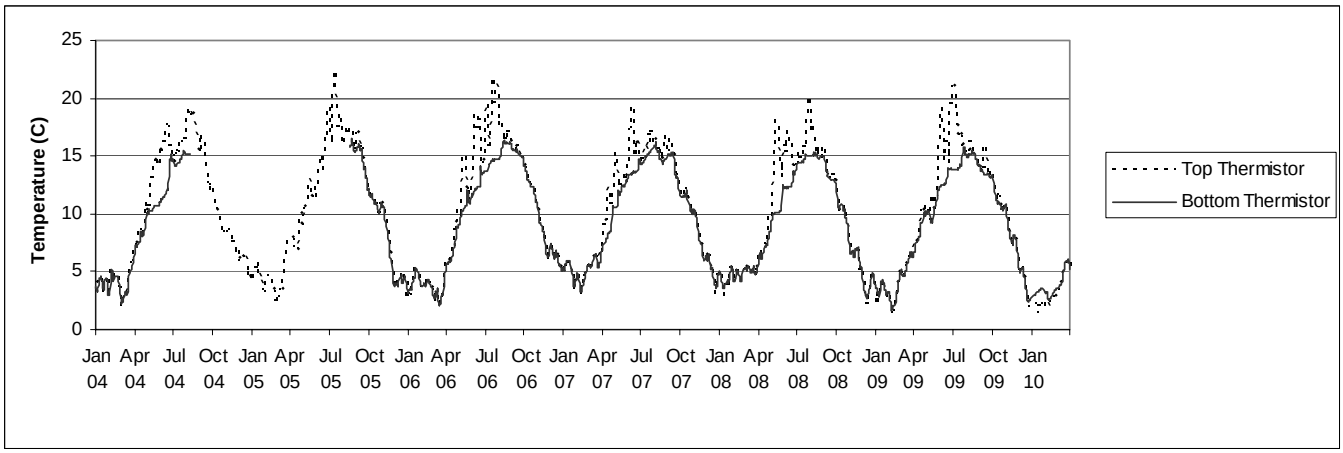
Species Scores (1-5)



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