UCL ENVIRONMENTAL CHANGE RESEARCH CENTRE

UK Upland Waters Monitoring Network (UKUWMN)

Allt na Coire Nan Con, Loch Chon and Loch Grannoch

Annual Summary Progress Report to Forest Research. April 15 - March 16

E. M. Shilland, D. T. Monteith, K. Millidine & I. A. Malcolm

2016

UK UPLAND WATERS MONITORING NETWORK (UKUWMN)

ALLT NA COIRE NAN CON, LOCH CHON AND LOCH GRANNOCH

ANNUAL SUMMARY PROGRESS REPORT TO FOREST RESEARCH. April 2015 - March 2016.

Ewan M. Shilland[1], Don T. Monteith[2], Karen Millidine[3] & Iain A. Malcolm[3]

2016

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Cover Photo: Loch Chon, 20th October 2015 © Ewan Shilland

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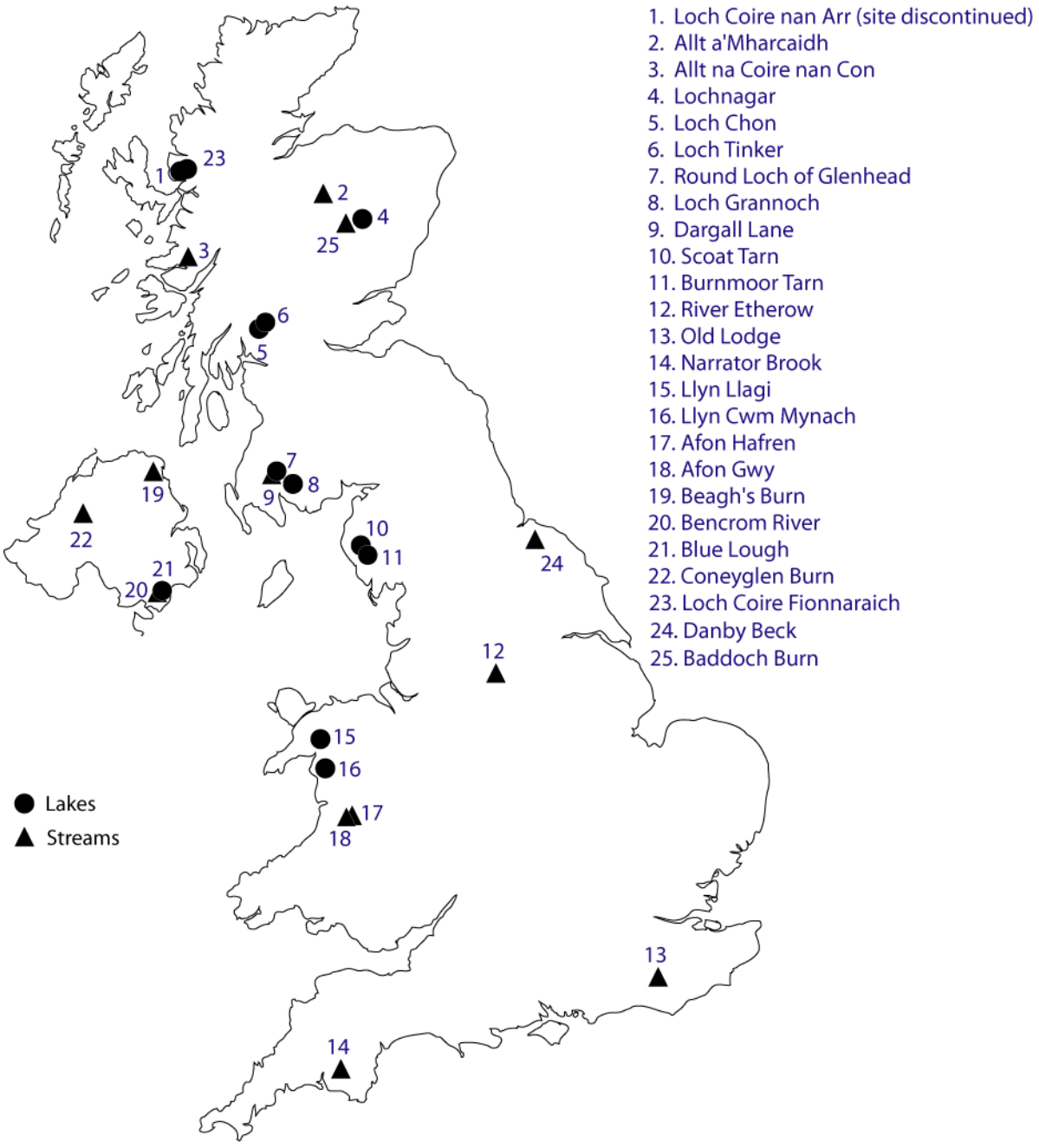
2 INTRODUCTION

Originally named the Acid Waters Monitoring Network, the UK Upland Waters Monitoring Network (UKUWMN) has been operating continuously since 1988. This report presents a summary of work undertaken in the contract year 2015-2016 at three Scottish forested sites currently supported in part by Forest Research: Allt na Coire nan Con, Loch Chon and Loch Grannoch. The UKUWMN 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), the Scottish Environmental Protection Agency (SEPA), Scottish Natural Heritage (SNH) and ENSIS Ltd. who have recently supported the rest of the programme at the three sites.

In order to present the Forest Research funded aspects of the UKUWMN in context, all sampling performed in 2015-16 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 March 2015.

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 UKUWMN web site. A special issue of the journal Ecological Indicators was produced in 2014, the majority of the papers in which feature interpretation of UKUWMN sites and data. The papers can be found online here. A full description of sampling methods and analytical procedures, together with site descriptions, is also presented on the UKUWMN methods web page.

3 LOCATION OF UKUWMN SITES



4 SUMMARY OF WORK UNDERTAKEN 2015-2016

4.1 Summary Overview

During the period from April 2015 to March 2016 the funded chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded with few problems at all three sites. Unfortunately the 2015 macrophyte survey at Allt na Coire nan Con was impossible for the second year running due to spate conditions in the stream at the time of sampling.

Additional work was undertaken at Loch Chon, with a bathymetry produced on the 12th of August 2015 and an extra trap array and thermistor installed for MSc. teaching purposes.

4.2 Water Chemistry

Samples were collected from Loch Grannoch and Loch Chon in early June, September and December 2015 and March 2016 by Marine Scotland Pitlochry. Monthly dip samples were collected from Allt na Coire nan Con by a local Forestry Commission operative, Pete Madden. All samples were delivered to the analytical laboratories at Marine Scotland Science, Pitlochry (MSS) and the Centre for Ecology and Hydrology (CEH) and are being analysed and archived in the UKUWMN central chemistry database at CEH Lancaster. Quality control is being performed on the data prior to it being presented in the annual UKUWMN data report and online on the UKUWMN website.

4.3 Sediment Traps

Sediment traps were recovered and replaced by a team from ENSIS on the on the 12th of August 2015 at Loch Chon and on the 2nd of August 2015 at Loch Grannoch. Diatoms in the sediment retrieved from the traps were made into slides and have been archived pending funding becoming available for analysis. Spheroidal Carbonaceous Particles from the sediment are being counted by Prof N. Rose. Trap sediment samples for trace metals were collected and have been archived pending funding becoming available for analysis.

4.4 Thermistors

Top and bottom thermistors and thermistor chains were removed and replaced on the 12th of August 2015 at Loch Chon and 2nd of August 2015 at Loch Grannoch. All units had functioned well during the previous year and the data were added to the ENSIS/MSS thermistor water temperature database. The stream thermistor at Allt na

Coire nan Con functioned well and data have been added to the MSS stream thermistor database.

4.5 Epilithic Diatoms

Epilithic diatoms were retrieved from three sampling points around Loch Chon on the 12th of August 2015 and at four sampling points around Loch Grannoch on the 2nd of August 2015. Three samples were retrieved from Allt na Coire nan Con on the 12th of July 2015. All samples were preserved in Ethanol to enable future eDNA work on the material if required. Sub-samples of each have been made into slides and will be archived pending funding becoming available for analysis.

4.6 Macroinvertebrates

Aquatic macroinvertebrates were sampled at Allt na Coire nan Con by QMuL on the 7th of May 2015, and by UCL at Loch Chon on the 2nd May and Loch Grannoch on the 3rd May. Five 1 minute kick samples were performed at the sites and all samples were preserved in Ethanol to enable future eDNA work on the material if required. The Coire nan Con samples were counted at QMuL and the data sent to ENSIS Ltd. The data will be quality screened and added to the UKUWMN biological database at ENSIS. Similar to the 2014 samples, the 2015 Loch Grannoch and Loch Chon samples have been archived, awaiting funding for analysis.

4.7 Fish

Fish surveying was performed at the three sites in autumn 2015 by Marine Scotland Science, Pitlochry. The fish data have been checked and added to the MSS fish database.

4.8 Aquatic Macrophytes

Being unfunded, aquatic macrophyte surveys were not performed at the loch sites in 2015. Unfortunately, for the second year running, Allt na Coire nan Con was not surveyed on the site visit of 12th of July 2015 due to spate conditions in the stream.

4.9 Data Management and Reporting

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

The 2014-2015 annual report is in the process of being uploaded to the UWMN 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 (2014-2015) 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"). The lower reach is coloured blue, middle reach pink and upper reach green.
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.
Section 8:	For lake sites only. Time series depth-temperature contour plot of data from a thermistor chain suspended near the deepest part of the site.

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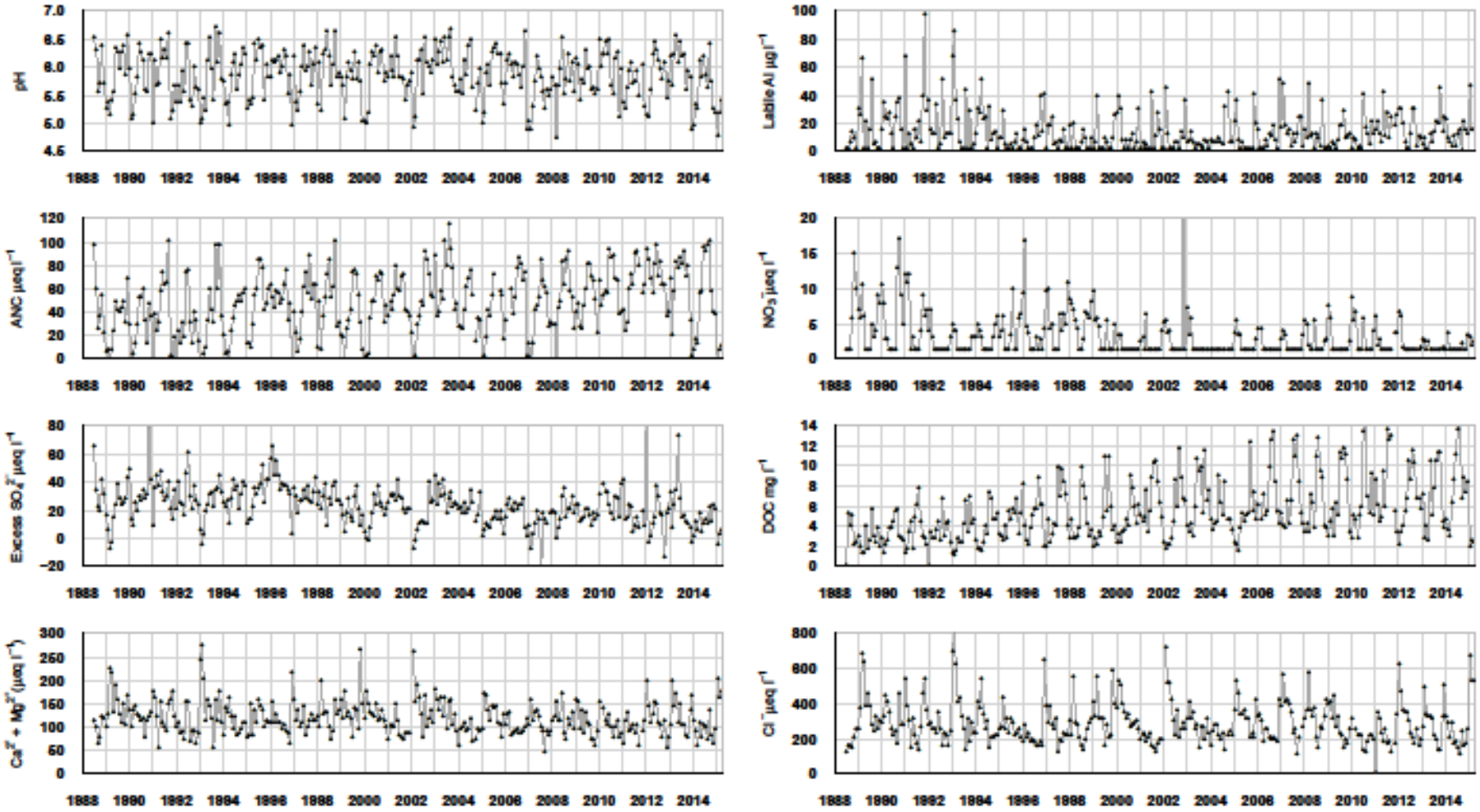
Palmer, M. A., Bell, S. L. & Butterfield, I. 1992 A botanical classification of standing waters in Britain: applications for conservation and monitoring. *Aquatic conservation: marine and freshwater ecosystems,* **2**, 125-143.

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

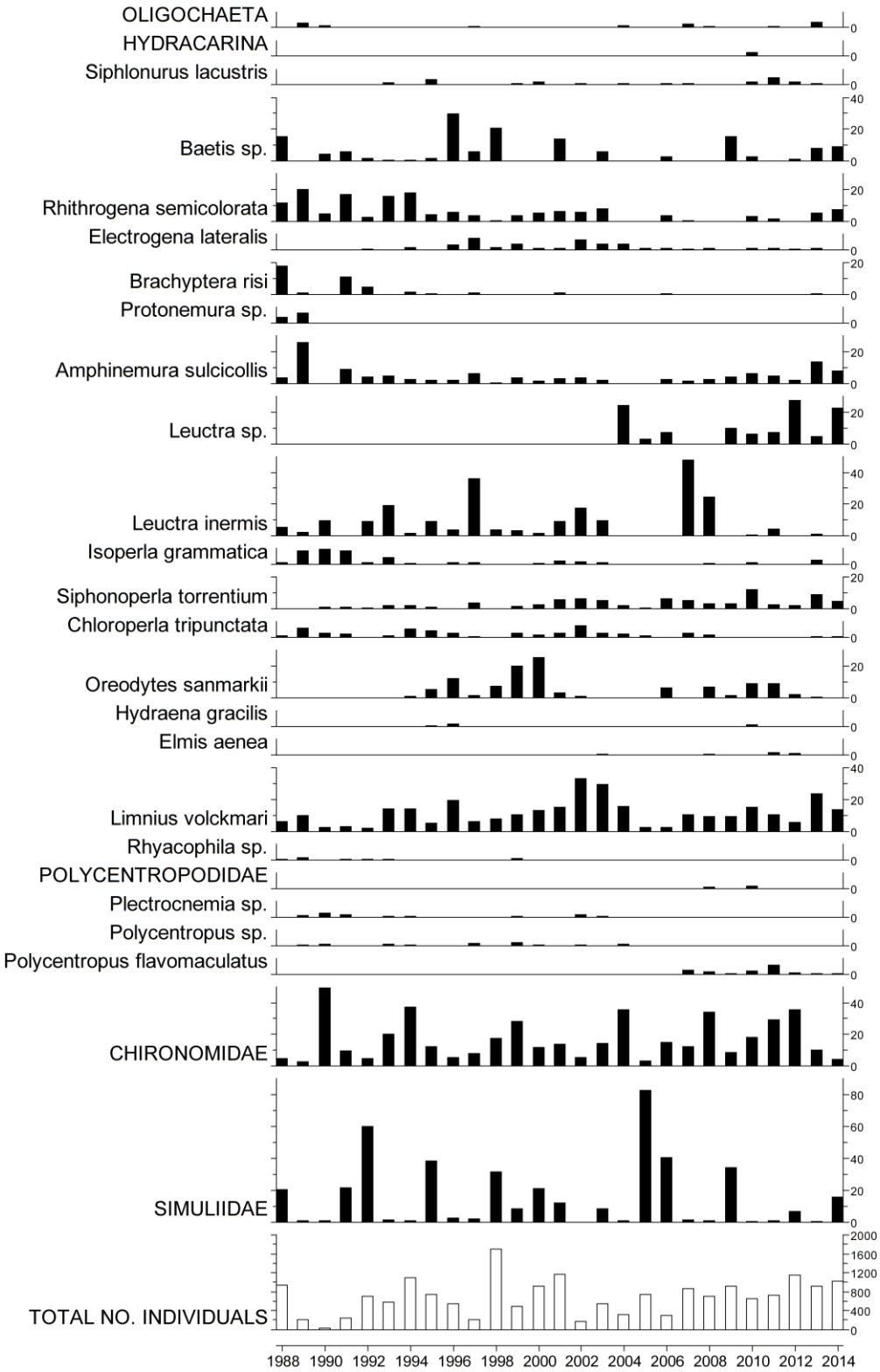
7.1.1 Spot sampled chemistry data



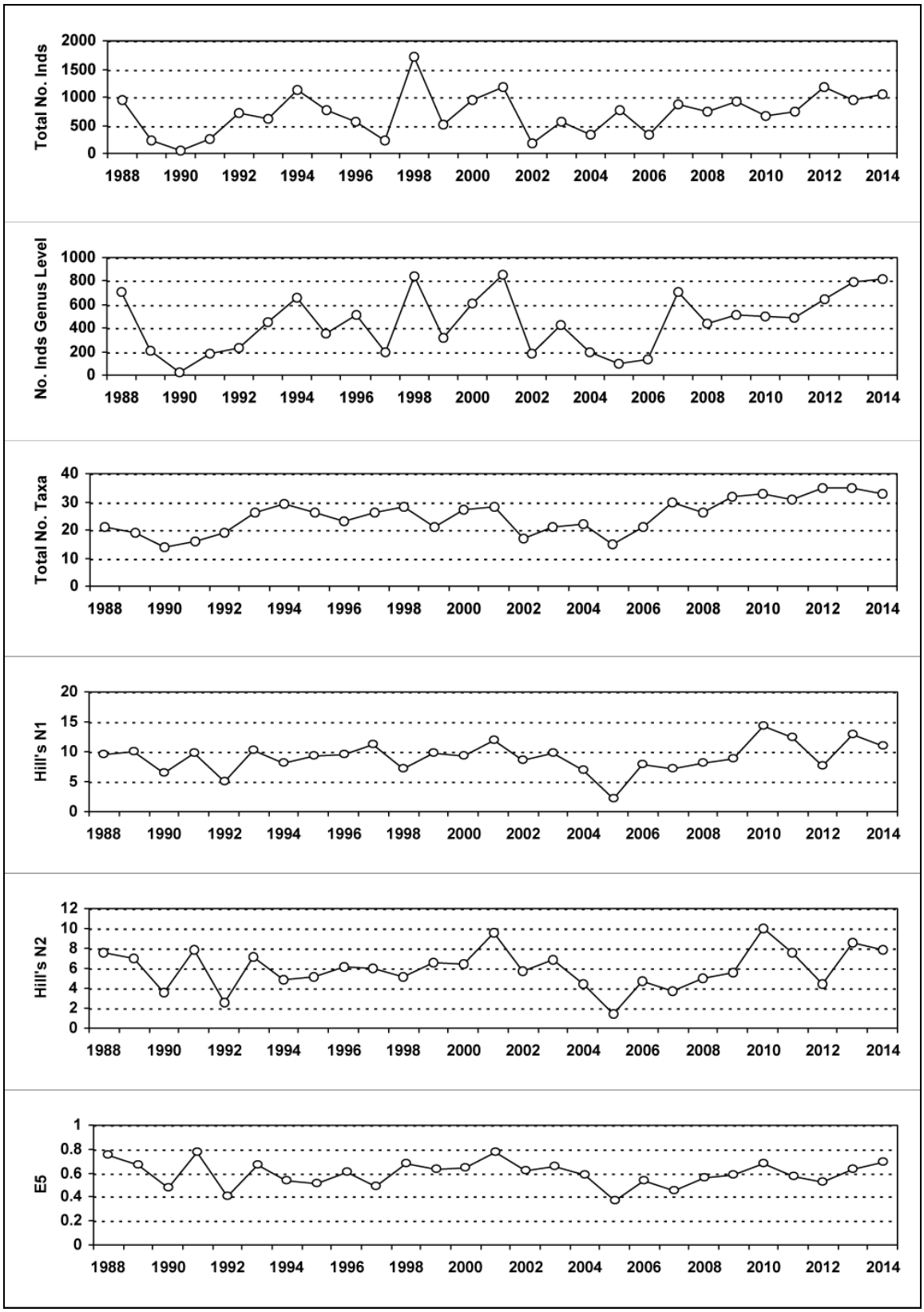
µeq l $^{-1}$, *µg l $^{-1}$, **mg l $^{-1}$	pH	ANC	Ca $^{2+}$	Mg $^{2+}$	Na $^{+}$	K $^{+}$	*Soluble Al	*Labile Al	Cl $^{-}$	*SO_4^{2-}	xSO_4^{2-}	NO_3^{-}	**DOC
Mean 1st 5 yrs	5.81	32.14	58.91	70.20	274.34	9.14	64.76	21.47	325.23	62.07	27.96	4.79	3.18
14-15 mean	5.63	53.86	51.04	65.78	265.36	8.05	85.67	14.75	289.17	42.21	11.89	1.88	7.83
14-15 std dev	0.48	38.01	13.78	33.59	126.15	2.71	34.14	11.93	186.63	15.60	8.48	0.78	4.26

7.1.2 Macroinvertebrate data

7.1.2.1 Percentage abundance summary, Allt na Coire nan Con

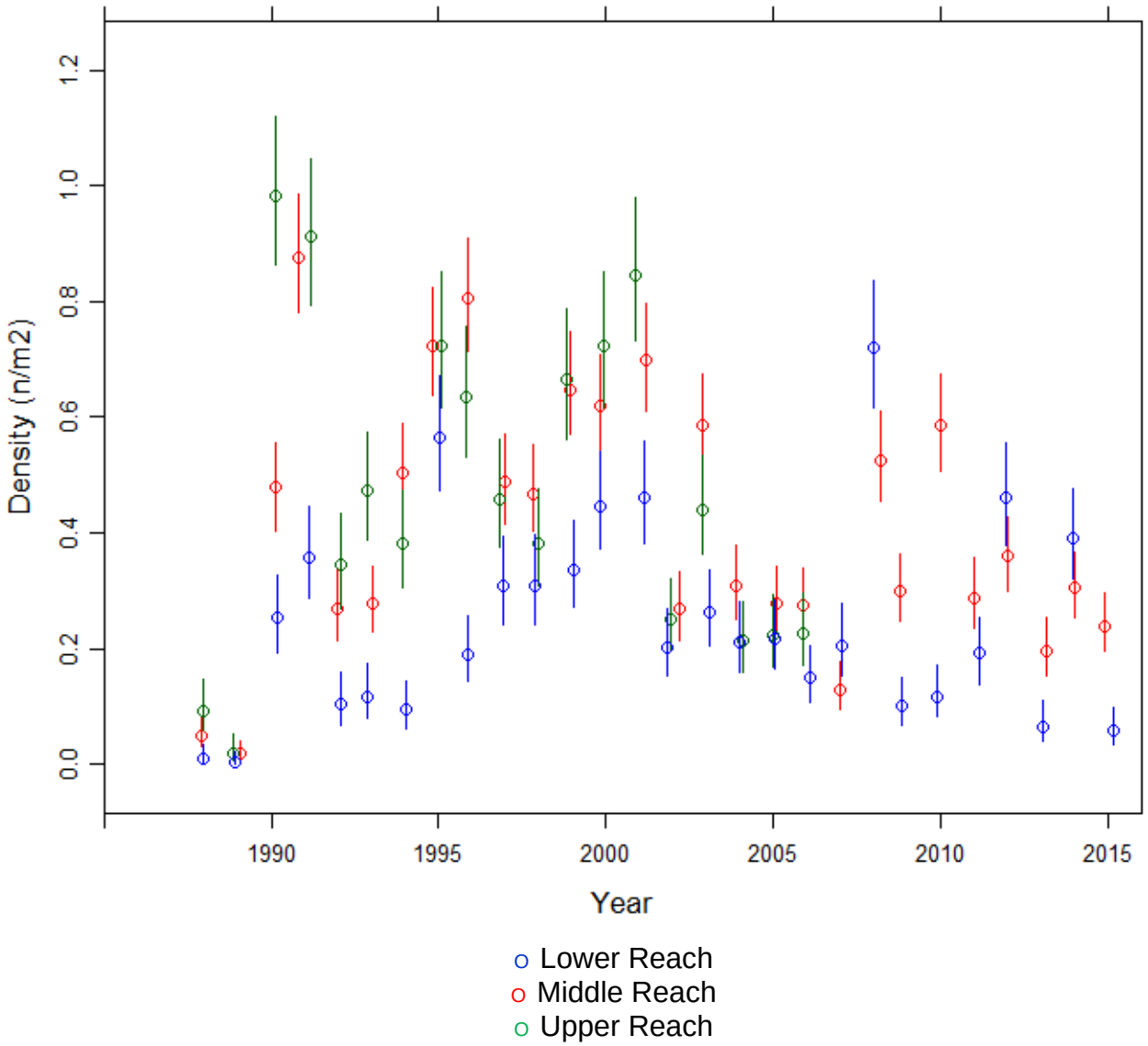


7.1.2.2 Summary statistics, Allt na Coire nan Con

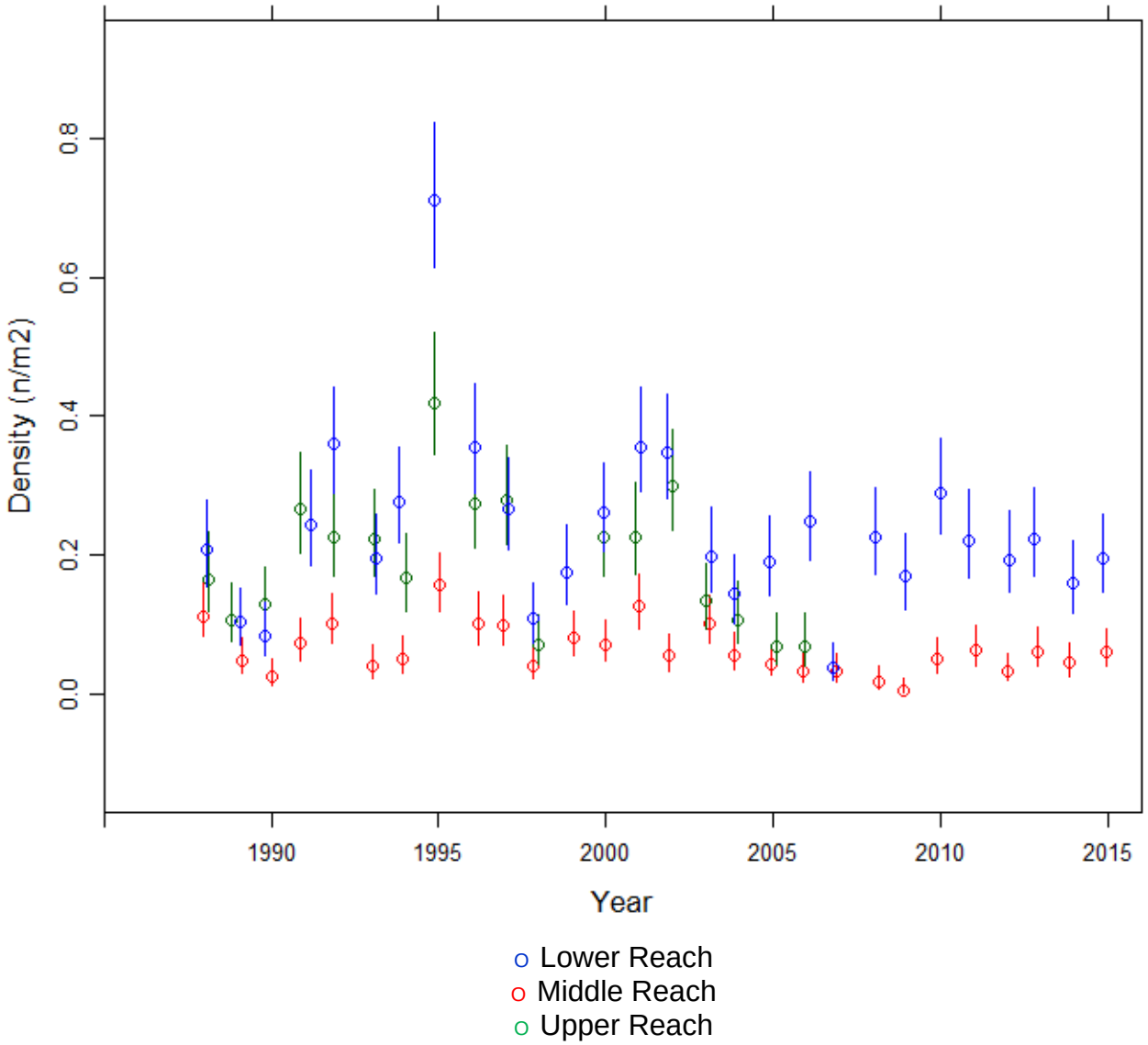


7.1.3 Fish data

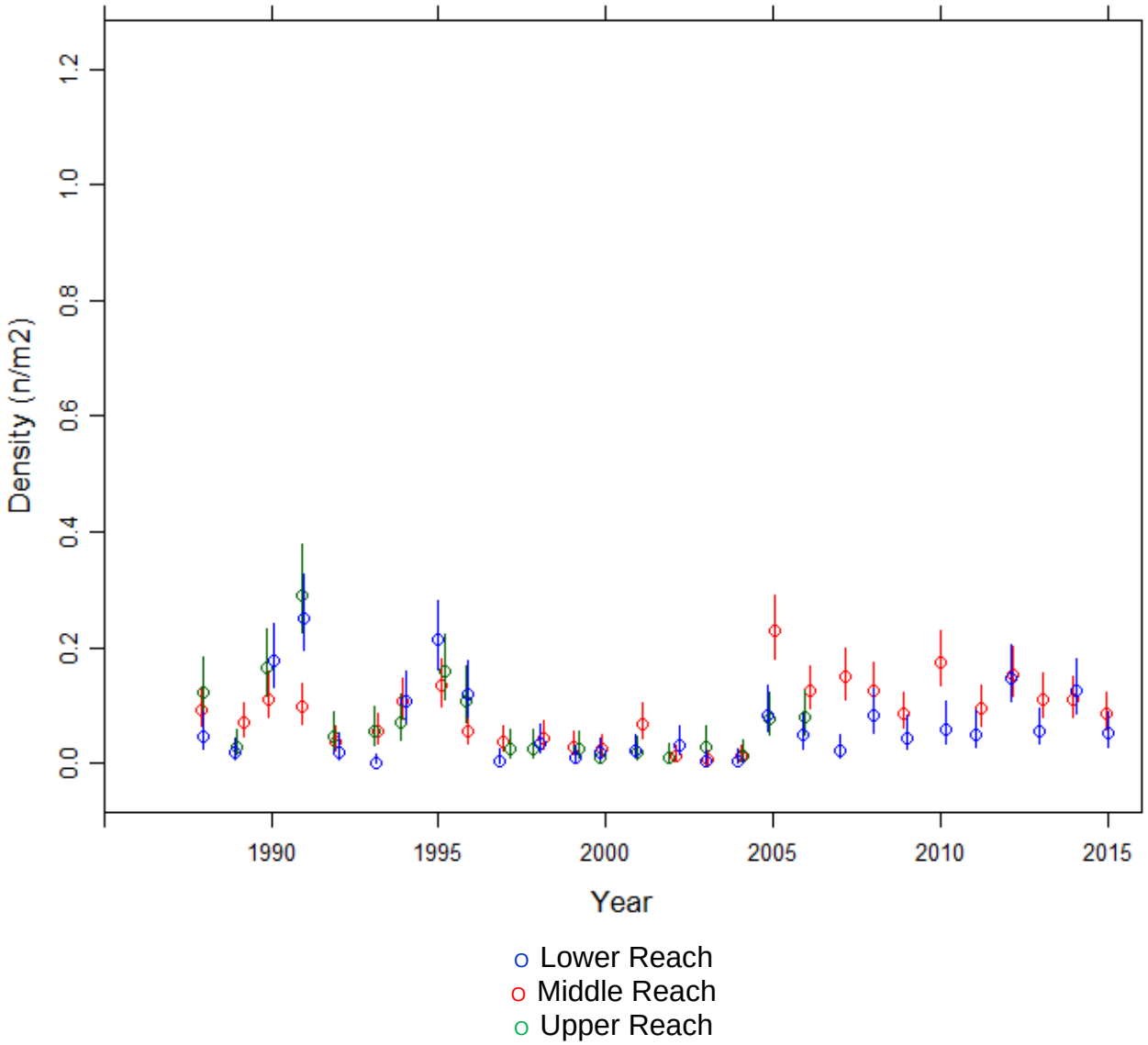
7.1.3.1 Summary of Salmon fry densities (numbers m^{-2}), Allt na Coire nan Con



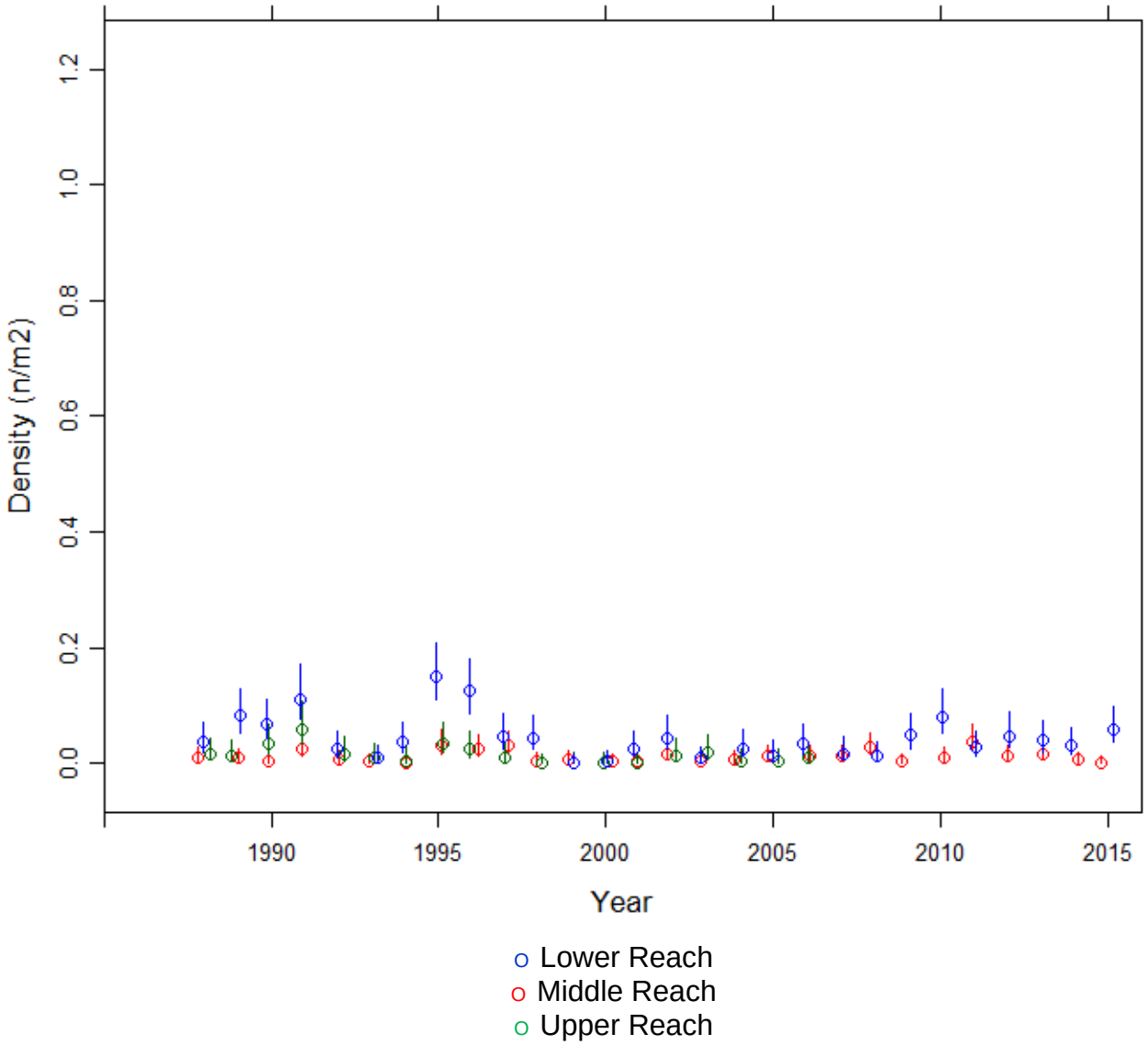
7.1.3.2 Summary of Salmon parr densities (numbers m^{-2}), Allt na Coire nan Con



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



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



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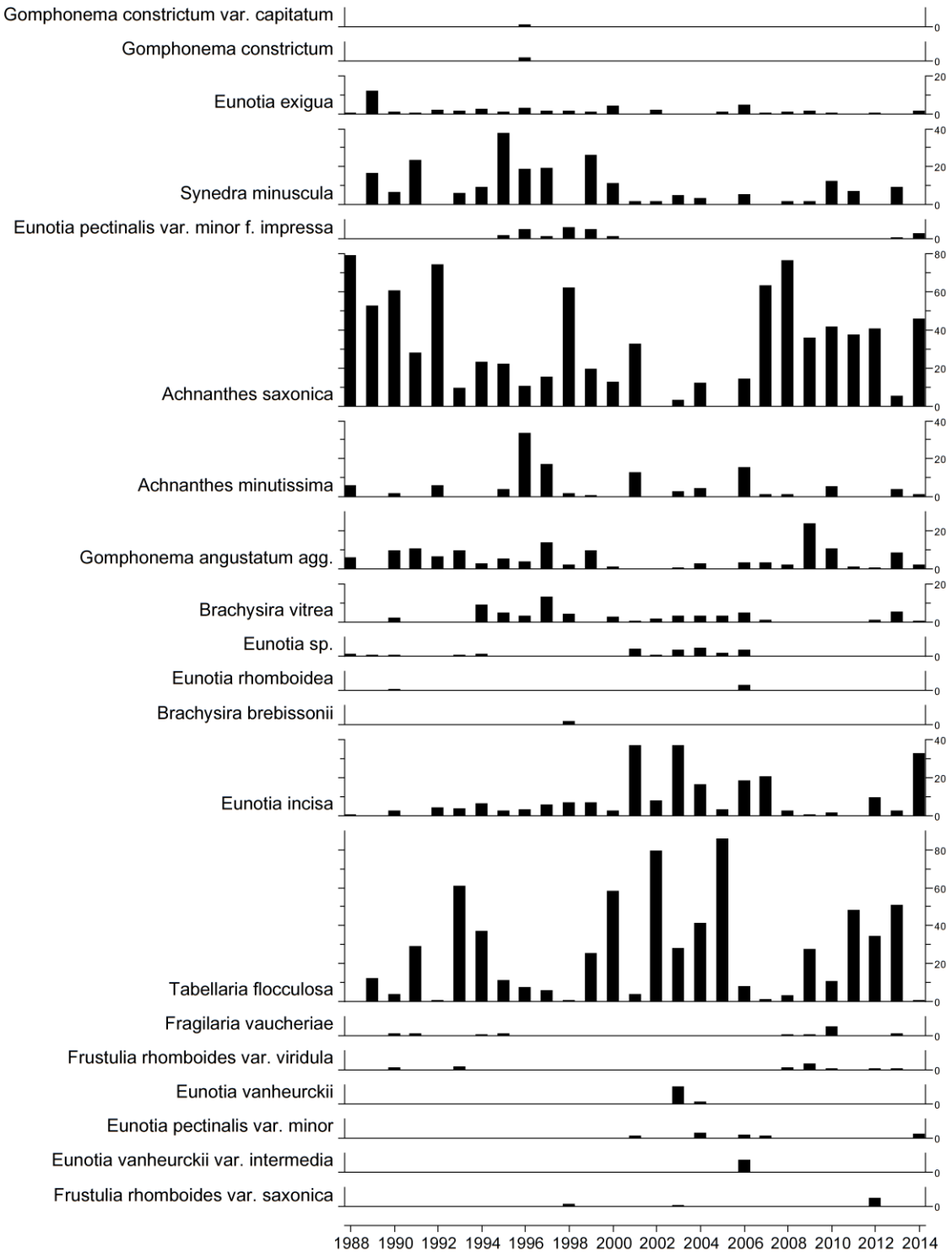
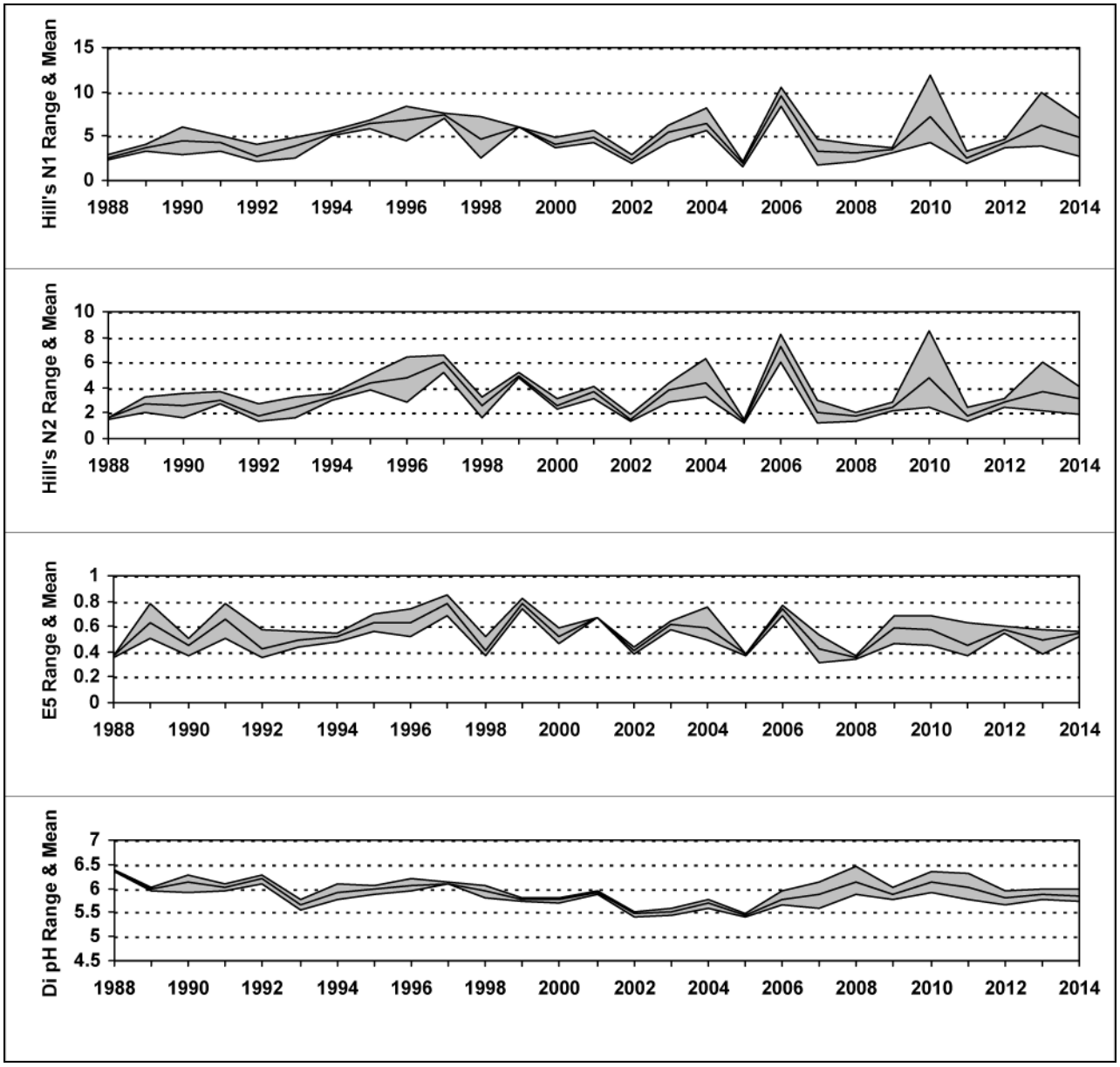
7.1.4 Epilithic diatom data

7.1.4.1 Percentage abundance summary, Allt na Coire nan Con

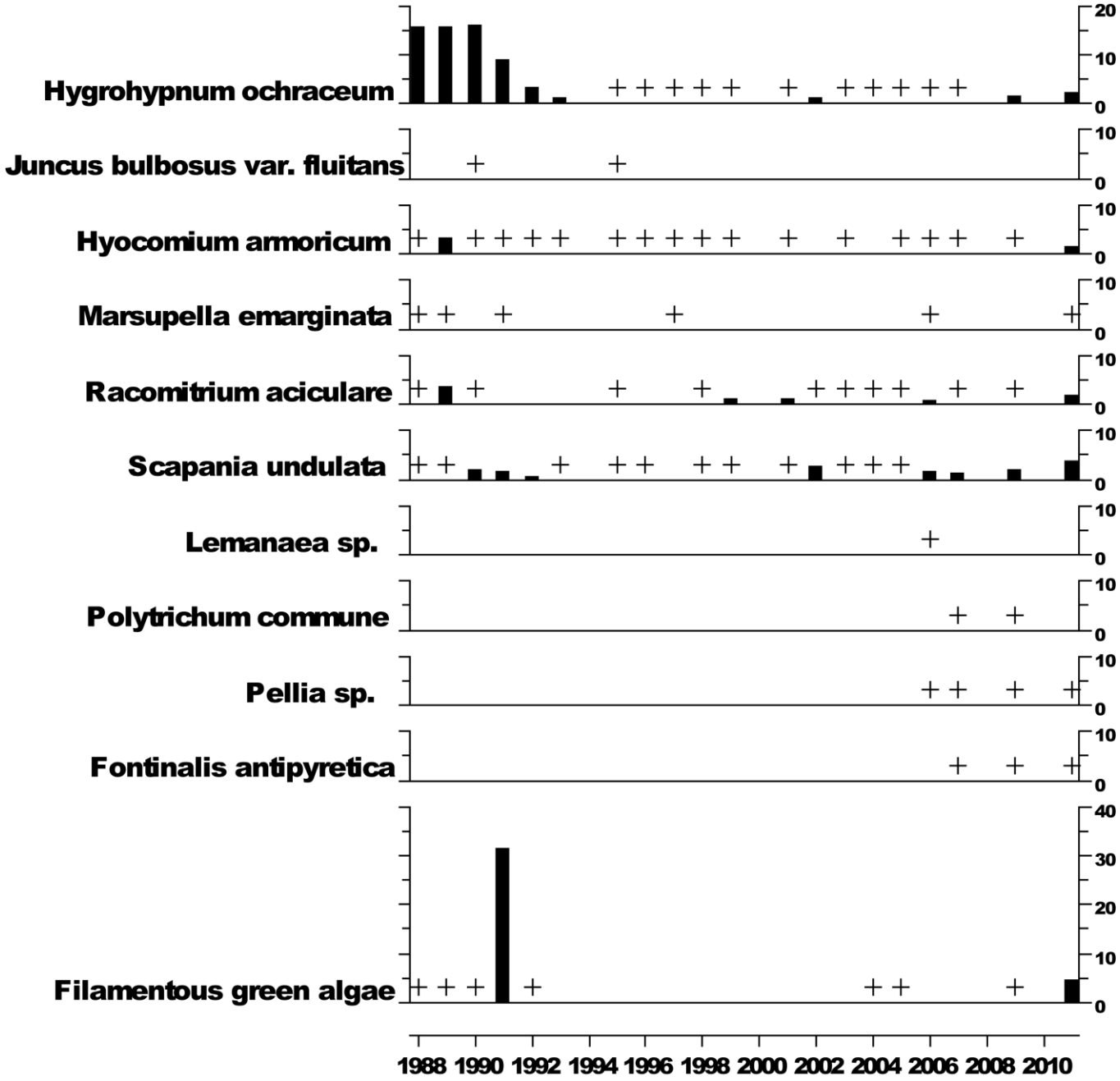


7.1.4.2 Summary statistics, Allt na Coire nan Con



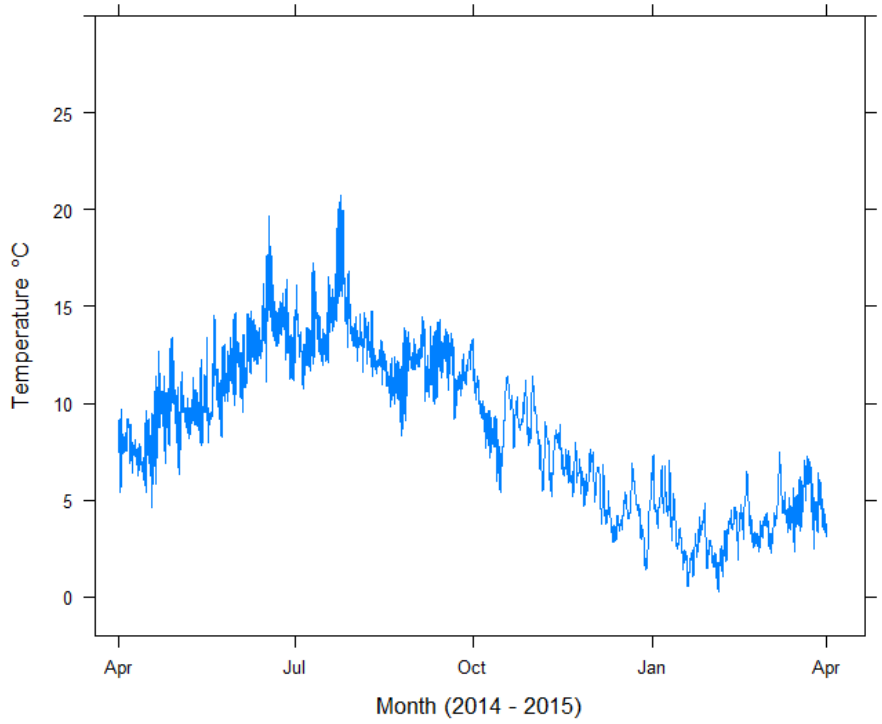
7.1.5 Aquatic macrophyte data, Allt na Coire nan Con

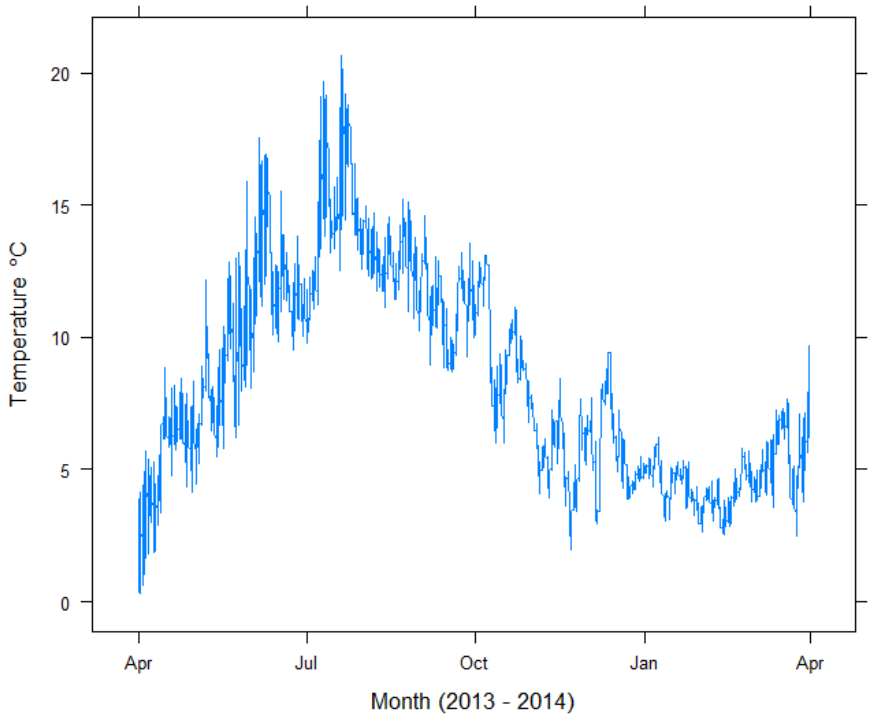
Percentage Species Cover

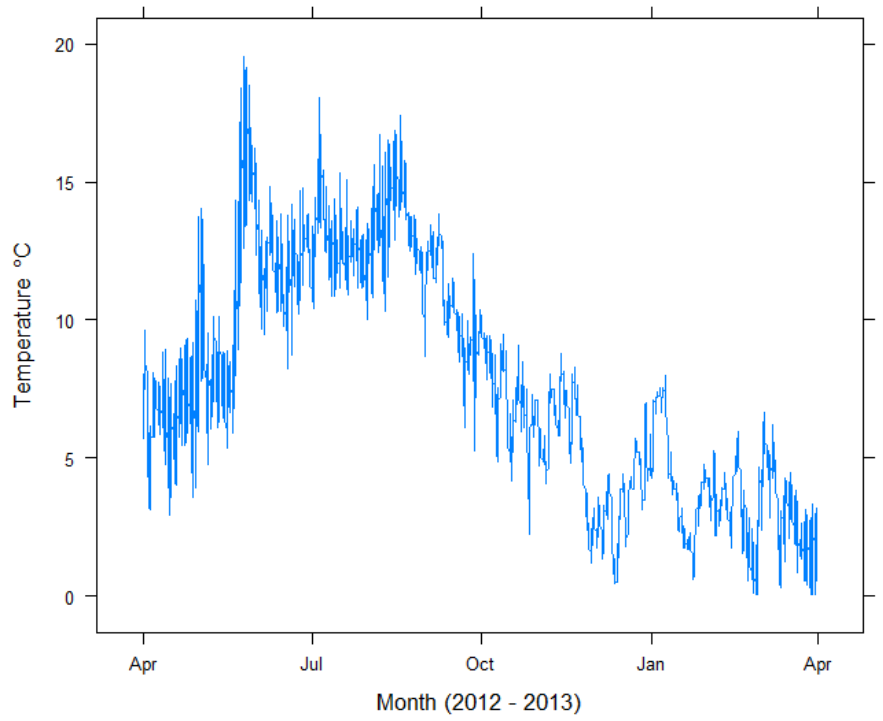


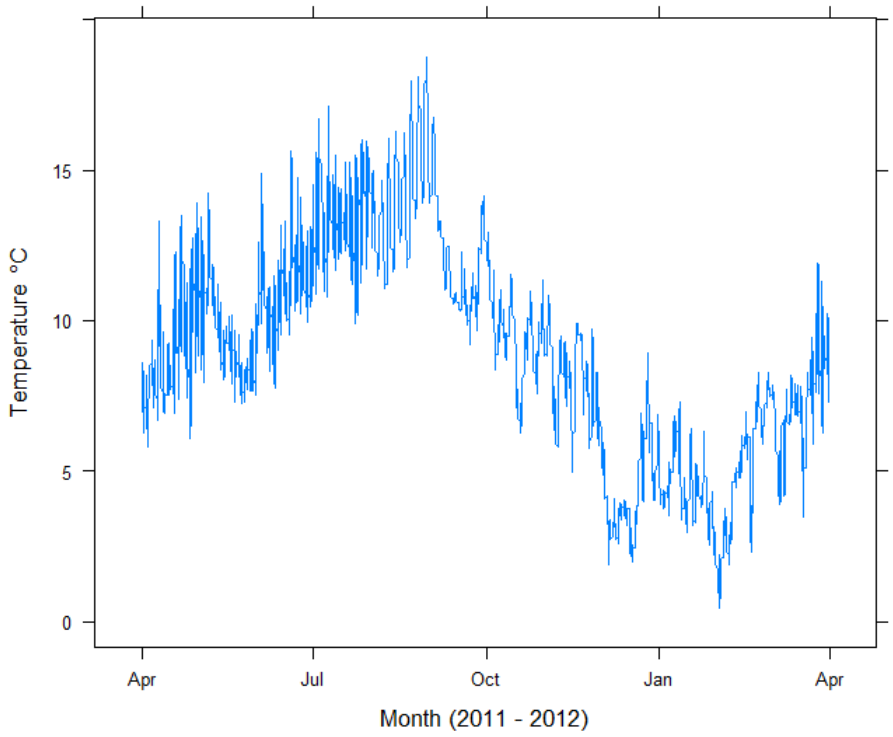
\+ Represents <0.5% abundance
No surveys in 2008, 2010, 2014 and 2015 due to spate conditions.

7.1.6 Thermistor data, Allt na Coire nan Con



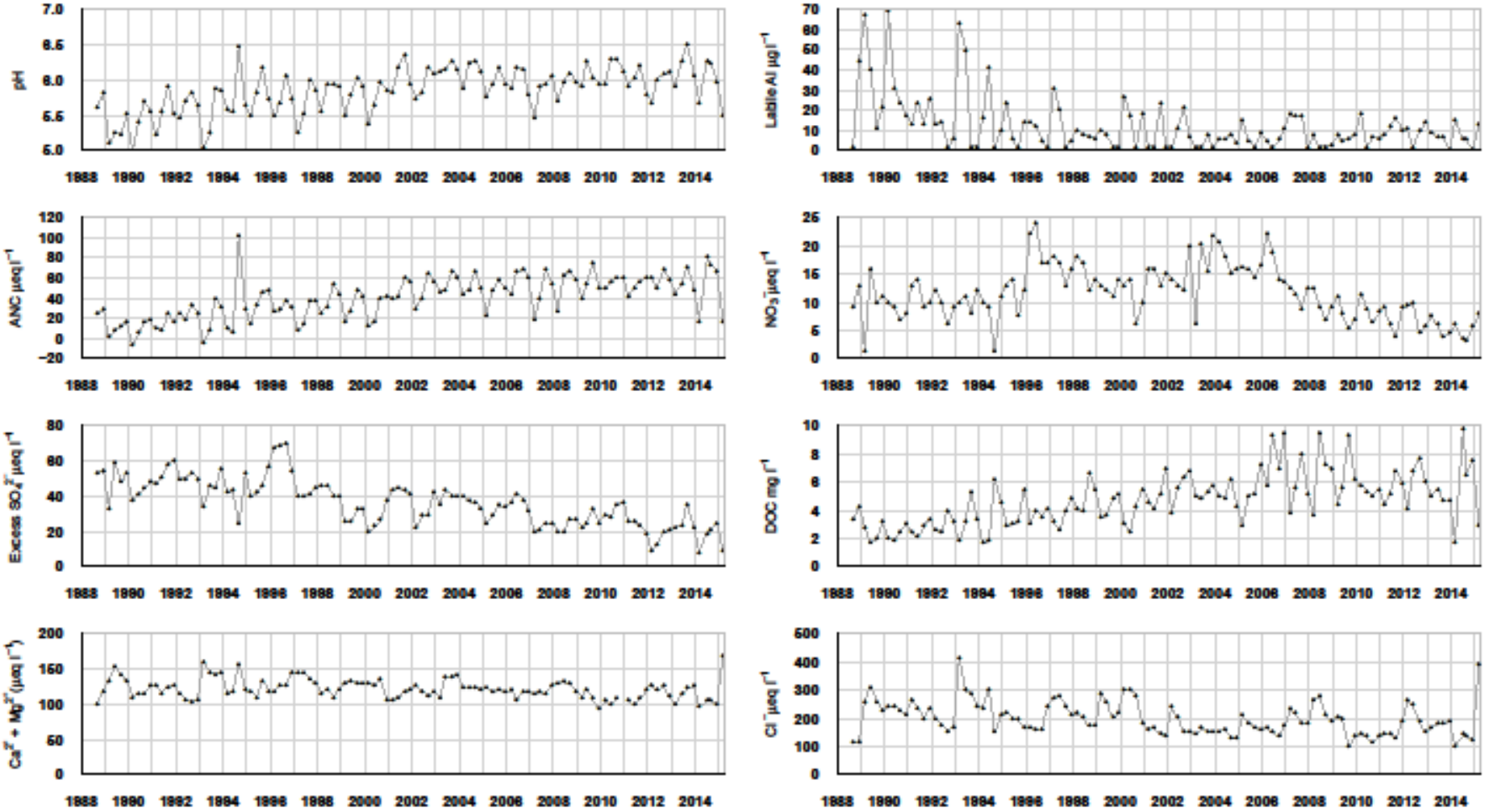



Temperature °C
20
15
10
5
0
Apr
Jul
Oct
Jan
Apr
Month (2012 - 2013)


Temperature °C
15
10
5
0
Apr
Jul
Oct
Jan
Apr
Month (2011 - 2012)

7.2 Loch Chon

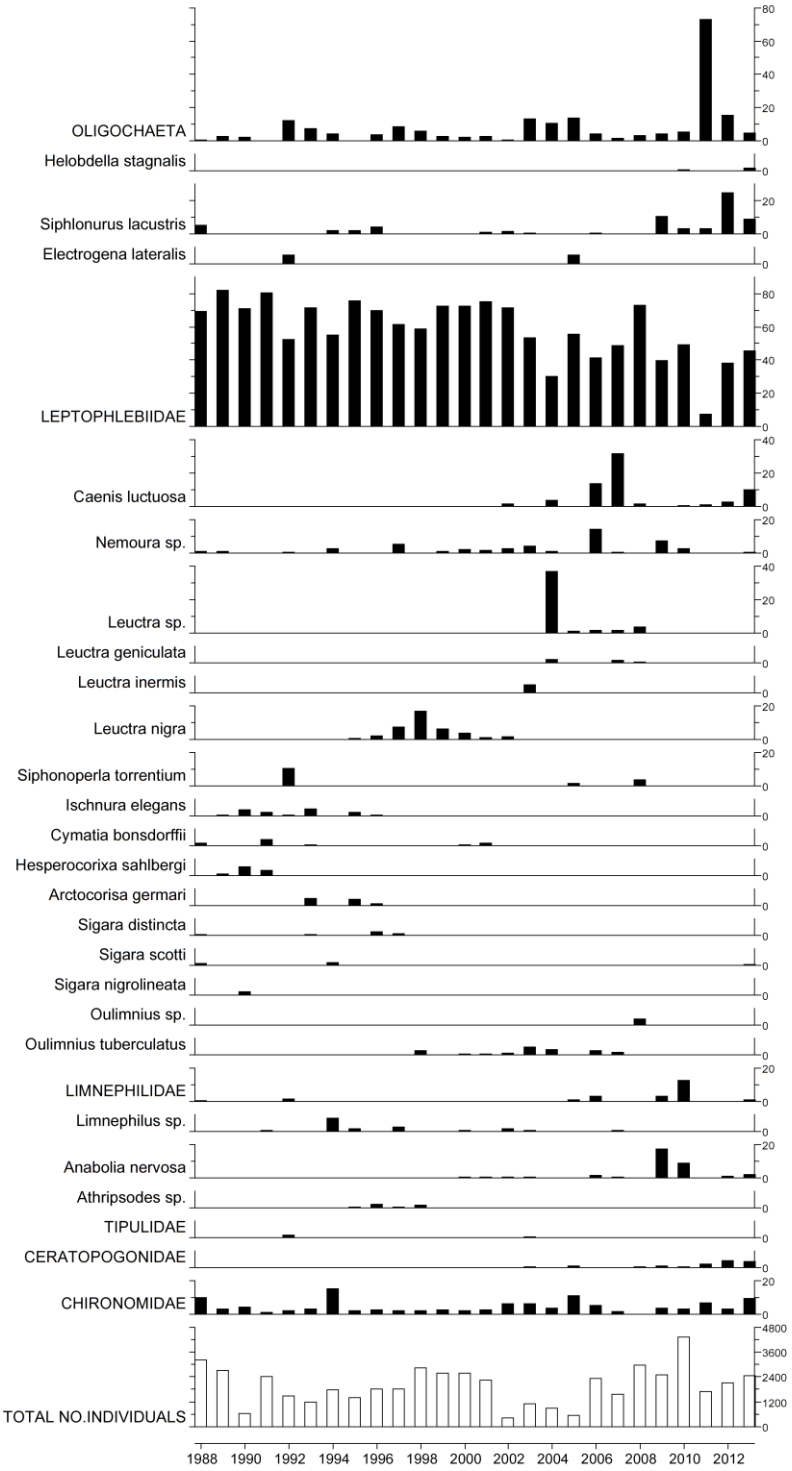
7.2.1 Spot sampled chemistry data



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
14-15 mean	6.00	58.93	73.12	46.96	171.46	5.64	37.00	6.50	198.06	38.86	18.10	5.09	6.70
14-15 std dev	0.37	28.52	13.39	19.59	73.93	1.59	12.03	4.93	127.33	7.06	6.71	2.20	2.87

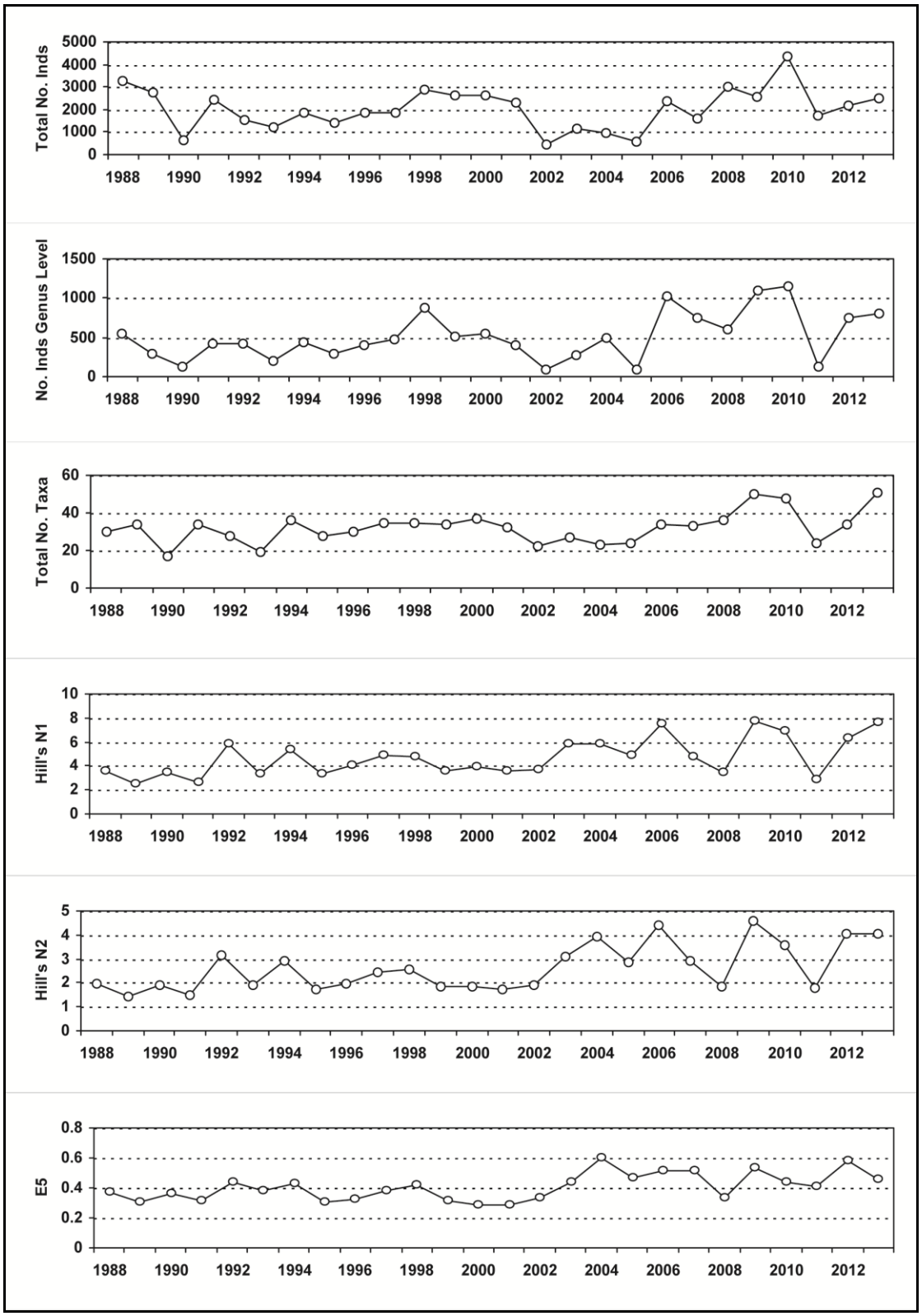
7.2.2 Macroinvertebrate data

7.2.2.1 Percentage abundance summary, Loch Chon



2014 and 2015 samples archived, awaiting funding for analysis.

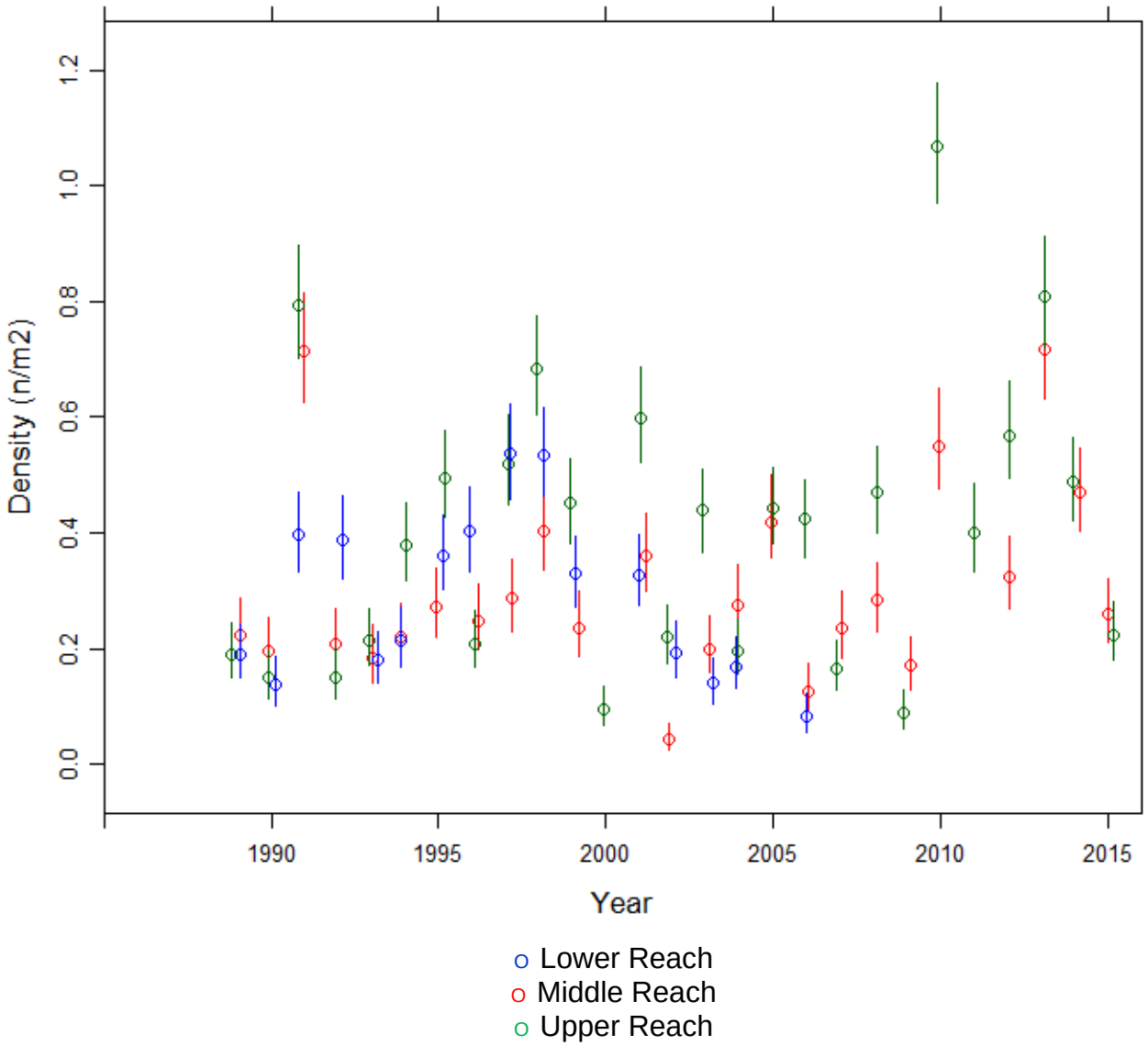
7.2.2.2 Summary statistics, Loch Chon



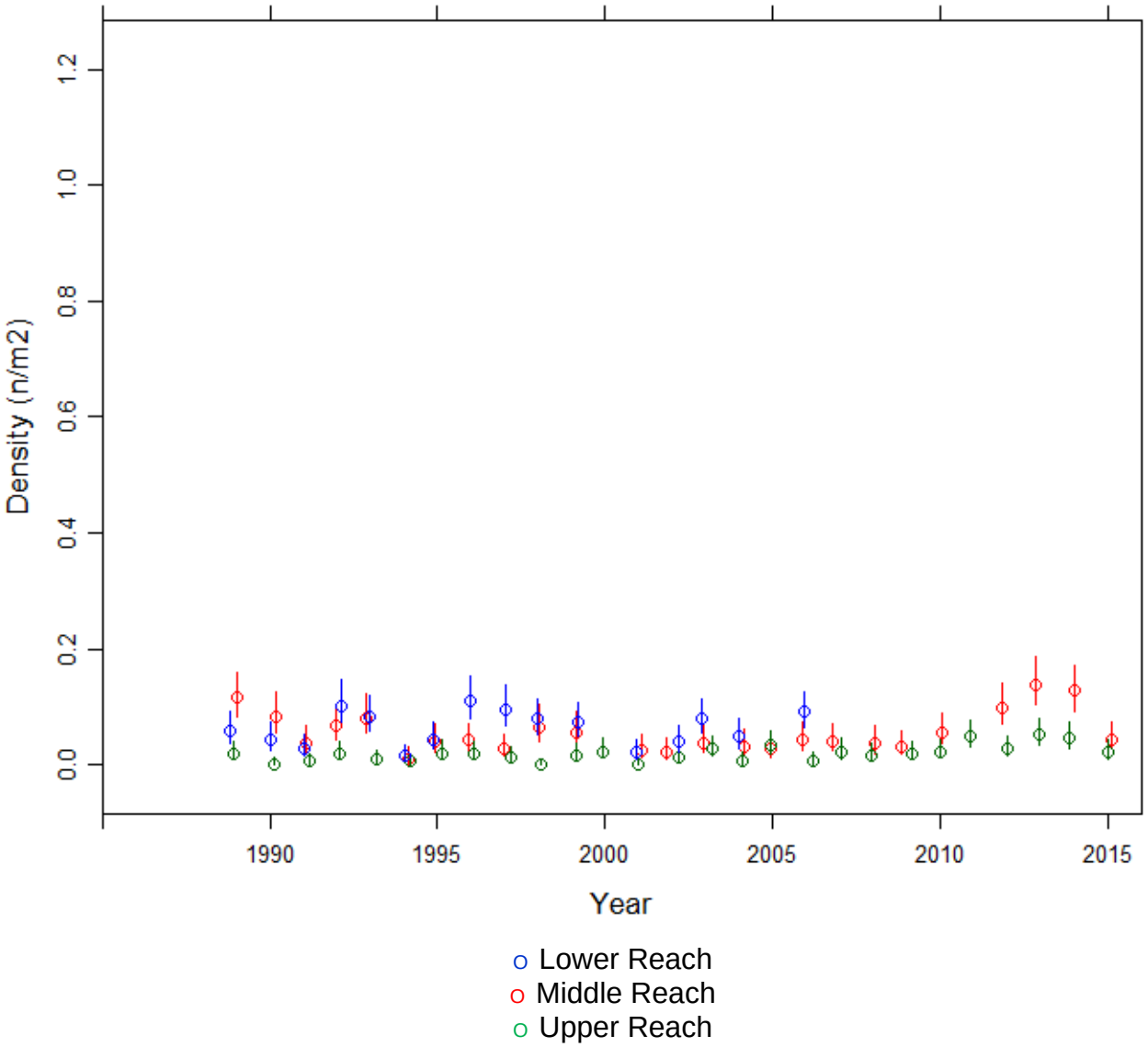
2014 and 2015 samples archived, awaiting funding for analysis.

7.2.3 Fish data (for outflow stream)

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

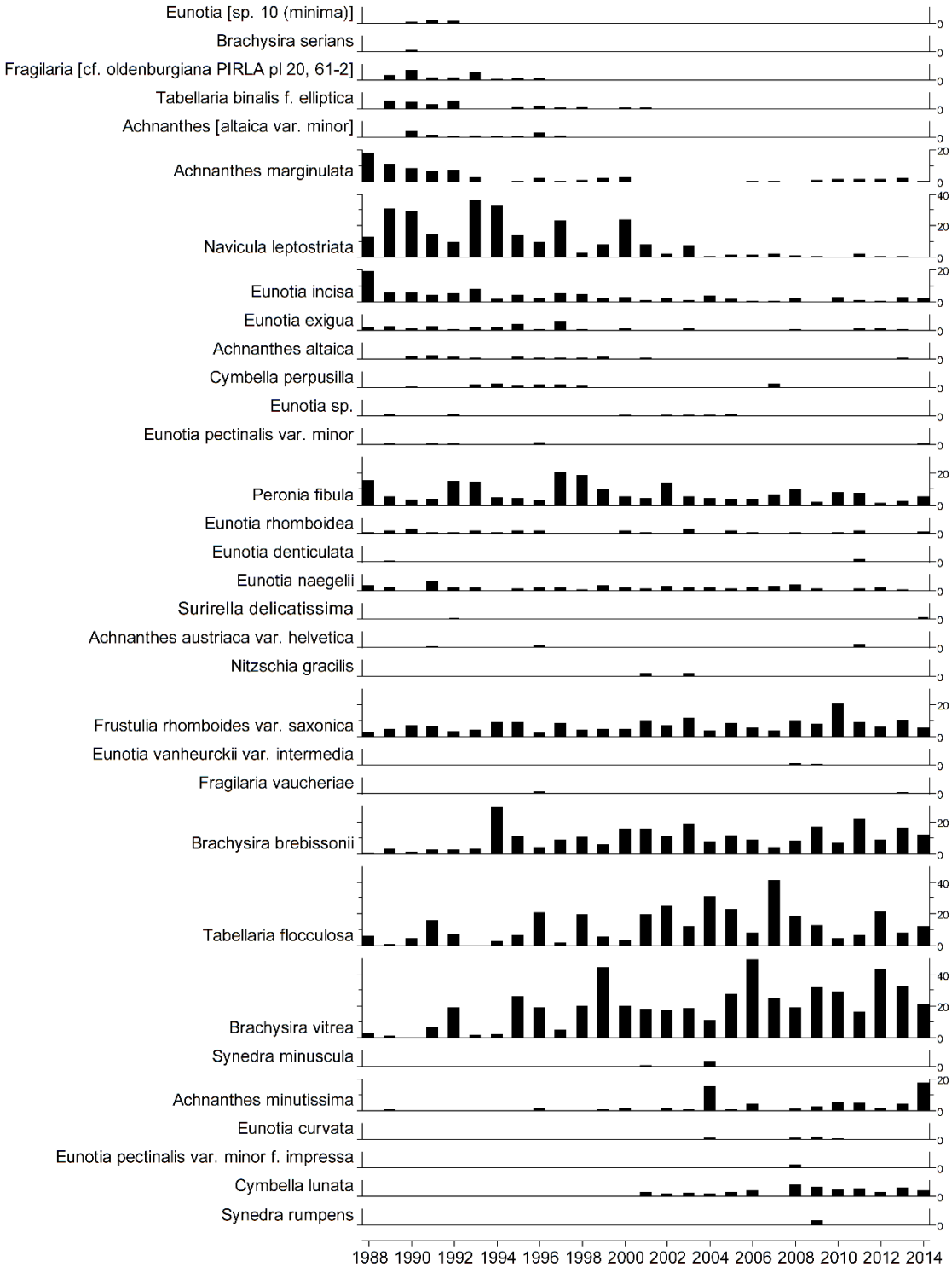


7.2.3.2 Summary of Trout parr densities (numbers m^{-2}), Loch Chon

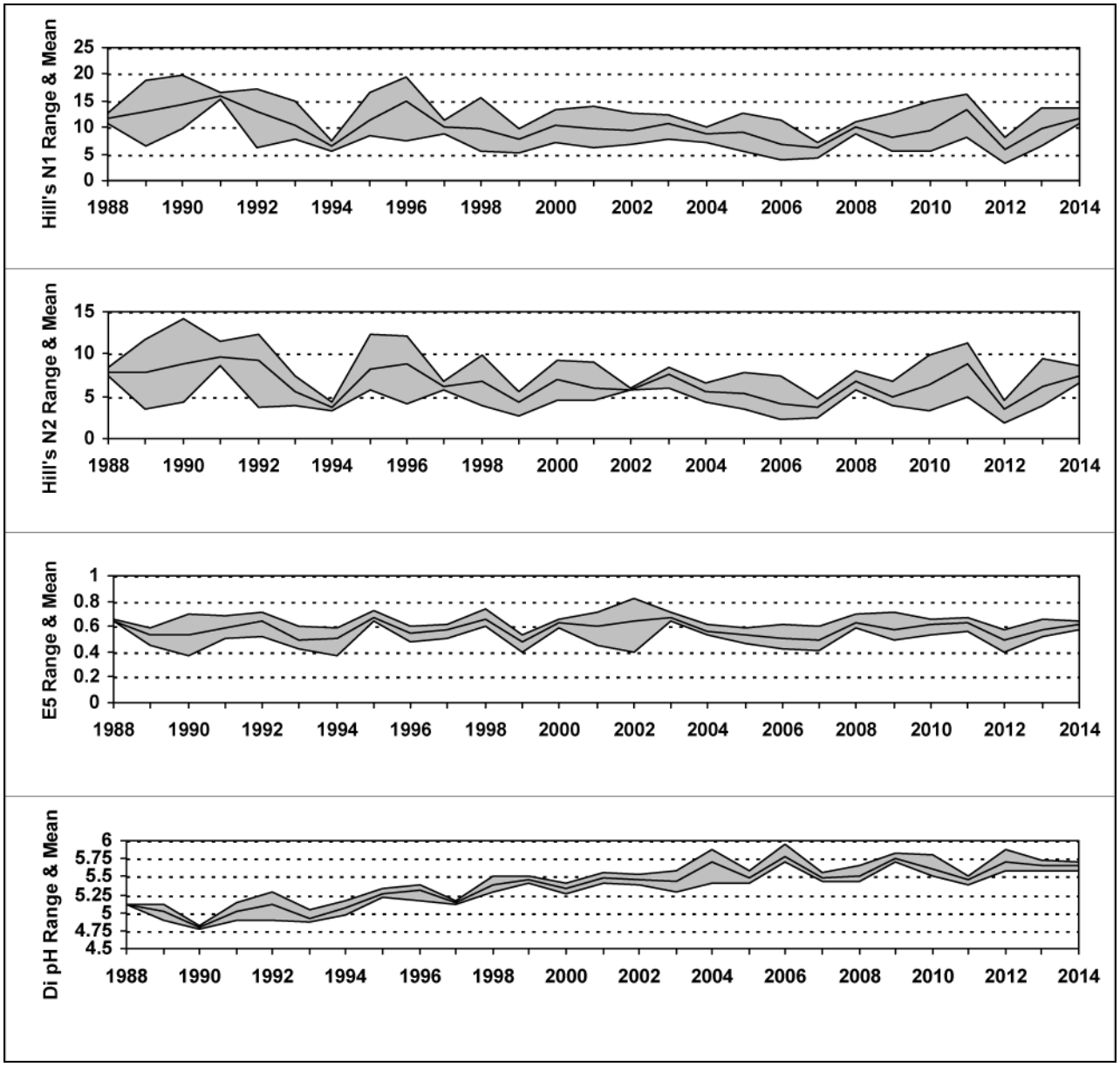


7.2.4 Epilithic diatom data

7.2.4.1 Percentage abundance summary, Loch Chon

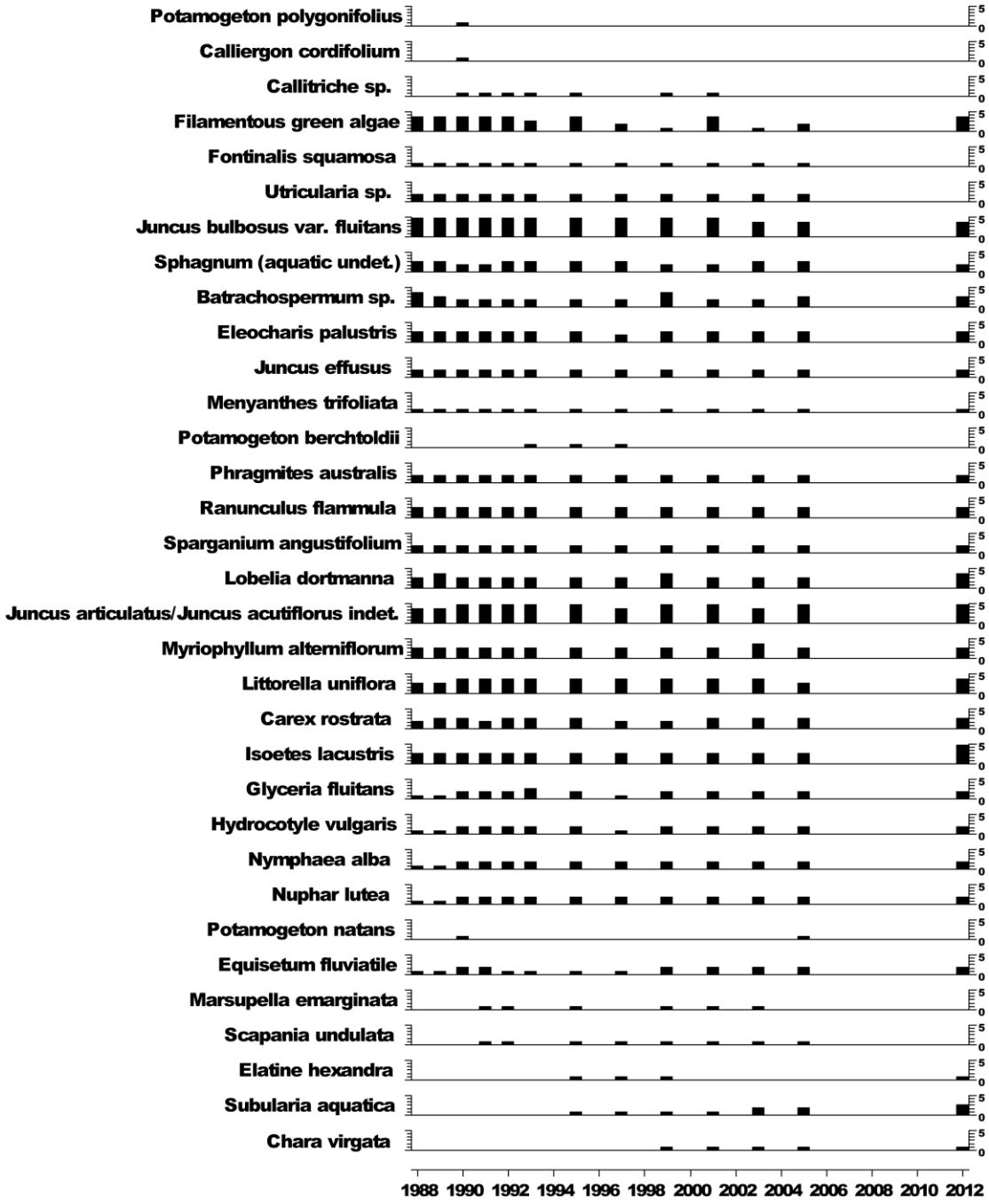


7.2.4.2 Summary statistics, Loch Chon



7.2.5 Aquatic macrophyte data, Loch Chon

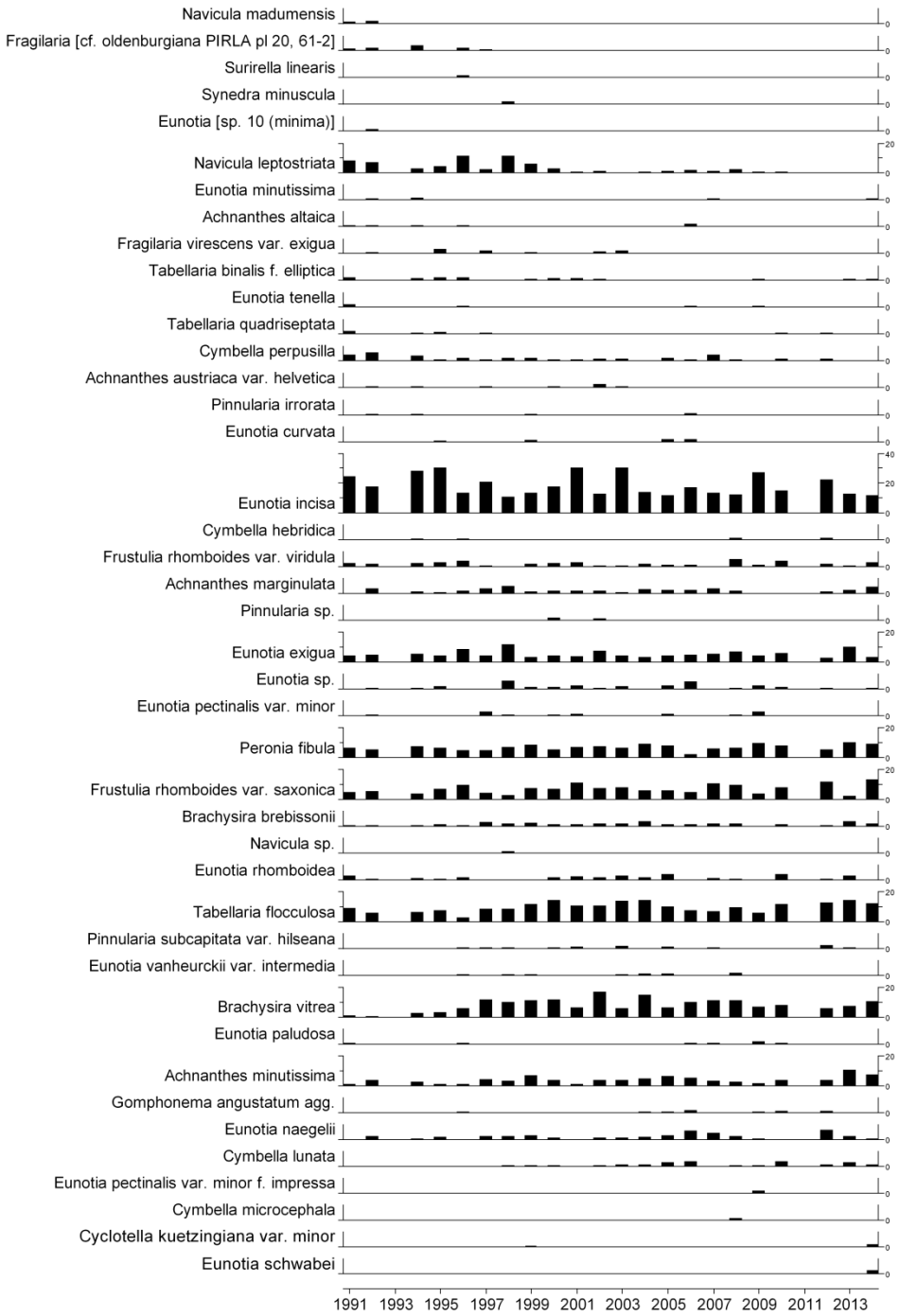
Species Scores (1-5)



No surveys 2007-2011 and 2013-2015 due to funding cuts.

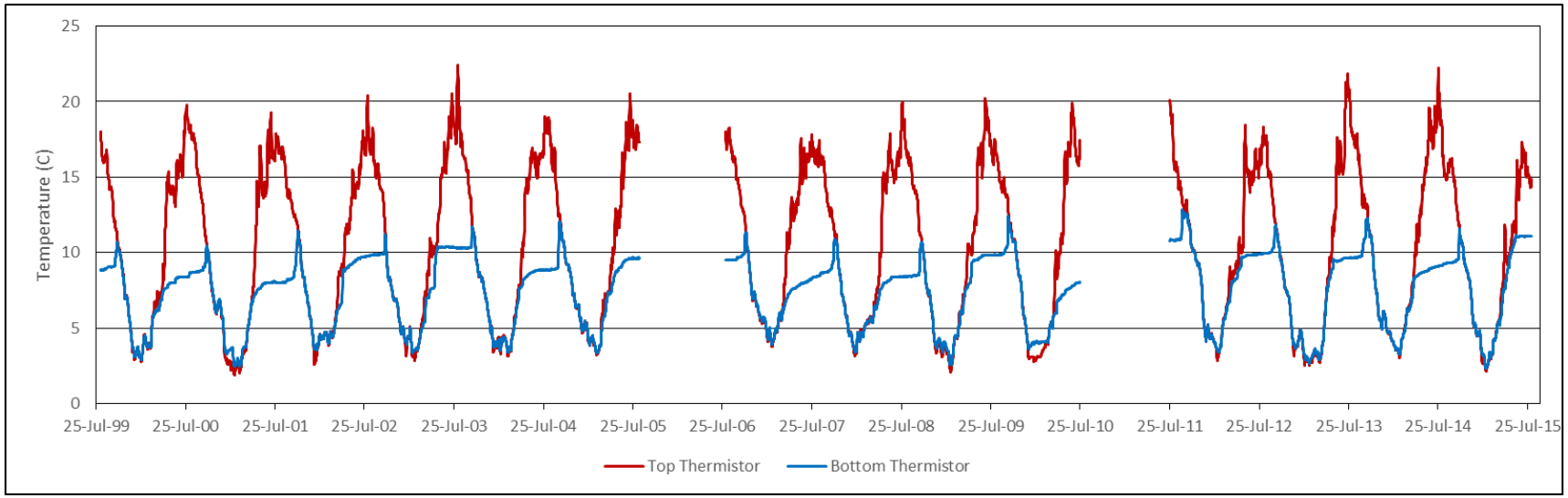
7.2.6 Sediment trap diatom data, Loch Chon

Relative percentage frequency of diatom taxa



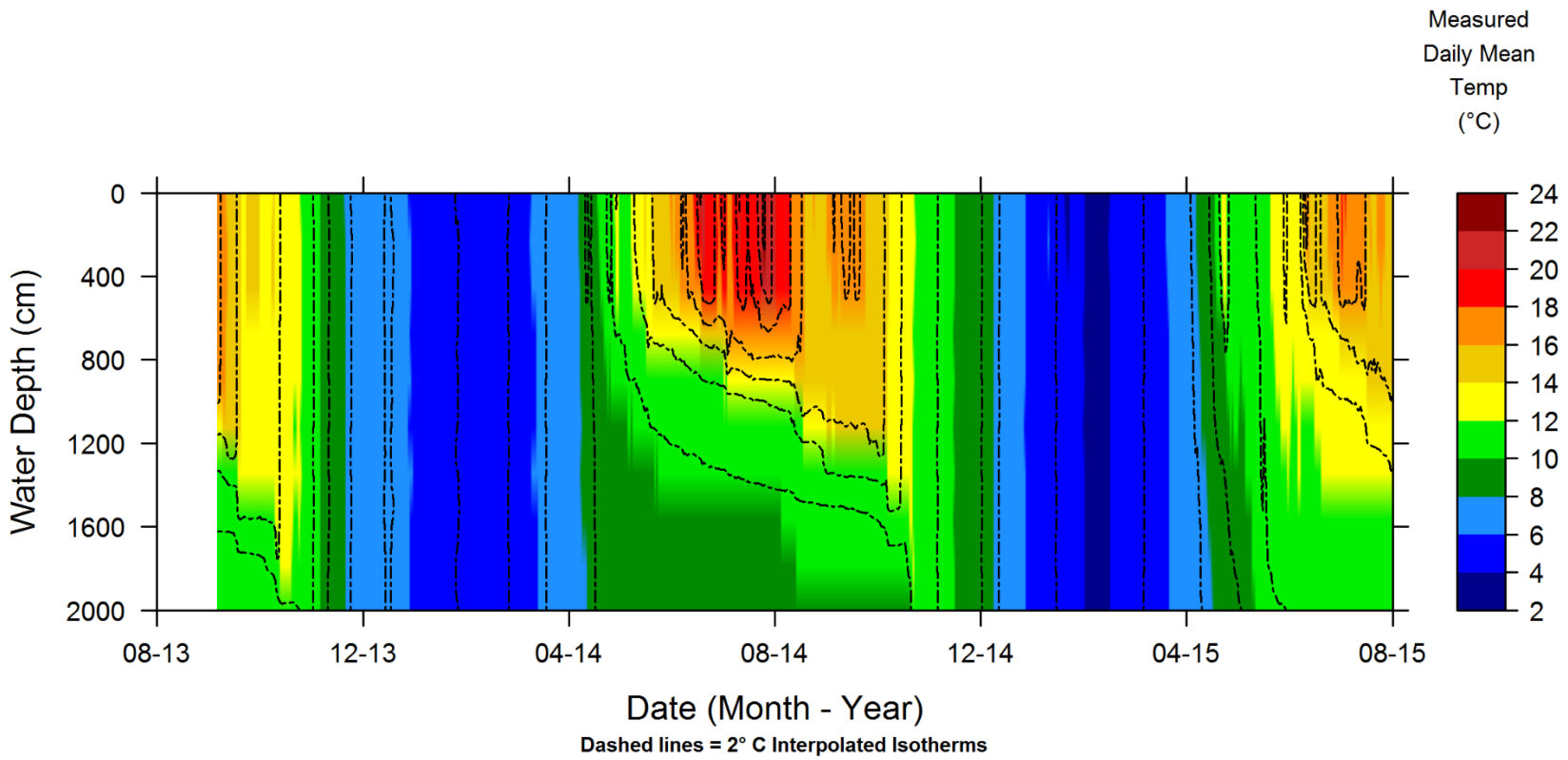
Traps not recovered in 1993 or 2011

7.2.7 Sediment trap thermistor data, Loch Chon



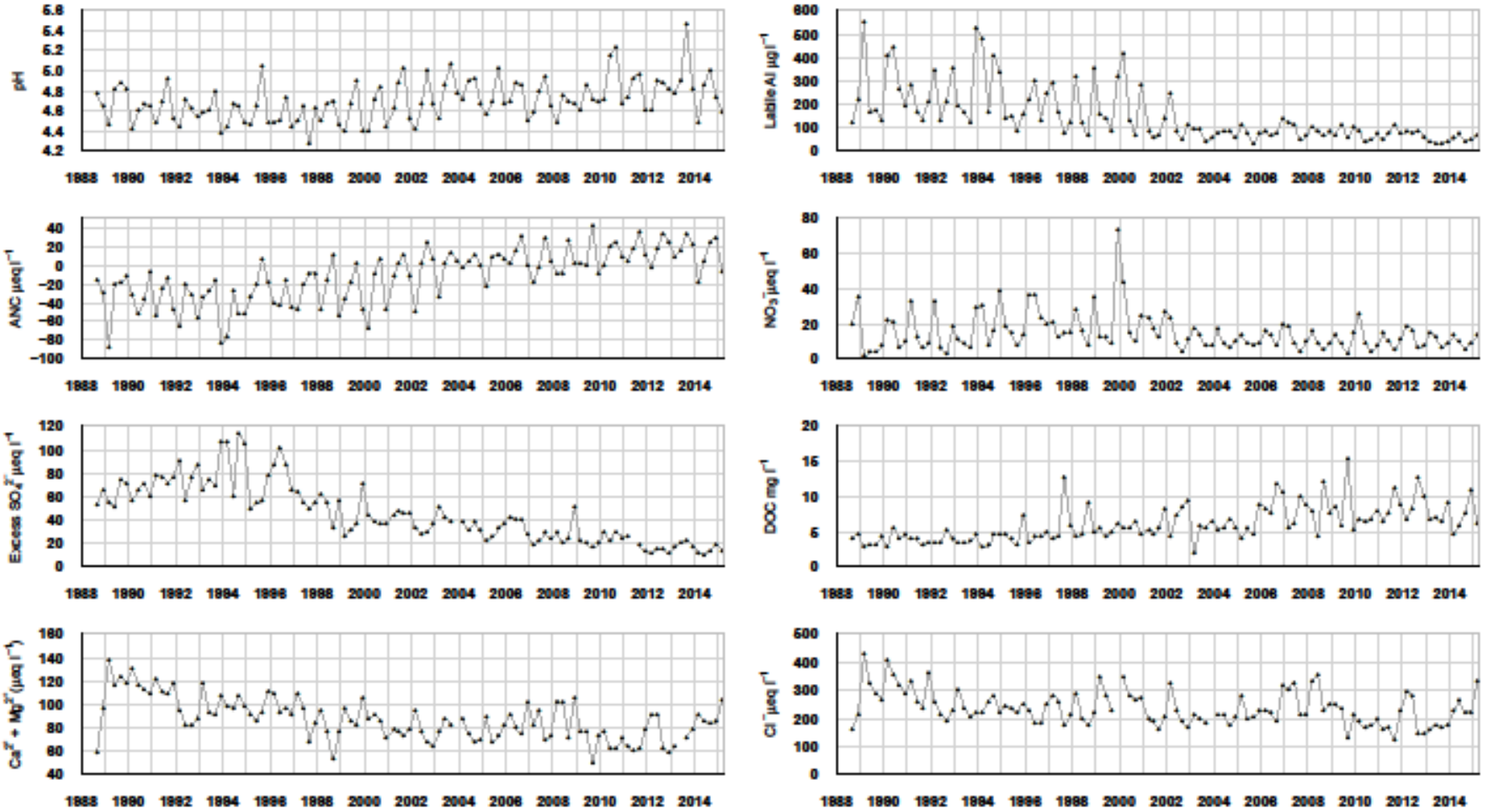
Thermistors not recovered in 2006 or 2011

7.2.8 Thermistor chain data, Loch Chon



7.3 Loch Grannoch

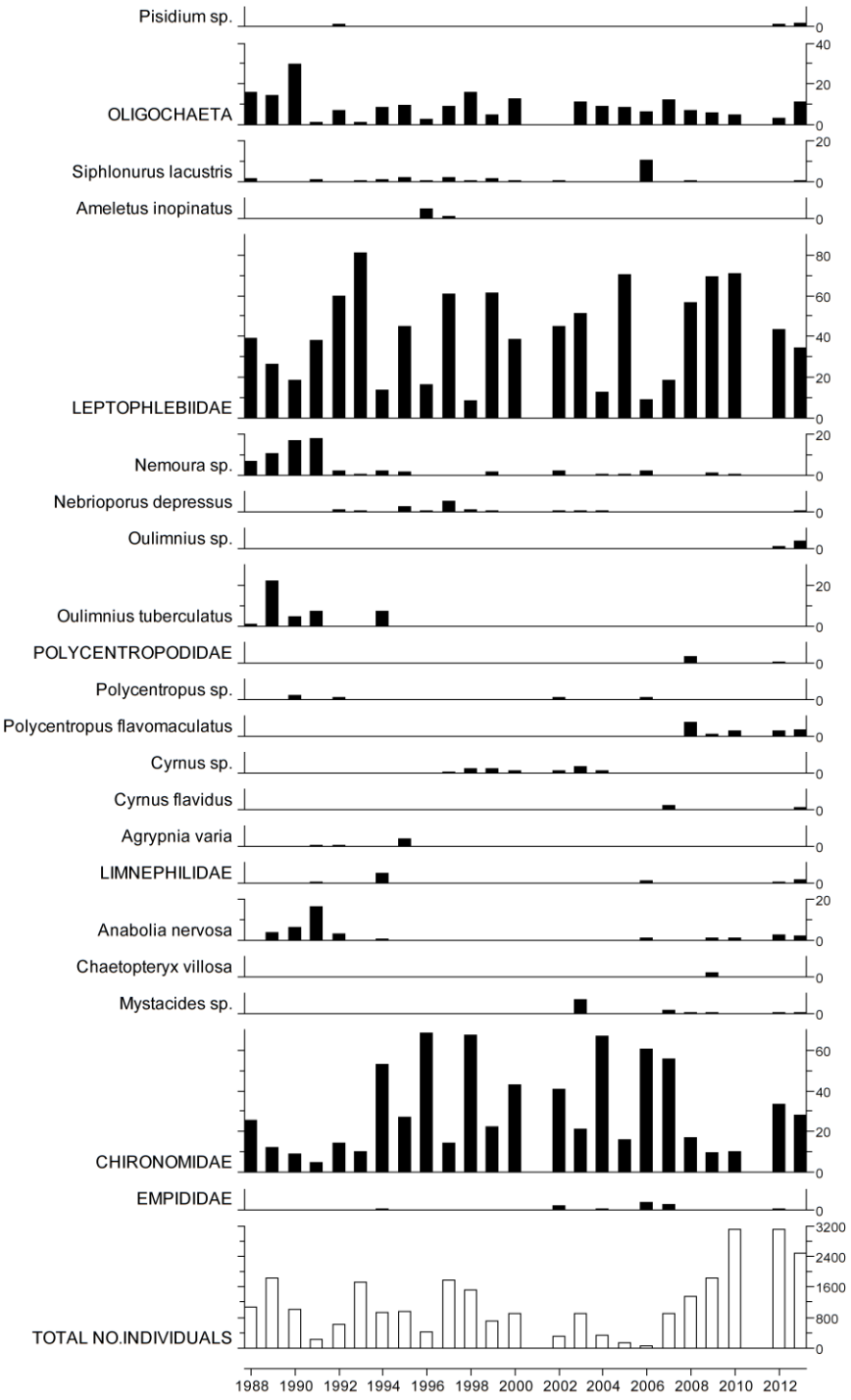
7.3.1 Spot sampled chemistry data



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
14-15 mean	4.79	12.70	37.57	51.93	228.92	8.48	153.75	59.75	260.24	41.33	14.04	9.66	7.64
14-15 std dev	0.17	16.90	2.13	7.88	28.96	2.77	19.19	16.21	51.55	4.98	3.62	3.11	2.34

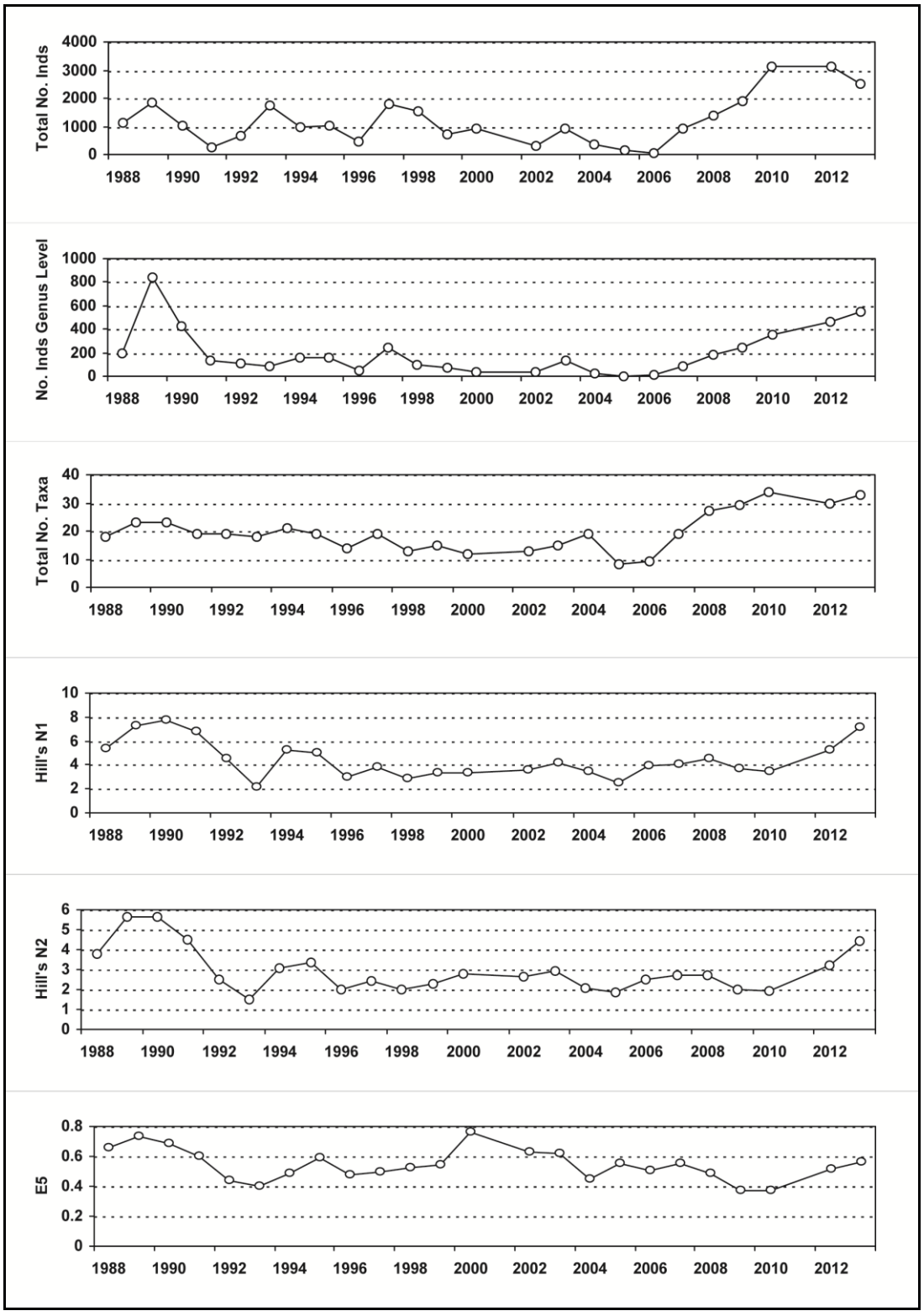
7.3.2 Macroinvertebrate data

7.3.2.1 Percentage abundance summary, Loch Grannoch



2014 and 2015 samples archived, awaiting funding for analysis. Not sampled in 2011. No sampling in 2001 due to Foot and Mouth restrictions.

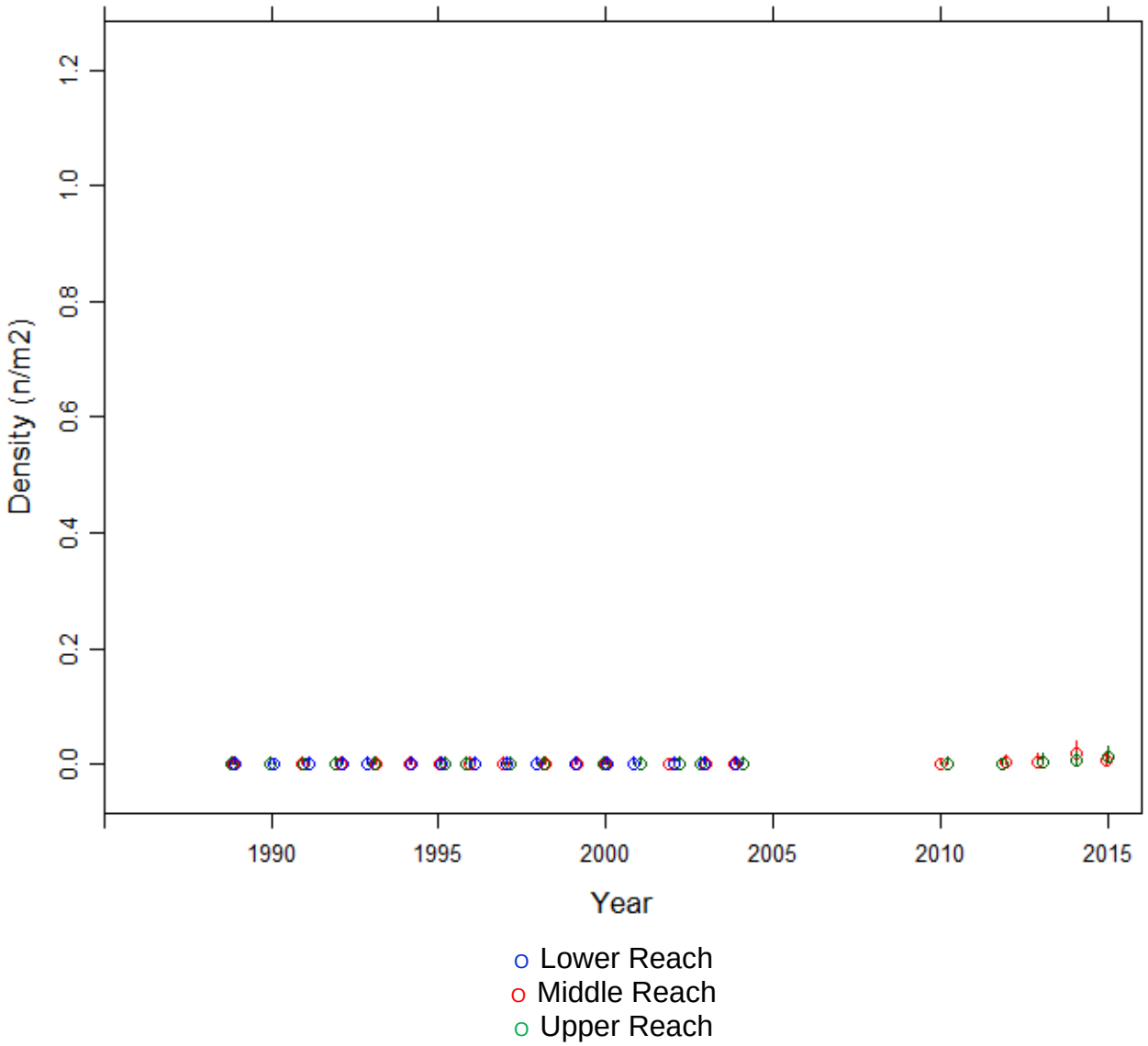
7.3.2.2 Summary statistics, Loch Grannoch



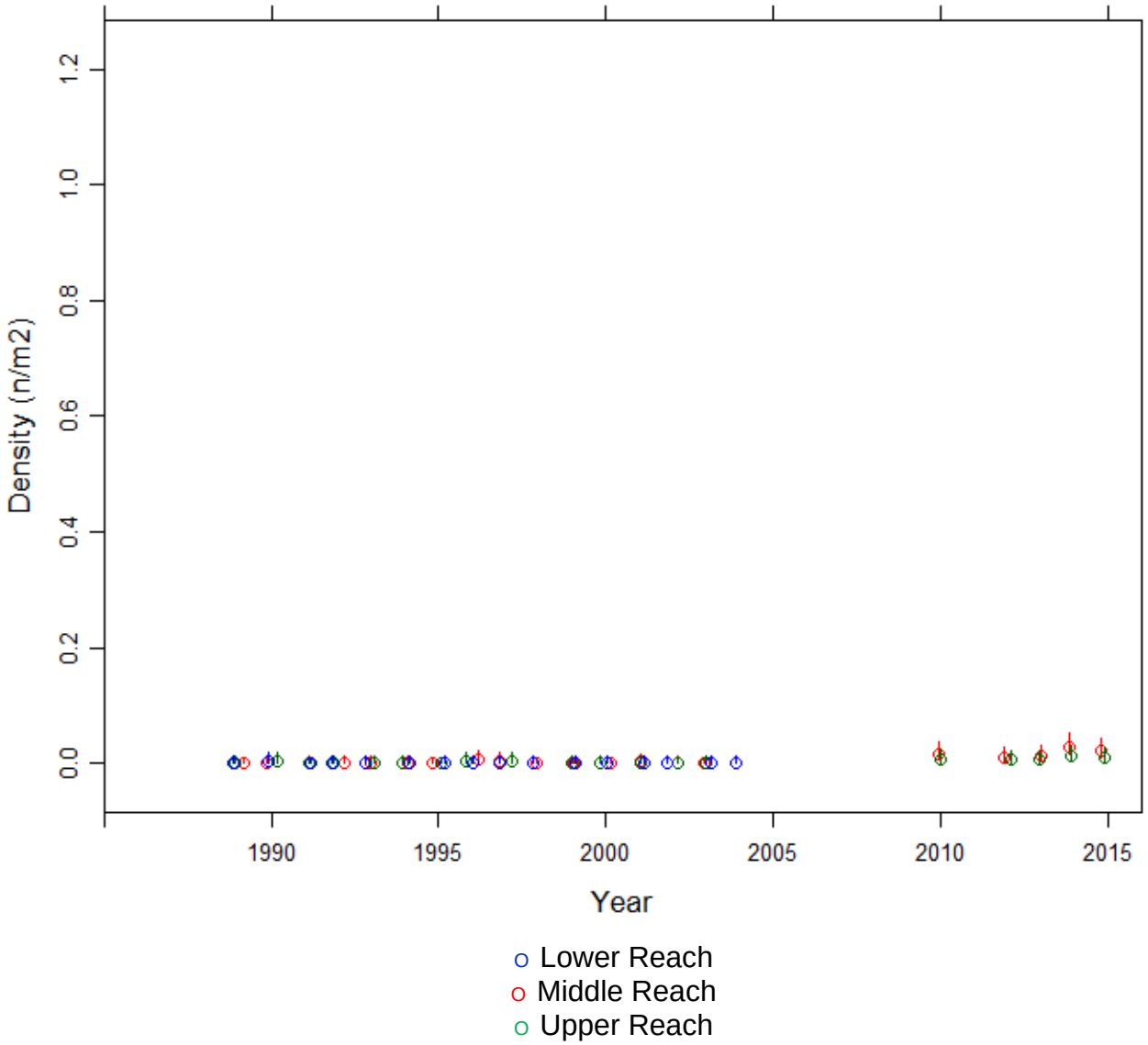
2014 and 2015 samples archived, awaiting funding for analysis. Not sampled in 2011. No sampling in 2001 due to Foot and Mouth restrictions.

7.3.3 Fish data (for outflow stream)

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

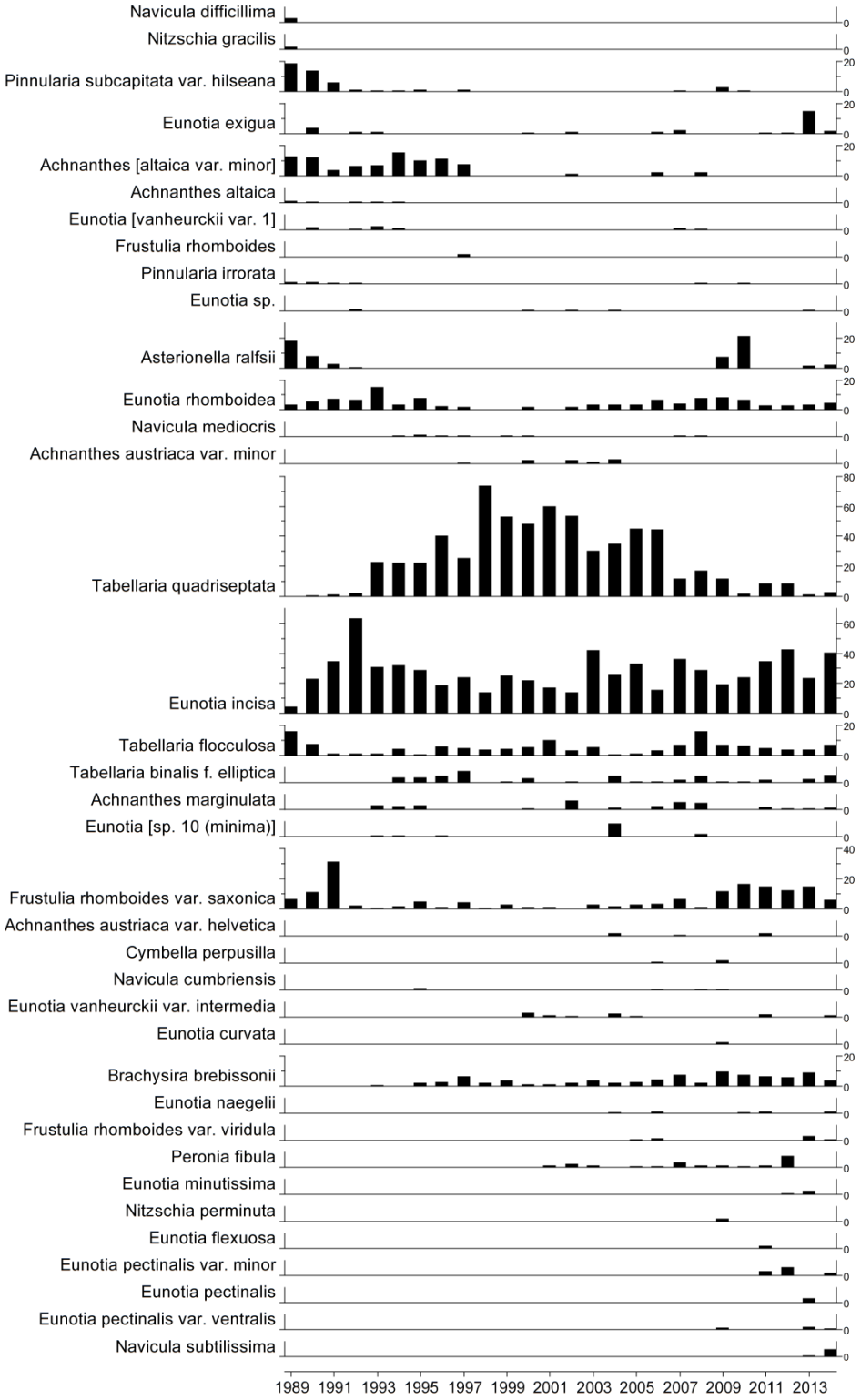


7.3.3.2 Summary of Trout parr densities (numbers m^{-2}), Loch Grannoch

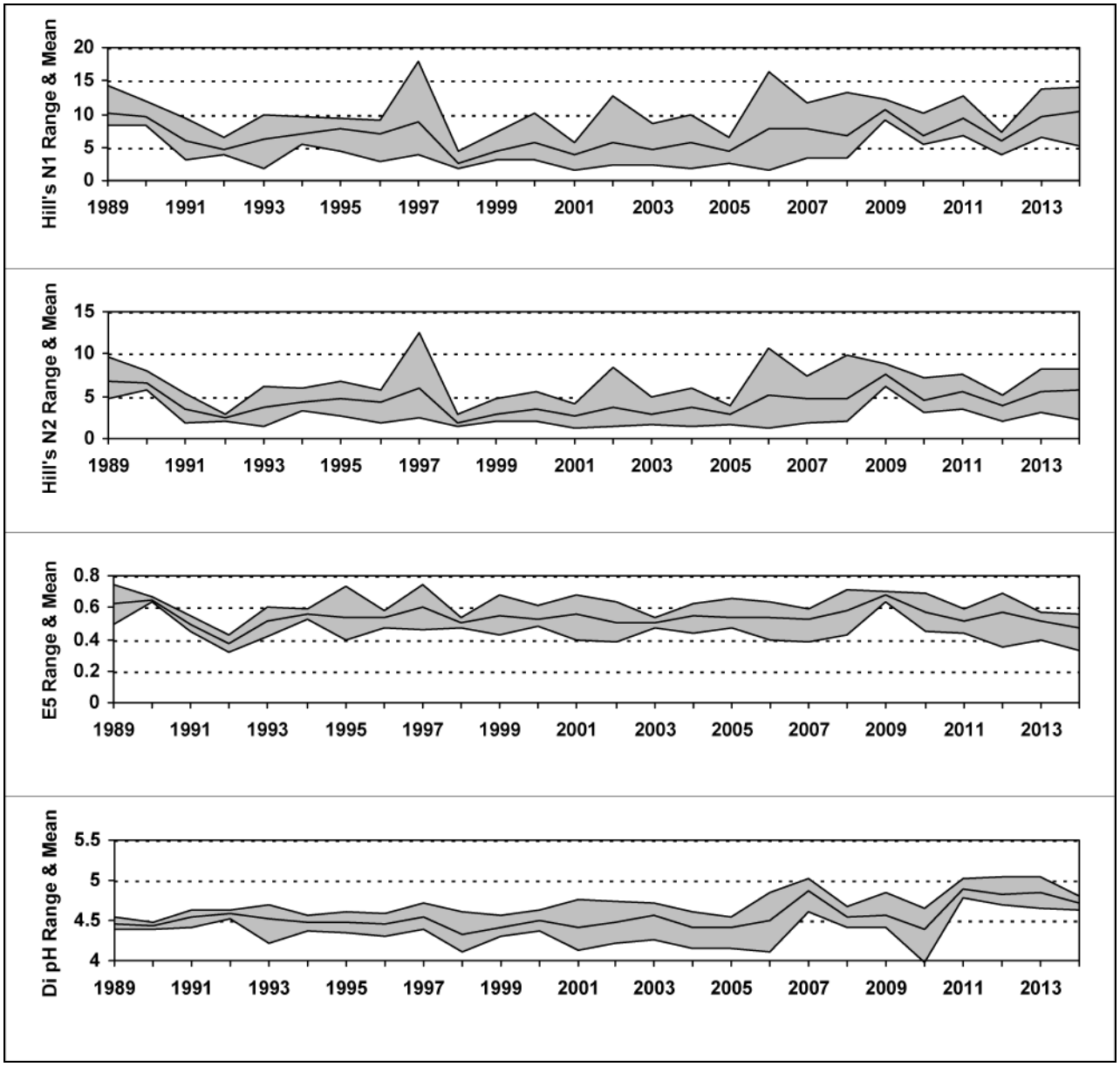


7.3.4 Epilithic diatom data

7.3.4.1 Percentage abundance summary, Loch Grannoch

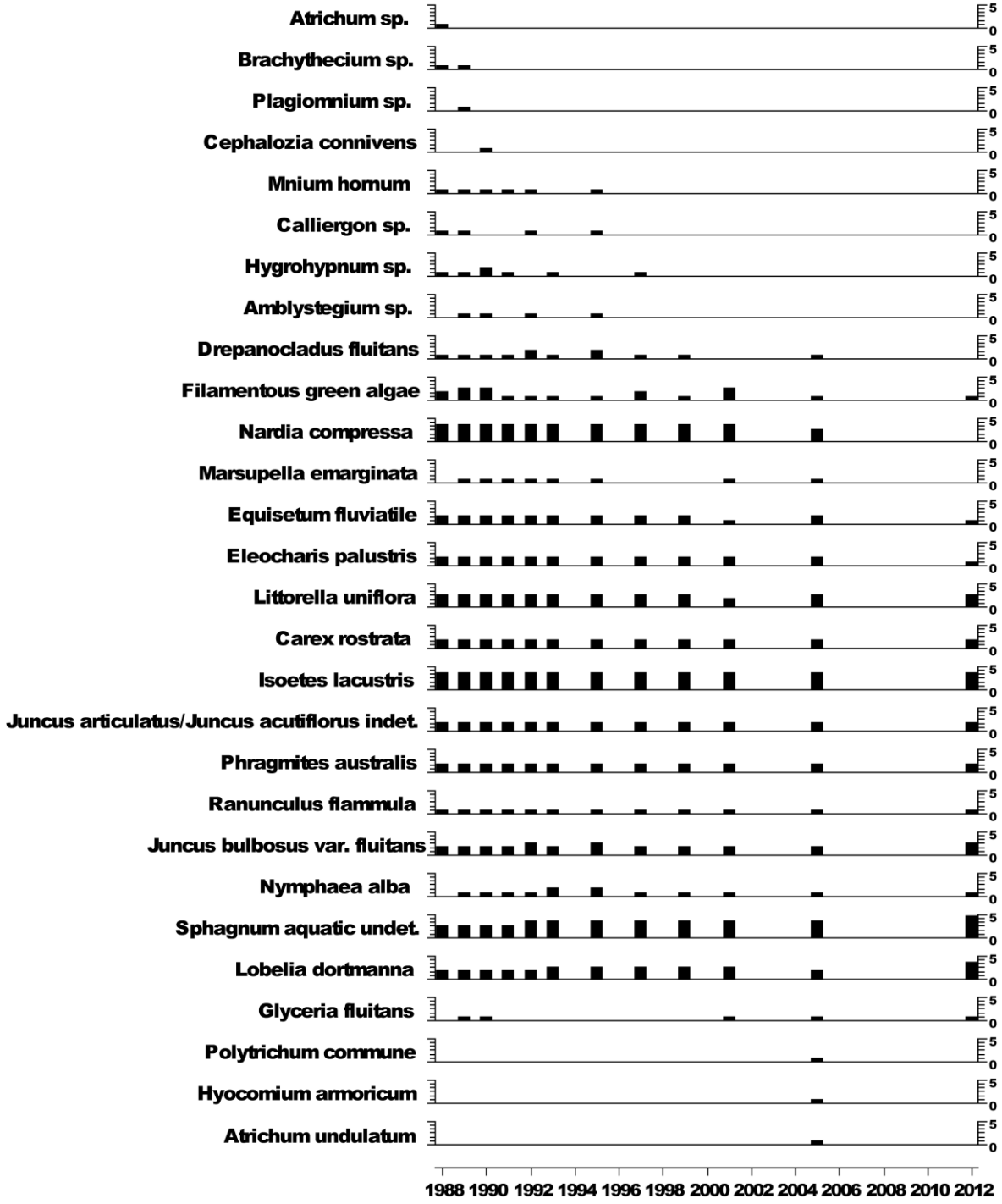


7.3.4.2 Summary statistics, Loch Grannoch



7.3.5 Aquatic macrophyte data, Loch Grannoch

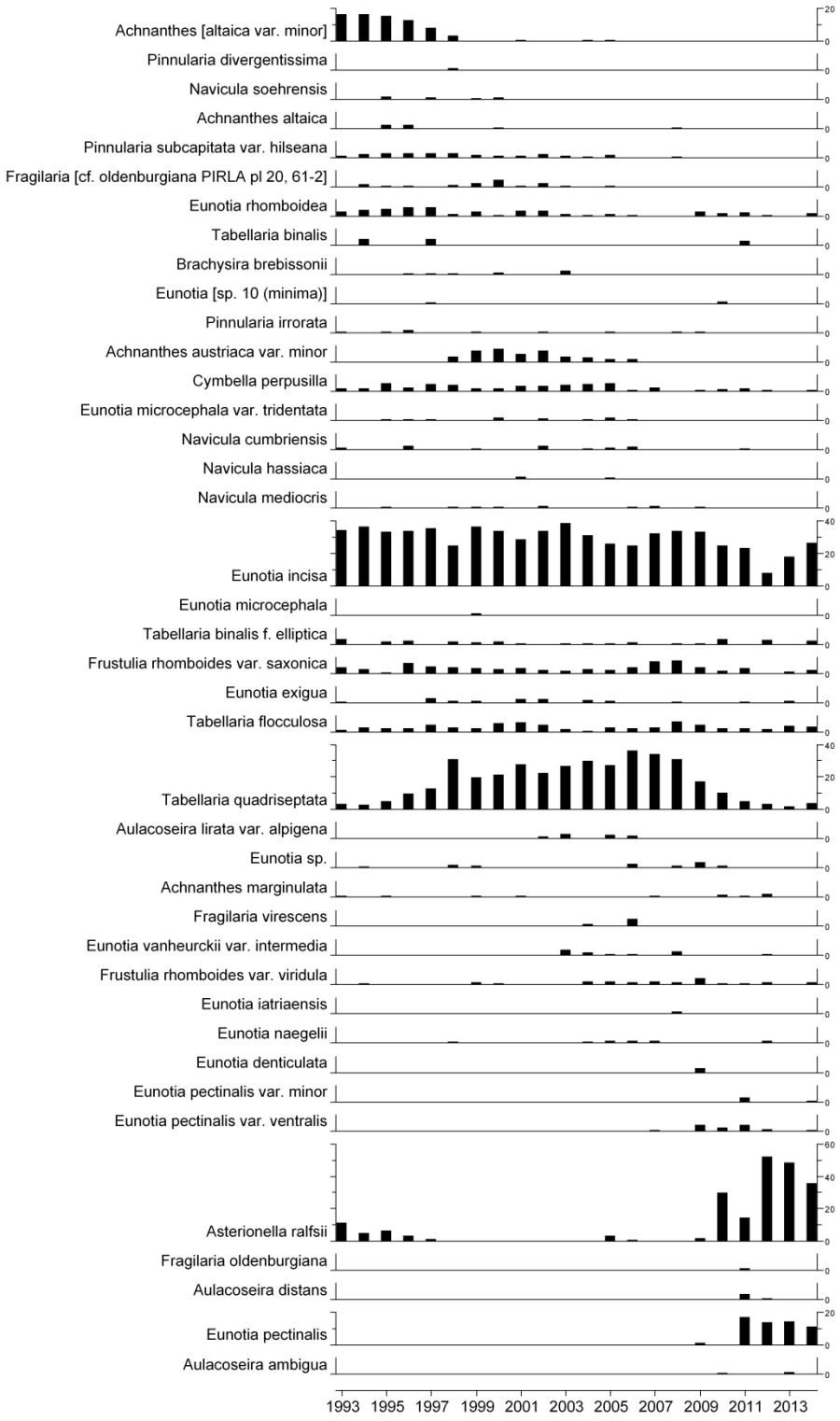
Species Scores (1-5)



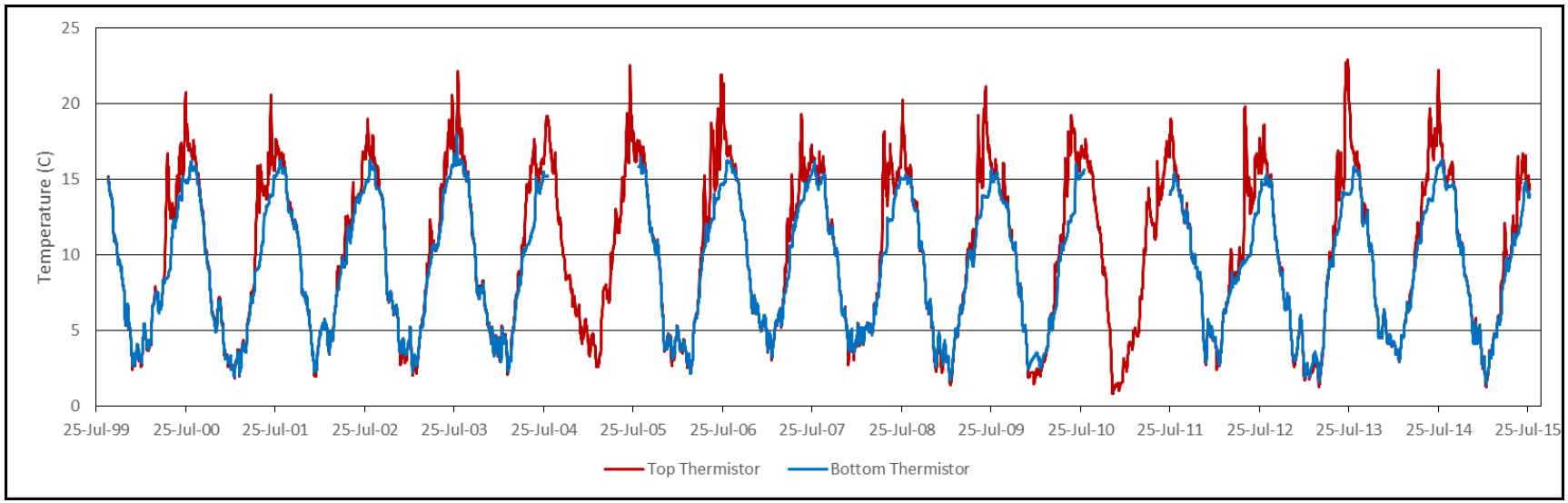
No surveys 2007-2011 and 2013-2015 due to funding cuts.

7.3.6 Sediment trap diatom data, Loch Grannoch

Relative percentage frequency of diatom taxa



7.3.7 Sediment trap thermistor data, Loch Grannoch



7.3.8 Thermistor chain data, Loch Grannoch