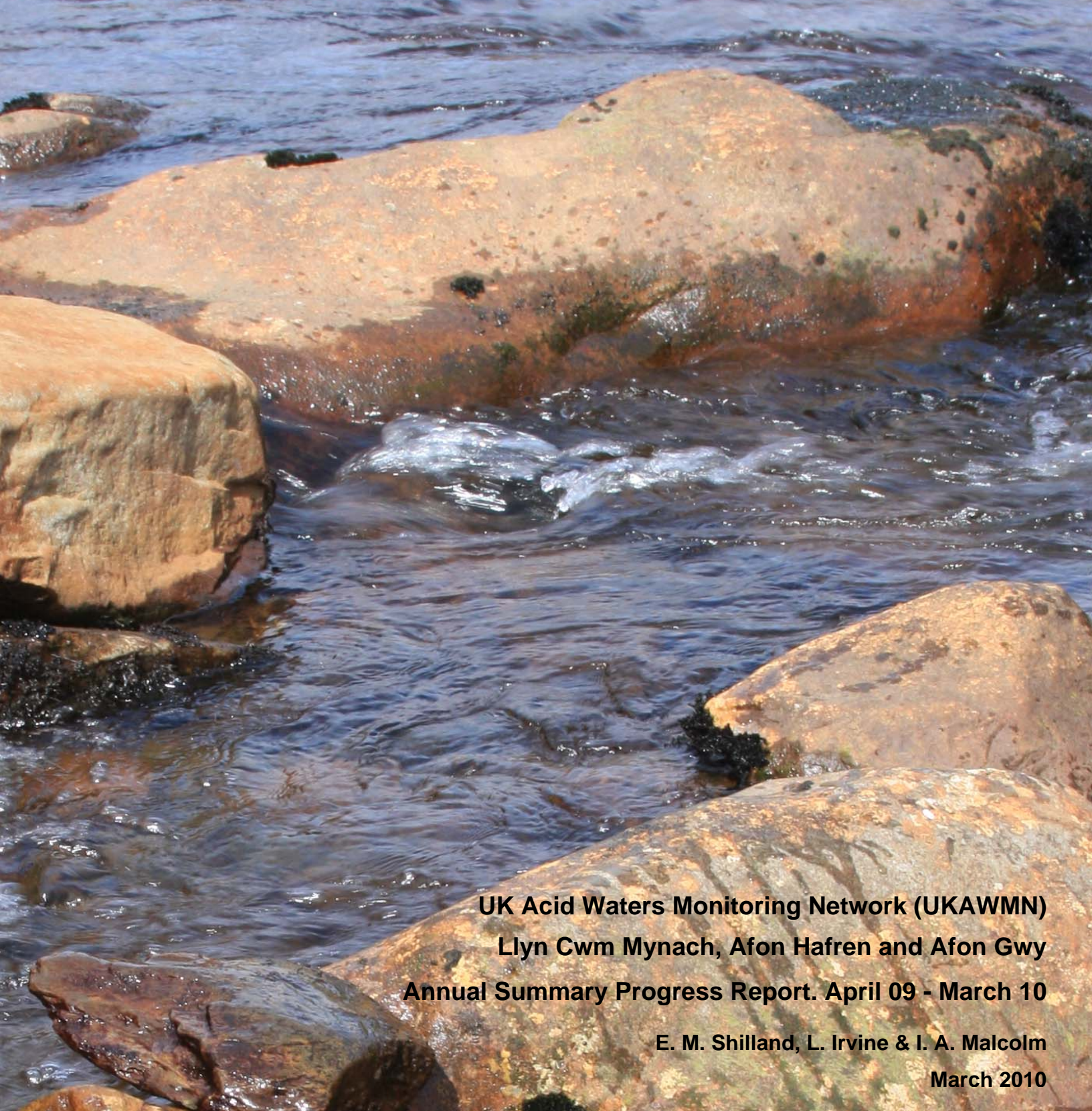




UCL



**UK Acid Waters Monitoring Network (UKAWMN)
Llyn Cwm Mynach, Afon Hafren and Afon Gwy
Annual Summary Progress Report. April 09 - March 10**

**E. M. Shilland, L. Irvine & I. A. Malcolm
March 2010**

**UK ACID WATERS MONITORING NETWORK (UKAWMN) –
CONTRACT 22 01 249**

LLYN CWM MYNACH, AFON HAFREN AND AFON GWY

ANNUAL SUMMARY PROGRESS REPORT April 2009 - March 2010

**REPORT TO THE WELSH ASSEMBLY GOVERNMENT,
COUNTRYSIDE COUNCIL FOR WALES AND ENVIRONMENT
AGENCY, WALES**

Ewan M. Shilland¹, Lynne Irvine² & Ian A. Malcolm³

March 2010

¹ ECRC, UCL

² CEH Lancaster

³ Marine Scotland, Pitlochry

1 Table of Contents

1	Table of Contents	3
2	List of Figures	4
3	Llyn Cwm Mynach	5
3.1	Summary Overview	5
3.2	Water Chemistry	5
3.3	Sediment Traps.....	5
3.4	Thermistors	6
3.5	Epilithic Diatoms.....	6
3.6	Macroinvertebrates	6
3.7	Fish	6
3.8	Aquatic Macrophytes.....	6
3.9	Data Management and Reporting	6
3.10	Llyn Cwm Mynach Recent Publications	7
3.11	Llyn Cwm Mynach Bibliography	9
3.12	Llyn Cwm Mynach Summary Data to March 2008	18
3.12.1	Spot sampled chemistry data	18
3.12.2	Macroinvertebrate data	19
3.12.2.1	Percentage abundance summary, Llyn Cwm Mynach	19
3.12.2.1	Macroinvertebrate summary statistics, Llyn Cwm Mynach.....	20
3.12.3	Fish data (for outflow stream).....	21
3.12.3.1	Summary of Trout fry density (numbers m ⁻²), Llyn Cwm Mynach.....	21
3.12.3.2	Summary of Trout parr density (numbers m ⁻²), Llyn Cwm Mynach	22
3.12.4	Epilithic diatom data	23
3.12.4.1	Percentage abundance summary, Llyn Cwm Mynach	23
3.12.4.1	Diatom summary statistics, Llyn Cwm Mynach	24
3.12.5	Aquatic macrophyte data, Llyn Cwm Mynach	25
3.12.6	Sediment trap data, Llyn Cwm Mynach.....	26
3.12.7	Thermistor data, Llyn Cwm Mynach.....	27
4	Afon Hafren	28
4.1	Summary Overview	28
4.2	Water Chemistry	28
4.3	Epilithic Diatoms.....	29
4.4	Macroinvertebrates	29
4.5	Fish	29
4.6	Aquatic Macrophytes.....	29
4.7	Data Management and Reporting	29
4.8	Afon Hafren Recent Publications	30
4.9	Afon Hafren Bibliography	31
4.10	Afon Hafren Summary Data to March 2008	43
4.10.1	Spot sampled chemistry data	43
4.10.2	Macroinvertebrate data	44
4.10.2.1	Percentage abundance summary, Afon Hafren	44
4.10.2.1	Macroinvertebrate summary statistics, Afon Hafren.....	45
4.10.3	Fish data.....	46
4.10.3.1	Summary of Trout fry density (numbers m ⁻²), Afon Hafren.....	46
4.10.3.2	Summary of Trout parr density (numbers m ⁻²), Afon Hafren	47
4.10.4	Epilithic diatom data	48

4.10.4.1	Percentage abundance summary, Afon Hafren	48
4.10.4.1	Diatom summary statistics, Afon Hafren	49
4.10.5	Aquatic macrophyte data, Afon Hafren	50
5	Afon Gwy	51
5.1	Summary Overview	51
5.2	Water Chemistry	51
5.3	Epilithic Diatoms.....	52
5.4	Macroinvertebrates	52
5.5	Fish	52
5.6	Aquatic Macrophytes.....	52
5.7	Data Management and Reporting	52
5.8	Afon Gwy Recent Publications.....	53
5.9	Afon Gwy Bibliography.....	54
5.10	Afon Gwy Summary Data to March 2008.....	65
5.10.1	Spot sampled chemistry data	65
5.10.2	Macroinvertebrate data	66
5.10.2.1	Percentage abundance summary, Afon Gwy.....	66
5.10.2.1	Macroinvertebrate summary statistics, Afon Gwy	67
5.10.3	Fish data.....	68
5.10.3.1	Summary of Salmon fry densities (numbers m ⁻²), Afon Gwy.....	68
5.10.3.2	Summary of Salmon parr densities (numbers m ⁻²), Afon Gwy	69
5.10.3.3	Summary of Trout fry density (numbers m ⁻²), Afon Gwy	70
5.10.3.4	Summary of Trout parr density (numbers m ⁻²), Afon Gwy	71
5.10.4	Epilithic diatom data	72
5.10.4.1	Percentage abundance summary, Afon Gwy.....	72
5.10.4.2	Diatom summary statistics, Afon Gwy	73
5.10.5	Aquatic macrophyte data, Afon Gwy	74

2 List of Figures

Figure 1	Llyn Cwm Mynach. Looking southeast through the trees from the northern end of the lake.....	5
Figure 2	Afon Hafren biological survey section 10 th July 2009	28
Figure 3	Afon Gwy biological survey section 10 th July 2009.....	51

All photographs © Ewan Shilland

3 Llyn Cwm Mynach



Figure 1 Llyn Cwm Mynach. Looking southeast through the trees from the northern end of the lake.

3.1 Summary Overview

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 2009 to March 2010.

3.2 Water Chemistry

Samples were collected by CEH in early June, September and December 2009, delivered to the analytical laboratories on schedule and have been analysed, quality controlled and archived in the UKAWMN central chemistry database at CEH Lancaster. March 2010 samples have been collected and are in the process of being analysed.

3.3 Sediment Traps

Sediment traps were recovered and replaced on the 4th of August 2009 by a team from ENSIS. Diatoms in the sediment retrieved from the traps are currently being analysed.

3.4 Thermistors

Lake top and bottom thermistors were removed and replaced on the 4th of August 2009 by a team from ENSIS. Both had functioned well during the previous year and the data were added to the ENSIS 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 2009. The samples have been made into slides and are currently in the process of being analysed.

3.6 Macroinvertebrates

Aquatic macroinvertebrates were sampled on the 17th April 2009 by a team from QMuL. Five 1 minute kick samples were performed. The samples were counted and the data sent to ENSIS Ltd. After quality screening the data was added to the UKAWMN biological database at ENSIS.

3.7 Fish

Fish surveying was performed on the 19th September 2009 by the Game and Wildlife Conservation Trust. The data has been forwarded to ENSIS Ltd. After quality screening the data will be added to the UKAWMN biological database at ENSIS.

3.8 Aquatic Macrophytes

Aquatic macrophytes were not surveyed in 2009, according to the AWMN protocol of surveying lake sites every two years.

3.9 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 2008-2009 annual report is nearly ready to be uploaded to the AWMN web page in late March 2010, and the section on Llyn Cwm Mynach appears in section 3.12 below.

An interpretative report detailing 20 years of the UKAWMN is undergoing a final edit and will also be published in 2010.

Further publications from the contract period utilizing data from Llyn Cwm Mynach are detailed in section 3.10 below. Section 3.11 provides a bibliography for the site.

3.10 Llyn Cwm Mynach Recent Publications

Battarbee, R. W., Kernan, M., Monteith, D. T. & Curtis, C. J. (2010) Summary and Recommendations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 279-293, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Simpson, G. L. (2010) Acid Deposition Trends at AWMN Sites. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 31-52, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Battarbee, R. W., Heliwell, R., Flower, R. J., Simpson, G. L., Monteith, D. T., Shilland, E. M., Aherne, J. & MacDougall, G. (2010) Recovery Progress: Reference Conditions and Restoration Targets. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 206-237, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Flower, R. J., Simpson, G. L., Kreiser, A. M., Yang, H., Shilland, E. M. & Battarbee, R. W. (2010) Epilithic Diatoms. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 97-111, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G., Winterbottom, J. H., Orton, S., Murphy, J., Simpson, G. L. & Shilland, E. M. (2010) Macroinvertebrates. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 126-139, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Monteith, D. T., Battarbee, R. W., Curtis, C. J., Shilland, E. M. & Simpson, G. L. (2010) Introduction. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 23-30, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Battarbee, R. W., Curtis, C. J., Monteith, D. T. & Shilland, E. M. (2010) *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 1-477, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Malcolm, I., Bacon, P., Middlemas, S., Collen, P. & Shilland, E. M. (2010) Salmonid Fish Populations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 140-165, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Rose, N. L., Yang, H. (2010) Trace Metals. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 166-205, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. (2010) Aquatic Macrophytes. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 112-125, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G. (2009) *Sustained Research on Stream Communities: A Model System and The Comparative Approach*, 175-312, ELSEVIER ACADEMIC PRESS INC, SAN DIEGO.

Shilland, E. M., Hutchins, M. (2009) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249 Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2008 - March 2009. Report to the Welsh Assembly Government, Countryside Council for Wales and Environment Agency, Wales. 1-61. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. & Hutchins, M. (2009) The United Kingdom Acid Waters Monitoring Network Data Report for 2007-2008 (year 20). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-205. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Battarbee, R. W., Monteith, D. T., Juggins, S., Simpson, G. L., Shilland, E. M., Flower, R. J. & Kreiser, A. M. (2008) Assessing the accuracy of diatom-based transfer functions in defining reference pH conditions for acidified lakes in the United Kingdom. *The Holocene*, **18**, 57-67.

Evans, C. D., Monteith, D. T., Reynolds, B. & Clark, J. M. (2008) Buffering of recovery from acidification by organic acids. *Science of the Total Environment*, **404**, 316-325.

Neal, C., Loftis, S., Evans, C. D., Reynolds, B., Tipping, E. & Neal, M. (2008) Increasing iron concentrations in UK upland waters. *Aquatic Geochemistry*, **14**, 263-288.

NERC. (2008) Clear to brown: upland waters return to natural state. NERC Annual Review 2007-2008, 11. Natural Environment Research Council, Polaris House, North Star Avenue, Swindon.

Rippey, B., Rose, N., Yang, H. D., Harrad, S., Robson, M. & Travers, S. (2008) An assessment of toxicity in profundal lake sediment due to deposition of heavy metals and persistent organic pollutants from the atmosphere. *Environment International*, **34**, 345-356.

Shilland, E. M. (2008) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249. Llyn Cwm Mynach - Annual Summary Progress Report. April 2007 - March 2008. Report to the Welsh Assembly Government. 1-20. ENSIS Ltd, University College London, London.

Skjelkvale, B. L., de Wit, H. A. (2008) ICP Waters. 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North America. NIVA Report SNO: 5684-2008, 1-55. Norwegian Institute for Water Research, Oslo, Norway.

Winterbottom, J. H., Orton, S. E. (2008) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty First Year: 2008. Summary of species identification and

abundance. 1-12. School of Biological Sciences, Queen Mary University of London, London.

3.11 Llyn Cwm Mynach Bibliography

Battarbee, R. W., Kernan, M., Monteith, D. T. & Curtis, C. J. (2010) Summary and Recommendations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 279-293, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Simpson, G. L. (2010) Acid Deposition Trends at AWMN Sites. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 31-52, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Battarbee, R. W., Heliwell, R., Flower, R. J., Simpson, G. L., Monteith, D. T., Shilland, E. M., Aherne, J. & MacDougall, G. (2010) Recovery Progress: Reference Conditions and Restoration Targets. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 206-237, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Flower, R. J., Simpson, G. L., Kreiser, A. M., Yang, H., Shilland, E. M. & Battarbee, R. W. (2010) Epilithic Diatoms. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 97-111, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G., Winterbottom, J. H., Orton, S., Murphy, J., Simpson, G. L. & Shilland, E. M. (2010) Macroinvertebrates. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 126-139, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Monteith, D. T., Battarbee, R. W., Curtis, C. J., Shilland, E. M. & Simpson, G. L. (2010) Introduction. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 23-30, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Battarbee, R. W., Curtis, C. J., Monteith, D. T. & Shilland, E. M. (2010) *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 1-477, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Malcolm, I., Bacon, P., Middlemas, S., Collen, P. & Shilland, E. M. (2010) Salmonid Fish Populations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 140-165, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Rose, N. L., Yang, H. (2010) Trace Metals. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 166-205, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. (2010) Aquatic Macrophytes. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 112-125, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G. (2009) *Sustained Research on Stream Communities: A Model System and The Comparative Approach*, 175-312, ELSEVIER ACADEMIC PRESS INC, SAN DIEGO.

Shilland, E. M., Monteith, D. T. & Hutchins, M. (2009) The United Kingdom Acid Waters Monitoring Network Data Report for 2007-2008 (year 20). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-205. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Shilland, E. M., Hutchins, M. (2009) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249 Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2008 - March 2009. Report to the Welsh Assembly Government, Countryside Council for Wales and Environment Agency, Wales. 1-61. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Battarbee, R. W., Monteith, D. T., Juggins, S., Simpson, G. L., Shilland, E. M., Flower, R. J. & Kreiser, A. M. (2008) Assessing the accuracy of diatom-based transfer functions in defining reference pH conditions for acidified lakes in the United Kingdom. *The Holocene*, **18**, 57-67.

Evans, C. D., Monteith, D. T., Reynolds, B. & Clark, J. M. (2008) Buffering of recovery from acidification by organic acids. *Science of the Total Environment*, **404**, 316-325.

Neal, C., Loftis, S., Evans, C. D., Reynolds, B., Tipping, E. & Neal, M. (2008) Increasing iron concentrations in UK upland waters. *Aquatic Geochemistry*, **14**, 263-288.

NERC. (2008) Clear to brown: upland waters return to natural state. NERC Annual Review 2007-2008, 11. Natural Environment Research Council, Polaris House, North Star Avenue, Swindon.

Rippey, B., Rose, N., Yang, H. D., Harrad, S., Robson, M. & Travers, S. (2008) An assessment of toxicity in profundal lake sediment due to deposition of heavy metals and persistent organic pollutants from the atmosphere. *Environment International*, **34**, 345-356.

Shilland, E. M. (2008) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249. Llyn Cwm Mynach - Annual Summary Progress Report. April 2007 - March 2008. Report to the Welsh Assembly Government. 1-20. ENSIS Ltd, University College London, London.

Skjelkvale, B. L., de Wit, H. A. (2008) ICP Waters. 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North America. NIVA Report SNO: 5684-2008, 1-55. Norwegian Institute for Water Research, Oslo., Oslo, Norway.

- Winterbottom, J. H., Orton, S. E. (2008) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty First Year: 2008. Summary of species identification and abundance. 1-12. School of Biological Sciences, Queen Mary University of London, London.
- Beaumont, W. R. C. (2007) Acid Waters Monitoring 2006 Report on Fish Studies. 1-34. Centre for Ecology & Hydrology, Dorset.
- Curtis, C. J., Simpson, G. L. (2007) Freshwater Umbrella - The effect of nitrogen deposition and climate change on freshwaters in the UK. Report to DEFRA under contract CPEA17. ECRC Research Report 115. ENSIS Ltd. University College London, London.
- Evans, C. D., Monteith, D. T., Wright, R. & Clark, J. (2007) Issues affecting upland water quality: Climate change, acidity, nitrogen and water colour. Kernan, M. R., Battarbee, R. W., and Binney, H. A. 21-25. ENSIS Publishing, University College London, London, London. Climate Change and Aquatic Ecosystems in the UK.
- Monteith, D. T., Stoddard, J. L., Evans, C. D., de Wit, H. A., Forsius, M., Hogasen, T., Wilander, A., Skjelkvale, B. L., Jeffries, D. S., Vuorenmaa, J., Keller, B., Kopacek, J. & Vesely, J. (2007) Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. *Nature*, **450**, 537-540.
- Monteith, D. T., Simpson, G. L. (2007) Macroinvertebrate classification diagnostic tool development. Final report to SNIFFER, Project WFD60. 1-84. SNIFFER, Edinburgh.
- Monteith, D. T., Shilland, E. M. (2007) The United Kingdom Acid Waters Monitoring Network Assessment of the First 18 Years of Data. Data Summary Annex Accompanying Research Project Final Report. Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-276. ENSIS Ltd. Environmental Change Research Centre, University College London, London.
- Shilland, E. M., Monteith, D. T., Hutchins, M. & Beaumont, W. R. C. (2007) The United Kingdom Acid Waters Monitoring Network Data Report for 2006-2007 (year 19). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-203. ENSIS Ltd. Environmental Change Research Centre, University College London, London.
- Beaumont, W. R. C. (2006) Acid Waters Monitoring 2005 Report on Fish Studies. 1-30. Centre for Ecology & Hydrology, Dorset.
- Evans, C. D., Chapman, P., Clark, J., Monteith, D. T. & Cresser, M. (2006) Alternative explanations for rising dissolved organic carbon export from organic soils. *Global Change Biology*, **12**, 2044-2054.
- Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2006) The United Kingdom Acid Waters Monitoring Network Data Report for 2005-2006 (year 18). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-203. ENSIS Ltd. Environmental Change research Centre, University College London, London.

Beaumont, W. R. C. (2005) Acid Waters Monitoring 2004 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

Cooper, D. M. (2005) Evidence of sulphur and nitrogen deposition signals at the United Kingdom Acid Waters Monitoring Network sites. *Environmental Pollution*, **137**, 41-54.

Curtis, C. J., Evans, C. D., Helliwell, R. C. & Monteith, D. T. (2005) Nitrate leaching as a confounding factor in chemical recovery from acidification in UK upland waters. *Environmental Pollution*, **137**, 73-82.

Davies, J. J. L., Jenkins, A., Monteith, D. T., Evans, C. D. & Cooper, D. M. (2005) Trends in surface water chemistry of acidified UK Freshwaters, 1988-2002. *Environmental Pollution*, **137**, 27-39.

Evans, C. D., Monteith, D. T. & Cooper, D. M. (2005) Long-term increases in surface water dissolved organic carbon: Observations, possible causes and environmental impacts. *Environmental Pollution*, **137**, 55-71.

Monteith, D. T. (2005) The United Kingdom Acid Waters Monitoring Network: a review of the first 15 years and introduction to the special issue. *Environmental Pollution*, **137**, 3-13.

Monteith, D. T., Hildrew, A. G., Flower, R. J., Raven, P. J., Beaumont, W. R. B., Collen, P., Kreiser, A. M., Shilland, E. M. & Winterbottom, J. H. (2005) Biological responses to the chemical recovery of acidified fresh waters in the UK. *Environmental Pollution*, **137**, 83-101.

Neal, C., Neal, M., Reynolds, B., Maberly, S. C., May, L., Ferrier, R. C., Smith, J. & Parker, J. E. (2005) Silicon concentrations in UK surface waters. *Journal of Hydrology*, **304**, 75-93.

Rose, N. L., Monteith, D. T. (2005) Temporal trends in spheroidal carbonaceous particle deposition derived from annual sediment traps and lake sediment cores and their relationship with non-marine sulphate. *Environmental Pollution*, **137**, 151-163.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2005) The United Kingdom Acid Waters Monitoring Network Data Report for 2004-2005 (year 17). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-188. ENSIS Ltd., London.

Simpson, G. L., Shilland, E. M., Winterbottom, J. H. & Keay, J. (2005) Defining reference conditions for acidified waters using a modern analogue approach. *Environmental Pollution*, **137**, 119-133.

Beaumont, W. R. C. (2004) Acid Waters Monitoring 2003 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2004) The United Kingdom Acid Waters Monitoring Network Data Report for 2003-2004 (year 16). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-188. ENSIS Ltd., London.

Beaumont, W. R. C. (2003) Acid Waters Monitoring 2002 Report on Fish Studies. 1-25. Centre for Ecology & Hydrology, Dorset.

Cooper, D. M., Jenkins, A. (2003) Response of acid lakes in the UK to reductions in atmospheric deposition of sulfur. *Science of the Total Environment*, **313**, 91-100.

Neal, C., Neal, M., Davies, H. & Smith, J. (2003) Fluoride in UK rivers. *The Science of The Total Environment*, **314-316**, 209-231.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2003) The United Kingdom Acid Waters Monitoring Network Data Report for 2002-2003 (year 15). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Beaumont, W. R. C. (2002) Acid Waters Monitoring 2001 Report on Fish Studies. 1-14. Centre for Ecology & Hydrology, Dorset.

Beaumont, W. R. C. (2002) Acid Waters Monitoring 2001 Report on Fish Studies: Addendum. 1-8. Centre for Ecology & Hydrology, Dorset.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2002) The United Kingdom Acid Waters Monitoring Network Data Report for 2001-2002 (year 14). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2002) The United Kingdom Acid Waters Monitoring Network Data Report for 2000-2001 (year 13). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Beaumont, W. R. C., McDonnell, N. (2001) Acid Waters Monitoring 2000 Report on Fish Studies. 1-18. Centre for Ecology & Hydrology, Dorset.

CLAM. (2001) Summary of Research under DETR Contract "Acidification of freshwaters: the role of nitrogen and the prospects for recovery", EPG1/3/117. Curtis, C. J. and Simpson, G. Research Report No. 79. Environmental Change Research Centre, University College London, London.

Evans, C. D., Cullen, J. M., Alewell, C., Kopacek, J., Marchetto, A., Moldan, F., Prechtel, A., Rogora, M., Vesely, J. & Wright, R. (2001) Recovery from acidification in European surface waters. *Hydrology and Earth System Sciences*, **5**, 283-297.

Evans, C. D., Monteith, D. T. & Harriman, R. (2001) Long-term variability in the deposition of marine ions at west coast sites in the UK Acid Waters Monitoring Network: impacts on

surface water chemistry and significance for trend determination. *The Science of The Total Environment*, **265**, 115-129.

Evans, C. D., Monteith, D. T. (2001) Chemical trends at lakes and streams in the UK Acid Waters Monitoring Network, 1988-2000: Evidence for recent recovery at a national scale. *Hydrology and Earth System Sciences*, **5**, 351-366.

Jenkins, A., Cullen, J. M. (2001) An Assessment of the potential impact of the Gothenburg Protocol on surface water chemistry using the dynamic MAGIC model at acid sensitive sites in the UK. *Hydrology and Earth System Sciences*, **5**, 529-541.

Monteith, D. T., Evans, C. D. (2001) United Kingdom Acid Waters Monitoring Network. 1-24. Department of the Environment, Transport and the Regions, London.

Monteith, D. T., Evans, C. D. & Patrick, S. (2001) Monitoring acid waters in the UK: 1988-1998 Trends. *Water Air and Soil Pollution*, **130**, 1307-1312.

NEGTA. (2001) Transboundary Air Pollution: Acidification, Eutrophication and Ground-Level Ozone in the UK. 1-314. Department For Environment, Food and Rural Affairs (DEFRA), London.

Beaumont, W. R. C., Ingram, A. (2000) Acid Waters Monitoring 1999 Report on Fish Studies. Centre for Ecology & Hydrology, Dorset.

Monteith, D. T., Evans, C. D. (2000) United Kingdom Acid Waters Monitoring Network 10 Year Report. Analysis and Interpretation of Results, April 1988 - March 1998. Monteith, D. T. and Evans, C. D. 1-364. ENSIS Ltd, London.

Beaumont, W. R. C., Sturgess, P. (1999) Acid Waters Monitoring 1998 Report on Fish Studies. 1-26. Institute of Freshwater Ecology, Dorset.

Beaumont, W. R. C., Sturgess, P. & Pinder, A. (1999) Acid Waters Monitoring Report on Fish Studies 1988-1997. 1-129. Institute of Freshwater Ecology, Dorset.

Curtis, C. J., Murlis, J., Battarbee, R. W., Bull, K., Campbell, G., Fowler, D., Jenkins, A., Monteith, D. T., Ormerod, S. & Reynolds, B. (1999) Acid deposition in the UK: a review of environmental damage and recovery prospects. NSCA Occasional Paper No.1, 1-28. National Society for Clean Air and Environmental Protection, Brighton.

Stevenson, R. (1999) COMMERCIALISATION OF SMALL HYDRO THROUGH COMMUNITY PARTICIPATION. 1-94. Dulas Ltd, for the Energy Technology Support Unit (ETSU) on behalf of the Department of Trade and Industry.

Beaumont, W. R. C., Pinder, A. (1998) Acid Waters Monitoring 1997 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

Helliwell, R. C., Ferrier, R. C. & Jenkins, A. (1998) A two-layer application of the MAGIC model to predict the effects of land use scenarios and reductions in deposition on acid sensitive soils in the UK. *Hydrology and Earth System Sciences*, **2**, 497-507.

Jenkins, A., Helliwell, R. C., Swingewood, P. J., Sefton, C., Renshaw, M. & Ferrier, R. C. (1998) Will reduced sulphur emissions under the Second Sulphur Protocol lead to recovery of acid sensitive sites in UK? *Environmental Pollution*, **99**, 309-318.

Monteith, D. T., Renshaw, M. & Patrick, S. T. (1998) Monitoring the long term chemical and biological response to changing sulphur and nitrogen emissions of sensitive waters, United Kingdom. *Headwaters: Water Resources and Soil Conservation* 111-125.

Monteith, D. T., Evans, C. D., Beaumont, W. R. C. & Delinikajtis, C. (1998) The United Kingdom Acid Waters Monitoring Network Data Report for 1997-1998 (year 10). Report to the DETR and the DoE Northern Ireland. ENSIS Ltd, London.

Sefton, C. E. M., Jenkins, A. (1998) A regional application of the MAGIC model in Wales: calibration and assessment of future recovery using a Monte-Carlo approach. *Hydrology and Earth System Sciences*, **2**, 521-531.

Beaumont, W. R. C., Bradley, D. C. (1997) Acid Waters Monitoring 1996 Report on Fish Studies. 1-36. Centre for Ecology & Hydrology, Dorset.

Monteith, D. T., Renshaw, M., Evans, C. D. & Patrick, S. T. (1997) The United Kingdom Acid Waters Monitoring Network Data Report for 1996-1997 (year 9). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Rose, N. L., Bird, D. J., Keohane, B., Harriman, R. & Battarbee, R. W. (1997) The analysis of trace metals in surface waters from Scotland and Wales. A Report to the DoE, Air Quality Division. Research Report No. 39. Environmental Change Research Centre, University College London, London.

Beaumont, W. R. C. (1996) Acid Waters Monitoring 1995 Report on Fish Studies. 1-25. Institute of Freshwater Ecology, Dorset.

Campbell, G. W., Lee, D. S. (1996) Atmospheric deposition of sulphur and nitrogen species in the UK. *Freshwater Biology*, **36**, 151-167.

Jenkins, A., Boorman, D. & Renshaw, M. (1996) The UK acid waters monitoring network: An assessment of chemistry data, 1988-93. *Freshwater Biology*, **36**, 169-178.

Juggins, S., Flower, R. J. & Battarbee, R. W. (1996) Palaeolimnological evidence for recent chemical and biological changes in UK acid waters monitoring network sites. *Freshwater Biology*, **36**, 203-219.

Lancaster, J., Patrick, S. (1996) The UK acid waters monitoring network: A preface. *Freshwater Biology*, **36**, 129-130.

Lancaster, J., Real, M., Juggins, S., Monteith, D. T., Flower, R. J. & Beaumont, W. R. C. (1996) Monitoring temporal changes in the biology of acid waters. *Freshwater Biology*, **36**, 179-201.

Monteith, D. T., Renshaw, M., Beaumont, W. R. C. & Patrick, S. T. (1996) The United Kingdom Acid Waters Monitoring Network Data Report for 1995-1996 (year 8). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Patrick, S., Battarbee, R. W. & Jenkins, A. (1996) Monitoring acid waters in the UK: An overview of the UK acid waters monitoring network and summary of the first interpretative exercise. *Freshwater Biology*, **36**, 131-150.

Beaumont, W. R. C. (1995) Acid Waters Monitoring 1994 Report on Fish Studies. 1-26. Institute of Freshwater Ecology, Dorset.

Jenkins, A., Campbell, G., Renshaw, M., Boorman, D., Stedman, J. & Patrick, S. (1995) Surface water acidification in the UK; Current status, recent trends and future predictions. *Water Air and Soil Pollution*, **85**, 565-570.

Monteith, D. T., Renshaw, M. & Beaumont, W. R. C. (1995) The United Kingdom Acid Waters Monitoring Network Data Report for 1994-1995 (year 7). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Patrick, S. T., Monteith, D. T. & Jenkins, A. (1995) UK Acid Waters Monitoring Network: The first five years. Analysis and interpretation of results, April 1988 - March 1993. 1-320. ENSIS Publishing, London.

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

Beaumont, W. R. C., Miles, L. (1994) Acid Waters Monitoring 1993 Report on Fish Studies. 1-42. Institute of Freshwater Ecology, Dorset.

Monteith, D. T., Renshaw, M., Beaumont, W. R. C. & Patrick, S. T. (1994) The United Kingdom Acid Waters Monitoring Network Data Report for 1993-1994 (year 6). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Beaumont, W. R. C. (1993) Acid Waters Monitoring 1992 Report on Fish Studies. 1-18. Institute of Freshwater Ecology, Dorset.

Juggins, S., Shaw, C., Patrick, S. T., Monteith, D. T., Beaumont, W. R. C. & Reed, J. (1993) The United Kingdom Acid Waters Monitoring Network Data Report for 1992-1993 (year 5). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Rose, N. L. (1-1-1993) An Assessment of the Potential of the United Kingdom Acid Waters Monitoring Network to Monitor the Impact of Atmospheric Trace metals and Persistent

Organic Compounds on Freshwaters. 1-87. Environmental Change Research Centre, University College London, London. Research Papers No 9.

Beaumont, W. R. C. (1992) Acid Waters Monitoring 1991 Report on Fish Studies. 1-16. Institute of Freshwater Ecology, Dorset.

Juggins, S., Shaw, C., Patrick, S. T., Monteith, D. T., Beaumont, W. R. C. & Reed, J. (1992) The United Kingdom Acid Waters Monitoring Network Data Report for 1991-1992 (year 4). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Juggins, S., Waters, D., Patrick, S. T. & Beaumont, W. R. C. (1991) The United Kingdom Acid Waters Monitoring Network Data Report for 1990-1991 (year 3). Report to the DoE and the DoE Northern Ireland. 1-124. ENSIS Ltd, London.

Orange, A. (1991) A Lichen and Bryophyte Survey of RSPB Woodlands in the Mawddach Area. Department of Botany, National Museum of Wales: Report to Royal Society for the Protection of Birds.

Patrick, S. T., Waters, D., Juggins, S. & Jenkins, A. (1991) The United Kingdom Acid Waters Monitoring Network. Site descriptions and methodology report. 1-63. ENSIS Ltd, London.

Juggins, S., Waters, D., Patrick, S. T., Jenkins, A. & Beaumont, W. R. C. (1990) The United Kingdom Acid Waters Monitoring Network Data Report for 1989-1990 (year 2). Report to the DoE. 1-101. ENSIS Ltd, London.

Round, F. E. (1990) Diatom Communities their Response to Changes in Acidity. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences Palaeolimnology and Lake Acidification*, **327**, 243-249.

Juggins, S., Watson, D., Waters, D., Patrick, S. T., Jenkins, A. & . (1989) The United Kingdom Acid Waters Monitoring Network Introduction and Data Report for 1988-1989 (year 1). Report to the DoE. 1-91. ENSIS Ltd, London.

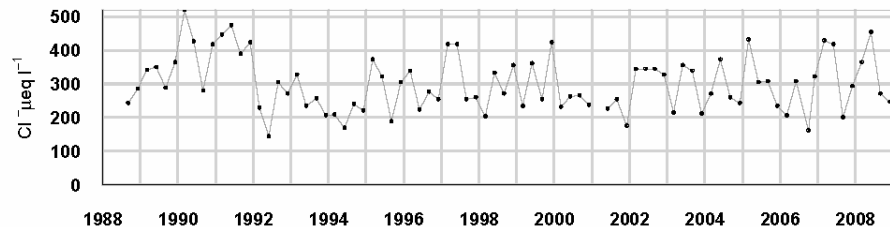
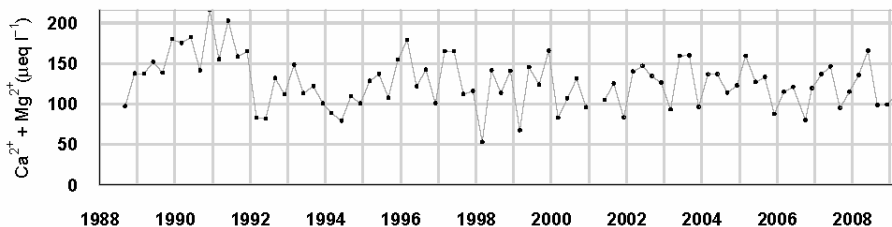
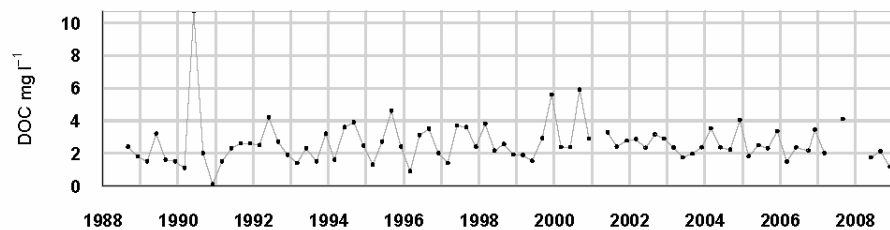
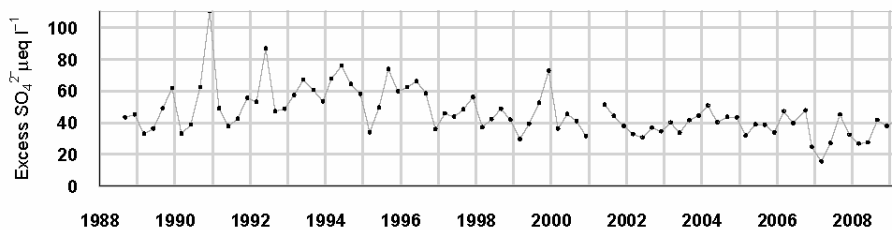
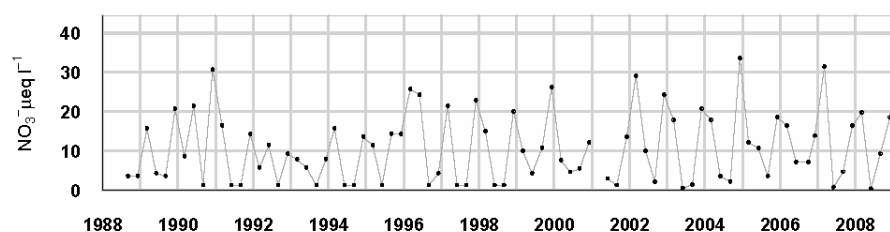
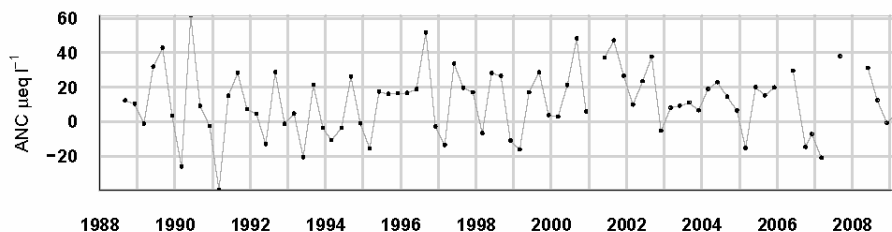
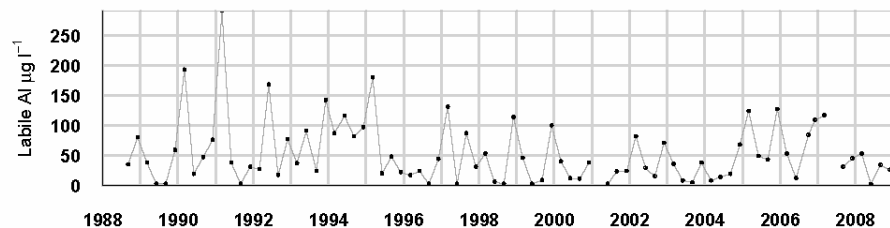
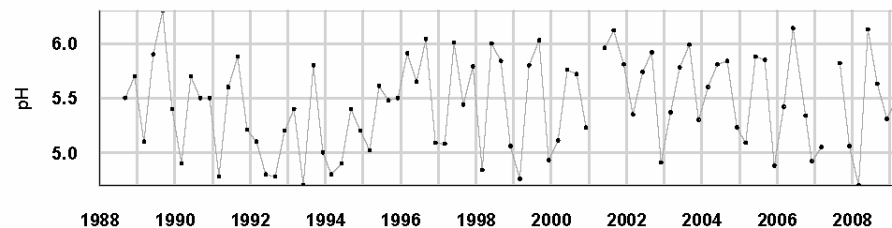
Battarbee, R. W., Anderson, N. J., Appleby, P. G., Flower, R. J., Fritz, S. C., Haworth, E. Y., Higgitt, S., Jones, V. J., Kreiser, A. M., Munro, M. A. R., Natkanski, J., Oldfield, F., Patrick, S. T., Raven, P. J., Richardson, N. G., Rippey, B. & Stevenson, A. C. (1988) Lake Acidification in the United Kingdom. 1-68. ENSIS Ltd, London.

Kreiser, A. M., Stevenson, A. C., Patrick, S. T., Rippey, B., Appleby, P. G., Oldfield, F., Darley, J., Higgitt, S., Battarbee, R. W. & Raven, P. J. (1987) Palaeoecological Evaluation of the recent Acidification of Welsh Lakes. 10, Llyn Cwm Mynach, Gwynedd. Patrick, S. T. and Stevenson, A. C. Research paper No. 27, 1-65. Palaeoecology Research Unit, University College London, London.

Ward, F. (1931) The Lakes of Wales. A Guide for Anglers and Others, Jenkins, London.

3.12 Llyn Cwm Mynach Summary Data to March 2008

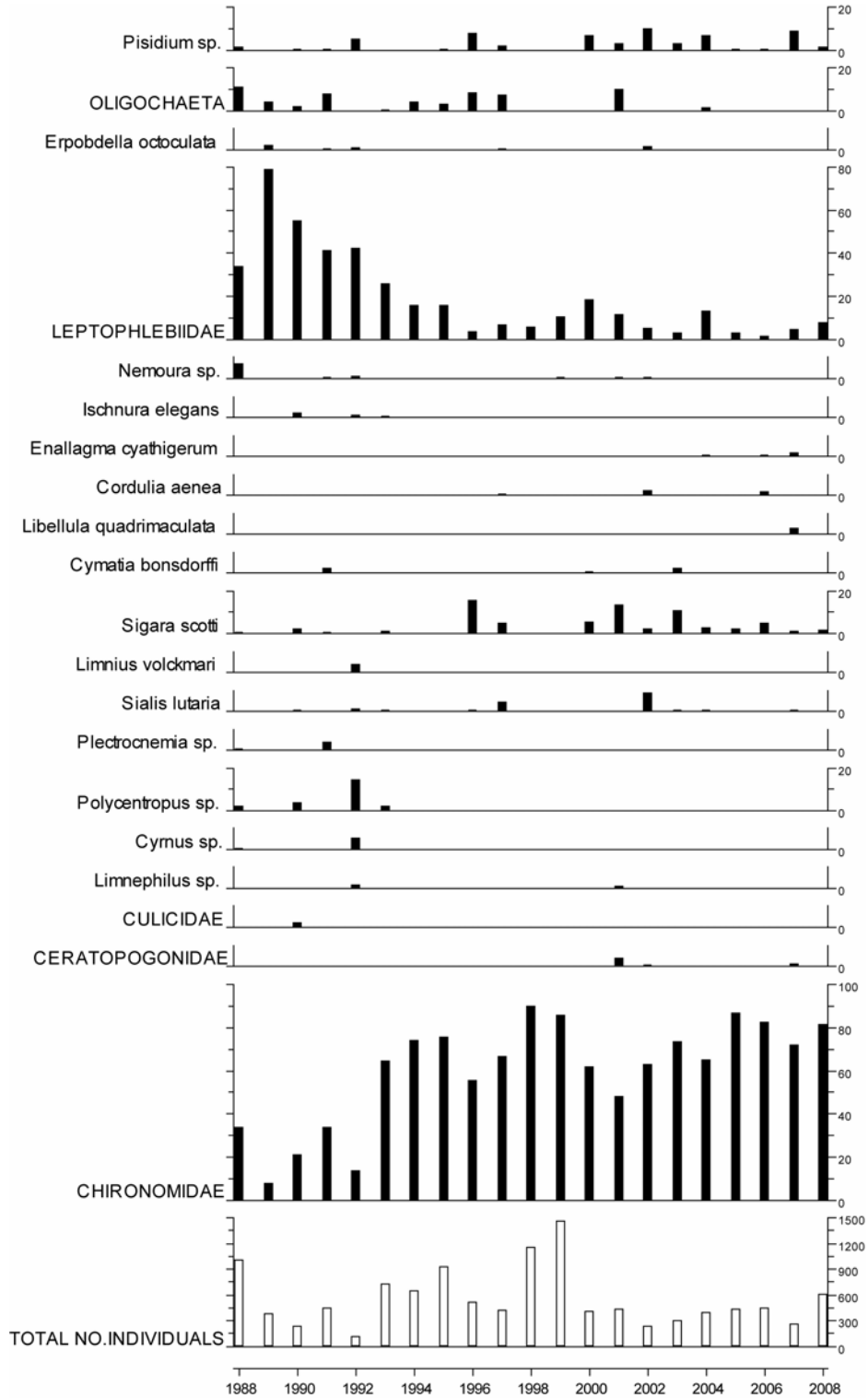
3.12.1 Spot sampled chemistry data



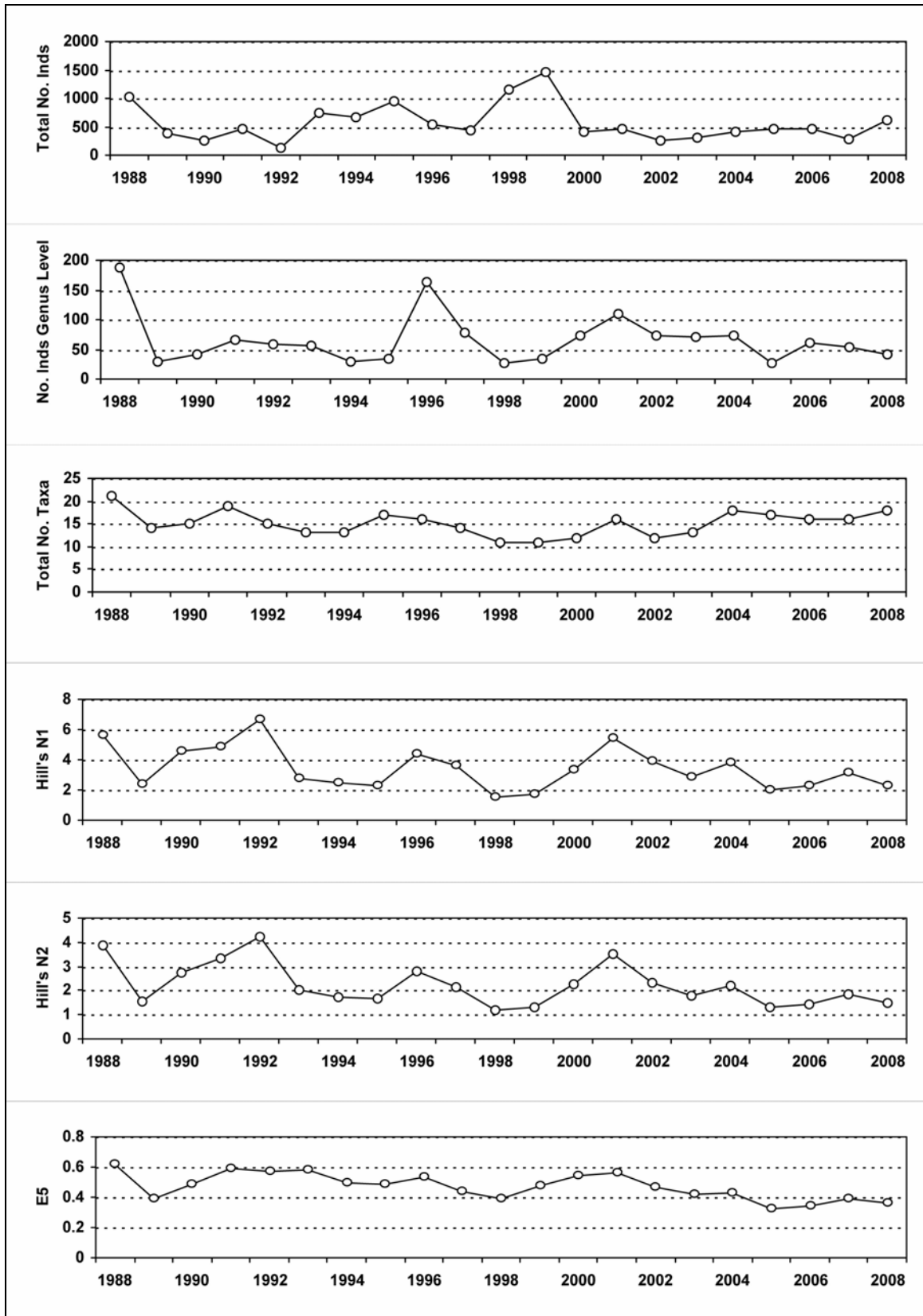
$\mu\text{eq l}^{-1}$, * $\mu\text{g l}^{-1}$, ** mg l^{-1}	pH	ANC	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	*Soluble Al	*Labile Al	Cl ⁻	*SO ₄ ²⁻	xSO ₄ ²⁻	NO ₃ ⁻	**DOC
Mean 1 st 5 yrs	5.35	7.68	77.79	67.45	291.02	3.36	110.75	66.58	337.67	88.32	52.91	9.40	2.50
08-09 mean	5.64	11.80	60.53	57.99	254.69	5.06	51.25	28.75	297.33	68.27	37.09	18.12	1.79
08-09 std dev	0.35	13.95	16.62	15.49	80.36	1.88	33.75	21.12	106.76	5.29	6.70	19.04	0.44

3.12.2 Macroinvertebrate data

3.12.2.1 Percentage abundance summary, Llyn Cwm Mynach

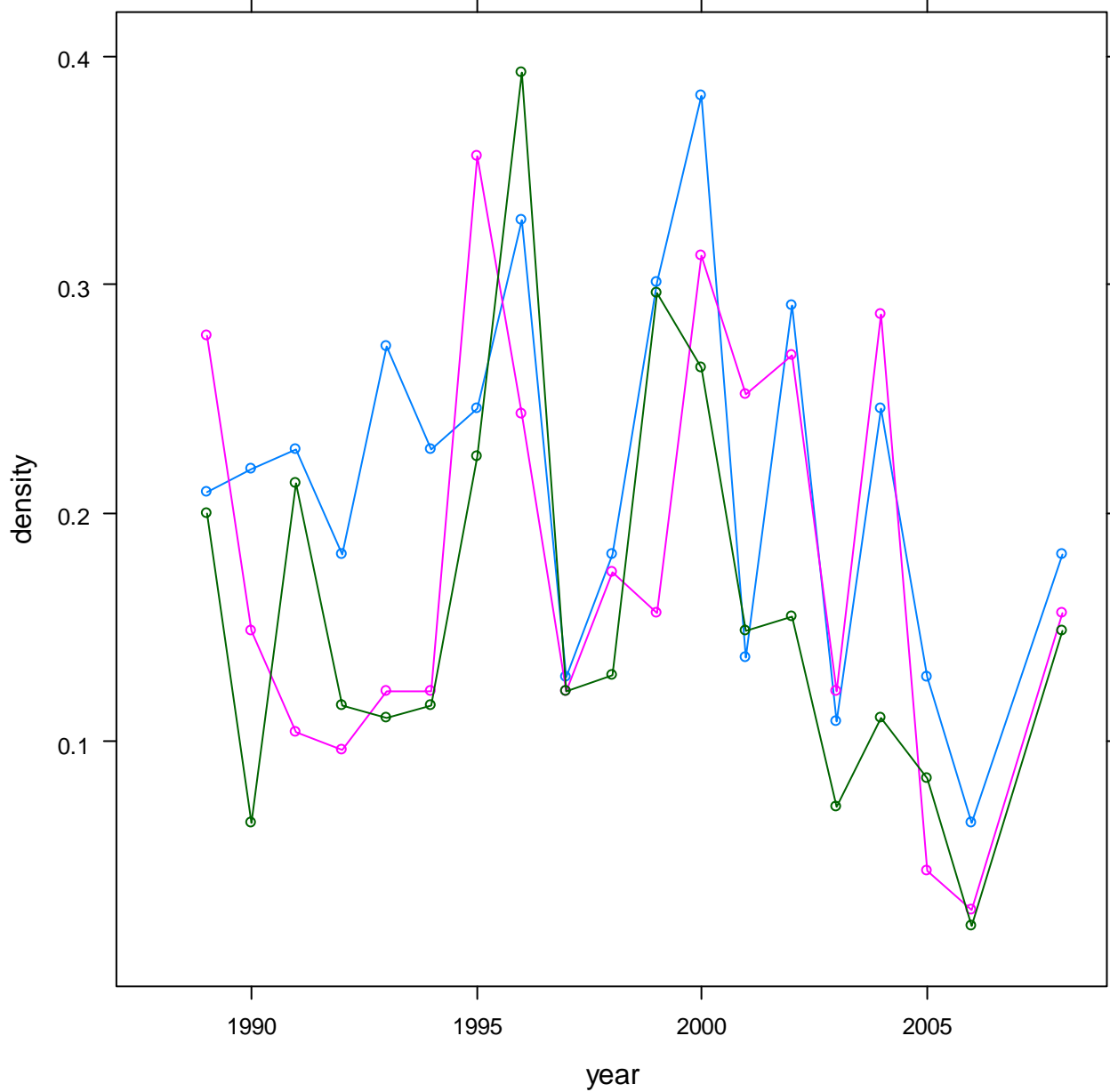


3.12.2.1 Macroinvertebrate summary statistics, Llyn Cwm Mynach



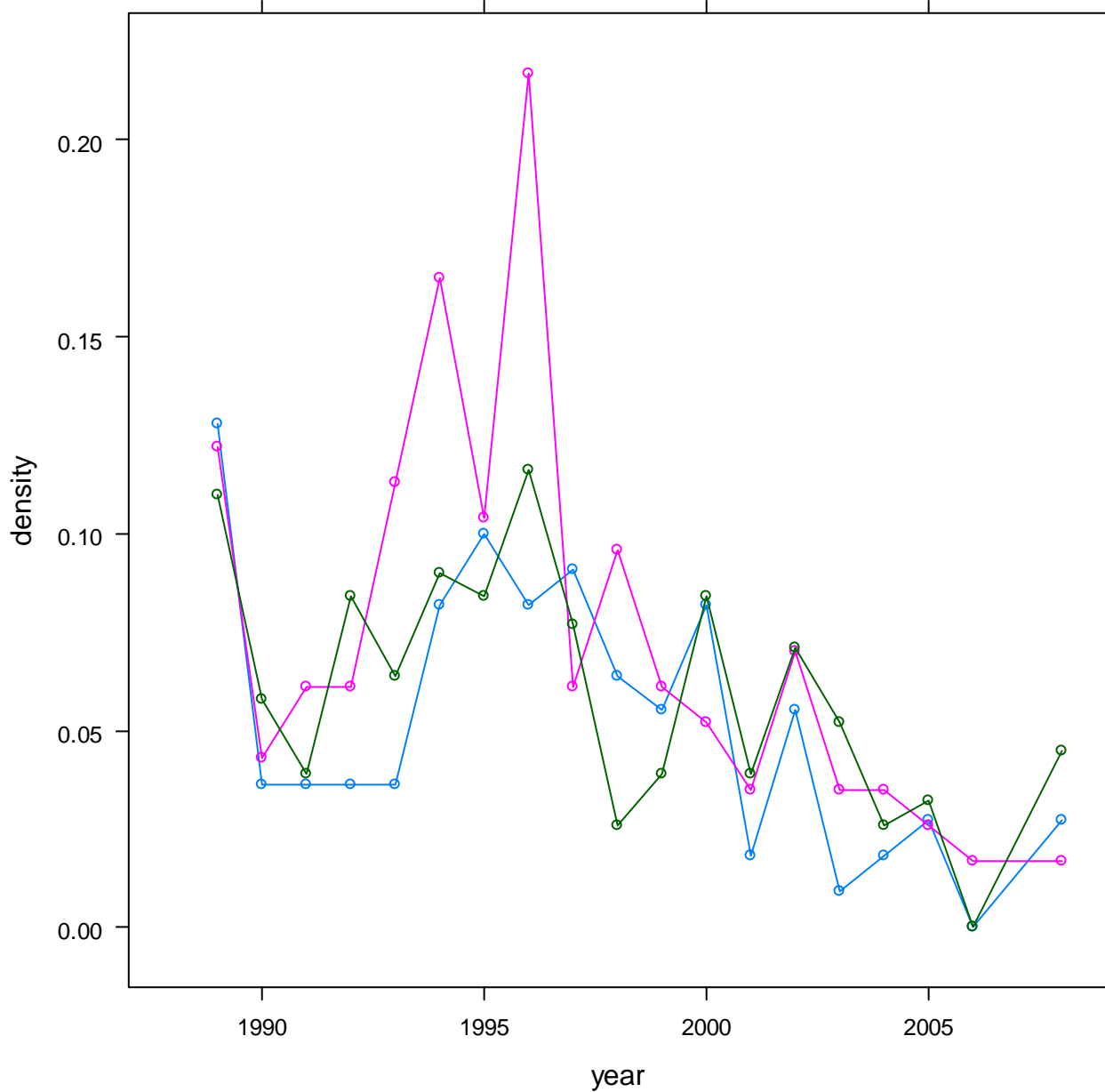
3.12.3 Fish data (for outflow stream)

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



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

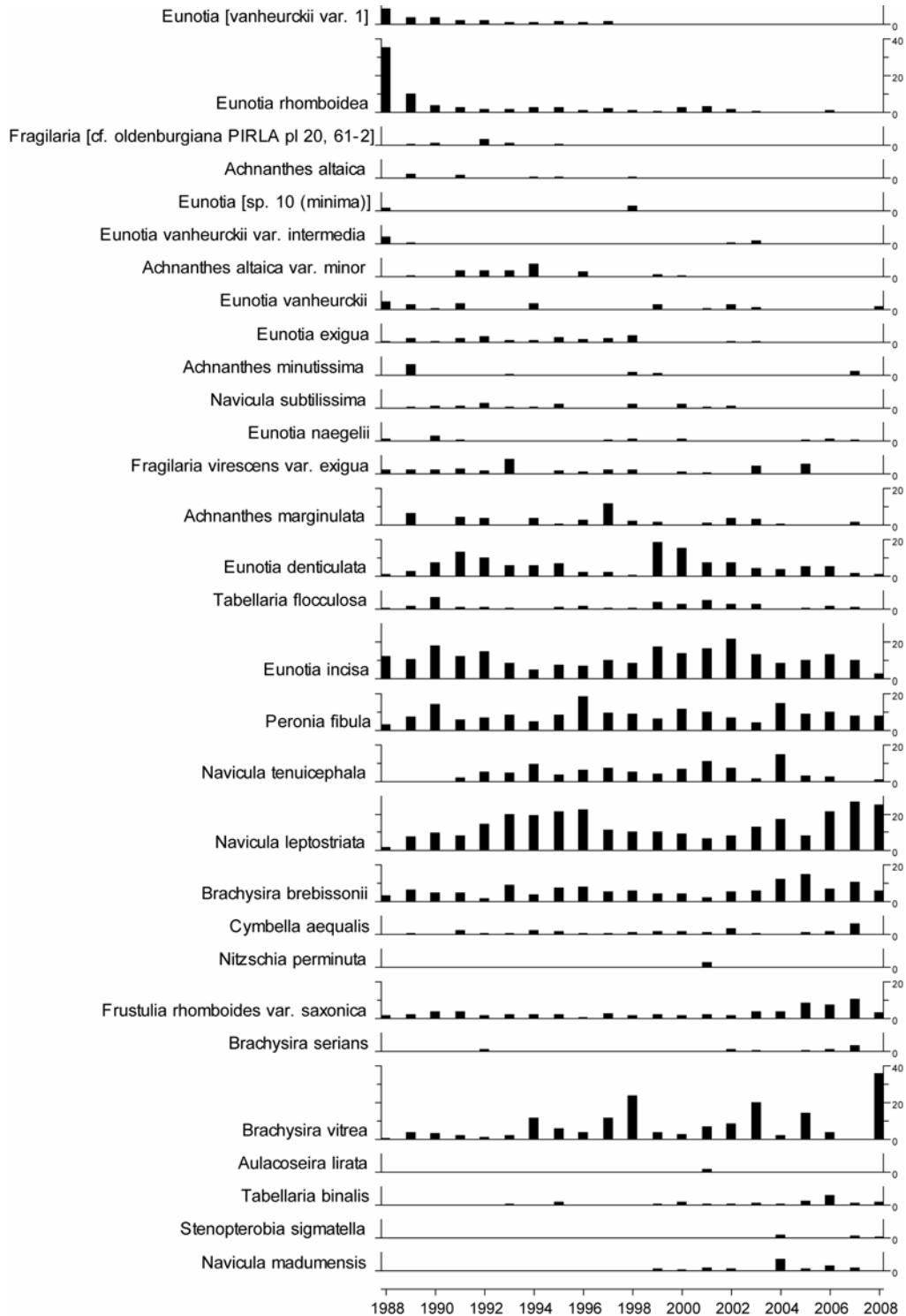
3.12.3.2 Summary of Trout parr density (numbers m⁻²), Llyn Cwm Mynach



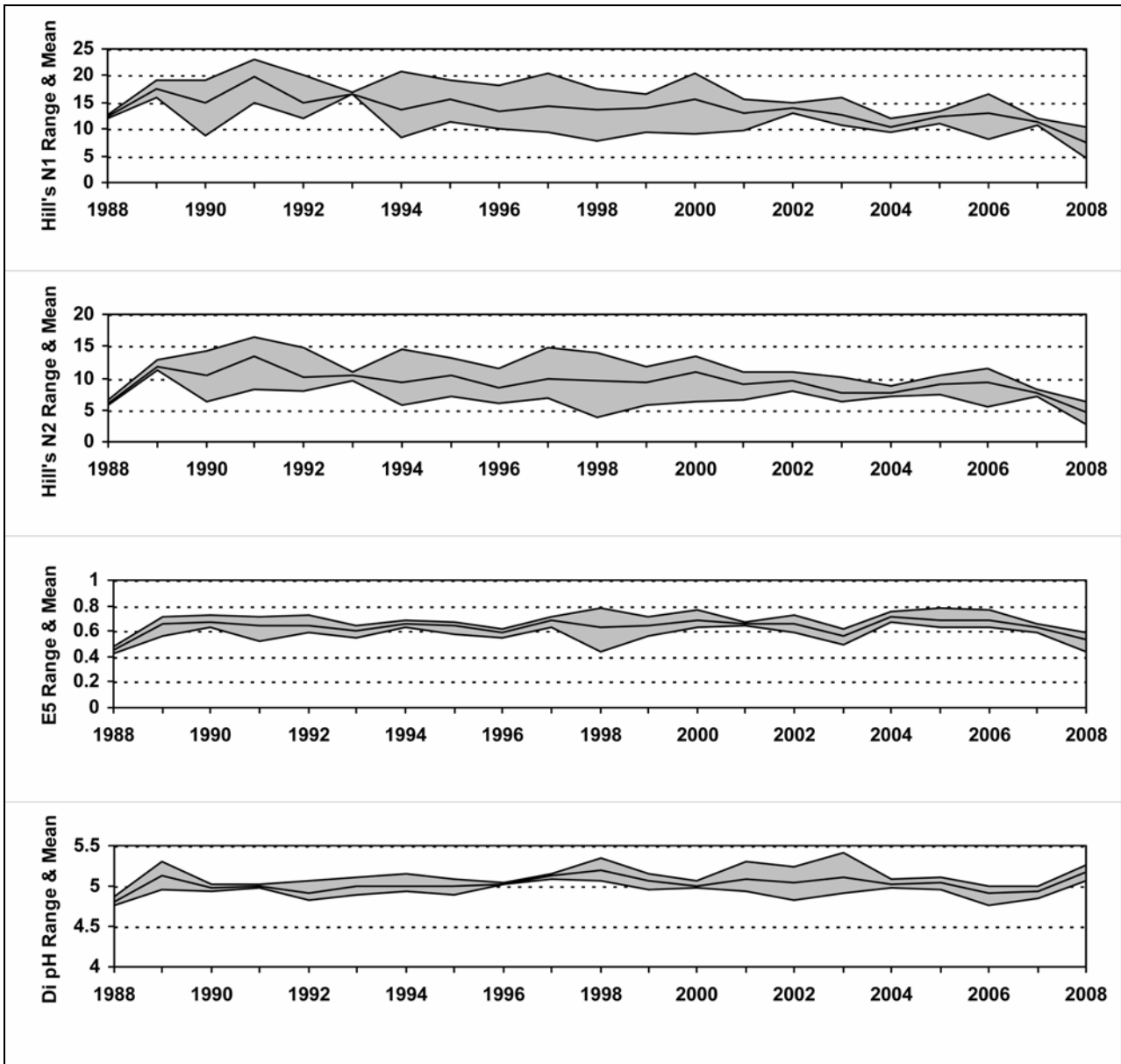
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

3.12.4 Epilithic diatom data

3.12.4.1 Percentage abundance summary, Llyn Cwm Mynach

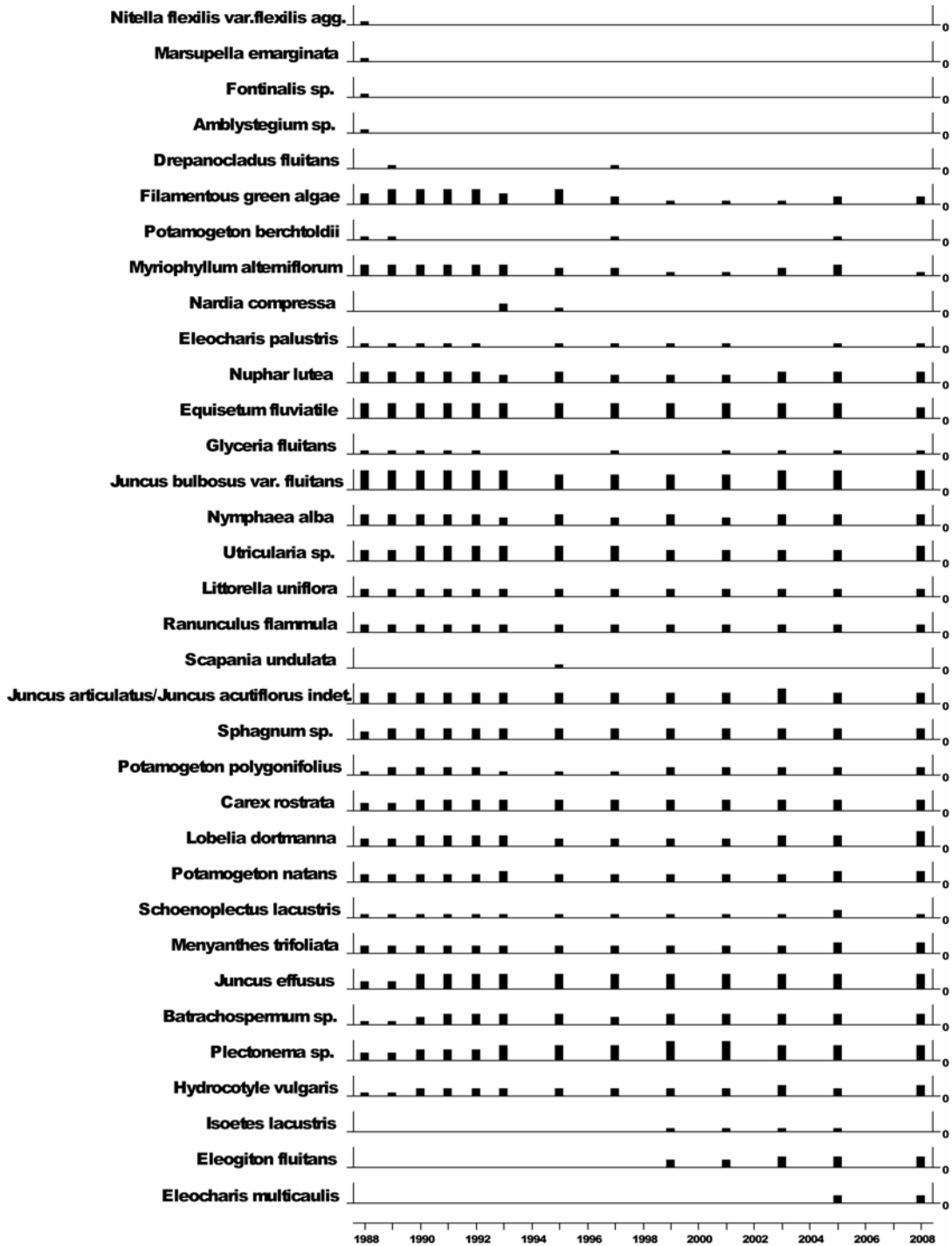


3.12.4.1 Diatom summary statistics, Llyn Cwm Mynach



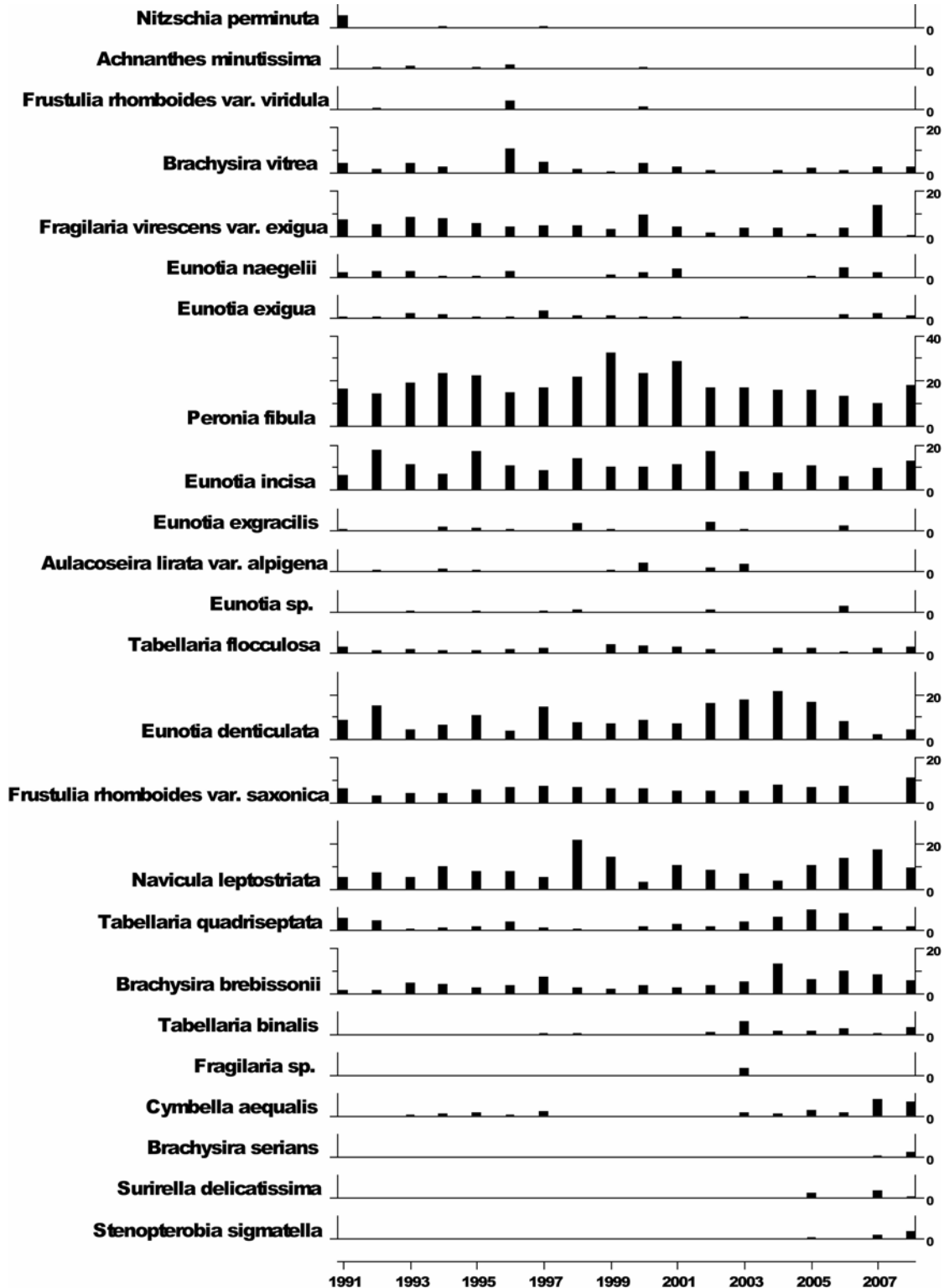
3.12.5 Aquatic macrophyte data, Llyn Cwm Mynach

Species Scores (1-5)

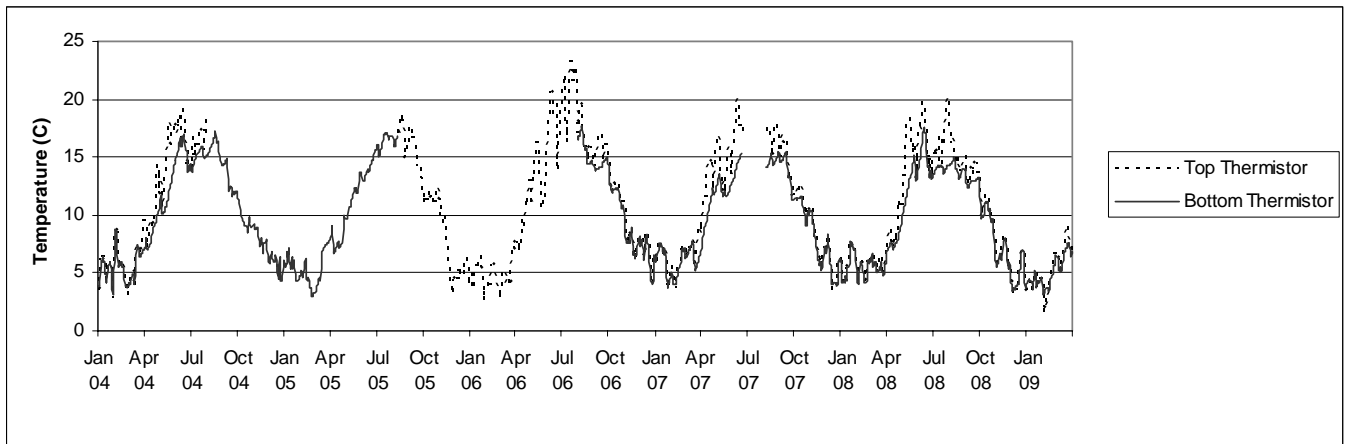


3.12.6 Sediment trap data, Llyn Cwm Mynach

Relative percentage frequency of diatom taxa



3.12.7 Thermistor data, Llyn Cwm Mynach



4 Afon Hafren



Figure 2 Afon Hafren biological survey section 10th July 2009

4.1 Summary Overview

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 2009 to March 2010.

4.2 Water Chemistry

Samples were collected by CEH early every month throughout the period April 2009 to March 2010, delivered to the analytical laboratories on schedule and are in the process of being analysed, quality controlled and archived in the UKAWMN central chemistry database at CEH Lancaster.

4.3 Epilithic Diatoms

Epilithic diatoms were retrieved by a team from ENSIS from three sampling points in the stream on the 10th of July 2009, after high water levels had frustrated surveying efforts on an earlier visit. The samples have been made into slides and are currently in the process of being analysed.

4.4 Macroinvertebrates

Aquatic macroinvertebrates were sampled on the 17th April 2009 by a team from QMuL. Five 1 minute kick samples were performed. The samples were counted and the data sent to ENSIS Ltd. After quality screening the data was added to the UKAWMN biological database at ENSIS.

4.5 Fish

Fish surveying was performed on the 26th August 2009 by a team from the Environment Agency Wales. Unfortunately fish weights were not recorded. The data has been forwarded to ENSIS Ltd. After quality screening the data will be added to the UKAWMN biological database at ENSIS.

4.6 Aquatic Macrophytes

Aquatic macrophytes were surveyed by a team from ENSIS on 10th of July 2009. Percentage cover scores were recorded and data will be added to the ENSIS biological database after microscope confirmation of bryophyte identifications.

4.7 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 2008-2009 annual report is nearly ready to be uploaded to the AWMN web page in late March 2010, and the section on Afon Hafren appears in section 4.10 below.

An interpretative report detailing 20 years of the UKAWMN is undergoing a final edit and will also be published 2010.

Further publications from the contract period utilizing data from Afon Hafren are detailed in section 4.8 below. Section 4.9 provides a bibliography for the site.

4.8 Afon Hafren Recent Publications

Battarbee, R. W., Kernan, M., Monteith, D. T. & Curtis, C. J. (2010) Summary and Recommendations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 279-293, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Simpson, G. L. (2010) Acid Deposition Trends at AWMN Sites. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 31-52, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Battarbee, R. W., Heliwell, R., Flower, R. J., Simpson, G. L., Monteith, D. T., Shilland, E. M., Aherne, J. & MacDougall, G. (2010) Recovery Progress: Reference Conditions and Restoration Targets. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 206-237, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Flower, R. J., Simpson, G. L., Kreiser, A. M., Yang, H., Shilland, E. M. & Battarbee, R. W. (2010) Epilithic Diatoms. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 97-111, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G., Winterbottom, J. H., Orton, S., Murphy, J., Simpson, G. L. & Shilland, E. M. (2010) Macroinvertebrates. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 126-139, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Battarbee, R. W., Curtis, C. J., Monteith, D. T. & Shilland, E. M. (2010) *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 1-477, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Monteith, D. T., Battarbee, R. W., Curtis, C. J., Shilland, E. M. & Simpson, G. L. (2010) Introduction. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 23-30, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Malcolm, I., Bacon, P., Middlemas, S., Collen, P. & Shilland, E. M. (2010) Salmonid Fish Populations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 140-165, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Rose, N. L., Yang, H. (2010) Trace Metals. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 166-205, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. (2010) Aquatic Macrophytes. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 112-125, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G. (2009) *Sustained Research on Stream Communities: A Model System and The Comparative Approach*, 175-312, Elsevier Academic Press Inc, SAN DIEGO.

Shilland, E. M., Hutchins, M. (2009) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249 Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2008 - March 2009. Report to the Welsh Assembly Government, Countryside Council for Wales and Environment Agency, Wales. 1-61. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. & Hutchins, M. (2009) The United Kingdom Acid Waters Monitoring Network Data Report for 2007-2008 (year 20). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-205. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Evans, C. D., Monteith, D. T., Reynolds, B. & Clark, J. M. (2008) Buffering of recovery from acidification by organic acids. *Science of the Total Environment*, **404**, 316-325.

Neal, C., Lofts, S., Evans, C. D., Reynolds, B., Tipping, E. & Neal, M. (2008) Increasing iron concentrations in UK upland waters. *Aquatic Geochemistry*, **14**, 263-288.

NERC. (2008) Clear to brown: upland waters return to natural state. NERC Annual Review 2007-2008 , 11. Natural Environment Research Council, Polaris House, North Star Avenue, Swindon.

Skjelkvale, B. L., de Wit, H. A. (2008) ICP Waters. 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North America. NIVA Report SNO: 5684-2008, 1-55. Norwegian Institute for Water Research, Oslo, Norway.

Winterbottom, J. H., Orton, S. E. (2008) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty First Year: 2008. Summary of species identification and abundance. 1-12. School of Biological Sciences, Queen Mary University of London, London.

4.9 Afon Hafren Bibliography

Battarbee, R. W., Kernan, M., Monteith, D. T. & Curtis, C. J. (2010) Summary and Recommendations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 279-293, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Simpson, G. L. (2010) Acid Deposition Trends at AWMN Sites. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 31-52, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Battarbee, R. W., Heliwell, R., Flower, R. J., Simpson, G. L., Monteith, D. T., Shilland, E. M., Aherne, J. & MacDougall, G. (2010) Recovery Progress: Reference Conditions and Restoration Targets. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 206-237, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Flower, R. J., Simpson, G. L., Kreiser, A. M., Yang, H., Shilland, E. M. & Battarbee, R. W. (2010) Epilithic Diatoms. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 97-111, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G., Winterbottom, J. H., Orton, S., Murphy, J., Simpson, G. L. & Shilland, E. M. (2010) Macroinvertebrates. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 126-139, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Battarbee, R. W., Curtis, C. J., Monteith, D. T. & Shilland, E. M. (2010) *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 1-477, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Monteith, D. T., Battarbee, R. W., Curtis, C. J., Shilland, E. M. & Simpson, G. L. (2010) Introduction. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 23-30, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Malcolm, I., Bacon, P., Middlemas, S., Collen, P. & Shilland, E. M. (2010) Salmonid Fish Populations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 140-165, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Rose, N. L., Yang, H. (2010) Trace Metals. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 166-205, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. (2010) Aquatic Macrophytes. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 112-125, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G. (2009) *Sustained Research on Stream Communities: A Model System and The Comparative Approach*, 175-312, Elsevier Academic Press Inc, SAN DIEGO.

Shilland, E. M., Hutchins, M. (2009) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249 Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2008 - March 2009. Report to the Welsh Assembly Government,

Countryside Council for Wales and Environment Agency, Wales. 1-61. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. & Hutchins, M. (2009) The United Kingdom Acid Waters Monitoring Network Data Report for 2007-2008 (year 20). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-205. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Evans, C. D., Monteith, D. T., Reynolds, B. & Clark, J. M. (2008) Buffering of recovery from acidification by organic acids. *Science of the Total Environment*, **404**, 316-325.

Neal, C., Lofts, S., Evans, C. D., Reynolds, B., Tipping, E. & Neal, M. (2008) Increasing iron concentrations in UK upland waters. *Aquatic Geochemistry*, **14**, 263-288.

NERC. (2008) Clear to brown: upland waters return to natural state. NERC Annual Review 2007-2008, 11. Natural Environment Research Council, Polaris House, North Star Avenue, Swindon.

Skjelkvale, B. L., de Wit, H. A. (2008) ICP Waters. 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North America. NIVA Report SNO: 5684-2008, 1-55. Norwegian Institute for Water Research, Oslo., Oslo, Norway.

Winterbottom, J. H., Orton, S. E. (2008) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty First Year: 2008. Summary of species identification and abundance. 1-12. School of Biological Sciences, Queen Mary University of London, London.

Beaumont, W. R. C. (2007) Acid Waters Monitoring 2006 Report on Fish Studies. 1-34. Centre for Ecology & Hydrology, Dorset.

Curtis, C. J., Simpson, G. L. (2007) Freshwater Umbrella - The effect of nitrogen deposition and climate change on freshwaters in the UK. Report to DEFRA under contract CPEA17. ECRC Research Report 115. ENSIS Ltd. University College London, London.

Evans, C. D., Monteith, D. T., Wright, R. & Clark, J. (2007) Issues affecting upland water quality: Climate change, acidity, nitrogen and water colour. Kernan, M. R., Battarbee, R. W., and Binney, H. A. 21-25. ENSIS Publishing, University College London, London, London. Climate Change and Aquatic Ecosystems in the UK.

Marc, V., Robinson, M. (2007) The long-term water balance (1972-2004) of upland forestry and grassland at Plynlimon, mid-Wales. *Hydrology and Earth System Sciences*, **11**, 44-60.

Monteith, D. T., Stoddard, J. L., Evans, C. D., de Wit, H. A., Forsius, M., Hogasen, T., Wilander, A., Skjelkvale, B. L., Jeffries, D. S., Vuorenmaa, J., Keller, B., Kopacek, J. &

Vesely, J. (2007) Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. *Nature*, **450**, 537-540.

Monteith, D. T., Shilland, E. M. (2007) The United Kingdom Acid Waters Monitoring Network Assessment of the First 18 Years of Data. Data Summary Annex Accompanying Research Project Final Report. Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-276. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Neal, M., Neal, C., Wickham, H. & Harman, S. (2007) Determination of bromide, chloride, fluoride, nitrate and sulphate by ion chromatography: comparisons of methodologies for rainfall, cloud water and river waters at the Plynlimon catchments of mid-Wales. *Hydrology and Earth System Sciences*, **11**, 294-300.

Shand, P., Darbyshire, D. P. F., Goody, D. & Haria, A. H. (2007) Sr-87/Sr-86 as an indicator of flowpaths and weathering rates in the Plynlimon experimental catchments, Wales, UK. *Chemical Geology*, **236**, 247-265.

Shilland, E. M., Monteith, D. T., Hutchins, M. & Beaumont, W. R. C. (2007) The United Kingdom Acid Waters Monitoring Network Data Report for 2006-2007 (year 19). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-203. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Beaumont, W. R. C. (2006) Acid Waters Monitoring 2005 Report on Fish Studies. 1-30. Centre for Ecology & Hydrology, Dorset.

Haria, A. H., Shand, P. (2006) Near-stream soil water-groundwater coupling in the headwaters of the Afon Hafren, Wales: Implications for surface water quality. *Journal of Hydrology*, **331**, 567-579.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2006) The United Kingdom Acid Waters Monitoring Network Data Report for 2005-2006 (year 18). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-203. ENSIS Ltd. Environmental Change research Centre, University College London, London.

Webb, B. W., Crisp, D. T. (2006) Afforestation and stream temperature in a temperate maritime environment. *Hydrological Processes*, **20**, 51-66.

Beaumont, W. R. C. (2005) Acid Waters Monitoring 2004 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

Cooper, D. M. (2005) Evidence of sulphur and nitrogen deposition signals at the United Kingdom Acid Waters Monitoring Network sites. *Environmental Pollution*, **137**, 41-54.

Curtis, C. J., Evans, C. D., Helliwell, R. C. & Monteith, D. T. (2005) Nitrate leaching as a confounding factor in chemical recovery from acidification in UK upland waters. *Environmental Pollution*, **137**, 73-82.

Davies, J. J. L., Jenkins, A., Monteith, D. T., Evans, C. D. & Cooper, D. M. (2005) Trends in surface water chemistry of acidified UK Freshwaters, 1988-2002. *Environmental Pollution*, **137**, 27-39.

Evans, C. D., Monteith, D. T. & Cooper, D. M. (2005) Long-term increases in surface water dissolved organic carbon: Observations, possible causes and environmental impacts. *Environmental Pollution*, **137**, 55-71.

Ledger, M. E., Hildrew, A. G. (2005) The ecology of acidification and recovery: changes in herbivore-algal food web linkages across a stream pH gradient. *Environmental Pollution*, **137**, 103-118.

Monteith, D. T. (2005) The United Kingdom Acid Waters Monitoring Network: a review of the first 15 years and introduction to the special issue. *Environmental Pollution*, **137**, 3-13.

Monteith, D. T., Hildrew, A. G., Flower, R. J., Raven, P. J., Beaumont, W. R. B., Collen, P., Kreiser, A. M., Shilland, E. M. & Winterbottom, J. H. (2005) Biological responses to the chemical recovery of acidified fresh waters in the UK. *Environmental Pollution*, **137**, 83-101.

Neal, C. (2005) Lanthanum, cerium, praseodymium and yttrium in waters in an upland acidic and acid sensitive environment, mid-Wales. *Hydrology and Earth System Sciences*, **9**, 645-656.

Neal, C., Neal, M., Reynolds, B., Maberly, S. C., May, L., Ferrier, R. C., Smith, J. & Parker, J. E. (2005) Silicon concentrations in UK surface waters. *Journal of Hydrology*, **304**, 75-93.

Neal, C., Robson, A. J., Neal, M. & Reynolds, B. (2005) Dissolved organic carbon for upland acidic and acid sensitive catchments in mid-Wales. *Journal of Hydrology*, **304**, 203-220.

Robinson, M., Dupeyrat, A. (2005) Effects of commercial timber harvesting on streamflow regimes in the Plynlimon catchments, mid-Wales. *Hydrological Processes*, **19**, 1213-1226.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2005) The United Kingdom Acid Waters Monitoring Network Data Report for 2004-2005 (year 17). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-188. ENSIS Ltd., London.

Beaumont, W. R. C. (2004) Acid Waters Monitoring 2003 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

- Brandt, C., Robinson, M. & Finch, J. W. (2004) Anatomy of a catchment: the relation of physical attributes of the Plynlimon catchments to variations in hydrology and water status. *Hydrology and Earth System Sciences*, **8**, 345-354.
- Haria, A. H., Shand, P. (2004) Evidence for deep sub-surface flow routing in forested upland Wales: implications for contaminant transport and stream flow generation. *Hydrology and Earth System Sciences*, **8**, 334-344.
- Hindar, A., Torseth, K., Henriksen, A. & Orsolini, Y. (2004) The Significance of the North Atlantic Oscillation (NAO) for Sea-Salt Episodes and Acidification-Related Effects in Norwegian Rivers. *Environmental Science & Technology*, **38**, 26-33.
- Neal, C. (2004) The water quality functioning of the upper River Severn, Plynlimon, mid-Wales: issues of monitoring, process understanding and forestry. *Hydrology and Earth System Sciences*, **8**, 521-532.
- Neal, C., Neal, M., Wickham, H., Hill, L., Reynolds, B. & Williams, B. (2004) The impact of conifer harvesting on stream water quality: the Afon Hafren, mid-Wales. *Hydrology and Earth System Sciences*, **8**, 503-520.
- Ness, L., Neal, C., Davies, T. D. & Reynolds, B. (2004) Impacts of the North Atlantic Oscillation on stream water chemistry in mid-Wales. *Hydrology and Earth System Sciences*, **8**, 409-421.
- Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2004) The United Kingdom Acid Waters Monitoring Network Data Report for 2003-2004 (year 16). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 160. 1-188. ENSIS Ltd., London.
- Whitehead, P. G., Hill, T. J. & Neal, C. (2004) Impacts of forestry on nitrogen in upland and lowland catchments: a comparison of the River Severn at Plynlimon in mid-Wales and the Bedford Ouse in south-east England using the INCA Model. *Hydrology and Earth System Sciences*, **8**, 533-544.
- Beaumont, W. R. C. (2003) Acid Waters Monitoring 2002 Report on Fish Studies. 1-25. Centre for Ecology & Hydrology, Dorset.
- Neal, C. (2003) Dissolved beryllium in rainfall, stream and shallow groundwaters in the Upper River Severn catchments, Plynlimon, mid Wales. *The Science of The Total Environment*, **314-316**, 171-184.
- Neal, C., Neal, M., Davies, H. & Smith, J. (2003) Fluoride in UK rivers. *The Science of The Total Environment*, **314-316**, 209-231.
- Neal, C., Reynolds, B., Neal, M., Hill, L., Wickham, H. & Pugh, B. (2003) Nitrogen in rainfall, cloud water, throughfall, stemflow, stream water and groundwater for the Plynlimon catchments of mid-Wales. *The Science of The Total Environment*, **314-316**, 121-151.

Neal, C., Reynolds, B., Neal, M., Hughes, S., Wickham, H., Hill, L., Rowland, P. & Pugh, B. (2003) Soluble reactive phosphorus levels in rainfall, cloud water, throughfall, stemflow, soil waters, stream waters and groundwaters for the Upper River Severn area, Plynlimon, mid Wales. *The Science of The Total Environment*, **314-316**, 99-120.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2003) The United Kingdom Acid Waters Monitoring Network Data Report for 2002-2003 (year 15). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Beaumont, W. R. C. (2002) Acid Waters Monitoring 2001 Report on Fish Studies. 1-14. Centre for Ecology & Hydrology, Dorset.

Beaumont, W. R. C. (2002) Acid Waters Monitoring 2001 Report on Fish Studies: Addendum. 1-8. Centre for Ecology & Hydrology, Dorset.

Dawson, J. J. C., Billett, M. F., Neal, C. & Hill, S. (2002) A comparison of particulate, dissolved and gaseous carbon in two contrasting upland streams in the UK. *Journal of Hydrology*, **257**, 226-246.

Hill, T., Whitehead, P. & Neal, C. (2002) Modelling long-term stream acidification in the chemically heterogeneous Upper Severn catchment, Mid-Wales. *The Science of The Total Environment*, **286**, 215-232.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2002) The United Kingdom Acid Waters Monitoring Network Data Report for 2001-2002 (year 14). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2002) The United Kingdom Acid Waters Monitoring Network Data Report for 2000-2001 (year 13). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Beaumont, W. R. C., McDonnell, N. (2001) Acid Waters Monitoring 2000 Report on Fish Studies. 1-18. Centre for Ecology & Hydrology, Dorset.

CLAM. (2001) Summary of Research under DETR Contract "Acidification of freshwaters: the role of nitrogen and the prospects for recovery", EPG1/3/117. Curtis, C. J. and Simpson, G. Research Report No. 79. Environmental Change Research Centre, University College London, London.

Evans, C. D., Cullen, J. M., Alewell, C., Kopacek, J., Marchetto, A., Moldan, F., Prechtel, A., Rogora, M., Vesely, J. & Wright, R. (2001) Recovery from acidification in European surface waters. *Hydrology and Earth System Sciences*, **5**, 283-297.

Evans, C. D., Monteith, D. T. (2001) Chemical trends at lakes and streams in the UK Acid Waters Monitoring Network, 1988-2000: Evidence for recent recovery at a national scale. *Hydrology and Earth System Sciences*, **5**, 351-366.

Jenkins, A., Cullen, J. M. (2001) An Assessment of the potential impact of the Gothenburg Protocol on surface water chemistry using the dynamic MAGIC model at acid sensitive sites in the UK. *Hydrology and Earth System Sciences*, **5**, 529-541.

Monteith, D. T., Evans, C. D. & Patrick, S. (2001) Monitoring acid waters in the UK: 1988-1998 Trends. *Water Air and Soil Pollution*, **130**, 1307-1312.

Monteith, D. T., Evans, C. D. (2001) United Kingdom Acid Waters Monitoring Network. 1-24. Department of the Environment, Transport and the Regions, London.

Neal, C., Reynolds, B., Neal, M., Pugh, B., Hill, L. & Wickham, H. (2001) Long-term changes in the water quality of rainfall, cloud water and stream water for moorland, forested and clear-felled catchments at Plynlimon, mid-Wales. *Hydrology and Earth System Sciences*, **5**, 459-476.

NEGTA. (2001) Transboundary Air Pollution: Acidification, Eutrophication and Ground-Level Ozone in the UK. 1-314. Department For Environment, Food and Rural Affairs (DEFRA), London.

Wright, R. F., Alewell, C., Cullen, J. M., Evans, C. D., Marchetto, A., Moldan, F., Prechtel, A. & Rogora, M. (2001) Trends in nitrogen deposition and leaching in acid-sensitive streams in Europe. *Hydrology and Earth System Sciences*, **5**, 299-310.

Beaumont, W. R. C., Ingram, A. (2000) Acid Waters Monitoring 1999 Report on Fish Studies. Centre for Ecology & Hydrology, Dorset.

Monteith, D. T., Evans, C. D. (2000) United Kingdom Acid Waters Monitoring Network 10 Year Report. Analysis and Interpretation of Results, April 1988 - March 1998. Monteith, D. T. and Evans, C. D. 1-364. ENSIS Ltd, London.

Neal, C., Kirchner, J. W. (2000) Sodium and chloride levels in rainfall, mist, streamwater and groundwater at the Plynlimon catchments, mid-Wales: inferences on hydrological and chemical controls. *Hydrology and Earth System Sciences*, **4**, 295-310.

Neal, C. (2000) The fractionation of the elements in river waters with respect to the continental crust: a UK perspective based on a river enrichment factor approach. *Hydrology and Earth System Sciences*, **4**, 499-509.

Neal, C., Neal, M. & Wickham, H. (2000) Phosphate measurement in natural waters: two examples of analytical problems associated with silica interference using phosphomolybdic acid methodologies. *The Science of The Total Environment*, **251-252**, 511-522.

Beaumont, W. R. C., Sturgess, P. & Pinder, A. (1999) Acid Waters Monitoring Report on Fish Studies 1988-1997. 1-129. Institute of Freshwater Ecology, Dorset.

Beaumont, W. R. C., Sturgess, P. (1999) Acid Waters Monitoring 1998 Report on Fish Studies. 1-26. Institute of Freshwater Ecology, Dorset.

Curtis, C. J., Murlis, J., Battarbee, R. W., Bull, K., Campbell, G., Fowler, D., Jenkins, A., Monteith, D. T., Ormerod, S. & Reynolds, B. (1999) Acid deposition in the UK: a review of environmental damage and recovery prospects. NSCA Occasional Paper No.1, 1-28. National Society for Clean Air and Environmental Protection, Brighton.

Beaumont, W. R. C., Pinder, A. (1998) Acid Waters Monitoring 1997 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

Helliwell, R. C., Ferrier, R. C. & Jenkins, A. (1998) A two-layer application of the MAGIC model to predict the effects of land use scenarios and reductions in deposition on acid sensitive soils in the UK. *Hydrology and Earth System Sciences*, **2**, 497-507.

Jenkins, A., Helliwell, R. C., Swingewood, P. J., Sefton, C., Renshaw, M. & Ferrier, R. C. (1998) Will reduced sulphur emissions under the Second Sulphur Protocol lead to recovery of acid sensitive sites in UK? *Environmental Pollution*, **99**, 309-318.

Monteith, D. T., Renshaw, M. & Patrick, S. T. (1998) Monitoring the long term chemical and biological response to changing sulphur and nitrogen emissions of sensitive waters, United Kingdom. *Headwaters: Water Resources and Soil Conservation* 111-125.

Monteith, D. T., Evans, C. D., Beaumont, W. R. C. & Delinikajtis, C. (1998) The United Kingdom Acid Waters Monitoring Network Data Report for 1997-1998 (year 10). Report to the DETR and the DoE Northern Ireland. ENSIS Ltd, London.

Neal, C., Reynolds, B., Adamson, J. K., Stevens, P. A., Neal, M., Harrow, M. & Hill, S. (1998) Analysis of the impacts of major anion variations on surface water acidity particularly with regard to conifer harvesting: Case studies from Wales and Northern England. *Hydrology and Earth System Sciences*, **2**, 303-322.

Sefton, C. E. M., Jenkins, A. (1998) A regional application of the MAGIC model in Wales: calibration and assessment of future recovery using a Monte-Carlo approach. *Hydrology and Earth System Sciences*, **2**, 521-531.

Beaumont, W. R. C., Bradley, D. C. (1997) Acid Waters Monitoring 1996 Report on Fish Studies. 1-36. Centre for Ecology & Hydrology, Dorset.

Gee, J. H. R., Smith, B. D. (1997) Benthic invertebrates in the headwaters of the Wye and Severn: effects of forestry and clear-felling. *Hydrology and Earth System Sciences*, **1**, 549-556.

Monteith, D. T., Renshaw, M., Evans, C. D. & Patrick, S. T. (1997) The United Kingdom Acid Waters Monitoring Network Data Report for 1996-1997 (year 9). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Reynolds, B., Fowler, D., Smith, R. I. & Hall, J. R. (1997) Atmospheric inputs and catchment solute fluxes for major ions in five Welsh upland catchments. *Journal of Hydrology*, **194**, 305-329.

Robertson, A. L., Lancaster, J., Belyea, L. R. & Hildrew, A. G. (1997) Hydraulic habitat and the assemblage structure of stream benthic microcrustacea. *Journal of the North American Benthological Society*, **16**, 562-575.

Beaumont, W. R. C. (1996) Acid Waters Monitoring 1995 Report on Fish Studies. 1-25. Institute of Freshwater Ecology, Dorset.

Campbell, G. W., Lee, D. S. (1996) Atmospheric deposition of sulphur and nitrogen species in the UK. *Freshwater Biology*, **36**, 151-167.

Crisp, D. T., Beaumont, W. R. C. (1996) The trout (*Salmo trutta* L.) populations of the headwaters of the Rivers Severn and Wye, mid-Wales, UK. *The Science of The Total Environment*, **177**, 113-123.

Jenkins, A., Boorman, D. & Renshaw, M. (1996) The UK acid waters monitoring network: An assessment of chemistry data, 1988-93. *Freshwater Biology*, **36**, 169-178.

Lancaster, J., Real, M., Juggins, S., Monteith, D. T., Flower, R. J. & Beaumont, W. R. C. (1996) Monitoring temporal changes in the biology of acid waters. *Freshwater Biology*, **36**, 179-201.

Lancaster, J., Patrick, S. (1996) The UK acid waters monitoring network: A preface. *Freshwater Biology*, **36**, 129-130.

Monteith, D. T., Renshaw, M., Beaumont, W. R. C. & Patrick, S. T. (1996) The United Kingdom Acid Waters Monitoring Network Data Report for 1995-1996 (year 8). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Neal, C., Smith, C. J., Jeffery, H. A., Harrow, M. & Neal, M. (1996) Dissolved chromium pollution in rainfall and surface waters in mid-Wales during the mid-1980s. *The Science of The Total Environment*, **188**, 127-138.

Patrick, S., Battarbee, R. W. & Jenkins, A. (1996) Monitoring acid waters in the UK: An overview of the UK acid waters monitoring network and summary of the first interpretative exercise. *Freshwater Biology*, **36**, 131-150.

Battarbee, R. W., Allott, T. E. H., Bull, K., Christie, A. E. G., Curtis, C. J., Flower, R. J., Hall, J. R., Harriman, R., Jenkins, A., Juggins, S., Kreiser, A. M., Metcalfe, S. E., Ormerod, S. J. & Patrick, S. T. (1995) Critical Loads of Acid Deposition for United Kingdom Freshwaters. Critical Loads Advisory Group. Sub group Report on

Freshwaters. 1-80. Institute of Terrestrial Ecology (Edinburgh Research Station), Penicuik.

Beaumont, W. R. C. (1995) Acid Waters Monitoring 1994 Report on Fish Studies. 1-26. Institute of Freshwater Ecology, Dorset.

Jenkins, A. (1995) Freshwater Recovery and Future Trends. Battarbee, R. W. 61-67. ENSIS Ltd, London. Acid Rain and Its Impact: The Critical Loads Debate. 17-9-1993.

Jenkins, A., Campbell, G., Renshaw, M., Boorman, D., Stedman, J. & Patrick, S. (1995) Surface water acidification in the UK; Current status, recent trends and future predictions. *Water Air and Soil Pollution*, **85**, 565-570.

Monteith, D. T., Renshaw, M. & Beaumont, W. R. C. (1995) The United Kingdom Acid Waters Monitoring Network Data Report for 1994-1995 (year 7). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Neal, C. (1995) Aluminium speciation variations in an acidic upland stream draining the Hafren spruce forest, Plynlimon, Mid-Wales. *Journal of Hydrology*, **164**, 39-51.

Patrick, S. T., Monteith, D. T. & Jenkins, A. (1995) UK Acid Waters Monitoring Network: The first five years. Analysis and interpretation of results, April 1988 - March 1993. 1-320. ENSIS Publishing, London.

Beaumont, W. R. C., Miles, L. (1994) Acid Waters Monitoring 1993 Report on Fish Studies. 1-42. Institute of Freshwater Ecology, Dorset.

Monteith, D. T., Renshaw, M., Beaumont, W. R. C. & Patrick, S. T. (1994) The United Kingdom Acid Waters Monitoring Network Data Report for 1993-1994 (year 6). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Beaumont, W. R. C. (1993) Acid Waters Monitoring 1992 Report on Fish Studies. 1-18. Institute of Freshwater Ecology, Dorset.

Juggins, S., Shaw, C., Patrick, S. T., Monteith, D. T., Beaumont, W. R. C. & Reed, J. (1993) The United Kingdom Acid Waters Monitoring Network Data Report for 1992-1993 (year 5). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Lancaster, J., Hildrew, A. G. (1993) Characterizing In-Stream Flow Refugia. *Canadian Journal of Fisheries and Aquatic Sciences*, **50**, 1663-1675.

Orange, A. (1993) Effects of Channel Liming on the Bryophytes and Lichens of the Upper River Severn. Department of Botany, National Museum of Wales: Report to National Rivers Authority.

Rose, N. L. (1-1-1993) An Assessment of the Potential of the United Kingdom Acid Waters Monitoring Network to Monitor the Impact of Atmospheric Trace metals and

Persistent Organic Compounds on Freshwaters. 1-87. Environmental Change Research Centre, University College London, London. Research Papers No 9.

Beaumont, W. R. C. (1992) Acid Waters Monitoring 1991 Report on Fish Studies. 1-16. Institute of Freshwater Ecology, Dorset.

Juggins, S., Shaw, C., Patrick, S. T., Monteith, D. T., Beaumont, W. R. C. & Reed, J. (1992) The United Kingdom Acid Waters Monitoring Network Data Report for 1991-1992 (year 4). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Juggins, S., Waters, D., Patrick, S. T. & Beaumont, W. R. C. (1991) The United Kingdom Acid Waters Monitoring Network Data Report for 1990-1991 (year 3). Report to the DoE and the DoE Northern Ireland. 1-124. ENSIS Ltd, London.

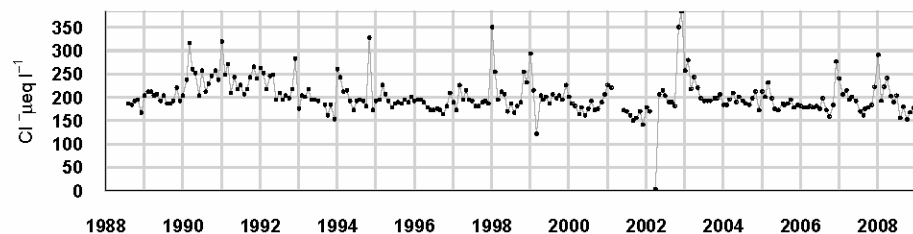
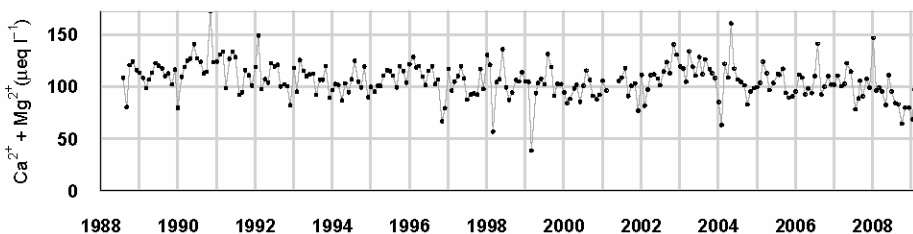
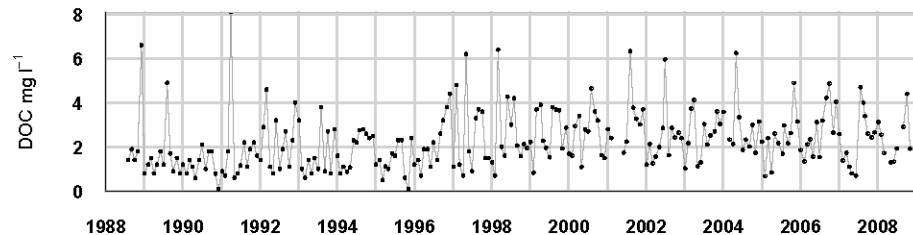
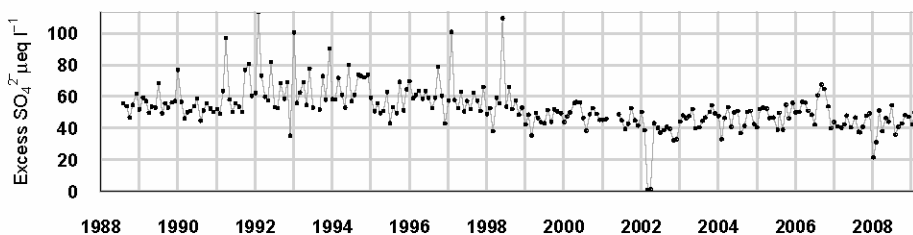
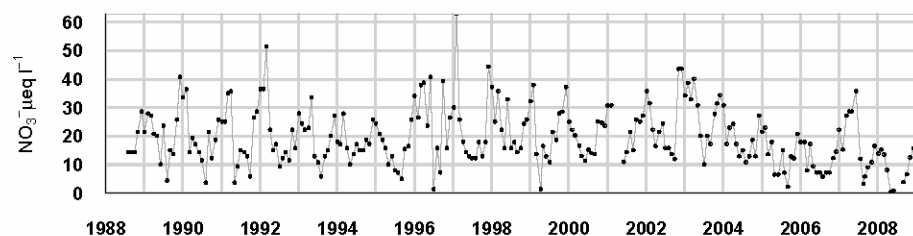
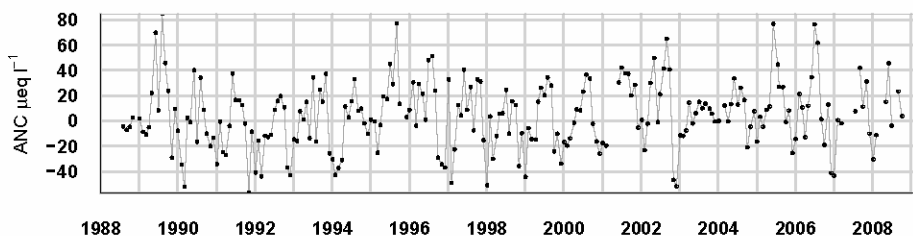
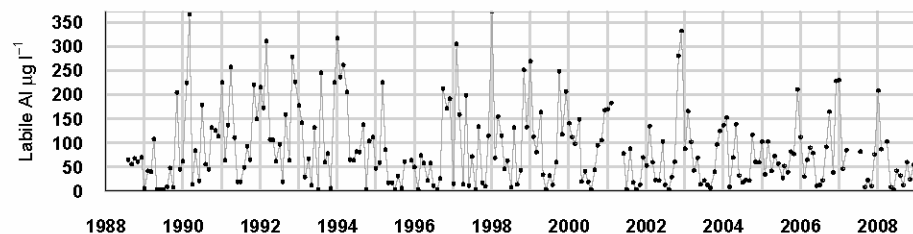
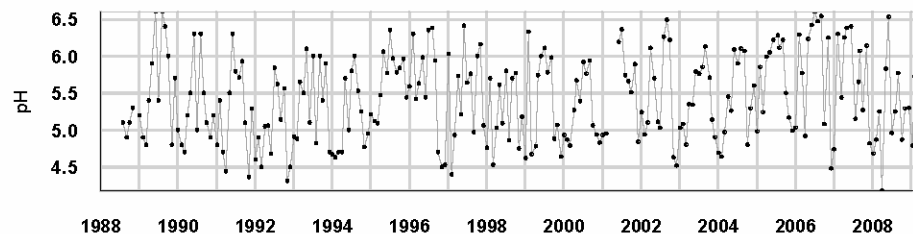
Patrick, S. T., Waters, D., Juggins, S. & Jenkins, A. (1991) The United Kingdom Acid Waters Monitoring Network. Site descriptions and methodology report. 1-63. ENSIS Ltd, London.

Juggins, S., Waters, D., Patrick, S. T., Jenkins, A. & Beaumont, W. R. C. (1990) The United Kingdom Acid Waters Monitoring Network Data Report for 1989-1990 (year 2). Report to the DoE. 1-101. ENSIS Ltd, London.

Juggins, S., Watson, D., Waters, D., Patrick, S. T., Jenkins, A. & . (1989) The United Kingdom Acid Waters Monitoring Network Introduction and Data Report for 1988-1989 (year 1). Report to the DoE. 1-91. ENSIS Ltd, London.

4.10 Afon Hafren Summary Data to March 2008

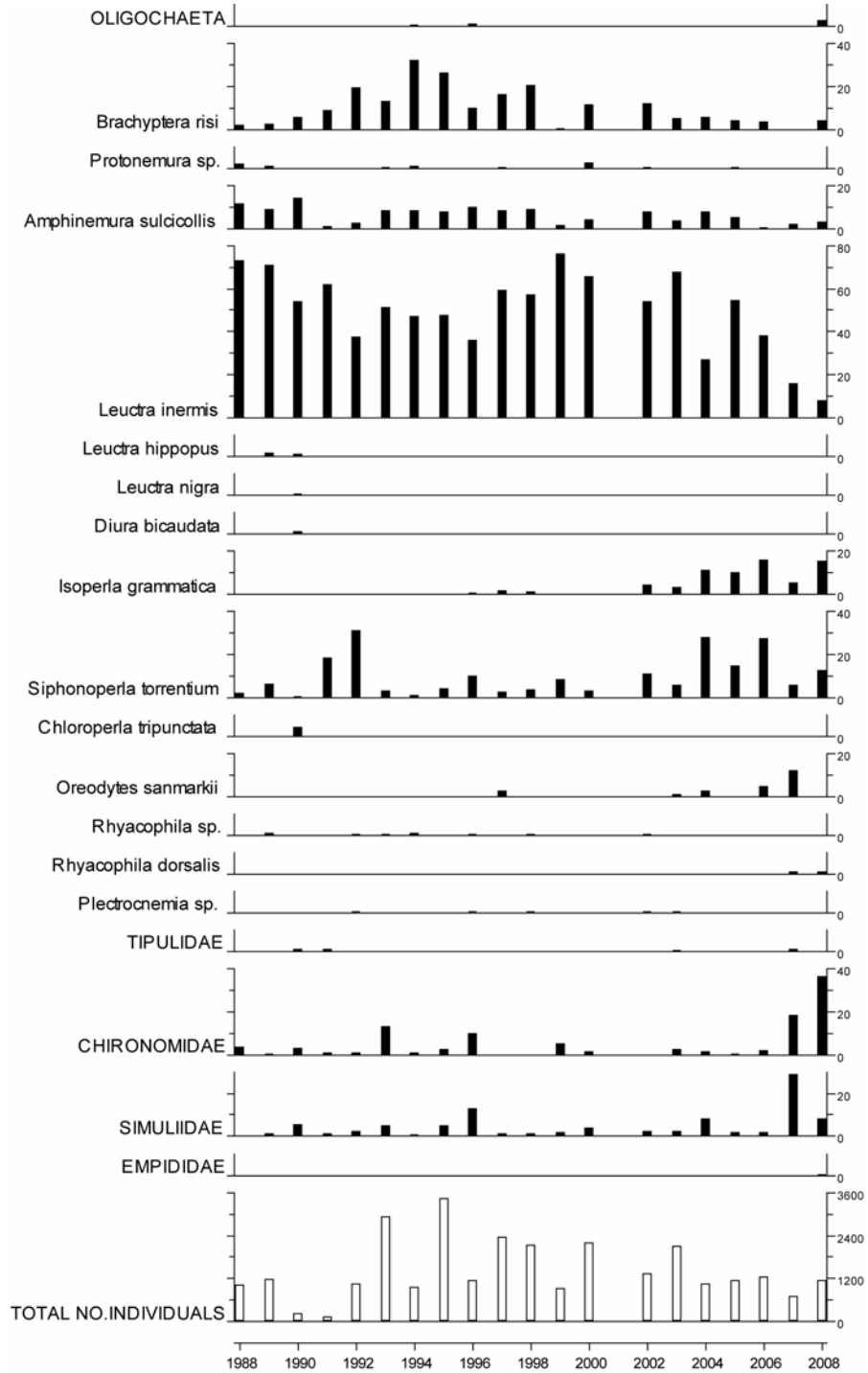
4.10.1 Spot sampled chemistry data



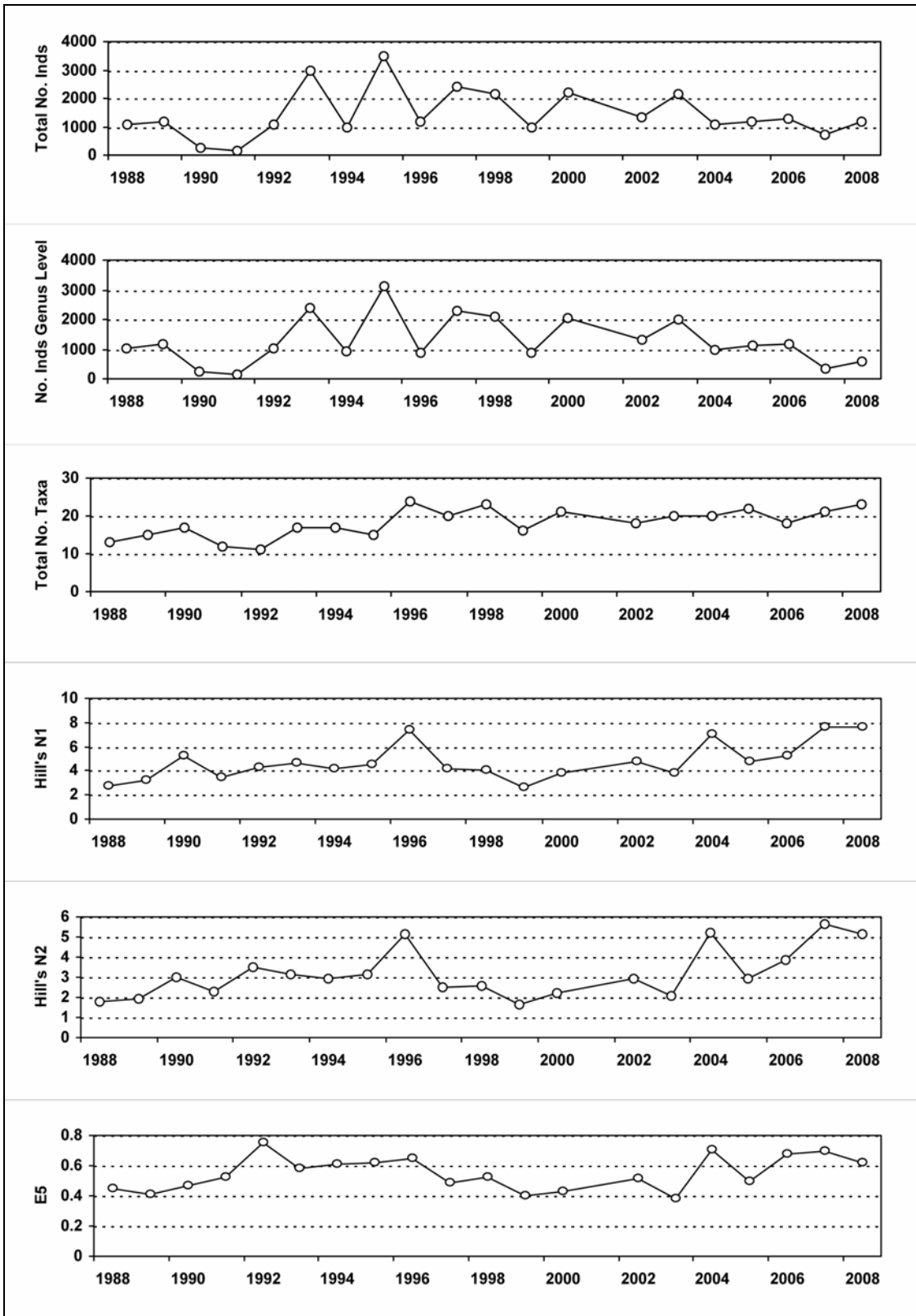
$\mu\text{eq l}^{-1}$, * $\mu\text{g l}^{-1}$, ** mg l^{-1}	pH	ANC	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	*Soluble Al	*Labile Al	Cl ⁻	*SO ₄ ²⁻	xSO ₄ ²⁻	NO ₃ ⁻	**DOC
Mean 1 st 5 yrs	5.29	-2.40	47.91	66.41	200.39	3.16	170.00	101.71	221.09	82.97	59.79	5.29	-2.40
08-09 mean	5.37	16.62	32.38	54.20	165.63	2.71	91.92	36.25	182.10	63.79	44.70	5.37	16.62
08-09 std dev	0.63	19.18	6.46	7.79	17.43	1.68	65.33	32.67	24.75	6.08	5.28	0.63	19.18

4.10.2 Macroinvertebrate data

4.10.2.1 Percentage abundance summary, Afon Hafren



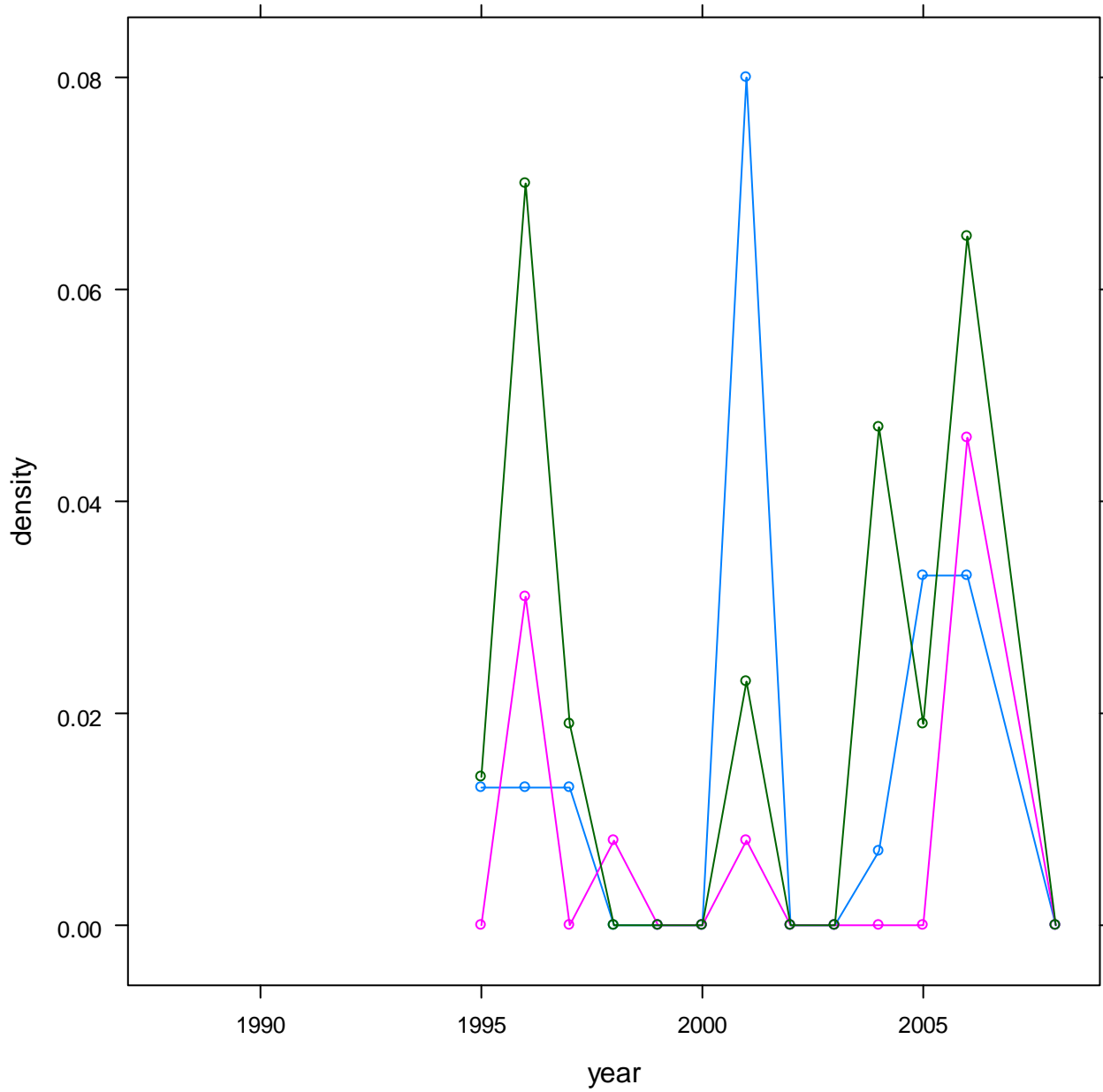
4.10.2.1 Macroinvertebrate summary statistics, Afon Hafren



No sampling in 2001 due to Foot and Mouth restrictions.

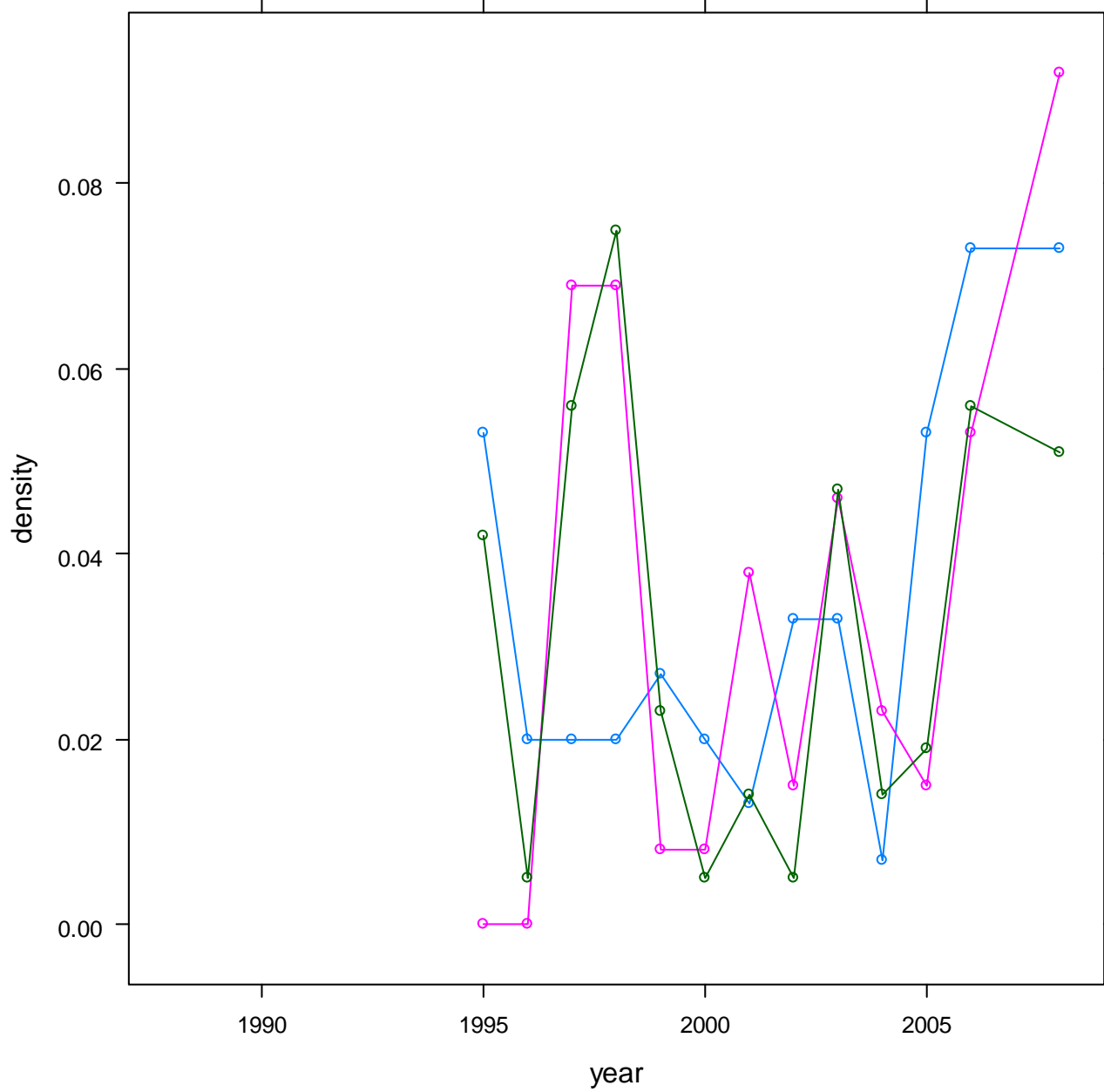
4.10.3 Fish data

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



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

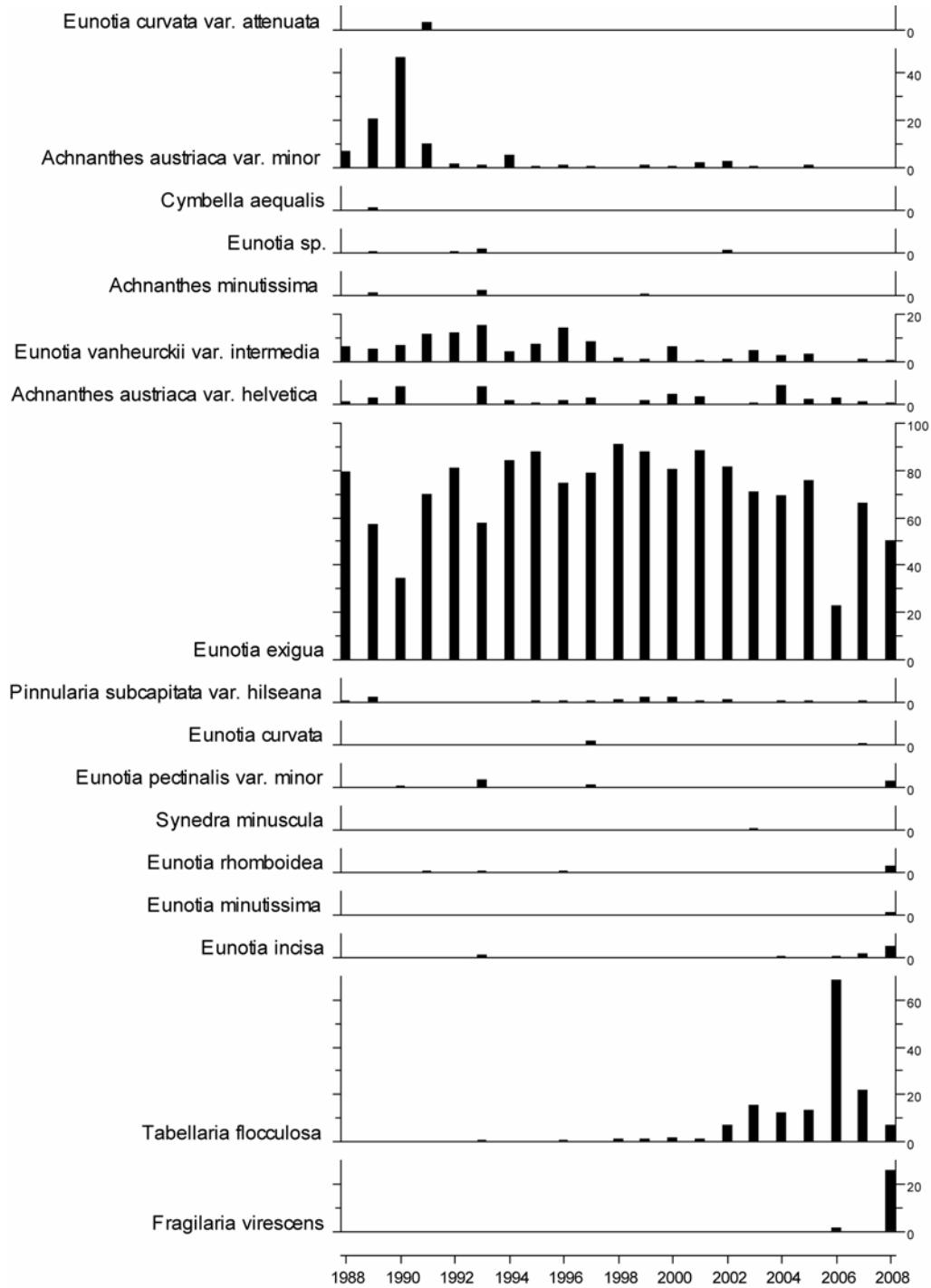
4.10.3.2 Summary of Trout parr density (numbers m⁻²), Afon Hafren



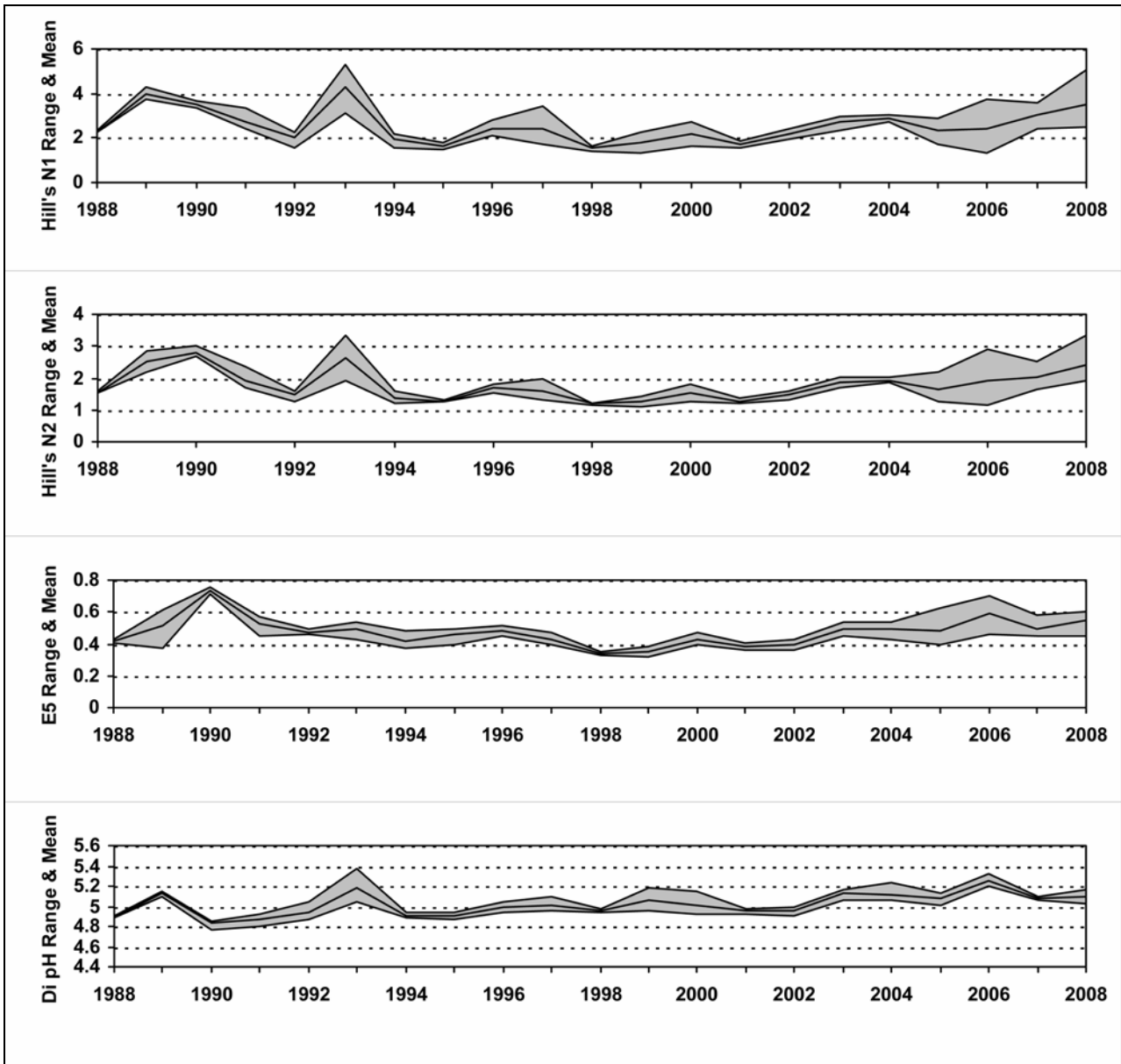
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

4.10.4 Epilithic diatom data

4.10.4.1 Percentage abundance summary, Afon Hafren

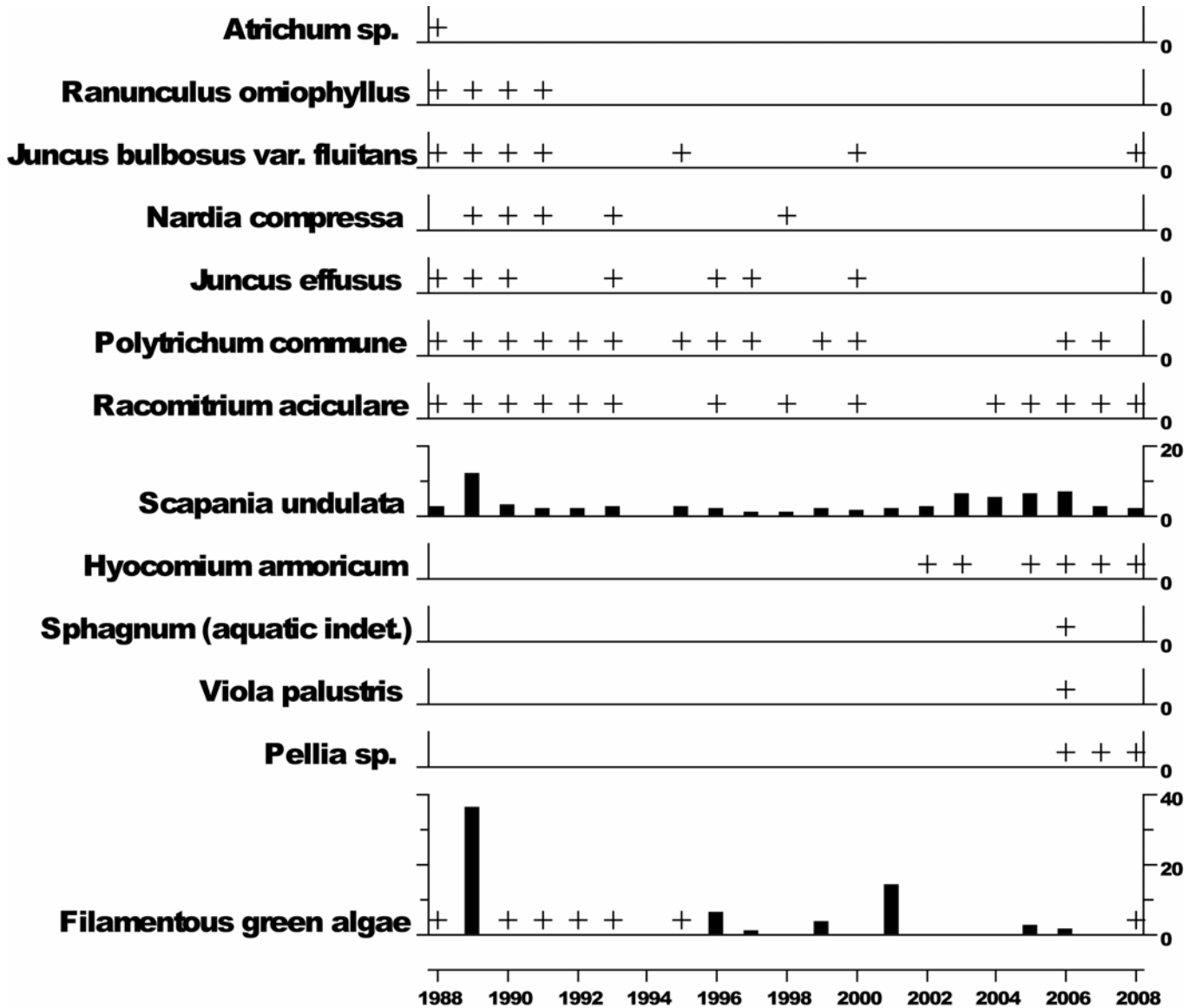


4.10.4.1 Diatom summary statistics, Afon Hafren



4.10.5 Aquatic macrophyte data, Afon Hafren

Percentage Species Cover



+ Represents <1% abundance

5 Afon Gwy



Figure 3 Afon Gwy biological survey section 10th July 2009

5.1 Summary Overview

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 2009 to March 2010.

5.2 Water Chemistry

Samples were collected by CEH early every month throughout the period April 2009 to March 2010, delivered to the analytical laboratories on schedule and are in the process of being analysed, quality controlled and archived in the UKAWMN central chemistry database at CEH Lancaster. Unfortunately the water sample from 02/06/09 was lost.

5.3 Epilithic Diatoms

Epilithic diatoms were retrieved by a team from ENSIS from three sampling points in the stream on the 10th of July 2009. The samples have been made into slides and are currently in the process of being analysed.

5.4 Macroinvertebrates

Aquatic macroinvertebrates were sampled on the 17th April 2009 by a team from QMuL. Five 1 minute kick samples were performed. The samples were counted and the data sent to ENSIS Ltd. After quality screening the data was added to the UKAWMN biological database at ENSIS.

5.5 Fish

Fish surveying was performed on the 25th August 2009 by a team from the Environment Agency Wales. Unfortunately fish weights were not recorded. The data has been forwarded to ENSIS Ltd. After quality screening the data will be added to the UKAWMN biological database at ENSIS. No Salmon were recorded in 2009.

5.6 Aquatic Macrophytes

Aquatic macrophytes were surveyed by a team from ENSIS on 10th of July 2009. Percentage cover scores were recorded and data will be added to the ENSIS biological database after microscope confirmation of bryophyte identifications.

5.7 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 2008-2009 annual report is nearly ready to be uploaded to the AWMN web page in late March 2010, and the section on Afon Gwy appears in section 5.10 below.

An interpretative report detailing 20 years of the UKAWMN is undergoing a final edit and will also be published in 2010.

Further publications from the contract period utilizing data from Afon Gwy are detailed in section 5.8 below. Section 5.9 provides a bibliography for the site.

5.8 Afon Gwy Recent Publications

Battarbee, R. W., Kernan, M., Monteith, D. T. & Curtis, C. J. (2010) Summary and Recommendations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 279-293, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Simpson, G. L. (2010) Acid Deposition Trends at AWMN Sites. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 31-52, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Battarbee, R. W., Heliwell, R., Flower, R. J., Simpson, G. L., Monteith, D. T., Shilland, E. M., Aherne, J. & MacDougall, G. (2010) Recovery Progress: Reference Conditions and Restoration Targets. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 206-237, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Flower, R. J., Simpson, G. L., Kreiser, A. M., Yang, H., Shilland, E. M. & Battarbee, R. W. (2010) Epilithic Diatoms. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 97-111, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G., Winterbottom, J. H., Orton, S., Murphy, J., Simpson, G. L. & Shilland, E. M. (2010) Macroinvertebrates. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 126-139, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Monteith, D. T., Battarbee, R. W., Curtis, C. J., Shilland, E. M. & Simpson, G. L. (2010) Introduction. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 23-30, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Battarbee, R. W., Curtis, C. J., Monteith, D. T. & Shilland, E. M. (2010) *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 1-477, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Malcolm, I., Bacon, P., Middlemas, S., Collen, P. & Shilland, E. M. (2010) Salmonid Fish Populations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 140-165, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Rose, N. L., Yang, H. (2010) Trace Metals. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 166-205, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. (2010) Aquatic Macrophytes. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 112-125, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G. (2009) *Sustained Research on Stream Communities: A Model System and The Comparative Approach*, 175-312, Elsevier Academic Press Inc, SAN DIEGO.

Shilland, E. M., Hutchins, M. (2009) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249 Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2008 - March 2009. Report to the Welsh Assembly Government, Countryside Council for Wales and Environment Agency, Wales. 1-61. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. & Hutchins, M. (2009) The United Kingdom Acid Waters Monitoring Network Data Report for 2007-2008 (year 20). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-205. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Evans, C. D., Monteith, D. T., Reynolds, B. & Clark, J. M. (2008) Buffering of recovery from acidification by organic acids. *Science of the Total Environment*, **404**, 316-325.

Neal, C., Lofts, S., Evans, C. D., Reynolds, B., Tipping, E. & Neal, M. (2008) Increasing iron concentrations in UK upland waters. *Aquatic Geochemistry*, **14**, 263-288.

NERC. (2008) Clear to brown: upland waters return to natural state. NERC Annual Review 2007-2008 , 11. Natural Environment Research Council, Polaris House, North Star Avenue, Swindon.

Skjelkvale, B. L., de Wit, H. A. (2008) ICP Waters. 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North America. NIVA Report SNO: 5684-2008, 1-55. Norwegian Institute for Water Research, Oslo., Oslo, Norway.

Winterbottom, J. H., Orton, S. E. (2008) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty First Year: 2008. Summary of species identification and abundance. 1-12. School of Biological Sciences, Queen Mary University of London, London.

5.9 Afon Gwy Bibliography

Battarbee, R. W., Kernan, M., Monteith, D. T. & Curtis, C. J. (2010) Summary and Recommendations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 279-293, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Simpson, G. L. (2010) Acid Deposition Trends at AWMN Sites. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 31-52, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Curtis, C. J., Battarbee, R. W., Heliwell, R., Flower, R. J., Simpson, G. L., Monteith, D. T., Shilland, E. M., Aherne, J. & MacDougall, G. (2010) Recovery Progress: Reference Conditions and Restoration Targets. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 206-237, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Flower, R. J., Simpson, G. L., Kreiser, A. M., Yang, H., Shilland, E. M. & Battarbee, R. W. (2010) Epilithic Diatoms. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 97-111, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G., Winterbottom, J. H., Orton, S., Murphy, J., Simpson, G. L. & Shilland, E. M. (2010) Macroinvertebrates. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 126-139, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Monteith, D. T., Battarbee, R. W., Curtis, C. J., Shilland, E. M. & Simpson, G. L. (2010) Introduction. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 23-30, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Kernan, M., Battarbee, R. W., Curtis, C. J., Monteith, D. T. & Shilland, E. M. (2010) *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 1-477, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Malcolm, I., Bacon, P., Middlemas, S., Collen, P. & Shilland, E. M. (2010) Salmonid Fish Populations. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 140-165, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Rose, N. L., Yang, H. (2010) Trace Metals. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 166-205, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. (2010) Aquatic Macrophytes. In: *UK Acid Waters Monitoring Network 20 Year Interpretative Report*, 112-125, ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Hildrew, A. G. (2009) *Sustained Research on Stream Communities: A Model System and The Comparative Approach*, 175-312, Elsevier Academic Press Inc, SAN DIEGO.

Shilland, E. M., Hutchins, M. (2009) UK Acid Waters Monitoring Network (UKAWMN) - Contract 22 01 249 Llyn Cwm Mynach, Afon Hafren and Afon Gwy Annual Summary Progress Report April 2008 - March 2009. Report to the Welsh Assembly Government,

Countryside Council for Wales and Environment Agency, Wales. 1-61. ENSIS Ltd, Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T. & Hutchins, M. (2009) The United Kingdom Acid Waters Monitoring Network Data Report for 2007-2008 (year 20). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-205. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Chapman, P. J., Clark, J. M., Reynolds, B. & Adamson, J. K. (2008) The influence of organic acids in relation to acid deposition in controlling the acidity of soil and stream waters on a seasonal basis. *Environmental Pollution*, **151**, 110-120.

Evans, C. D., Reynolds, B., Hinton, C., Hughes, S., Norris, D., Grant, S. & Williams, B. (2008) Effects of decreasing acid deposition and climate change on acid extremes in an upland stream. *Hydrology and Earth System Sciences*, **12**, 337-351.

Evans, C. D., Monteith, D. T., Reynolds, B. & Clark, J. M. (2008) Buffering of recovery from acidification by organic acids. *Science of the Total Environment*, **404**, 316-325.

Evans, C. D., Norris, D., Ostle, N., Grant, H., Rowe, E. C., Curtis, C. J. & Reynolds, B. (2008) Rapid immobilisation and leaching of wet-deposited nitrate in upland organic soils. *Environmental Pollution*, **156**, 636-643.

Lapworth, D. J., Shand, P., Abesser, C., Darling, W. G., Haria, A. H., Evans, C. D. & Reynolds, B. (2008) Groundwater nitrogen composition and transformation within a moorland catchment, mid-Wales. *Science of the Total Environment*, **390**, 241-254.

Neal, C., Lofts, S., Evans, C. D., Reynolds, B., Tipping, E. & Neal, M. (2008) Increasing iron concentrations in UK upland waters. *Aquatic Geochemistry*, **14**, 263-288.

NERC. (2008) Clear to brown: upland waters return to natural state. NERC Annual Review 2007-2008, 11. Natural Environment Research Council, Polaris House, North Star Avenue, Swindon.

Skjelkvale, B. L., de Wit, H. A. (2008) ICP Waters. 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North America. NIVA Report SNO: 5684-2008, 1-55. Norwegian Institute for Water Research, Oslo., Oslo, Norway.

Winterbottom, J. H., Orton, S. E. (2008) United Kingdom Acid Waters Monitoring Network Invertebrate Survey. Twenty First Year: 2008. Summary of species identification and abundance. 1-12. School of Biological Sciences, Queen Mary University of London, London.

Beaumont, W. R. C. (2007) Acid Waters Monitoring 2006 Report on Fish Studies. 1-34. Centre for Ecology & Hydrology, Dorset.

Curtis, C. J., Simpson, G. L. (2007) Freshwater Umbrella - The effect of nitrogen deposition and climate change on freshwaters in the UK. Report to DEFRA under contract CPEA17. ECRC Research Report 115. ENSIS Ltd. University College London, London.

Evans, C. D., Monteith, D. T., Wright, R. & Clark, J. (2007) Issues affecting upland water quality: Climate change, acidity, nitrogen and water colour. Kernan, M. R., Battarbee, R. W., and Binney, H. A. 21-25. ENSIS Publishing, University College London, London, London. Climate Change and Aquatic Ecosystems in the UK.

Marc, V., Robinson, M. (2007) The long-term water balance (1972-2004) of upland forestry and grassland at Plynlimon, mid-Wales. *Hydrology and Earth System Sciences*, **11**, 44-60.

Monteith, D. T., Stoddard, J. L., Evans, C. D., de Wit, H. A., Forsius, M., Hogasen, T., Wilander, A., Skjelkvale, B. L., Jeffries, D. S., Vuorenmaa, J., Keller, B., Kopacek, J. & Vesely, J. (2007) Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. *Nature*, **450**, 537-540.

Monteith, D. T., Shilland, E. M. (2007) The United Kingdom Acid Waters Monitoring Network Assessment of the First 18 Years of Data. Data Summary Annex Accompanying Research Project Final Report. Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-276. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Shilland, E. M., Monteith, D. T., Hutchins, M. & Beaumont, W. R. C. (2007) The United Kingdom Acid Waters Monitoring Network Data Report for 2006-2007 (year 19). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-203. ENSIS Ltd. Environmental Change Research Centre, University College London, London.

Beaumont, W. R. C. (2006) Acid Waters Monitoring 2005 Report on Fish Studies. 1-30. Centre for Ecology & Hydrology, Dorset.

Curtis, C. J., Emmett, B. A., Reynolds, B. & Shilland, J. (2006) How important is N₂O production in removing atmospherically deposited nitrogen from UK moorland catchments? *Soil Biology & Biochemistry*, **38**, 2081-2091.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2006) The United Kingdom Acid Waters Monitoring Network Data Report for 2005-2006 (year 18). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-203. ENSIS Ltd. Environmental Change research Centre, University College London, London.

Webb, B. W., Crisp, D. T. (2006) Afforestation and stream temperature in a temperate maritime environment. *Hydrological Processes*, **20**, 51-66.

- Wright, R. F., Aherne, J., Bishop, K., Camarero, L., Cosby, B. J., Erlandsson, M., Evans, C. D., Forsius, M., Hardekopf, D. W., Helliwell, R., Hruska, J., Jenkins, A., Kopacek, J., Moldan, F., Posch, M. & Rogora, M. (2006) Modelling the effect of climate change on recovery of acidified freshwaters: Relative sensitivity of individual processes in the MAGIC model. *Science of the Total Environment*, **365**, 154-166.
- Beaumont, W. R. C. (2005) Acid Waters Monitoring 2004 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.
- Cooper, D. M. (2005) Evidence of sulphur and nitrogen deposition signals at the United Kingdom Acid Waters Monitoring Network sites. *Environmental Pollution*, **137**, 41-54.
- Curtis, C. J., Evans, C. D., Helliwell, R. C. & Monteith, D. T. (2005) Nitrate leaching as a confounding factor in chemical recovery from acidification in UK upland waters. *Environmental Pollution*, **137**, 73-82.
- Davies, J. J. L., Jenkins, A., Monteith, D. T., Evans, C. D. & Cooper, D. M. (2005) Trends in surface water chemistry of acidified UK Freshwaters, 1988-2002. *Environmental Pollution*, **137**, 27-39.
- Evans, C. D., Monteith, D. T. & Cooper, D. M. (2005) Long-term increases in surface water dissolved organic carbon: Observations, possible causes and environmental impacts. *Environmental Pollution*, **137**, 55-71.
- Evans, C. D. (2005) Modelling the effects of climate change on an acidic upland stream. *Biogeochemistry*, **74**, 21-46.
- Ledger, M. E., Hildrew, A. G. (2005) The ecology of acidification and recovery: changes in herbivore-algal food web linkages across a stream pH gradient. *Environmental Pollution*, **137**, 103-118.
- Monteith, D. T., Hildrew, A. G., Flower, R. J., Raven, P. J., Beaumont, W. R. B., Collen, P., Kreiser, A. M., Shilland, E. M. & Winterbottom, J. H. (2005) Biological responses to the chemical recovery of acidified fresh waters in the UK. *Environmental Pollution*, **137**, 83-101.
- Monteith, D. T. (2005) The United Kingdom Acid Waters Monitoring Network: a review of the first 15 years and introduction to the special issue. *Environmental Pollution*, **137**, 3-13.
- Neal, C., Neal, M., Reynolds, B., Maberly, S. C., May, L., Ferrier, R. C., Smith, J. & Parker, J. E. (2005) Silicon concentrations in UK surface waters. *Journal of Hydrology*, **304**, 75-93.
- Robinson, M., Dupeyrat, A. (2005) Effects of commercial timber harvesting on streamflow regimes in the Plynlimon catchments, mid-Wales. *Hydrological Processes*, **19**, 1213-1226.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2005) The United Kingdom Acid Waters Monitoring Network Data Report for 2004-2005 (year 17). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 1-188. ENSIS Ltd., London.

Beaumont, W. R. C. (2004) Acid Waters Monitoring 2003 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

Brandt, C., Robinson, M. & Finch, J. W. (2004) Anatomy of a catchment: the relation of physical attributes of the Plynlimon catchments to variations in hydrology and water status. *Hydrology and Earth System Sciences*, **8**, 345-354.

Evans, C. D., Reynolds, B., Curtis, C. J., Crook, H. D., Norris, D. & Brittain, S. A. (2004) A conceptual model of spatially heterogeneous nitrogen leaching from a Welsh moorland catchment. *Water, Air and Soil Pollution: Focus*, **4**, 97-105.

Neal, C. (2004) The water quality functioning of the upper River Severn, Plynlimon, mid-Wales: issues of monitoring, process understanding and forestry. *Hydrology and Earth System Sciences*, **8**, 521-532.

Shilland, E. M., Monteith, D. T., Bonjean, M. & Beaumont, W. R. C. (2004) The United Kingdom Acid Waters Monitoring Network Data Report for 2003-2004 (year 16). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160). 160. 1-188. ENSIS Ltd., London.

Beaumont, W. R. C. (2003) Acid Waters Monitoring 2002 Report on Fish Studies. 1-25. Centre for Ecology & Hydrology, Dorset.

Neal, C., Neal, M., Davies, H. & Smith, J. (2003) Fluoride in UK rivers. *The Science of The Total Environment*, **314-316**, 209-231.

Page, T., Beven, K. J., Freer, J. & Jenkins, A. (2003) Investigating the uncertainty in predicting responses to atmospheric deposition using the model of acidification of groundwater in catchments (MAGIC) within a generalised likelihood uncertainty estimation (GLUE) framework. *Water Air and Soil Pollution*, **142**, 71-94.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2003) The United Kingdom Acid Waters Monitoring Network Data Report for 2002-2003 (year 15). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Beaumont, W. R. C. (2002) Acid Waters Monitoring 2001 Report on Fish Studies. 1-14. Centre for Ecology & Hydrology, Dorset.

Beaumont, W. R. C. (2002) Acid Waters Monitoring 2001 Report on Fish Studies: Addendum. 1-8. Centre for Ecology & Hydrology, Dorset.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2002) The United Kingdom Acid Waters Monitoring Network Data Report for 2000-2001 (year 13). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Shilland, E. M., Monteith, D. T., Smith, J. & Beaumont, W. R. C. (2002) The United Kingdom Acid Waters Monitoring Network Data Report for 2001-2002 (year 14). Report to the Department for Environment, Food and Rural Affairs (Contract EPG 1/3/160) and the Department of the Environment Northern Ireland (Contract CON 4/4 (38)). 1-178. ENSIS Ltd, London.

Beaumont, W. R. C., McDonnell, N. (2001) Acid Waters Monitoring 2000 Report on Fish Studies. 1-18. Centre for Ecology & Hydrology, Dorset.

CLAM. (2001) Summary of Research under DETR Contract "Acidification of freshwaters: the role of nitrogen and the prospects for recovery", EPG1/3/117. Curtis, C. J. and Simpson, G. Research Report No. 79. Environmental Change Research Centre, University College London, London.

Evans, C. D., Cullen, J. M., Alewell, C., Kopacek, J., Marchetto, A., Moldan, F., Prechtel, A., Rogora, M., Vesely, J. & Wright, R. (2001) Recovery from acidification in European surface waters. *Hydrology and Earth System Sciences*, **5**, 283-297.

Evans, C. D., Monteith, D. T. (2001) Chemical trends at lakes and streams in the UK Acid Waters Monitoring Network, 1988-2000: Evidence for recent recovery at a national scale. *Hydrology and Earth System Sciences*, **5**, 351-366.

Hayman, G., Vincent, K., Hasler, S., Baker, S., Donovan, B., Smith, M., Sutton, M., Tang, Y. S., Dragosits, U., Love, L., Fowler, D., Sansom, L. & Page, H. (2001) Operation and Management of the UK Acid Deposition Monitoring Networks. 1-166. AEA Technology Plc, Culham, Oxon.

Hayman, G., Hasler, S., Vincent, K., Baker, S., Donovan, B., Smith, M., Davies, M., Sutton, M., Tang, Y. S., Dragosits, U., Love, L., Fowler, D., Sansom, L. & Page, H. (2001) Operation and Management of the UK Acid Deposition Monitoring Networks: Data Summary for 2000. 1-205. AEA Technology Plc, Culham, Oxon.

Jenkins, A., Cullen, J. M. (2001) An Assessment of the potential impact of the Gothenburg Protocol on surface water chemistry using the dynamic MAGIC model at acid sensitive sites in the UK. *Hydrology and Earth System Sciences*, **5**, 529-541.

Langan, S. J., Hodson, M. E., Bain, D. C., Hournung, M., Reynolds, B., Hall, J. R. & Johnston, L. (2001) The Role of Mineral Weathering Rate Determinations in Generating Uncertainties in the Calculation of Critical Loads of Acidity and their Exceedance. *Water, Air and Soil Pollution: Focus*, **1**, 299-312.

- Monteith, D. T., Evans, C. D. (2001) United Kingdom Acid Waters Monitoring Network. 1-24. Department of the Environment, Transport and the Regions, London.
- Monteith, D. T., Evans, C. D. & Patrick, S. (2001) Monitoring acid waters in the UK: 1988-1998 Trends. *Water Air and Soil Pollution*, **130**, 1307-1312.
- NEG-TAP. (2001) Transboundary Air Pollution: Acidification, Eutrophication and Ground-Level Ozone in the UK. 1-314. Department For Environment, Food and Rural Affairs (DEFRA), London.
- Wright, R. F., Alewell, C., Cullen, J. M., Evans, C. D., Marchetto, A., Moldan, F., Prechtel, A. & Rogora, M. (2001) Trends in nitrogen deposition and leaching in acid-sensitive streams in Europe. *Hydrology and Earth System Sciences*, **5**, 299-310.
- Beaumont, W. R. C., Ingram, A. (2000) Acid Waters Monitoring 1999 Report on Fish Studies. Centre for Ecology & Hydrology, Dorset.
- CLAM. (2000) Critical Loads of Acidity and Metals: Interim Report to the Department of Environment, Transport and the Regions (Contract no. EPG/1/3/117). Kernan, M. R. and Curtis, C. J. Research Report No. 64, 1-63. Environmental Change Research Centre, University College London, London.
- Hayman, G., Vincent, K., Hasler, S., Baker, S., Donovan, B., Smith, M., Sansom, L. & Page, H. (2000) Acid Deposition Monitoring in the UK: 1986 to 1998. 1-151. AEA Technology Plc, Culham, Oxon.
- Monteith, D. T., Evans, C. D. & Reynolds, B. (2000) Are temporal variations in the nitrate content of UK upland freshwaters linked to the North Atlantic Oscillation? *Hydrological Processes*, **14**, 1745-1749.
- Monteith, D. T., Evans, C. D. (2000) United Kingdom Acid Waters Monitoring Network 10 Year Report. Analysis and Interpretation of Results, April 1988 - March 1998. Monteith, D. T. and Evans, C. D. 1-364. ENSIS Ltd, London.
- Beaumont, W. R. C., Sturgess, P. & Pinder, A. (1999) Acid Waters Monitoring Report on Fish Studies 1988-1997. 1-129. Institute of Freshwater Ecology, Dorset.
- Beaumont, W. R. C., Sturgess, P. (1999) Acid Waters Monitoring 1998 Report on Fish Studies. 1-26. Institute of Freshwater Ecology, Dorset.
- Curtis, C. J., Murlis, J., Battarbee, R. W., Bull, K., Campbell, G., Fowler, D., Jenkins, A., Monteith, D. T., Ormerod, S. & Reynolds, B. (1999) Acid deposition in the UK: a review of environmental damage and recovery prospects. NSCA Occasional Paper No.1, 1-28. National Society for Clean Air and Environmental Protection, Brighton.
- Beaumont, W. R. C., Pinder, A. (1998) Acid Waters Monitoring 1997 Report on Fish Studies. 1-27. Centre for Ecology & Hydrology, Dorset.

- Helliwell, R. C., Ferrier, R. C. & Jenkins, A. (1998) A two-layer application of the MAGIC model to predict the effects of land use scenarios and reductions in deposition on acid sensitive soils in the UK. *Hydrology and Earth System Sciences*, **2**, 497-507.
- Jenkins, A., Helliwell, R. C., Swingewood, P. J., Sefton, C., Renshaw, M. & Ferrier, R. C. (1998) Will reduced sulphur emissions under the Second Sulphur Protocol lead to recovery of acid sensitive sites in UK? *Environmental Pollution*, **99**, 309-318.
- Monteith, D. T., Renshaw, M. & Patrick, S. T. (1998) Monitoring the long term chemical and biological response to changing sulphur and nitrogen emissions of sensitive waters, United Kingdom. *Headwaters: Water Resources and Soil Conservation* 111-125.
- Monteith, D. T., Evans, C. D., Beaumont, W. R. C. & Delinikajtis, C. (1998) The United Kingdom Acid Waters Monitoring Network Data Report for 1997-1998 (year 10). Report to the DETR and the DoE Northern Ireland. ENSIS Ltd, London.
- Beaumont, W. R. C., Bradley, D. C. (1997) Acid Waters Monitoring 1996 Report on Fish Studies. 1-36. Centre for Ecology & Hydrology, Dorset.
- Gee, J. H. R., Smith, B. D. (1997) Benthic invertebrates in the headwaters of the Wye and Severn: effects of forestry and clear-felling. *Hydrology and Earth System Sciences*, **1**, 549-556.
- Monteith, D. T., Renshaw, M., Evans, C. D. & Patrick, S. T. (1997) The United Kingdom Acid Waters Monitoring Network Data Report for 1996-1997 (year 9). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.
- Reynolds, B., Fowler, D., Smith, R. I. & Hall, J. R. (1997) Atmospheric inputs and catchment solute fluxes for major ions in five Welsh upland catchments. *Journal of Hydrology*, **194**, 305-329.
- Robertson, A. L., Lancaster, J., Belyea, L. R. & Hildrew, A. G. (1997) Hydraulic habitat and the assemblage structure of stream benthic microcrustacea. *Journal of the North American Benthological Society*, **16**, 562-575.
- Beaumont, W. R. C. (1996) Acid Waters Monitoring 1995 Report on Fish Studies. 1-25. Institute of Freshwater Ecology, Dorset.
- Campbell, G. W., Lee, D. S. (1996) Atmospheric deposition of sulphur and nitrogen species in the UK. *Freshwater Biology*, **36**, 151-167.
- Crisp, D. T., Beaumont, W. R. C. (1996) The trout (*Salmo trutta* L.) populations of the headwaters of the Rivers Severn and Wye, mid-Wales, UK. *The Science of The Total Environment*, **177**, 113-123.
- Forti, M. C., Neal, C. & Robson, A. J. (1996) Modelling the long-term changes in stream, soil and ground water chemistry for an acid moorland in the Welsh uplands: the

influence of variations in chemical weathering. *The Science of The Total Environment*, **180**, 187-200.

Jenkins, A., Boorman, D. & Renshaw, M. (1996) The UK acid waters monitoring network: An assessment of chemistry data, 1988-93. *Freshwater Biology*, **36**, 169-178.

Lancaster, J., Patrick, S. (1996) The UK acid waters monitoring network: A preface. *Freshwater Biology*, **36**, 129-130.

Lancaster, J., Real, M., Juggins, S., Monteith, D. T., Flower, R. J. & Beaumont, W. R. C. (1996) Monitoring temporal changes in the biology of acid waters. *Freshwater Biology*, **36**, 179-201.

Langan, S. J., Reynolds, B. & Bain, D. C. (1996) The calculation of base cation release from mineral weathering in soils derived from Palaeozoic greywackes and shales in upland UK. *Geoderma*, **69**, 275-285.

Monteith, D. T., Renshaw, M., Beaumont, W. R. C. & Patrick, S. T. (1996) The United Kingdom Acid Waters Monitoring Network Data Report for 1995-1996 (year 8). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Patrick, S., Battarbee, R. W. & Jenkins, A. (1996) Monitoring acid waters in the UK: An overview of the UK acid waters monitoring network and summary of the first interpretative exercise. *Freshwater Biology*, **36**, 131-150.

Sklash, M. G., Beven, K. J., Gilman, K. & Darling, W. G. (1996) Isotope studies of pipeflow at Plynlimon, Wales, UK. *Hydrological Processes*, **10**, 921-944.

Battarbee, R. W., Allott, T. E. H., Bull, K., Christie, A. E. G., Curtis, C. J., Flower, R. J., Hall, J. R., Harriman, R., Jenkins, A., Juggins, S., Kreiser, A. M., Metcalfe, S. E., Ormerod, S. J. & Patrick, S. T. (1995) Critical Loads of Acid Deposition for United Kingdom Freshwaters. Critical Loads Advisory Group. Sub group Report on Freshwaters. 1-80. Institute of Terrestrial Ecology (Edinburgh Research Station), Penicuik.

Beaumont, W. R. C. (1995) Acid Waters Monitoring 1994 Report on Fish Studies. 1-26. Institute of Freshwater Ecology, Dorset.

Jenkins, A. (1995) Freshwater Recovery and Future Trends. Battarbee, R. W. 61-67. ENSIS Ltd, London. Acid Rain and Its Impact: The Critical Loads Debate. 17-9-1993.

Monteith, D. T., Renshaw, M. & Beaumont, W. R. C. (1995) The United Kingdom Acid Waters Monitoring Network Data Report for 1994-1995 (year 7). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Patrick, S. T., Monteith, D. T. & Jenkins, A. (1995) UK Acid Waters Monitoring Network: The first five years. Analysis and interpretation of results, April 1988 - March 1993. 1-320. ENSIS Publishing, London.

Beaumont, W. R. C., Miles, L. (1994) Acid Waters Monitoring 1993 Report on Fish Studies. 1-42. Institute of Freshwater Ecology, Dorset.

Monteith, D. T., Renshaw, M., Beaumont, W. R. C. & Patrick, S. T. (1994) The United Kingdom Acid Waters Monitoring Network Data Report for 1993-1994 (year 6). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Beaumont, W. R. C. (1993) Acid Waters Monitoring 1992 Report on Fish Studies. 1-18. Institute of Freshwater Ecology, Dorset.

Juggins, S., Shaw, C., Patrick, S. T., Monteith, D. T., Beaumont, W. R. C. & Reed, J. (1993) The United Kingdom Acid Waters Monitoring Network Data Report for 1992-1993 (year 5). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Lancaster, J., Hildrew, A. G. (1993) Characterizing In-Stream Flow Refugia. *Canadian Journal of Fisheries and Aquatic Sciences*, **50**, 1663-1675.

Rose, N. L. (1-1-1993) An Assessment of the Potential of the United Kingdom Acid Waters Monitoring Network to Monitor the Impact of Atmospheric Trace metals and Persistent Organic Compounds on Freshwaters. 1-87. Environmental Change Research Centre, University College London, London. Research Papers No 9.

Beaumont, W. R. C. (1992) Acid Waters Monitoring 1991 Report on Fish Studies. 1-16. Institute of Freshwater Ecology, Dorset.

Beven, K., Binley, A. (1992) The Future of Distributed Models - Model Calibration and Uncertainty Prediction. *Hydrological Processes*, **6**, 279-298.

Juggins, S., Shaw, C., Patrick, S. T., Monteith, D. T., Beaumont, W. R. C. & Reed, J. (1992) The United Kingdom Acid Waters Monitoring Network Data Report for 1991-1992 (year 4). Report to the DoE and the DoE Northern Ireland. ENSIS Ltd, London.

Neal, C., Robson, A., Reynolds, B. & Jenkins, A. (1992) Prediction of Future Short-Term Stream Chemistry - A Modeling Approach. *Journal of Hydrology*, **130**, 87-103.

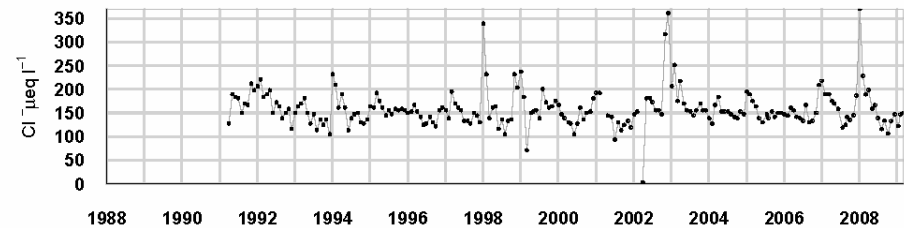
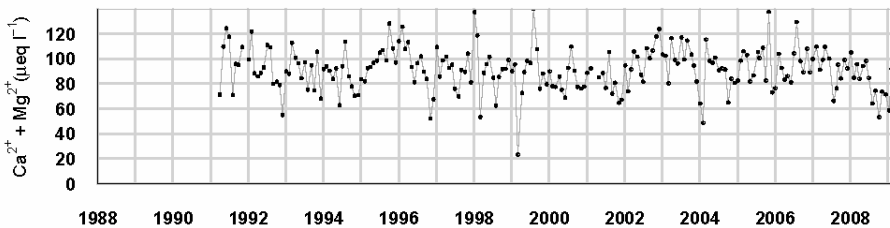
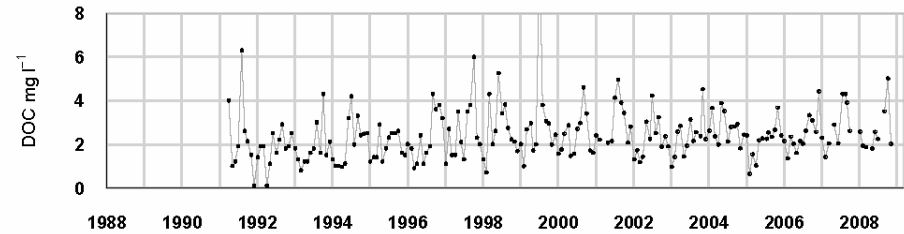
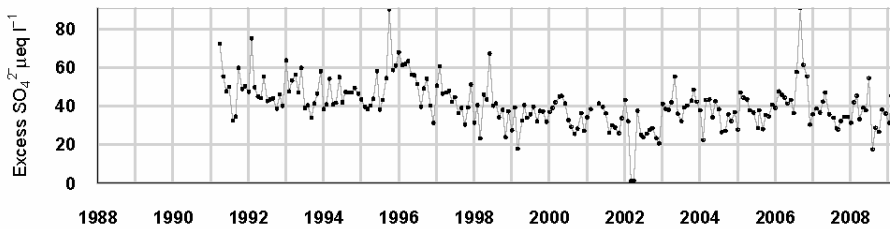
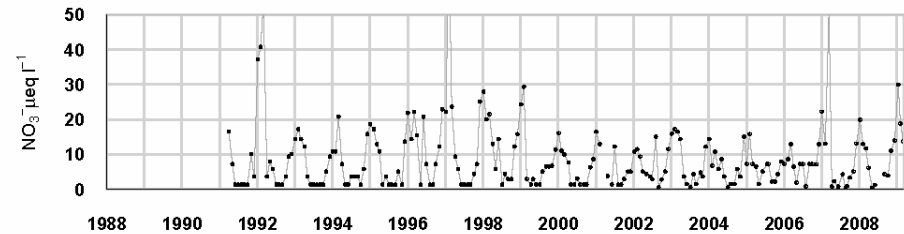
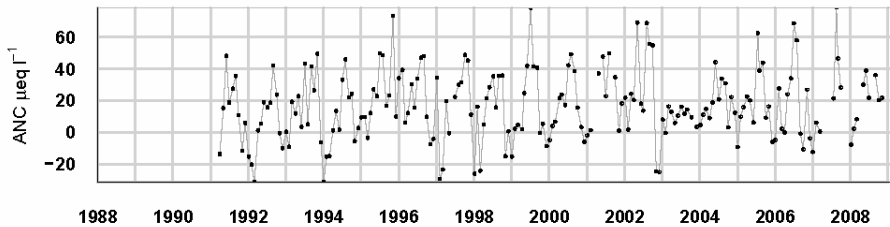
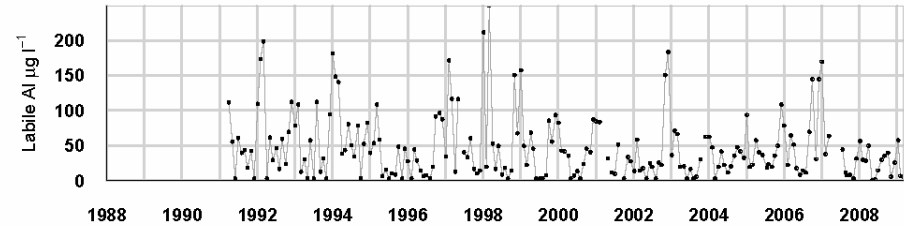
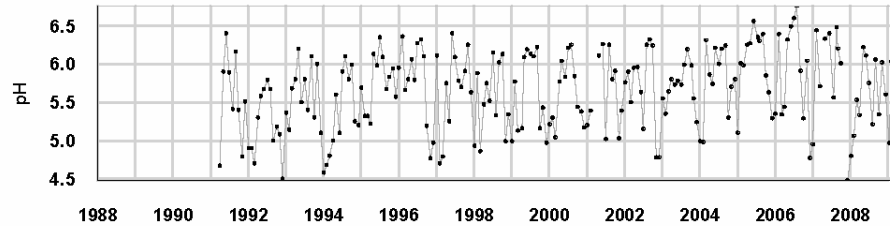
Juggins, S., Waters, D., Patrick, S. T. & Beaumont, W. R. C. (1991) The United Kingdom Acid Waters Monitoring Network Data Report for 1990-1991 (year 3). Report to the DoE and the DoE Northern Ireland. 1-124. ENSIS Ltd, London.

Patrick, S. T., Waters, D., Juggins, S. & Jenkins, A. (1991) The United Kingdom Acid Waters Monitoring Network. Site descriptions and methodology report. 1-63. ENSIS Ltd, London.

Juggins, S., Waters, D., Patrick, S. T., Jenkins, A. & Beaumont, W. R. C. (1990) The United Kingdom Acid Waters Monitoring Network Data Report for 1989-1990 (year 2). Report to the DoE. 1-101. ENSIS Ltd, London.

5.10 Afon Gwy Summary Data to March 2008

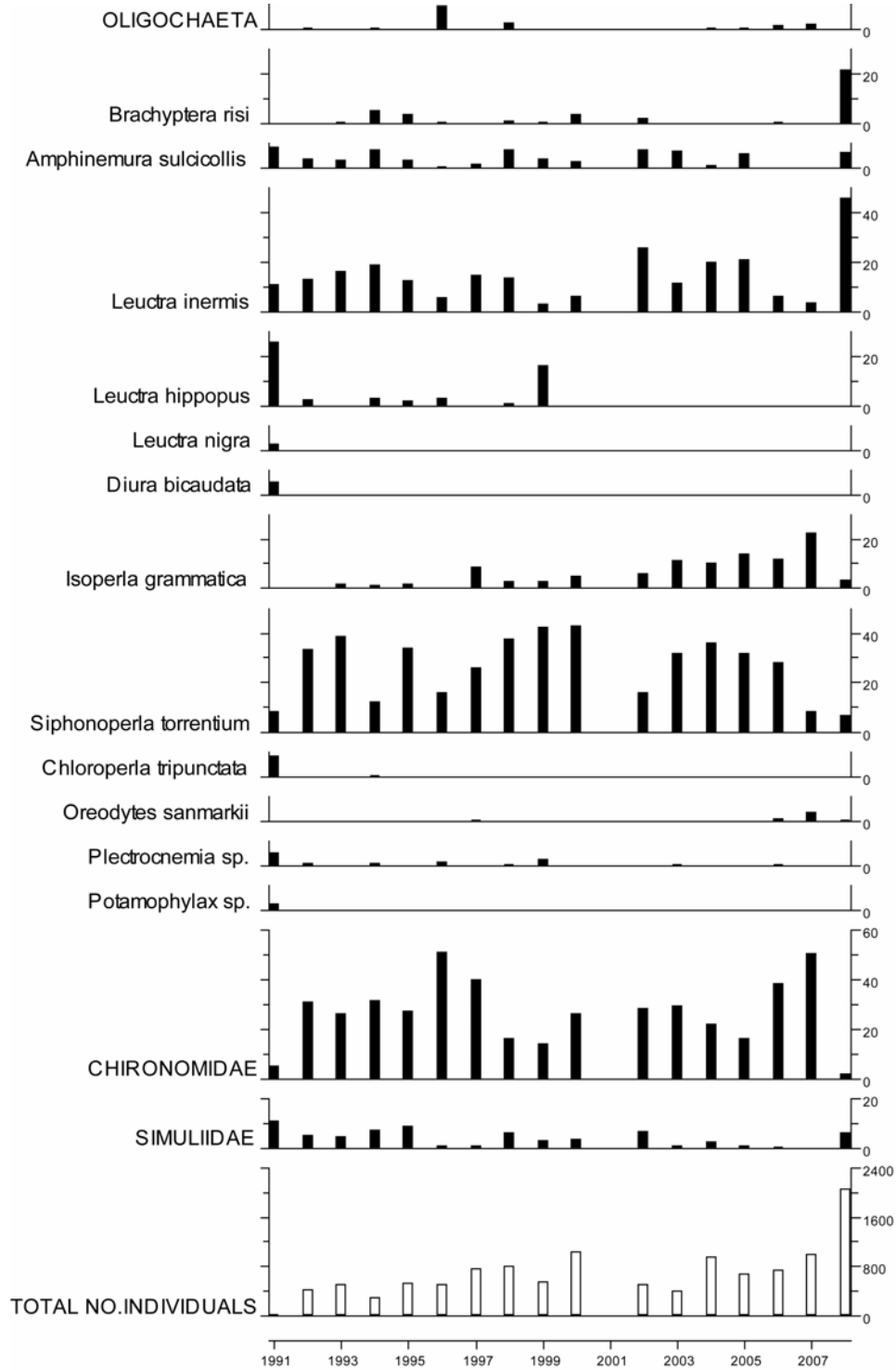
5.10.1 Spot sampled chemistry data



$\mu\text{eq l}^{-1}$, * $\mu\text{g l}^{-1}$, ** 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 1 st 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
08-09 mean	5.73	27.96	30.44	47.70	135.29	2.99	57.83	22.08	142.51	51.09	36.14	10.27	2.85
08-09 std dev	0.42	8.07	7.24	8.21	23.15	1.76	46.08	19.76	24.60	11.18	10.00	9.17	1.21

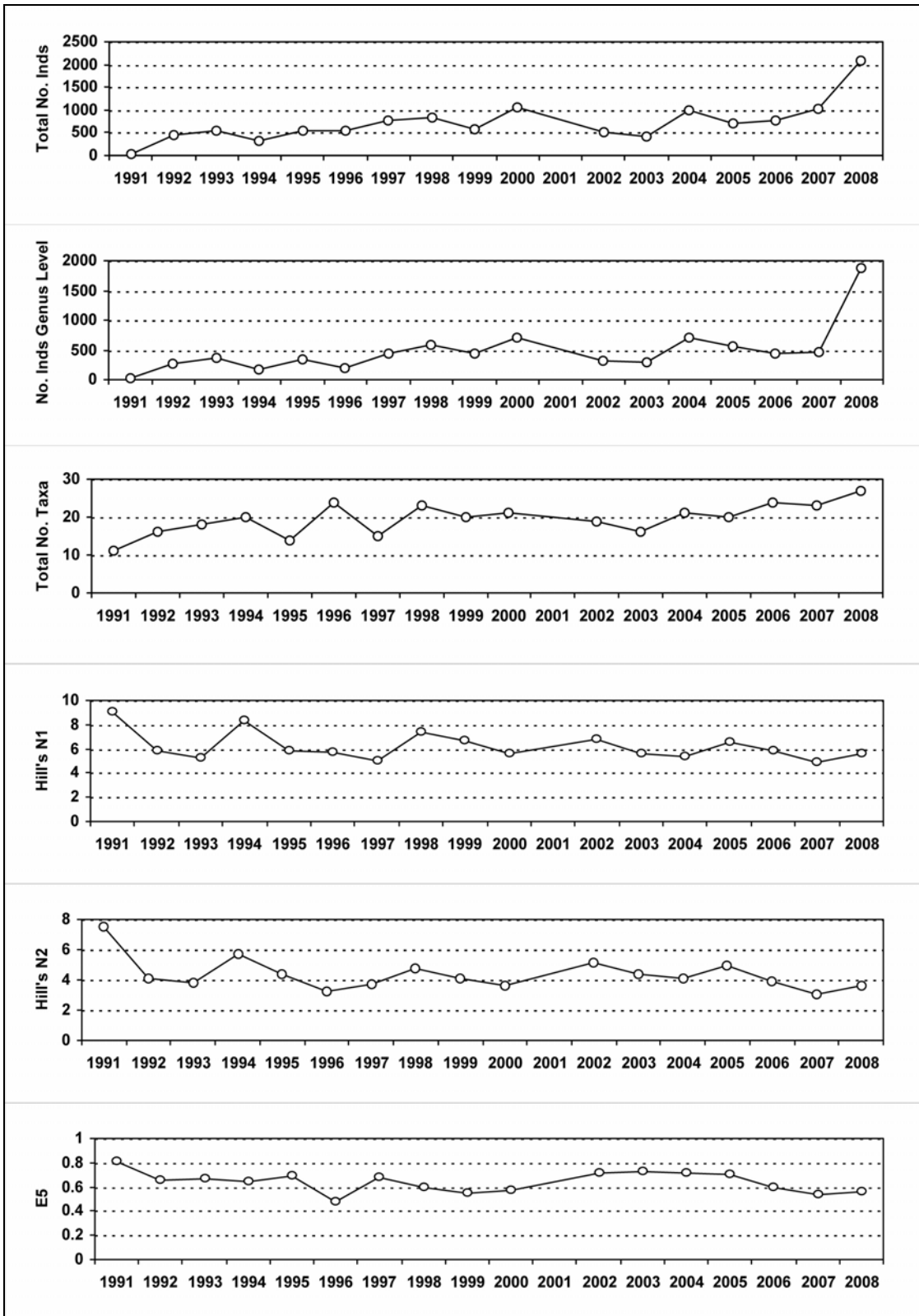
5.10.2 Macroinvertebrate data

5.10.2.1 Percentage abundance summary, Afon Gwy



No sampling in 2001 due to Foot and Mouth restrictions.

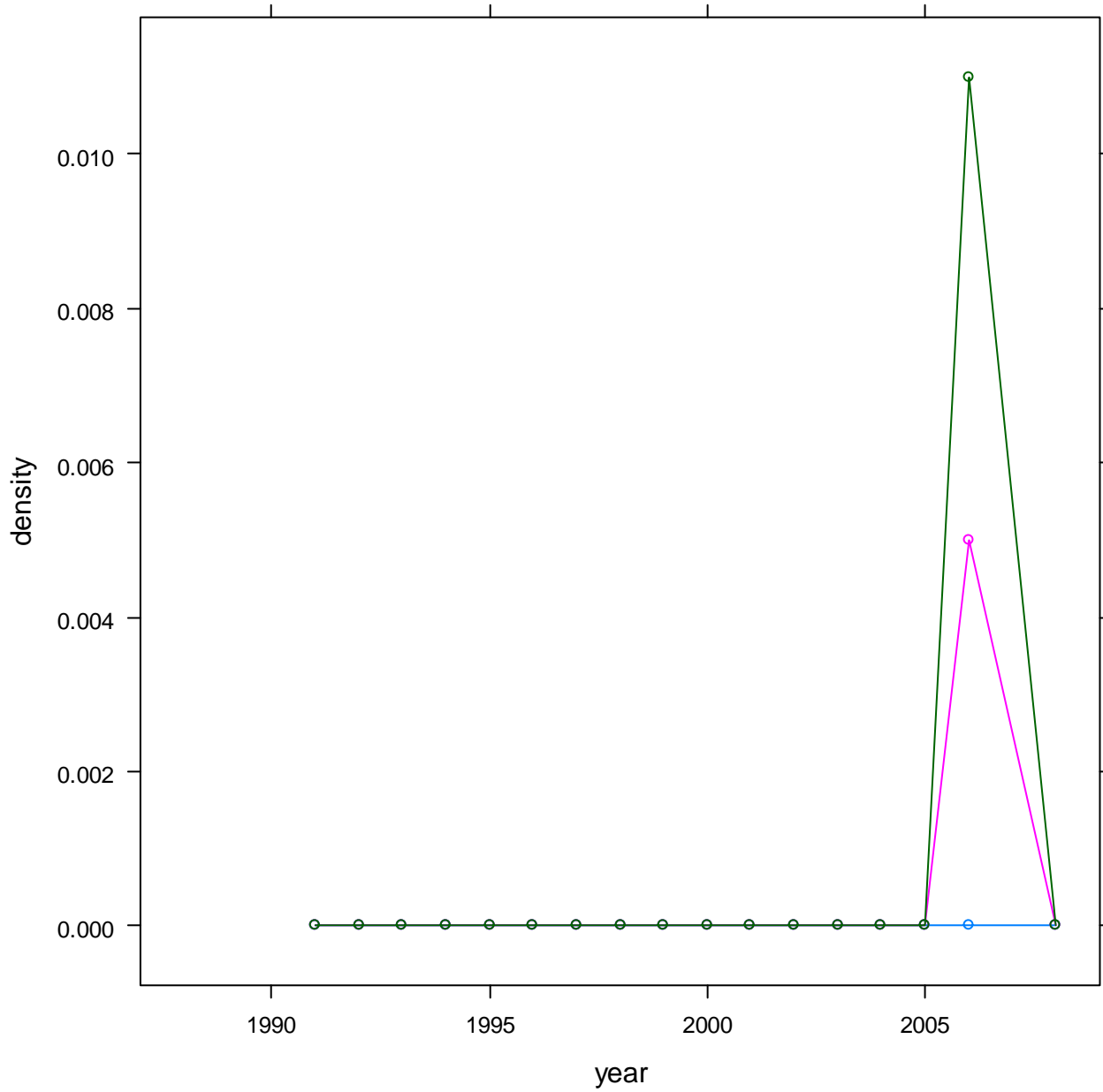
5.10.2.1 Macroinvertebrate summary statistics, Afon Gwy



No sampling in 2001 due to Foot and Mouth restrictions.

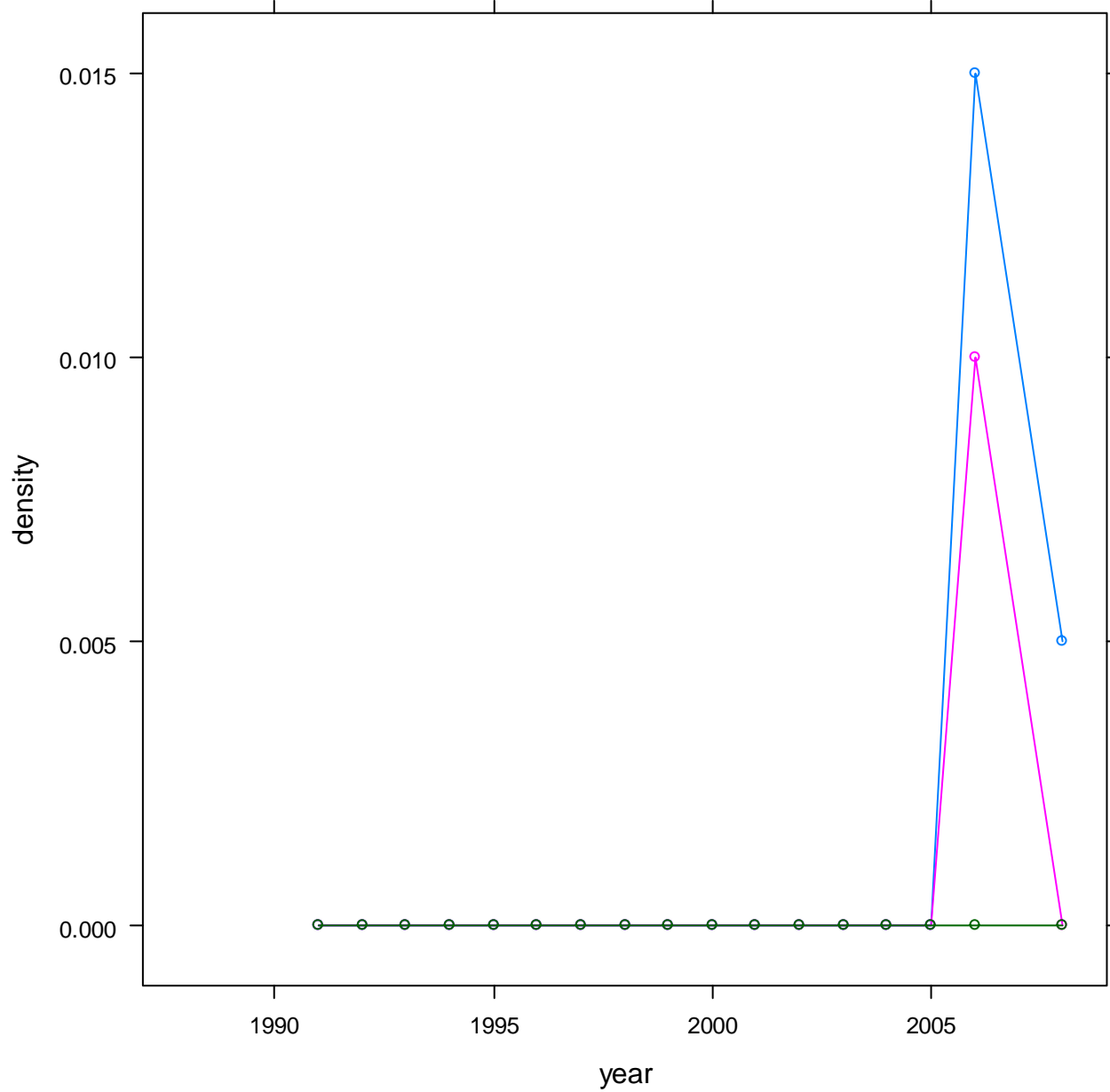
5.10.3 Fish data

5.10.3.1 Summary of Salmon fry densities (numbers m⁻²), Afon Gwy



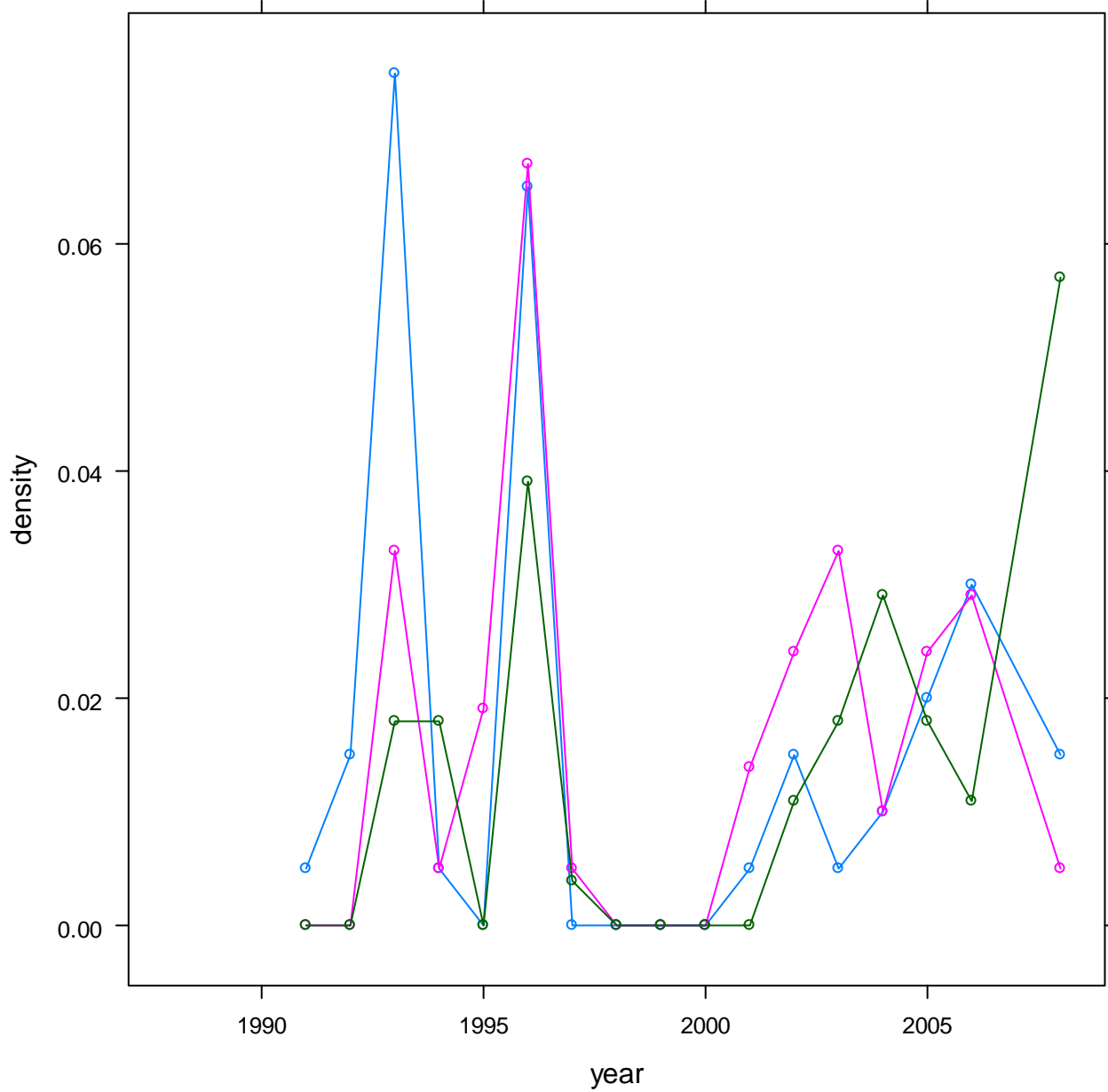
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

5.10.3.2 Summary of Salmon parr densities (numbers m⁻²), Afon Gwy



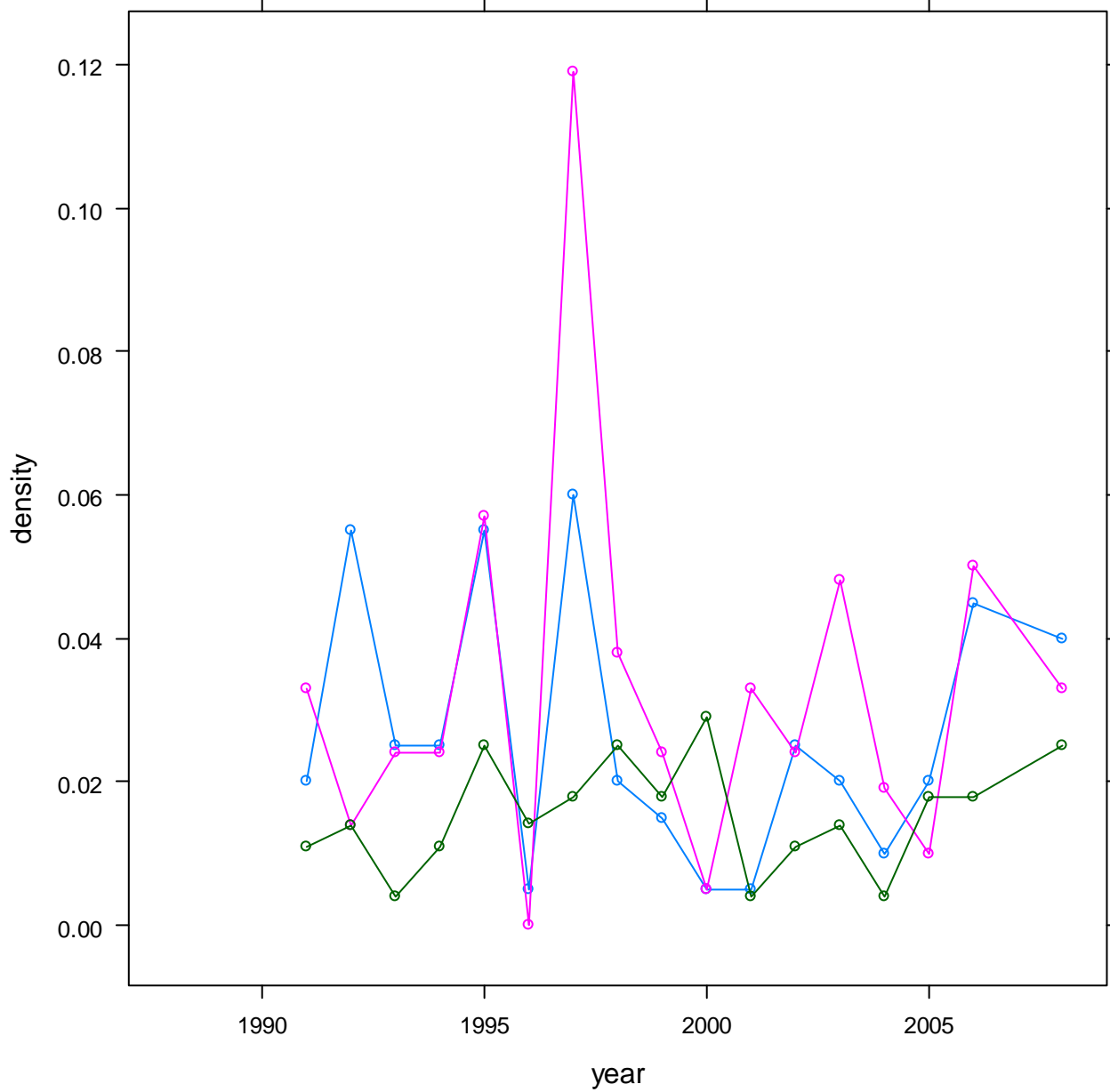
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

5.10.3.3 Summary of Trout fry density (numbers m⁻²), Afon Gwy



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

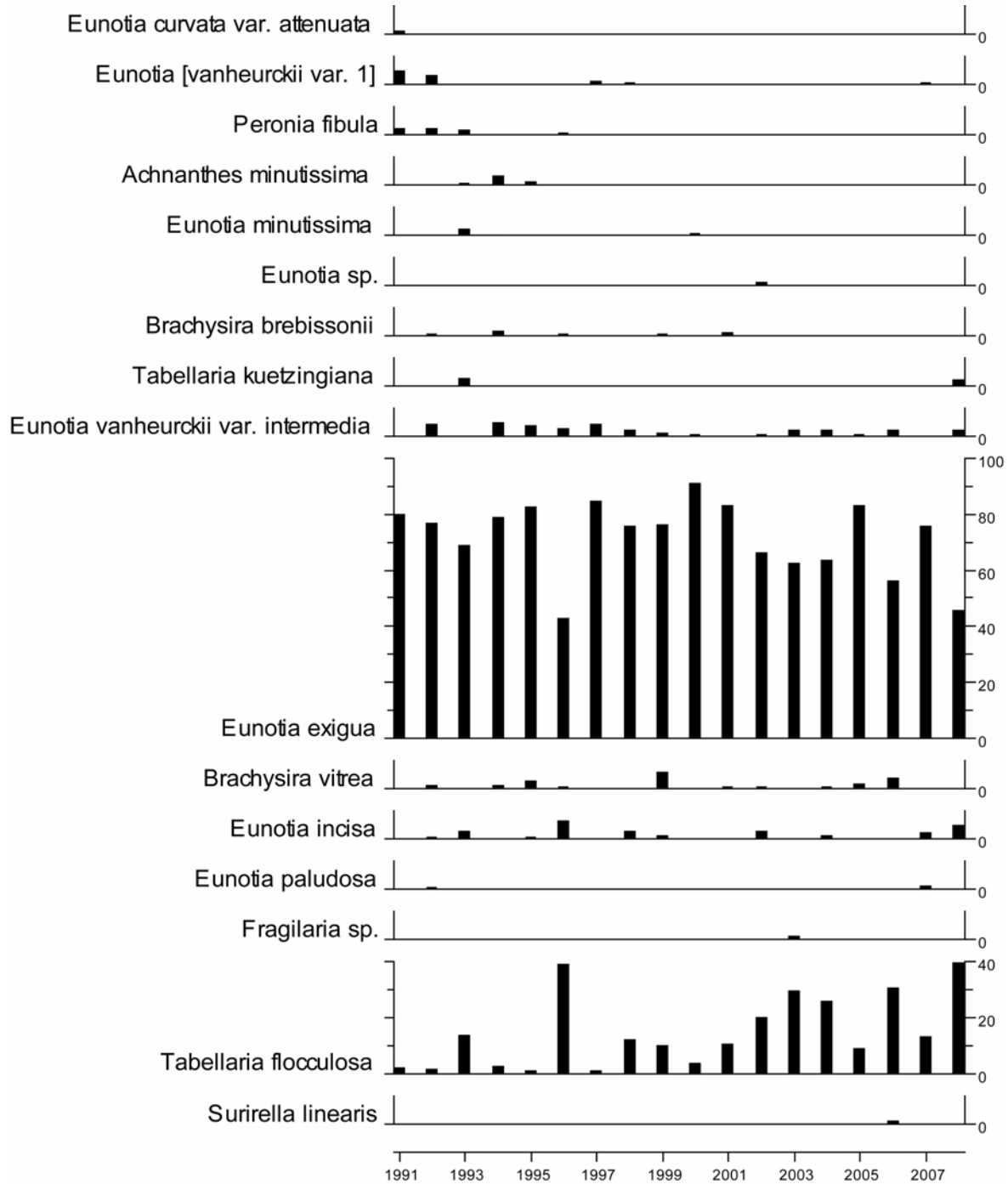
5.10.3.4 Summary of Trout parr density (numbers m⁻²), Afon Gwy



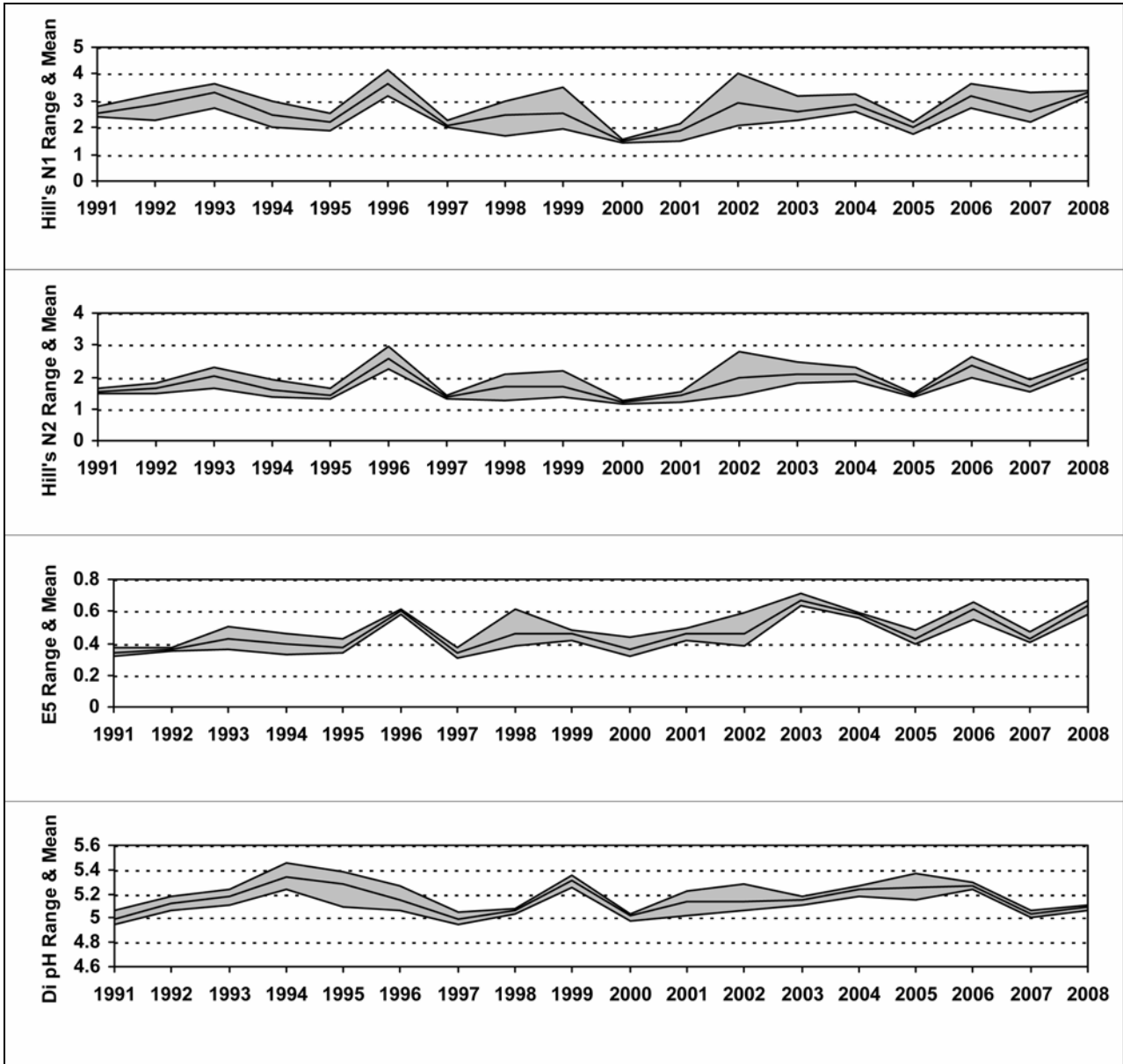
Blue series = Reach 1
Pink series = Reach 2
Green series = Reach 3

5.10.4 Epilithic diatom data

5.10.4.1 Percentage abundance summary, Afon Gwy

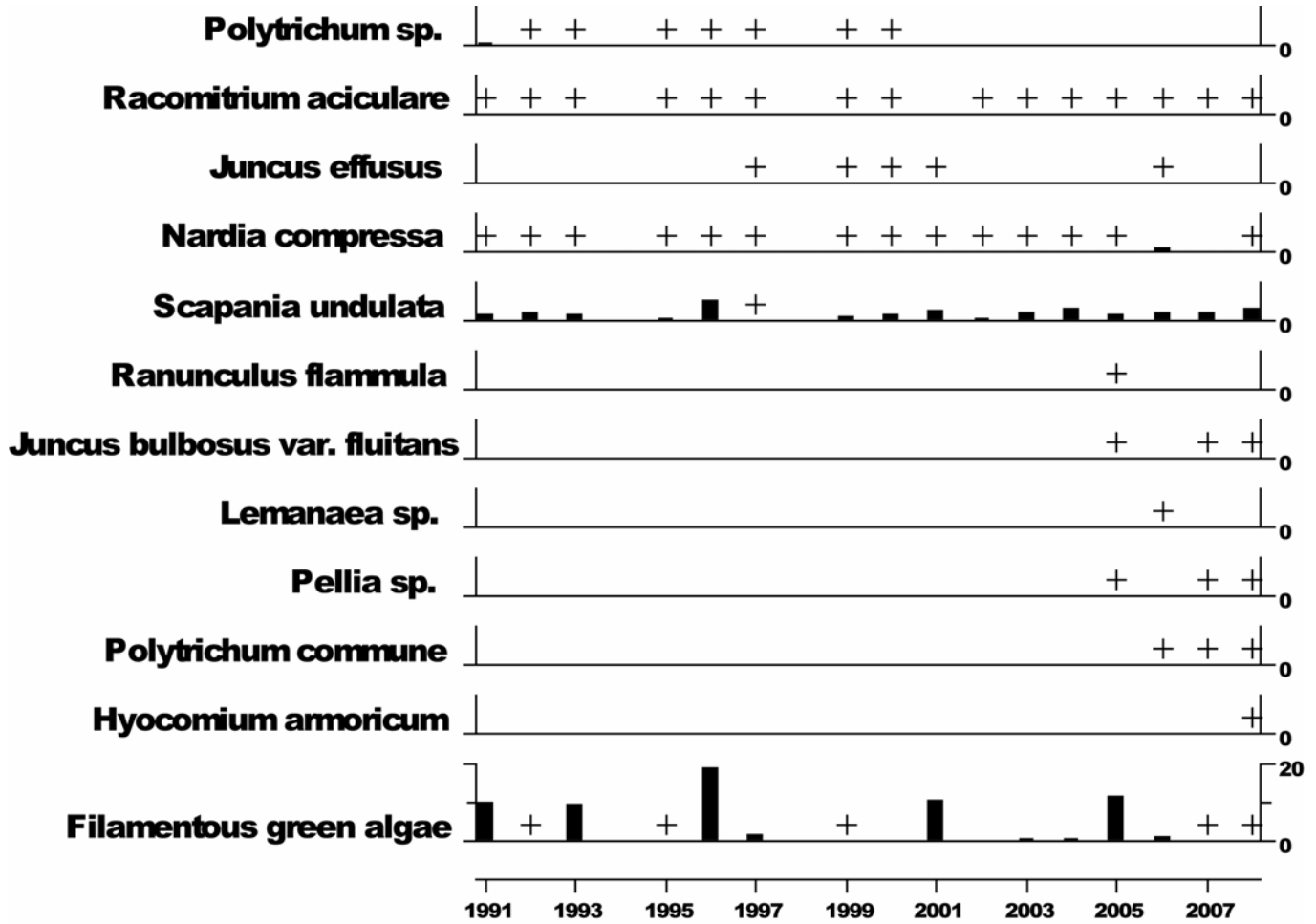


5.10.4.2 Diatom summary statistics, Afon Gwy



5.10.5 Aquatic macrophyte data, Afon Gwy

Percentage Species Cover



+ Represents <1% abundance