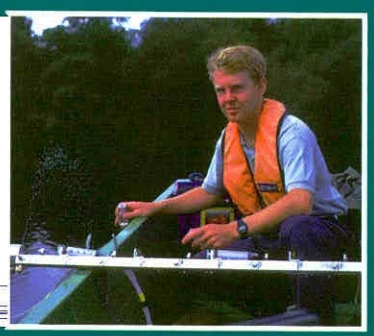


Institute of Freshwater Ecology

Scientific Report 1997-98

Centre for Ecology and Hydrology

Natural Environment Research Council

Institute of Freshwater Ecology Mission Statement

The Institute's mission is:-

"To conduct research of the highest quality and to develop integrated theory for the science of fresh and estuarine waters. This research will be conducted at the species, population, community and ecosystem levels and will include investigations of the genetic, physiological and behavioural mechanisms by which organisms interact with their environment. Research will also be undertaken into the biological, chemical and physical components and processes which control aquatic ecosystems, especially the mechanisms of response to natural and anthropogenic change. The Institute will study the dynamics of interactions between terrestrial and freshwater ecosystems, and the control of the chemical composition and physical structure of water bodies and their retention and transport of soluble and particulate material. The information gained will be used to develop strategies for the sustainable management, conservation and exploitation of freshwater systems at national and global levels.

The Institute will also collect, validate and manage relevant environmental data in the furtherance of its research programme and will act as an international resource of expertise and information. It will continue to develop its programme for long-term, multidisciplinary research, undertake commissioned research on behalf of its customer base, provide training of the highest quality and maintain its international reputation. The Institute of Freshwater Ecology will collaborate with the component Institutes of the Centre for Ecology and Hydrology, the Freshwater Biological Association and other organisations to ensure achievement of these aims."

Front Cover Illustrations:

Large photograph - *Algal bloom on Lake Windermere.*

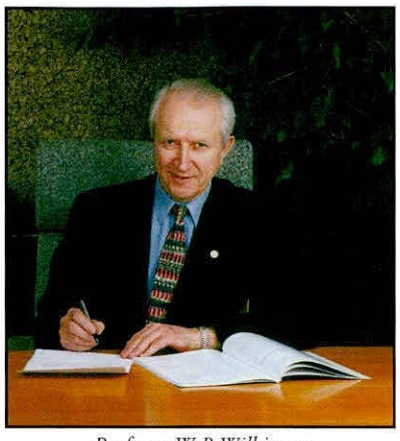
Small photographs
- *Discharge of industrial airfill at low and high levels.*
- Cladophora, *blanket weed around Windermere which has greatly reduced since 1992.*
- *Multiple-syringe sampler on Priest Pot used to collect water from close depth intervals.*
- *Weed cutting on the River Frome, Dorset.*

Report of the Institute of Freshwater Ecology 1997-98

Centre for Ecology and Hydrology

Natural Environment Research Council

FOREWORD



Professor W B Wilkinson
Director.

The environmental agenda has shown no diminution during the year. Issues such as deforestation, dryland degradation and climate change persist. Natural disasters, resulting from flood, drought and forest fires, have caused disruption to the lives of millions of people and many deaths worldwide. Man-made disasters, resulting from pollution or other causes, are all too evident.

Internationally, there is a growing political will to address such problems. The United Nations Framework Convention on Climate Change, aimed at stabilisation of greenhouse gases in the atmosphere, has taken its first historic steps towards achieving this goal through the 1997 Kyoto Protocol. Nationally, with a change in Government, we have seen environmental issues move up the agenda. The Right Honourable Michael Meacher, MP, Minister for the Environment, in presenting the 1998 NERC Lecture, showed both his personal and the Government's commitment towards sustainable management.

To address such issues a multi-disciplinary approach is needed and CEH, with one of the strongest capabilities in the world for undertaking holistic research in the terrestrial and freshwater sciences, is well placed in this respect.

The NERC Council places a high value on our science and has shown a willingness to invest in the future of CEH through a programme of rationalisation and restructuring. The first step has been to approve a £2.86 million extension to CEH's Wallingford site. I am confidant that investments at other CEH sites, rising from the package approved by Council last year as part of the so-called 'Prior Options' Review, will be made during the coming years.

The impact of the rationalisation and restructuring activity has caused some uncertainty amongst staff during the year. However, our staff are highly skilled, innovative and well motivated, and it is to their credit that, during these uncertain times, they have not only maintained scientific output but increased it in some areas. For example, CEH peer review publications have increased by 21% this year over last.

Under the leadership of its Director, Professor Alan Pickering, CEH's **Institute of Freshwater Ecology** has had an excellent year. During the year, the Institute has contributed fully to the Centre's 10 Science Programmes and has joint research projects in place with all of the other CEH Institutes. Moreover, the continued success of IFE scientists in leading multinational research programmes funded by the European Commission underlines the competence of the staff and the reputation of the Institute of Freshwater Ecology for science of the highest quality. Descriptions of these scientific activities are presented in this report.

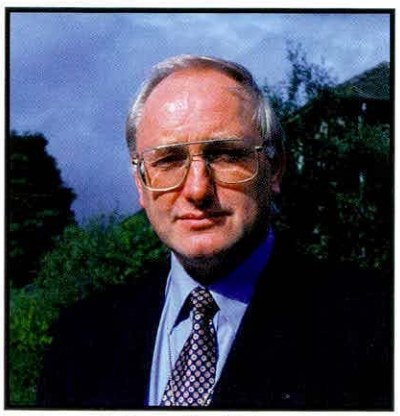
This year's annual reporting follows the arrangement established last year, whereby the CEH Annual Report provides an overview of our scientific progress and principal achievements, while the Scientific Reports of the Centre's component Institutes:

The Institute of Freshwater Ecology
The Institute of Hydrology
The Institute of Terrestrial Ecology
The Institute of Virology and Environmental Microbiology

present more detailed reviews of the science. I commend this Scientific Report from the Institute of Freshwater Ecology to you, together with the overview CEH Annual Report and the complementary reports from the other CEH Institutes.

Contents

Director's Introduction



Professor Alan Pickering
Director.

Continued success in leading European consortia for EU funding has enhanced the growing reputation of the IFE for scientific leadership and sound project management.

The structure of the 1997/98 Annual Report follows the pattern established last year for all CEH Institutes. Annual Scientific Reports will cover the research carried out by each Institute whereas the CEH Annual Report will focus on some of the more generic issues of strategic planning and future developments in environmental science, management, performance and review. The Institute of Freshwater Ecology's Annual Scientific Report summarises some of the scientific achievements during a year which has witnessed ongoing changes to the way in which NERC manages its overall research portfolio. It is to the credit of the IFE staff they they have maintained a clear focus on their scientific objectives yet, at the same time, have generated an increased Commissioned Research income over recent years to complement the NERC-funded research programme. 1997/98 saw continued success in leading European consortia for EU funding and has enhanced the growing reputation of the IFE for scientific leadership and sound project management. The Institute is now actively involved in ten major EU-funded programmes and is Co-ordinator of several of these.

The CEH Science Programme (formerly the Core Strategic Programme) is now well-established and forms the framework for increasing cross-Institute collaboration. This has been supported by an expansion of the CEH Integrating Fund and we are now beginning to see the fruition of some of the projects started three years ago. In total, the IFE is actively collaborating with the other CEH Institutes in 28 research projects. The IFE Annual Scientific Report is structured around the CEH Science Programme and this year we report on scientific advances in six of the ten Programme Areas. Long-term environmental monitoring is firmly established as an appropriate activity for the NERC Centres and Surveys and the IFE plays an important role in this respect. With additional support from NERC the Institute has, for the first time, been able to begin the process of integration of its many data sets with those of the Freshwater Biological Association and arrange for their curation in an appropriate digital format. However, data curation in isolation of the science is a sterile activity but this Annual Scientific Report demonstrates the unique value of such datasets. They enable us to formulate the relevant hypotheses for subsequent testing, to identify the key processes governing ecological systems, to develop and validate process-based computer models for scientific research and to use these models to assist with decision making for environmental managers. Freshwater ecology has moved from a descriptive science to one of prediction, based on the best science available. The Annual Scientific Report illustrates this theme in several areas of activity and underlines the synergy of a multidisciplinary approach to the understanding and management of complex environmental problems.

It is inevitable that much of the IFE's research effort is focused on water resource issues, both quality and quantity. *In Programme 4 – Freshwater Resources* we show how much care and knowledge is needed in the correct interpretation of long-term data. The peak bloom of a common Spring diatom in certain Cumbrian lakes is demonstrably earlier now than it was 50 years ago but the explanation lies not in the associated long-term increase in Spring temperatures but in changes of nutrient availability. What might have

been interpreted as evidence of global warming is, in fact, a response to local factors increasing nutrient levels within the lakes. The latest developments in processed-based algal water quality modelling, resulting in a version of the IFE's PROTECH model based on carbon metabolism, has the capability to predict the type of changes we have seen through long-term monitoring. We are now in a position to predict, with an increasing degree of confidence, the growth patterns for a range of algal groups, given different, future, environmental scenarios.

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Fish are important freshwater resources and we have made significant progress in our understanding of their population control and habitat requirements. Density-dependent factors are shown to operate during spawning for a population of brown trout which, unusually, does not exhibit density-dependent population control during the juvenile stages. Density-dependence results from the interplay between fish behaviour and their habitat requirements. From a radio-tagging exercise of a non-salmonid species, we are now beginning to appreciate the real habitat requirements of fish – these can involve parts of the environment which are, for most parts of the year, terrestrial! A new Integrating Fund study with the Institute of Hydrology will extend our knowledge of the links between habitat availability and river flow. Whilst our understanding of population control and habitat requirement is improving in some areas, there are still major uncertainties surrounding the national decline in salmon stocks. The development and validation of automated smolt counting facilities on the River Frome provides the infrastructure for a serious study of the overall freshwater survival of one of the few natural salmon populations in the south of the country. It is imperative that these unique facilities are retained during any future rationalisation and restructuring programme. Fish produced through aquaculture are also important freshwater resources. However, the stress of confinement and handling, together with less than ideal water quality, can predispose such fish to disease. The IFE has made a major contribution to validating a new anti-fungal treatment for such fish, a treatment which does not have the adverse environmental and health concerns of previous treatments.

In *Programme 5 – Biodiversity and Population Processes* we are challenging the hypothesis, for free-living microbes at least, that there is global ubiquity with no endemism. To date we have been unable to disprove the hypothesis, thereby raising major questions regarding the concepts of biodiversity and sustainable development as currently applied to microorganisms. Intensive studies on a well-characterised, small water body dominated by microbial processes have shown that observed microbial biodiversity is a function of niche availability and the application of molecular techniques for microbial identification reveals the complexity of such microbial communities. This theme is also apparent in a comparison of the phytoplankton of a large, relatively stable, African lake compared with a much smaller, capricious, Scottish loch. More numerous in fresh waters than bacteria, free virus particles can be identified by electron microscopy. We have exploited the recent availability of high performance fluorochromes to develop a light microscope technique capable of enumerating free virus particles in natural water samples. This technology will form the basis of a systematic study of virus numbers in different types of fresh waters.

In contrast to the microbial situation, when considering larger plant and animals geographical isolation and

endemism become prominent features. This is important in our work on the conservation of the UK's last two remaining populations of the vendace, a small, glacial relict fish. Deteriorating water quality and competition from introduced species is a threat to survival at one site and, therefore, a reintroduction programme to Scottish sites has been implemented, as a measure to conserve the genetic stock.

The IFE input into *Programme 6 – Control of Pests and Diseases* is relatively small but includes an important study on invasive aquatic plants. Bankside and aquatic 'weeds' have, over recent years, presented major problems to riparian managers. For example, the current costs of implementing a mangement control strategy for the Australian Swamp Stonecrop (which is predicted to colonise over 1000 sites in the UK by the millenium) is estimated as some £3 million. It is important to identifiy such problems *before* extensive invasion has occurred – this requires knowledge of the basic biology of potentially invasive species, including their means of propagation, to ensure that management practices are based on the best science.

The value of long-term environmental monitoring is exemplified in a study within *Programme Area 7 – Pollution Assessment and Control*, which shows how acidification problems in Cumbria have ameliorated over recent years. However, the recovery of surface waters is delayed by at least a decade when compared with the rainwater chemistry. The most likely explanation is the retention of sulphate in the catchments and the time taken for its ultimate release. In a collaborative study with the Institute of Terrestrial Ecology, we have identified a common process responsible for the control of radiocaesium in both terrestrial and freshwater systems following the Chernobyl accident. Based on studies from eleven different European countries, we conclude that slow immobilisation by clay minerals in the soils controls the activity of this nuclide on a catchment-wide basis. The generic nature of this conclusion will have important consequences for future planning in the event of this type of accident.

Contamination of river sediments by micro-organic pollutants are shown to have significant effects on the invertebrates inhabiting this part of the ecosystem. Moreover, the suspended sediments are generally more contaminated than the river-bottom sediments, an observation which brings into scrutiny the way in which river water is normally analysed for such pollutants. Major organic contamination of groundwaters has been studied in a collaborative project focused on the impact of a coal-tar processing plant. Detoxifying microbial activity (phenol degradation) decreases with increasing levels of contamination but, even at very high pollutant levels, some culturable bacteria can be isolated. This demonstrates the extraordinary adaptability of the microbial community under such extreme conditions and could be used to support the argument from our work under *Programme 5* that if a niche exists, a suitable microbe(s) will be present to exploit it!

In previous IFE Annual Reports we have highlighted the importance of the latitudinal position of the Gulf Stream in determining the intensity of lake stratification during the Spring and early Summer, with consequent effects for lake biology. Under *Programme 9 – Global Change* we are now beginning to elucidate the effect of another climatic variable, the North Atlantic Oscillation (NAO), which influences lake temperatures during the Winter. The impact of this on two contrasting

The value of long-term environmental monitoring is exemplified in a study which shows how acidification problems in Cumbria have ameliorated over recent years.

species of zooplankton is demonstrated. The future challenge will be to model the interaction between the Gulf Stream and NAO effects on lake biology, a challenge which is being tackled by a new EU-funded programme REFLECT.

The background to REFLECT is reported under *Programe 10 – Integrating Generic Science*, in which the theme of environmental monitoring is maintained. The application of Automatic Water Quality Monitoring Stations for continuous, high resolution recording shows how single weather events can markedy alter the thermal structure of a lake over a 24 h period. The use of such technology allows the rapid accumulation of large amounts of environmental data, data which require validation, curation and easy access. The establishment of an IFE Data Centre is a new innovation which will permit the joint curation of the IFE and FBA data sets within the overall framework of the NERC Data Policy and the CEH Designated Data Centres. Analysis of just one component of these data, the National Database for the Macroinvertebrate Fauna of British Rivers, reveals three species of mayfly new to Great Britain during the last 10 years. This type of analysis will become more important if, as predicted, global climate change continues during the next century.

The establishment of an IFE Data Centre is a new innovation which will permit the joint curation of the IFE and FBA data sets within the overall framework of the NERC Data Policy and the CEH Designated Data Centres.

Having highlighted some of the *scientific* achievements of the Institute of Freshwater Ecology, the Director's Introduction for 1997/98 would not be complete without some reference to the CEH Rationalisation and Restructuring Programme and its potential impact on the IFE. In September 1997, NERC approved, in principle, a CEH proposal to merge the River Laboratory of the IFE and the Furzebrook Research Station of ITE on a new site in Dorset and to explore the feasibility of merging the Merlewood Laboratory of ITE with the IFE and FBA, on the Windermere site. The rationale for the restructuring was to enhance scientific synergy and to provide high quality research facilities for the future. These proposed moves are part of a larger programme of restructuring within CEH and have the full endorsement of the FBA. At the time of writing this Introduction I am not in a position to provide details of progress, suffice it to say that staff have been briefed following each significant planning meeting and that NERC are currently considering a costed proposal to proceed with the Dorset merger, commencing in 1998/99. However, it is important to recognise that throughout this process, senior management have concentrated on two key issues; the benefit to environmental science, and the welfare of the staff. Further development of the plans for Cumbria will require approval and financial support from NERC but staff should look upon the exercise as an opportunity to develop and consolidate environmental research in the UK. Whilst media attention is focused on the Millenium, we are planning for the next 25 years and more!

In summary, the 1997/98 Annual Scientific report of the Institute of Freshwater Ecology celebrates the scientific achievements of a vibrant and active research organisation with a bright future within the NERC-funded CEH family of research Institutes. The focus of this year's Report on the theme of environmental monitoring has shown how the data so produced are converted into knowledge and scientific understanding for the sustainable management of freshwater resources, both in the UK and abroad.

The Relationship between the Institute of Freshwater Ecology and the Freshwater Biological Association

Directors' Introduction

Both organisations are committed to working together on scientific problems of mutual interest.

This year has witnessed the conclusion of negotiations towards a formal Agreement between the NERC (as represented by the IFE) and the FBA, clarifying the relative roles and responsibilities of each organisation. This Agreement has the full support of both Directors and is essential for the smooth management of the two organisations, co-located both in Cumbria and in Dorset. In principle, the IFE will undertake formal responsibility for site management and for the provision of well-found laboratory facilities for both organisations. The FBA will maintain responsibility for providing appropriate services to its members and for running its research programme within the overall NERC framework. The joint data holdings, collections and library stock will be managed by the IFE on behalf of both organisations, without affecting ownership. An Advisory Committee, with representation from both organisations, will support these activities and will endeavour to identify new opportunities for further development of these important resources. Both Directors welcome these new arrangements and look forward to thier implementation during the coming year.

Professor A D Pickering

IFE

The IFE and FBA have also worked closely on the CEH plans for implementing the NERC Rationalisation and Restructuring Programme. If approved by NERC, the merger of the IFE River Laboratory with ITE Furzebrook on a new site in Dorset will provide an opportunity for scientific synergy and new facilities for the FBA as well as the NERC Institutes. The retention of the unique experimental facilities on the River Frome are an integral component of these plans, ensuring that the interests of freshwater science are best served. The plans for merger of ITE Merlewood with the IFE and FBA on the Windermere site are less well-developed but do involve extensive collaboration between all three parties.

This exercise has demonstrated the strength of the unique relationship between the IFE and FBA and places both organisations in a strong position to cope with future change that includes the appointment of a new Chief Executive of the FBA. Both organisations look forward to developing complementary research programmes and to working together on scientific problems of mutual interest. We are confident that the new Chief Executive of the FBA will play a full and active role in this process.

Professor C S Reynolds

FBA

The Science Programme of CEH provides a base that underpins national and international requirements in the terrestrial and freshwater sciences. The Programme is wide-ranging and is divided into 10 component Programmes, all of which address issues of current environmental relevance and important scientific challenges. The Programme as a whole involves extensive collaboration with academic organisations throughout the world and with international research programmes.

CEH Science Programme

1: Soils and Soil–Vegetation Interactions

This programme is designed to improve our understanding and ability to model key soil processes controlling the transformations of materials within soils and the flux of water through the soil–vegetation–atmosphere continuum.

2: Land Use Science

This is aimed at promoting an integrated approach to land use science that is applicable to the wide range of user community requirements. The programme's themes will be developed to provide the basis for large-scale, long-term analytical studies of major land use change.

3: The Urban Environment

This relatively new programme aims to extend the interdisciplinary knowledge base and to understand the key environmental patterns and processes in urban situations and particularly change due to human activities. This knowledge is required to plan more sustainable urban environments.

4: Freshwater Resources

Increasing demands on freshwater resources have resulted in the need for a scientific basis for the effective strategic and sustainable management of freshwater resources. This programme will address this by integrating CEH research in the areas of water quantity, water quality, and the ecological aspects of freshwater systems.

5: Biodiversity

Aimed at improving our understanding of microbiological and biological resources at a range of spatial scales. The research considers the underlying processes and resulting functions, and directs knowledge to the sustainable management of biodiversity.

6: Pest and Disease Control and Risk Assessment for GMOs

The primary aim of this programme is to undertake research in the provision of novel pest and disease control strategies whilst addressing any possible risk to the environment. The use of molecular biology is essential to maintain a novel and progressive approach to the themes of pest control and animal disease control.

7: Pollution Assessment and Control

This programme is aimed at developing a better understanding of generic processes such as atmospheric transport, fluxes of pollutants and the fate of pollutants, in order to predict more accurately the likely impacts on environments and organisms.

8: Environmental Risks and Extreme Events

This research programme will develop understanding of how environmental extremes affect mankind and the natural environment, developing quantitative, predictive tools to describe these effects, and contributing to mitigating measures.

9: Global Change

This programme will help to reduce uncertainty in the magnitude of global change and its impacts. The research is focused on improving the accuracy of global change predictions through measurement programmes, the development of scaling-up methods and models, and the identification of ecosystem responses.

10: Integrating Generic Science

Programme 10 has been designed to provide a research framework for those areas of CEH science which underpin the nine other programmes (eg providing the data and technological support), as well as conducting its own fundamental research.

The following section of this Scientific Report describes research which is currently being carried out in six of the ten programmes by the Institute of Freshwater Ecology. Further details of the Themes and Issues that make up each of the ten Science Programmes are listed in Appendix 3 of the CEH Annual Report.