UCL ENVIRONMENTAL CHANGE RESEARCH CENTRE

UK Upland Waters Monitoring Network (UKUWMN)

Llyn Llagi, Llyn Cwm Mynach, Afon Hafren and Afon Gwy

Annual Summary Progress Report. April 16 - March 17

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

October 2017

UK UPLAND WATERS MONITORING NETWORK (UKUWMN) –

LLYN LLAGI, LLYN CWM MYNACH, AFON HAFREN AND AFON GWY

ANNUAL SUMMARY PROGRESS REPORT April 2016 - March 2017

REPORT TO THE WELSH ASSEMBLY GOVERNMENT AND NATURAL RESOURCES WALES

Ewan M. Shilland[1], Don T. Monteith[2], Karen Millidine[3], Ian A. Malcolm[3] & Dave A. Norris[4]

October 2017

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[3] Marine Scotland, Pitlochry
[4] CEH Bangor

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Cover photo: Afon Hafren survey section, September 2016.

3 Llyn Llagi

Figure 1 Llyn Llagi. looking towards Snowdon, 4th August 2016.

3.1 Summary Overview

The funded chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at Llyn Llagi during the period from April 2016 to March 2017.

In February 2017 the outflow logger and stageboard were removed pending building works for a National Trust micro-hydro scheme at the site. Subsequently plans for the scheme were withdrawn and it is hoped that the equipment can be reinstalled at the original location.

3.2 Water Chemistry

Samples were collected by CEH in early June, September and December 2016, and March 2017. They were delivered to the analytical laboratories on schedule and have all been analysed. The data is in the process of being quality controlled and archived in the UKUWMN central chemistry database at CEH Lancaster.

3.3 Sediment Traps

Sediment traps were recovered and replaced on the 4th of August 2016 by a team from ENSIS. Spheroidial Carbonaceous Particles in the sediment retrieved from the traps are currently being analysed. The sediment trap diatoms have been made into slides and await funding for analysis.

3.4 Thermistors

Lake top and bottom thermistors and the thermistor chain were removed and replaced on the 4th of August 2016 by a team from ENSIS. All had functioned well during the previous year and the data were added to the ENSIS and MS thermistor water temperature database.

3.5 Epilithic Diatoms

Epilithic diatoms were retrieved by a team from ENSIS from three sampling points around the lake on the 4th of August 2016. The samples have been made into slides.

3.6 Macroinvertebrates

Aquatic macroinvertebrates were sampled on the 16th April 2016 by a team from QMuL. Five 1 minute kick samples were performed. The samples have been archived pending funding being available for analysis.

3.7 Fish

Due to resourcing cuts, fish surveying was not performed in Autumn 2016.

3.8 Aquatic Macrophytes

Aquatic macrophytes were not surveyed at Llyn Llagi in 2016.

3.9 Data Management and Reporting

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

The 2015-2016 summary diagrams have been uploaded to the UKUWMN web page. The section on Llyn Llagi appears in section 3.11 below.

The UKUWMN website page detailing Llyn Llagi can be found here:
http://uwmn.defra.gov.uk/sites/site_15.php

Further publications from the contract period utilizing UKUWMN data from Llyn Llagi are detailed in section 3.10 below.

3.10 Llyn Llagi Recent UKUWMN Output

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Garmo, O. A., de Wit, H. A., Høgåsen, T., Lund, E., Wright, R. F., Aherne, J., Arle, J., Colombo, L., Fölster, J., Hruška, J., Indriksone, I., Jeffries, D. S., Krám, P., Monteith, D. T., Paterson, A., Rogora, M., Rzychon, D., Steingruber, S., Stoddard, J. L., Talkop, R., Ulanczyk, R. P. & Vuorenmaa, J. (2015) Trends in water chemistry. In: *ICP Waters Report 119/2015. Chemical and biological recovery in acid-sensitive waters: trends and prognosis*, 8-39, NIVA, Oslo, Norway.

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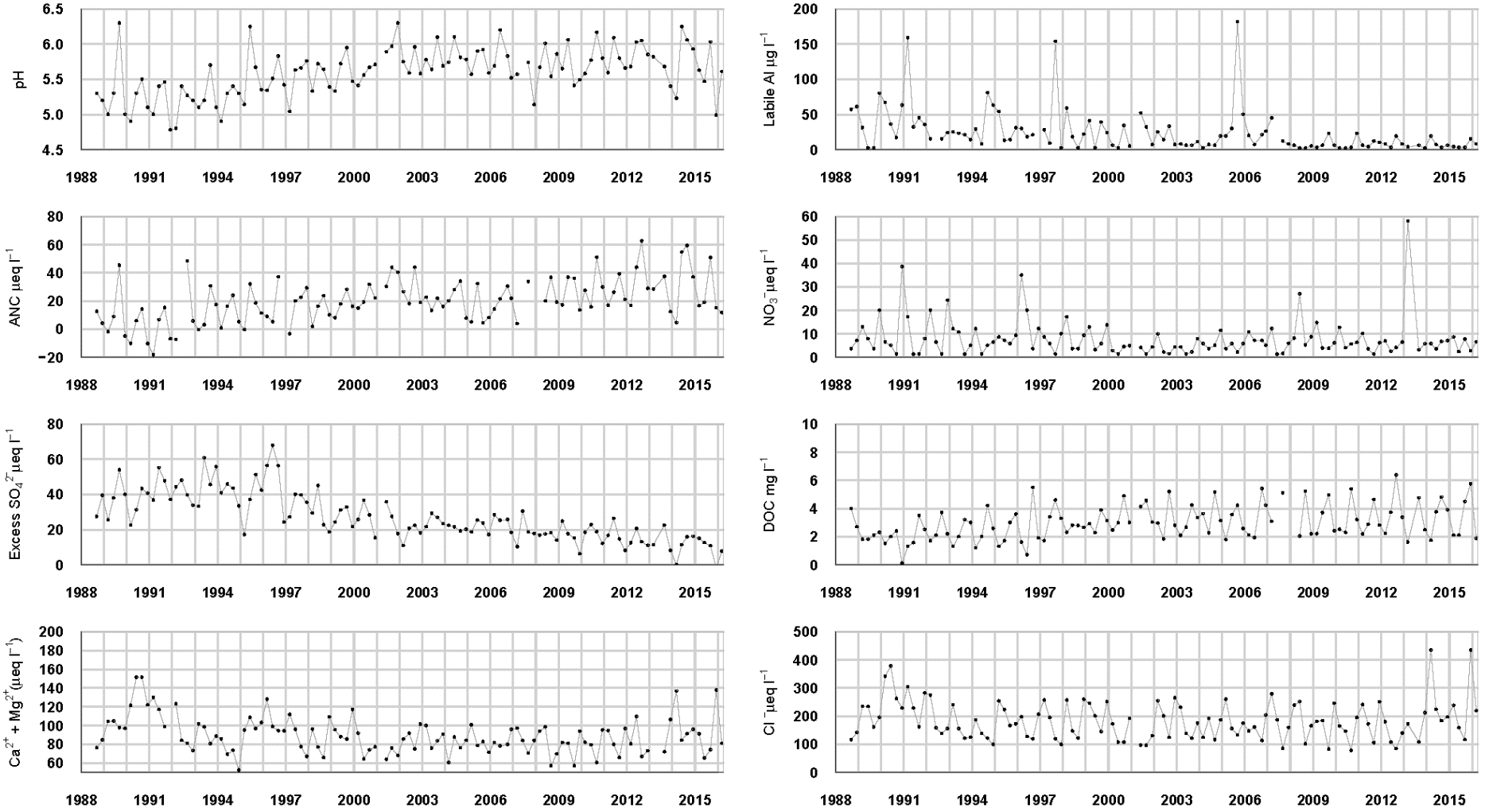
3.11 Llyn Llagi Summary Data to March 2016

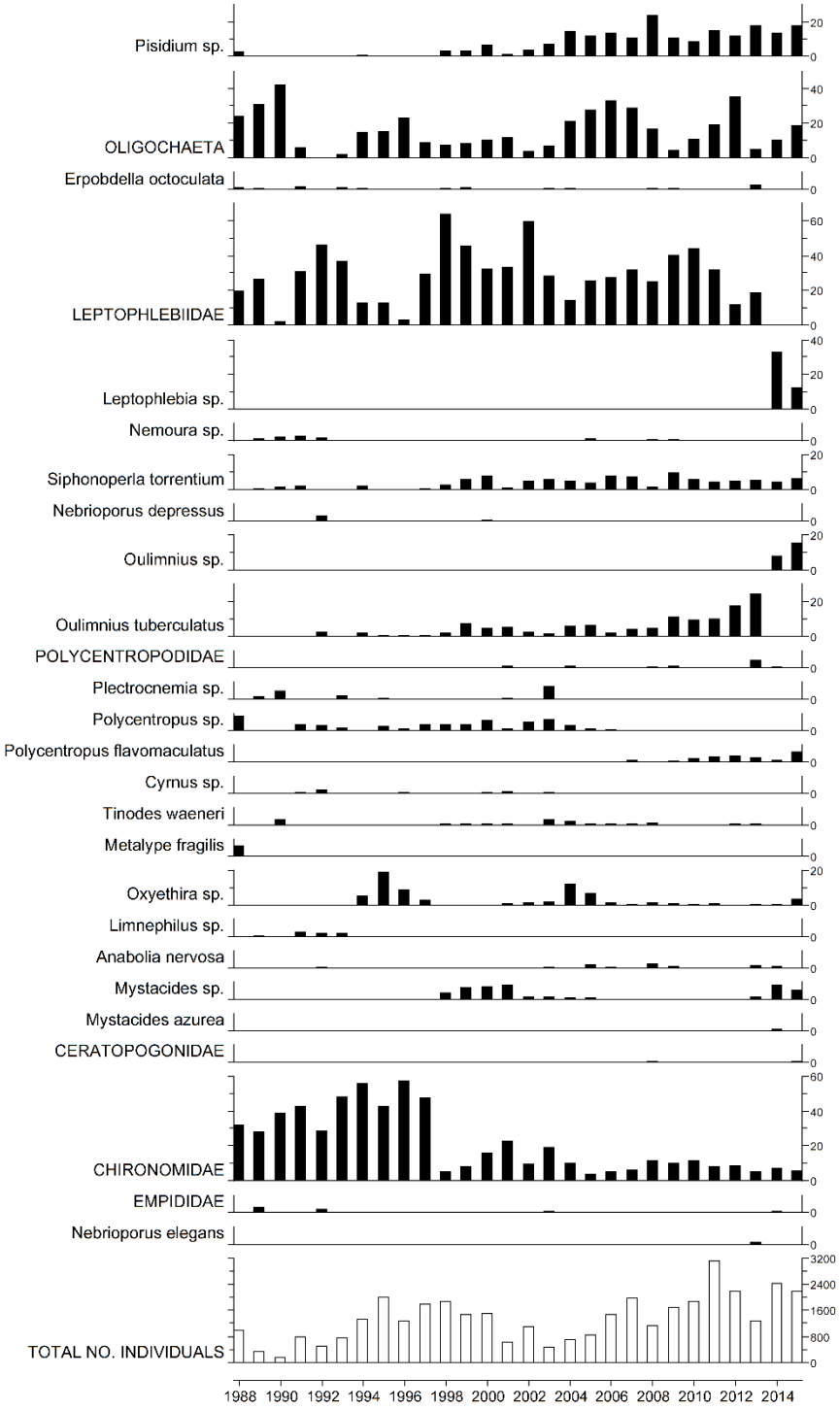
3.11.1 Spot sampled chemistry data



µeq l⁻¹ , *µg l⁻¹, **mg l⁻¹	pH	ANC	Ca 2+	Mg 2+	Na +	K +	*Soluble Al	*Labile Al	Cl -	*SO4 2-	xSO4 2-	NO3 -	**DOC
Mean 1st 5 yrs	5.23	5.71	56.70	49.69	185.75	3.54	75.37	41.61	219.33	62.91	39.91	10.44	2.13
15-16 mean	5.52	24.12	41.35	48.10	202.71	5.01	33.75	7.25	232.10	31.68	7.35	4.82	3.55
15-16 std dev	0.43	18.03	10.56	22.95	98.26	3.00	10.59	5.68	141.31	8.69	6.43	2.69	1.88

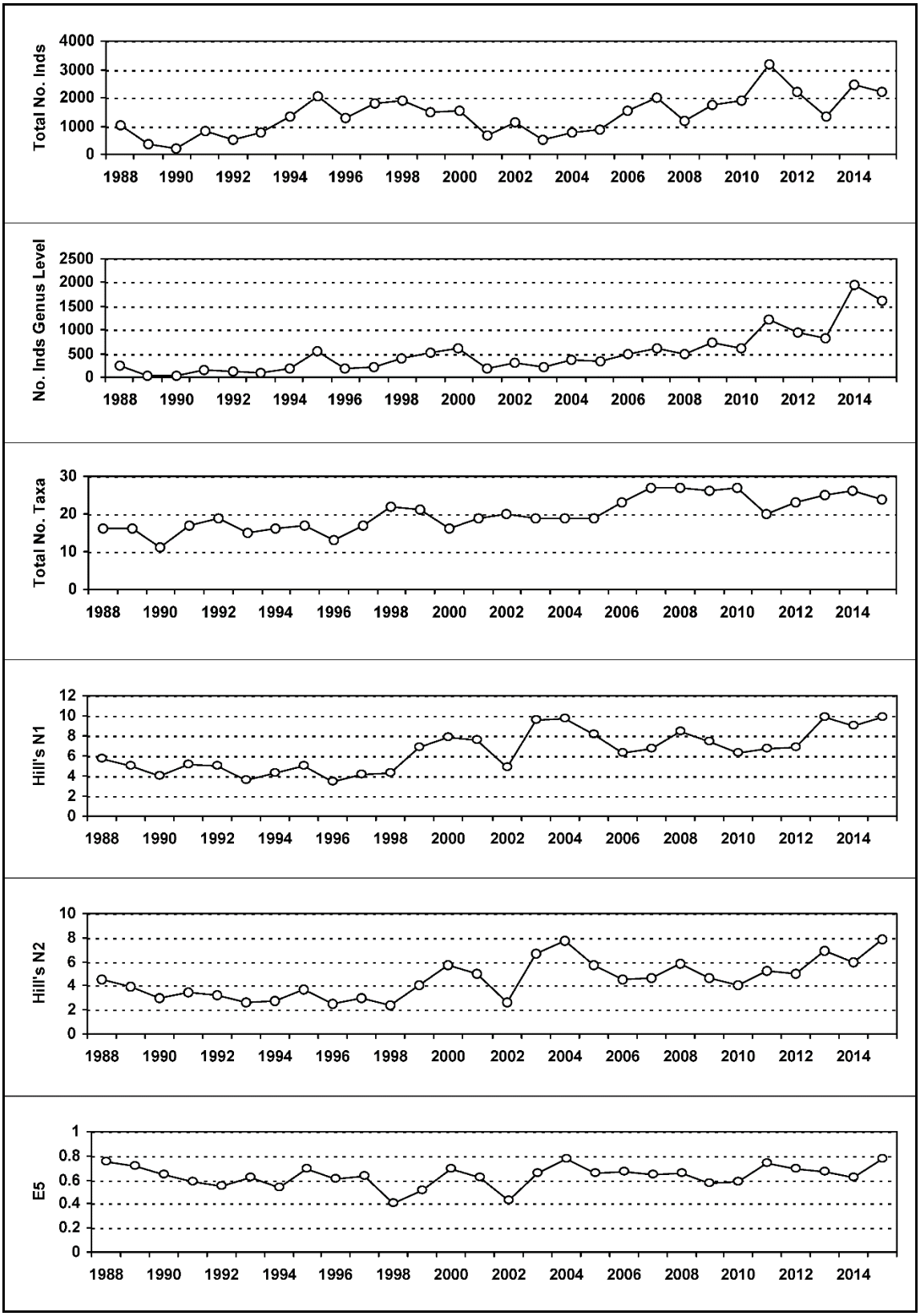
3.11.2 Macroinvertebrate data

3.11.2.1 Percentage abundance summary, Llyn Llagi



2016 samples archived awaiting funding for analysis

3.11.2.1 Macroinvertebrate summary statistics, Llyn Llagi



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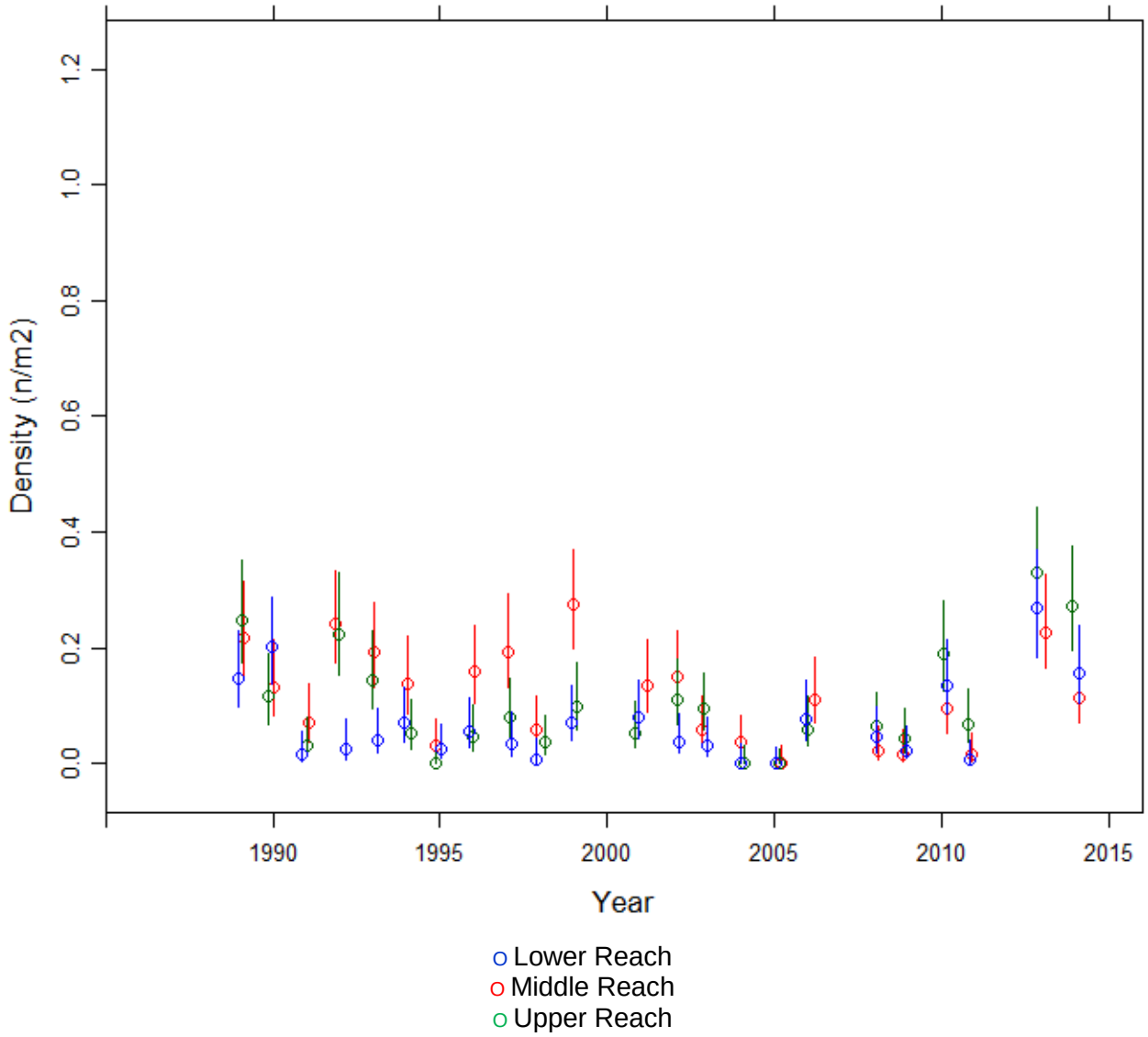
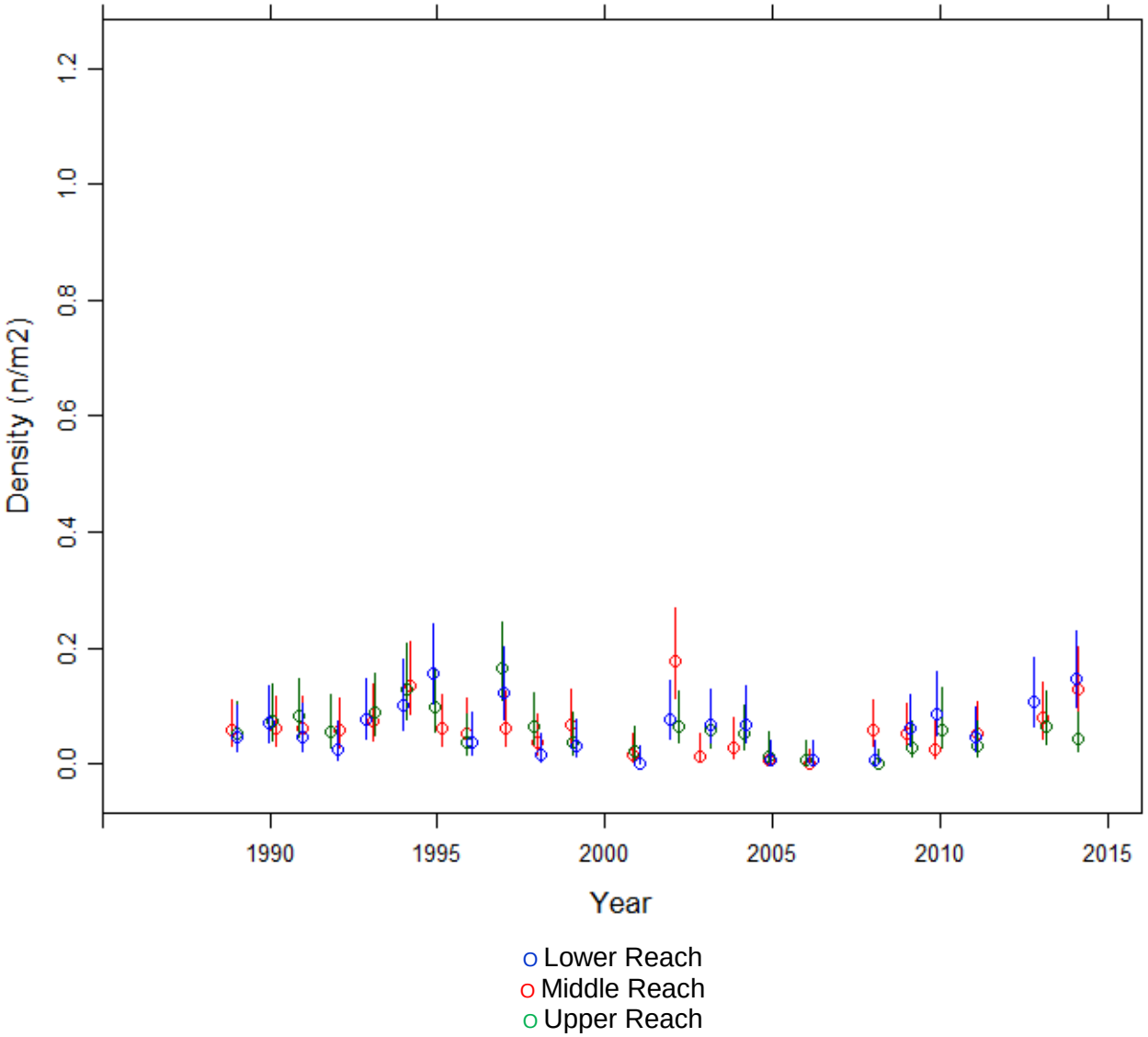
3.11.3 Fish data (for outflow stream)

3.11.3.1 Summary of Trout fry density (numbers m^{-2}), Llyn Llagi



Fishing no longer funded after 2014.

3.11.3.2 Summary of Trout parr density (numbers m^{-2}), Llyn Llagi



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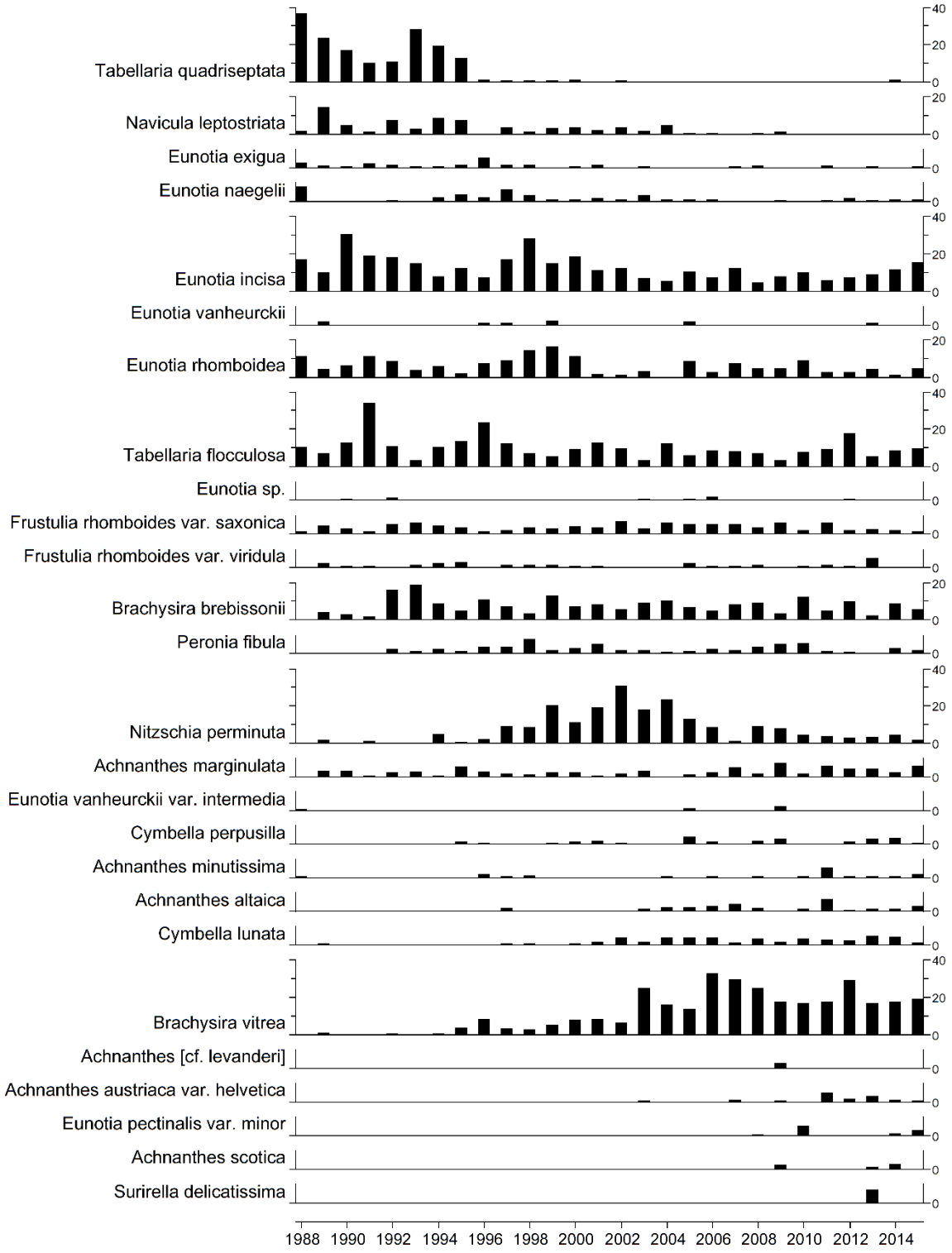
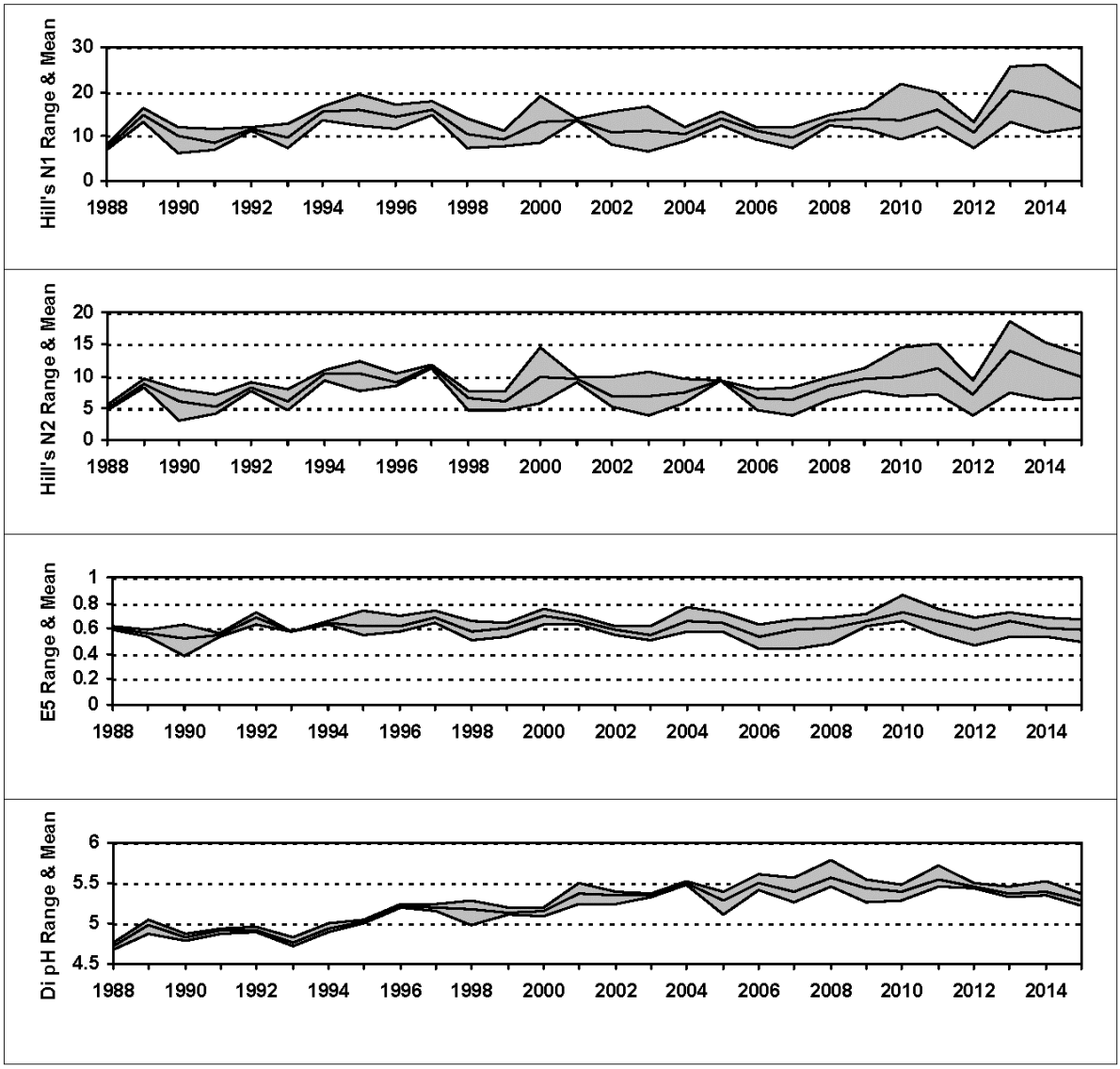
3.11.4 Epilithic diatom data

3.11.4.1 Percentage abundance summary, Llyn Llagi

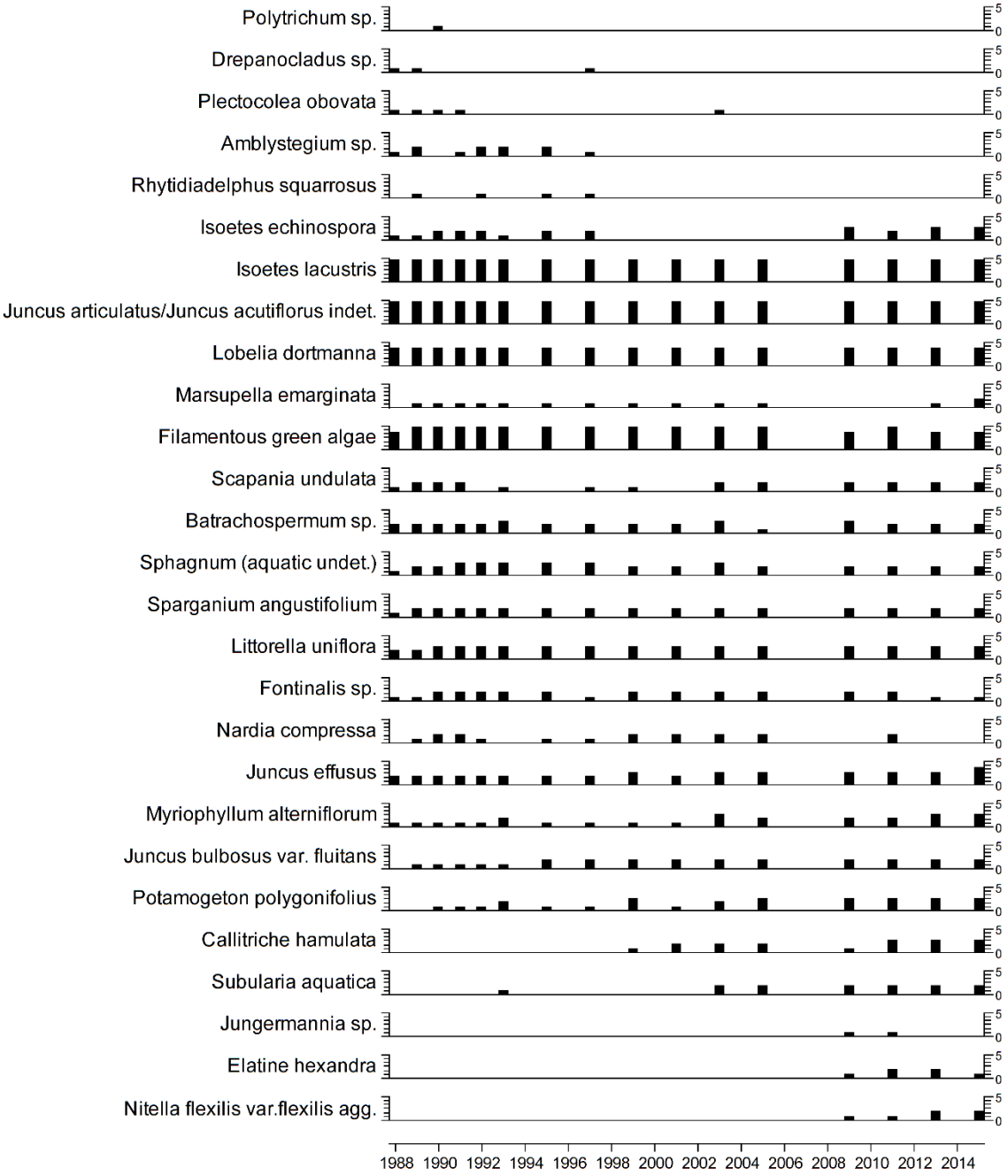


3.11.4.1 Diatom summary statistics, Llyn Llagi



3.11.5 Aquatic macrophyte data, Llyn Llagi

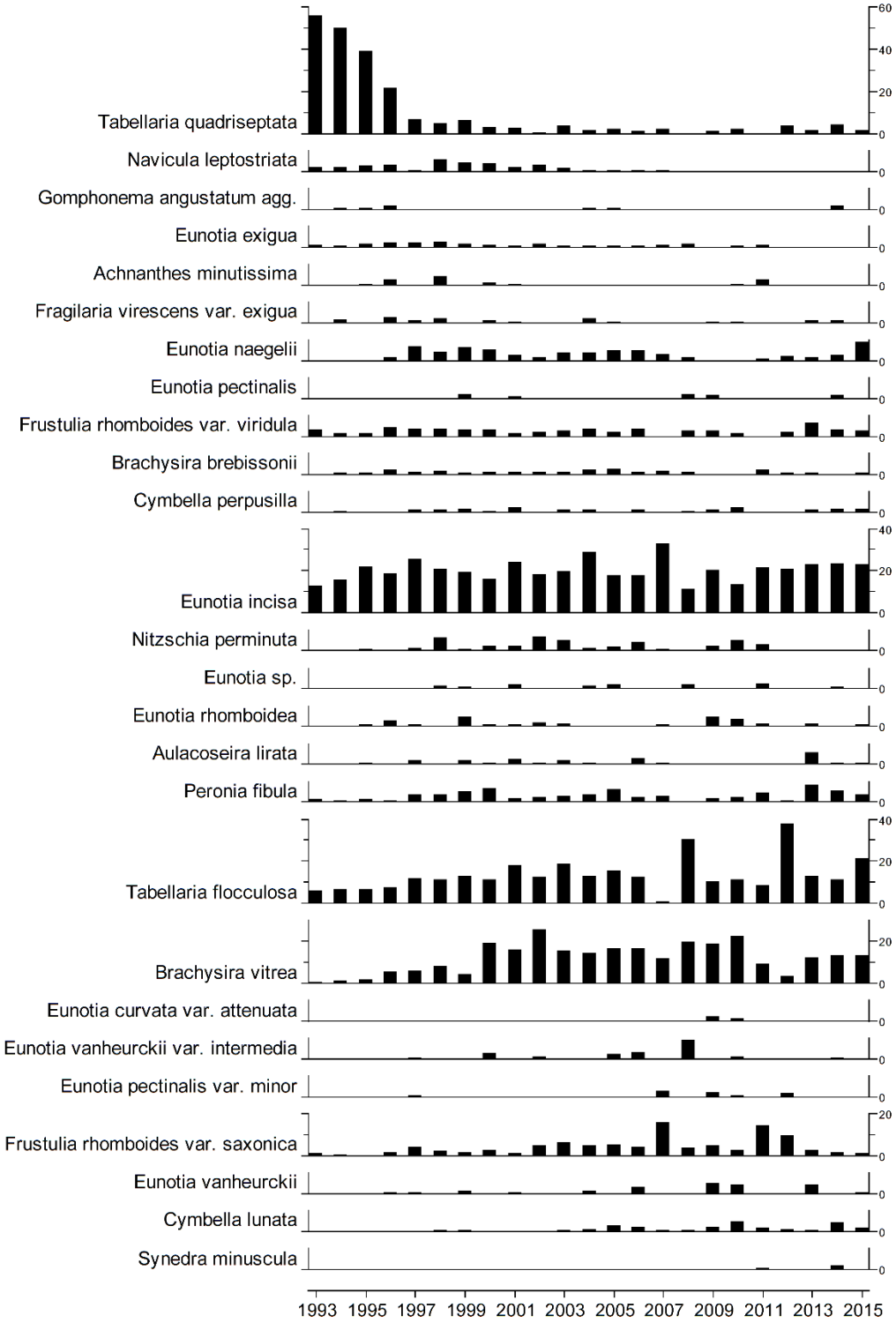
Species Scores (1-5)



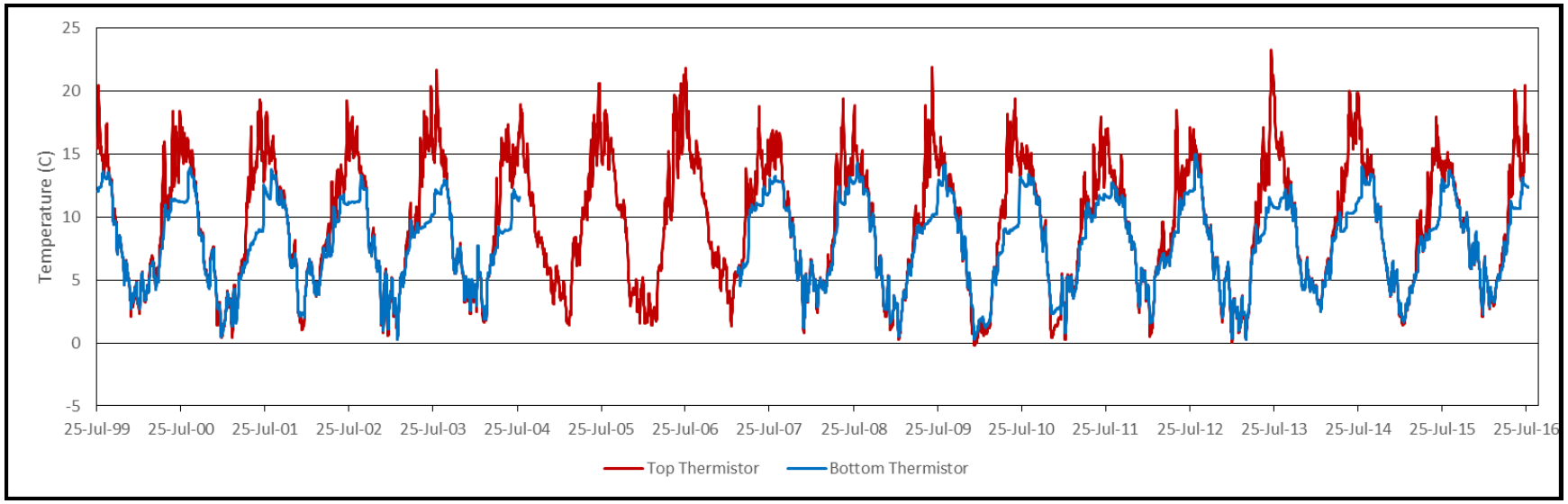
No survey in 2007 due to funding cuts

3.11.6 Sediment trap data, Llyn Llagi

Relative percentage frequency of diatom taxa

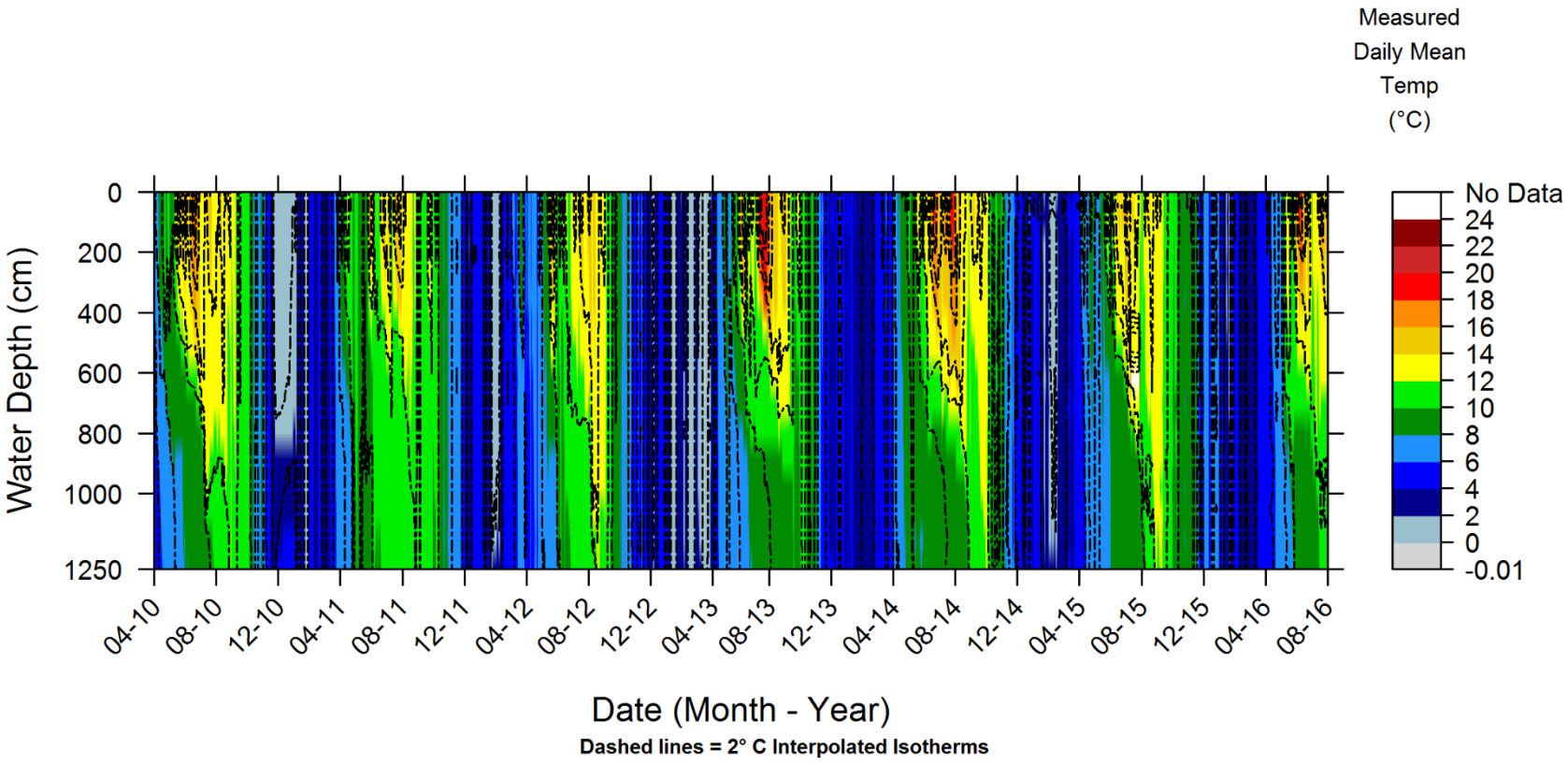


3.11.7 Sediment trap thermistor data, Llyn Llagi



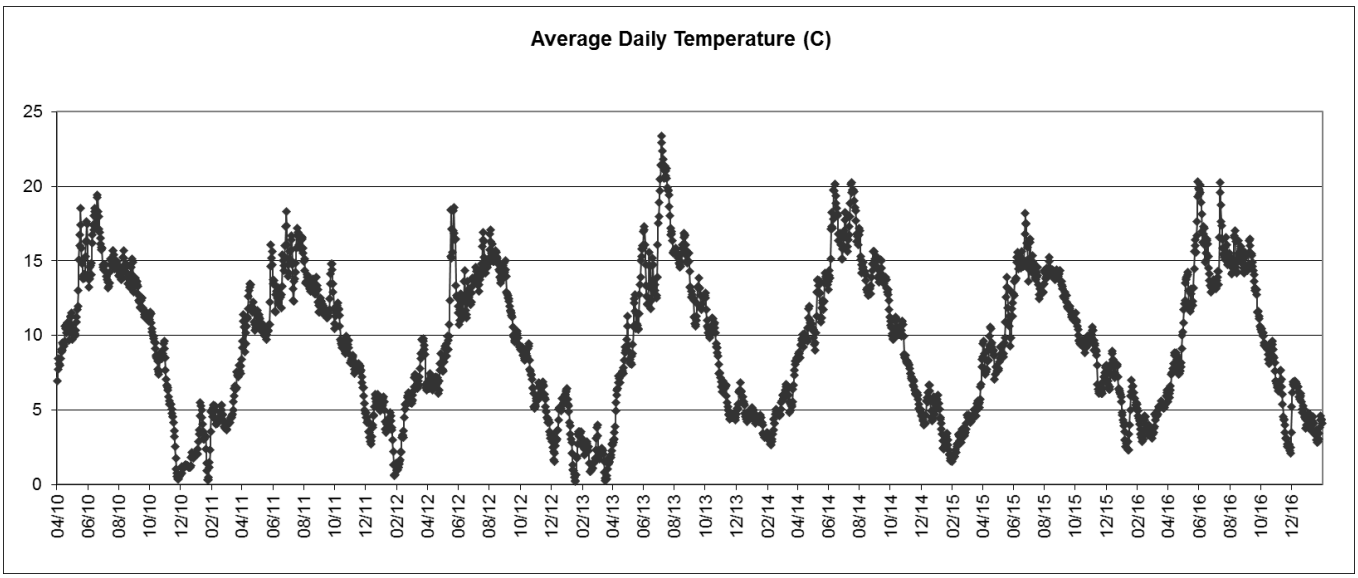
3.11.8 Thermistor chain data, Llyn Llagi

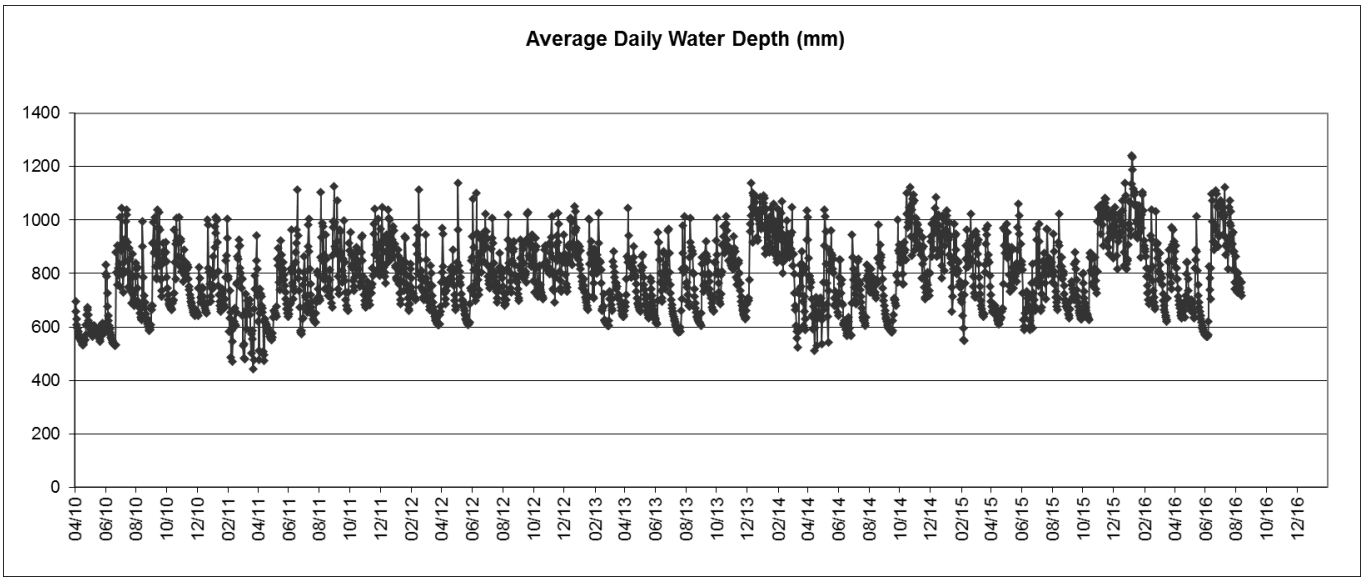
3.11.8.1 Llyn Llagi 2010-2016



3.11.9 Automatic sensor data, Llyn Llagi

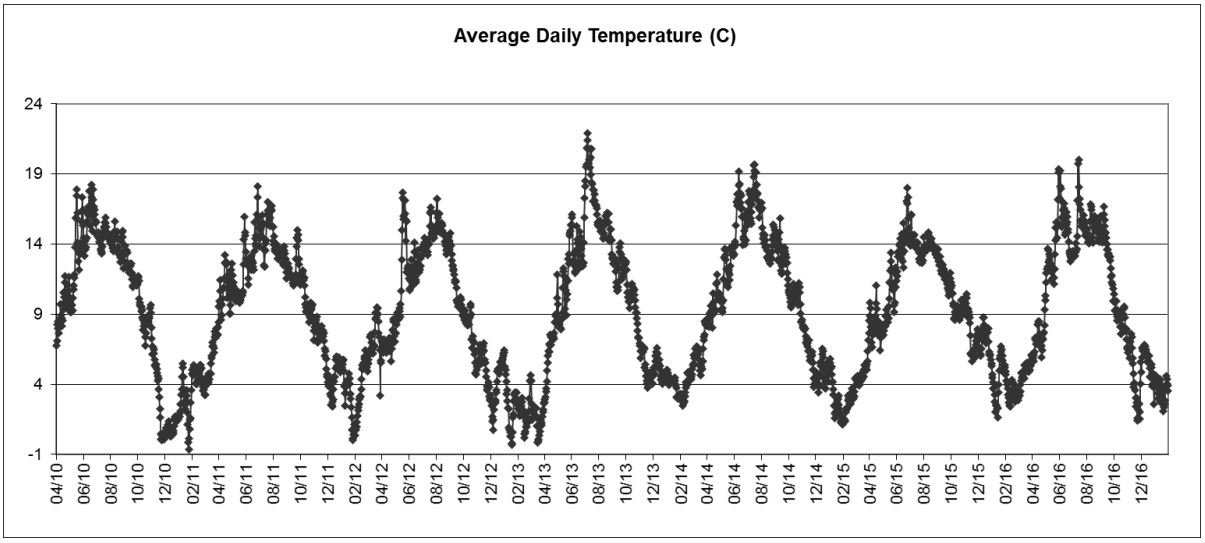
3.11.9.1 Lake sensor data, Llyn Llagi

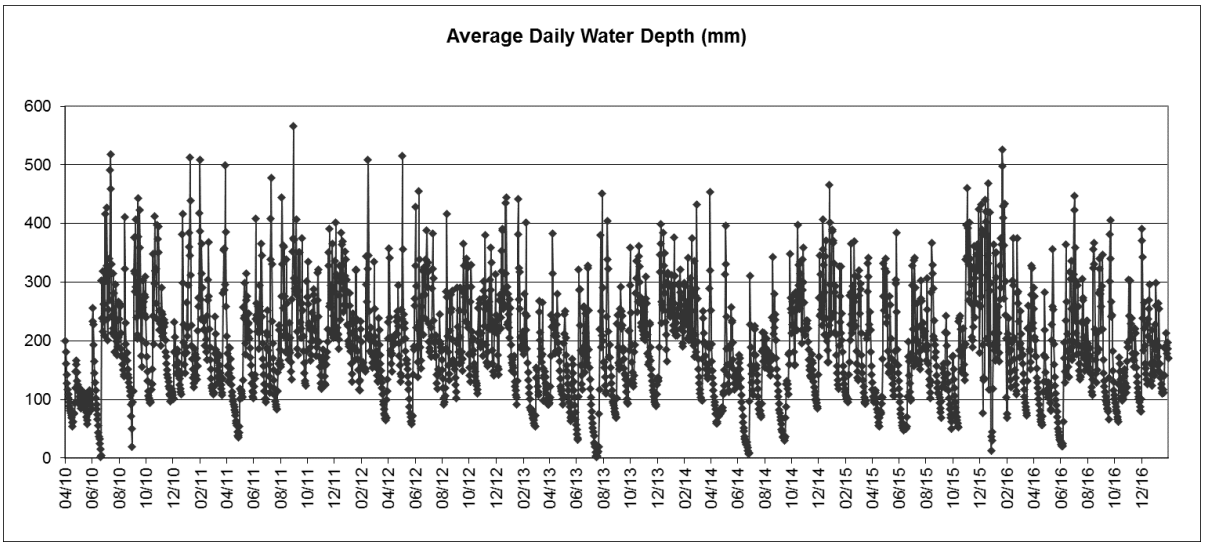


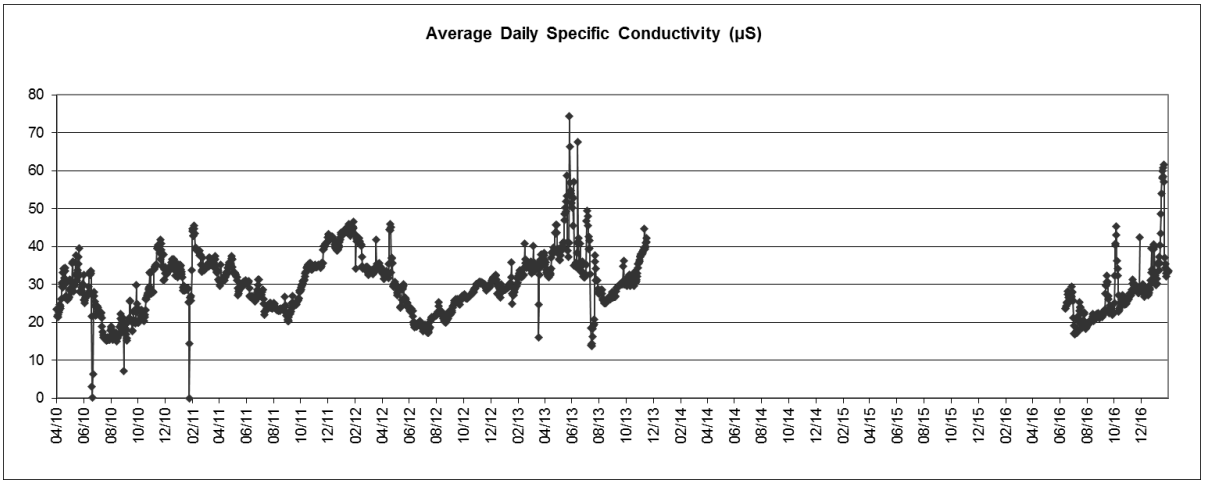


Data gap due to probe malfunction

3.11.9.2 Outflow sensor data, Llyn Llagi







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4 Llyn Cwm Mynach

Figure 2 Llyn Cwm Mynach. Looking southeast from the North West end of the lake, 3rd August 2016.

4.1 Summary Overview

Funded chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at Llyn Cwm Mynach during the period from April 2016 to March 2017.

A supplementary CEH and Woodland Trust project continues to look at the effects of differing forestry practices in the catchment, with water samples being analysed at CEH Bangor.

4.2 Water Chemistry

Samples were collected by the Woodland Trust in early June, September and December 2016, and March 2017. They were delivered to the analytical laboratories on schedule and have all been analysed. The data is in the process of being quality controlled and archived in the UKUWMN central chemistry database at CEH Lancaster.

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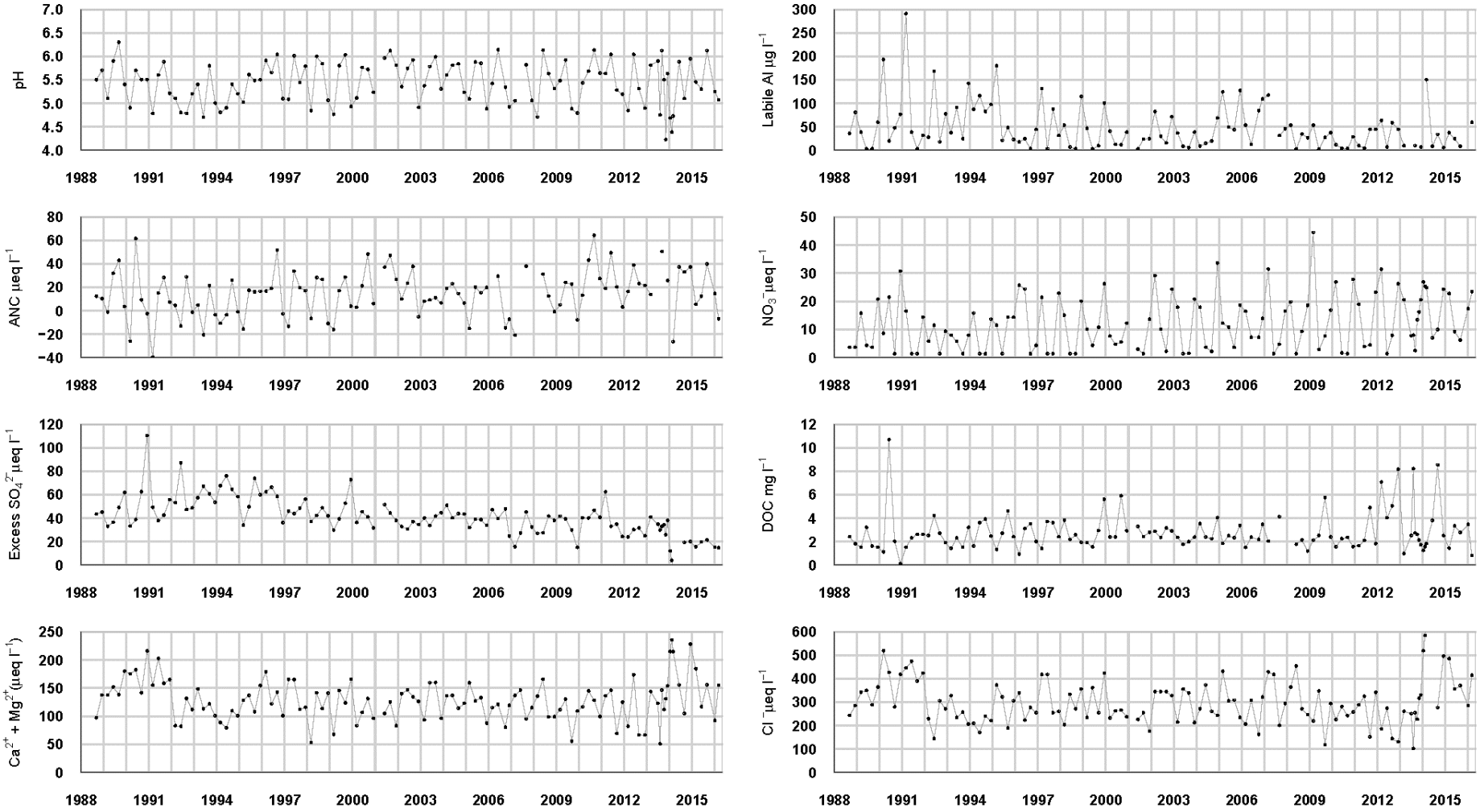
4.11 Llyn Cwm Mynach Summary Data to March 2016

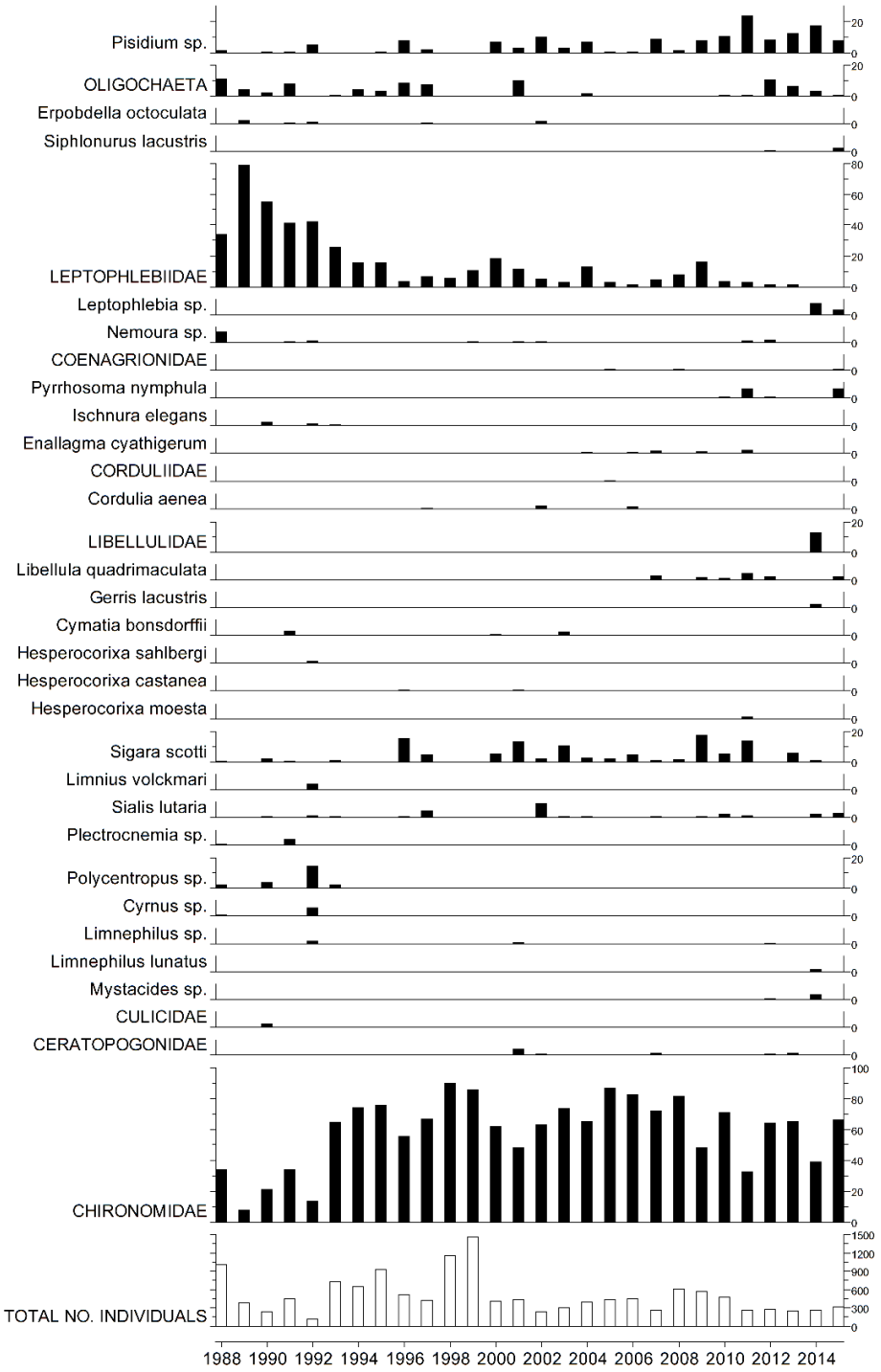
4.11.1 Spot sampled chemistry data



µeq l⁻¹ , *µg l⁻¹, **mg l⁻¹	pH	ANC	Ca 2+	Mg 2+	Na +	K +	*Soluble Al	*Labile Al	Cl -	*SO4 2-	xSO4 2-	NO3 -	**DOC
Mean 1st 5 yrs	5.35	7.68	77.79	67.45	291.02	3.36	110.75	66.58	337.67	88.32	52.91	9.40	2.50
15-16 mean	5.43	14.81	61.16	68.60	327.34	6.92	84.33	30.33	356.15	54.94	17.60	14.00	2.58
15-16 std dev	0.47	19.25	18.66	13.93	50.85	2.54	41.93	26.08	53.79	6.77	3.31	7.83	1.23

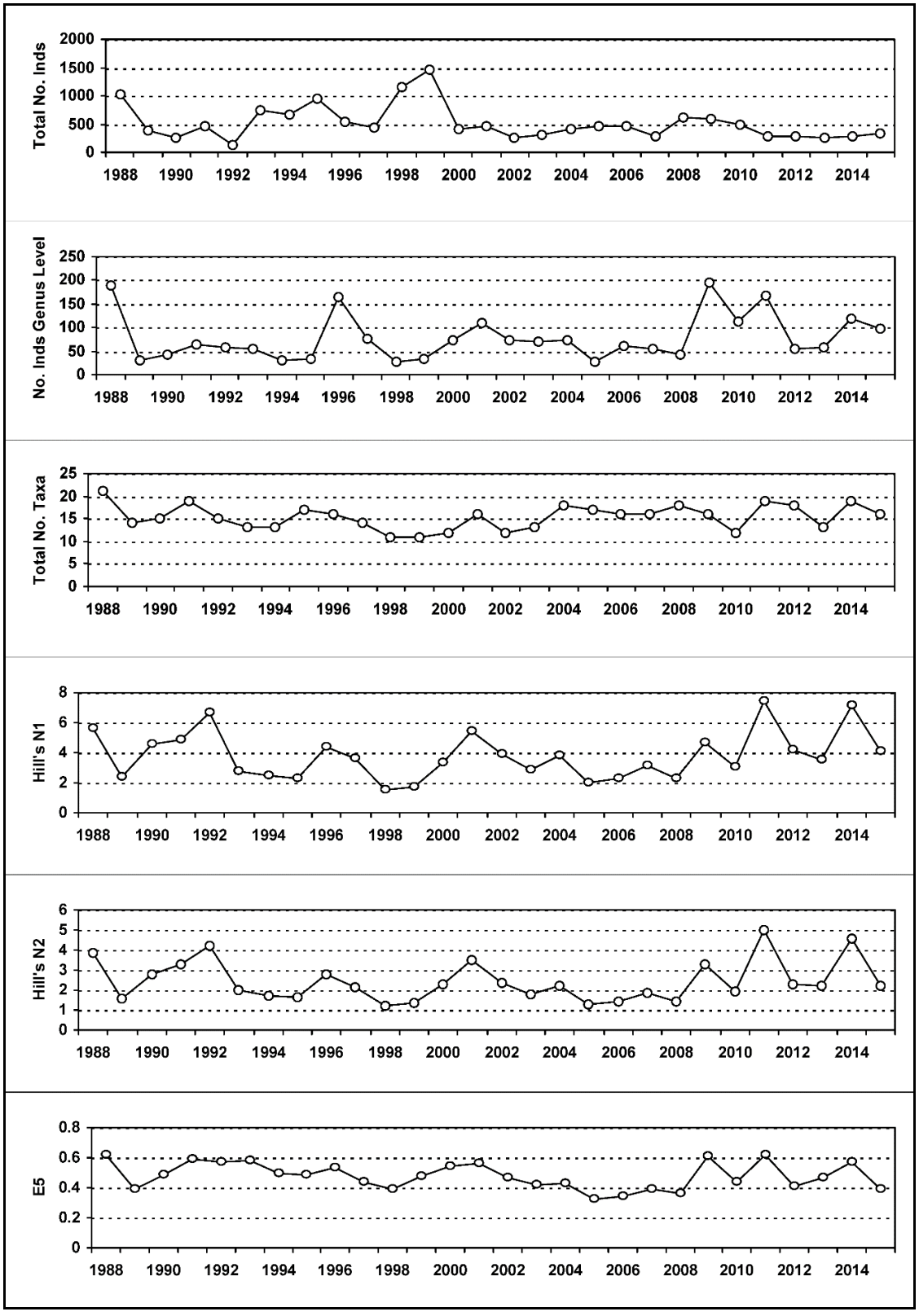
4.11.2 Macroinvertebrate data

4.11.2.1 Percentage abundance summary, Llyn Cwm Mynach



2016 samples archived awaiting funding for analysis

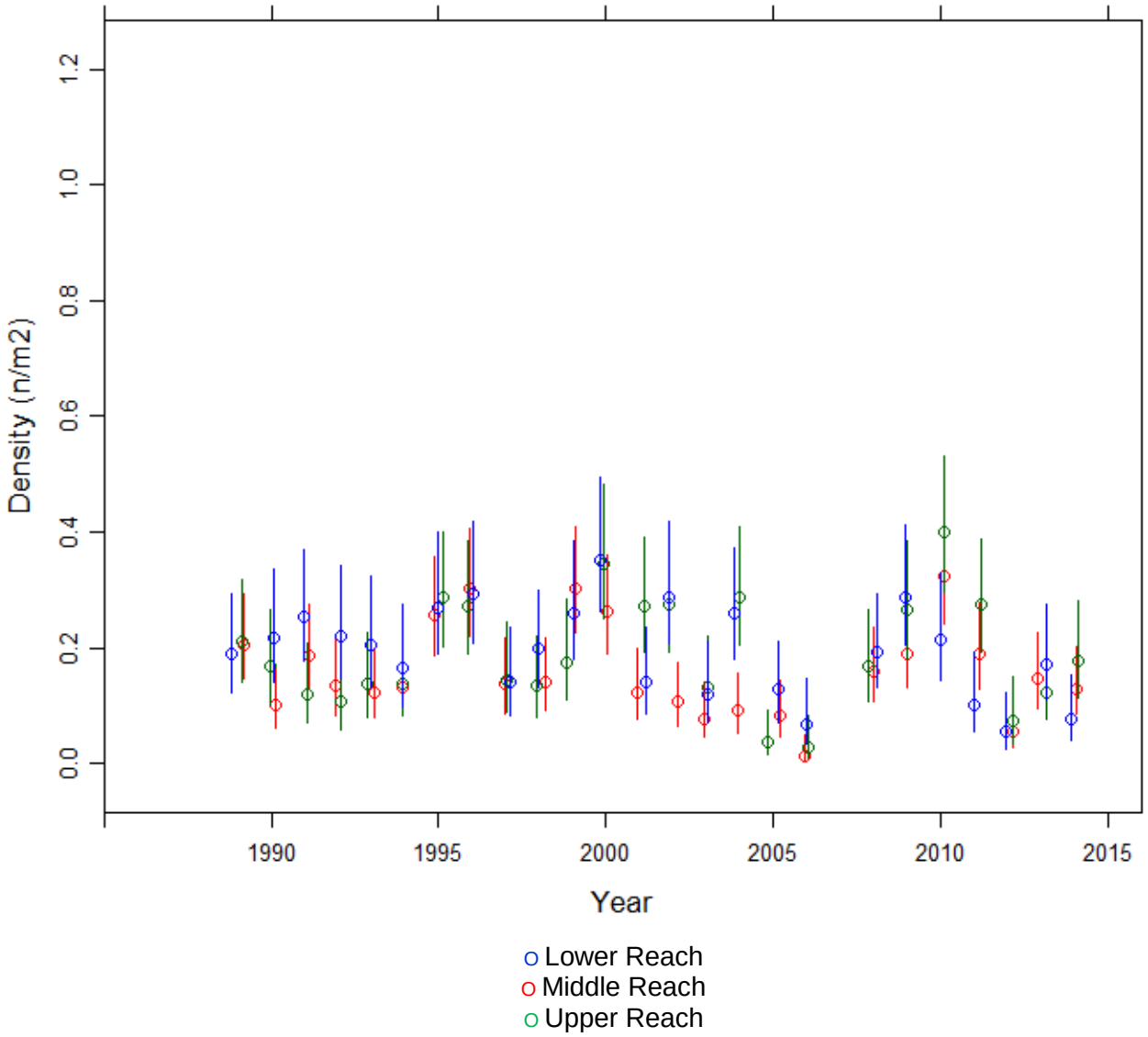
4.11.2.1 Macroinvertebrate summary statistics, Llyn Cwm Mynach



2016 samples archived awaiting funding for analysis

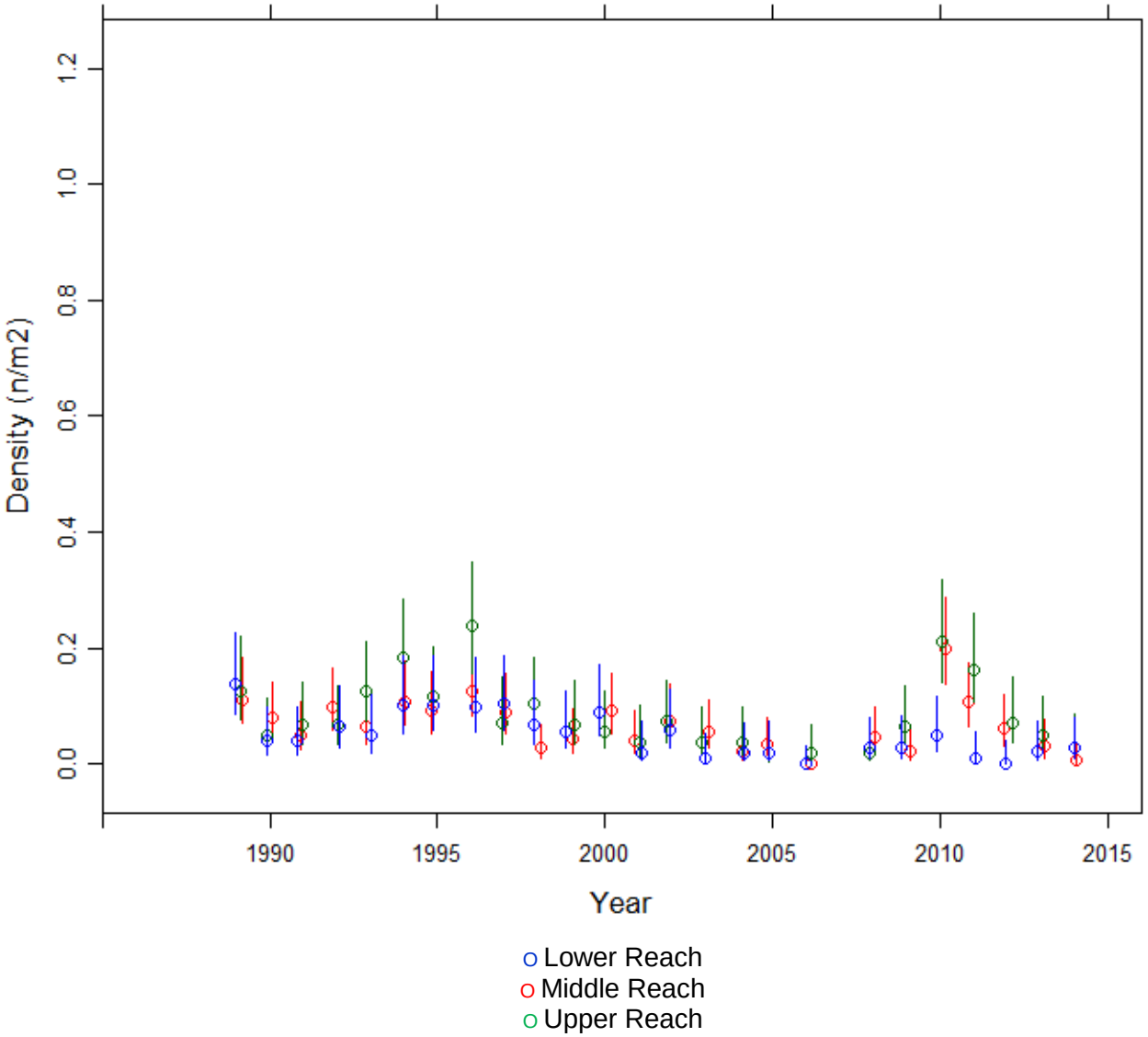
4.11.3 Fish data (for outflow stream)

4.11.3.1 Summary of Trout fry density (numbers m^{-2}), Llyn Cwm Mynach



Fishing no longer funded after 2014.

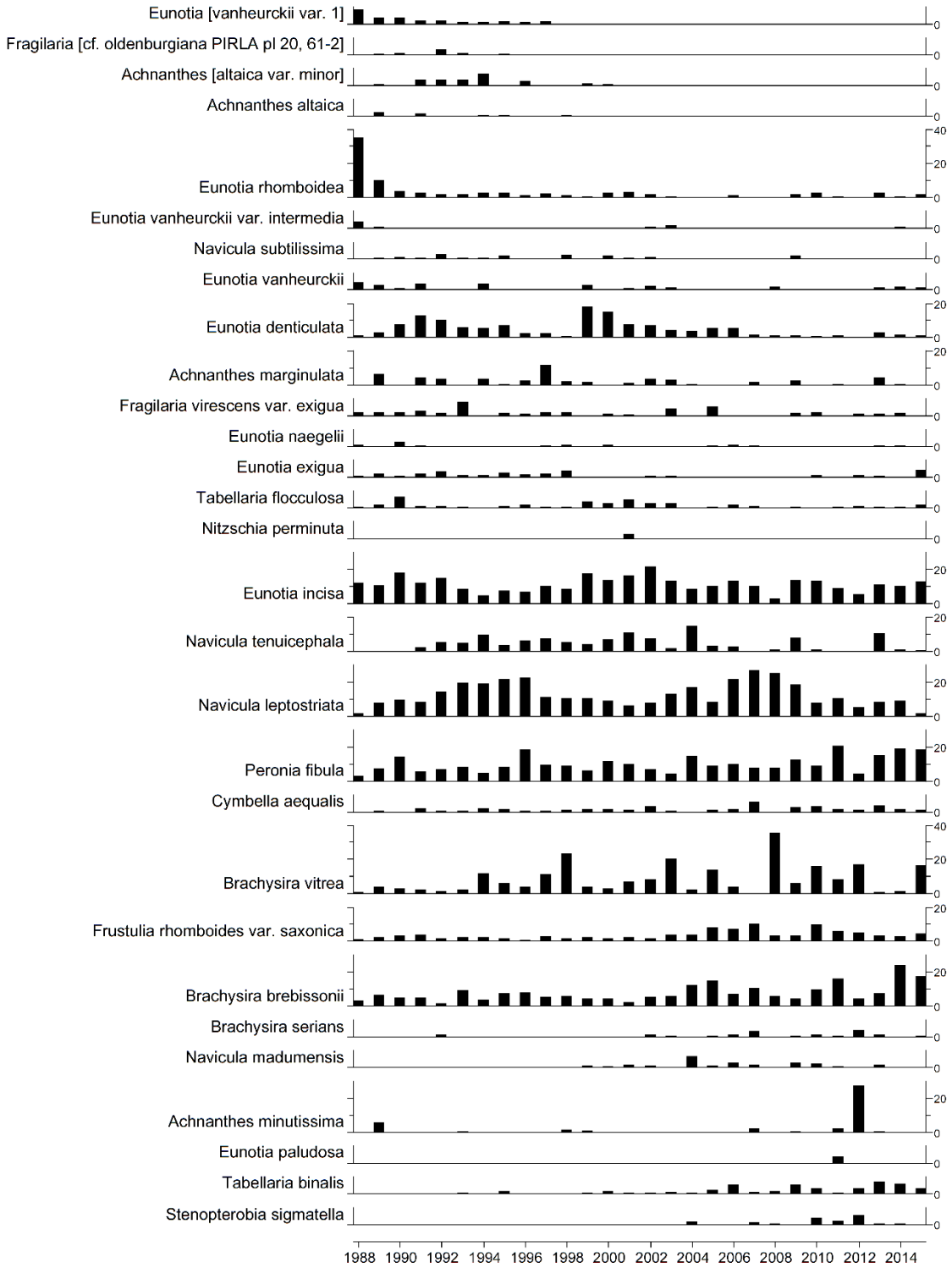
4.11.3.2 Summary of Trout parr density (numbers m^{-2}), Llyn Cwm Mynach



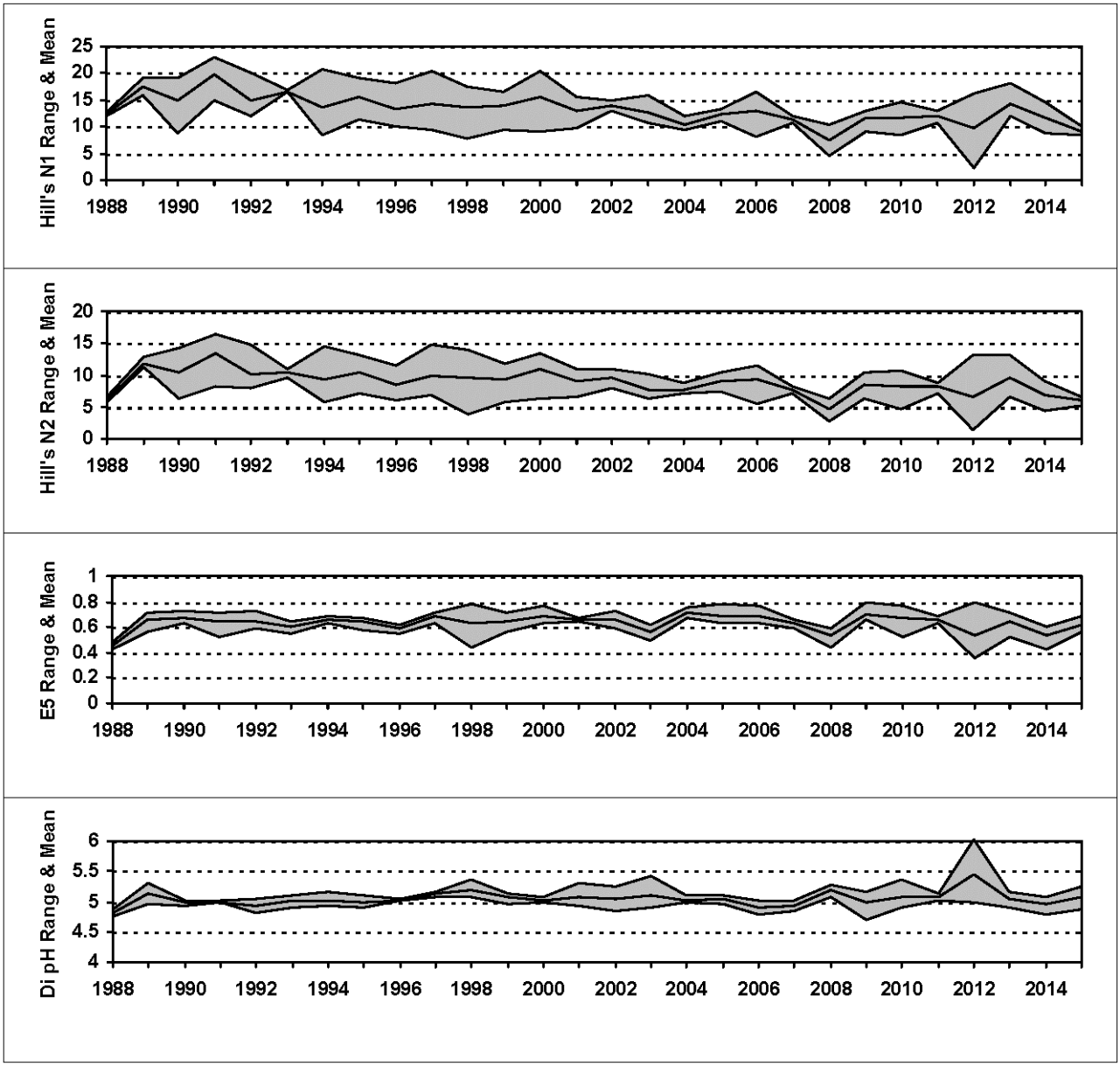
Fishing no longer funded after 2014.

4.11.4 Epilithic diatom data

4.11.4.1 Percentage abundance summary, Llyn Cwm Mynach

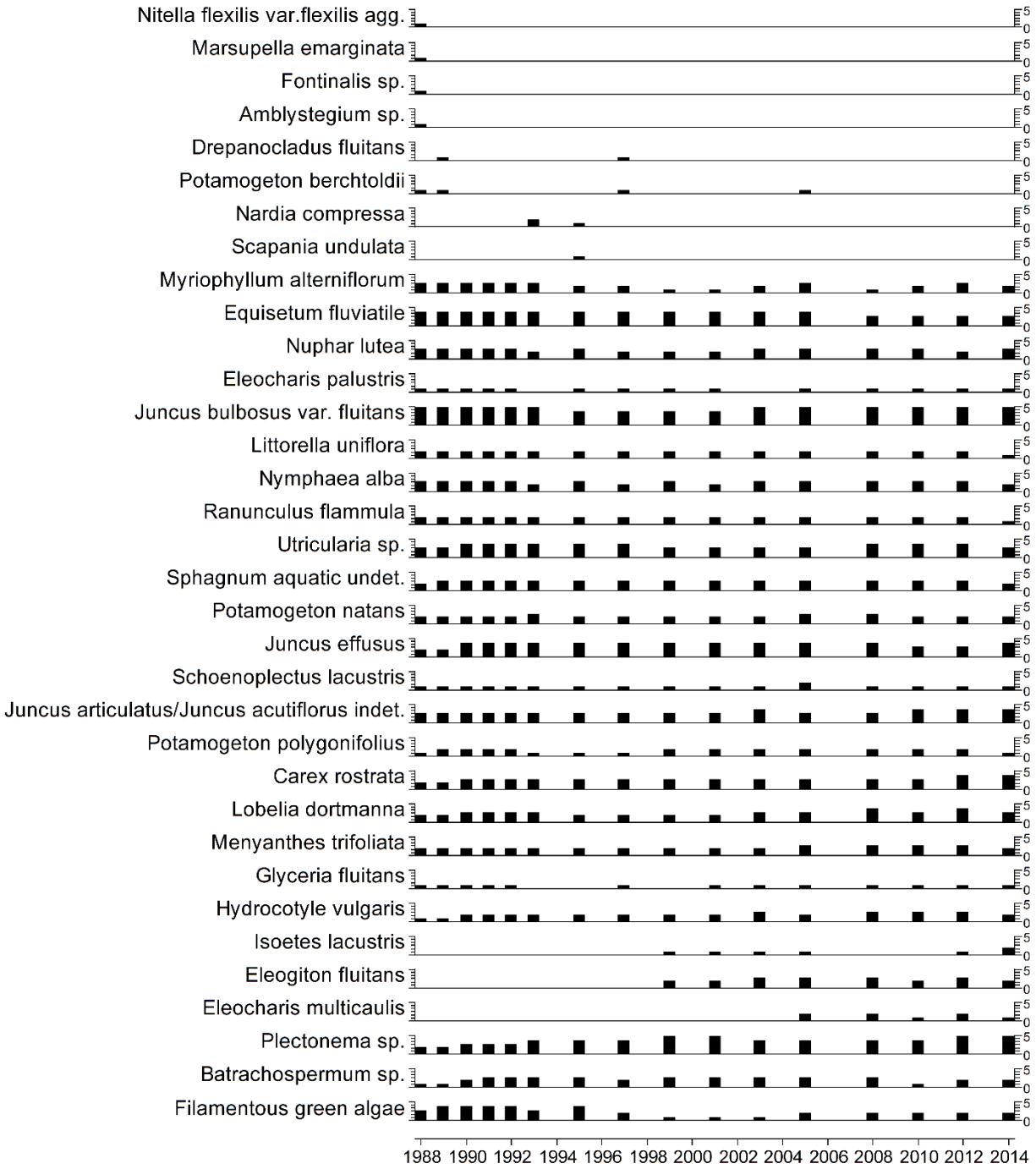


4.11.4.2 Diatom summary statistics, Llyn Cwm Mynach



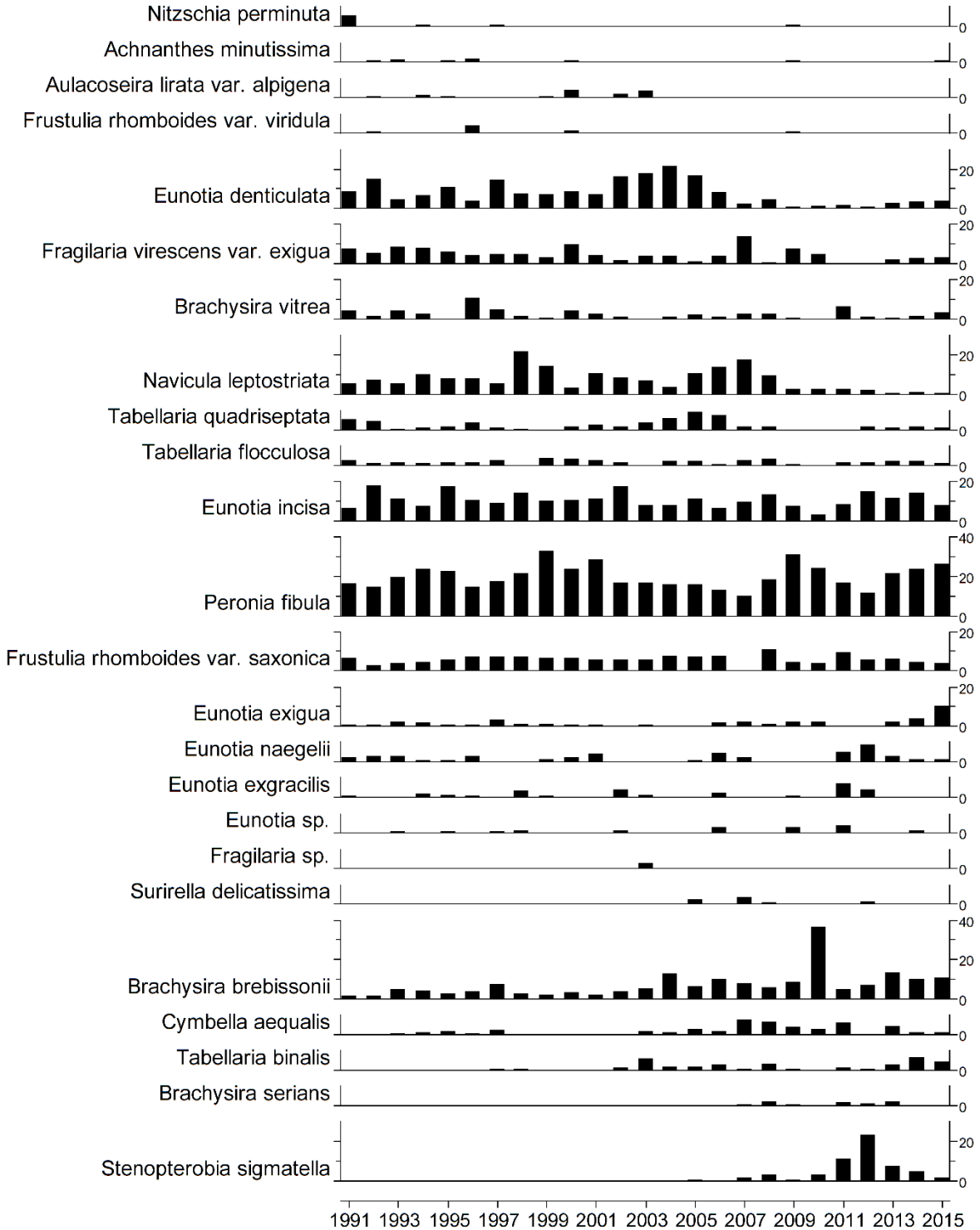
4.11.5 Aquatic macrophyte data, Llyn Cwm Mynach

Species Scores (1-5)

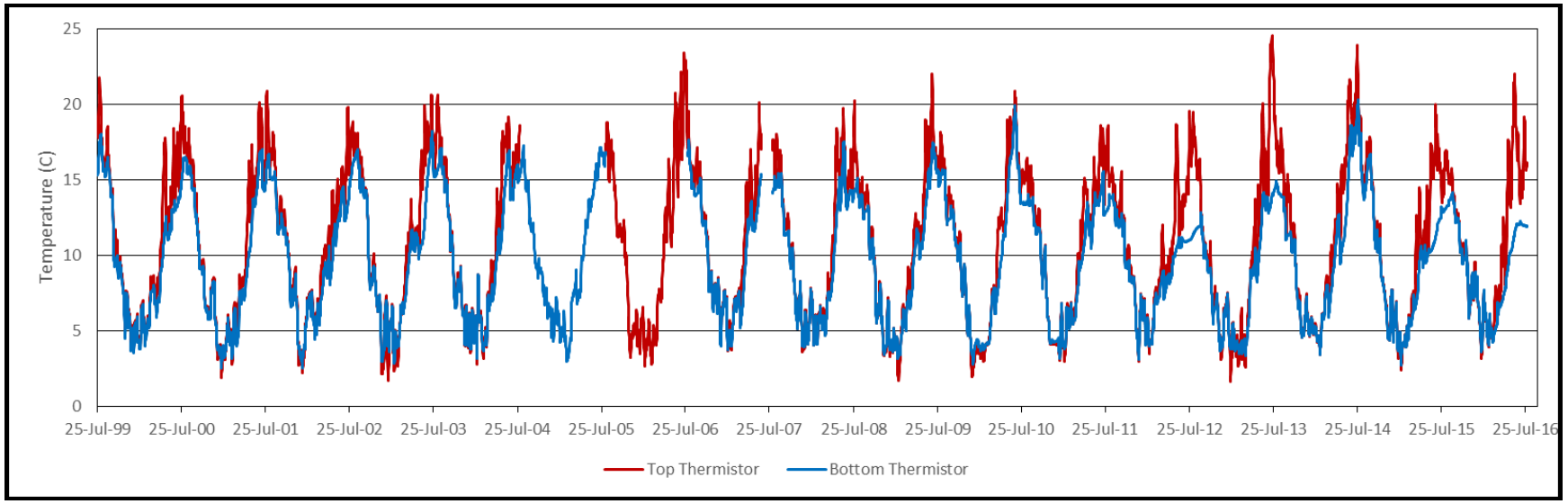


4.11.6 Sediment trap data, Llyn Cwm Mynach

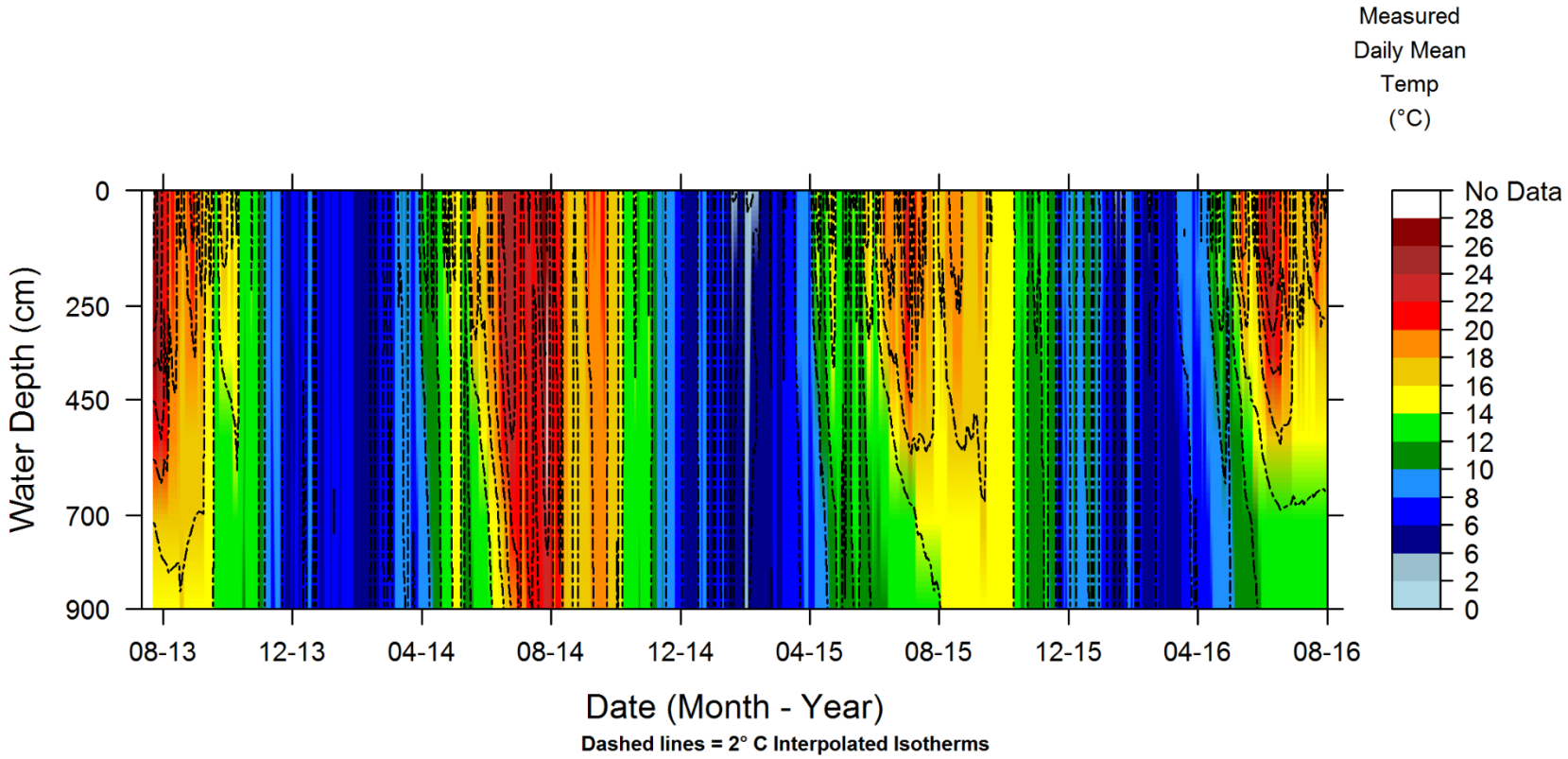
Relative percentage frequency of diatom taxa



4.11.7 Sediment trap thermistor data, Llyn Cwm Mynach



4.11.8 Thermistor chain data, Llyn Cwm Mynach



5 Afon Hafren

Figure 3 Afon Hafren biological survey section 23rd September 2016

5.1 Summary Overview

Funded chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at Afon Hafren during the period from April 2016 to March 2017.

5.2 Water Chemistry

Samples were collected by CEH early every month throughout the period April 2016 to March 2017, delivered to the analytical laboratories on schedule and are in the process

of being analysed, quality controlled and archived in the UKUWMN central chemistry database at CEH Lancaster.

5.3 Thermistors

The MS thermistor at Afon Hafren was reinstalled in a new location, the stilling well at the weir, by Ben Winterbourn from CEH on the 17th May 2016. The unit was retrieved on the 7th of July 2016 but unfortunately a slight amount of water had leaked inside. After prolonged drying however, the data was recovered, checked and archived in the central ENSIS and MS temperature database.

5.4 Epilithic Diatoms

Epilithic diatoms were retrieved by a team from ENSIS from three sampling points in the stream on the 7th of July 2016. The samples have been made into slides.

5.5 Macroinvertebrates

Aquatic macroinvertebrates were sampled on the 16th April 2016 by a team from QMuL. Five 1 minute kick samples were performed. The samples have been archived pending funding being available for analysis.

5.6 Fish

Due to resourcing cuts, fish surveying was not performed in Autumn 2016.

5.7 Aquatic Macrophytes

Aquatic macrophytes were surveyed by a team from ENSIS on 23rd of September 2016 after spate conditions prevented the survey in the July visit. Percentage cover scores were recorded and data will be added to the ENSIS biological database after microscope confirmation of bryophyte identifications.

5.8 Data Management and Reporting

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

The 2015-2016 summary diagrams have been uploaded to the UKUWMN web page. The section on Afon Hafren appears in section 5.10 below.

The UKUWMN website page detailing Afon Hafren can be found here: http://uwmn.defra.gov.uk/sites/site_17.php

Further publications from the contract period utilizing UKUWMN data from Afon Hafren are detailed in section 5.9 below.

5.9 Afon Hafren Recent UKUWMN Output

Gray C., Hildrew A.G., Lu X., Ma A., Mcelroy D., Monteith D., O Gorman E., Shilland E. & Woodward G. (2016) Chapter Ten - Recovery and Nonrecovery of Freshwater Food Webs from the Effects of Acidification. In: *Advances in Ecological Research. Large-Scale Ecology: Model Systems to Global Perspectives.* (Ed J.D. Alex), pp. 475-534. Academic Press.

Juggins S., Kelly M., Allott T., Kelly-Quinn M. & Monteith D. (2016) A Water Framework Directive-compatible metric for assessing acidification in UK and Irish rivers using diatoms. *Science of the Total Environment,* **568,** 671-678.

Oosthoek S. (2016) Global browning: Why the world's fresh water is getting murkier. In: *New Scientist*, pp. 34-35, Vol. 3055. Reed Business Information, London.

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Shilland E.M., Monteith D.T., Millidine K., Malcolm I.A. & Norris D.A. (2016) UK Upland Waters Monitoring Network (UKUWMN) - Contract 22 01 249 Llyn Llagi, Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2015 - March 2016. Report to the Welsh Government and Natural Resources Wales. pp. 1-76, London.

Velle G., Mahlum S., Monteith D.T., De Wit H., Arle J., Eriksson L., Fjellheim A., Frolova M., Fölster J., Grudule N., Halvorsen G.A., Hildrew A., Hruska J., Indriksone I., Kamasová L., Kopácek J., Krám P., Orton S., Senoo T., Shilland E.M., Stuchlík E., Telford R.J., Ungermanova L., Wiklund M.L. & Wright R.F. (2016) Biodiversity of macro-invertebrates in acid-sensitive waters: trends and relations to water chemistry and climate. pp. 1-38, Norway.

Battarbee, R. W. (2015) Forestry, 'acid rain', and the acidification of lakes. In: *Nature's Conscience: the life and legacy of Derek Ratcliffe*, 385-400, Langford Press, Peterborough.

Battarbee, R. W. (2015) Remote lakes: pristine or polluted. UK and Ireland Lakes Network annual conference, Abergavenny. 4th March 2015.

Evans, C. D. (2015) UK and international freshwater monitoring. Swedish Agricultural University, Uppsala. 11th May 2015, Invited keynote. Meeting to mark 50 years of freshwater monitoring in Sweden, attended by the King and Crown Princess.

Evans, C. D., Monteith, D. T., Shilland, E. M., Battarbee, R. W., Patrick, S. T. & Malcolm, I. A. (2015) 35 years of upland water quality monitoring in the UK: Foreseen events, unforeseen events, non-events and extreme events. 9th International Conference on Acid Deposition, Rochester, New York. October 19-23, 2015.

Garmo, O. A., de Wit, H. A., Høgåsen, T., Lund, E., Wright, R. F., Aherne, J., Arle, J., Colombo, L., Fölster, J., Hruška, J., Indriksone, I., Jeffries, D. S., Krám, P., Monteith, D. T., Paterson, A., Rogora, M., Rzychon, D., Steingruber, S., Stoddard, J. L., Talkop, R., Ulanczyk, R. P. & Vuorenmaa, J. (2015) Trends in water chemistry. In: *ICP Waters Report 119/2015. Chemical and biological recovery in acid-sensitive waters: trends and prognosis*, 8-39, NIVA, Oslo, Norway.

Hudson, L. (24-8-2015) Package "cheddar". 1-109. https://cran.r-project.org/web/packages/cheddar/index.html.

Laize, C. L. R. & Bruna Meredith, C. (2015) Water temperatures for the period 1984 to 2007 at 35 sites on 21 UK rivers. NERC Environmental Information Data Centre.

Monteith, D. T., Battarbee, R. W., Hildrew, A. G., Malcolm, I. A., Shilland, E. M., Evans, C. D. & Kernan, M. (2015) Hindered, stubborn or confused? Explaining the patchiness of biological responses to the declining acidity of surface waters. 9th International Conference on Acid Deposition, Rochester, New York. October 19-23, 2015.

Monteith, D. T., Henrys, P. A., Evans, C. D., Malcolm, I. A., Shilland, E. M. & Pereira, M. G. (2015) Spatial controls on dissolved organic carbon in upland waters inferred from a simple statistical model. *Biogeochemistry* 1-15.

Pearce-Higgins, J. W., BREWER, M. J., Elston, D. A., Martay, B., Powney, G. D., Isaac, N. J. B., Monteith, D. T., Henrys, P. A., Vaughan, I. P., Ormerod, S. J., Green, S., Edwards, F. K., Johnston, A., Bell, J. R., Harrington, R., Brereton, T. M., Barlow, K. E., Battarbee, R. W. & Shilland, E. M. (2015) BICCO-Net II. Final report to the Biological Impacts of Climate Change Observation Network (BICCO-Net) Steering Group. 1-69. Defra, London.

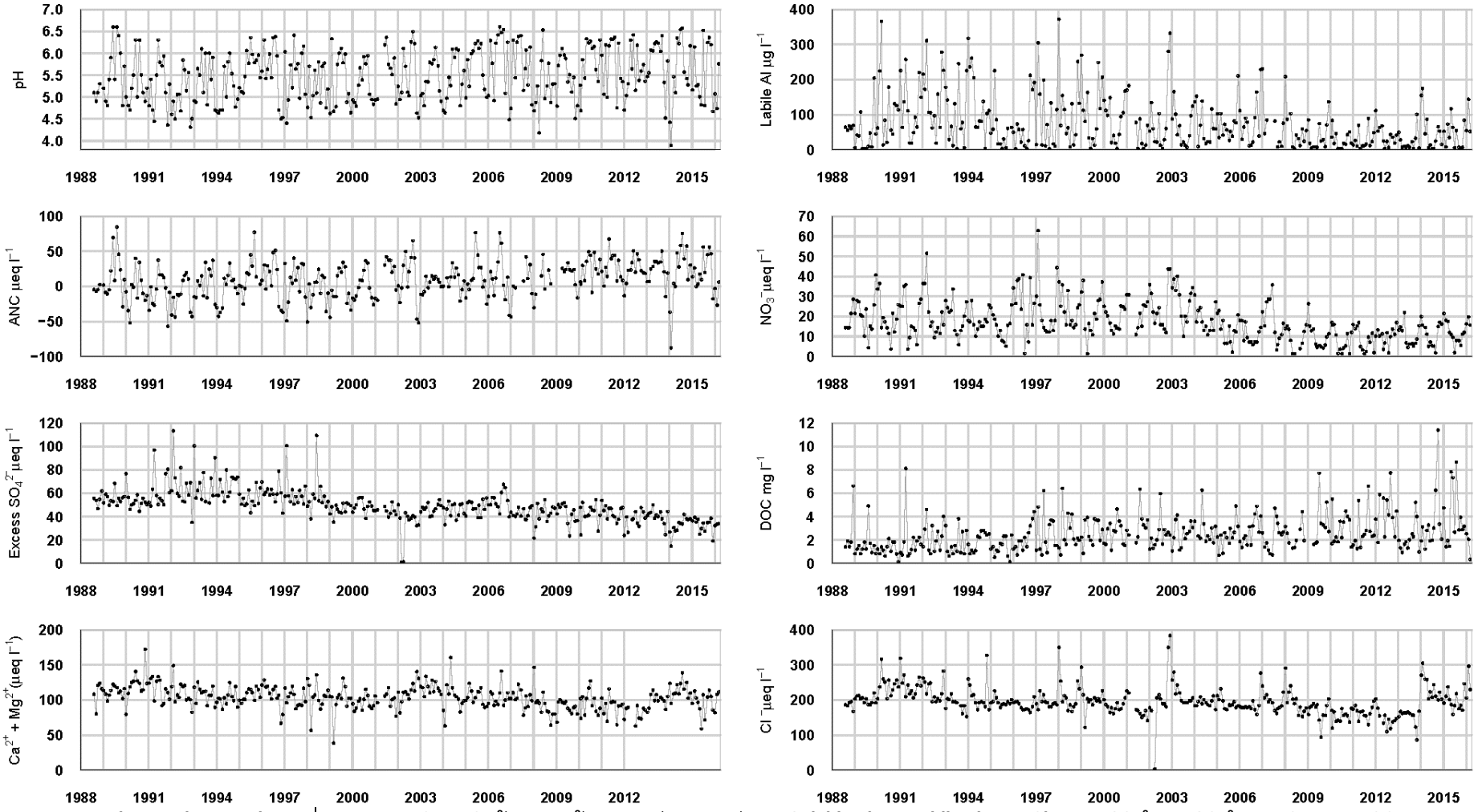
Shilland, E. M., Monteith, D. T., Millidine, K., Malcolm, I. A. & Norris, D. A. (2015) UK Upland Waters Monitoring Network (UKUWMN) - Contract 22 01 249 Llyn Llagi, Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2014 - March 2015. Report to the Welsh Government and Natural Resources Wales. 1-71. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Woolway, R. I., Monteith, D. T., Rose, N. L., Yang, H., Malcolm, I. A., Millidine, K. J., Hildrew, A. G., Evans, C. D., Sime, I., Hatton-Ellis, T., Kernan, M., Patrick, S. T., Turner, S. D. & Battarbee, R. W. (2015) Tracking the impact of climate change on UK surface waters recovering from acidification. Poster. 9th International Conference on Acid Deposition, Rochester, New York. October 19-23, 2015.

Winterbottom, J. H. & Orton, S. E. (2015) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty Seventh Year: 2014. Summary of species identification and abundance. 1-13. School of Biological Sciences, Queen Mary University of London, London.

5.10 Afon Hafren Summary Data to March 2016

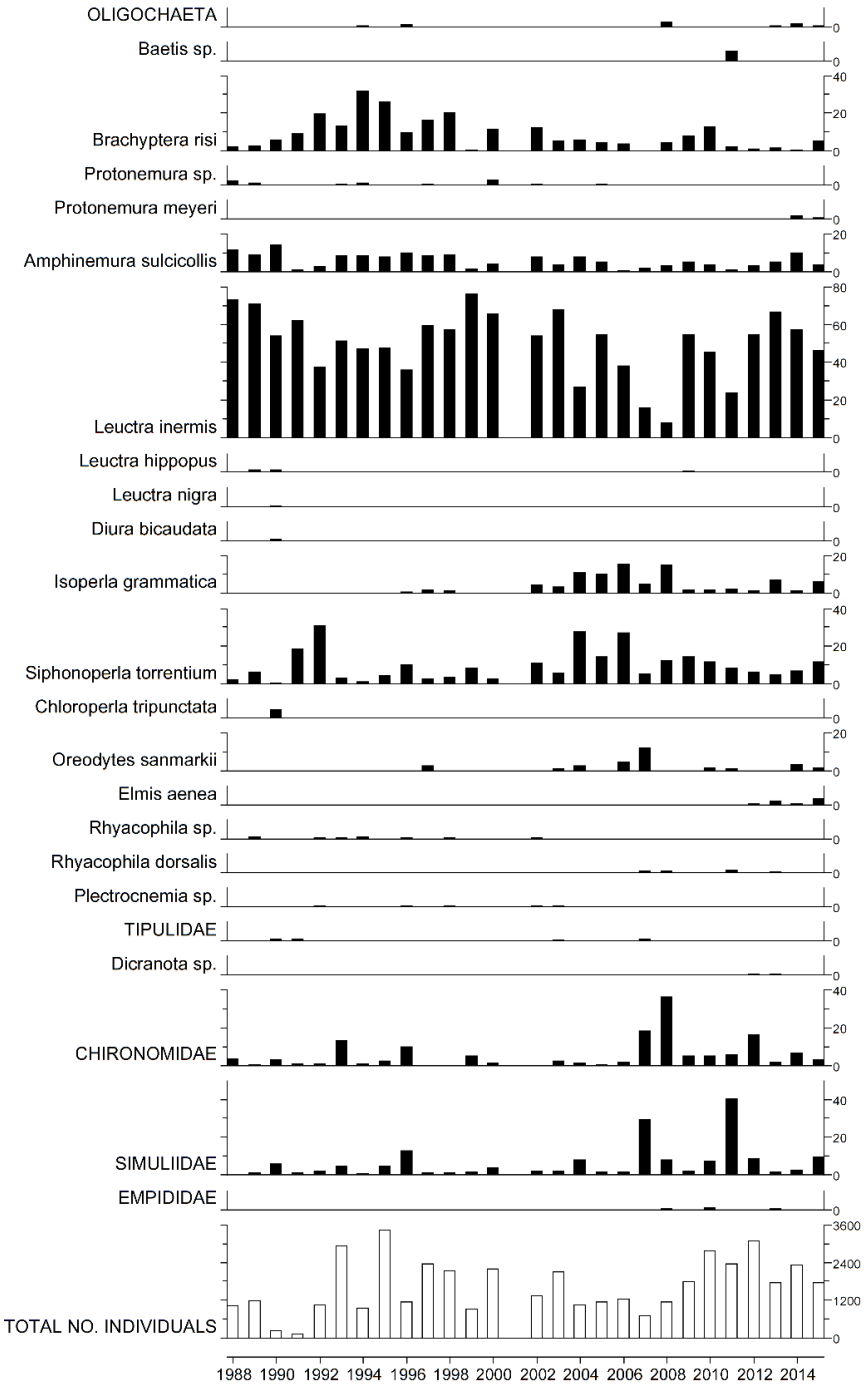
5.10.1 Spot sampled chemistry data



µeq l⁻¹ , *µg l⁻¹, **mg l⁻¹	pH	ANC	Ca 2+	Mg 2+	Na +	K +	*Soluble Al	*Labile Al	Cl -	*SO4 2-	xSO4 2-	NO3 -	**DOC
Mean 1st 5 yrs	5.29	-2.40	47.91	66.41	200.39	3.16	170.00	101.71	221.09	82.97	59.79	20.58	1.76
15-16 mean	5.45	17.53	35.34	58.74	182.56	3.44	119.33	51.58	204.40	53.12	31.69	10.82	3.79
15-16 std dev	0.71	27.99	9.37	9.29	19.41	2.11	83.01	45.26	38.54	6.03	5.66	4.88	2.66

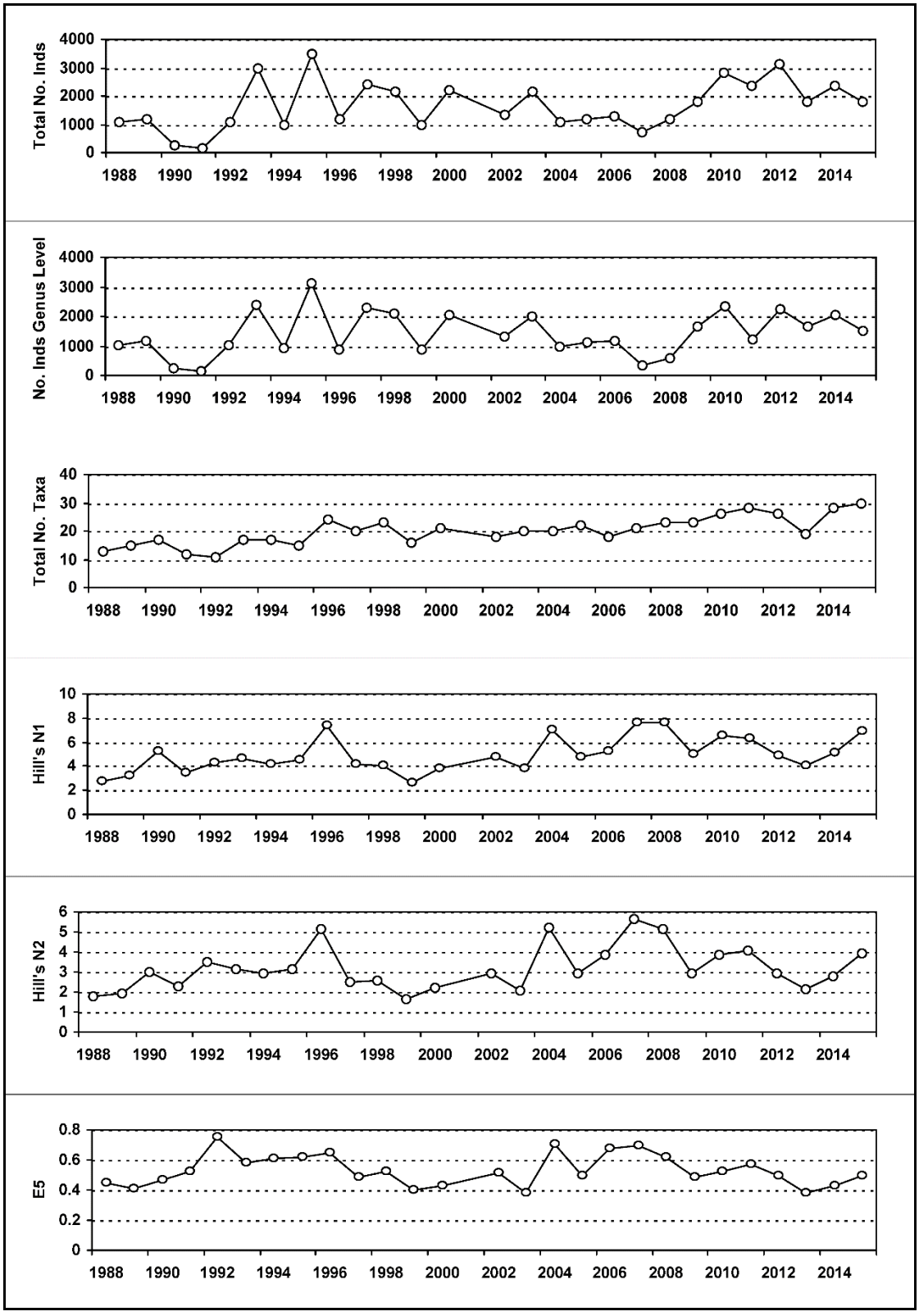
5.10.2 Macroinvertebrate data

5.10.2.1 Percentage abundance summary, Afon Hafren



2016 samples archived awaiting funding for analysis
No sampling in 2001 due to Foot and Mouth restrictions.

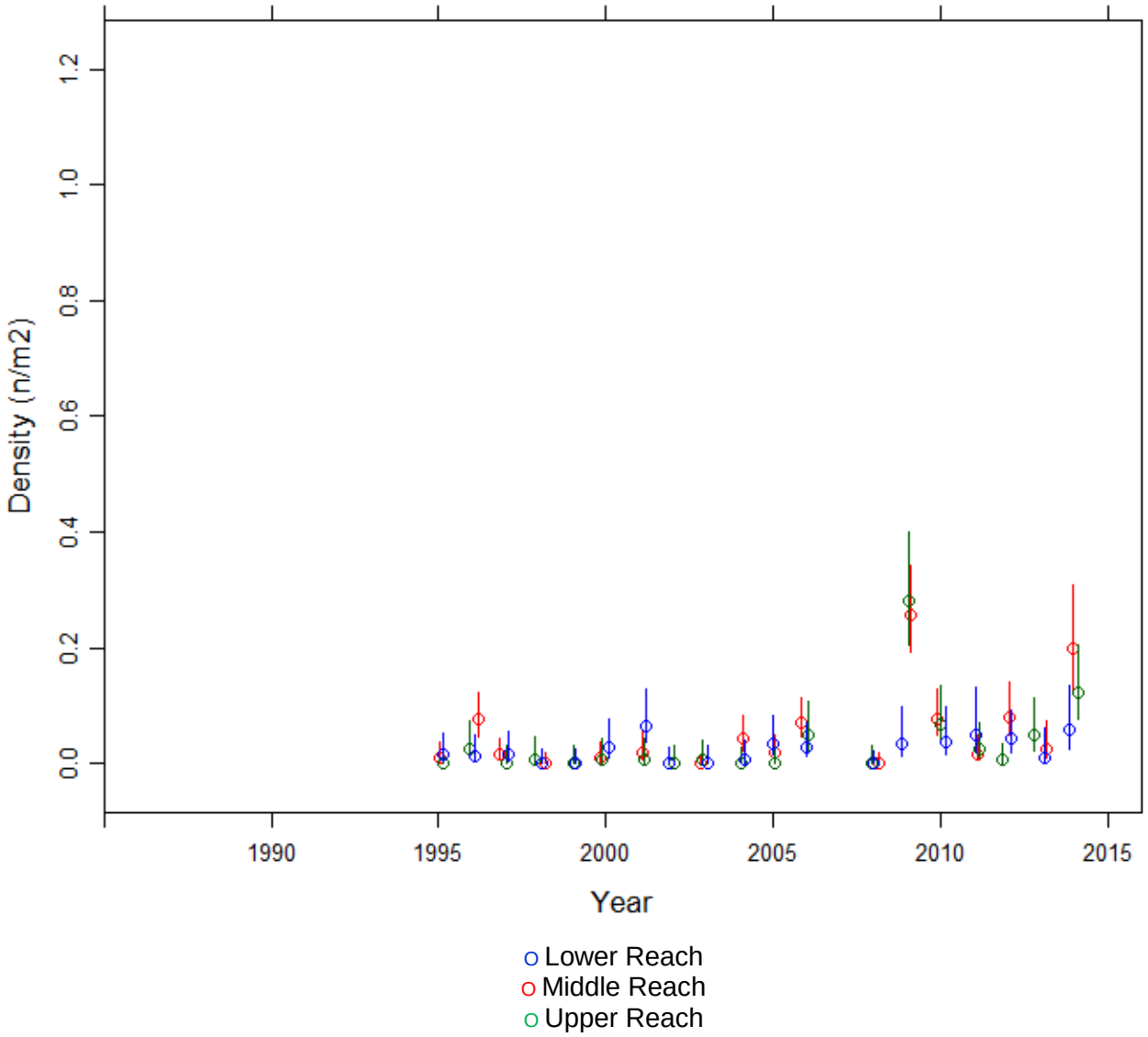
5.10.2.1 Macroinvertebrate summary statistics, Afon Hafren



2016 samples archived awaiting funding for analysis
No sampling in 2001 due to Foot and Mouth restrictions.

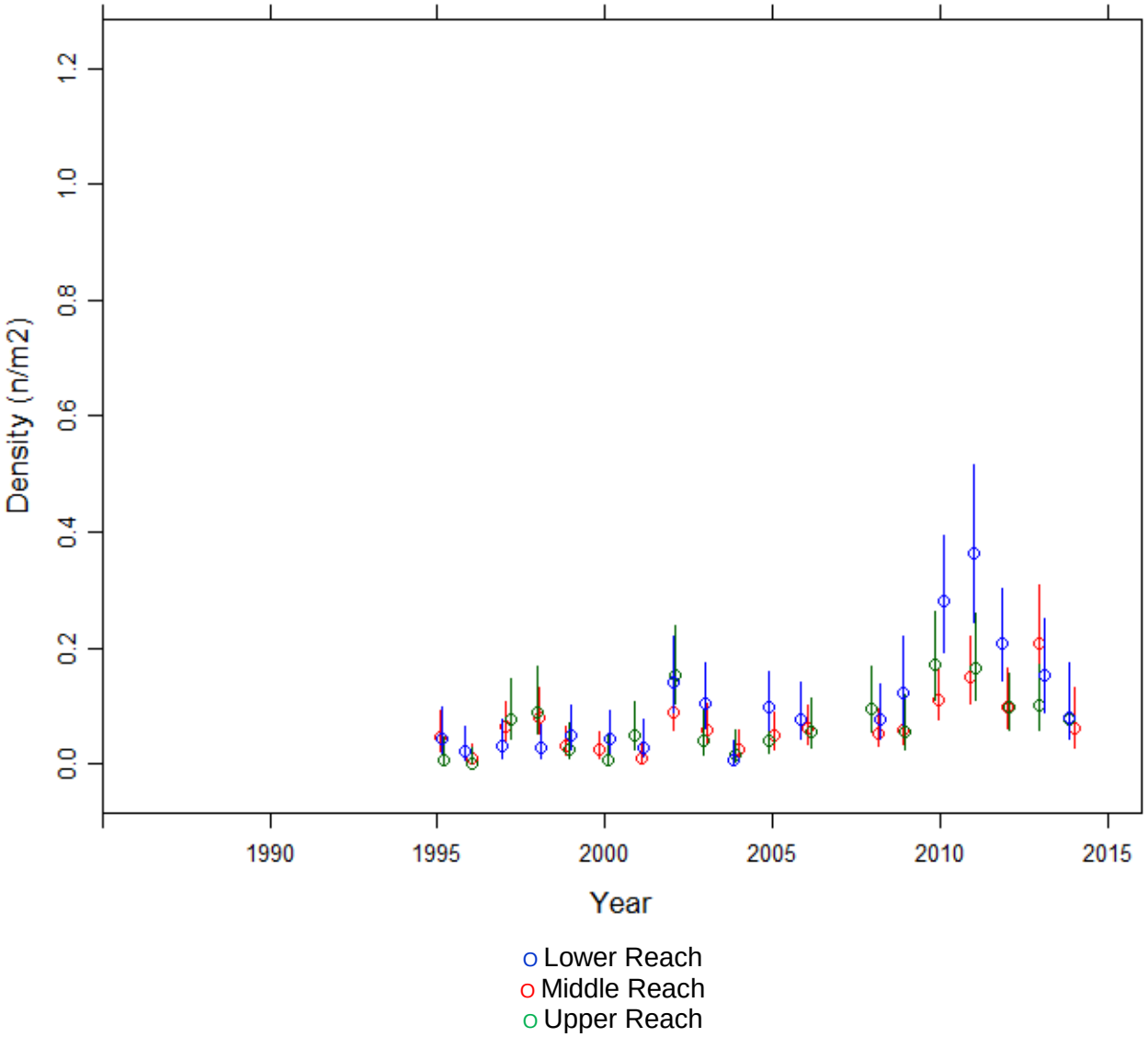
5.10.3 Fish data

5.10.3.1 Summary of Trout fry density (numbers m^{-2}), Afon Hafren



Fishing no longer funded after 2014.

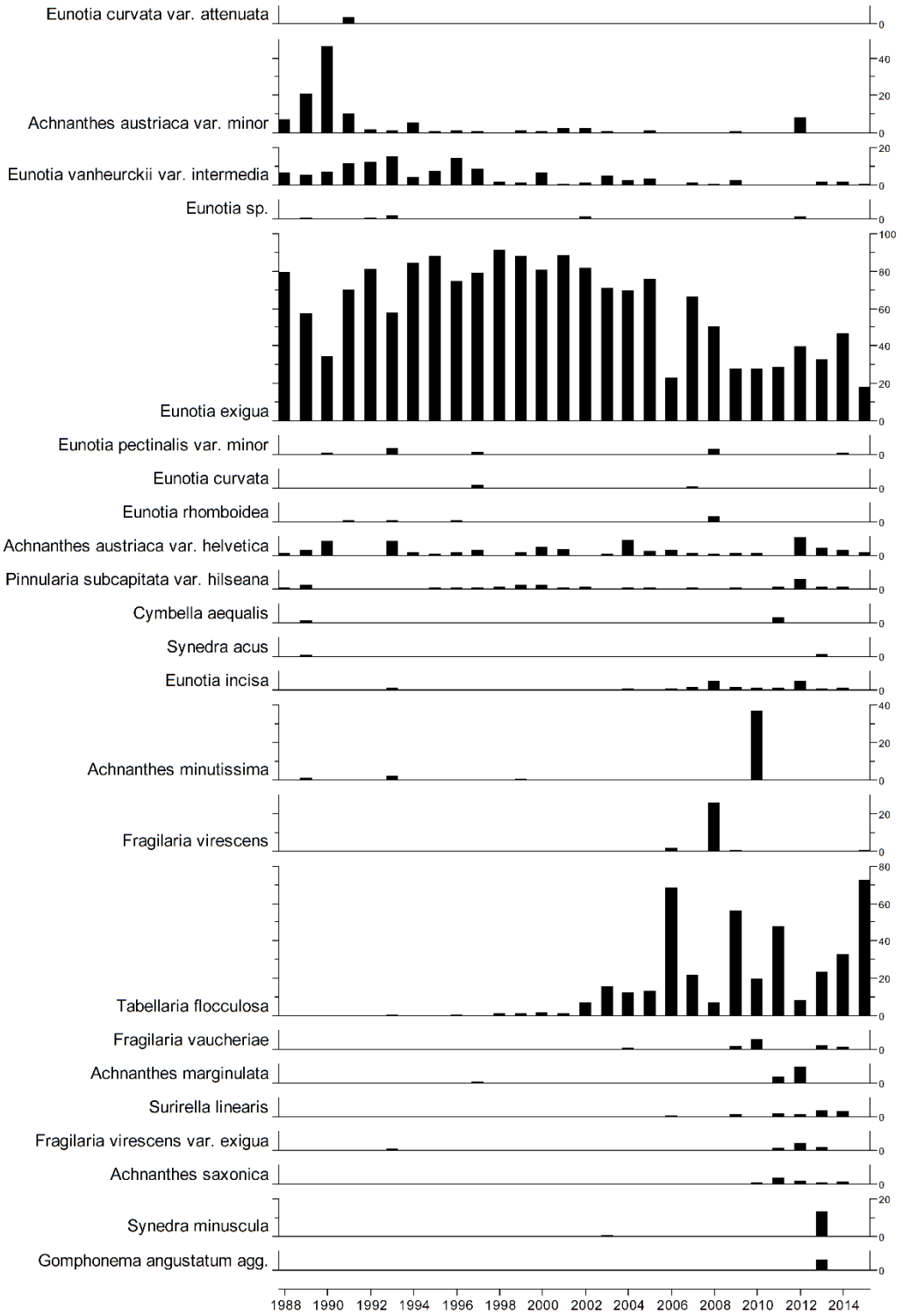
5.10.3.2 Summary of Trout parr density (numbers m^{-2}), Afon Hafren



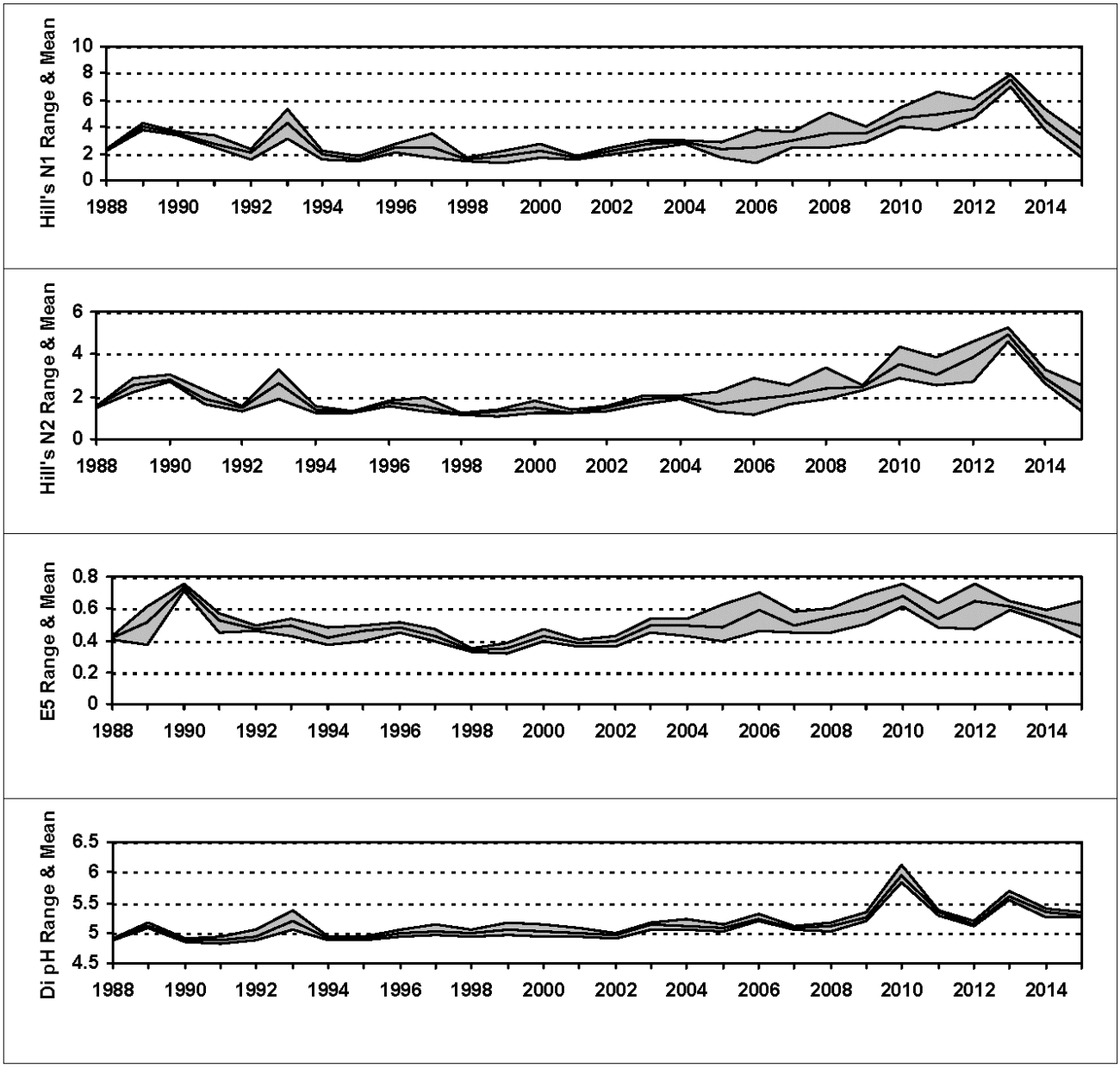
Fishing no longer funded after 2014.

5.10.4 Epilithic diatom data

5.10.4.1 Percentage abundance summary, Afon Hafren

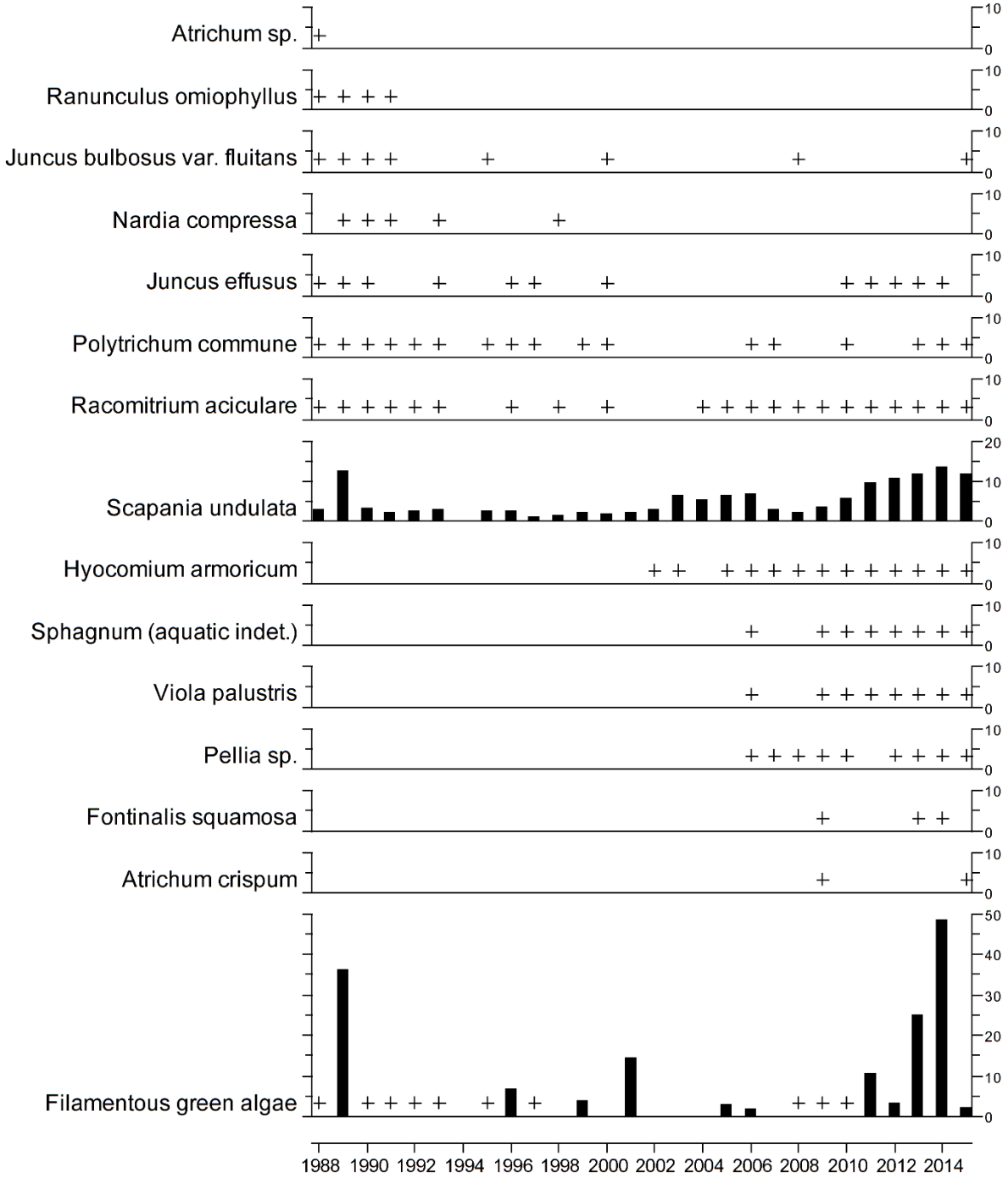


5.10.4.1 Diatom summary statistics, Afon Hafren



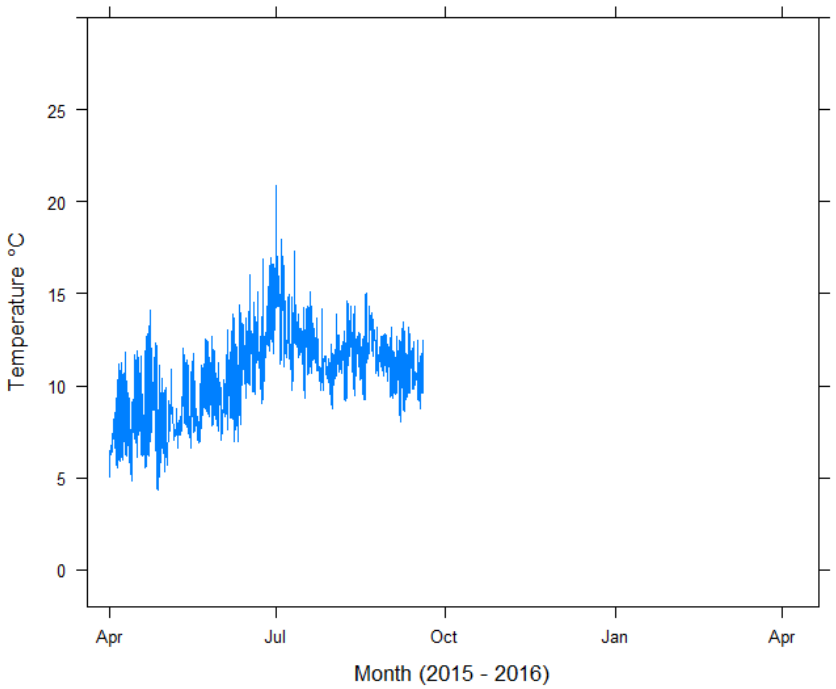
5.10.5 Aquatic macrophyte data, Afon Hafren

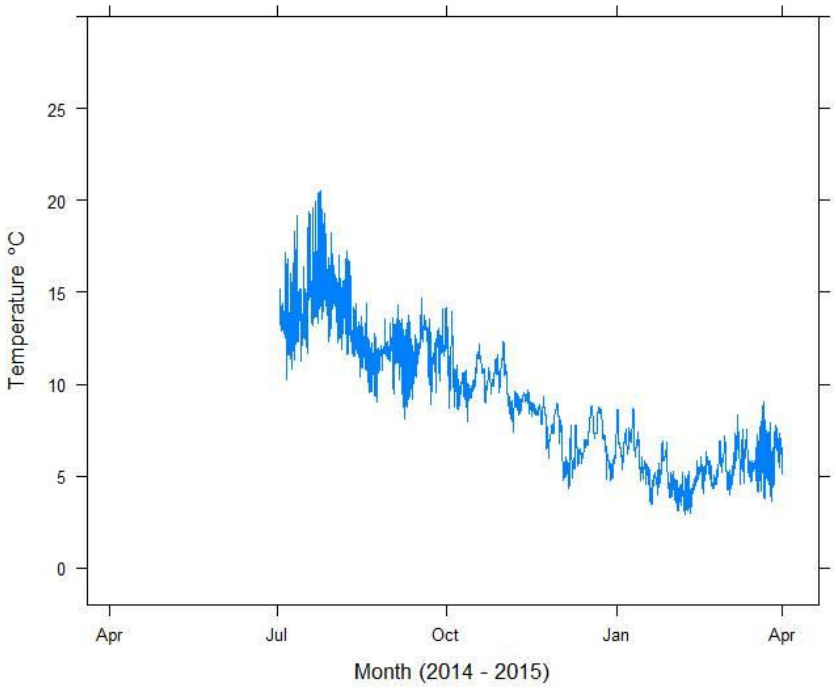
Percentage Species Cover

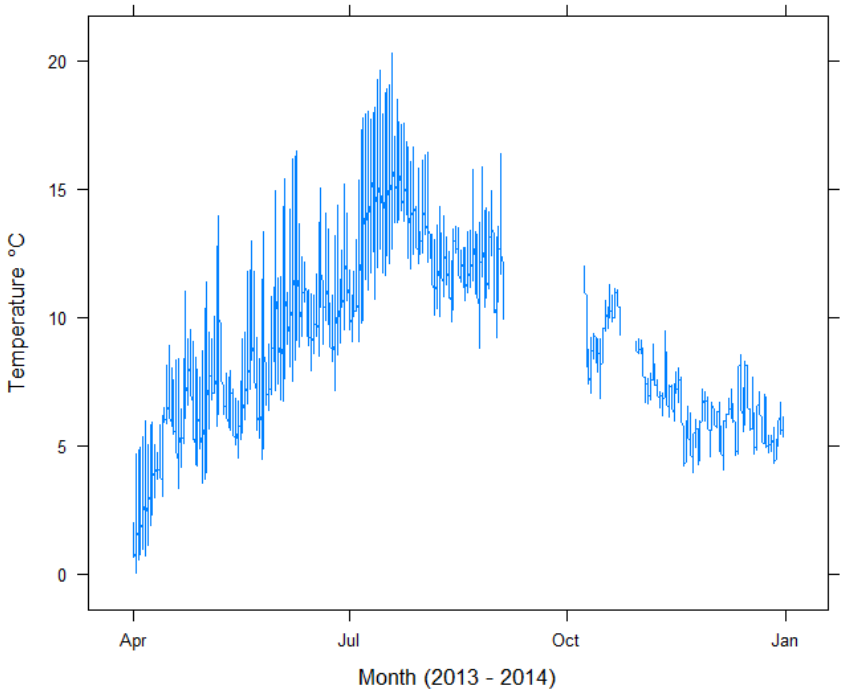


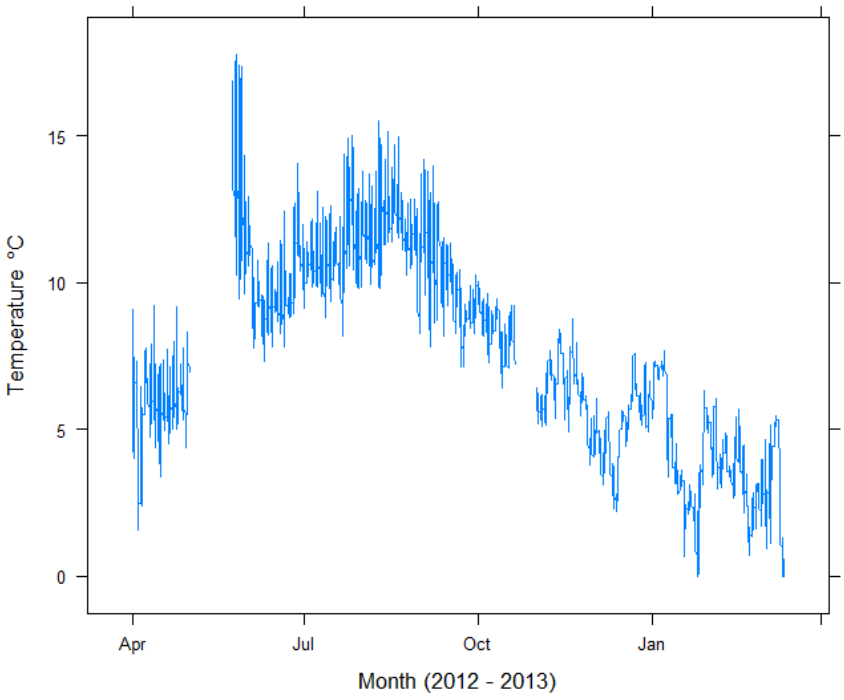
+ Represents <0.5% abundance

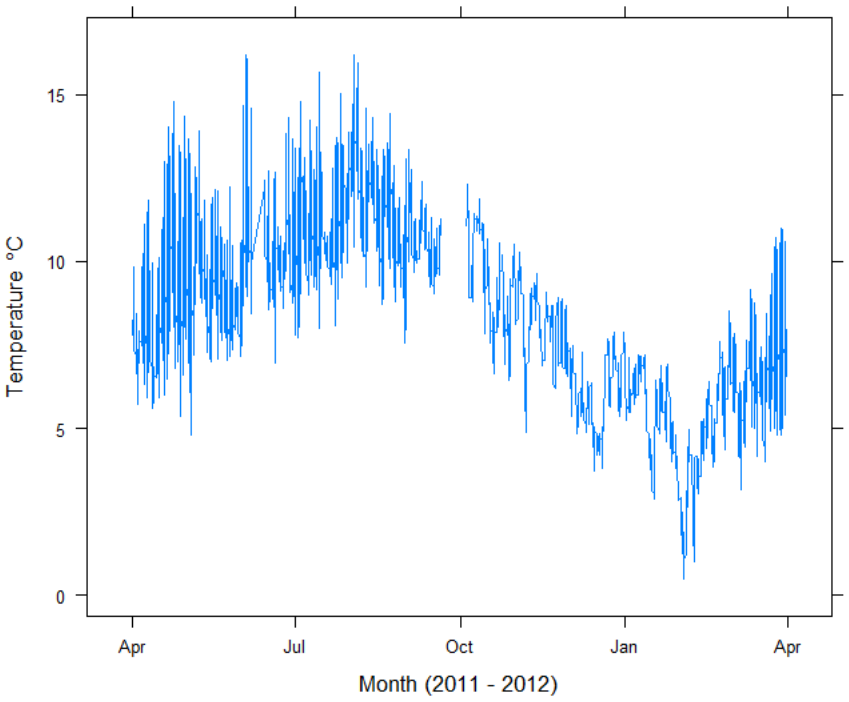
5.10.6 Thermistor data, Afon Hafren






Temperature °C
0
5
10
15
20
Apr
Jul
Oct
Jan
Month (2013 - 2014)


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



Gaps due to thermistor malfunction

6 Afon Gwy

Figure 4 Afon Gwy biological survey section 23rd September 2016

6.1 Summary Overview

Funded chemical and biological sample collection, analysis and data collation, quality control and archiving proceeded without any problems at Afon Gwy during the period from April 2016 to March 2017.

6.2 Water Chemistry

Samples were collected by CEH early every month throughout the period April 2016 to March 2017, delivered to the analytical laboratories on schedule and are in the process of being analysed, quality controlled and archived in the UKUWMN central chemistry database at CEH Lancaster.

6.3 Thermistors

A thermistor, supplied by Marine Scotland, was downloaded and replaced on 23rd of September 2016 by a team from ENSIS Ltd. It had functioned well during the previous year and the data were added to the ENSIS and MS thermistor water temperature database.

6.4 Epilithic Diatoms

Epilithic diatoms were retrieved by a team from ENSIS from three sampling points in the stream on the 7th of July 2016. The samples have been made into slides.

6.5 Macroinvertebrates

Aquatic macroinvertebrates were sampled on the 16th April 2016 by a team from QMuL. Five 1 minute kick samples were performed. The samples have been archived pending funding being available for analysis.

6.6 Fish

Due to resourcing cuts, fish surveying was not performed in Autumn 2016.

6.7 Aquatic Macrophytes

Aquatic macrophytes were surveyed by a team from ENSIS on 23rd of September 2016. Percentage cover scores were recorded and data will be added to the ENSIS biological database after microscope confirmation of bryophyte identifications.

6.8 Data Management and Reporting

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

The 2015-2016 summary diagrams have been uploaded to the UKUWMN web page. The section on on Afon Gwy appears in section 6.10 below.

The UKUWMN website page detailing Afon Gwy can be found here:
http://uwmn.defra.gov.uk/sites/site_18.php

Further publications from the contract period utilizing UKUWMN data from Afon Gwy are detailed in section 6.9 below.

6.9 Afon Gwy Recent UKUWMN Output

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Juggins S., Kelly M., Allott T., Kelly-Quinn M. & Monteith D. (2016) A Water Framework Directive-compatible metric for assessing acidification in UK and Irish rivers using diatoms. *Science of the Total Environment,* **568,** 671-678.

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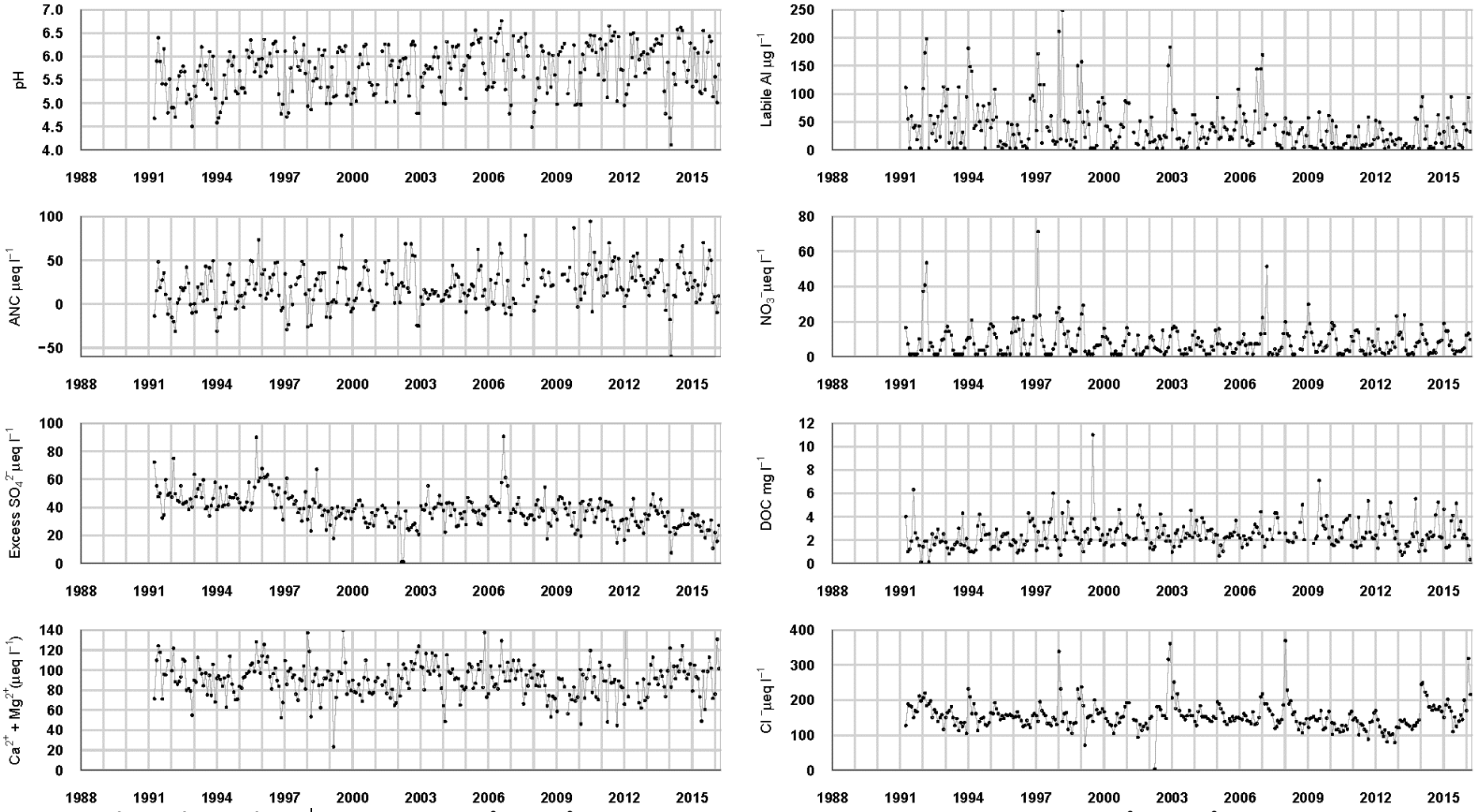
6.10 Afon Gwy Summary Data to March 2016

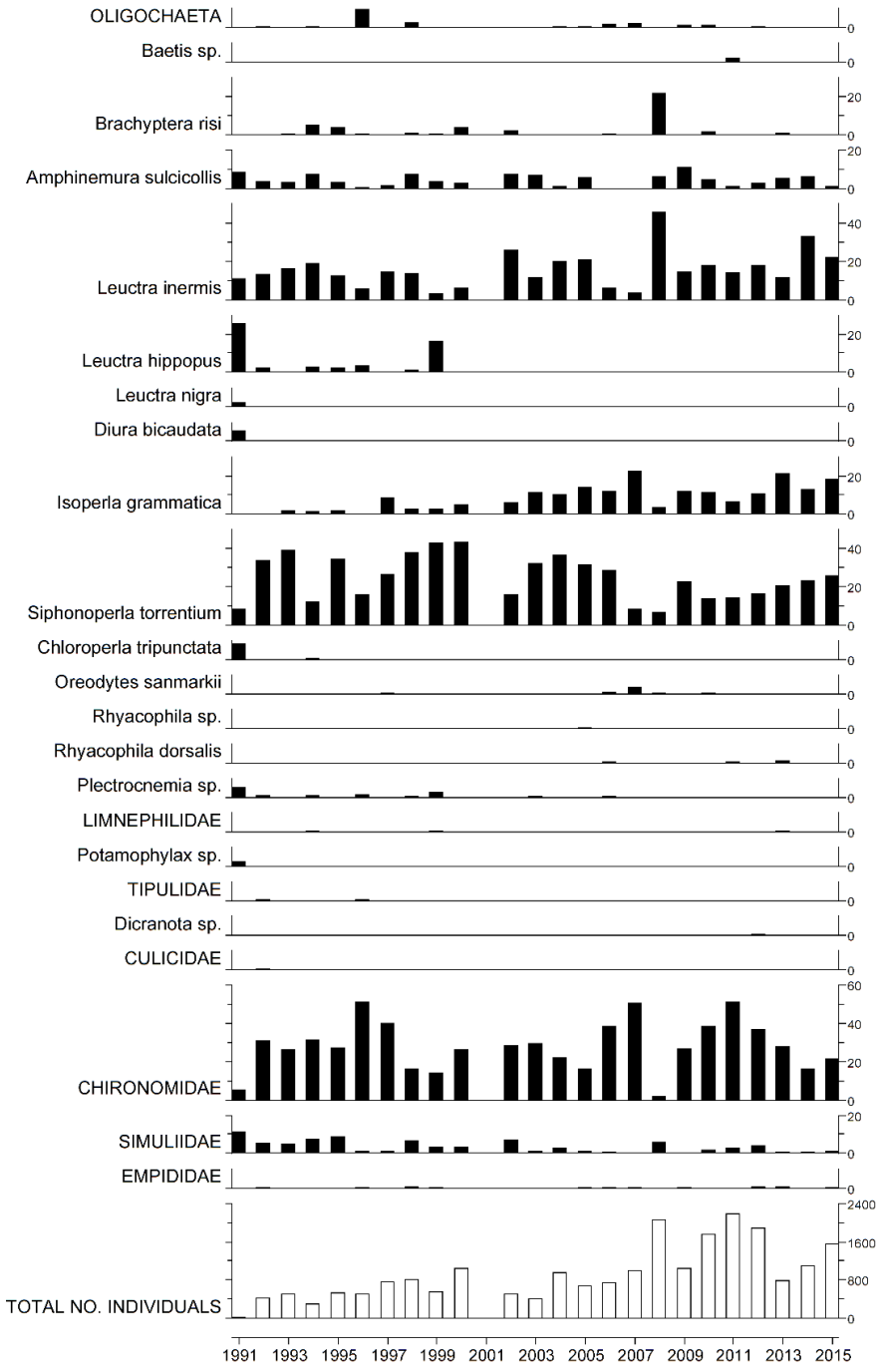
6.10.1 Spot sampled chemistry data



µeq l⁻¹ , *µg l⁻¹, **mg l⁻¹	pH	ANC	Ca 2+	Mg 2+	Na +	K +	*Soluble Al	*Labile Al	Cl -	*SO4 2-	xSO4 2-	NO3 -	**DOC
Mean 1st 5 yrs	5.51	14.13	40.42	53.22	147.31	3.24	106.64	53.64	159.84	65.67	48.91	8.65	1.98
15-16 mean	5.72	24.15	35.65	53.04	150.73	3.22	68.33	33.42	172.93	41.81	23.68	6.05	2.63
15-16 std dev	0.55	25.35	10.94	13.24	33.61	2.47	47.58	32.09	54.70	7.22	6.67	3.93	1.31

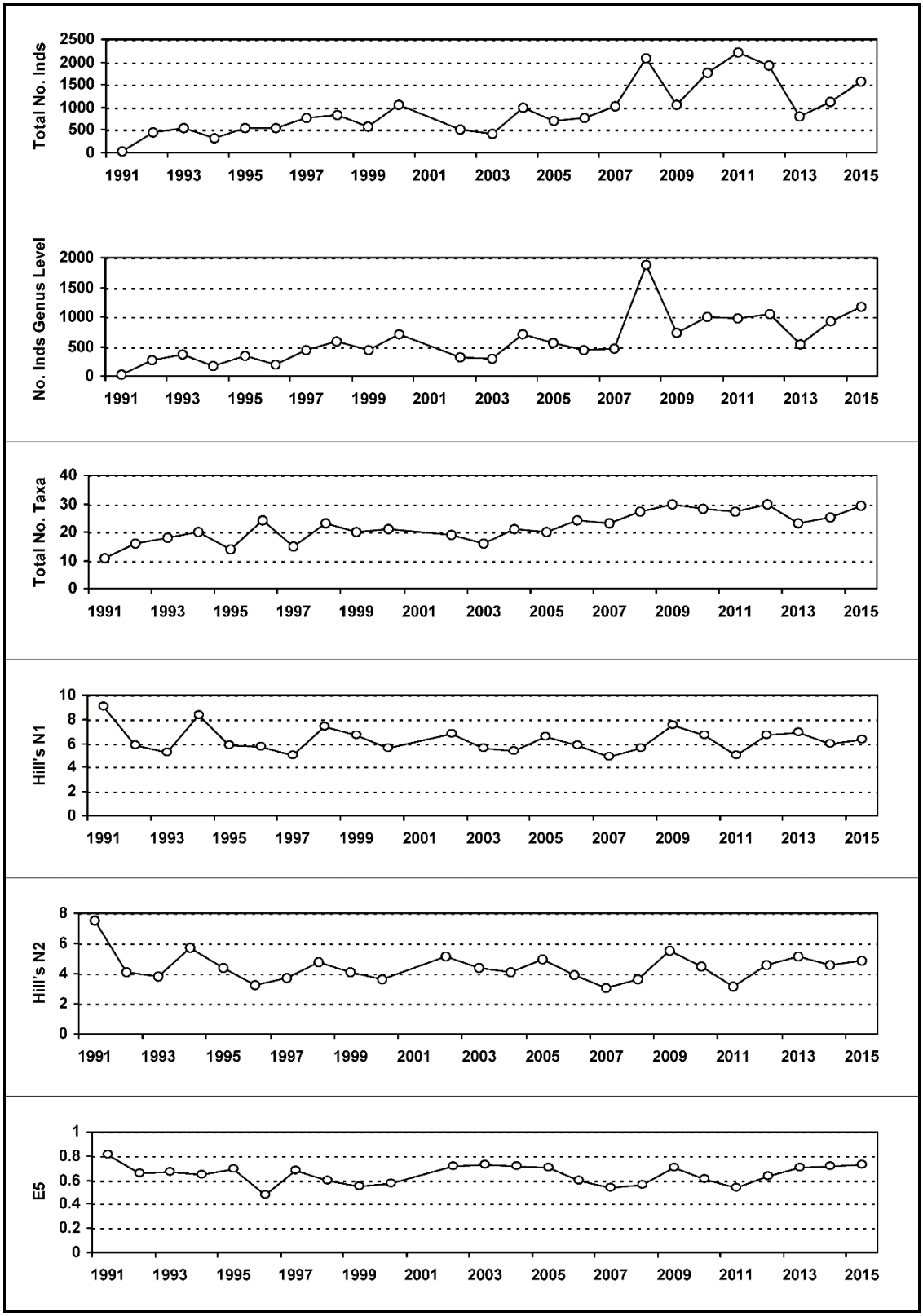
6.10.2 Macroinvertebrate data

6.10.2.1 Percentage abundance summary, Afon Gwy



2016 samples archived awaiting funding for analysis
No sampling in 2001 due to Foot and Mouth restrictions.

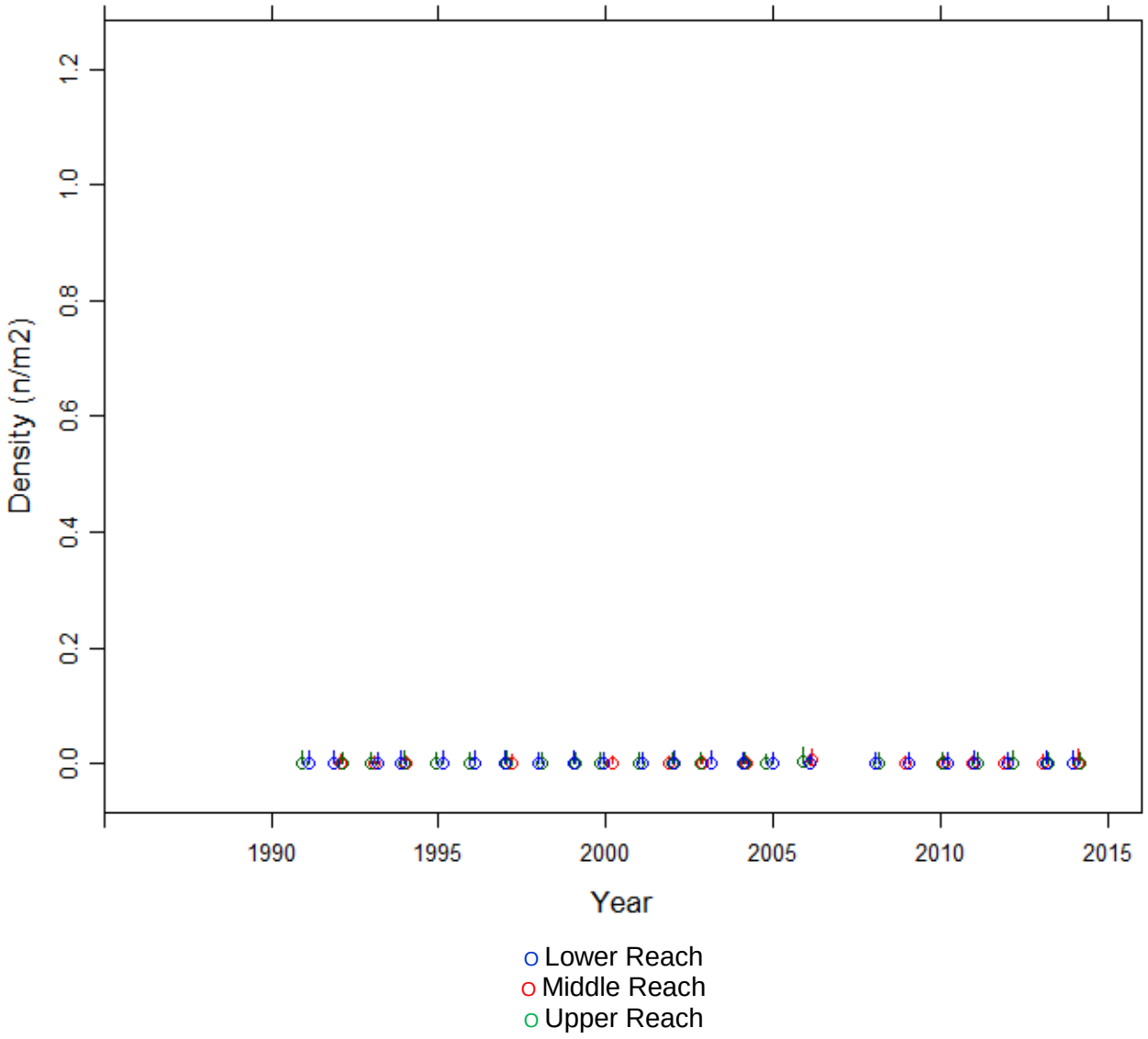
6.10.2.2 Macroinvertebrate summary statistics, Afon Gwy



2016 samples archived awaiting funding for analysis
No sampling in 2001 due to Foot and Mouth restrictions.

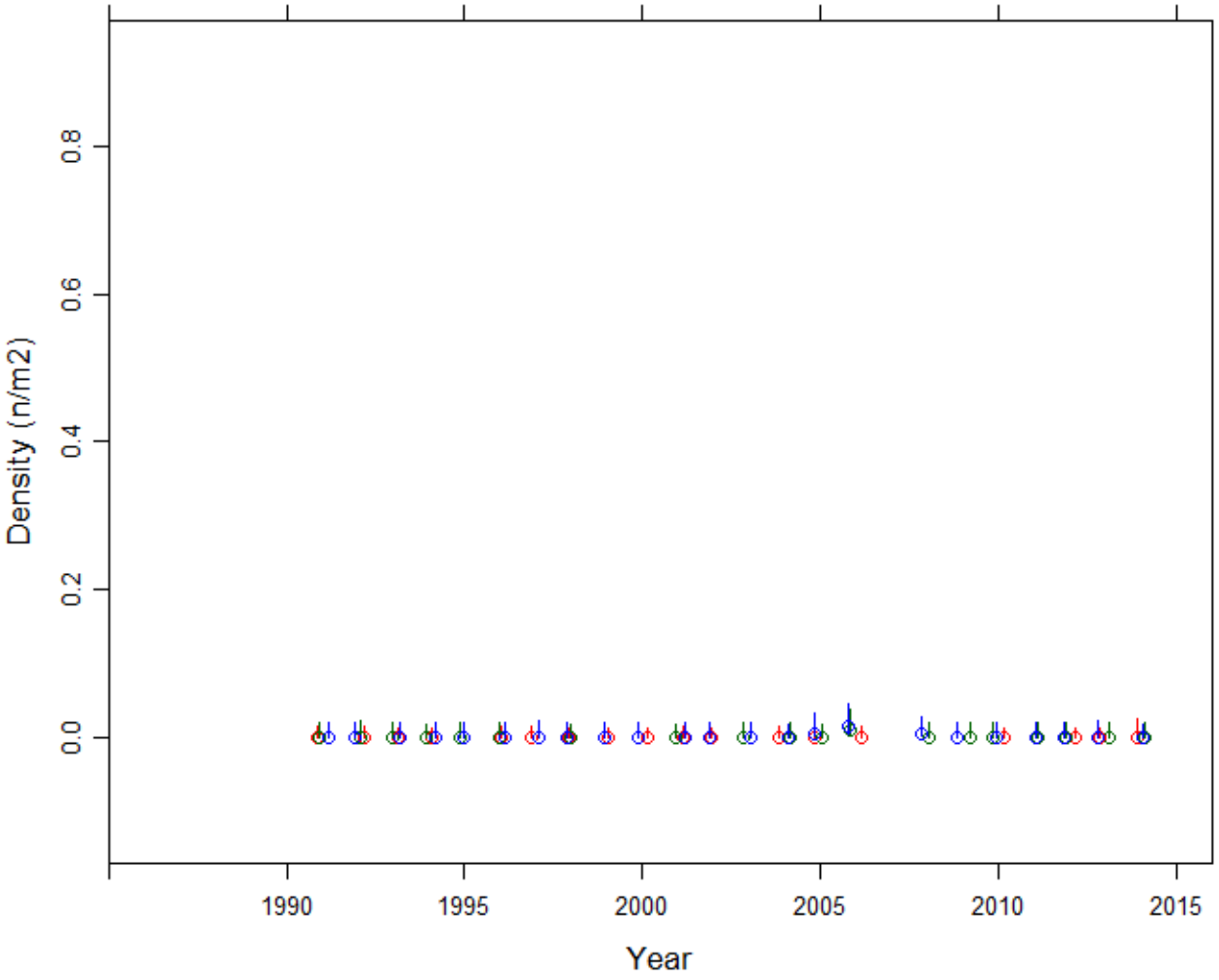
6.10.3 Fish data

6.10.3.1 Summary of Salmon fry densities (numbers m^{-2}), Afon Gwy



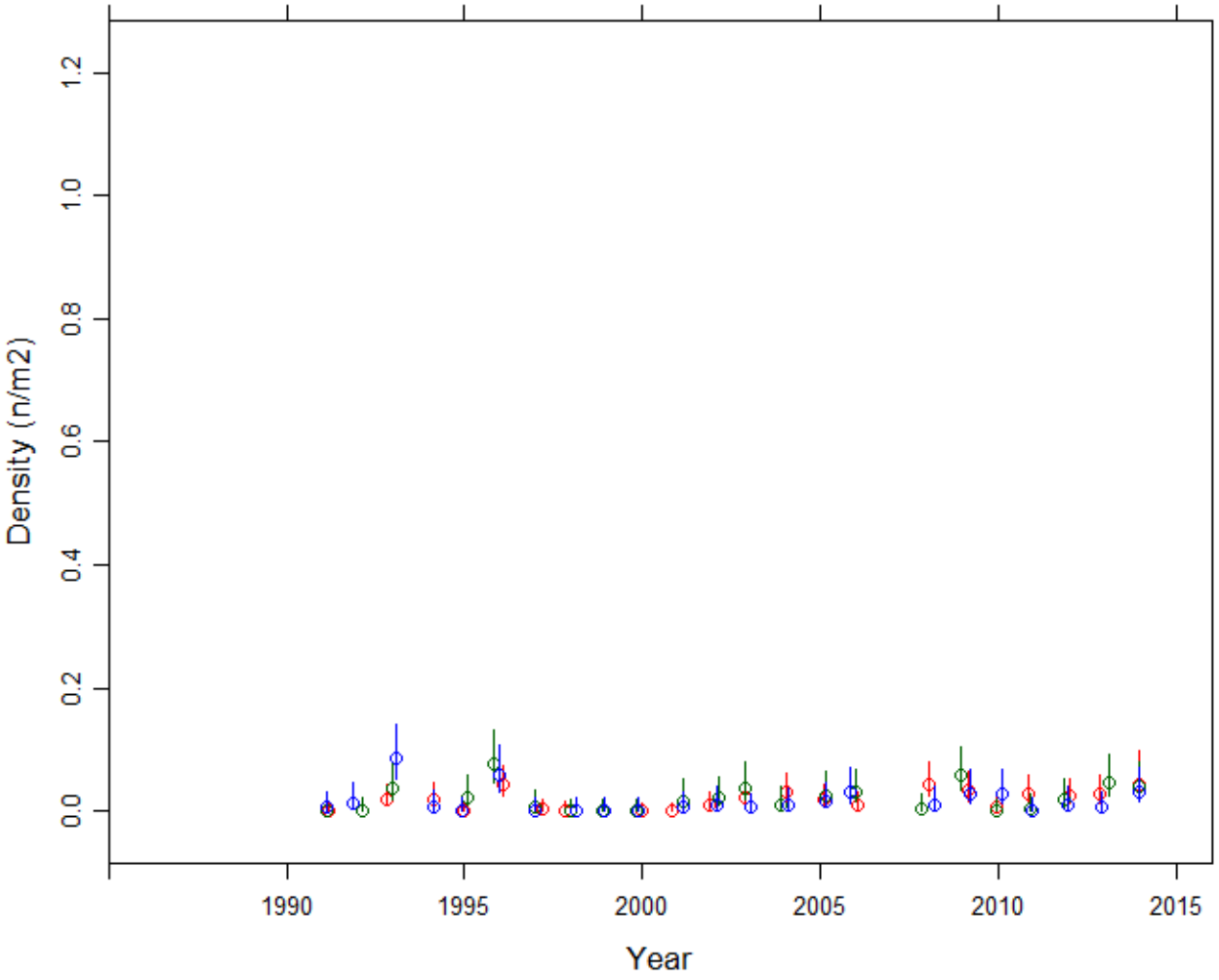
Fishing no longer funded after 2014.

6.10.3.2 Summary of Salmon parr densities (numbers m^{-2}), Afon Gwy



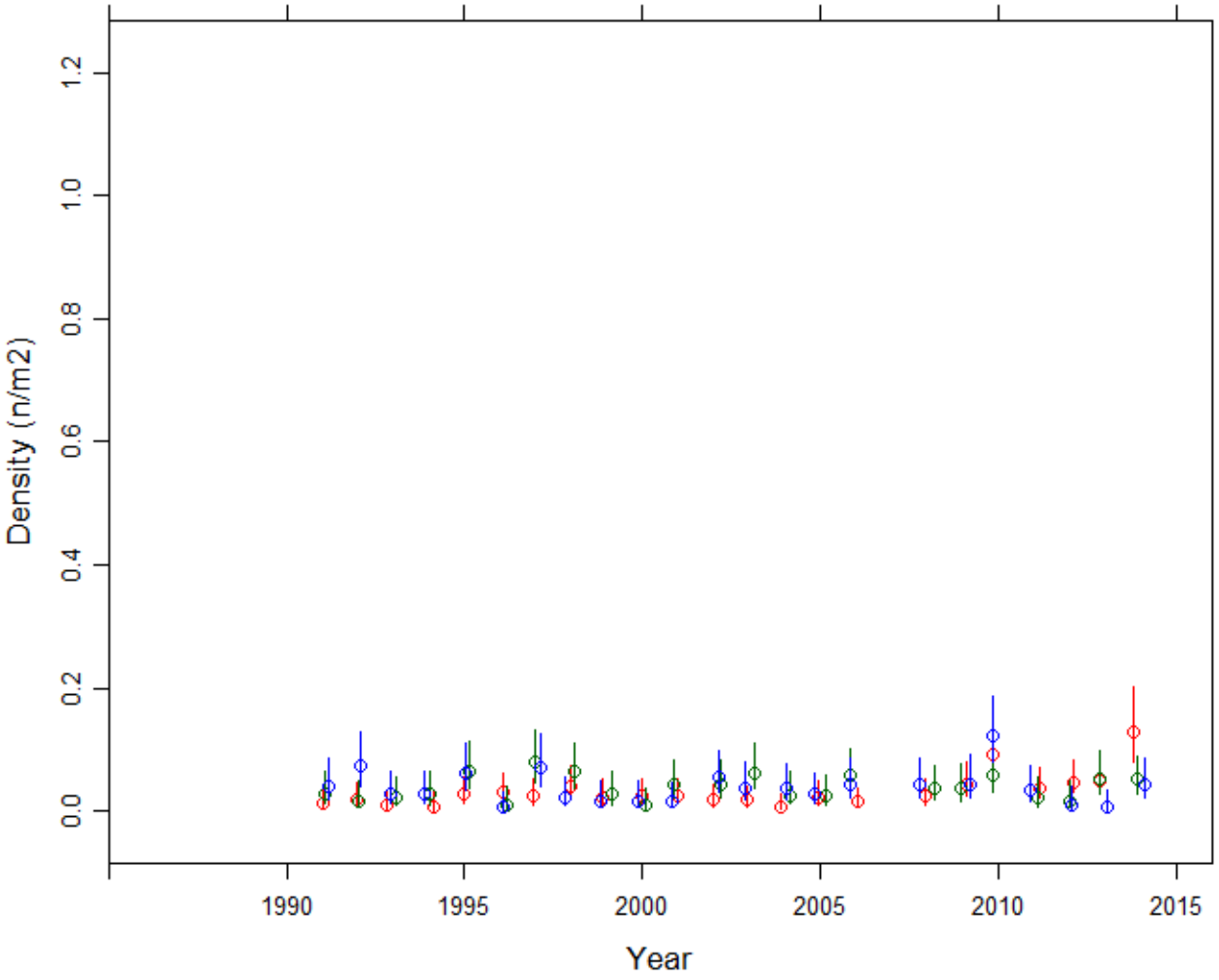
Fishing no longer funded after 2014.

6.10.3.3 Summary of Trout fry density (numbers m^{-2}), Afon Gwy



Fishing no longer funded after 2014.

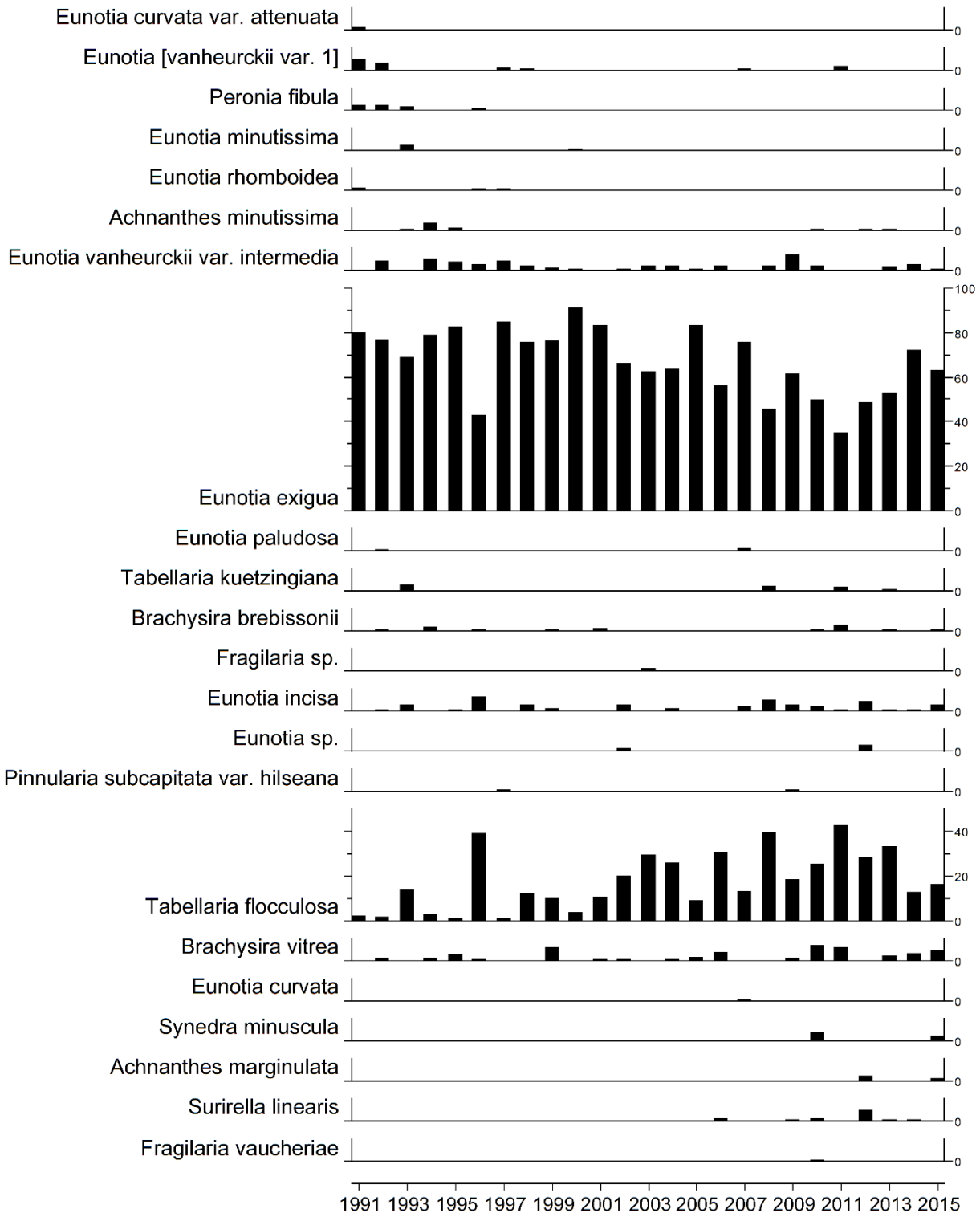
6.10.3.4 Summary of Trout parr density (numbers m^{-2}), Afon Gwy



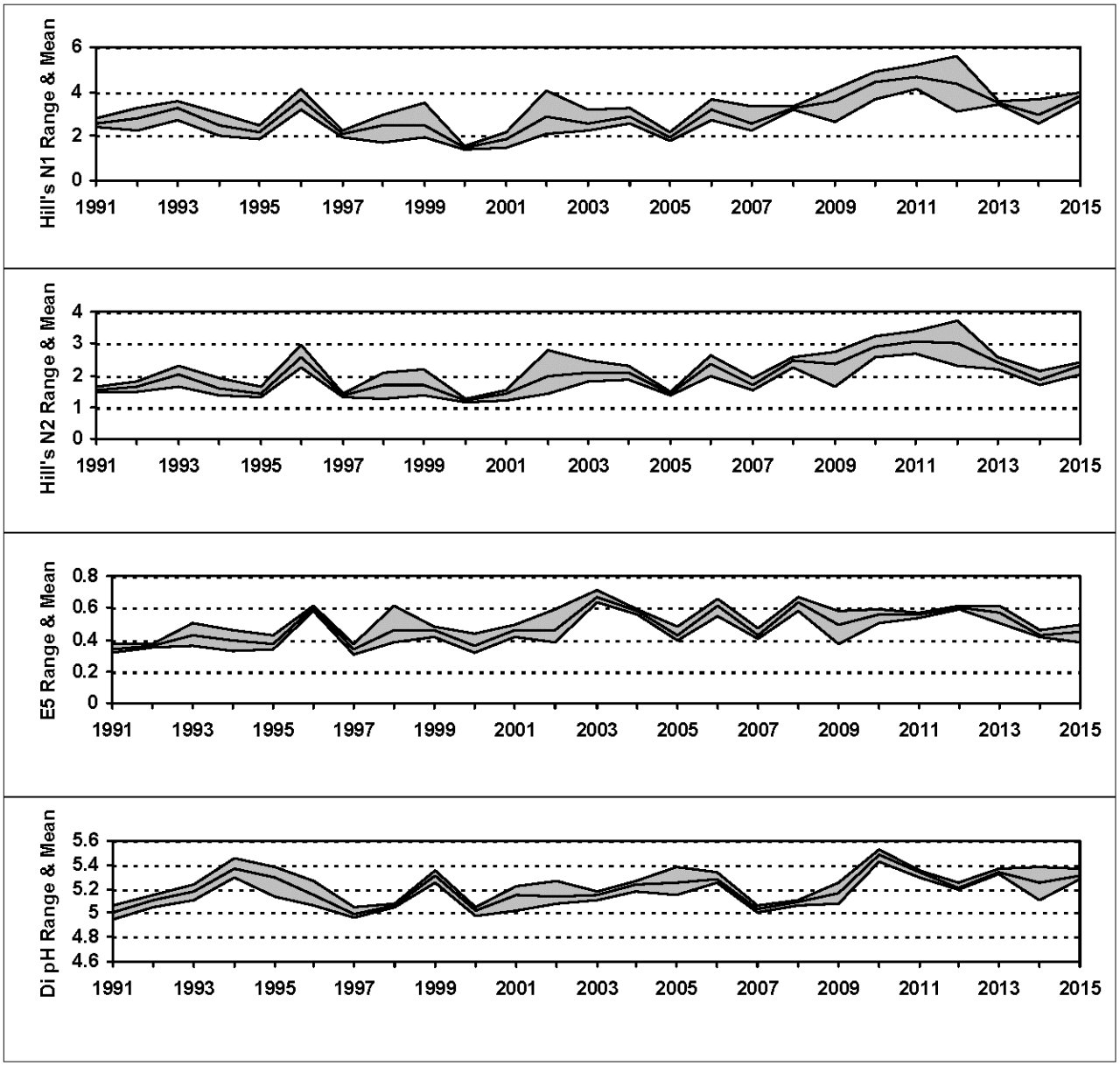
Fishing no longer funded after 2014

6.10.4 Epilithic diatom data

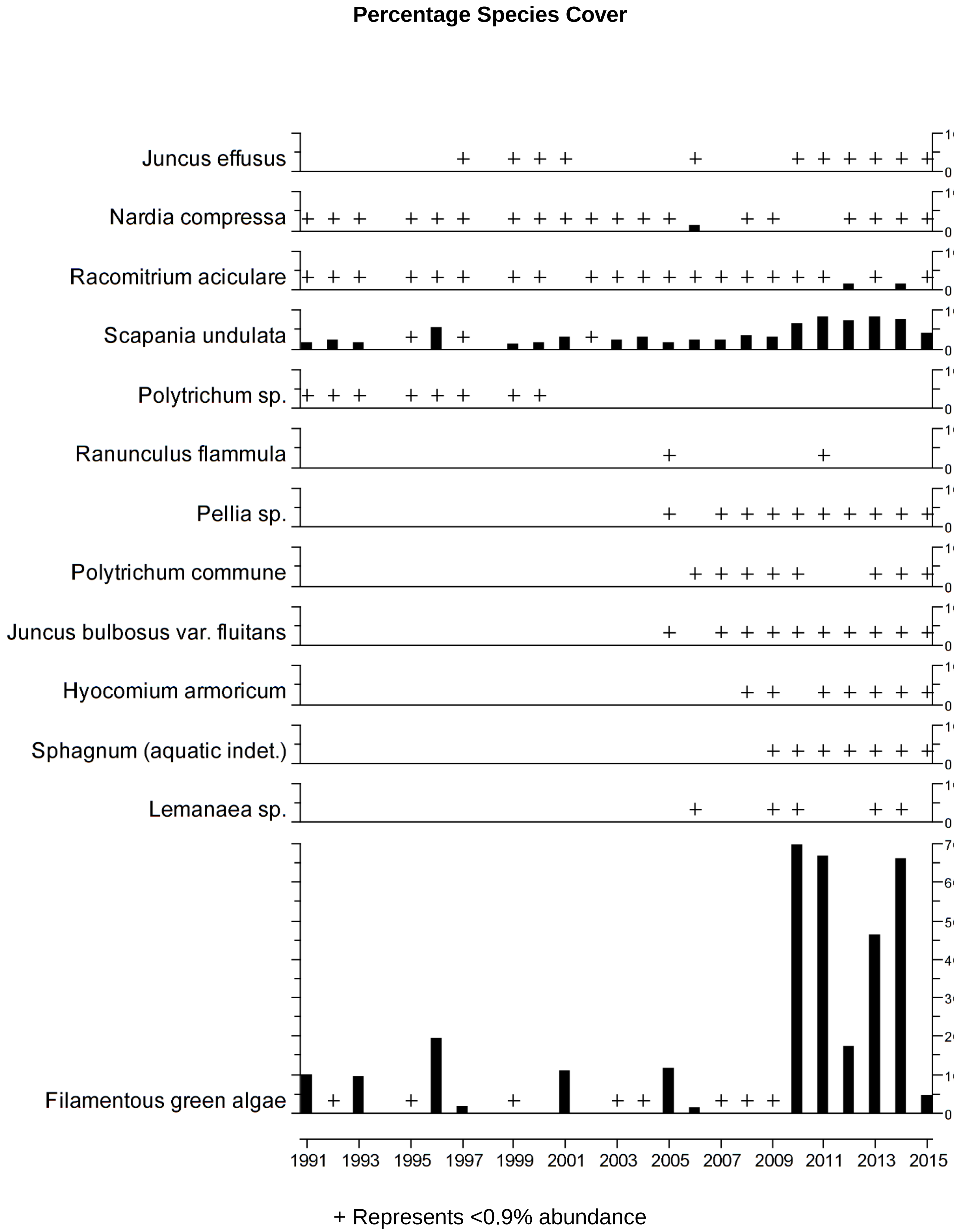
6.10.4.1 Percentage abundance summary, Afon Gwy



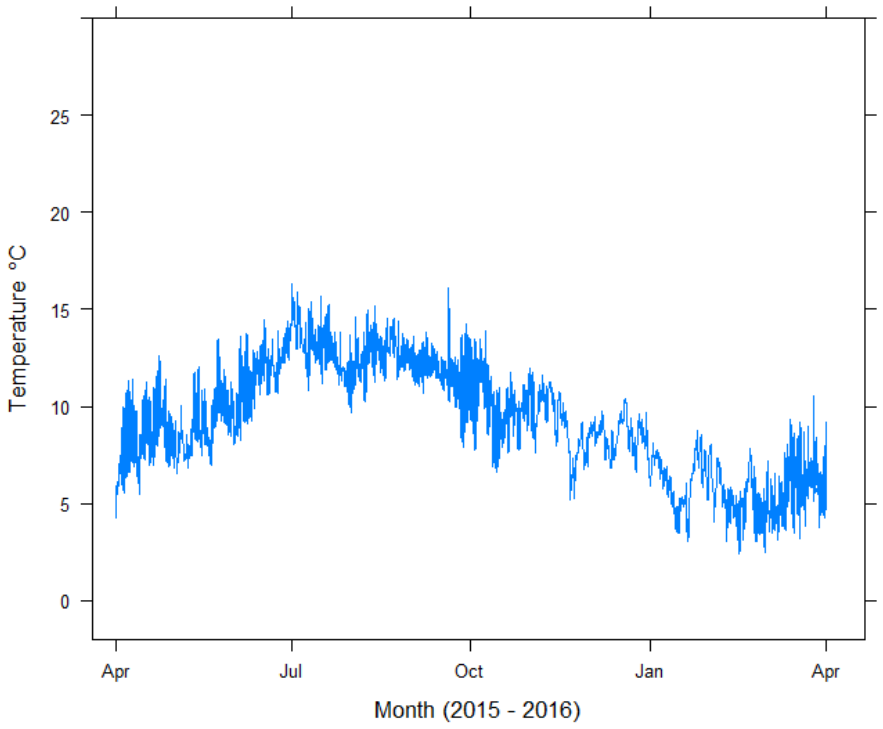
6.10.4.2 Diatom summary statistics, Afon Gwy

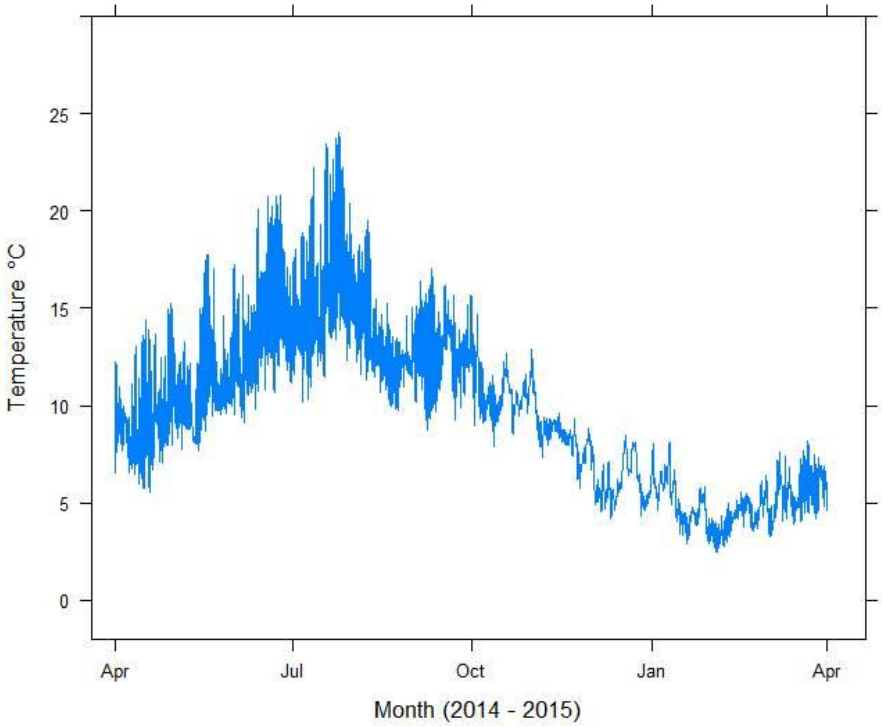


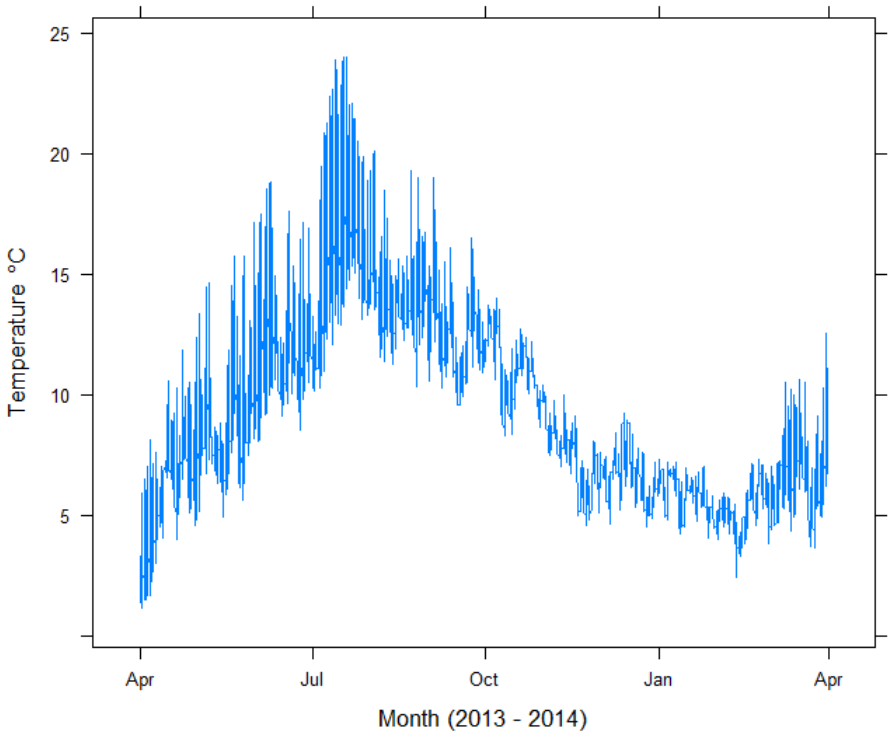
6.10.5 Aquatic macrophyte data, Afon Gwy

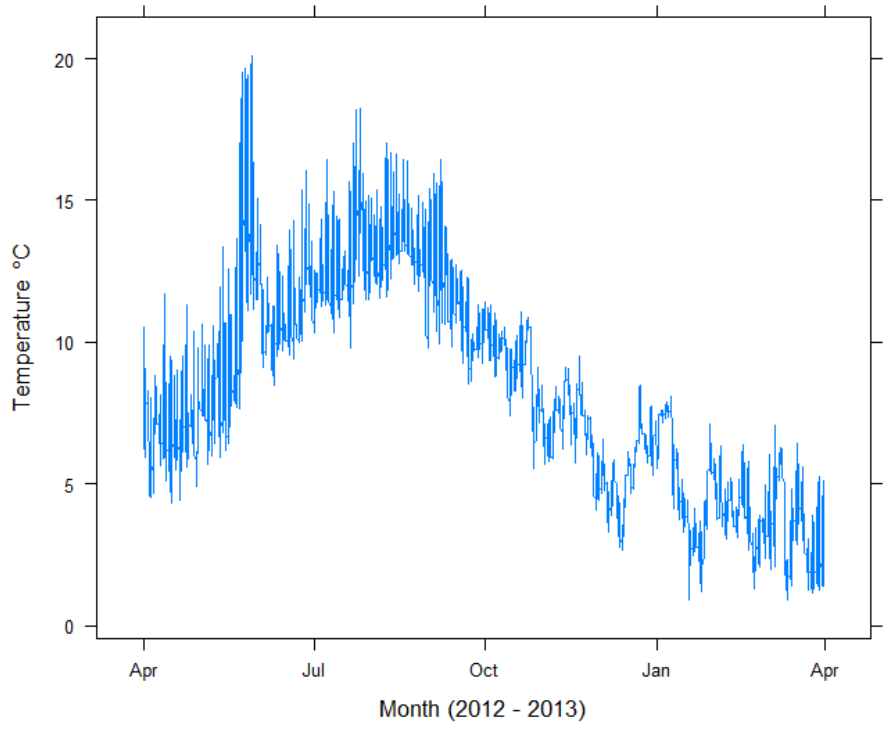


6.10.6 Thermistor data, Afon Gwy






Temperature °C
25
20
15
10
5
Apr
Jul
Oct
Jan
Apr
Month (2013 - 2014)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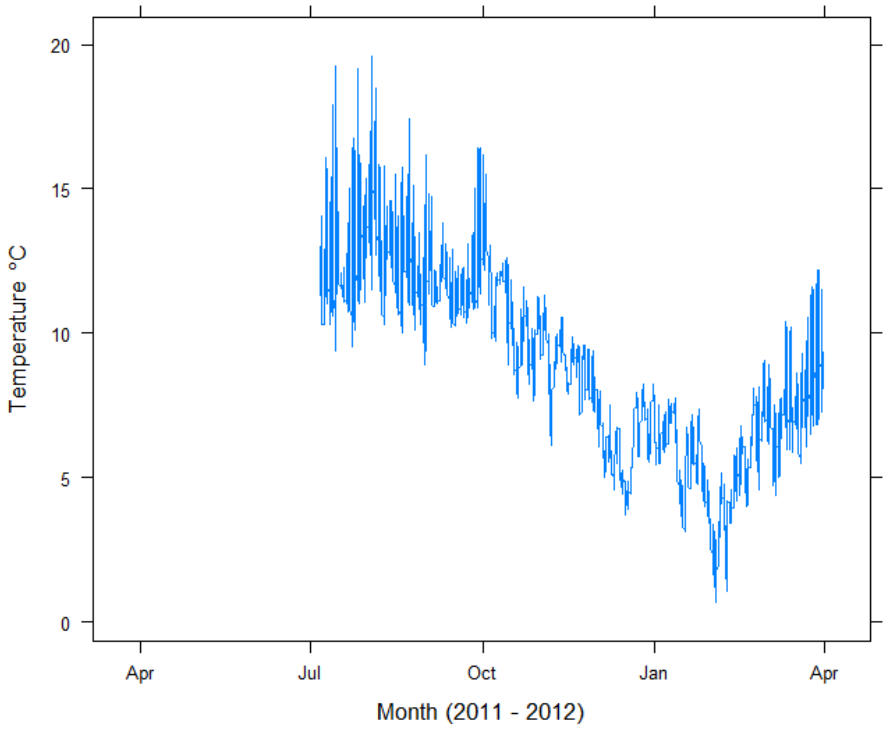
15
10
5
0
Apr
Jul
Oct
Jan
Apr
Month (2012 - 2013)


Temperature °C
20
15
10
5
0
Apr
Jul
Oct
Jan
Apr
Month (2011 - 2012)